

# Information, People, and Technology

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# Information, People, and Technology

Information, People and Technology presents the high points of an education in the College of Information Sciences and Technology. It opens an intellectual journey through the ideas and challenges that IT professionals face in the world. It will address major questions such as: How can we use technology to organize and integrate human enterprises? How can technology help people and organizations adapt rapidly and creatively? What can we do about information overload?

Three perspectives (or facets) address the core issues: information or the basic science of data encoding, transmission and storage; people or the interactions among technologies, institutions, regulations and users; and technology or the design and operation of basic information technology devices. Students completing the course will be confident users and consumers of information technology. Students will develop research and analytical skills to evaluate specific devices and understand how those devices function in larger socio-technical systems. Students will be able to predict and anticipate the impact of new technologies on human institutions as well as understand the potential impact of institutions on the use and design of information technologies.

The course employs an action-oriented approach. Students learn by doing—formulating and solving problems drawn from professional contexts, detecting and recovering from errors related to technology use, and locating, reading and studying materials that support their analysis and problem-solving. Students will accomplish this by participating in team-based learning. The course provides students with the opportunity to use, modify, and evaluate software to search for, frame, and express ideas with fluency. A variety of mechanisms are used to assess student performance. These evaluation methods typically include exams, quizzes, homework assignments, group projects, and peer and self-assessments.

IST 110 is the introductory course in IST, and, as such, serves as a prerequisite for 200-level (intermediate) IST courses. It is a required course for all majors and minors in IST, and meets requirements for a General Education or Bachelor of Arts Social Science (GS) course.

The course is delivered with significant student interaction with technology. At University Park, it is offered in multiple sections (typically 40-60 students per section), in the Fall and Spring semesters. At other Penn State campuses, it would be offered in class sizes typically ranging between 20-50 students.

General Education: GS

Diversity: None

Bachelor of Arts: None

Effective: Summer 2005

## PART I

# CHAPTER 1: INFORMATION SCIENCES

Information science represents a large part of what the College of Information Sciences and Technology is all about. This chapter will focus first on defining and explaining information science as a field. The chapter then shifts to the Internet, as it provides a critical lens in which we can study and explore information science.

My hope is throughout this chapter, and throughout the entire course, I can change the way you perceive information and technology, from the everyday use of mobile and communication technologies, to how you search for data, to data security and privacy, and much more!

### *Learning Objectives*

After reading this chapter, you be able to:

- Define information sciences.
- Describe the role of an information scientist in today's society.
- Define the Internet.
- Identify key points in the history of the Internet.

# I. Information Sciences Defined

From [https://en.wikipedia.org/wiki/Information\\_science](https://en.wikipedia.org/wiki/Information_science)

**Information science** is an [interdisciplinary](#) field primarily concerned with the analysis, collection, [classification](#), manipulation, storage, [retrieval](#), movement, dissemination, and protection of [information](#). Practitioners within the field study the application and usage of knowledge in [organizations](#), along with the interaction between people, organizations and any existing [information systems](#), with the aim of creating, replacing, improving, or understanding information systems. Information science is often (mistakenly) considered a branch of [computer science](#); however, it predates computer science and is actually a broad, interdisciplinary field, incorporating not only aspects of computer science, but often diverse fields such as [archival science](#), [cognitive science](#), [commerce](#), [communications](#), [law](#), [library science](#), [museology](#), [management](#), [mathematics](#), [philosophy](#), [public policy](#), and the [social sciences](#).

Information science should not be confused with [information theory](#) or [library science](#). Information theory is the study of a particular mathematical concept of information. Information science as an academic discipline is often taught in combination with Library science as Library and Information Science. Library science as such is a field related to the dissemination of information through [libraries](#) making use of the principles of information science. Information science deals with all the processes and techniques pertaining to the information life cycle, including capture, generation, packaging, dissemination, transformation, refining, repackaging, usage, storage, communication, protection, presentation etc. in any possible manner.

## Foundations of Information Science

### Scope and approach

Information science focuses on understanding [problems](#) from the perspective of the stakeholders involved and then applying information and other technologies as needed. In other words, it tackles systemic problems first rather than individual pieces of [technology](#) within that system. In this respect, one can see information science as a response to [technological determinism](#), the belief that technology “develops by its own laws, that it realizes its own potential, limited only by the material resources available and the creativity of its developers. It must therefore be regarded as an autonomous system controlling and ultimately permeating all other subsystems of society.”

Many universities have entire colleges, departments or schools devoted to the study of information science, while numerous information-science scholars work in disciplines such as [communication](#), [computer science](#), [law](#), [library science](#), and [sociology](#). Several institutions have formed an I-School Caucus (see [List of I-Schools](#)), but numerous others besides these also have comprehensive information foci.

Within information science, current issues as of 2013 include:

- [human-computer interaction](#)
- [groupware](#)
- the [semantic web](#)
- [value-sensitive design](#)
- [iterative design](#) processes
- the ways people generate, use and find information

## Definitions of information science

An early definition of Information science (going back to 1968, the year when the *American Documentation Institute* renamed itself as the *American Society for Information Science and Technology*) states:

“Information science is that discipline that investigates the properties and behavior of information, the forces governing the flow of information, and the means of processing information for optimum accessibility and usability. It is concerned with that body of knowledge relating to the origination, collection, organization, storage, retrieval, interpretation, transmission, transformation, and utilization of information. This includes the investigation of information representations in both natural and artificial systems, the use of codes for efficient message transmission, and the study of information processing devices and techniques such as computers and their programming systems. It is an interdisciplinary science derived from and related to such fields as mathematics, logic, linguistics, psychology, computer technology, operations research, the graphic arts, communications, library science, management, and other similar fields. It has both a pure science component, which inquires into the subject without regard to its application, and an applied science component, which develops services and products.” (Borko, 1968, p.3).

Some authors use [informatics](#) as a synonym for *information science*. This is especially true when related to the concept developed by [A. I. Mikhailov](#) and other Soviet authors in the mid-1960s. The Mikhailov school saw informatics as a discipline related to the study of scientific information. Informatics is difficult to precisely define because of the rapidly evolving and [interdisciplinary](#) nature of the field. Definitions reliant on the nature of the tools used for deriving meaningful information from data are emerging in Informatics academic programs.

Regional differences and international terminology complicate the problem. Some people note that much of what is called “Informatics” today was once called “Information Science” – at least in fields such as Medical Informatics. For example, when library scientists began also to use the phrase “Information Science” to refer to their work, the term “informatics” emerged:

- in the United States as a response by computer scientists to distinguish their work from that of library science
- in Britain as a term for a science of information that studies natural, as well as artificial or engineered, information-processing systems

Another term discussed as a synonym for “information studies” is “information systems”. [Brian Campbell Vickery](#)’s *Information Systems* (1973) places information systems within IS. Ellis, Allen, & Wilson (1999), on the other hand, provide a bibliometric investigation describing the relation between two **different** fields: “information science” and “information systems”.



**Paul Otlet, Information Scientist, 1868-1944**

Paul Otlet was an early information scientist, who wanted to catalog all the facts in the world. With collaborators, he began writing down facts on index cards, and storing them in a complex card catalog system.



Image from Zinneke, from Wikipedia: [https://en.wikipedia.org/wiki/Paul\\_Otlet#/media/File:Mundaneum\\_Tir%C3%A4ng\\_Karteikaarten.jpg](https://en.wikipedia.org/wiki/Paul_Otlet#/media/File:Mundaneum_Tir%C3%A4ng_Karteikaarten.jpg)

The card catalog system became known as the Repertoire Biblographique Universel, and grew to over 15 million index cards. Otlet would go on to create a fee-based service, in which anyone in the world could send Otlet a question via mail, then receive answers in the form of copies of applicable index cards from the catalog. In essence, Otlet created an analog search engine. We will be using Otlet's Repertoire Biblographique Universel as an example throughout the semester, as we talk about various technology topics, and how Otlet might do things different if he wanted to re-create this system in today's world.

## Philosophy of information

Philosophy of information (PI) studies conceptual issues arising at the intersection of [computer science](#), [information technology](#), and [philosophy](#). It includes the investigation of the conceptual nature and basic principles of [information](#), including its dynamics, utilisation and sciences, as well as the elaboration and application of information-theoretic and computational methodologies to its philosophical problems.

## Ontology

In computer science and information science, an ontology formally represents knowledge as a set of concepts within a [domain](#), and the relationships between those concepts. It can be used to [reason](#) about the entities within that domain and may be used to describe the domain.

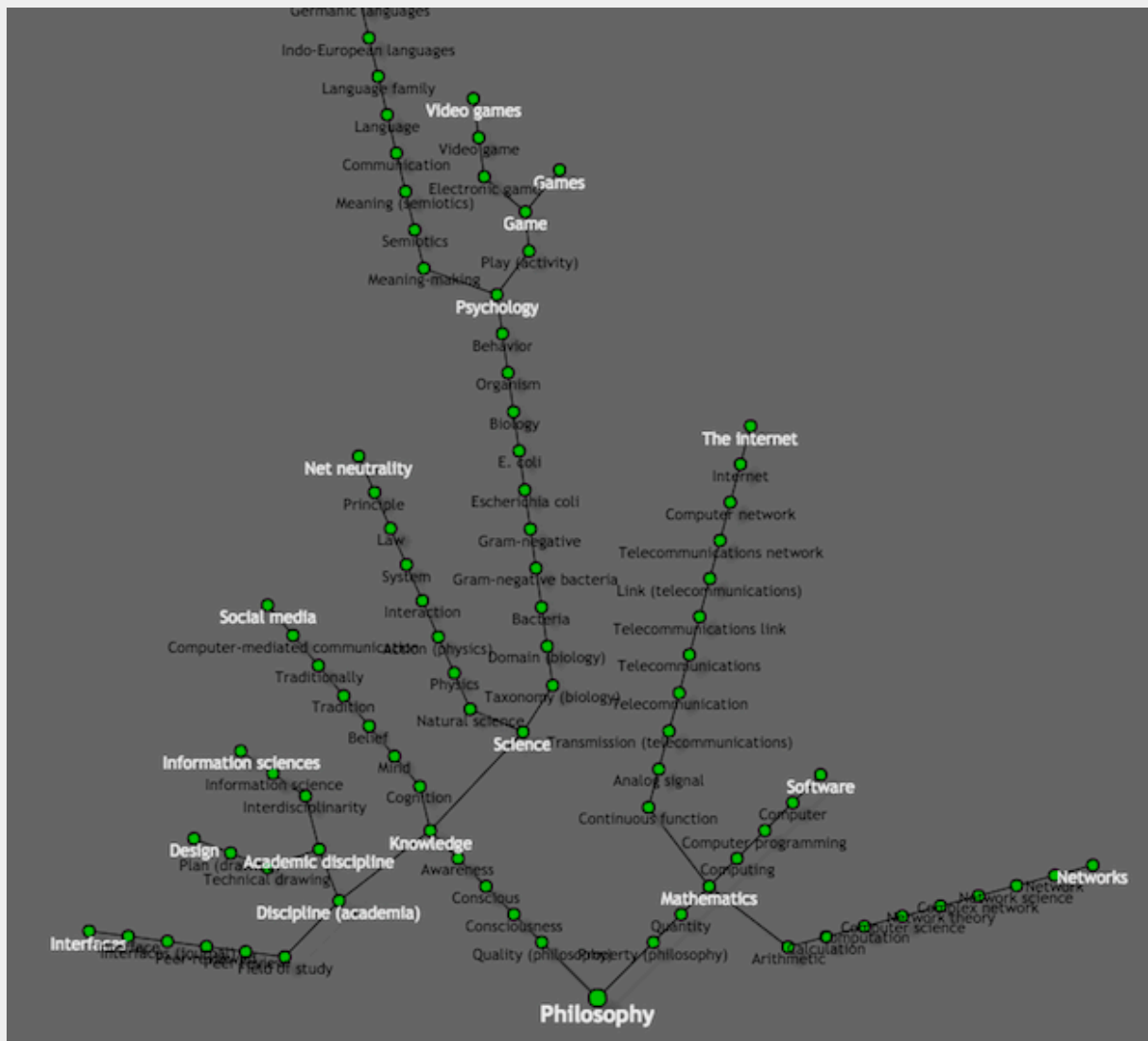
More specifically, an ontology is a model for describing the world that consists of a set of types, properties, and relationship types. Exactly what is provided around these varies, but they are the essentials of an ontology. There is also generally an expectation that there be a close resemblance between the real world and the features of the model in an ontology.

In theory, an ontology is a “formal, explicit specification of a shared conceptualisation.” An ontology renders shared [vocabulary](#) and [taxonomy](#) which models a domain with the definition of objects and/or concepts and their properties and relations.

Ontologies are the structural frameworks for organizing information and are used in [artificial intelligence](#), the [Semantic Web](#), [systems engineering](#), [software engineering](#), [biomedical informatics](#), [library science](#), [enterprise bookmarking](#), and [information architecture](#) as a form of [knowledge representation](#) about the world or some part of it. The creation of domain ontologies is also fundamental to the definition and use of an [enterprise architecture framework](#).

### Xefer

[Xefer](#), a web-based application in which you can enter various phrases or terms, then Xefer looks across Wikipedia and attempts to make linkages between all the things you entered. It's similar to Six Degrees of Kevin Bacon, in which all actors and actresses can be traced back to Kevin Bacon by six connection points or less. Below is an example of an Ontology created by adding several different keywords and phrases from our course to Xefer.



## 2. Information Science Careers and Fields

From [https://en.wikipedia.org/wiki/Information\\_science](https://en.wikipedia.org/wiki/Information_science)

### Information Science Careers

#### Information scientist

An information scientist is an individual, usually with a relevant subject degree or high level of subject knowledge, providing focused information to scientific and technical research staff in industry, a role quite distinct from and complementary to that of a librarian. The title also applies to an individual carrying out research in information science.

#### Information professional

An information professional is an individual who preserves, organizes, and disseminates information. Information professionals are skilled in the organization and retrieval of recorded knowledge. Traditionally, their work has been with print materials, but these skills are being increasingly used with electronic, visual, audio, and digital materials. Information professionals work in a variety of public, private, non-profit, and academic institutions. Information professionals can also be found within organizational and industrial contexts. Performing roles that include system design and development and system analysis.

### Related Fields

#### Information access

Information access is an area of research at the intersection of [Informatics](#), Information Science, [Information Security](#), [Language Technology](#), [Computer Science](#), and [Library Science](#). The objectives of information access research are to automate the processing of large and unwieldy amounts of information and to simplify users' access to it. Applicable technologies include [information retrieval](#), [text mining](#), [machine translation](#), and [text categorisation](#). In discussion, information access is often defined as concerning the insurance of free and closed access to information and is brought up in discussions on [copyright](#), [patent law](#), and [public domain](#).

#### Information architecture

Information architecture (IA) is the art and science of organizing and labelling [websites](#), [intranets](#), [online communities](#) and software to support usability. It is an emerging discipline and *community of practice* focused on bringing together principles of [design](#) and [architecture](#) to the *digital landscape*. Typically it involves a [model](#) or [concept](#) of [information](#) which is used and applied to activities that require explicit details of complex [information systems](#). These activities include [library](#) systems and [database](#) development.



## **Information management**

Information management (IM) is the collection and management of information from one or more sources and the distribution of that information to one or more audiences. This sometimes involves those who have a stake in, or a right to that information. Management means the organization of and control over the structure, processing and delivery of information. Throughout the 1970s this was largely limited to files, file maintenance, and the life cycle management of paper-based files, other media and records. With the proliferation of information technology starting in the 1970s, the job of information management took on a new light and also began to include the field of data maintenance.

## **Information retrieval**

Information retrieval (IR) is the area of study concerned with searching for documents, for [information](#) within documents, and for [metadata](#) about documents, as well as that of searching [structured storage](#), [relational databases](#), and the [World Wide Web](#). Automated information retrieval systems are used to reduce what has been called “[information overload](#)“. Many universities and [public libraries](#) use IR systems to provide access to books, journals and other documents. [Web search engines](#) are the most visible [IR applications](#).

An information retrieval process begins when a user enters a [query](#) into the system. Queries are formal statements of [information needs](#), for example search strings in web search engines. In information retrieval a query does not uniquely identify a single object in the collection. Instead, several objects may match the query, perhaps with different degrees of [relevancy](#).

An object is an entity that is represented by information in a [database](#). User queries are matched against the database information. Depending on the [application](#) the data objects may be, for example, text documents, images, audio, [mind maps](#) or videos. Often the documents themselves are not kept or stored directly in the IR system, but are instead represented in the system by document surrogates or metadata.

Most IR systems compute a numeric score on how well each object in the database match the query, and rank the objects according to this value. The top ranking objects are then shown to the user. The process may then be iterated if the user wishes to refine the query.

## **Information seeking**

Information seeking is the process or activity of attempting to obtain information in both human and technological contexts. Information seeking is related to, but different from, information retrieval (IR).

Much library and information science (LIS) research has focused on the information-seeking practices of practitioners within various fields of professional work. Studies have been carried out into the information-seeking behaviors of librarians, academics, medical professionals, engineers and lawyers (among others). Much of this research has drawn on the work done by Leckie, Pettigrew (now Fisher) and Sylvain, who in 1996 conducted an extensive review of the LIS literature (as well as the literature of other academic fields) on professionals' information seeking. The authors proposed an analytic model of professionals' information seeking behaviour, intended to be generalizable across the professions, thus providing a platform for future research in the area. The model was intended to “prompt new insights... and give rise to more refined and applicable theories of information seeking” (1996, p. 188). The model has been adapted by Wilkinson (2001) who proposes a model of the information seeking of lawyers.

## **Information society**

An information society is a [society](#) where the creation, distribution, diffusion, uses, integration and manipulation of [information](#) is a significant economic, political, and cultural activity. The aim of an information society is to gain competitive advantage internationally, through using [IT](#) in a creative and productive way. The [knowledge economy](#) is its economic counterpart, whereby wealth is created through the economic exploitation of understanding. People who have the means to partake in this form of society are sometimes called [digital citizens](#).

Basically, an information society is the means of getting information from one place to another (Wark, 1997, p. 22). As technology has become more advanced over time so too has the way we have adapted in sharing this information with each other.

Information society theory discusses the role of information and information technology in society, the question of which key concepts should be used for characterizing contemporary society, and how to define such concepts. It has become a specific branch of contemporary sociology.

### **Knowledge representation and reasoning**

Knowledge representation (KR) is an area of [artificial intelligence](#) research aimed at representing knowledge in symbols to facilitate [inferencing](#) from those [knowledge](#) elements, creating new elements of knowledge. The KR can be made to be independent of the underlying knowledge model or knowledge base system (KBS) such as a [semantic network](#).

Knowledge Representation (KR) research involves analysis of how to reason accurately and effectively and how best to use a set of symbols to represent a set of facts within a knowledge domain. A symbol vocabulary and a system of logic are combined to enable [inferences](#) about elements in the KR to create new KR sentences. Logic is used to supply formal [semantics](#) of how reasoning functions should be applied to the symbols in the KR system. Logic is also used to define how operators can process and reshape the knowledge. Examples of operators and operations include, negation, conjunction, adverbs, adjectives, quantifiers and modal operators. The logic is interpretation theory. These elements—symbols, operators, and interpretation theory—are what give sequences of symbols meaning within a KR.

# 3. The Internet

From <https://en.wikipedia.org/wiki/Internet>

The Internet provides a great lens in which to study information sciences, as the Internet is the great enabler of our time. Regardless of discipline, understanding how the Internet can be used as an information and communication platform, for a wide variety of purposes, will help you be successful both in this class, and well beyond graduation and in the workforce.

The **Internet** is the global system of interconnected [computer networks](#) that use the [Internet protocol suite](#) (TCP/IP) to link billions of devices worldwide. It is a *network of networks* that consists of millions of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies. The Internet carries an extensive range of information resources and services, such as the inter-linked [hypertext](#) documents and [applications](#) of the [World Wide Web](#) (WWW), [electronic mail](#), [telephony](#), and [peer-to-peer](#) networks for [file sharing](#).

The origins of the Internet date back to research commissioned by the [United States federal government](#) in the 1960s to build robust, fault-tolerant communication via computer networks. The primary precursor network, the [ARPANET](#), initially served as a backbone for interconnection of regional academic and military networks in the 1980s. The funding of the [National Science Foundation Network](#) as a new backbone in the 1980s, as well as private funding for other commercial extensions, led to worldwide participation in the development of new networking technologies, and the merger of many networks.<sup>[2]</sup> The linking of commercial networks and enterprises by the early 1990s marks the beginning of the transition to the modern Internet,<sup>[3]</sup> and generated a sustained exponential growth as generations of institutional, [personal](#), and [mobile](#) computers were connected to the network.

Although the Internet has been widely used by [academia](#) since the 1980s, the [commercialization](#) incorporated its services and technologies into virtually every aspect of modern life. Internet use grew rapidly in the West from the mid-1990s and from the late 1990s in the [developing world](#). In the 20 years since 1995, Internet use has grown 100-times, measured for the period of one year, to over one third of the [world population](#).

Most traditional communications media, including telephony and television, are being reshaped or redefined by the Internet, giving birth to new services such as [Internet telephony](#) and [Internet television](#). Newspaper, book, and other print publishing are adapting to [website](#) technology, or are reshaped into [blogging](#) and [web feeds](#). The entertainment industry was initially the fastest growing segment on the Internet. The Internet has enabled and accelerated new forms of personal interactions through [instant messaging](#), [Internet forums](#), and [social networking](#). [Online shopping](#) has grown exponentially both for major retailers and small [artisans](#) and traders. [Business-to-business](#) and [financial services](#) on the Internet affect [supply chains](#) across entire industries.

The Internet has no centralized governance in either technological implementation or policies for access and usage; each constituent network sets its own policies. Only the overarching definitions of the two principal [name spaces](#) in the Internet, the [Internet Protocol address](#) space and the [Domain Name System](#) (DNS), are directed by a maintainer organization, the [Internet](#)

[Corporation for Assigned Names and Numbers](#) (ICANN). The technical underpinning and standardization of the core protocols is an activity of the [Internet Engineering Task Force](#) (IETF), a non-profit organization of loosely affiliated international participants that anyone may associate with by contributing technical expertise.

### **Governance**

The Internet is a [global network](#) comprising many voluntarily interconnected autonomous networks. It operates without a central governing body.

The technical underpinning and standardization of the core protocols ([IPv4](#) and [IPv6](#)) is an activity of the [Internet Engineering Task Force](#) (IETF), a non-profit organization of loosely affiliated international participants that anyone may associate with by contributing technical expertise.

To maintain interoperability, the principal [name spaces](#) of the Internet are administered by the [Internet Corporation for Assigned Names and Numbers](#) (ICANN). ICANN is governed by an international board of directors drawn from across the Internet technical, business, academic, and other non-commercial communities. ICANN coordinates the assignment of unique identifiers for use on the Internet, including [domain names](#), Internet Protocol (IP) addresses, application port numbers in the transport protocols, and many other parameters. Globally unified name spaces are essential for maintaining the global reach of the Internet. This role of ICANN distinguishes it as perhaps the only central coordinating body for the global Internet.

### **Protocols**

While the hardware components in the Internet infrastructure can often be used to support other software systems, it is the design and the standardization process of the software that characterizes the Internet and provides the foundation for its scalability and success. The responsibility for the architectural design of the Internet software systems has been assumed by the [Internet Engineering Task Force](#) (IETF). The IETF conducts standard-setting work groups, open to any individual, about the various aspects of Internet architecture. Resulting contributions and standards are published as [Request for Comments](#) (RFC) documents on the IETF web site.

The principal methods of networking that enable the Internet are contained in specially designated RFCs that constitute the [Internet Standards](#). Other less rigorous documents are simply informative, experimental, or historical, or document the best current practices (BCP) when implementing Internet technologies.

The Internet standards describe a framework known as the [Internet protocol suite](#). This is a model architecture that divides methods into a layered system of protocols, originally documented in [RFC 1122](#) and [RFC 1123](#). The layers correspond to the environment or scope in which their services operate. At the top is the [application layer](#), space for the application-specific networking methods used in software applications. For example, a web browser program uses the [client-server](#) application model and a specific protocol of interaction between servers and clients, while many file-sharing systems use a [peer-to-peer](#) paradigm. Below this top layer, the [transport layer](#) connects applications on different hosts with a logical channel through the network with appropriate data exchange methods.

Underlying these layers are the networking technologies that interconnect networks at their borders and hosts via the physical connections. The [Internet layer](#) enables computers to identify and locate each other via [Internet Protocol \(IP\) addresses](#), and routes their traffic via intermediate (transit) networks. Last, at the bottom of the architecture is the [link layer](#), which provides

connectivity between hosts on the same network link, such as a physical connection in the form of a [local area network](#) (LAN) or a [dial-up connection](#). The model, also known as [TCP/IP](#), is designed to be independent of the underlying hardware, which the model, therefore, does not concern itself with in any detail. Other models have been developed, such as the [OSI model](#), that attempt to be comprehensive in every aspect of communications. While many similarities exist between the models, they are not compatible in the details of description or implementation; indeed, TCP/IP protocols are usually included in the discussion of OSI networking.

As user data is processed through the protocol stack, each abstraction layer adds encapsulation information at the sending host. Data is transmitted *over the wire* at the link level between hosts and routers. Encapsulation is removed by the receiving host. Intermediate relays update link encapsulation at each hop, and inspect the IP layer for routing purposes.

The most prominent component of the Internet model is the Internet Protocol (IP), which provides addressing systems ([IP addresses](#)) for computers on the Internet. IP enables internetworking and, in essence, establishes the Internet itself. [Internet Protocol Version 4](#) (IPv4) is the initial version used on the first generation of the Internet and is still in dominant use. It was designed to address up to ~4.3 billion ( $10^9$ ) Internet hosts. However, the explosive growth of the Internet has led to [IPv4 address exhaustion](#), which entered its final stage in 2011, when the global address allocation pool was exhausted. A new protocol version, IPv6, was developed in the mid-1990s, which provides vastly larger addressing capabilities and more efficient routing of Internet traffic. [IPv6](#) is currently in growing [deployment](#) around the world, since Internet address registries ([RIRs](#)) began to urge all resource managers to plan rapid adoption and conversion.

IPv6 is not directly interoperable by design with IPv4. In essence, it establishes a parallel version of the Internet not directly accessible with IPv4 software. Thus, translation facilities must exist for internetworking or nodes must have duplicate networking software for both networks. Essentially all modern computer operating systems support both versions of the Internet Protocol. Network infrastructure, however, is still lagging in this development. Aside from the complex array of physical connections that make up its infrastructure, the Internet is facilitated by bi- or multi-lateral commercial contracts, e.g., [peering agreements](#), and by technical specifications or protocols that describe the exchange of data over the network. Indeed, the Internet is defined by its interconnections and routing policies.

## Internet Services

### World Wide Web

Many people use the terms *Internet* and *World Wide Web*, or just the *Web*, interchangeably, but the two terms are not synonymous. The [World Wide Web](#) is the primary application that billions of people use on the Internet, and it has changed their lives immeasurably. However, the Internet provides many other services. The Web is a global set of [documents](#), [images](#) and other resources, logically interrelated by [hyperlinks](#) and referenced with [Uniform Resource Identifiers](#) (URIs). URIs symbolically identify services, [servers](#), and other databases, and the documents and resources that they can provide. [Hypertext Transfer Protocol](#) (HTTP) is the main access protocol of the World



Wide Web. [Web services](#) also use HTTP to allow software systems to communicate in order to share and exchange business logic and data.

World Wide Web browser software, such as [Microsoft's Internet Explorer](#), [Mozilla Firefox](#), [Opera](#), [Apple's Safari](#), and [Google Chrome](#), lets users navigate from one web page to another via hyperlinks embedded in the documents. These documents may also contain any combination of [computer data](#), including graphics, sounds, [text](#), [video](#), [multimedia](#) and interactive content that runs while the user is interacting with the page. [Client-side software](#) can include animations, [games](#), [office applications](#) and scientific demonstrations. Through [keyword-driven Internet research](#) using [search engines](#) like [Yahoo!](#) and [Google](#), users worldwide have easy, instant access to a vast and diverse amount of online information. Compared to printed media, books, encyclopedias and traditional libraries, the World Wide Web has enabled the decentralization of information on a large scale.

The Web has also enabled individuals and organizations to [publish](#) ideas and information to a potentially large [audience](#) online at greatly reduced expense and time delay. Publishing a web page, a blog, or building a website involves little initial [cost](#) and many cost-free services are available. However, publishing and maintaining large, professional web sites with attractive, diverse and up-to-date information is still a difficult and expensive proposition. Many individuals and some companies and groups use *web logs* or blogs, which are largely used as easily updatable online diaries. Some commercial organizations encourage [staff](#) to communicate advice in their areas of specialization in the hope that visitors will be impressed by the expert knowledge and free information, and be attracted to the corporation as a result.

One example of this practice is [Microsoft](#), whose [product developers](#) publish their personal blogs in order to pique the public's interest in their work. Collections of personal web pages published by large service providers remain popular and have become increasingly sophisticated. Whereas operations such as [Angelfire](#) and [GeoCities](#) have existed since the early days of the Web, newer offerings from, for example, [Facebook](#) and [Twitter](#) currently have large followings. These operations often brand themselves as [social network services](#) rather than simply as web page hosts.

[Advertising](#) on popular web pages can be lucrative, and [e-commerce](#) or the sale of products and services directly via the Web continues to grow.

When the Web developed in the 1990s, a typical web page was stored in completed form on a web server, formatted in [HTML](#), complete for transmission to a web browser in response to a request. Over time, the process of creating and serving web pages has become dynamic, creating a flexible design, layout, and content. Websites are often created using [content management](#) software with, initially, very little content. Contributors to these systems, who may be paid staff, members of an organization or the public, fill underlying databases with content using editing pages designed for that purpose while casual visitors view and read this content in HTML form. There may or may not be editorial, approval and security systems built into the process of taking newly entered content and making it available to the target visitors.

### **Communication**

[Email](#) is an important communications service available on the Internet. The concept of sending electronic text messages between parties in a way analogous to mailing letters or memos predates the creation of the Internet. Pictures, documents, and other files are sent as [email attachments](#). Emails can be [cc-ed](#) to multiple [email addresses](#).

[Internet telephony](#) is another common communications service made possible by the creation of the Internet. [VoIP](#) stands for Voice-over-[Internet Protocol](#), referring to the protocol that underlies all Internet communication. The idea began in the early 1990s with [walkie-talkie](#)-like voice applications for personal computers. In recent years many VoIP systems have become as easy to use and as convenient as a normal telephone. The benefit is that, as the Internet carries the voice traffic, VoIP can be free or cost much less than a traditional telephone call, especially over long distances and especially for those with always-on Internet connections such as [cable](#) or [ADSL](#). VoIP is maturing into a competitive alternative to traditional telephone service. Interoperability between different providers has improved and the ability to call or receive a call from a traditional telephone is available. Simple, inexpensive VoIP network adapters are available that eliminate the need for a personal computer.

Voice quality can still vary from call to call, but is often equal to and can even exceed that of traditional calls. Remaining problems for VoIP include [emergency telephone number](#) dialing and reliability. Currently, a few VoIP providers provide an emergency service, but it is not universally available. Older traditional phones with no “extra features” may be line-powered only and operate during a power failure; VoIP can never do so without a [backup power source](#) for the phone equipment and the Internet access devices. VoIP has also become increasingly popular for gaming applications, as a form of communication between players. Popular VoIP clients for gaming include [Ventrilo](#) and [Teamspeak](#). Modern video game consoles also offer VoIP chat features.

### **Data transfer**

[File sharing](#) is an example of transferring large amounts of data across the Internet. A [computer file](#) can be emailed to customers, colleagues and friends as an attachment. It can be uploaded to a website or [File Transfer Protocol](#) (FTP) server for easy download by others. It can be put into a “shared location” or onto a [file server](#) for instant use by colleagues. The load of bulk downloads to many users can be eased by the use of “[mirror](#)” servers or [peer-to-peer](#) networks. In any of these cases, access to the file may be controlled by user [authentication](#), the transit of the file over the Internet may be obscured by [encryption](#), and money may change hands for access to the file. The price can be paid by the remote charging of funds from, for example, a credit card whose details are also passed – usually fully encrypted – across the Internet. The origin and authenticity of the file received may be checked by [digital signatures](#) or by [MD5](#) or other message digests. These simple features of the Internet, over a worldwide basis, are changing the production, sale, and distribution of anything that can be reduced to a computer file for transmission. This includes all manner of print publications, software products, news, music, film, video, photography, graphics and the other arts. This in turn has caused seismic shifts in each of the existing industries that previously controlled the production and distribution of these products.

[Streaming media](#) is the real-time delivery of digital media for the immediate consumption or enjoyment by end users. Many radio and television broadcasters provide Internet feeds of their live audio and video productions. They may also allow time-shift viewing or listening such as Preview, Classic Clips and Listen Again features. These providers have been joined by a range of pure Internet “broadcasters” who never had on-air licenses. This means that an Internet-connected device, such as a computer or something more specific, can be used to access on-line media in much the same way as was previously possible only with a television or radio receiver. The range of available types of content is much wider, from specialized technical [webcasts](#) to on-demand popular multimedia services. [Podcasting](#) is a variation on this theme, where – usually audio –

material is downloaded and played back on a computer or shifted to a [portable media player](#) to be listened to on the move. These techniques using simple equipment allow anybody, with little censorship or licensing control, to broadcast audio-visual material worldwide.

Digital media streaming increases the demand for network bandwidth. For example, standard image quality needs 1 Mbit/s link speed for SD 480p, HD 720p quality requires 2.5 Mbit/s, and the top-of-the-line HDX quality needs 4.5 Mbit/s for 1080p.

[Webcams](#) are a low-cost extension of this phenomenon. While some webcams can give full-frame-rate video, the picture either is usually small or updates slowly. Internet users can watch animals around an African waterhole, ships in the [Panama Canal](#), traffic at a local roundabout or monitor their own premises, live and in real time. Video [chat rooms](#) and [video conferencing](#) are also popular with many uses being found for personal webcams, with and without two-way sound. YouTube was founded on 15 February 2005 and is now the leading website for free streaming video with a vast number of users. It uses a [flash](#)-based web player to stream and show video files. Registered users may upload an unlimited amount of video and build their own personal profile. [YouTube](#) claims that its users watch hundreds of millions, and upload hundreds of thousands of videos daily. Currently, YouTube also uses an [HTML5](#) player.



## 4. Internet Users and Usage

From <https://en.wikipedia.org/wiki/Internet>

### Users

Internet usage has seen tremendous growth. From 2000 to 2009, the number of Internet users globally rose from 394 million to 1.858 billion. By 2010, 22 percent of the world's population had access to computers with 1 billion [Google](#) searches every day, 300 million Internet users reading blogs, and 2 billion videos viewed daily on [YouTube](#). In 2014 the world's Internet users surpassed 3 billion or 43.6 percent of world population, but two-thirds of the users came from richest countries, with 78.0 percent of Europe countries population using the Internet, followed by 57.4 percent of the Americas.

The prevalent language for communication on the Internet has been English. This may be a result of the origin of the Internet, as well as the language's role as a [lingua franca](#). Early computer systems were limited to the characters in the [American Standard Code for Information Interchange](#) (ASCII), a subset of the [Latin alphabet](#).

After English (27%), the most requested languages on the [World Wide Web](#) are Chinese (25%), Spanish (8%), Japanese (5%), Portuguese and German (4% each), Arabic, French and Russian (3% each), and Korean (2%). By region, 42% of the world's [Internet users](#) are based in Asia, 24% in Europe, 14% in North America, 10% in Latin America and the [Caribbean](#) taken together, 6% in Africa, 3% in the Middle East and 1% in Australia/Oceania. The Internet's technologies have developed enough in recent years, especially in the use of [Unicode](#), that good facilities are available for development and communication in the world's widely used languages. However, some glitches such as [mojibake](#) (incorrect display of some languages' characters) still remain.

In an American study in 2005, the percentage of men using the Internet was very slightly ahead of the percentage of women, although this difference reversed in those under 30. Men logged on more often, spent more time online, and were more likely to be broadband users, whereas women tended to make more use of opportunities to communicate (such as email). Men were more likely to use the Internet to pay bills, participate in auctions, and for recreation such as downloading music and videos. Men and women were equally likely to use the Internet for shopping and banking. More recent studies indicate that in 2008, women significantly outnumbered men on most social networking sites, such as Facebook and Myspace, although the ratios varied with age. In addition, women watched more streaming content, whereas men downloaded more. In terms of blogs, men were more likely to blog in the first place; among those who blog, men were more likely to have a professional blog, whereas women were more likely to have a personal blog.

According to forecasts by [Euromonitor International](#), 44% of the world's population will be users of the Internet by 2020. Splitting by country, in 2012 Iceland, Norway, Sweden, the Netherlands, and Denmark had the highest [Internet penetration by the number of users](#), with 93% or more of the population with access.

Several neologisms exist that refer to Internet users: [Netizen](#) (as in as in "citizen of the net") refers to those [actively involved](#) in improving [online communities](#), the Internet in general or surrounding political affairs and rights such as [free speech](#), [Internaut](#) refers to operators or

technically highly capable users of the Internet, [digital citizen](#) refers to a person using the Internet in order to engage in society, politics, and government participation.

### **Usage**

The Internet allows greater flexibility in working hours and location, especially with the spread of unmetered high-speed connections. The Internet can be accessed almost anywhere by numerous means, including through [mobile Internet devices](#). Mobile phones, [datacards](#), [handheld game consoles](#) and [cellular routers](#) allow users to connect to the Internet [wirelessly](#). Within the limitations imposed by small screens and other limited facilities of such pocket-sized devices, the services of the Internet, including email and the web, may be available. Service providers may restrict the services offered and mobile data charges may be significantly higher than other access methods.

Educational material at all levels from pre-school to post-doctoral is available from websites. Examples range from [CBeebies](#), through school and high-school revision guides and [virtual universities](#), to access to top-end scholarly literature through the likes of [Google Scholar](#). For [distance education](#), help with [homework](#) and other assignments, self-guided learning, whiling away spare time, or just looking up more detail on an interesting fact, it has never been easier for people to access educational information at any level from anywhere. The Internet in general and the [World Wide Web](#) in particular are important enablers of both [formal](#) and [informal education](#). Further, the Internet allows universities, in particular, researchers from the social and behavioral sciences, to conduct research remotely via virtual laboratories, with profound changes in reach and generalizability of findings as well as in communication between scientists and in the publication of results.

The low cost and nearly instantaneous sharing of ideas, knowledge, and skills have made [collaborative](#) work dramatically easier, with the help of [collaborative software](#). Not only can a group cheaply communicate and share ideas but the wide reach of the Internet allows such groups more easily to form. An example of this is the [free software movement](#), which has produced, among other things, [Linux](#), [Mozilla Firefox](#), and [OpenOffice.org](#). Internet chat, whether using an [IRC](#) chat room, an [instant messaging](#) system, or a [social networking](#) website, allows colleagues to stay in touch in a very convenient way while working at their computers during the day. Messages can be exchanged even more quickly and conveniently than via email. These systems may allow files to be exchanged, drawings and images to be shared, or voice and video contact between team members.

[Content management](#) systems allow collaborating teams to work on shared sets of documents simultaneously without accidentally destroying each other's work. Business and project teams can share calendars as well as documents and other information. Such collaboration occurs in a wide variety of areas including scientific research, software development, conference planning, political activism and creative writing. Social and political collaboration is also becoming more widespread as both Internet access and [computer literacy](#) spread.

The Internet allows computer users to remotely access other computers and information stores easily from any access point. Access may be with [computer security](#), i.e. authentication and encryption technologies, depending on the requirements. This is encouraging new ways of working from home, collaboration and information sharing in many industries. An accountant sitting at home can [audit](#) the books of a company based in another country, on a [server](#) situated in a third country that is remotely maintained by IT specialists in a fourth. These accounts could have

been created by home-working bookkeepers, in other remote locations, based on information emailed to them from offices all over the world. Some of these things were possible before the widespread use of the Internet, but the cost of private [leased lines](#) would have made many of them infeasible in practice. An office worker away from their desk, perhaps on the other side of the world on a business trip or a holiday, can access their emails, access their data using [cloud computing](#), or open a [remote desktop](#) session into their office PC using a secure [virtual private network](#) (VPN) connection on the Internet. This can give the worker complete access to all of their normal files and data, including email and other applications, while away from the office. It has been referred to among [system administrators](#) as the Virtual Private Nightmare, because it extends the secure perimeter of a corporate network into remote locations and its employees' homes.

### **Social networking and entertainment**

Many people use the World Wide Web to access news, weather and sports reports, to plan and book vacations and to pursue their personal interests. People use [chat](#), messaging and email to make and stay in touch with friends worldwide, sometimes in the same way as some previously had [pen pals](#).

[Social networking](#) websites such as [Facebook](#), [Twitter](#), and [Myspace](#) have created new ways to socialize and interact. Users of these sites are able to add a wide variety of information to pages, to pursue common interests, and to connect with others. It is also possible to find existing acquaintances, to allow communication among existing groups of people. Sites like [LinkedIn](#) foster commercial and business connections. YouTube and [Flickr](#) specialize in users' videos and photographs.

While social networking sites were initially for individuals only, today they are widely used by businesses and other organizations to promote their brands, to market to their customers and to encourage posts to "[go viral](#)". "Black hat" social media techniques are also employed by some organizations, such as [spam](#) accounts and [astroturfing](#).

A risk for both individuals and organizations writing posts (especially public posts) on social networking websites, is that especially foolish or controversial posts occasionally lead to an unexpected and possibly large-scale backlash on social media from other Internet users. This is also a risk in relation to controversial *offline* behavior, if it is widely made known. The nature of this backlash can range widely from counter-arguments and public mockery, through insults and [hate speech](#), to, in extreme cases, rape and death [threats](#). The [online disinhibition effect](#) describes the tendency of many individuals to behave more stridently or offensively online than they would in person. A significant number of [feminist](#) women have been the target of various forms of [harassment](#) in response to posts they have made on social media, and Twitter in particular has been criticized in the past for not doing enough to aid victims of online abuse.

For organizations, such a backlash can cause overall [brand damage](#), especially if reported by the media. However, this is not always the case, as any brand damage in the eyes of people with an opposing opinion to that presented by the organization could sometimes be outweighed by strengthening the brand in the eyes of others. Furthermore, if an organization or individual gives in to demands that others perceive as wrong-headed, that can then provoke a counter-backlash.

Some websites, such as [Reddit](#), have rules forbidding the posting of [personal information](#) of individuals (also known as [doxxing](#)), due to concerns about such postings leading to mobs of large numbers of Internet users directing harassment at the specific individuals thereby identified. In

particular, the Reddit rule forbidding the posting of personal information is widely understood to imply that all identifying photos and names must be [censored](#) in Facebook [screenshots](#) posted to Reddit. However, the interpretation of this rule in relation to public Twitter posts is less clear, and in any case, like-minded people online have many other ways they can use to direct each other's attention to public social media posts they disagree with.

Children also face dangers online such as [cyberbullying](#) and [approaches by sexual predators](#), who sometimes pose as children themselves. Children may also encounter material which they may find upsetting, or material which their parents consider to be not age-appropriate. Due to naivety, they may also post personal information about themselves online, which could put them or their families at risk unless warned not to do so. Many parents choose to enable [Internet filtering](#), and/or supervise their children's online activities, in an attempt to protect their children from inappropriate material on the Internet. The most popular social networking websites, such as Facebook and Twitter, commonly forbid users under the age of 13. However, these policies are typically trivial to circumvent by registering an account with a false birth date, and a significant number of children aged under 13 join such sites anyway. Social networking sites for younger children, which claim to provide better levels of protection for children, also exist.

The Internet has been a major outlet for leisure activity since its inception, with entertaining [social experiments](#) such as [MUDs](#) and [MOOs](#) being conducted on university servers, and humor-related [Usenet](#) groups receiving much traffic. Today, many [Internet forums](#) have sections devoted to games and funny videos. Over 6 million people use blogs or message boards as a means of communication and for the sharing of ideas. The [Internet pornography](#) and [online gambling](#) industries have taken advantage of the World Wide Web, and often provide a significant source of advertising revenue for other websites. Although many governments have attempted to restrict both industries' use of the Internet, in general, this has failed to stop their widespread popularity.

Another area of leisure activity on the Internet is [multiplayer gaming](#). This form of recreation creates communities, where people of all ages and origins enjoy the fast-paced world of multiplayer games. These range from [MMORPG](#) to [first-person shooters](#), from [role-playing video games](#) to [online gambling](#). While online gaming has been around since the 1970s, modern modes of online gaming began with subscription services such as [GameSpy](#) and [MPlayer](#). Non-subscribers were limited to certain types of game play or certain games. Many people use the Internet to access and download music, movies and other works for their enjoyment and relaxation. Free and fee-based services exist for all of these activities, using centralized servers and distributed peer-to-peer technologies. Some of these sources exercise more care with respect to the original artists' copyrights than others.

Internet usage has been correlated to users' loneliness. Lonely people tend to use the Internet as an outlet for their feelings and to share their stories with others, such as in the "[I am lonely will anyone speak to me](#)" thread.

[Cybersectarianism](#) is a new organizational form which involves: "highly dispersed small groups of practitioners that may remain largely anonymous within the larger social context and operate in relative secrecy, while still linked remotely to a larger network of believers who share a set of practices and texts, and often a common devotion to a particular leader. Overseas supporters provide funding and support; domestic practitioners distribute tracts, participate in acts of resistance, and share information on the internal situation with outsiders. Collectively, members and practitioners of such sects construct viable virtual communities of faith, exchanging personal

testimonies and engaging in the collective study via email, on-line chat rooms, and web-based message boards.” In particular, the British government has raised concerns about the prospect of young British Muslims being indoctrinated into Islamic extremism by material on the Internet, being persuaded to join [terrorist](#) groups such as the so-called “[Islamic State](#)“, and then potentially committing acts of terrorism on returning to Britain after fighting in Syria or Iraq.

[Cyberslacking](#) can become a drain on corporate resources; the average UK employee spent 57 minutes a day surfing the Web while at work, according to a 2003 study by Peninsula Business Services. [Internet addiction disorder](#) is excessive computer use that interferes with daily life. Psychologist, Nicolas Carr believe that Internet use has other [effects on individuals](#), for instance improving skills of scan-reading and interfering with the deep thinking that leads to true creativity.

### **Electronic business**

[Electronic business](#) (*e-business*) encompasses business processes spanning the entire [value chain](#): purchasing, [supply chain management](#), [marketing](#), [sales](#), [customer](#) service, and business relationship. [E-commerce](#) seeks to add revenue streams using the Internet to build and enhance relationships with clients and partners.

According to [International Data Corporation](#), the size of worldwide e-commerce, when global business-to-business and -consumer transactions are combined, equate to \$16 trillion for 2013. A report by [Oxford Economics](#) adds those two together to estimate the total size of the [digital economy](#) at \$20.4 trillion, equivalent to roughly 13.8% of global sales.

While much has been written of the economic advantages of [Internet-enabled commerce](#), there is also evidence that some aspects of the Internet such as maps and location-aware services may serve to reinforce [economic inequality](#) and the [digital divide](#). Electronic commerce may be responsible for [consolidation](#) and the decline of [mom-and-pop](#), [brick and mortar](#) businesses resulting in increases in [income inequality](#).

Author [Andrew Keen](#), a long-time critic of the social transformations caused by the Internet, has recently focused on the economic effects of consolidation from Internet businesses. Keen cites a 2013 [Institute for Local Self-Reliance](#) report saying brick-and-mortar retailers employ 47 people for every \$10 million in sales while Amazon employs only 14. Similarly, the 700-employee room rental start-up [Airbnb](#) was valued at \$10 billion in 2014, about half as much as [Hilton Hotels](#), which employs 152,000 people. And car-sharing Internet startup [Uber](#) employs 1,000 full-time employees and is valued at \$18.2 billion, about the same valuation as [Avis](#) and [Hertz](#) combined, which together employ almost 60,000 people.

### **Telecommuting**

[Telecommuting](#) is the performance within a traditional worker and employer relationship when it is facilitated by tools such as [groupware](#), [virtual private networks](#), [conference calling](#), [videoconferencing](#), and [voice over IP](#) (VOIP) so that work may be performed from any location, most conveniently the worker’s home. It can be efficient and useful for companies as it allows workers to communicate over long distances, saving significant amounts of travel time and cost. As [broadband](#) Internet connections become commonplace, more workers have adequate bandwidth at home to use these tools to link their home to their corporate [intranet](#) and internal communication networks.

### **Crowdsourcing**

The Internet provides a particularly good venue for [crowdsourcing](#), because individuals tend to



be more open in web-based projects where they are not being physically judged or scrutinized and thus can feel more comfortable sharing.

### **Collaborative publishing**

[Wikis](#) have also been used in the academic community for sharing and dissemination of information across institutional and international boundaries. In those settings, they have been found useful for collaboration on [grant writing](#), [strategic planning](#), departmental documentation, and committee work. The [United States Patent and Trademark Office](#) uses a wiki to allow the public to collaborate on finding [prior art](#) relevant to examination of pending patent applications. [Queens](#), New York has used a wiki to allow citizens to collaborate on the design and planning of a local park.

The [English Wikipedia](#) has the largest user base among wikis on the World Wide Web and ranks in the top 10 among all Web sites in terms of traffic.

### **Politics and political revolutions**

The Internet has achieved new relevance as a political tool. The presidential campaign of [Howard Dean](#) in 2004 in the United States was notable for its success in soliciting donation via the Internet. Many political groups use the Internet to achieve a new method of organizing for carrying out their mission, having given rise to [Internet activism](#), most notably practiced by rebels in the [Arab Spring](#).

The [New York Times](#) suggested that [social media](#) websites, such as Facebook and Twitter, helped people organize the political revolutions in Egypt, by helping activists organize protests, communicate grievances, and disseminate information.

The potential of the Internet as a civic tool of communicative power was explored by Simon R. B. Berdal in his 2004 thesis:

As the globally evolving Internet provides ever new access points to virtual discourse forums, it also promotes new civic relations and associations within which communicative power may flow and accumulate. Thus, traditionally ... national-embedded peripheries get entangled into greater, international peripheries, with stronger combined powers... The Internet, as a consequence, changes the topology of the “centre-periphery” model, by stimulating conventional peripheries to interlink into “super-periphery” structures, which enclose and “besiege” several centres at once.

Berdal, therefore, extends the [Habermasian](#) notion of the [public sphere](#) to the Internet, and underlines the inherent global and civic nature that interwoven Internet technologies provide. To limit the growing civic potential of the Internet, Berdal also notes how “self-protective measures” are put in place by those threatened by it:

If we consider China’s attempts to filter “unsuitable material” from the Internet, most of us would agree that this resembles a self-protective measure by the system against the growing civic potentials of the Internet. Nevertheless, both types represent limitations to “peripheral capacities”. Thus, the Chinese government tries to prevent communicative power to build up and unleash (as the [1989 Tiananmen Square uprising](#) suggests, the government may find it wise to install “upstream measures”). Even though limited, the Internet is proving to be an empowering tool also to the Chinese periphery: Analysts believe that Internet petitions have influenced policy implementation in favour of the public’s online-articulated will ...

Incidents of politically motivated [Internet censorship](#) have now been recorded in many countries, including western democracies.

### **Philanthropy**

The spread of low-cost Internet access in developing countries has opened up new possibilities for [peer-to-peer](#) charities, which allow individuals to contribute small amounts to charitable projects for other individuals. Websites, such as [DonorsChoose](#) and [GlobalGiving](#), allow small-scale donors to direct funds to individual projects of their choice.

A popular twist on Internet-based philanthropy is the use of [peer-to-peer lending](#) for charitable purposes. [Kiva](#) pioneered this concept in 2005, offering the first web-based service to publish individual loan profiles for funding. Kiva raises funds for local intermediary [microfinance](#) organizations which post stories and updates on behalf of the borrowers. Lenders can contribute as little as \$25 to loans of their choice, and receive their money back as borrowers repay. Kiva falls short of being a pure peer-to-peer charity, in that loans are disbursed before being funded by lenders and borrowers do not communicate with lenders themselves.

However, the recent spread of low-cost Internet access in [developing countries](#) has made genuine international person-to-person philanthropy increasingly feasible. In 2009, the US-based nonprofit [Zidisha](#) tapped into this trend to offer the first person-to-person microfinance platform to link lenders and borrowers across international borders without intermediaries. Members can fund loans for as little as a dollar, which the borrowers then use to develop business activities that improve their families' incomes while repaying loans to the members with interest. Borrowers access the Internet via public cybercafes, donated laptops in village schools, and even smart phones, then create their own profile pages through which they share photos and information about themselves and their businesses. As they repay their loans, borrowers continue to share updates and dialogue with lenders via their profile pages. This direct web-based connection allows members themselves to take on many of the communication and recording tasks traditionally performed by local organizations, bypassing geographic barriers and dramatically reducing the cost of microfinance services to the entrepreneurs.

## 5. History of the Internet

From [https://en.wikipedia.org/wiki/History\\_of\\_the\\_Internet](https://en.wikipedia.org/wiki/History_of_the_Internet)

The **history of the Internet** begins with the development of electronic computers in the 1950s. Initial concepts of [packet networking](#) originated in several computer science laboratories in the United States, United Kingdom, and France. The US Department of Defense awarded contracts as early as the 1960s for packet network systems, including the development of the [ARPANET](#) (which would become the first network to use the [Internet Protocol](#)). The first message was sent over the ARPANET from computer science Professor Leonard Kleinrock's laboratory at [University of California, Los Angeles \(UCLA\)](#) to the second network node at [Stanford Research Institute \(SRI\)](#).

[Packet switching](#) networks such as ARPANET, [NPL network](#), [CYCLADES](#), [Merit Network](#), [Tymnet](#), and [Telenet](#), were developed in the late 1960s and early 1970s using a variety of [communications protocols](#). [Donald Davies](#) first designed a packet-switched network at the [National Physics Laboratory](#) in the UK, which became a testbed for UK research for almost two decades. The ARPANET project led to the development of protocols for [internetworking](#), in which multiple separate networks could be joined into a network of networks.

Access to the ARPANET was expanded in 1981 when the [National Science Foundation](#) (NSF) funded the [Computer Science Network](#) (CSNET). In 1982, the [Internet protocol suite](#) (TCP/IP) was introduced as the standard networking protocol on the ARPANET. In the early 1980s the NSF funded the establishment for national supercomputing centers at several universities, and provided interconnectivity in 1986 with the [NSFNET](#) project, which also created network access to the [supercomputer](#) sites in the United States from research and education organizations. Commercial [Internet service providers](#) (ISPs) began to emerge in the very late 1980s. The ARPANET was decommissioned in 1990. Limited private connections to parts of the Internet by officially commercial entities emerged in several American cities by late 1989 and 1990, and the NSFNET was decommissioned in 1995, removing the last restrictions on the use of the Internet to carry commercial traffic.

In the 1980s, research at CERN in Switzerland by British computer scientist [Tim Berners-Lee](#) resulted in the [World Wide Web](#), linking hypertext documents into an information system, accessible from any node on the network. Since the mid-1990s, the Internet has had a revolutionary impact on culture, commerce, and technology, including the rise of near-instant communication by [electronic mail](#), [instant messaging](#), [voice over Internet Protocol](#) (VoIP) telephone calls, [two-way interactive video calls](#), and the [World Wide Web](#) with its [discussion forums](#), [blogs](#), [social networking](#), and [online shopping](#) sites. The research and education community continues to develop and use advanced networks such as NSF's [very high speed Backbone Network Service](#) (vBNS), [Internet2](#), and [National LambdaRail](#). Increasing amounts of data are transmitted at higher and higher speeds over fiber optic networks operating at 1-Gbit/s, 10-Gbit/s, or more. The Internet's takeover of the global communication landscape was almost instant in historical terms: it only communicated 1% of the information flowing through two-way [telecommunications](#) networks in the year 1993, already 51% by 2000, and more than 97% of



the telecommunicated information by 2007. Today the Internet continues to grow, driven by ever greater amounts of online information, commerce, entertainment, and [social networking](#).

### **Precursors**

The concept of [data communication](#) – transmitting data between two different places through an electromagnetic medium such as radio or an electric wire – [predates the introduction of the first computers](#). Such communication systems were typically limited to point to point communication between two end devices. [Telegraph systems](#) and [telex machines](#) can be considered early precursors of this kind of communication. The [Telegraph](#) in the late 19th century was the first fully digital communication system.

Fundamental theoretical work in [data transmission](#) and [information theory](#) was developed by [Claude Shannon](#), [Harry Nyquist](#), and [Ralph Hartley](#) in the early 20th century.

Early computers had a central processing unit and remote terminals. As the technology evolved, new systems were devised to allow communication over longer distances (for terminals) or with higher speed (for interconnection of local devices) that were necessary for the [mainframe computer](#) model. These technologies made it possible to exchange data (such as files) between remote computers. However, the point-to-point communication model was limited, as it did not allow for direct communication between any two arbitrary systems; a physical link was necessary. The technology was also considered unsafe for strategic and military use because there were no alternative paths for the communication in case of an enemy attack.

### **Development of wide-area networking**

With limited exceptions, the earliest computers were connected directly to terminals used by individual users, typically in the same building or site. Such networks became known as [local-area networks](#) (LANs). Networking beyond this scope, known as [wide-area networks](#) (WANs), emerged during the 1950s and became established during the 1960s.

### **Inspiration for the Internet**

[J. C. R. Licklider](#), Vice President at [Bolt Beranek and Newman, Inc.](#), proposed a global network in his January 1960 paper [Man-Computer Symbiosis](#):

A network of such [computers], connected to one another by wide-band communication lines [which provided] the functions of present-day libraries together with anticipated advances in information storage and retrieval and [other] symbiotic functions

In August 1962, Licklider and Welden Clark published one of the first descriptions of a networked future in the paper “On-Line Man-Computer Communication.”

In October 1962, Licklider was hired by [Jack Ruina](#) as director of the newly established [Information Processing Techniques Office](#) (IPTO) within [DARPA](#), with a mandate to interconnect the [United States Department of Defense](#)’s main computers at Cheyenne Mountain, the Pentagon, and SAC HQ. There he formed an informal group within DARPA to further computer research. He began by writing memos describing a distributed network to the IPTO staff, whom he called “Members and Affiliates of the Intergalactic Computer Network”. As part of the information processing office’s role, three network terminals had been installed: one for [System Development Corporation](#) in [Santa Monica](#), one for [Project Genie](#) at [University of California, Berkeley](#), and one for the [Compatible Time-Sharing System](#) project at [Massachusetts Institute of Technology](#) (MIT). Licklider’s identified need for inter-networking would become obvious by the apparent waste of resources this caused.

For each of these three terminals, I had three different sets of user commands. So if I was talking

online with someone at S.D.C. and I wanted to talk to someone I knew at Berkeley or M.I.T. about this, I had to get up from the S.D.C. terminal, go over and log into the other terminal and get in touch with them....

I said, oh man, it's obvious what to do: If you have these three terminals, there ought to be one terminal that goes anywhere you want to go where you have interactive computing. That idea is the ARPAnet.

Although he left the IPTO in 1964, five years before the ARPANET went live, it was his vision of universal networking that provided the impetus for his successors such as [Lawrence Roberts](#) and [Robert Taylor](#) to further the ARPANET development. Licklider later returned to lead the IPTO in 1973 for two years.

### **Development of packet switching**

The issue of connecting separate physical networks to form one logical network was the first of many problems. In the 1960s, [Paul Baran](#) of the [RAND](#) Corporation produced a study of survivable networks for the U.S. military in the event of nuclear war. Information transmitted across Baran's network would be divided into what he called "message-blocks". Independently, [Donald Davies](#) ([National Physical Laboratory, UK](#)), proposed and was the first to put into practice a similar network based on what he called [packet-switching](#), the term that would ultimately be adopted. [Leonard Kleinrock](#) (MIT) developed a mathematical theory behind this technology (without the packets). Packet-switching provides better bandwidth utilization and response times than the traditional circuit-switching technology used for telephony, particularly on resource-limited interconnection links.

Packet switching is a rapid [store and forward](#) networking design that divides messages up into arbitrary packets, with routing decisions made per-packet. Early networks used [message switched systems](#) that required rigid routing structures prone to [single point of failure](#). This led Tommy Krash and Paul Baran's U.S. military-funded research to focus on using message-blocks to include network redundancy.

## **Networks that led to the Internet**

### **ARPANET**

Promoted to the head of the information processing office at [Defense Advanced Research Projects Agency](#) (DARPA), Robert Taylor intended to realize Licklider's ideas of an interconnected networking system. Bringing in [Larry Roberts](#) from MIT, he initiated a project to build such a network. The first ARPANET link was established between the [University of California, Los Angeles](#) ([UCLA](#)) and the [Stanford Research Institute](#) at 22:30 hours on October 29, 1969.

"We set up a telephone connection between us and the guys at SRI ...", Kleinrock ... said in an interview: "We typed the L and we asked on the phone,

"Do you see the L?"

"Yes, we see the L," came the response.

We typed the O, and we asked, "Do you see the O."

"Yes, we see the O."

Then we typed the G, and the system crashed ...  
Yet a revolution had begun” ....

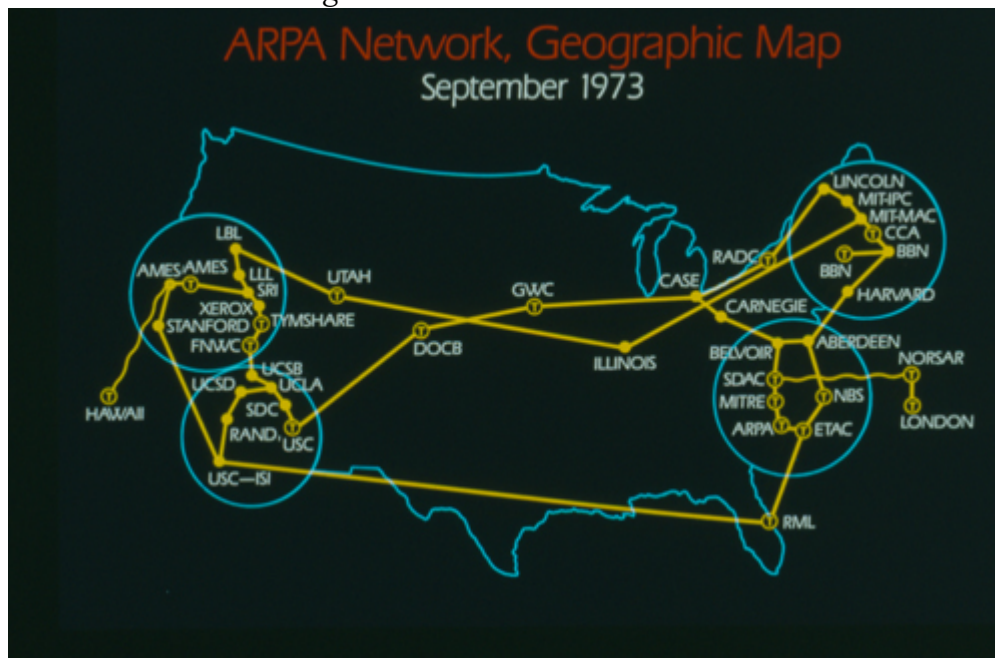


Image of ARPANet, from [blog.dreamhardware.com](http://blog.dreamhardware.com)

By December 5, 1969, a 4-node network was connected by adding the [University of Utah](#) and the [University of California, Santa Barbara](#). Building on ideas developed in [ALOHAnet](#), the ARPANET grew rapidly. By 1981, the number of hosts had grown to 213, with a new host being added approximately every twenty days.

ARPANET development was centered around the [Request for Comments](#) (RFC) process, still used today for proposing and distributing Internet Protocols and Systems. [RFC 1](#), entitled “Host Software”, was written by [Steve Crocker](#) from the [University of California, Los Angeles](#), and published on April 7, 1969. These early years were documented in the 1972 film [Computer Networks: The Heralds of Resource Sharing](#).

ARPANET became the technical core of what would become the Internet, and a primary tool in developing the technologies used. The early ARPANET used the [Network Control Program](#) (NCP, sometimes Network Control Protocol) rather than [TCP/IP](#). On January 1, 1983, known as [flag day](#), NCP on the ARPANET was replaced by the more flexible and powerful family of TCP/IP protocols, marking the start of the modern Internet.

International collaborations on ARPANET were sparse. For various political reasons, European developers were concerned with developing the [X.25](#) networks. Notable exceptions were the Norwegian Seismic Array ([NORSAR](#)) in 1972, followed in 1973 by Sweden with satellite links to the [Tanum](#) Earth Station and [Peter Kirstein](#)’s research group in the UK, initially at the Institute of Computer Science, London University and later at [University College London](#).

### NPL

In 1965, [Donald Davies](#) of the [National Physical Laboratory \(United Kingdom\)](#) proposed a national data network based on packet-switching. The proposal was not taken up nationally, but by 1970 he had designed and built the Mark I packet-switched network to meet the needs of the multidisciplinary laboratory and prove the technology under operational conditions. By 1976 12

computers and 75 terminal devices were attached and more were added until the network was replaced in 1986. NPL, followed by ARPANET, were the first two networks in the world to use packet switching.

### **Merit Network**

The [Merit Network](#) was formed in 1966 as the Michigan Educational Research Information Triad to explore computer networking between three of Michigan's public universities as a means to help the state's educational and economic development. With initial support from the [State of Michigan](#) and the [National Science Foundation](#) (NSF), the packet-switched network was first demonstrated in December 1971 when an interactive host to host connection was made between the [IBM mainframe computer](#) systems at the [University of Michigan](#) in [Ann Arbor](#) and [Wayne State University](#) in [Detroit](#).. Continual development of the Merti network set the stage for Merit's role in the [NSFNET](#) project starting in the mid-1980s.

### **CYCLADES**

The [CYCLADES](#) packet switching network was a French research network designed and directed by [Louis Pouzin](#). First demonstrated in 1973, it was developed to explore alternatives to the initial ARPANET design and to support network research generally. It was the first network to make the hosts responsible for the reliable delivery of data, rather than the network itself, using [unreliable datagrams](#) and associated end-to-end protocol mechanisms.

### **X.25 and public data networks**

Based on ARPA's research, packet switching network standards were developed by the [International Telecommunication Union](#) (ITU) in the form of X.25 and related standards. While using [packet switching](#), X.25 is built on the concept of virtual circuits emulating traditional telephone connections. In 1974, X.25 formed the basis for the SERCnet network between British academic and research sites, which later became [JANET](#). The initial ITU Standard on X.25 was approved in March 1976.

The [British Post Office](#), [Western Union International](#) and [Tymnet](#) collaborated to create the first international packet switched network, referred to as the [International Packet Switched Service](#) (IPSS), in 1978. This network grew from Europe and the US to cover Canada, Hong Kong, and Australia by 1981. By the 1990s it provided a worldwide networking infrastructure.

Unlike ARPANET, X.25 was commonly available for business use. [Telenet](#) offered its Telemail electronic mail service, which was also targeted to enterprise use rather than the general email system of the ARPANET.

### **UUCP and Usenet**

In 1979, two students at [Duke University](#), [Tom Truscott](#) and [Jim Ellis](#), originated the idea of using [Bourne shell](#) scripts to transfer news and messages on a serial line [UUCP](#) connection with nearby [University of North Carolina at Chapel Hill](#). Following public release of the software in 1980, the mesh of UUCP hosts forwarding on the Usenet news rapidly expanded. UUCPnet, as it would later be named, also created gateways and links between [FidoNet](#) and dial-up BBS hosts. UUCP networks spread quickly due to the lower costs involved, ability to use existing leased lines, [X.25](#) links or even [ARPANET](#) connections, and the lack of strict use policies compared to later networks like [CSNET](#) and [Bitnet](#).



# Merging the networks and creating the Internet (1973–95)

## TCP/IP

With so many different network methods, something was needed to unify them. [Robert E. Kahn](#) of [DARPA](#) and [ARPANET](#) recruited [Vinton Cerf](#) of [Stanford University](#) to work with him on the problem. By 1973, they had worked out a fundamental reformulation, where the differences between network protocols were hidden by using a common [internetwork protocol](#), and instead of the network being responsible for reliability, as in the ARPANET, the hosts became responsible. Cerf credits [Hubert Zimmermann](#), Gerard LeLann and [Louis Pouzin](#) (designer of the [CYCLADES](#) network) with important work on this design.

The specification of the resulting protocol, [RFC 675](#) – *Specification of Internet Transmission Control Program*, by Vinton Cerf, Yogen Dalal and Carl Sunshine, Network Working Group, December 1974, contains the first attested use of the term *internet*, as a shorthand for *internetworking*; later RFCs repeat this use, so the word started out as an [adjective](#) rather than the [noun](#) it is today.

With the role of the network reduced to the bare minimum, it became possible to join almost any networks together, no matter what their characteristics were, thereby solving Kahn's initial problem. DARPA agreed to fund development of prototype software, and after several years of work, the first demonstration of a gateway between the [Packet Radio](#) network in the SF Bay area and the ARPANET was conducted by the [Stanford Research Institute](#). On November 22, 1977 a three network demonstration was conducted including the ARPANET, the SRI's [Packet Radio Van](#) on the Packet Radio Network and the Atlantic Packet Satellite network.

Stemming from the first specifications of TCP in 1974, [TCP/IP](#) emerged in mid-late 1978 in nearly its final form, as used for the first decades of the Internet, known as "[IPv4](#)". (IPv4 eventually became superseded by its successor, called "[IPv6](#)", but this was largely due to the sheer number of devices being connected post-2005, which overwhelmed the numbers that IPv4 had been able to accommodate worldwide. However, due to IPv4's entrenched position by that time, the shift is still in its early stages as of 2015, and expected to take many years, decades, or perhaps longer, to complete).

The associated standards for IPv4 were published by 1981 as [RFCs](#) 791, 792 and 793, and adopted for use. DARPA sponsored or encouraged the development of TCP/IP implementations for many operating systems and then scheduled a migration of all hosts on all of its packet networks to TCP/IP. On January 1, 1983, known as [flag day](#), TCP/IP protocols became the only approved protocol on the ARPANET, replacing the earlier [NCP protocol](#).

### From ARPANET to NSFNET

After the ARPANET had been up and running for several years, ARPA looked for another agency to hand off the network to; ARPA's primary mission was funding cutting edge research and development, not running a communications utility. Eventually, in July 1975, the network had been turned over to the [Defense Communications Agency](#), also part of the [Department of Defense](#). In 1983, the [U.S. military](#) portion of the ARPANET was broken off as a separate network, the [MILNET](#). MILNET subsequently became the unclassified but military-only [NIPRNET](#), in parallel with the SECRET-level [SIPRNET](#) and [JWICS](#) for TOP SECRET and above. NIPRNET does have controlled security gateways to the public Internet.

The networks based on the ARPANET were government funded and therefore restricted to noncommercial uses such as research; unrelated commercial use was strictly forbidden. This initially restricted connections to military sites and universities. During the 1980s, the connections expanded to more educational institutions, and even to a growing number of companies such as [Digital Equipment Corporation](#) and [Hewlett-Packard](#), which were participating in research projects or providing services to those who were.

Several other branches of the [U.S. government](#), the [National Aeronautics and Space Administration](#) (NASA), the [National Science Foundation](#) (NSF), and the [Department of Energy](#) (DOE) became heavily involved in Internet research and started development of a successor to ARPANET. In the mid-1980s, all three of these branches developed the first Wide Area Networks based on TCP/IP. NASA developed the [NASA Science Network](#), NSF developed [CSNET](#) and DOE evolved the [Energy Sciences Network](#) or ESNNet.

NASA developed the TCP/IP based NASA Science Network (NSN) in the mid-1980s, connecting space scientists to data and information stored anywhere in the world. In 1989, the [DECnet](#)-based Space Physics Analysis Network (SPAN) and the TCP/IP-based NASA Science Network (NSN) were brought together at NASA Ames Research Center creating the first multiprotocol wide area network called the NASA Science Internet, or NSI. NSI was established to provide a totally integrated communications infrastructure to the NASA scientific community for the advancement of earth, space and life sciences. As a high-speed, multiprotocol, international network, NSI provided connectivity to over 20,000 scientists across all seven continents.

In 1981 NSF supported the development of the [Computer Science Network](#) (CSNET). CSNET connected with ARPANET using TCP/IP, and ran TCP/IP over [X.25](#), but it also supported departments without sophisticated network connections, using automated dial-up mail exchange.

In 1986, the NSF created [NSFNET](#), a 56 kbit/s [backbone](#) to support the NSF-sponsored [supercomputing](#) centers. The NSFNET also provided support for the creation of regional research and education networks in the United States, and for the connection of university and college campus networks to the regional networks. The use of NSFNET and the regional networks was not limited to supercomputer users and the 56 kbit/s network quickly became overloaded. NSFNET was upgraded to 1.5 Mbit/s in 1988 under a cooperative agreement with the [Merit Network](#) in partnership with [IBM](#), [MCI](#), and the [State of Michigan](#). The existence of NSFNET and the creation of [Federal Internet Exchanges](#) (FIXes) allowed the ARPANET to be decommissioned in 1990. NSFNET was expanded and upgraded to 45 Mbit/s in 1991, and was decommissioned in 1995 when it was replaced by backbones operated by several commercial [Internet Service Providers](#).

### **Transition towards the Internet**

The term “internet” was adopted in the first RFC published on the TCP protocol ([RFC 675: Internet Transmission Control Program](#), December 1974) as an abbreviation of the term *internetworking* and the two terms were used interchangeably. In general, an internet was any network using TCP/IP. It was around the time when ARPANET was interlinked with [NSFNET](#) in the late 1980s, that the term was used as the name of the network, Internet, being the large and global TCP/IP network.

As interest in networking grew and new applications for it were developed, the Internet’s technologies spread throughout the rest of the world. The network-agnostic approach in TCP/IP meant that it was easy to use any existing network infrastructure, such as the [IPSS X.25](#) network,

to carry Internet traffic. In 1984, University College London replaced its transatlantic satellite links with TCP/IP over IPSS.

Many sites unable to link directly to the Internet created simple gateways for the transfer of electronic mail, the most important application of the time. Sites with only intermittent connections used [UUCP](#) or [FidoNet](#) and relied on the gateways between these networks and the Internet. Some gateway services went beyond simple mail peering, such as allowing access to [File Transfer Protocol](#) (FTP) sites via UUCP or mail.

## TCP/IP goes global (1980s)

### **CERN, the European Internet, the link to the Pacific and beyond**

Between 1984 and 1988 [CERN](#) began installation and operation of [TCP/IP](#) to interconnect its major internal computer systems, workstations, PCs and an accelerator control system. CERN continued to operate a limited self-developed system (CERNET) internally and several incompatible (typically proprietary) network protocols externally. There was considerable resistance in Europe towards more widespread use of [TCP/IP](#), and the CERN TCP/IP intranets remained isolated from the Internet until 1989.

In 1988, Daniel Karrenberg, from [Centrum Wiskunde & Informatica](#) (CWI) in [Amsterdam](#), visited Ben Segal, [CERN](#)'s TCP/IP Coordinator, looking for advice about the transition of the European side of the UUCP Usenet network (much of which ran over X.25 links) over to TCP/IP. In 1987, Ben Segal had met with [Len Bosack](#) from the then still small company [Cisco](#) about purchasing some TCP/IP routers for CERN, and was able to give Karrenberg advice and forward him on to Cisco for the appropriate hardware. This expanded the European portion of the Internet across the existing UUCP networks, and in 1989 CERN opened its first external TCP/IP connections. This coincided with the creation of Réseaux IP Européens ([RIPE](#)), initially a group of IP network administrators who met regularly to carry out coordination work together. Later, in 1992, RIPE was formally registered as a [cooperative](#) in Amsterdam.

At the same time as the rise of internetworking in Europe, ad hoc networking to ARPA and in-between Australian universities formed, based on various technologies such as X.25 and [UUCPNet](#). These were limited in their connection to the global networks, due to the cost of making individual international UUCP dial-up or X.25 connections. In 1989, Australian universities joined the push towards using IP protocols to unify their networking infrastructures. [AARNet](#) was formed in 1989 by the [Australian Vice-Chancellors' Committee](#) and provided a dedicated IP based network for Australia.

The Internet began to penetrate Asia in the 1980s. In May 1982 [South Korea](#) became the second country to successfully set up TCP/IP IPv4 network. Japan, which had built the UUCP-based network [JUNET](#) in 1984, connected to [NSFNET](#) in 1989. It hosted the annual meeting of the [Internet Society](#), INET'92, in [Kobe](#). [Singapore](#) developed TECHNET in 1990, and [Thailand](#) gained a global Internet connection between Chulalongkorn University and UUNET in 1992.

## 6. The WWW and Web 2.0

From [https://en.wikipedia.org/wiki/History\\_of\\_the\\_Internet](https://en.wikipedia.org/wiki/History_of_the_Internet)

### **World Wide Web and introduction of browsers**

The [World Wide Web](#) (sometimes abbreviated “www” or “W3”) is an [information space](#) where documents and other [web resources](#) are identified by [URIs](#), interlinked by [hypertext](#) links, and can be accessed via the [Internet](#) using a [web browser](#) and (more recently) [web-based applications](#). It has become known simply as “the Web”. As of the 2010s, the World Wide Web is the primary tool billions use to interact on the Internet, and it has changed people’s lives immeasurably.

Precursors to the web browser emerged in the form of [hyperlinked](#) applications during the mid and late 1980s (the bare concept of hyperlinking had by then existed for some decades). Following these, [Tim Berners-Lee](#) is credited with inventing the World Wide Web in 1989 and developing in 1990 both the first [web server](#), and the first web browser, called [WorldWideWeb](#) (no spaces) and later renamed Nexus. Many others were soon developed, with [Marc Andreessen](#)’s 1993 [Mosaic](#) (later [Netscape](#)), being particularly easy to use and install, and often credited with sparking the internet boom of the 1990s. Today, the major web browsers are [Firefox](#), [Internet Explorer](#), [Google Chrome](#), [Opera](#) and [Safari](#).

A boost in web users was triggered in September 1993 by [NCSA Mosaic](#), a graphical browser which eventually ran on several popular office and home computers. This was the first web browser aiming to bring multimedia content to non-technical users, and therefore included images and text on the same page, unlike previous browser designs; its founder, [Marc Andreessen](#), also established the company that in 1994, released [Netscape Navigator](#), which resulted in one of the early [browser wars](#), when it ended up in a competition for dominance (which it lost) with [Microsoft Windows](#)’ [Internet Explorer](#). Commercial use restrictions were lifted in 1995. The online service America Online (AOL) offered their users a connection to the Internet via their own internal browser.

### **Use in wider society 1990s to early 2000s (Web 1.0)**

During the first decade or so of the public internet, the immense changes it would eventually enable in the 2000s were still nascent. In terms of providing context for this period, [mobile cellular devices](#) (“smartphones” and other cellular devices) which today provide near-universal access, were used for business and not a routine household item owned by parents and children worldwide. [Social media](#) in the modern sense had yet to come into existence, laptops were bulky and most households did not have computers. Data rates were slow and most people lacked means to video or digitize video so websites such as [YouTube](#) did not yet exist, media storage was transitioning slowly from [analog](#) tape to [digital optical discs](#) ([DVD](#) and to an extent still, [floppy disc](#) to [CD](#)). Enabling technologies used from the early 2000s such as [PHP](#), modern [Javascript](#) and [Java](#), technologies such as [AJAX](#), [HTML 4](#) (and its emphasis on [CSS](#)), and various [software frameworks](#), which enabled and simplified speed of web development, largely awaited invention and their eventual widespread adoption.

The Internet was widely used for [mailing lists](#), [emails](#), [e-commerce](#) and early popular [online shopping](#) ([Amazon](#) and [eBay](#) for example), [online forums](#) and [bulletin boards](#), and personal



websites and [blogs](#), and use was growing rapidly, but by more modern standards the systems used were static and lacked widespread social engagement. It awaited a number of events in the early 2000s to change from a communications technology to gradually develop into a key part of global society's infrastructure.

Typical design elements of these “Web 1.0” era websites included: Static pages instead of [dynamic HTML](#); content served from [filesystems](#) instead of [relational databases](#); pages built using [Server Side Includes](#) or [CGI](#) instead of a [web application](#) written in a [dynamic programming language](#); [HTML 3.2](#)-era structures such as [frames](#) and tables to create page layouts; online [guestbooks](#); overuse of [GIF](#) buttons and similar small graphics promoting particular items; and HTML forms sent via [email](#). (Support for [server side scripting](#) was rare on [shared servers](#) so the usual feedback mechanism was via email, using [mailto forms](#) and their [email program](#).)

During the period 1997 to 2001, the first [speculative investment bubble](#) related to the Internet took place, in which “[dot-com](#)” companies (referring to the “.com” [top level domain](#) used by businesses) were propelled to exceedingly high valuations as investors rapidly stoked [stock values](#), followed by a [market crash](#); the first [dot-com bubble](#). However this only temporarily slowed enthusiasm and growth, which quickly recovered and continued to grow.

The changes that would propel the Internet into its place as a social system took place during a relatively short period of no more than five years, starting from around 2004. They included:

- The call to “[Web 2.0](#)” in 2004 (first suggested in 1999),
- Accelerating adoption and commoditization among households of, and familiarity with, the necessary hardware (such as computers).
- Accelerating storage technology and data access speeds – [hard drives](#) emerged, took over from far smaller, slower [floppy discs](#), and grew from [megabytes](#) to [gigabytes](#) (and by around 2010, [terabytes](#)), [RAM](#) from hundreds of [kilobytes](#) to gigabytes as typical amounts on a system, and [Ethernet](#), the enabling technology for TCP/IP, moved from common speeds of kilobits to tens of megabits per second, to gigabits per second.
- High speed Internet and wider coverage of data connections, at lower prices, allowing larger traffic rates, more reliable simpler traffic, and traffic from more locations,
- The gradually accelerating perception of the ability of computers to create new means and approaches to communication, the emergence of social media and websites such as [Twitter](#) and [Facebook](#) to their later prominence, and global collaborations such as [Wikipedia](#) (which existed before but gained prominence as a result),

and shortly after (approximately 2007–2008 onward):

- The [mobile revolution](#), which provided access to the Internet to much of human society of all ages, in their daily lives, and allowed them to share, discuss, and continually update, inquire, and respond.
- [Non-volatile RAM](#) rapidly grew in size and reliability, and decreased in price, becoming a commodity capable of enabling high levels of computing activity on these small handheld devices as well as [solid-state drives](#) (SSD).
- An emphasis on power efficient processor and device design, rather than purely high processing power; one of the beneficiaries of this was [ARM](#), a British company which had

focused since the 1980s on powerful but low cost simple microprocessors. ARM rapidly gained dominance in the market for mobile and embedded devices.

With the call to Web 2.0, the period up to around 2004–2005 was retrospectively named and described by some as Web 1.0.

### **Web 2.0**

Main articles: [Web 2.0](#) and [Responsive web design](#)

The term “Web 2.0” describes [websites](#) that emphasize [user-generated content](#) (including user-to-user interaction), [usability](#), and [interoperability](#). It first appeared in a January 1999 article called “Fragmented Future” written by Darcy DiNucci, a consultant on [electronic information design](#), where she wrote:

*“The Web we know now, which loads into a [browser window](#) in essentially static screenfuls, is only an [embryo](#) of the Web to come. The first glimmerings of Web 2.0 are beginning to appear, and we are just starting to see how that embryo might develop. The Web will be understood not as screenfuls of text and graphics but as a transport mechanism, the ether through which interactivity happens. It will [...] appear on your computer screen, [...] on your TV set [...] your car dashboard [...] your cell phone [...] hand-held game machines [...] maybe even your microwave oven.”*

The term resurfaced during 2002 – 2004, and gained prominence in late 2004 following presentations by [Tim O’Reilly](#) and Dale Dougherty at the first [Web 2.0 Conference](#). In their opening remarks, [John Battelle](#) and Tim O’Reilly outlined their definition of the “Web as Platform”, where software applications are built upon the Web as opposed to upon the desktop. The unique aspect of this migration, they argued, is that “customers are building your business for you”. They argued that the activities of users generating content (in the form of ideas, text, videos, or pictures) could be “harnessed” to create value.

Web 2.0 does not refer to an update to any technical specification, but rather to cumulative changes in the way Web pages are made and used. Web 2.0 describes an approach, in which sites focus substantially upon allowing users to interact and collaborate with each other in a [social media](#) dialogue as creators of [user-generated content](#) in a [virtual community](#), in contrast to Web sites where people are limited to the passive viewing of [content](#). Examples of Web 2.0 include [social networking sites](#), [blogs](#), [wikis](#), [folksonomies](#), [video sharing](#) sites, [hosted services](#), [Web applications](#), and [mashups](#). Terry Flew, in his 3rd Edition of *New Media* described what he believed to characterize the differences between Web 1.0 and Web 2.0:

*“[The] move from personal websites to blogs and blog site aggregation, from publishing to participation, from web content as the outcome of large up-front investment to an ongoing and interactive process, and from content management systems to links based on tagging ([folksonomy](#))”.*

This era saw several household names gain prominence through their community-oriented operation – [YouTube](#), Twitter, Facebook, [Reddit](#) and Wikipedia being some examples.

### **The mobile revolution**

Main articles: [History of mobile phones](#) and [Mobile Web](#)

The process of change generally described as “Web 2.0” was itself greatly accelerated and transformed only a short time later by the increasing growth in mobile devices. This [mobile revolution](#) meant that computers in the form of smartphones became something many people

used, took with them everywhere, communicated with, used for photographs and videos they instantly shared or to shop or seek information “on the move” – and used socially, as opposed to items on a desk at home or just used for work.

Location-based services, services using location and other sensor information, and [crowdsourcing](#) (frequently but not always location based), became common, with posts tagged by location, or websites and services becoming location aware. Mobile-targeted websites (such as “m.website.com”) became common, designed especially for the new devices used. [Netbooks](#), [ultrabooks](#), widespread [4G](#) and [Wi-Fi](#), and mobile chips capable or running at nearly the power of desktops from not many years before on far lower power usage, became enablers of this stage of Internet development, and the term “[App](#)” emerged (short for “Application program” or “Program”) as did the “[App store](#)”.

## PART II

# CHAPTER 2: HARDWARE, SOFTWARE, AND NETWORKING

Now that we know a bit more about information science and the Internet, let's examine some of the nuts and bolts of how things get accomplished. This is often in the form of hardware, software, and networking, that allow us to use things like the World Wide Web, File sharing, playing video games, and taking advantage of the Internet and other technologies. The information in this chapter will also be helpful as you leave college and enter the workforce. One of the first questions you might be asked by your future employer is to identify the optimal hardware/software configuration you need in order to do your job. This information may also be useful in troubleshooting problems you have with a computer or getting online.

### *Learning Objectives*

After reading this chapter, you will be able to:

- identify the primary hardware components necessary to build a functional computer.
- describe the role of computer software, and how it interacts with hardware.
- describe how computers communicate over a network.
- describe the OSI model, including each layer and what it represents.

# 7. Computer Hardware

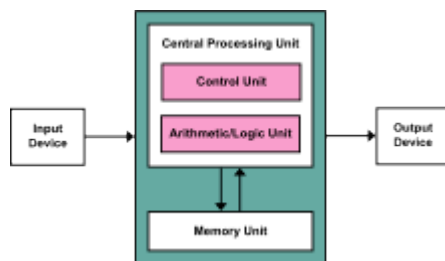
From [https://en.wikipedia.org/wiki/Computer\\_hardware](https://en.wikipedia.org/wiki/Computer_hardware)

**Computer hardware** (or simply **hardware** in computing contexts) is the collection of physical elements that constitutes a computer system. Computer hardware is the physical parts or components of a computer, such as the [monitor](#), [keyboard](#), [computer data storage](#), [hard disk drive](#) (HDD), graphic cards, sound cards, memory (RAM), motherboard, and so on, all of which are tangible physical objects.<sup>[1]</sup> By contrast, [software](#) is instructions that can be stored and run by hardware.

Software is any set of machine-readable instructions that directs a computer's processor to perform specific operations. A combination of hardware and software forms a usable computing system.

## Von Neumann architecture

Main article: [Von Neumann architecture](#)



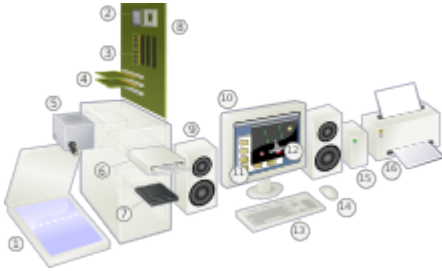
Von Neumann architecture scheme

The template for all modern computers is the [Von Neumann architecture](#), detailed in a [1945 paper](#) by Hungarian mathematician [John von Neumann](#). This describes a design architecture for an electronic [digital computer](#) with subdivisions of a [processing unit](#) consisting of an [arithmetic logic unit](#) and [processor registers](#), a [control unit](#) containing an [instruction register](#) and [program counter](#), a [memory](#) to store both data and [instructions](#), external [mass storage](#), and [input and output](#) mechanisms.<sup>[3]</sup> The meaning of the term has evolved to mean a [stored-program computer](#) in which an instruction fetch and a data operation cannot occur at the same time because they share a common [bus](#). This is referred to as the [Von Neumann bottleneck](#) and often limits the performance of the system.

# Different systems

There are a number of different types of computer system in use today.

## Personal computer



Basic hardware components of a modern personal computer, including a [monitor](#), a [motherboard](#), a [CPU](#), a [RAM](#), two [expansion cards](#), a [power supply](#), an [optical disc drive](#), a [hard disk drive](#), a [keyboard](#) and a [mouse](#).



Inside a custom-built computer: power supply at the bottom has its own cooling fan

The [personal computer](#), also known as the PC, is one of the most common types of computer due to its versatility and relatively low price. [Laptops](#) are generally very similar, although they may use lower-power or reduced size components.

## Case

Main article: [Computer case](#)



The computer case is a plastic or metal enclosure that houses most of the components. Those found on [desktop computers](#) are usually small enough to fit under a desk; however, in recent years more compact designs have become more commonplace, such as the all-in-one style designs from [Apple](#), namely the [iMac](#). A case can be either big or small, but the [form factor](#) of motherboard for which it is designed matters more. Laptops are computers that usually come in a [clamshell](#) form factor; however, in more recent years, deviations from this form factor, such as laptops that have a detachable screen that become tablet computers in their own right, have started to emerge.

## *Power supply*

Main article: [Power supply unit \(computer\)](#)

A power supply unit (PSU) converts alternating current (AC) electric power to low-voltage DC power for the internal components of the computer. Laptops are capable of running from a built-in battery, normally for a period of hours.<sup>[6]</sup>

## *Motherboard*

Main article: [Motherboard](#)

The motherboard is the main component of a computer. It is a large rectangular board with integrated circuitry that connects the other parts of the computer including the [CPU](#), the [RAM](#), the disk drives ([CD](#), [DVD](#), [hard disk](#), or any others) as well as any peripherals connected via the ports or the [expansion slots](#).

Components directly attached to or to part of the motherboard include:

- The [CPU](#) (Central Processing Unit), which performs most of the calculations which enable a computer to function, and is sometimes referred to as the brain of the computer. It is usually [cooled](#) by a heatsink and fan, or water-cooling system. Most newer CPUs include an on-die [Graphics Processing Unit \(GPU\)](#). The [clock speed](#) of CPUs governs how fast it executes instructions, and is measured in GHz; typical values lie between 1 GHz and 5 GHz. Many modern computers have the option to overclock the CPU which enhances performance at the expense of greater thermal output and thus a need for improved cooling.
- The [chipset](#), which includes the [north bridge](#), mediates communication between the CPU and the other components of the system, including main memory.
- [Random-Access Memory](#) (RAM), which stores the code and data that are being actively accessed by the CPU. RAM usually comes on [DIMMs](#) in the sizes 2GB, 4GB, and 8GB, but can be much larger.
- [Read-Only Memory](#) (ROM), which stores the [BIOS](#) that runs when the computer is powered on or otherwise begins execution, a process known as [Bootstrapping](#), or “[booting](#)” or

“booting up.” The [BIOS](#) (Basic Input Output System) includes boot [firmware](#) and power management firmware. Newer motherboards use [Unified Extensible Firmware Interface](#) (UEFI) instead of BIOS.

- [Buses](#) that connect the CPU to various internal components and to expand cards for graphics and sound.
- The [CMOS battery](#), which powers the memory for date and time in the BIOS chip. This battery is generally a watch battery.
- The [video card](#) (also known as the graphics card), which processes computer graphics. More powerful graphics cards are better suited to handle strenuous tasks, such as playing intensive video games.

## *Expansion cards*

Main article: [Expansion card](#)

An [expansion card](#) in computing is a printed circuit board that can be inserted into an expansion slot of a computer motherboard or backplane to add functionality to a computer system via the expansion bus. Expansion cards can be used to obtain or expand on features not offered by the motherboard.

## *Storage devices*

Main article: [Computer data storage](#)

Computer data storage, often called storage or memory, refers to computer components and recording media that retain digital data. Data storage is a core function and fundamental component of computers.

## *Fixed media*

Data is stored by a computer using a variety of media. [Hard disk drives](#) are found in virtually all older computers, due to their high capacity and low cost, but [solid-state drives](#) are faster and more power efficient, although currently more expensive than hard drives, so are often found in more expensive computers. Some systems may use a [disk array controller](#) for greater performance or reliability.

## Removable media

To transfer data between computers, a [USB flash drive](#) or [optical disc](#) may be used. Their usefulness depends on being readable by other systems; the majority of machines have an optical disk drive, and virtually all have a [USB](#) port.

## *Input and output peripherals*

Main article: [Peripheral](#)

[Input](#) and [output](#) devices are typically housed externally to the main computer chassis. The following are either standard or very common to many computer systems.

### Input

[Input devices](#) allow the user to enter information into the system, or control its operation. Most personal computers have a [mouse](#) and [keyboard](#), but laptop systems typically use a [touchpad](#) instead of a mouse. Other input devices include [webcams](#), [microphones](#), [joysticks](#), and [image scanners](#).

### Output device

[Output devices](#) display information in a human readable form. Such devices could include [printers](#), [speakers](#), [monitors](#) or a [Braille embosser](#).

## 8. Computer Software

From <https://en.wikipedia.org/wiki/Software>

**Computer software**, or simply **software**, is that part of a [computer system](#) that consists of encoded information or computer instructions, in contrast to the physical [hardware](#) from which the system is built.

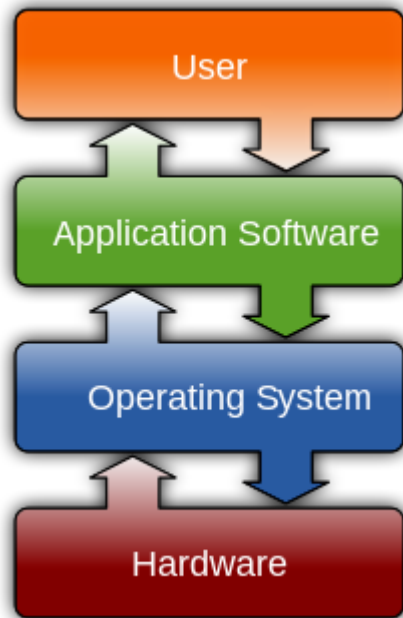


Image by McGeddon, from [https://commons.wikimedia.org/wiki/File:Operating\\_system\\_placement\\_\(software\).svg](https://commons.wikimedia.org/wiki/File:Operating_system_placement_(software).svg)

The term “software” was first proposed by [Alan Turing](#) and used in this sense by [John W. Tukey](#) in 1957. In [computer science](#) and [software engineering](#), **computer software** is all [information](#) processed by [computer systems](#), [programs](#) and [data](#).

Computer software includes [computer programs](#), [libraries](#) and related non-executable [data](#), such as [online documentation](#) or [digital media](#). Computer hardware and software require each other and neither can be realistically used on its own.

At the lowest level, executable code consists of [machine language](#) instructions specific to an individual [processor](#)—typically a [central processing unit](#) (CPU). A machine language consists of groups of [binary values](#) signifying processor instructions that change the state of the computer from its preceding state. For example, an instruction may change the value stored in a particular storage location in the computer—an effect that is not directly observable to the user. An instruction may also (indirectly) cause something to appear on a display of the computer system—a state change which should be visible to the user. The processor carries out the instructions in the order they are provided, unless it is instructed to [“jump” to a different instruction](#), or interrupted.

The majority of software is written in [high-level programming languages](#) that are easier and

more efficient for programmers, meaning closer to a [natural language](#).<sup>[1]</sup> High-level languages are translated into machine language using a [compiler](#) or an [interpreter](#) or a combination of the two. Software may also be written in a low-level [assembly language](#), essentially, a vaguely [mnemonic](#) representation of a machine language using a natural language alphabet, which is translated into machine language using an [assembler](#).

## History

Main article: [History of software](#)

An outline ([algorithm](#)) for what would have been the first piece of software was written by [Ada Lovelace](#) in the 19th century, for the planned [Analytical Engine](#). However, neither the Analytical Engine nor any software for it were ever created

The first theory about software—prior to creation of computers as we know them today—was proposed by Alan Turing in his 1935 essay *Computable numbers with an application to the Entscheidungsproblem* (decision problem).

This eventually led to the creation of the twin academic fields of computer science and software engineering, which both study software and its creation. Computer science is more theoretical (Turing's essay is an example of computer science), whereas software engineering focuses on more practical concerns.

However, prior to 1946, software as we now understand it—programs stored in the memory of stored-program digital computers—did not yet exist. The very first electronic computing devices were instead rewired in order to “reprogram” them.



Ada Lovelace, 1815 – 1852

Ada Lovelace is considered by many to be the first computer programmer, as she wrote the first algorithm that was designed to be executed by Charles Babbage's Analytical Engine. Many people assume that computers, and related technologies, were mostly created by men. This is not true, as Lovelace, and countless other women, made large contributions to the evolution of computing and related technologies.

# Types of software

See also: [List of software categories](#)

On virtually all computer platforms, software can be grouped into a few broad categories.

## Purpose, or domain of use

Based on the goal, computer software can be divided into:

- [Application software](#), which is software that uses the computer system to perform special functions or provide [entertainment functions](#) beyond the basic operation of the computer itself. There are many different types of application software, because the range of tasks that can be performed with a modern computer is so large—see [list of software](#).
- [System software](#), which is software that directly operates the [computer hardware](#), to provide basic functionality needed by users and other software, and to provide a platform for running application software.<sup>[2]</sup> System software includes:
  - [Operating systems](#), which are essential collections of software that manage resources and provides common services for other software that runs “on top” of them. [Supervisory programs](#), [boot loaders](#), [shells](#) and [window systems](#) are core parts of operating systems. In practice, an operating system comes bundled with additional software (including application software) so that a user can potentially do some work with a computer that only has an operating system.
  - [Device drivers](#), which operate or control a particular type of device that is attached to a computer. Each device needs at least one corresponding device driver; because a computer typically has at minimum at least one input device and at least one output device, a computer typically needs more than one device driver.
  - [Utilities](#), which are computer programs designed to assist users in the maintenance and care of their computers.
- [Malicious software](#) or *malware*, which is software that is developed to harm and disrupt computers. As such, malware is undesirable. Malware is closely associated with computer-related crimes, though some malicious programs may have been designed as [practical jokes](#).

## Programming tools

Main article: [Programming tool](#)

Programming tools are also software in the form of programs or applications that [software](#)



[developers](#) (also known as *programmers*, *coders*, *hackers* or *software engineers*) use to create, [debug](#), [maintain](#) (i.e. improve or fix), or otherwise [support](#) software. Software is written in one or more programming languages; there are many programming languages in existence, and each has at least one implementation, each of which consists of its own set of programming tools. These tools may be relatively self-contained programs such as [compilers](#), [debuggers](#), [interpreters](#), [linkers](#), and [text editors](#), that can be combined together to accomplish a task; or they may form an [integrated development environment](#) (IDE), which combines much or all of the functionality of such self-contained tools. IDEs may do this by either invoking the relevant individual tools or by re-implementing their functionality in a new way. An IDE can make it easier to do specific tasks, such as searching in files in a particular project. Many programming language implementations provide the option of using both individual tools or an IDE.

## Software topics

### Architecture

See also: [Software architecture](#)

Users often see things differently from programmers. People who use modern general purpose computers (as opposed to [embedded systems](#), [analog computers](#) and [supercomputers](#)) usually see three layers of software performing a variety of tasks: platform, application, and user software.

- Platform software: The [Platform](#) includes the [firmware](#), [device drivers](#), an [operating system](#), and typically a [graphical user interface](#) which, in total, allow a user to interact with the computer and its [peripherals](#) (associated equipment). Platform software often comes bundled with the computer. On a [PC](#) one will usually have the ability to change the platform software.
- Application software: [Application software](#) or Applications are what most people think of when they think of software. Typical examples include office suites and video games. [Application software](#) is often purchased separately from computer hardware. Sometimes applications are bundled with the computer, but that does not change the fact that they run as independent applications. Applications are usually independent programs from the operating system, though they are often tailored for specific platforms. Most users think of compilers, databases, and other “system software” as applications.
- User-written software: [End-user development](#) tailors systems to meet users’ specific needs. User software include spreadsheet templates and [word processor](#) templates. Even email filters are a kind of user software. Users create this software themselves and often overlook how important it is. Depending on how competently the user-written software has been integrated into default application packages, many users may not be aware of the distinction

between the original packages, and what has been added by co-workers.

# 9. Computer Networks

[https://en.wikipedia.org/wiki/Computer\\_network](https://en.wikipedia.org/wiki/Computer_network)

A **computer network** or **data network** is a [telecommunications network](#) which allows [computers](#) to [exchange data](#). In computer networks, networked computing devices exchange data with each other using a [data link](#). The connections between nodes are established using either [cable media](#) or [wireless media](#). The best-known computer network is the [Internet](#).

Network computer devices that originate, route and terminate the data are called [network nodes](#).<sup>[1]</sup> Nodes can include [hosts](#) such as [personal computers](#), [phones](#), [servers](#) as well as [networking hardware](#). Two such devices can be said to be networked together when one device is able to exchange information with the other device, whether or not they have a direct connection to each other.

Computer networks differ in the [transmission medium](#) used to carry their signals, the [communications protocols](#) to organize network traffic, the network's size, [topology](#) and organizational intent.

Computer networks support an enormous number of [applications](#) and [services](#) such as access to the [World Wide Web](#), [digital video](#), [digital audio](#), shared use of [application and storage servers](#), [printers](#), and [fax machines](#), and use of [email](#) and [instant messaging](#) applications as well as many others. In most cases, application-specific communications protocols are [layered](#) (i.e. carried as [payload](#)) over other more general communications protocols.

## Properties

Computer networking may be considered a branch of [electrical engineering](#), [telecommunications](#), [computer science](#), [information technology](#) or [computer engineering](#), since it relies upon the theoretical and practical application of the related disciplines.

A computer network facilitates interpersonal communications allowing users to communicate efficiently and easily via various means: email, instant messaging, chat rooms, telephone, video telephone calls, and video conferencing. Providing access to information on shared storage devices is an important feature of many networks. A network allows sharing of files, data, and other types of information giving authorized users the ability to access information stored on other computers on the network. A network allows sharing of network and computing resources. Users may access and use resources provided by devices on the network, such as printing a document on a shared network printer. [Distributed computing](#) uses computing resources across a network to accomplish tasks. A computer network may be used by [computer crackers](#) to deploy [computer viruses](#) or [computer worms](#) on devices connected to the network, or to prevent these devices from accessing the network via a [denial of service](#) attack.

# Network packet

Main article: [Network packet](#)

Computer communication links that do not support packets, such as traditional [point-to-point telecommunication links](#), simply transmit data as a [bit stream](#). However, most information in computer networks is carried in *packets*. A network packet is a formatted unit of [data](#) (a list of bits or bytes, usually a few tens of bytes to a few kilobytes long) carried by a [packet-switched network](#).

In packet networks, the data is formatted into packets that are sent through the network to their destination. Once the packets arrive they are reassembled into their original message. With packets, the [bandwidth](#) of the transmission medium can be better shared among users than if the network were [circuit switched](#). When one user is not sending packets, the link can be filled with packets from other users, and so the cost can be shared, with relatively little interference, provided the link isn't overused.

Packets consist of two kinds of data: control information, and user data (payload). The control information provides data the network needs to deliver the user data, for example: source and destination [network addresses](#), [error detection](#) codes, and sequencing information. Typically, control information is found in [packet headers](#) and [trailers](#), with [payload data](#) in between.

Often the route a packet needs to take through a network is not immediately available. In that case the packet is [queued](#) and waits until a link is free.

## Network nodes

Main article: [Node \(networking\)](#)

Apart from any physical transmission medium there may be, networks comprise additional basic [system](#) building blocks, such as [network interface controller](#) (NICs), [repeaters](#), [hubs](#), [bridges](#), [switches](#), [routers](#), [modems](#), and [firewalls](#).

## *Types of Networks*

Nanoscale network – A [nanoscale communication](#) network has key components implemented at the nanoscale including message carriers and leverages physical principles that differ from macroscale communication mechanisms. Nanoscale communication extends communication to very small sensors and actuators such as those found in biological systems and also tends to operate in environments that would be too harsh for classical communication.<sup>[16]</sup>

Personal area network – A [personal area network](#) (PAN) is a computer network used for communication among computer and different information technological devices close to one person. Some examples of devices that are used in a PAN are personal computers, printers,

fax machines, telephones, PDAs, scanners, and even video game consoles. A PAN may include wired and wireless devices. The reach of a PAN typically extends to 10 meters.<sup>[17]</sup> A wired PAN is usually constructed with USB and FireWire connections while technologies such as Bluetooth and infrared communication typically form a wireless PAN.

Local area network – A [local area network](#) (LAN) is a network that connects computers and devices in a limited geographical area such as a home, school, office building, or closely positioned group of buildings. Each computer or device on the network is a [node](#). Wired LANs are most likely based on [Ethernet](#) technology. Newer standards such as [ITU-T G.hn](#) also provide a way to create a wired LAN using existing wiring, such as coaxial cables, telephone lines, and power lines.<sup>[18]</sup>

The defining characteristics of a LAN, in contrast to a [wide area network](#) (WAN), include higher [data transfer rates](#), limited geographic range, and lack of reliance on [leased lines](#) to provide connectivity. Current Ethernet or other [IEEE 802.3](#) LAN technologies operate at data transfer rates up to [100 Gbit/s](#), standardized by [IEEE](#) in 2010.<sup>[19]</sup> Currently, [400 Gbit/s Ethernet](#) is being developed.

A LAN can be connected to a WAN using a [router](#).

Home area network – A [home area network](#) (HAN) is a residential LAN used for communication between digital devices typically deployed in the home, usually a small number of personal computers and accessories, such as printers and mobile computing devices. An important function is the sharing of Internet access, often a broadband service through a cable TV or [digital subscriber line](#) (DSL) provider.

Storage area network – A [storage area network](#) (SAN) is a dedicated network that provides access to consolidated, block level data storage. SANs are primarily used to make storage devices, such as disk arrays, tape libraries, and optical jukeboxes, accessible to servers so that the devices appear like locally attached devices to the operating system. A SAN typically has its own network of storage devices that are generally not accessible through the local area network by other devices. The cost and complexity of SANs dropped in the early 2000s to levels allowing wider adoption across both enterprise and small to medium-sized business environments.

Campus area network – A [campus area network](#) (CAN) is made up of an interconnection of LANs within a limited geographical area. The networking equipment (switches, routers) and transmission media (optical fiber, copper plant, [Cat5](#) cabling, etc.) are almost entirely owned by the campus tenant / owner (an enterprise, university, government, etc.).

For example, a university campus network is likely to link a variety of campus buildings to connect academic colleges or departments, the library, and student residence halls.

Backbone network – A [backbone network](#) is part of a computer network infrastructure that provides a path for the exchange of information between different LANs or sub-networks. A backbone can tie together diverse networks within the same building, across different buildings, or over a wide area.

For example, a large company might implement a backbone network to connect departments that are located around the world. The equipment that ties together the departmental networks constitutes the network backbone. When designing a network backbone, [network performance](#) and [network congestion](#) are critical factors to take into account. Normally, the backbone network's capacity is greater than that of the individual networks connected to it.

Another example of a backbone network is the [Internet backbone](#), which is the set of [wide area networks](#) (WANs) and [core routers](#) that tie together all networks connected to the [Internet](#).

Metropolitan area network – A [Metropolitan area network](#) (MAN) is a large computer network that usually spans a city or a large campus

Wide area network – A [wide area network](#) (WAN) is a computer network that covers a large geographic area such as a city, country, or spans even intercontinental distances. A WAN uses a communications channel that combines many types of media such as telephone lines, cables, and air waves. A WAN often makes use of transmission facilities provided by common carriers, such as telephone companies. WAN technologies generally function at the lower three layers of the [OSI reference model](#): the [physical layer](#), the [data link layer](#), and the [network layer](#).

Enterprise private network – An [enterprise private network](#) is a network that a single organization builds to interconnect its office locations (e.g., production sites, head offices, remote offices, shops) so they can share computer resources.

Virtual private network – A [virtual private network](#) (VPN) is an overlay network in which some of the links between nodes are carried by open connections or virtual circuits in some larger network (e.g., the Internet) instead of by physical wires. The data link layer protocols of the virtual network are said to be tunneled through the larger network when this is the case. One common application is secure communications through the public Internet, but a VPN need not have explicit security features, such as authentication or content encryption. VPNs, for example, can be used to separate the traffic of different user communities over an underlying network with strong security features.

VPN may have best-effort performance, or may have a defined service level agreement (SLA) between the VPN customer and the VPN service provider. Generally, a VPN has a topology more complex than point-to-point.

Global area network – A [global area network](#) (GAN) is a network used for supporting mobile across an arbitrary number of wireless LANs, satellite coverage areas, etc. The key challenge in mobile communications is handing off user communications from one local coverage area to the next. In IEEE Project 802, this involves a succession of terrestrial [wireless LANs](#).<sup>[20]</sup>

## Intranet

An [intranet](#) is a set of networks that is under the control of a single administrative entity. The intranet uses the [IP](#) protocol and IP-based tools such as web browsers and file transfer applications. The administrative entity limits use of the intranet to its authorized users. Most commonly, an intranet is the internal LAN of an organization. A large intranet typically has at least one web server to provide users with organizational information. An intranet is also anything behind the router on a local area network.

## Extranet

An [extranet](#) is a network that is also under the administrative control of a single organization, but supports a limited connection to a specific external network. For example, an organization



may provide access to some aspects of its intranet to share data with its business partners or customers. These other entities are not necessarily trusted from a security standpoint. Network connection to an extranet is often, but not always, implemented via WAN technology.

## Darknet

A [darknet](#) is an overlay network, typically running on the internet, that is only accessible through specialized software. A darknet is an anonymizing network where connections are made only between trusted peers – sometimes called “friends” ([F2F](#))<sup>[21]</sup> – using non-standard [protocols](#) and [ports](#).

Darknets are distinct from other distributed [peer-to-peer](#) networks as [sharing](#) is anonymous (that is, [IP addresses](#) are not publicly shared), and therefore users can communicate with little fear of governmental or corporate interference.<sup>[22]</sup>

# 10. The OSI Model

[https://en.wikipedia.org/wiki/OSI\\_model](https://en.wikipedia.org/wiki/OSI_model)

The **Open Systems Interconnection model (OSI model)** is a [conceptual model](#) that characterizes and standardizes the [communication functions](#) of a telecommunication or computing system without regard to their underlying internal structure and technology. Its goal is the interoperability of diverse communication systems with standard protocols. The model partitions a communication system into [abstraction layers](#). The original version of the model defined seven layers.

A layer serves the layer above it and is served by the layer below it. For example, a layer that provides error-free communications across a network provides the path needed by applications above it, while it calls the next lower layer to send and receive packets that comprise the contents of that path. Two instances at the same layer are visualized as connected by a *horizontal* connection in that layer.

The model is a product of the [Open Systems Interconnection](#) project at the [International Organization for Standardization](#) (ISO), maintained by the identification ISO/IEC 7498-1.

## Layer 1: Physical Layer

The [physical layer](#) has the following major functions:

- It defines the [electrical](#) and physical specifications of the data connection. It defines the relationship between a device and a physical [transmission medium](#) (e.g., a copper or [fiber optical cable](#), radio frequency). This includes the layout of [pins](#), [voltages](#), line [impedance](#), [cable specifications](#), signal timing and similar characteristics for connected devices and frequency (5 GHz or 2.4 GHz etc.) for wireless devices.
- It is responsible for transmission and reception of unstructured raw data in a physical medium.
- It defines transmission mode i.e. simplex, half duplex, full duplex.
- It defines the [network topology](#) as [bus](#), [mesh](#), or [ring](#) being some of the most common.
- It mostly deals with raw data.

The physical layer is the layer of low-level networking equipment, such as some [hubs](#), cabling, and [repeaters](#). The physical layer is never concerned with protocols or other such higher-layer items.

**Examples of hardware in this layer:**

- Network adapter
- Repeater
- Network hub

- Modem
- Fiber Media Converter

## Layer 2: Data Link Layer

The [data link layer](#) provides [node-to-node data transfer](#)—a link between two directly connected nodes. It detects and possibly corrects errors that may occur in the physical layer. It, among other things, defines the protocol to establish and terminate a connection between two physically connected devices. It also defines the protocol for [flow control](#) between them.

## Layer 3: Network Layer

The [network layer](#) provides the functional and procedural means of transferring variable length [data](#) sequences (called [datagrams](#)) from one node to another connected to the same *network*. It translates logical network address into physical machine address. A network is a medium to which many nodes can be connected, on which every node has an *address* and which permits nodes connected to it to transfer messages to other nodes connected to it by merely providing the content of a message and the address of the destination node and letting the network find the way to deliver the message to the destination node, possibly [routing](#) it through intermediate nodes. If the message is too large to be transmitted from one node to another on the data link layer between those nodes, the network may implement message delivery by splitting the message into several fragments at one node, sending the fragments independently, and reassembling the fragments at another node. It may, but need not, report delivery errors.

Message delivery at the network layer is not necessarily guaranteed to be reliable; a network layer protocol may provide reliable message delivery, but it need not do so.

## Layer 4: Transport Layer

The [transport layer](#) provides the functional and procedural means of transferring variable-length data sequences from a source to a destination host via one or more networks, while maintaining the quality of service functions.

An example of a transport-layer protocol in the standard Internet stack is [Transmission Control Protocol](#) (TCP), usually built on top of the [Internet Protocol](#) (IP).

The transport layer controls the reliability of a given link through flow control, [segmentation/desectionation](#), and error control. Some protocols are state- and connection-oriented. This

means that the transport layer can keep track of the segments and retransmit those that fail. The transport layer also provides the acknowledgement of the successful data transmission and sends the next data if no errors occurred. The transport layer creates packets out of the message received from the application layer. Packetizing is a process of dividing the long message into smaller messages.

An easy way to visualize the transport layer is to compare it with a post office, which deals with the dispatch and classification of mail and parcels sent. Do remember, however, that a post office manages the outer envelope of mail. Higher layers may have the equivalent of double envelopes, such as cryptographic presentation services that can be read by the addressee only. Roughly speaking, [tunneling protocols](#) operate at the transport layer, such as carrying non-IP protocols such as [IBM's SNA](#) or [Novell's IPX](#) over an IP network, or end-to-end encryption with [IPsec](#). While [Generic Routing Encapsulation](#) (GRE) might seem to be a network-layer protocol, if the encapsulation of the payload takes place only at endpoint, GRE becomes closer to a transport protocol that uses IP headers but contains complete frames or packets to deliver to an endpoint. [L2TP](#) carries [PPP](#) frames inside transport packet.

Although not developed under the OSI Reference Model and not strictly conforming to the OSI definition of the transport layer, the [Transmission Control Protocol](#) (TCP) and the [User Datagram Protocol](#) (UDP) of the Internet Protocol Suite are commonly categorized as layer-4 protocols within OSI.

## Layer 5: Session Layer

The [session layer](#) controls the dialogues (connections) between computers. It establishes, manages and terminates the connections between the local and remote application. It provides for [full-duplex](#), [half-duplex](#), or [simplex](#) operation, and establishes checkpointing, adjournment, termination, and restart procedures. The OSI model made this layer responsible for graceful close of sessions, which is a property of the [Transmission Control Protocol](#), and also for session checkpointing and recovery, which is not usually used in the Internet Protocol Suite. The session layer is commonly implemented explicitly in application environments that use [remote procedure calls](#).

## Layer 6: Presentation Layer

The [presentation layer](#) establishes context between application-layer entities, in which the application-layer entities may use different syntax and semantics if the presentation service provides a mapping between them. If a mapping is available, presentation service data units are encapsulated into session protocol data units, and passed down the protocol stack.

This layer provides independence from data representation (e.g., [encryption](#)) by translating between application and network formats. The presentation layer transforms data into the form

that the application accepts. This layer formats and encrypts data to be sent across a network. It is sometimes called the syntax layer.<sup>[9]</sup>

## Layer 7: Application Layer

The [application layer](#) is the OSI layer closest to the end user, which means both the OSI application layer and the user interact directly with the software application. This layer interacts with software applications that implement a communicating component. Such application programs fall outside the scope of the OSI model. Application-layer functions typically include identifying communication partners, determining resource availability, and synchronizing communication. When identifying communication partners, the application layer determines the identity and availability of communication partners for an application with data to transmit. When determining resource availability, the application layer must decide whether sufficient network resources for the requested communication exist. In synchronizing communication, all communication between applications requires cooperation that is managed by the application layer. This layer supports application and end-user processes. Communication partners are identified, quality of service is identified, user authentication and privacy are considered, and any constraints on data syntax are identified. Everything at this layer is application-specific.

## PART III

# CHAPTER 3: WEB SEARCH

Web search is something we rely on every day, but rarely think about how it works. Why is that? This chapter is designed to teach you the basics about how web search works, and also provide you with some tips that might help you better find important information you are looking for, as efficiently as possible.

### *Learning Objectives*

After reading this chapter, you will be able to:

- Describe search engines, and how they work.
- Identify the pros and cons of personalized searches.



## II. Search Engines

From [https://en.wikipedia.org/wiki/Web\\_search\\_engine](https://en.wikipedia.org/wiki/Web_search_engine)

A **web search engine** is a software system that is designed to search for information on the [World Wide Web](#). The search results are generally presented in a line of results often referred to as [search engine results pages](#) (SERPs). The information may be a mix of [web pages](#), images, and other types of files. Some search engines also [mine data](#) available in [databases](#) or [open directories](#). Unlike [web directories](#), which are maintained only by human editors, search engines also maintain [real-time](#) information by running an [algorithm](#) on a [web crawler](#).

Modern Web Browser History

[JumpStation](#) (created in December 1993<sup>[7]</sup> by [Jonathon Fletcher](#)) used a [web robot](#) to find web pages and to build its index, and used a [web form](#) as the interface to its query program. It was thus the first WWW resource-discovery tool to combine the three essential features of a web search engine (crawling, indexing, and searching) as described below. Because of the limited resources available on the platform it ran on, its indexing and hence searching were limited to the titles and headings found in the web pages the crawler encountered.

One of the first “all text” crawler-based search engines was [WebCrawler](#), which came out in 1994. Unlike its predecessors, it allowed users to search for any word in any webpage, which has become the standard for all major search engines since. It was also the first one widely known by the public. Also in 1994, [Lycos](#) (which started at [Carnegie Mellon University](#)) was launched and became a major commercial endeavor.

Soon after, many search engines appeared and vied for popularity. These included [Magellan](#), [Excite](#), [Infoseek](#), [Inktomi](#), [Northern Light](#), and [AltaVista](#). [Yahoo!](#) was among the most popular ways for people to find web pages of interest, but its search function operated on its [web directory](#), rather than its full-text copies of web pages. Information seekers could also browse the directory instead of doing a keyword-based search.

In 1996, [Netscape](#) was looking to give a single search engine an exclusive deal as the featured search engine on Netscape’s web browser. There was so much interest that instead Netscape struck deals with five of the major search engines: for \$5 million a year, each search engine would be in rotation on the Netscape search engine page. The five engines were Yahoo!, Magellan, Lycos, Infoseek, and Excite.<sup>[8][9]</sup>

[Google](#) adopted the idea of selling search terms in 1998, from a small search engine company named [goto.com](#). This move had a significant effect on the SE business, which went from struggling to one of the most profitable businesses in the internet.<sup>[10]</sup>

Search engines were also known as some of the brightest stars in the Internet investing frenzy that occurred in the late 1990s.<sup>[11]</sup> Several companies entered the market spectacularly, receiving record gains during their [initial public offerings](#). Some have taken down their public search engine, and are marketing enterprise-only editions, such as Northern Light. Many search engine companies were caught up in the [dot-com bubble](#), a speculation-driven market boom that peaked in 1999 and ended in 2001.

Around 2000, [Google’s search engine](#) rose to prominence.<sup>[12]</sup> The company achieved better

results for many searches with an innovation called [PageRank](#), as was explained in the paper *Anatomy of a Search Engine* written by [Sergey Brin](#) and [Larry Page](#), the later founders of Google.<sup>[13]</sup> This [iterative algorithm](#) ranks web pages based on the number and PageRank of other web sites and pages that link there, on the premise that good or desirable pages are linked to more than others. Google also maintained a minimalist interface to its search engine. In contrast, many of its competitors embedded a search engine in a [web portal](#). In fact, Google search engine became so popular that spoof engines emerged such as [Mystery Seeker](#).

By 2000, [Yahoo!](#) was providing search services based on Inktomi's search engine. Yahoo! acquired Inktomi in 2002, and [Overture](#) (which owned [AlltheWeb](#) and AltaVista) in 2003. Yahoo! switched to Google's search engine until 2004, when it launched its own search engine based on the combined technologies of its acquisitions.

[Microsoft](#) first launched MSN Search in the fall of 1998 using search results from Inktomi. In early 1999 the site began to display listings from [Looksmart](#), blended with results from Inktomi. For a short time in 1999, MSN Search used results from AltaVista instead. In 2004, [Microsoft](#) began a transition to its own search technology, powered by its own [web crawler](#) (called [msnbot](#)).

Microsoft's rebranded search engine, [Bing](#), was launched on June 1, 2009. On July 29, 2009, Yahoo! and Microsoft finalized a deal in which [Yahoo! Search](#) would be powered by Microsoft Bing technology.

## 12. How Search Engines Work

From [https://en.wikipedia.org/wiki/Web\\_search\\_engine](https://en.wikipedia.org/wiki/Web_search_engine)

A search engine maintains the following processes in near real time:

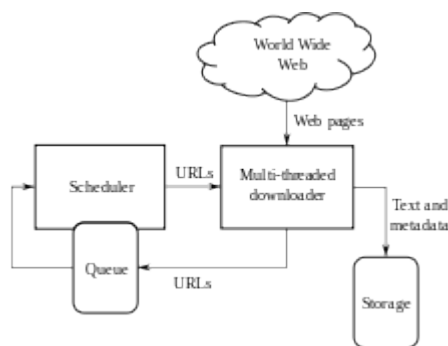
1. [Web crawling](#)
2. [Indexing](#)
3. [Searching](#)<sup>[14]</sup>

Web search engines get their information by [web crawling](#) from site to site. The “spider” checks for the standard filename [robots.txt](#), addressed to it, before sending certain information back to be [indexed](#) depending on many factors, such as the titles, page content, [JavaScript](#), [Cascading Style Sheets](#) (CSS), headings, as evidenced by the standard [HTML](#) markup of the informational content, or its metadata in HTML [meta tags](#).

Indexing means associating words and other definable tokens found on web pages to their domain names and HTML-based fields. The associations are made in a public database, made available for web search queries. A query from a user can be a single word. The index helps find information relating to the query as quickly as possible.<sup>[14]</sup>

Some of the techniques for indexing, and [cacheing](#) are trade secrets, whereas web crawling is a straightforward process of visiting all sites on a systematic basis.

Between visits by the *spider*, the cached version of page (some or all the content needed to render it) stored in the search engine working memory is quickly sent to an inquirer. If a visit is overdue, the search engine can just act as a [web proxy](#) instead. In this case the page may differ from the search terms indexed.<sup>[14]</sup> The cached page holds the appearance of the version whose words were indexed, so a cached version of a page can be useful to the web site when the actual page has been lost, but this problem is also considered a mild form of [linkrot](#).



High-level architecture of a standard Web crawler

Typically when a user enters a [query](#) into a search engine it is a few [keywords](#).<sup>[15]</sup> The [index](#) already has the names of the sites containing the keywords, and these are instantly obtained from the index. The real processing load is in generating the web pages that are the search results list: Every page in the entire list must be [weighted](#) according to information in the indexes.<sup>[14]</sup> Then the top

search result item requires the lookup, reconstruction, and markup of the *snippets* showing the context of the keywords matched. These are only part of the processing each search results web page requires, and further pages (next to the top) require more of this post processing.

Beyond simple keyword lookups, search engines offer their own GUI- or command-driven operators and search parameters to refine the search results. These provide the necessary controls for the user engaged in the feedback loop users create by *filtering* and *weighting* while refining the search results, given the initial pages of the first search results. For example, from 2007 the Google.com search engine has allowed one to *filter* by date by clicking “Show search tools” in the leftmost column of the initial search results page, and then selecting the desired date range.<sup>[16]</sup> It’s also possible to *weight* by date because each page has a modification time. Most search engines support the use of the [boolean operators](#) AND, OR and NOT to help end users refine the [search query](#). Boolean operators are for literal searches that allow the user to refine and extend the terms of the search. The engine looks for the words or phrases exactly as entered. Some search engines provide an advanced feature called [proximity search](#), which allows users to define the distance between keywords.<sup>[14]</sup> There is also [concept-based searching](#) where the research involves using statistical analysis on pages containing the words or phrases you search for. As well, natural language queries allow the user to type a question in the same form one would ask it to a human.<sup>[17]</sup> A site like this would be ask.com.<sup>[18]</sup>

The usefulness of a search engine depends on the [relevance](#) of the *result set* it gives back. While there may be millions of web pages that include a particular word or phrase, some pages may be more relevant, popular, or authoritative than others. Most search engines employ methods to [rank](#) the results to provide the “best” results first. How a search engine decides which pages are the best matches, and what order the results should be shown in, varies widely from one engine to another.<sup>[14]</sup> The methods also change over time as Internet usage changes and new techniques evolve. There are two main types of search engine that have evolved: one is a system of predefined and hierarchically ordered keywords that humans have programmed extensively. The other is a system that generates an “[inverted index](#)” by analyzing texts it locates. This first form relies much more heavily on the computer itself to do the bulk of the work.

Most Web search engines are commercial ventures supported by [advertising](#) revenue and thus some of them allow advertisers to [have their listings ranked higher](#) in search results for a fee. Search engines that do not accept money for their search results make money by running [search related ads](#) alongside the regular search engine results. The search engines make money every time someone clicks on one of these ads.<sup>[19]</sup>

# 13. Personalized Search

**Personalized search** refers to search experiences that are tailored specifically to an individual's interests by incorporating information about the individual beyond specific query provided. Pitkow et al. describe two general approaches to personalizing search results, one involving modifying the user's query and the other re-ranking search results.<sup>[1]</sup>

## History

Google introduced Personalized search in 2004 and it was implemented in 2005 to Google search. Google has personalized search set up for not just those who have a Google account but everyone as well. There is not very much information on how exactly Google personalizes their searches, however, it is believed that they use user language, location, and web history.<sup>[2]</sup>

Early search engines, like [Yahoo!](#) and [AltaVista](#), found results based only on key words. Personalized search, as pioneered by [Google](#), has become far more complex with the goal to “understand exactly what you mean and give you exactly what you want.”<sup>[3]</sup> Using mathematical algorithms, search engines are now able to return results based on the number of links to and from sites; the more links a site has, the higher it is placed on the page.<sup>[4]</sup> Search engines have two degrees of expertise: the shallow expert and the deep expert. An expert from the shallowest degree serves as a witness who knows some specific information on a given event. A deep expert, on the other hand, has comprehensible knowledge that gives it the capacity to deliver unique information that is relevant to each individual inquirer.<sup>[5]</sup> If a person knows what he or she wants then the search engine will act as a shallow expert and simply locate that information. But search engines are also capable of deep expertise in that they rank results indicating that those near the top are more relevant to a user's wants than those below.<sup>[6]</sup>

While many [search engines](#) take advantage of information about people in general, or about specific groups of people, personalized search depends on a user profile that is unique to the individual. Research systems that personalize search results model their users in different ways. Some rely on users explicitly specifying their interests or on demographic/cognitive characteristics.<sup>[7][8]</sup> But user supplied information can be hard to collect and keep up to date. Others have built implicit user models based on content the user has read or their history of interaction with Web pages.<sup>[9][10][11][12][13]</sup>

There are several publicly available systems for personalizing Web search results (e.g., [Google Personalized Search](#) and [Bing's](#) search result personalization<sup>[14]</sup>). However, the technical details and evaluations of these commercial systems are proprietary. One technique Google uses to personalize searches for its users is to track log in time and if the user has enabled web history in his browser. The more you keep going the same site through a search result from Google, it believes that you like that page. So when you do certain searches, Google's personalized search algorithm gives the page a boost, moving it up through the ranks. Even if you're signed out, Google

may personalize your results because it keeps a 180-day record of what a particular web browser has searched for, linked to a cookie in that browser.<sup>[15]</sup>

In order to better understand how personalized search results are being presented to the users, a group of researchers at Northeastern University set out to answer this question. By comparing an aggregate set of searches from logged in users against a control group, the research team found that 11.7% of results show differences due to personalization, however this varies widely by search query and result ranking position.<sup>[16]</sup> Of various factors tested, the two that had measurable impact were being logged in with a Google account and the IP address of the searching users. It should also be noted that results with high degrees of personalization include companies and politics. One of the factors driving personalization is localization of results, with company queries showing store locations relevant to the location of the user. So, for example, if you searched for “used car sales,” Google may churn out results of local car dealerships in your area. On the other hand, queries with the least amount of personalization include factual queries (“what is”) and health.<sup>[17]</sup>

When measuring personalization, it is important to eliminate background noise. In this context, one type of background noise is the carry-over effect. The carry-over effect can be defined as follows: when you perform a search and follow it with a subsequent search, the results of the second search is influenced by the first search. An interesting point to note is that the top ranked URLs are less likely to change based off personalization, with most personalization occurring at the lower ranks. This is a style of personalization, based on recent search history, but it is not a consistent element of personalization because the phenomenon times out after 10 minutes, according to the researchers.<sup>[18]</sup>

## The Filter Bubble

Main article: [Filter bubble](#)

Several concerns have been brought up regarding personalized search. It decreases the likelihood of finding new information by biasing search results towards what the user has already found. It introduces potential privacy problems in which a user may not be aware that their search results are personalized for them, and wonder why the things that they are interested in have become so relevant. Such a problem has been coined as the “filter bubble” by author [Eli Pariser](#). He argues that people are letting major websites drive their destiny and make decisions based on the vast amount of data they’ve collected on individuals. This can isolate users in their own worlds or “filter bubbles” where they only see information that they want to, such a consequence of “The Friendly World Syndrome.” As a result, people are much less informed of problems in the developing world which can further widen the gap between the North (developed countries) and the South (developing countries).<sup>[19]</sup>

The methods of personalization, and how useful it is to “promote” certain results which have been showing up regularly in searches by like-minded individuals in the same community. The personalization method makes it very easy to understand how the Filter Bubble happens. As



certain results are bumped up and viewed more by individuals, other results not favored by them are relegated to obscurity. As this happens on a community-wide level, it results in the community, consciously or not, sharing a skewed perspective of events.<sup>[20]</sup>

An area of particular concern to some parts of the world is the use of personalized search as a form of control over the people utilizing the search by only giving them particular information. This can be used to give particular influence over highly talked about topics such as gun control or even gear people to side with a particular political regime in different countries.<sup>[21]</sup> While total control by a particular government just from personalized search is a stretch, control of the information readily available from searches can easily be controlled by the richest corporations. The biggest example of a corporation controlling the information is Google. Google is not only feeding you the information they want but they are at times using your personalized search to gear you towards their own companies or affiliates. This has led to a complete control of various parts of the web and a pushing out of their competitors such as how Google Maps took a major control over the online map and direction industry with MapQuest and others forced to take a backseat.<sup>[22]</sup>

Many search engines use concept-based user profiling strategies that derive only topics that users are highly interested in but for best results, according to researchers Wai-Tin and Dik Lun, both positive and negative preferences should be considered. Such profiles, applying negative and positive preferences, result in highest quality and most relevant results by separating alike queries from unlike queries. For example, typing in 'apple' could refer to either the fruit or the [Macintosh](#) computer and providing both preferences aids search engines' ability to learn which apple the user is really looking for based on the links clicked. One concept-strategy the researchers came up with to improve personalized search and yield both positive and negative preferences is the click-based method. This method captures a user's interests based on which links they click on in a results list, while downgrading unclicked links.<sup>[23]</sup>

The feature also has profound effects on the [search engine optimization](#) industry, due to the fact that search results will no longer be ranked the same way for every user.<sup>[24]</sup> An example of this is found in Eli Pariser's, *The Filter Bubble*, where he had two friends type in "BP" into Google's search bar. One friend found information on the BP oil spill in the Gulf of Mexico while the other retrieved investment information.<sup>[25]</sup>

Some have noted that personalized search results not only serve to customize a user's search results, but also [advertisements](#). This has been criticized as an [invasion of privacy](#).<sup>[26]</sup>

# 14. Search Neutrality

From [https://en.wikipedia.org/wiki/Search\\_neutrality](https://en.wikipedia.org/wiki/Search_neutrality)

**Search neutrality** is a [principle](#) that search engines should have no editorial policies other than that their results be comprehensive, impartial and based solely on relevance.<sup>[1]</sup> This means that when a user queries a search engine, the engine should return the most relevant results found in the provider's domain (those sites which the engine has knowledge of), without manipulating the order of the results (except to rank them by relevance), excluding results, or in any other way manipulating the results to a certain [bias](#).

Search neutrality is related to [network neutrality](#) in that they both aim to keep any one organization from limiting or altering a user's access to services on the Internet. Search neutrality aims to keep the [organic search](#) results (results returned because of their relevance to the search terms, as opposed to results sponsored by advertising) of a search engine free from any manipulation, while network neutrality aims to keep those who provide and govern access to the Internet from limiting the availability of resources to access any given content.

## Background

Search neutrality became a concern after [search engines](#), most notably [Google](#), were accused of search bias.<sup>[2]</sup> Competitors and companies claim search engines systematically favor some sites (and some kind of sites) over others in their lists of results, disrupting the objective results users believe they are getting.<sup>[3]</sup> The call for search neutrality goes beyond traditional search engines. Sites like [Amazon.com](#) and [Facebook](#) are also accused of skewing results.<sup>[4]</sup> Amazon's search results are influenced by companies that pay to rank higher in their search results while Facebook filters their newsfeed lists to conduct social experiments.<sup>[4]</sup>

## “Vertical search” spam penalties

In order to find information on the Web, most users make use of [search engines](#), which crawl the web, index it and show a list of results ordered by relevance. The use of search engines to access information through the web has become a key factor for online businesses companies, which depend on the flow of users visiting their pages.<sup>[5]</sup> One of these companies is Foundem. Foundem provides a “[vertical search](#)” service to compare products available on online markets for the U.K. Many people see these “vertical search” sites as spam.<sup>[6]</sup> Beginning in 2006 and for three and a half years following, Foundem's traffic and business dropped significantly due to a “penalty” applied by Google.<sup>[7]</sup> Adam Raff, co-founder of Foundem, first coined the term search neutrality in December 2009 in his op-ed piece in [The New York Times](#) after Google removed

the “penalty” from Foundem.<sup>[1]</sup> Foundem launched SearchNeutrality.org, a website dedicated to promote investigations against Google, in the same year. Most of Foundem’s accusations claim that Google applies penalties to other vertical search engines just because they represent competition.<sup>[8]</sup> Foundem is backed by a Microsoft proxy group, the ‘Initiative for Competitive Online Marketplace’.<sup>[9]</sup>

## Arguments

There are a number of arguments for and against search neutrality.

### Pros

- Those who advocate search neutrality argue that the results would not be biased towards sites with more advertising, but towards sites most relevant to the user.<sup>[13]</sup>
- Search neutrality encourages sites to have more quality content rather than pay to rank higher on organic results.
- Restrains search engines from only supporting their best advertisers.<sup>[13]</sup>
- Search engines would allow traffic to sites that depend on visitors, keeping their results comprehensive, impartial, and based solely on relevance.<sup>[14][15]</sup>
- Allows for organized, logical manipulation of search results by an objective, automatic algorithm. At the same time, disallowing underhanded ranking of results on an individual basis.<sup>[15]</sup>
- Personalized search results might suppress information that disagrees with users’ [worldviews](#), isolating them in their own cultural or ideological “[filter bubbles](#)”.<sup>[16]</sup>

### Cons

- Forcing search engines to treat all websites equally would lead to the removal of their biased look at the Internet. A biased view of the Internet is exactly what search users are seeking. By performing a search the user is seeking what that search engine perceives as the “best” result to their query. Enforced search neutrality would, essentially, remove this bias. Users continually return to a specific search engine because they find the “biased” or “subjective” results to fit their needs.<sup>[15]</sup>
- Search neutrality has the possibility of causing search engines to become stagnant. If site A is first on a [SERP](#) (search engine results page) one month, and then tenth the next month search neutrality advocates cry “foul play,” but in reality it is often the pages loss in

popularity, relevance, or quality content that has caused the move. The case against Google brought forth by the owners of Foundem extoll this phenomenon and regulation could limit the search engine's ability to adjust ranking based on their own metrics.<sup>[15]</sup>

- Proponents of search neutrality desire transparency in a search engine's ranking algorithm. Requiring transparent algorithms leads to two concerns. These algorithms are the companies private [intellectual property](#) and should not be forced into the open. This would be similar to forcing a soda manufacturer to publish their recipes. The second concern is that opening the algorithm would allow spammers to exploit and target how the algorithm functions directly. This would permit spammers to circumvent the metrics in place that prevent spammed websites from being at the top of a SERP.<sup>[15]</sup>
- Removing a search engine's ability to directly manipulate rankings limits their ability to penalize dishonest websites that practice [black hat](#) techniques to improve their rankings. Any site who finds a way to circumvent the algorithm would benefit from a search engine's inability to manually decrease their ranking causing a spam site to gain high ranking for extended periods of time.<sup>[15]</sup>

## PART IV

# CHAPTER 4: SOCIAL MEDIA

Social Media. A phrase that often elicits various reactions, from praise to scrutiny. Social Media, now a common phrase in the news, is arguably over two decades old. Websites from the mid-90s boasted the same ability for users to generate their own content and interact online, though it was very difficult so few people engaged in these activities. It wasn't until the early 2000s, with sites like Friendster, MySpace, and others, when Social Media usage started to exponentially grow.

Whether you use social media or not, you need to be aware of how information posted to sites like Facebook, Twitter, SnapChat, and other sites is used, stored, searched, and sometimes mined. Ultimately, this is your online identity, and you need the knowledge and skills in order to best manage your online identity, crafting an image of yourself that the world can see.

### *Learning Objectives*

After reading this lesson, you will be able to:

- Define and describe social media.
- Describe social media mining, and what it means for the things you choose to share on social media.
- Identify ways in which organizations, from corporations to terrorist groups, leverage social media for various purposes.

# 15. Social Media Introduction

From Wikipedia: [https://en.wikipedia.org/wiki/Social\\_media](https://en.wikipedia.org/wiki/Social_media)

**Social media** are [computer-mediated](#) technologies that allow individuals, companies, [NGOs](#), governments, and other organizations to view, create and share [information](#), ideas, career interests,<sup>[1]</sup> and other forms of expression via [virtual communities](#) and [networks](#). The variety of stand-alone and built-in social media services currently available introduces challenges of definition; however, there are some common features.<sup>[2]</sup>

1. social media are interactive [Web 2.0 Internet](#)-based applications,<sup>[2][3]</sup>
2. [user-generated content](#) such as text posts or comments, [digital photos](#) or videos, as well as data generated through all online interactions, are the lifeblood of the social media organism,<sup>[2][3]</sup>
3. users create service-specific profiles for the website or [app](#), that are designed and maintained by the social media [organization](#),<sup>[2][4]</sup> and
4. social media facilitate the development of online [social networks](#) by connecting a user's profile with those of other individuals and/or groups.<sup>[2][4]</sup>

Social media use [web-based](#) and mobile technologies on [smartphones](#) and [tablet computers](#) to create highly interactive platforms through which individuals, communities and organizations can share, co-create, discuss, and modify user-generated content or pre-made content posted online. They introduce substantial and pervasive changes to communication between businesses, organizations, communities, and individuals.<sup>[5]</sup> Social media changes the way individuals and large organizations communicate. These changes are the focus of the emerging field of [technoself](#) studies.

Social media differ from paper-based or traditional electronic media such as [TV broadcasting](#) in many ways, including quality,<sup>[6]</sup> [reach](#), frequency, usability, immediacy, and permanence. Social media operate in a dialogic transmission system (many sources to many receivers).<sup>[7]</sup> This is in contrast to [traditional media](#) that operates under a monologic transmission model (one source to many receivers), such as a paper newspaper which is delivered to many subscribers. Some of the most popular social media websites are [Facebook](#) (and its associated [Facebook Messenger](#)), [WhatsApp](#), [Tumblr](#), [Instagram](#), [Twitter](#), [Baidu Tieba](#), [Pinterest](#), [LinkedIn](#), [Gab](#), [Google+](#), [YouTube](#), [Viber](#) and [Snapchat](#). These social media websites have more than 100,000,000 registered users.

Observers have noted a range of positive and negative impacts from social media use. Social media can help to improve individuals' sense of connectedness with real and/or online communities and social media can be an effective communications (or marketing) tool for corporations, entrepreneurs, nonprofit organizations, including advocacy groups and political parties and governments. At the same time, concerns have been raised about possible links between heavy social media use and depression and even the issues of [cyberbullying](#), online [harassment](#) and [trolling](#). According to Nielsen, Internet users continue to spend more time with social media sites than any other type of site. At the same time, the total time spent on social

media in the U.S. across PC and mobile devices increased by 99 percent to 121 billion minutes in July 2012 compared to 66 billion minutes in July 2011.<sup>[8]</sup> For content contributors, the benefits of participating in social media have gone beyond simply social sharing to building reputation and bringing in career opportunities and monetary income.<sup>[9]</sup>

## Management

There is an increasing trend towards using [social media monitoring](#) tools that allow marketers and companies to search, track, and analyze online conversations on the Web about their brand or products or about related topics of interest.<sup>[24][25]</sup> This can be useful in [public relations](#) management and [advertising campaign](#) tracking, allowing the user to measure [return on investment](#), competitor-auditing, and general public engagement. Tools range from free, basic applications to subscription-based, more in-depth tools. Social media tracking also enables companies to respond quickly to online posts that criticize their product or service. By responding quickly to critical online posts, and helping the user to resolve the concerns, this helps the company to lessen the negative effects that online complaints can have about company product or service sales. In the US, for example, if a customer criticizes a major hotel chain's cleanliness or service standards on a social media website, a company representative will usually quickly be alerted to this critical post, so that the company representative can go online and express concern for the sub-par service and offer the complaining person a [coupon](#) or [discount](#) on their next purchase, plus a promise to forward their concerns to the hotel manager so that the problem will not be repeated.

The “honeycomb framework” defines how social media services focus on some or all of seven functional building blocks.<sup>[5]</sup> These building blocks help explain the engagement needs of the social media audience. For instance, [LinkedIn](#) users are thought to care mostly about identity, reputation, and relationships, whereas [YouTube's](#) primary features are sharing,<sup>[26]</sup> conversations, groups, and reputation. Many companies build their own social “containers” that attempt to link the seven functional building blocks around their brands. These are private communities that engage people around a more narrow theme, as in around a particular brand, vocation or hobby, rather than social media containers such as [Google+](#), [Facebook](#), and [Twitter](#). PR departments face significant challenges in dealing with viral negative sentiment directed at organizations or individuals on social media platforms (dubbed “sentimentitis”), which may be a reaction to an announcement or event.<sup>[27]</sup> In a 2011 article,<sup>[5]</sup> Jan H. Kietzmann, Kristopher Hermkens, Ian P. McCarthy and Bruno S. Silvestre describe the honeycomb relationship as “present[ing] a framework that defines social media by using *seven functional building blocks*: identity, conversations, sharing, presence, relationships, reputation, and groups.”

The elements of the honeycomb framework include:

- **Identity:** This block represents the extent to which users reveal their identities in a social media setting. This can include disclosing information such as name, age, gender, profession, location, and also information that portrays users in certain ways.<sup>[5]</sup>



- **Conversations:** This block represents the extent to which users communicate with other users in a social media setting. Many social media sites are designed primarily to facilitate conversations among individuals and groups. These conversations happen for all sorts of reasons. People tweet, blog, make online comments and send messages to other users to meet new like-minded people, to find a romantic partner, to build their self-esteem, or to be on the cutting edge of new ideas or trending topics. Yet others see social media as a way of making their message heard and positively impacting humanitarian causes, environmental problems, economic issues, or political debates.<sup>[5]</sup>
- **Sharing:** This block represents the extent to which users exchange, distribute, and receive content, ranging from a short text post to a link or a [digital photo](#). The term ‘social’ implies that exchanges between people are crucial. In many cases, however, sociality is about the objects that mediate these ties between people—the reasons why they meet online and associate with each other.<sup>[5]</sup>
- **Presence:** This block represents the extent to which users can know if other users are accessible. It includes knowing where others are, in the virtual world and/or in the real world, and whether they are available.<sup>[5]</sup> Some social media sites have icons that indicate when other users are online.
- **Relationships:** This block represents the extent to which users can be related or linked up to other users. Two or more users have some form of association that leads them to converse, share objects of sociality, send texts or messages, meet up, or simply just list each other as a friend or fan.<sup>[5]</sup>
- **Reputation:** This block represents the extent to which users can identify the standing of others, including themselves, in a social media setting. [Reputation](#) can have different meanings on social media platforms. In most cases, reputation is a matter of trust, but because information technologies are not yet good at determining such highly qualitative criteria, social media sites rely on ‘mechanical Turks’: tools that automatically aggregate user-generated information to determine trustworthiness.<sup>[5]</sup> [Reputation management](#) is another aspect and use of social media.
- **Groups:** This block represents the extent to which users can form communities and sub-communities of people with similar backgrounds, demographics or interests. The more ‘social’ a network becomes, the wider the group of friends, followers, and contacts can be developed.<sup>[5]</sup>

## Most popular sites

This is a list of the leading social networks based on number of active user accounts as of April 2016.<sup>[36]</sup>

1. [Facebook](#): 1,650,000,000 users.
2. [WhatsApp](#) 1,000,000,000 users.
3. [Facebook Messenger](#): 900,000,000 users.

4. [QQ](#): 853,000,000 users.
5. [WeChat](#): 706,000,000 users.
6. [QZone](#): 653,000,000 users.
7. [Tumblr](#): 555,000,000 users.
8. [Instagram](#): 400,000,000 users.
9. [Twitter](#): 320,000,000 users.
10. [Baidu Tieba](#): 300,000,000 users.
11. [Skype](#): 300,000,000 users.
12. [Viber](#): 280,000,000 users.
13. [Sina Weibo](#): 222,000,000 users.
14. [Line](#): 215,000,000 users.
15. [Snapchat](#): 200,000,000 users.

## Criticisms

**We worry that social media is kind of the virtual bathhouse**— Dr. Lynn Fitzgibbons, an infectious disease physician Santa Barbara County Public Health Department<sup>[63]</sup>

Criticisms of social media range from criticisms of the ease of use of specific platforms and their capabilities, disparity of information available, issues with trustworthiness and reliability of information presented,<sup>[64]</sup> the impact of social media use on an individual's concentration,<sup>[65]</sup> ownership of media content, and the meaning of interactions created by social media. Although some social media platforms offer users the opportunity to cross-post simultaneously, some social network platforms have been criticized for poor interoperability between platforms, which leads to the creation of information silos, viz. isolated pockets of data contained in one social media platform.<sup>[66]</sup> However, it is also argued that social media have positive effects such as allowing the democratization of the Internet<sup>[67]</sup> while also allowing individuals to advertise themselves and form friendships.<sup>[68]</sup> Others<sup>[69]</sup> have noted that the term “social” cannot account for technological features of a platform alone, hence the level of sociability should be determined by the actual performances of its users. There has been a dramatic decrease in face-to-face interactions as more and more social media platforms have been introduced with the threat of cyber-bullying and online sexual predators being more prevalent.<sup>[70]</sup> Social media may expose children to images of alcohol, [tobacco](#), and sexual behaviors<sup>[relevant? - discuss]</sup>.<sup>[71]</sup> In regards to cyber-bullying, it has been proven that individuals who have no experience with cyber-bullying often have a better well-being than individuals who have been bullied online.<sup>[72]</sup>

Twitter is increasingly a target of heavy activity of marketers. Their actions, focused on gaining massive numbers of followers, include use of advanced scripts and manipulation techniques that distort the prime idea of social media by abusing human trustfulness.<sup>[73]</sup> Twitter also promotes social connections among students. It can be used to enhance communication building and critical thinking. Domizi (2013) utilized Twitter in a graduate seminar requiring students to post weekly tweets to extend classroom discussions. Students reportedly used Twitter to connect

with content and other students. Additionally, students found it “to be useful professionally and personally.”<sup>[74]</sup> British-American entrepreneur and author [Andrew Keen](#) criticizes social media in his book [The Cult of the Amateur](#), writing, “Out of this anarchy, it suddenly became clear that what was governing the infinite monkeys now inputting away on the Internet was the law of digital Darwinism, the survival of the loudest and most opinionated. Under these rules, the only way to intellectually prevail is by infinite filibustering.”<sup>[75]</sup> This is also relative to the issue “justice” in the social network. For example, the phenomenon “[Human flesh search engine](#)” in Asia raised the discussion of “private-law” brought by social network platform. Comparative media professor [José van Dijck](#) contends in her book “[The Culture of Connectivity](#)” (2013) that to understand the full weight of social media, their technological dimensions should be connected to the social and the cultural. She critically describes six social media platforms. One of her findings is the way Facebook had been successful in framing the term ‘sharing’ in such a way that third party use of user data is neglected in favour of intra-user connectedness.

## Privacy

Privacy rights advocates warn users about uses for the information that can be gathered through social media. Some information is captured without the user’s knowledge or consent, such as through electronic tracking and third party application on social networks. Others include law enforcement and governmental use of this information,<sup>[100]</sup> including the gathering of so-called [social media intelligence](#) through [data mining](#) techniques.<sup>[101]</sup> Additional privacy concerns relate to the impact of social media monitoring by employers whose policies include prohibitions against workers’ postings on social networking sites.<sup>[102]</sup> A survey done in 2010 from different universities revealed that there are lines drawn between personal and professional lives. Many of the users surveyed admitted to misrepresenting themselves online.<sup>[103]</sup> Employees can be concerned because their social media sites reflect their personal lives and not their professional lives, but yet employers are censoring them on the Internet.

Other privacy concerns with employers and social media are when employers use social media as a tool to screen a prospective employee. This issue raises many ethical questions that some consider an employer’s right and others consider [discrimination](#). Except in the states of California, Maryland, and Illinois, there are no laws that prohibit employers from using social media profiles as a basis of whether or not someone should be hired.<sup>[104]</sup> [Title VII](#) also prohibits discrimination during any aspect of employment including hiring or firing, recruitment, or testing.<sup>[105]</sup> Social media has been integrating into the workplace and this has led to conflicts within employees and employers.<sup>[106]</sup> Particularly, Facebook has been seen as a popular platform for employers to investigate in order to learn more about potential employees. This conflict first started in Maryland when an employer requested and received an employee’s Facebook username and password. State lawmakers first introduced legislation in 2012 to prohibit employers from requesting passwords to personal social accounts in order to get a job or to keep a job. This led to Canada, Germany, the U.S. Congress and 11 U.S. states to pass or propose legislation that prevents employers’ access to private social accounts of employees.<sup>[107]</sup>

Many Western European countries have already implemented laws that restrict the regulation of social media in the workplace. States including Arkansas, California, Colorado, Illinois, Maryland, Michigan, Nevada, New Jersey, New Mexico, Utah, Washington, and Wisconsin have passed legislation that protects potential employees and current employees from employers that demand them to give forth their username or password for a social media account.<sup>[108]</sup> Laws that forbid employers from disciplining an employee based on activity off the job on social media sites have also been put into act in states including California, Colorado, Connecticut, North Dakota, and New York. Several states have similar laws that protect students in colleges and universities from having to grant access to their social media accounts. Eight states have passed the law that prohibits post secondary institutions from demanding social media login information from any prospective or current students and privacy legislation has been introduced or is pending in at least 36 states as of July 2013.<sup>[109]</sup> As of May 2014, legislation has been introduced and is in the process of pending in at least 28 states and has been enacted in Maine and Wisconsin.<sup>[110]</sup> In addition, the National Labor Relations Board has been devoting a lot of their attention to attacking employer policies regarding social media that can discipline employees who seek to speak and post freely on social media sites.<sup>[111]</sup>

# 16. Social Media Mining

From wikipedia: [https://en.wikipedia.org/wiki/Social\\_media\\_mining](https://en.wikipedia.org/wiki/Social_media_mining)

**Social media mining** is the process of representing, analyzing, and extracting actionable patterns and trends from raw [social media data](#).<sup>[1]</sup> The term “mining” is an analogy to the resource extraction process of [mining](#) for rare minerals. Resource extraction mining requires mining companies to sift through vast quantities of raw ore to find the precious minerals; likewise, social media “mining” requires human data analysts and automated software programs to sift through massive amounts of raw social media data (e.g., on social media usage, online behaviours, sharing of content, connections between individuals, online buying behaviour, etc.) in order to discern patterns and trends. These patterns and trends are of interest to companies, governments and not-for-profit organizations, as these organizations can use these patterns and trends to design their strategies or introduce new programs (or, for companies, new products, processes and services).

Social media mining uses a range of basic concepts from [computer science](#), [data mining](#), [machine learning](#) and [statistics](#). Social media miners develop [algorithms](#) suitable for investigating massive files of social media data. Social media mining is based on theories and methodologies from [social network analysis](#), [network science](#), [sociology](#), [ethnography](#), optimization and mathematics. It encompasses the tools to formally represent, measure, model, and mine meaningful patterns from large-scale social media data.<sup>[2]</sup> In the 2010s, major corporations, as well as governments and not-for-profit organizations engage in social media mining to find out more about key populations of interest, which, depending on the organization carrying out the “mining”, may be customers, clients, or citizens.

## Background

As defined by Kaplan and Haenlein,<sup>[3]</sup> social media is the “group of internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content.” There are many categories of social media including, but not limited to, social networking (Facebook or LinkedIn), microblogging (Twitter), photo sharing (Flickr, Photobucket, or Picasa), news aggregation (Google reader, StumbleUpon, or Feedburner), video sharing (YouTube, MetaCafe), livecasting (Ustream or Twitch.tv), virtual worlds (Kaneva), social gaming (World of Warcraft), social search (Google, Bing, or Ask.com), and instant messaging (Google Talk, Skype, or Yahoo! messenger).

The first social media website was introduced by [GeoCities](#) in 1994. It enabled users to create their own homepages without having a sophisticated knowledge of [HTML](#) coding. The first social networking site, [SixDegree.com](#), was introduced in 1997. Since then, many other social media sites have been introduced, each providing service to millions of people. These individuals form a virtual world in which individuals (social atoms), entities (content, sites, etc.) and interactions

(between individuals, between entities, between individuals and entities) coexist. Social norms and human behavior govern this virtual world. By understanding these social norms and models of human behavior and combining them with the observations and measurements of this virtual world, one can systematically analyze and mine social media. Social media mining is the process of representing, analyzing, and extracting meaningful patterns from data in social media, resulting from social interactions. It is an interdisciplinary field encompassing techniques from computer science, data mining, machine learning, social network analysis, network science, sociology, ethnography, statistics, optimization, and mathematics. Social media mining faces grand challenges such as the big data paradox, obtaining sufficient samples, the noise removal fallacy, and evaluation dilemma. Social media mining represents the virtual world of social media in a computable way, measures it, and designs models that can help us understand its interactions. In addition, social media mining provides necessary tools to mine this world for interesting patterns, analyze information diffusion, study influence and homophily, provide effective recommendations, and analyze novel social behavior in social media.

# 17. Social Media in Corporations

From wikipedia: [https://en.wikipedia.org/wiki/Corporate\\_social\\_media](https://en.wikipedia.org/wiki/Corporate_social_media)

**Corporate social media** is the use of [social media websites](#) and [social media marketing](#) techniques by and within [corporations](#),<sup>[1]</sup> ranging from [small businesses](#) and tiny [entrepreneurial startups](#) to mid-size businesses to huge multinational firms. In the 2010s, an increasing number of corporations, across most industries, have adopted the use of social media either within in the workplace, for employees, as part of an [Intranet](#) or using the publicly-available [Internet](#). As a result, corporate use of [social networking](#) and [micro blogging](#) sites such as [Facebook](#), [Twitter](#), [Pinterest](#), and [LinkedIn](#), has substantially increased. According to an article by the [Harvard Business Review](#), “Fifty-eight percent of companies are currently engaged in social networks like Facebook, microblogs like Twitter, and sharing multimedia on platforms such as [YouTube](#).” The Harvard Business Review cites an additional 21% of companies as being in the process of implementing a formal social media initiative.<sup>[2]</sup> The 2014 HBR report indicates 79% of companies have or will have social media initiatives in place. This percentage is an increase over a similar 2010 report that indicated that two-thirds of companies had or would have social media initiatives in place.<sup>[3]</sup>

## Policies

The widespread and growing use of social media by corporations is resulting in the development and implementation of formal written policies. Corporate social media use has grown so rapidly that certain regulated industries are now required to maintain formal written social media policies. For example, the [Federal Financial Institutions Examination Council](#), a consortium of bank and credit union regulators, implemented in December 2013, formal social media guidance for its banks and credit unions. In the eyes of regulators, risks associated with social media use are of a level that requires formal attention. At a minimum, regulators require that organizations “listen” to what is being said about them on social media platforms in an effort to identify legal, compliance, and reputational concerns.<sup>[4]</sup>

Corporations can also find themselves at risk when it comes to their employees’ use of social media as well. Social media environments have created the need for distinct and often strict reputation-management practices. Some corporations have resorted to monitoring the social media accounts of its employees in order to spot posts and comments that are related to workplace issues or the employer, potentially harmful to business or even leak private corporate information.<sup>[5]</sup>

Many corporations have used social media during the hiring process as well. Survey data shows that within a one-year period 15 percent of finance and accounting professionals found new jobs through social media.<sup>[6]</sup> Social media can be both helpful and detrimental to those searching for employment. Hiring managers sometimes search social media to look for reasons not to hire a job



applicant. According to a 2013 survey from CareerBuilder.com, 43 percent of employers use social networking sites to research potential hires. Another 45 percent are researching the “fit” of a job candidate with their company by conducting a search via Google or another search engine. 51 percent of employers who research candidates on social media say they’ve found postings which have caused them to not hire a candidate.<sup>[7]</sup> Job applicants who have racist or homophobic jokes, inappropriate photos, offensive content, or photos depicting [drunkenness](#) or other potentially undesirable behaviours may be screened out of hiring processes. Some observers have stated that employer viewing of job candidates’ social media profiles may raise [privacy](#) concerns.

## Benefits and risks

Despite the identified risks associated with social media, corporations are recognizing the benefits associated with adopting a corporate social media strategy. Benefits include lower cost and more effective marketing and advertising initiatives (as compared with traditional marketing methods such as [billboard](#) ads and [TV commercials](#)), improved internal and external corporate communications, and enhanced overall brand awareness. As a result, corporations are investing at an increasing rate in social business software and services such as [Jive Engage](#), [Yammer](#) or [eXo Platform](#). The belief is that the benefits outweigh the potential risks of bad press, customer complaints, and brand bashing.

Conversely, businesses can find themselves in a bad situation when they use social media poorly. An example of poor social media execution came in November 2013 when JP Morgan decided to have a question and answer session via Twitter. During that time, 2 out of 3 tweets received were negative due to prior scrutiny they had faced. In this case, using social media and interacting with the public did not help to promote them in a positive way. Another example came on September 11, 2013, when AT&T posted a picture on Twitter of a cell phone capturing a picture of the Twin Towers memorial lights with the caption “Never forget.” The tweet was met with great backlash from consumers for using a tragedy as a marketing opportunity, with many customers threatening to leave AT&T. After seeing the backlash it was receiving, AT&T removed the post and apologized within about an hour of its posting.<sup>[8]</sup>

# 18. Case Study: Terrorist Usage of Social Media

From wikipedia: [https://en.wikipedia.org/wiki/Terrorism\\_and\\_social\\_media](https://en.wikipedia.org/wiki/Terrorism_and_social_media)

Due to the convenience, affordability, and broad reach of [social media](#) platforms such as [YouTube](#), [Facebook](#) and [Twitter](#), [terrorist](#) groups have increasingly used social media to further their goals and spread their message. Attempts have been made by various governments and agencies to thwart the use of social media by terrorist organizations.

## Use of social media

In a study by Gabriel Weimann from the [University of Haifa](#), Weimann found that nearly 90% of organized terrorism on the internet takes place via social media.<sup>[4]</sup> According to Weimann, terror groups use social media platforms like Twitter, Facebook, YouTube, and internet forums to spread their messages, recruit members and gather intelligence.<sup>[4]</sup>

Terror groups take to social media because social media tools are cheap and accessible, facilitate quick, broad dissemination of messages, and allow for unfettered communication with an audience without the filter or “selectivity” of mainstream news outlets.<sup>[5]</sup> Also, social media platforms allow terror groups to engage with their networks. Whereas previously terror groups would release messages via intermediaries, social media platforms allow terror groups to release messages directly to their intended audience and converse with their audience in real time:<sup>[6]</sup>

HSMPress is using Twitter the way social media experts have always advised- not just broadcasting, but engaging in conversation. Spend some time following the account, and you realize that you're dealing with a real human being with real ideas—albeit boastful, hypocritical, violent ideas.<sup>[6]</sup>

## Terror groups using social media

[Al-Qaeda](#) has been noted as being one of the terror groups that uses social media the most extensively.<sup>[7]</sup> Brian Jenkins, senior advisor for the [Rand Corporation](#), commented on Al-Qaeda's dominant presence on the web:

While almost all terrorist organizations have websites, al Qaeda is the first to fully exploit the internet. This reflects al Qaeda's unique characteristics. It regards itself as a global

movement and therefore depends on a global communications network to reach its perceived constituents. It sees its mission as not simply creating terror among its foes but awakening the Muslim community. Its leaders view communications as 90 percent of the struggle. Despite the risks imposed by intense manhunts, its leaders communicate regularly with video and audio messages, which are posted on its websites and disseminated on the Internet. The number of websites devoted to the al Qaeda-inspired movement has grown from a handful to reportedly thousands, although many of these are ephemeral.<sup>[7]</sup>

Known terrorist group the [Islamic State of Iraq and the Levant](#), also translated to [ISIS](#), uses the widespread of news over social media to their advantage when releasing threatening videos of beheadings. As of November 16, 2014, following the beheading of former [U.S. Army Ranger Peter Kassig](#), there have now been five recorded executions of Westerners taken captive in Syria.<sup>[8]</sup> [James Foley](#), [David Cawthorne Haines](#), [Alan Henning](#), and [Steven Sotloff](#) are also among the men kidnapped and executed by ISIS. The videos of the brutal beheadings are both posted online by ISIS, where they can be viewed by anyone using their own discretion, and sent to government officials as threats. Posting the executions online allows the terrorist groups the power to manipulate and cause havoc among the population viewing them,<sup>[9]</sup> and the videos have the ability to instill fear within the Western world. The videos are typically high production quality and generally show the entirety of the gruesome act, with the hostage speaking a few words before they are killed on camera.

In the case of U.S. aid worker Peter Kassig, his video did not show the actual beheading act and he did not speak any final words before the execution.<sup>[8]</sup> His silence and the fact that the actual execution was not included in the video raised question about his video was different than the rest.<sup>[10]</sup> In response to Kassig's beheading, his family expressed their wish that news media avoid doing what the group wants by refraining from publishing or distributing the video.<sup>[10]</sup> By refusing to circulate the video of the beheading, it therefore loses the ability to manipulate Americans or further the cause of the terrorist group.<sup>[10]</sup>

The [Taliban](#) has been active on Twitter since May 2011, and has more than 7,000 followers. Tweeting under the handle @alemarahweb, the Taliban tweets frequently, on some days nearly hourly. This account is currently suspended.<sup>[11]</sup>

In December 2011, it was discovered that the [Somalia](#)-based terror cell [Al-Shabab](#) was using a Twitter account under the name @HSMPress.<sup>[12]</sup> Since opening on December 7, 2011, the account has amassed tens of thousands of followers and tweets frequently.<sup>[12]</sup>

Shortly after a series of coordinated [Christmas](#) bombings in [Kono](#), [Nigeria](#), in 2011, the Nigerian-based terror group Boko Haram released a video statement defending their actions to YouTube.<sup>[13]</sup>

#### **AQAP and Islamic State (ISIS/ISIL/DAESH)**

[Islamic State](#) has emerged as one of the most potent users of social media. In many respects, Islamic State learned their propaganda craft from al Qaeda on the Arabian Peninsula (AQAP). However, IS quickly eclipsed its mentor, deploying a whole range of narratives, images and political proselytizing through various social media platforms.<sup>[14]</sup> A study by Berger and Morgan estimated that at least 46,000 Twitter accounts were used by ISIS supporters between September and December 2014.<sup>[15]</sup> However, as ISIS supporters regularly get suspended and then easily create

new, duplicate accounts,<sup>[14]</sup> counting ISIS Twitter accounts over a few months can overestimate the number of unique people represented by 20-30%.<sup>[16]</sup>

However, as the November 2015 attacks in Paris demonstrate, IS also uses old-fashioned methods of communication and propaganda. Lewis notes that the attacks in Paris represent the sort of 'propaganda in action' which was a method developed by the 19th century [anarchists](#) in Europe. The November 2015 IS attacks were perpetrated without prior warning, largely because the operatives met face-to-face and used other non-digital means of communication.

## PART V

# CHAPTER 6: THE IMPORTANCE OF DATA

Data are everywhere. With so many people online, leveraging dozens of different systems and tools, all these interactions create data. Each time you login to a social networking service, it's logged somewhere, and those logs are then aggregated and analyzed by data scientists to drive future designs on that specific system. With the cost of storage continuing to drop, it makes sense for many organizations to capture and archive user data; even if they don't have immediate plans to leverage that data. This chapter provides an introduction to data and analytics as it relates to information sciences and technology.

### *Learning Objectives*

After reading this chapter, you will be able to:

- Describe big data, and identify trends related to big data.
- Describe analytics, and how it is being applied in different industries.

# 19. (Big) Data

From Wikipedia: <https://en.wikipedia.org/wiki/Data>

**Data** is a set of values of subjects with respect to [qualitative](#) or [quantitative variables](#).

Data and [information](#) or [knowledge](#) are often used interchangeably; however data becomes [information](#) when it is viewed in context or in post-analysis.<sup>[1]</sup> While the concept of data is commonly associated with [scientific research](#), data is collected by a huge range of organizations and institutions, including businesses (e.g., sales data, revenue, profits, [stock price](#)), governments (e.g., [crime rates](#), [unemployment rates](#), [literacy](#) rates) and non-governmental organizations (e.g., censuses of the number of [homeless people](#) by non-profit organizations).

Data is [measured](#), [collected and reported](#), and [analyzed](#), whereupon it can be [visualized](#) using graphs, images or other analysis tools. Data as a general [concept](#) refers to the fact that some existing [information](#) or [knowledge](#) is [represented](#) or [coded](#) in some form suitable for better usage or [processing](#). [Raw data](#) (“unprocessed data”) is a collection of [numbers](#) or [characters](#) before it has been “cleaned” and corrected by researchers. Raw data needs to be corrected to remove [outliers](#) or obvious instrument or data entry errors (e.g., a thermometer reading from an outdoor Arctic location recording a tropical temperature). Data processing commonly occurs by stages, and the “processed data” from one stage may be considered the “raw data” of the next stage. [Field data](#) is raw data that is collected in an uncontrolled “[in situ](#)” environment. [Experimental data](#) is data that is generated within the context of a scientific investigation by observation and recording. Data has been described as the new [oil](#) of the [digital economy](#).<sup>[2][3]</sup>

From Wikipedia: [https://en.wikipedia.org/wiki/Big\\_data](https://en.wikipedia.org/wiki/Big_data)

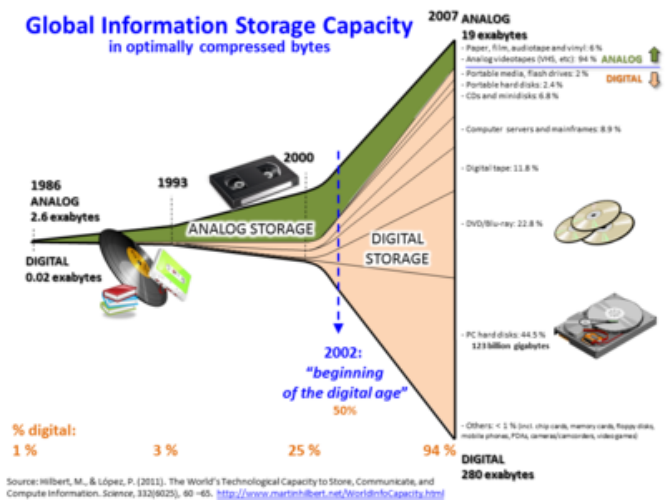
**Big data** is a term for [data sets](#) that are so large or complex that traditional [data processing](#) applications are inadequate to deal with them. Challenges include [analysis](#), capture, [data curation](#), search, [sharing](#), [storage](#), [transfer](#), [visualization](#), [querying](#), updating and [information privacy](#). The term “big data” often refers simply to the use of [predictive analytics](#), [user behavior analytics](#), or certain other advanced data analytics methods that extract value from data, and seldom to a particular size of data set.<sup>[2]</sup> “There is little doubt that the quantities of data now available are indeed large, but that’s not the most relevant characteristic of this new data ecosystem.”<sup>[3]</sup>

Analysis of data sets can find new correlations to “spot business trends, prevent diseases, combat crime and so on”.<sup>[4]</sup> Scientists, business executives, practitioners of medicine, advertising and [governments](#) alike regularly meet difficulties with large data-sets in areas including [Internet search](#), finance, [urban informatics](#), and [business informatics](#). Scientists encounter limitations in [e-Science](#) work, including [meteorology](#), [genomics](#),<sup>[5]</sup> [connectomics](#), complex physics simulations, biology and environmental research.<sup>[6]</sup>

Data sets grow rapidly – in part because they are increasingly gathered by cheap and numerous information-sensing [mobile devices](#), aerial ([remote sensing](#)), software logs, [cameras](#), microphones, [radio-frequency identification](#) (RFID) readers and [wireless sensor networks](#).<sup>[7][8]</sup> The world’s technological per-capita capacity to store information has roughly doubled every 40

months since the 1980s;<sup>[9]</sup> as of 2012, every day 2.5 exabytes ( $2.5 \times 10^{18}$ ) of data is generated.<sup>[10]</sup> One question for large enterprises is determining who should own big-data initiatives that affect the entire organization.<sup>[11]</sup>

Relational database management systems and desktop statistics- and visualization- packages often have difficulty handling big data. The work may require “massively parallel software running on tens, hundreds, or even thousands of servers”.<sup>[12]</sup> What counts as “big data” varies depending on the capabilities of the users and their tools, and expanding capabilities make big data a moving target. “For some organizations, facing hundreds of gigabytes of data for the first time may trigger a need to reconsider data management options. For others, it may take tens or hundreds of terabytes before data size becomes a significant consideration.”<sup>[13]</sup>



## Applications



Bus wrapped with SAP Big data parked outside IDF13.

Big data has increased the demand of information management specialists in that Software AG, Oracle Corporation, IBM, Microsoft, SAP, EMC, HP and Dell have spent more than \$15 billion on software firms specializing in data management and analytics. In 2010, this industry was worth more than \$100 billion and was growing at almost 10 percent a year: about twice as fast as the software business as a whole.<sup>[4]</sup>

Developed economies increasingly use data-intensive technologies. There are 4.6 billion mobile-phone subscriptions worldwide, and between 1 billion and 2 billion people accessing the internet.<sup>[4]</sup> Between 1990 and 2005, more than 1 billion people worldwide entered the middle class, which means more people become more literate, which in turn leads to information growth. The world's effective capacity to exchange information through telecommunication networks was



281 [petabytes](#) in 1986, 471 [petabytes](#) in 1993, 2.2 exabytes in 2000, 65 [exabytes](#) in 2007<sup>[9]</sup> and predictions put the amount of internet traffic at 667 exabytes annually by 2014.<sup>[4]</sup> According to one estimate, one third of the globally stored information is in the form of alphanumeric text and still image data,<sup>[54]</sup> which is the format most useful for most big data applications. This also shows the potential of yet unused data (i.e. in the form of video and audio content).

While many vendors offer off-the-shelf solutions for Big Data, experts recommend the development of in-house solutions custom-tailored to solve the company's problem at hand if the company has sufficient technical capabilities.<sup>[55]</sup>

## Government

The use and adoption of big data within governmental processes is beneficial and allows efficiencies in terms of cost, productivity, and innovation,<sup>[56]</sup> but does not come without its flaws. Data analysis often requires multiple parts of government (central and local) to work in collaboration and create new and innovative processes to deliver the desired outcome. Below are the thought<sup>[by whom?]</sup> leading examples within the governmental big data space.

### *United States of America*

- In 2012, the [Obama administration](#) announced the Big Data Research and Development Initiative, to explore how big data could be used to address important problems faced by the government.<sup>[57]</sup> The initiative is composed of 84 different big data programs spread across six departments.<sup>[58]</sup>
- Big data analysis played a large role in [Barack Obama's successful 2012 re-election campaign](#).<sup>[59]</sup>
- The [United States Federal Government](#) owns six of the ten most powerful [supercomputers](#) in the world.<sup>[60]</sup>
- The [Utah Data Center](#) has been constructed by the United States [National Security Agency](#). When finished, the facility will be able to handle a large amount of information collected by the NSA over the Internet. The exact amount of storage space is unknown, but more recent sources claim it will be on the order of a few [exabytes](#).<sup>[61][62][63]</sup>

## Manufacturing

Based on TCS 2013 Global Trend Study, improvements in supply planning and product quality provide the greatest benefit of big data for manufacturing.<sup>[73]</sup> Big data provides an infrastructure for transparency in manufacturing industry, which is the ability to unravel uncertainties such as

inconsistent component performance and availability. Predictive manufacturing as an applicable approach toward near-zero downtime and transparency requires vast amount of data and advanced prediction tools for a systematic process of data into useful information.<sup>[74]</sup> A conceptual framework of predictive manufacturing begins with data acquisition where different type of sensory data is available to acquire such as acoustics, vibration, pressure, current, voltage and controller data. Vast amount of sensory data in addition to historical data construct the big data in manufacturing. The generated big data acts as the input into predictive tools and preventive strategies such as [Prognostics](#) and Health Management (PHM).<sup>[75][76]</sup>

### *Cyber-physical models*

Current PHM implementations mostly use data during the actual usage while analytical algorithms can perform more accurately when more information throughout the machine's lifecycle, such as system configuration, physical knowledge and working principles, are included. There is a need to systematically integrate, manage and analyze machinery or process data during different stages of machine life cycle to handle data/information more efficiently and further achieve better transparency of machine health condition for manufacturing industry.

With such motivation a cyber-physical (coupled) model scheme has been developed. The coupled model is a digital twin of the real machine that operates in the cloud platform and simulates the health condition with an integrated knowledge from both data driven analytical algorithms as well as other available physical knowledge. It can also be described as a 5S systematic approach consisting of sensing, storage, synchronization, synthesis and service. The coupled model first constructs a digital image from the early design stage. System information and physical knowledge are logged during product design, based on which a simulation model is built as a reference for future analysis. Initial parameters may be statistically generalized and they can be tuned using data from testing or the manufacturing process using parameter estimation. After that step, the simulation model can be considered a mirrored image of the real machine—able to continuously record and track machine condition during the later utilization stage. Finally, with the increased connectivity offered by cloud computing technology, the coupled model also provides better accessibility of machine condition for factory managers in cases where physical access to actual equipment or machine data is limited.<sup>[34]</sup>

## Healthcare

Big data analytics has helped healthcare improve by providing personalized medicine and prescriptive analytics, clinical risk intervention and predictive analytics, waste and care variability reduction, automated external and internal reporting of patient data, standardized medical terms and patient registries and fragmented point solutions.<sup>[77]</sup> The level of data generated within healthcare systems is not trivial. With the added adoption of mHealth, eHealth and wearable

technologies the volume of data will continue to increase. There is now an even greater need for such environments to pay greater attention to data and information quality.<sup>[78]</sup> “Big data very often means ‘dirty data’ and the fraction of data inaccuracies increases with data volume growth.” Human inspection at the big data scale is impossible and there is a desperate need in health service for intelligent tools for accuracy and believability control and handling of information missed.<sup>[79]</sup>

## Education

A [McKinsey Global Institute](#) study found a shortage of 1.5 million highly trained data professionals and managers<sup>[46]</sup> and a number of universities<sup>[80]</sup> including [University of Tennessee](#) and [UC Berkeley](#), have created masters programs to meet this demand. Private bootcamps have also developed programs to meet that demand, including free programs like [The Data Incubator](#) or paid programs like [General Assembly](#).<sup>[81]</sup>

## Media

To understand how the media utilizes Big Data, it is first necessary to provide some context into the mechanism used for media process. It has been suggested by Nick Couldry and Joseph Turow that [practitioners](#) in Media and Advertising approach big data as many actionable points of information about millions of individuals. The industry appears to be moving away from the traditional approach of using specific media environments such as newspapers, magazines, or television shows and instead tap into consumers with technologies that reach targeted people at optimal times in optimal locations. The ultimate aim is to serve, or convey, a message or content that is (statistically speaking) in line with the consumers mindset. For example, publishing environments are increasingly tailoring messages (advertisements) and content (articles) to appeal to consumers that have been exclusively gleaned through various [data-mining](#) activities.<sup>[82]</sup>

- Targeting of consumers (for advertising by marketers)
- Data-capture

## Technology

- [eBay.com](#) uses two data warehouses at 7.5 [petabytes](#) and 40PB as well as a 40PB [Hadoop](#) cluster for search, consumer recommendations, and merchandising.<sup>[83]</sup>
- [Amazon.com](#) handles millions of back-end operations every day, as well as queries from more than half a million third-party sellers. The core technology that keeps Amazon running is

Linux-based and as of 2005 they had the world's three largest Linux databases, with capacities of 7.8 TB, 18.5 TB, and 24.7 TB. <sup>[84]</sup>

- Facebook handles 50 billion photos from its user base. <sup>[85]</sup>
- As of August 2012, [Google](#) was handling roughly 100 billion searches per month. <sup>[86]</sup>
- [Oracle NoSQL Database](#) has been tested to past the 1M ops/sec mark with 8 shards and proceeded to hit 1.2M ops/sec with 10 shards. <sup>[87]</sup>

## *Retail*

- [Walmart](#) handles more than 1 million customer transactions every hour, which are imported into databases estimated to contain more than 2.5 petabytes (2560 terabytes) of data—the equivalent of 167 times the information contained in all the books in the US [Library of Congress](#). <sup>[4]</sup>

## *Retail banking*

- FICO Card Detection System protects accounts world-wide. <sup>[89]</sup>
- The volume of business data worldwide, across all companies, doubles every 1.2 years, according to estimates. <sup>[90][91]</sup>

## *Real estate*

- [Windermere Real Estate](#) uses anonymous GPS signals from nearly 100 million drivers to help new home buyers determine their typical drive times to and from work throughout various times of the day. <sup>[92]</sup>

## Science

The [Large Hadron Collider](#) experiments represent about 150 million sensors delivering data 40 million times per second. There are nearly 600 million collisions per second. After filtering and refraining from recording more than 99.99995% <sup>[93]</sup> of these streams, there are 100 collisions of interest per second. <sup>[94][95][96]</sup>

- As a result, only working with less than 0.001% of the sensor stream data, the data flow from all four LHC experiments represents 25 petabytes annual rate before replication (as of 2012). This becomes nearly 200 petabytes after replication.

- If all sensor data were recorded in LHC, the data flow would be extremely hard to work with. The data flow would exceed 150 million petabytes annual rate, or nearly 500 [exabytes](#) per day, before replication. To put the number in perspective, this is equivalent to 500 [quintillion](#) ( $5 \times 10^{20}$ ) bytes per day, almost 200 times more than all the other sources combined in the world.

The [Square Kilometre Array](#) is a radio telescope built of thousands of antennas. It is expected to be operational by 2024. Collectively, these antennas are expected to gather 14 exabytes and store one petabyte per day.<sup>[97][98]</sup> It is considered one of the most ambitious scientific projects ever undertaken.<sup>[99]</sup>

## Sports

Big data can be used to improve training and understanding competitors, using [sport sensors](#). Besides, it is possible to predict winners in a match using big data analytics.<sup>[105]</sup> Future performance of players could be predicted as well. Thus, players' value and salary is determined by data collected throughout the season.<sup>[106]</sup>

The movie [MoneyBall](#) demonstrates how big data could be used to scout players and also identify undervalued players.<sup>[107]</sup>

In Formula One races, race cars with hundreds of sensors generate terabytes of data. These sensors collect data points from tire pressure to fuel burn efficiency. Then, this data is transferred to team headquarters in United Kingdom through fiber optic cables that could carry data at the speed of light.<sup>[108]</sup> Based on the data, engineers and data analysts decide whether adjustments should be made in order to win a race. Besides, using big data, race teams try to predict the time they will finish the race beforehand, based on simulations using data collected over the season.<sup>[109]</sup>

## 20. Introduction to Analytics

From wikipedia: <https://en.wikipedia.org/wiki/Analytics>

**Analytics** is the discovery, interpretation, and communication of meaningful patterns in data. Especially valuable in areas rich with recorded information, analytics relies on the simultaneous application of [statistics](#), [computer programming](#) and [operations research](#) to quantify performance. Analytics often favors [data visualization](#) to communicate insight.

Organizations may apply analytics to business data to describe, predict, and improve business performance. Specifically, areas within analytics include [predictive analytics](#), [prescriptive analytics](#), [enterprise decision management](#), retail analytics, store assortment and [stock-keeping unit](#) optimization, marketing optimization and [marketing mix modeling](#), [web analytics](#), sales force sizing and optimization, price and promotion modeling, predictive science, credit [risk analysis](#), and [fraud analytics](#). Since analytics can require extensive computation (see [big data](#)), the algorithms and software used for analytics harness the most current methods in computer science, statistics, and mathematics.<sup>[1]</sup>

### Analytics vs. analysis

Analytics is [multidisciplinary](#). There is extensive use of mathematics and statistics, the use of descriptive techniques and predictive models to gain valuable knowledge from data—data analysis. The insights from data are used to recommend action or to guide decision making rooted in business context. Thus, analytics is not so much concerned with individual analyses or analysis steps, but with the entire [methodology](#). There is a pronounced tendency to use the term *analytics* in business settings e.g. [text analytics](#) vs. the more generic [text mining](#) to emphasize this broader perspective.<sup>[citation needed]</sup> There is an increasing use of the term *advanced analytics*,<sup>[citation needed]</sup> typically used to describe the technical aspects of analytics, especially in the emerging fields such as the use of [machine learning](#) techniques like [neural networks](#) to do [predictive modeling](#).

### Examples

#### Marketing optimization

Marketing has evolved from a creative process into a highly data-driven process. Marketing organizations use analytics to determine the outcomes of campaigns or efforts and to guide decisions for investment and consumer targeting. Demographic studies, customer segmentation,

conjoint analysis and other techniques allow marketers to use large amounts of consumer purchase, survey and panel data to understand and communicate marketing strategy.

[Web analytics](#) allows marketers to collect session-level information about interactions on a website using an operation called [sessionization](#). [Google Analytics](#) is an example of a popular free analytics tool that marketers use for this purpose. Those interactions provide web analytics information systems with the information necessary to track the referrer, search keywords, identify IP address, and track activities of the visitor. With this information, a marketer can improve marketing campaigns, website creative content, and information architecture.

Analysis techniques frequently used in marketing include marketing mix modeling, pricing and promotion analyses, sales force optimization and customer analytics e.g.: segmentation. Web analytics and optimization of web sites and online campaigns now frequently work hand in hand with the more traditional marketing analysis techniques. A focus on digital media has slightly changed the vocabulary so that *marketing mix modeling* is commonly referred to as *attribution modeling* in the digital or [marketing mix modeling](#) context.

These tools and techniques support both strategic marketing decisions (such as how much overall to spend on marketing, how to allocate budgets across a portfolio of brands and the marketing mix) and more tactical campaign support, in terms of targeting the best potential customer with the optimal message in the most cost effective medium at the ideal time.

## Portfolio analytics

A common application of business analytics is [portfolio analysis](#). In this, a [bank](#) or lending agency has a collection of accounts of varying [value](#) and [risk](#). The accounts may differ by the social status (wealthy, middle-class, poor, etc.) of the holder, the geographical location, its net value, and many other factors. The lender must balance the return on the [loan](#) with the risk of default for each loan. The question is then how to evaluate the portfolio as a whole.

The least risk loan may be to the very wealthy, but there are a very limited number of wealthy people. On the other hand, there are many poor that can be lent to, but at greater risk. Some balance must be struck that maximizes return and minimizes risk. The analytics solution may combine [time series](#) analysis with many other issues in order to make decisions on when to lend money to these different borrower segments, or decisions on the interest rate charged to members of a portfolio segment to cover any losses among members in that segment.

## Risk analytics

Predictive models in the banking industry are developed to bring certainty across the risk scores for individual customers. Credit scores are built to predict individual's delinquency behavior and widely used to evaluate the credit worthiness of each applicant. Furthermore, risk analyses are carried out in the scientific world and the insurance industry. It is also extensively used in financial



institutions like Online Payment Gateway companies to analyse if a transaction was genuine or fraud. For this purpose they use the transaction history of the customer. This is more commonly used in Credit Card purchase, when there is a sudden spike in the customer transaction volume the customer gets a call of confirmation if the transaction was initiated by him/her. This helps in reducing loss due to such circumstances.

## Digital analytics

Digital analytics is a set of business and technical activities that define, create, collect, verify or transform digital data into reporting, research, analyses, recommendations, optimizations, predictions, and automations.<sup>[2]</sup> This also includes the SEO (Search Engine Optimization) where the keyword search is tracked and that data is used for marketing purposes. Even banner ads and clicks come under digital analytics. All marketing firms rely on digital analytics for their digital marketing assignments, where MROI (Marketing Return on Investment) is important.

## Security analytics

Security analytics refers to information technology (IT) solutions that gather and analyze security events to bring situational awareness and enable IT staff to understand and analyze events that pose the greatest risk.<sup>[3]</sup> Solutions in this area include [security information and event management](#) solutions and user behavior analytics solutions.

## Software analytics

Main article: [Software analytics](#)

Software analytics is the process of collecting information about the way a piece of [software](#) is used and produced.

## Challenges

In the industry of commercial analytics software, an emphasis has emerged on solving the challenges of analyzing massive, complex data sets, often when such data is in a constant state of change. Such data sets are commonly referred to as [big data](#). Whereas once the problems posed

by big data were only found in the scientific community, today big data is a problem for many businesses that operate transactional systems online and, as a result, amass large volumes of data quickly.<sup>[4]</sup>

The analysis of [unstructured data](#) types is another challenge getting attention in the industry. Unstructured data differs from [structured data](#) in that its format varies widely and cannot be stored in traditional relational databases without significant effort at data transformation.<sup>[5]</sup> Sources of unstructured data, such as email, the contents of word processor documents, PDFs, geospatial data, etc., are rapidly becoming a relevant source of [business intelligence](#) for businesses, governments and universities.<sup>[6]</sup> For example, in Britain the discovery that one company was illegally selling fraudulent doctor's notes in order to assist people in defrauding employers and insurance companies,<sup>[7]</sup> is an opportunity for insurance firms to increase the vigilance of their unstructured data analysis. The McKinsey Global Institute estimates that big data analysis could save the American health care system \$300 billion per year and the European public sector €250 billion.<sup>[8]</sup>

These challenges are the current inspiration for much of the innovation in modern analytics information systems, giving birth to relatively new machine analysis concepts such as [complex event processing](#), full text search and analysis, and even new ideas in presentation.<sup>[9]</sup> One such innovation is the introduction of grid-like architecture in machine analysis, allowing increases in the speed of massively parallel processing by distributing the workload to many computers all with equal access to the complete data set.<sup>[10]</sup>

Analytics is increasingly used in [education](#), particularly at the district and government office levels. However, the complexity of student performance measures presents challenges when educators try to understand and use analytics to discern patterns in student performance, predict graduation likelihood, improve chances of student success, etc. For example, in a study involving districts known for strong data use, 48% of teachers had difficulty posing questions prompted by data, 36% did not comprehend given data, and 52% incorrectly interpreted data.<sup>[11]</sup> To combat this, some analytics tools for educators adhere to an [over-the-counter data](#) format (embedding labels, supplemental documentation, and a help system, and making key package/display and content decisions) to improve educators' understanding and use of the analytics being displayed.<sup>[12]</sup>

One more emerging challenge is dynamic regulatory needs. For example, in the banking industry, Basel III and future capital adequacy needs are likely to make even smaller banks adopt internal risk models. In such cases, cloud computing and open source [R \(programming language\)](#) can help smaller banks to adopt risk analytics and support branch level monitoring by applying predictive analytics.<sup>[citation needed]</sup>

## 2I. Data Visualization

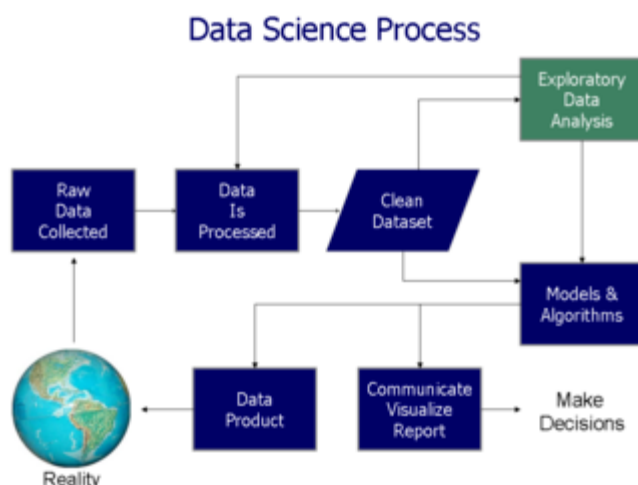
From wikipedia: [https://en.wikipedia.org/wiki/Data\\_visualization](https://en.wikipedia.org/wiki/Data_visualization)

**Data visualization** or **data visualisation** is viewed by many disciplines as a modern equivalent of [visual communication](#). It involves the creation and study of the [visual](#) representation of [data](#), meaning “information that has been abstracted in some schematic form, including attributes or variables for the units of [information](#)“.<sup>[1]</sup>

A primary goal of data visualization is to communicate information clearly and efficiently via [statistical graphics](#), [plots](#) and [information graphics](#). Numerical data may be encoded using dots, lines, or bars, to visually communicate a quantitative message.<sup>[2]</sup> Effective visualization helps users analyze and reason about data and evidence. It makes complex data more accessible, understandable and usable. Users may have particular analytical tasks, such as making comparisons or understanding [causality](#), and the design principle of the graphic (i.e., showing comparisons or showing causality) follows the task. Tables are generally used where users will look up a specific measurement, while charts of various types are used to show patterns or relationships in the data for one or more variables.

Data visualization is both an art and a science. It is viewed as a branch of [descriptive statistics](#) by some, but also as a [grounded theory](#) development tool by others. The rate at which data is generated has increased. Data created by internet activity and an expanding number of sensors in the environment, such as satellites, are referred to as “[Big Data](#)”. Processing, analyzing and communicating this data present a variety of ethical and analytical challenges for data visualization. The field of [data science](#) and practitioners called [data scientists](#) have emerged to help address this challenge.<sup>[3]</sup>

### Overview



Data visualization is one of the steps in analyzing data and presenting it to users.

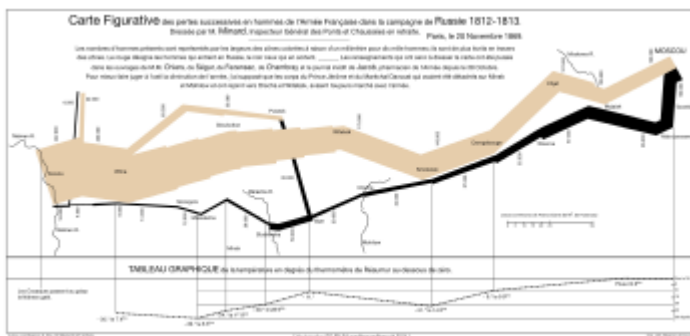
Data visualization refers to the techniques used to communicate data or information by encoding it as visual objects (e.g., points, lines or bars) contained in graphics. The goal is to communicate information clearly and efficiently to users. It is one of the steps in [data analysis](#) or [data science](#). According to Friedman (2008) the “main goal of data visualization is to communicate information clearly and effectively through graphical means. It doesn’t mean that data visualization needs to look boring to be functional or extremely sophisticated to look beautiful. To convey ideas effectively, both aesthetic form and functionality need to go hand in hand, providing insights into a rather sparse and complex data set by communicating its key-aspects in a more intuitive way. Yet designers often fail to achieve a balance between form and function, creating gorgeous data visualizations which fail to serve their main purpose – to communicate information”.<sup>[4]</sup>

Indeed, [Fernanda Viegas](#) and [Martin M. Wattenberg](#) have suggested that an ideal visualization should not only communicate clearly, but stimulate viewer engagement and attention.<sup>[5]</sup>

Not limited to the communication of an information, a well-crafted data visualization is also a way to a better understanding of the data (in a data-driven research perspective),<sup>[6]</sup> as it helps uncover trends, realize insights, explore sources, and tell stories.<sup>[7]</sup>

Data visualization is closely related to [information graphics](#), [information visualization](#), [scientific visualization](#), [exploratory data analysis](#) and [statistical graphics](#). In the new millennium, data visualization has become an active area of research, teaching and development. According to Post et al. (2002), it has united scientific and information visualization.<sup>[8]</sup>

## Characteristics of effective graphical displays



[Charles Joseph Minard](#)'s 1869 diagram of [Napoleon's March](#) – an early example of an information graphic.

The greatest value of a picture is when it forces us to notice what we never expected to see.

[JOHN TUKEY](#)<sup>[9]</sup>

Professor [Edward Tufte](#) explained that users of information displays are executing particular *analytical* tasks such as making comparisons or determining causality. The *design*

principle of the information graphic should support the analytical task, showing the comparison or causality.<sup>[10]</sup>

In his 1983 book *The Visual Display of Quantitative Information*, [Edward Tufte](#) defines ‘graphical displays’ and principles for effective graphical display in the following passage: “Excellence in statistical graphics consists of complex ideas communicated with clarity, precision and efficiency. Graphical displays should:

- show the data
- induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production or something else
- avoid distorting what the data has to say
- present many numbers in a small space
- make large data sets coherent
- encourage the eye to compare different pieces of data
- reveal the data at several levels of detail, from a broad overview to the fine structure
- serve a reasonably clear purpose: description, exploration, tabulation or decoration
- be closely integrated with the statistical and verbal descriptions of a data set.

Graphics *reveal* data. Indeed graphics can be more precise and revealing than conventional statistical computations.”<sup>[11]</sup>

For example, the Minard diagram shows the losses suffered by Napoleon’s army in the 1812–1813 period. Six variables are plotted: the size of the army, its location on a two-dimensional surface (x and y), time, direction of movement, and temperature. The line width illustrates a comparison (size of the army at points in time) while the temperature axis suggests a cause of the change in army size. This multivariate display on a two dimensional surface tells a story that can be grasped immediately while identifying the source data to build credibility. Tufte wrote in 1983 that: “It may well be the best statistical graphic ever drawn.”<sup>[11]</sup>

Not applying these principles may result in [misleading graphs](#), which distort the message or support an erroneous conclusion. According to Tufte, [chartjunk](#) refers to extraneous interior decoration of the graphic that does not enhance the message, or gratuitous three dimensional or perspective effects. Needlessly separating the explanatory key from the image itself, requiring the eye to travel back and forth from the image to the key, is a form of “administrative debris.” The ratio of “data to ink” should be maximized, erasing non-data ink where feasible.<sup>[11]</sup>

The [Congressional Budget Office](#) summarized several best practices for graphical displays in a June 2014 presentation. These included: a) Knowing your audience; b) Designing graphics that can stand alone outside the context of the report; and c) Designing graphics that communicate the key messages in the report.<sup>[12]</sup>

## Visual perception and data visualization

A human can distinguish differences in line length, shape orientation, and color (hue) readily

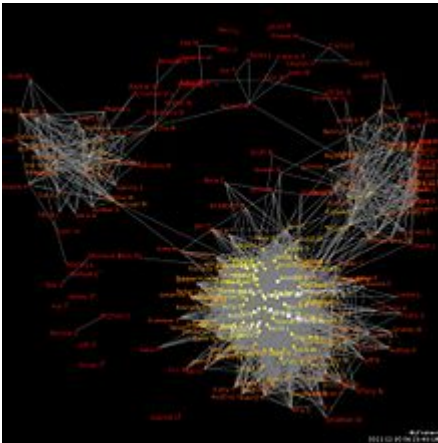
without significant processing effort; these are referred to as “[pre-attentive attributes](#).” For example, it may require significant time and effort (“attentive processing”) to identify the number of times the digit “5” appears in a series of numbers; but if that digit is different in size, orientation, or color, instances of the digit can be noted quickly through pre-attentive processing.<sup>[14]</sup>

Effective graphics take advantage of pre-attentive processing and attributes and the relative strength of these attributes. For example, since humans can more easily process differences in line length than surface area, it may be more effective to use a bar chart (which takes advantage of line length to show comparison) rather than pie charts (which use surface area to show comparison).<sup>[14]</sup>

## Human perception/cognition and data visualization

There is a human side to data visualization. With the “studying [of] human perception and cognition ...” we are better able to understand the target of the data which we display.<sup>[15]</sup> Cognition refers to processes in human beings like perception, attention, learning, memory, thought, concept formation, reading, and problem solving.<sup>[16]</sup> The basis of data visualization evolved because as a picture is worth a thousand words, data displayed graphically allows for an easier comprehension of the information. Proper visualization provides a different approach to show potential connections, relationships, etc. which are not as obvious in non-visualized quantitative data. Visualization becomes a means of data exploration. Human brain neurons involve multiple functions but 2/3 of the brain’s neurons are dedicated to vision.<sup>[17]</sup> With a well-developed sense of sight, analysis of data can be made on data, whether that data is quantitative or qualitative. Effective visualization follows from understanding the processes of human perception and being able to apply this to intuitive visualizations is important. Understanding how humans see and organize the world is critical to effectively communicating data to the reader. This leads to more intuitive designs.

# Data presentation architecture



A data visualization from [social media](#)

**Data presentation architecture (DPA)** is a skill-set that seeks to identify, locate, manipulate, format and present data in such a way as to optimally communicate meaning and proper knowledge.

Historically, the term *data presentation architecture* is attributed to Kelly Latt.<sup>[23]</sup> “Data Presentation Architecture (DPA) is a rarely applied skill set critical for the success and value of [Business Intelligence](#). Data presentation architecture weds the science of numbers, data and statistics in [discovering valuable information](#) from data and making it usable, relevant and actionable with the arts of data visualization, communications, [organizational psychology](#) and [change management](#) in order to provide business intelligence solutions with the data scope, delivery timing, format and visualizations that will most effectively support and drive operational, tactical and strategic behaviour toward understood business (or organizational) goals. DPA is neither an IT nor a business skill set but exists as a separate field of expertise. Often confused with data visualization, data presentation architecture is a much broader skill set that includes determining what data on what schedule and in what exact format is to be presented, not just the best way to present data that has already been chosen (which is data visualization). Data visualization skills are one element of DPA.”

## Objective

DPA has two main objectives:

- To use data to provide knowledge in the most efficient manner possible (minimize noise, complexity, and unnecessary data or detail given each audience’s needs and roles)
- To use data to provide knowledge in the most effective manner possible (provide relevant, timely and complete data to each audience member in a clear and understandable manner)



that conveys important meaning, is actionable and can affect understanding, behavior and decisions)

# 22. Artificial Intelligence and Machine Learning

From Wikipedia: [https://en.wikipedia.org/wiki/Artificial\\_intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence)

In [computer science](#), **artificial intelligence (AI)**, sometimes called **machine intelligence**, is [intelligence](#) demonstrated by [machines](#), in contrast to the **natural intelligence** displayed by humans. Colloquially, the term “artificial intelligence” is often used to describe machines (or computers) that mimic “cognitive” functions that humans associate with the [human mind](#), such as “learning” and “problem solving”.<sup>[1]</sup>

As machines become increasingly capable, tasks considered to require “intelligence” are often removed from the definition of AI, a phenomenon known as the [AI effect](#).<sup>[2]</sup> A quip in Tesler’s Theorem says “AI is whatever hasn’t been done yet.”<sup>[3]</sup> For instance, [optical character recognition](#) is frequently excluded from things considered to be AI, having become a routine technology.<sup>[4]</sup> Modern machine capabilities generally classified as AI include successfully [understanding human speech](#),<sup>[5]</sup> competing at the highest level in [strategic game](#) systems (such as [chess](#) and [Go](#)),<sup>[6]</sup> [autonomously operating cars](#), intelligent routing in [content delivery networks](#), and [military simulations](#).

Artificial intelligence can be classified into three different types of systems: analytical, human-inspired, and humanized artificial intelligence.<sup>[7]</sup> Analytical AI has only characteristics consistent with [cognitive intelligence](#); generating a cognitive representation of the world and using learning based on past experience to inform future decisions. Human-inspired AI has elements from cognitive and [emotional intelligence](#); understanding human emotions, in addition to cognitive elements, and considering them in their [decision making](#). Humanized AI shows characteristics of all types of competencies (i.e., cognitive, emotional, and [social intelligence](#)), is able to be [self-conscious](#) and is [self-aware](#) in interactions.

The field was founded on the claim that [human intelligence](#) “can be so precisely described that a machine can be made to simulate it”.<sup>[19]</sup> This raises philosophical arguments about the nature of the [mind](#) and the ethics of creating artificial beings endowed with human-like intelligence which are issues that have been explored by [myth](#), [fiction](#) and [philosophy](#) since [antiquity](#).<sup>[20]</sup> Some people also consider AI to be [a danger to humanity](#) if it progresses unabated.<sup>[21]</sup> Others believe that AI, unlike previous technological revolutions, will create a [risk of mass unemployment](#).<sup>[22]</sup>

In the twenty-first century, AI techniques have experienced a resurgence following concurrent advances in [computer power](#), large amounts of [data](#), and theoretical understanding; and AI techniques have become an essential part of the [technology industry](#), helping to solve many challenging problems in computer science, [software engineering](#) and [operations research](#).<sup>[23][12]</sup>

# Machine Learning

From Wikipedia: [https://en.wikipedia.org/wiki/Machine\\_learning](https://en.wikipedia.org/wiki/Machine_learning)

**Machine learning (ML)** is the [scientific study](#) of [algorithms](#) and [statistical models](#) that [computer systems](#) use to perform a specific task without using explicit instructions, relying on patterns and [inference](#) instead. It is seen as a subset of [artificial intelligence](#). Machine learning algorithms build a [mathematical model](#) based on sample data, known as “[training data](#)“, in order to make predictions or decisions without being explicitly programmed to perform the task.<sup>[1][2]:2</sup> Machine learning algorithms are used in a wide variety of applications, such as [email filtering](#) and [computer vision](#), where it is difficult or infeasible to develop a conventional algorithm for effectively performing the task.

Machine learning is closely related to [computational statistics](#), which focuses on making predictions using computers. The study of [mathematical optimization](#) delivers methods, theory and application domains to the field of machine learning. [Data mining](#) is a field of study within machine learning, and focuses on [exploratory data analysis](#) through [unsupervised learning](#).<sup>[3][4]</sup> In its application across business problems, machine learning is also referred to as [predictive analytics](#).

## Supervised and Unsupervised Machine Learning

Machine learning tasks are classified into several broad categories. In [supervised learning](#), the algorithm builds a mathematical model from a set of data that contains both the inputs and the desired outputs. For example, if the task were determining whether an image contained a certain object, the [training data](#) for a supervised learning algorithm would include images with and without that object (the input), and each image would have a label (the output) designating whether it contained the object. In special cases, the input may be only partially available, or restricted to special feedback.<sup>[clarification needed]</sup> [Semi-supervised learning](#) algorithms develop mathematical models from incomplete training data, where a portion of the sample input doesn't have labels.

[Classification](#) algorithms and [regression](#) algorithms are types of supervised learning. Classification algorithms are used when the outputs are restricted to a [limited set](#) of values. For a classification algorithm that filters emails, the input would be an incoming email, and the output would be the name of the folder in which to file the email. For an algorithm that identifies spam emails, the output would be the prediction of either “[spam](#)” or “not spam”, represented by the [Boolean](#) values true and false. [Regression](#) algorithms are named for their continuous outputs, meaning they may have any value within a range. Examples of a continuous value are the temperature, length, or price of an object.

In [unsupervised learning](#), the algorithm builds a mathematical model from a set of data which contains only inputs and no desired output labels. Unsupervised learning algorithms are used to find structure in the data, like grouping or [clustering](#) of data points. Unsupervised learning can discover patterns in the data, and can group the inputs into categories, as in [feature learning](#). [Dimensionality reduction](#) is the process of reducing the number of “features”, or inputs, in a set of data.

## PART VI

# CHAPTER 5: THE INTERNET OF THINGS

The Internet of Things (IoT), as a concept, is nearly ten years old. Many individuals and organizations imagined the IoT gaining more adoption by this point in time, though we do continue to see interesting examples of new devices and sensors connecting to the Internet, and leveraging the Cloud to provide us (or others) interesting and useful data. From small sensors inside the human body, to entire ‘connected’ cities, the Internet of Things holds tremendous promise for our future. To truly realize the promise of the IoT, we need to also solve challenges around security, standards, and ethics, to name a few.

### *Learning Objectives*

After reading this chapter, you will be able to:

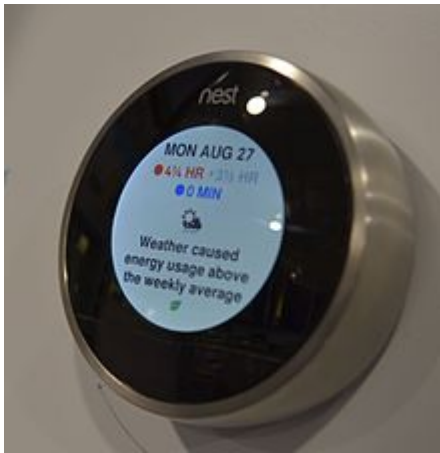
- Describe the Internet of Things (IoT), and provide examples of devices or technologies that are part of the IoT.
- Identify and describe challenges that impact the adoption of the IoT.

## 23. Applications of the IoT

[https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)

### Internet of things

From Wikipedia, the free encyclopedia  
(Redirected from [Internet of Things](#))



A [Nest Learning Thermostat](#) reporting on energy usage and local weather

The **internet of things (IoT)** is the network of physical devices, vehicles, buildings and other items—[embedded](#) with [electronics](#), [software](#), [sensors](#), actuators, and [network connectivity](#) that enable these objects to collect and exchange data.<sup>[1]</sup> In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as “the infrastructure of the information society.”<sup>[2]</sup> The IoT allows objects to be sensed and controlled remotely across existing network infrastructure,<sup>[3]</sup> creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.<sup>[4][5][6][7][8][9]</sup> When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of [cyber-physical systems](#), which also encompasses technologies such as [smart grids](#), [smart homes](#), [intelligent transportation](#) and [smart cities](#). Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing [Internet](#) infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.<sup>[10]</sup>

[British](#) entrepreneur [Kevin Ashton](#) coined the term in 1999 while working at Auto-ID Labs

(originally called Auto-ID centers, referring to a global network of objects connected to [radio-frequency identification](#), or RFID).<sup>[11]</sup> Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond [machine-to-machine](#) (M2M) communications and covers a variety of protocols, domains, and applications.<sup>[12]</sup> The interconnection of these embedded devices (including [smart objects](#)), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a [smart grid](#),<sup>[13]</sup> and expanding to the areas such as [smart cities](#).<sup>[14][15]</sup>

“Things,” in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, [biochip](#) transponders on farm animals, electric clams in coastal waters,<sup>[16]</sup> automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring<sup>[17]</sup> or field operation devices that assist firefighters in [search and rescue](#) operations.<sup>[18]</sup> Legal scholars suggest to look at “Things” as an “inextricable mixture of hardware, software, data and service”.<sup>[19]</sup> These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.<sup>[20]</sup> Current market examples include [smart thermostat](#) systems and washer/dryers that use Wi-Fi for remote monitoring.

As well as the expansion of Internet-connected automation into a plethora of new application areas, IoT is also expected to generate large amounts of data from diverse locations, with the consequent necessity for quick aggregation of the data, and an increase in the need to index, store, and process such data more effectively. IoT is one of the platforms of today’s Smart City, and Smart Energy Management Systems.<sup>[21][22]</sup>

## Early history

As of 2013, the vision of the internet of things has evolved due to a convergence of multiple technologies, ranging from wireless communication to the Internet and from [embedded systems](#) to [micro-electromechanical systems](#) (MEMS).<sup>[18]</sup> This means that the traditional fields of embedded systems, [wireless sensor networks](#), [control systems](#), [automation](#) (including [home](#) and [building automation](#)), and others all contribute to enabling the internet of things<sup>[23]</sup> (IoT).

The concept of a network of smart devices was discussed as early as 1982, with a modified Coke machine at [Carnegie Mellon University](#) becoming the first internet-connected appliance,<sup>[24]</sup> able to report its inventory and whether newly loaded drinks were cold.<sup>[25]</sup> [Mark Weiser](#)’s seminal 1991 paper on [ubiquitous computing](#), “The Computer of the 21st Century”, as well as academic venues such as UbiComp and PerCom produced the contemporary vision of IoT.<sup>[26][27]</sup> In 1994 Reza Raji described the concept in [IEEE Spectrum](#) as “[moving] small packets of data to a large set of nodes, so as to integrate and automate everything from home appliances to entire factories”.<sup>[28]</sup> Between 1993 and 1996 several companies proposed solutions like [Microsoft](#)’s [at Work](#) or [Novell](#)’s [NEST](#). However, only in 1999 did the field start gathering momentum. [Bill Joy](#) envisioned Device to Device (D2D) communication as part of his “Six Webs” framework, presented at the World Economic Forum at Davos in 1999.<sup>[29]</sup>

The concept of the internet of things first became popular in 1999, through the [Auto-ID Center](#) at [MIT](#) and related market-analysis publications.<sup>[30]</sup> Radio-frequency identification ([RFID](#))

was seen by Kevin Ashton (one of the founders of the original [Auto-ID Center](#)) as a prerequisite for the internet of things at that point.<sup>[31]</sup> If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them.<sup>[32][33]</sup> Besides using RFID, the [tagging](#) of things may be achieved through such technologies as [near field communication](#), [barcodes](#), [QR codes](#) and [digital watermarking](#).<sup>[34][35]</sup>

In its original interpretation,<sup>[when?]</sup> one of the first consequences of implementing the internet of things by equipping all objects in the world with minuscule identifying devices or machine-readable identifiers would be to transform daily life.<sup>[36][37]</sup> For instance, instant and ceaseless [inventory control](#) would become ubiquitous.<sup>[37]</sup> A person's ability to interact with objects could be altered remotely based on immediate or present needs, in accordance with existing [end-user agreements](#).<sup>[31]</sup> For example, such technology could grant motion-picture publishers much more control over end-user private devices by remotely enforcing [copyright restrictions](#) and [digital restrictions management](#), so the ability of a customer who bought a [Blu-ray disc](#) to watch the movie becomes dependent on so-called "copyright holder's" decision, similar to Circuit City's failed [DIVX](#).

## Applications



A 2012 [internet refrigerator](#) from LG

According to [Gartner, Inc.](#) (a technology research and advisory corporation), there will be nearly 20.8 billion devices on the internet of things by 2020.<sup>[38]</sup> [ABI Research](#) estimates that more than 30 billion devices will be wirelessly connected to the internet of things by 2020.<sup>[39]</sup> As per a recent survey and study done by [Pew Research](#) Internet Project, a large majority of the technology experts and engaged Internet users who responded—83 percent—agreed with the notion that the



Internet/Cloud of Things, embedded and [wearable computing](#) (and the corresponding dynamic systems<sup>[40]</sup>) will have widespread and beneficial effects by 2025.<sup>[41]</sup> As such, it is clear that the IoT will consist of a very large number of devices being connected to the Internet.<sup>[42]</sup> In an active move to accommodate new and emerging technological innovation, the UK Government, in their 2015 budget, allocated £40,000,000 towards research into the internet of things. The British [Chancellor of the Exchequer George Osborne](#), posited that the internet of things is the next stage of the [information revolution](#) and referenced the inter-connectivity of everything from urban transport to medical devices to household appliances.<sup>[43]</sup>

Integration with the Internet implies that devices will use an [IP address](#) as a unique identifier. However, due to the [limited address space](#) of [IPv4](#) (which allows for 4.3 billion unique addresses), objects in the IoT will have to use [IPv6](#) to accommodate the extremely large address space required.<sup>[44][45][46][47][48]</sup> Objects in the IoT will not only be devices with sensory capabilities, but also provide actuation capabilities (e.g., bulbs or locks controlled over the Internet).<sup>[49]</sup> To a large extent, the future of the internet of things will not be possible without the support of IPv6; and consequently the global adoption of IPv6 in the coming years will be critical for the successful development of the IoT in the future.<sup>[45][46][47][48]</sup>

The ability to network embedded devices with limited CPU, memory and power resources means that IoT finds applications in nearly every field.<sup>[50]</sup> Such systems could be in charge of collecting information in settings ranging from natural ecosystems to buildings and factories,<sup>[49]</sup> thereby finding applications in fields of [environmental sensing](#) and [urban planning](#).<sup>[51]</sup> On the other hand, IoT systems could also be responsible for performing actions, not just sensing things. [Intelligent shopping systems](#), for example, could monitor specific users' purchasing habits in a store by tracking their specific mobile phones. These users could then be provided with special offers on their favorite products, or even location of items that they need, which their fridge has automatically conveyed to the phone.<sup>[52][53]</sup> Additional examples of sensing and actuating are reflected in applications that deal with heat, electricity and [energy management](#), as well as cruise-assisting [transportation systems](#).<sup>[54]</sup> Other applications that the internet of things can provide is enabling extended home security features and home automation.<sup>[55]</sup> The concept of an "internet of living things" has been proposed to describe networks of [biological sensors](#) that could use cloud-based analyses to allow users to study DNA or other molecules.<sup>[56]</sup> All these advances add to the numerous list of IoT applications. Now with IoT, you can control the electrical devices installed in your house while you are sorting out your files in office. Your water will be warm as soon as you get up in the morning for the shower. All credit goes to smart devices which make up the smart home. Everything connected with the help of Internet.<sup>[57]</sup>

However, the application of the IoT is not only restricted to these areas. Other specialized use cases of the IoT may also exist. An overview of some of the most prominent application areas is provided here. Based on the application domain, IoT products can be classified broadly into five different categories: smart wearable, smart home, smart city, smart environment, and smart enterprise. The IoT products and solutions in each of these markets have different characteristics.<sup>[58]</sup>

## 24. Applications of the IoT (continued)

from [https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)

### Environmental monitoring

[Environmental monitoring](#) applications of the IoT typically use sensors to assist in environmental protection<sup>[63]</sup> by monitoring air or [water quality](#),<sup>[16]</sup> [atmospheric](#) or [soil conditions](#),<sup>[64]</sup> and can even include areas like monitoring the [movements of wildlife](#) and their [habitats](#).<sup>[65]</sup> Development of resource constrained devices connected to the Internet also means that other applications like [earthquake](#) or [tsunami early-warning systems](#) can also be used by emergency services to provide more effective aid. IoT devices in this application typically span a large geographic area and can also be mobile.<sup>[49]</sup> It has been argued that the standardization IoT brings to wireless sensing will revolutionize this area.<sup>[66]</sup>

### Infrastructure management

Monitoring and controlling operations of [urban](#) and rural [infrastructures](#) like bridges, railway tracks, on- and offshore- wind-farms is a key application of the IoT.<sup>[67]</sup> The IoT infrastructure can be used for monitoring any events or changes in structural conditions that can compromise safety and increase risk. It can also be used for scheduling repair and maintenance activities in an efficient manner, by coordinating tasks between different service providers and users of these facilities.<sup>[49]</sup> IoT devices can also be used to control critical infrastructure like bridges to provide access to ships. Usage of IoT devices for monitoring and operating infrastructure is likely to improve incident management and emergency response coordination, and quality of service, up-times and reduce costs of operation in all infrastructure related areas.<sup>[68]</sup> Even areas such as waste management can benefit from automation and optimization that could be brought in by the IoT.<sup>[69]</sup>

### Manufacturing

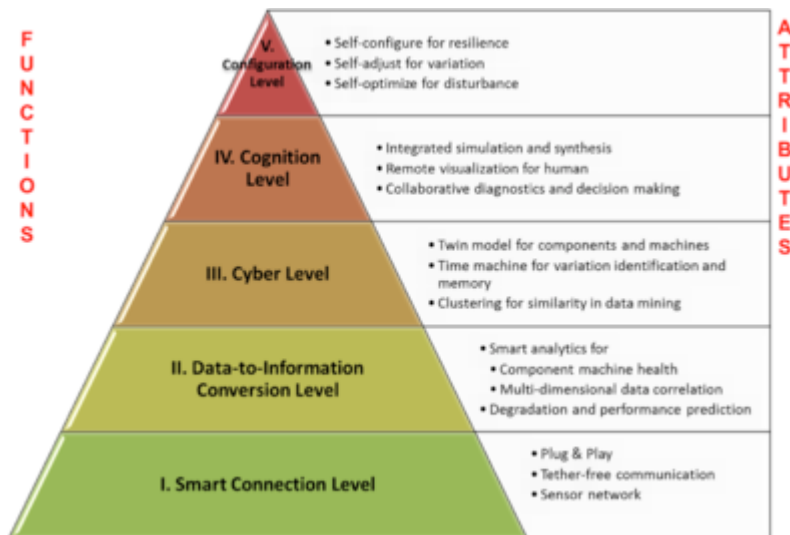
Network control and management of [manufacturing equipment](#), [asset](#), and situation management, or manufacturing [process control](#) bring the IoT within the realm on industrial applications and

smart manufacturing as well.<sup>[70]</sup> The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and [supply chain networks](#), by networking machinery, sensors and control systems together.<sup>[49]</sup>

[Digital control systems](#) to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IoT.<sup>[67]</sup> But it also extends itself to asset management via [predictive maintenance](#), [statistical evaluation](#), and measurements to maximize reliability.<sup>[71]</sup> Smart industrial management systems can also be integrated with the [Smart Grid](#), thereby enabling real-time energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by a large number of networked sensors.<sup>[49]</sup>

[National Science Foundation](#) established an Industry/University Cooperative Research Center on [intelligent maintenance systems](#) (IMS) in 2001 with a research focus to use IoT-based [predictive analytics](#) technologies to monitor connected machines and to predict machine degradation, and further to prevent potential failures.<sup>[72]</sup> The vision to achieve near-zero breakdown using IoT-based predictive analytics led the future development of e-manufacturing and e-maintenance activities.<sup>[73]</sup>

The term IIOT ([industrial internet of things](#)) is often encountered in the manufacturing industries, referring to the industrial subset of the IoT. IIoT in manufacturing would probably generate so much business value that it will eventually lead to the fourth industrial revolution, so the so-called [Industry 4.0](#). It is estimated that in the future, successful companies will be able to increase their revenue through internet of things by creating new business models and improve productivity, exploit analytics for innovation, and transform workforce.<sup>[74]</sup> The potential of growth by implementing IIoT will generate \$12 trillion of global GDP by 2030.<sup>[75]</sup>



Design architecture of cyber-physical systems-enabled manufacturing system<sup>[76]</sup>

While connectivity and data acquisition are imperative for IIoT, they should be the foundation and path to something bigger but not the purpose. Among all the technologies, predictive maintenance is probably a relatively “easier win” since it is applicable to existing assets and management

systems. The objective of intelligent maintenance systems is to reduce unexpected downtime and increase productivity. And to realize that alone would generate around up to 30% over total maintenance costs.<sup>[77]</sup> [Industrial big data](#) analytics will play a vital role in manufacturing asset predictive maintenance, although that is not the only capability of industrial big data.<sup>[78][79]</sup> Cyber-physical systems (CPS) is the core technology of industrial big data and it will be an interface between human and the cyber world. Cyber-physical systems can be designed by following the 5C (connection, conversion, cyber, cognition, configuration) architecture,<sup>[76]</sup> and it will transform the collected data into actionable information, and eventually interfere with the physical assets to optimize processes.

An IoT-enabled intelligent system of such cases has been demonstrated by the NSF Industry/University Collaborative Research Center for Intelligent Maintenance Systems (IMS) at University of Cincinnati on a band saw machine in IMTS 2014 in Chicago.<sup>[80]</sup> Band saw machines are not necessarily expensive, but the band saw belt expenses are enormous since they degrade much faster. However, without sensing and intelligent analytics, it can be only determined by experience when the band saw belt will actually break. The developed [prognostics](#) system will be able to recognize and monitor the degradation of band saw belts even if the condition is changing, so that users will know in near real time when is the best time to replace band saw. This will significantly improve user experience and operator safety, and save costs on replacing band saw belts before they actually break. The developed analytical algorithms were realized on a cloud server, and was made accessible via the Internet and on mobile devices.<sup>[80]</sup>

## Energy management

Integration of [sensing](#) and [actuation](#) systems, connected to the Internet, is likely to optimize energy consumption as a whole.<sup>[49]</sup> It is expected that IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance [power generation](#) and energy usage.<sup>[81]</sup> Such devices would also offer the opportunity for users to remotely control their devices, or centrally manage them via a [cloud](#) based interface, and enable advanced functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.).<sup>[49]</sup> In fact, a few systems that allow remote control of electric outlets are already available in the market, e.g., Belkin's WeMo,<sup>[82]</sup> Ambery Remote Power Switch,<sup>[83]</sup> Budderfly,<sup>[84]</sup> Telkonet's EcoGuard,<sup>[85]</sup> WhizNets Inc.,<sup>[86]</sup> etc.

Besides home based [energy management](#), the IoT is especially relevant to the Smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.<sup>[81]</sup> Using [advanced metering infrastructure \(AMI\)](#) devices connected to the Internet backbone, electric utilities can not only collect data from end-user connections, but also manage other distribution automation devices like transformers and reclosers.<sup>[49]</sup>

## Medical and healthcare systems

IoT devices can be used to enable [remote health monitoring](#) and [emergency notification systems](#). These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers, Fitbit electronic wristbands or advanced hearing aids.<sup>[49]</sup> Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well.<sup>[87]</sup> Other consumer devices to encourage healthy living, such as, connected scales or [wearable heart monitors](#), are also a possibility with the IoT.<sup>[88]</sup> More and more end-to-end health monitoring IoT platforms are coming up for antenatal and chronic patients, helping one manage health vitals and recurring medication requirements.<sup>[citation needed]</sup>

## Building and home automation

IoT devices can be used to monitor and control the mechanical, electrical and electronic systems used in various types of buildings (e.g., public and private, industrial, institutions, or residential)<sup>[49]</sup> in [home automation](#) and [building automation](#) systems.

## Transportation



Digital variable speed-limit sign

The IoT can assist in integration of communications, control, and information processing across various [transportation systems](#). Application of the IoT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user). Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, [smart](#)

[traffic control](#), smart parking, [electronic toll collection systems](#), [logistic](#) and [fleet management](#), [vehicle control](#), and safety and road assistance.<sup>[49]</sup>

## Large scale deployments

There are several planned or ongoing large-scale deployments of the IoT, to enable better management of cities and systems. For example, [Songdo](#), South Korea, the first of its kind fully equipped and wired [smart city](#), is near completion. Nearly everything in this city is planned to be wired, connected and turned into a constant stream of [data](#) that would be monitored and analyzed by an array of computers with little, or no human intervention.<sup>[citation needed]</sup>

Another application is a currently undergoing project in [Santander](#), Spain. For this deployment, two approaches have been adopted. This city of 180,000 inhabitants, has already seen 18,000 city application downloads for their smartphones. This application is connected to 10,000 sensors that enable services like parking search, environmental monitoring, digital city agenda among others. City context information is used in this deployment so as to benefit merchants through a spark deals mechanism based on city behavior that aims at maximizing the impact of each notification.<sup>[89]</sup>

Other examples of large-scale deployments underway include the Sino-Singapore Guangzhou Knowledge City;<sup>[90]</sup> work on improving air and water quality, reducing noise pollution, and increasing transportation efficiency in San Jose, California;<sup>[91]</sup> and smart traffic management in western Singapore.<sup>[92]</sup> French company, [Sigfox](#), commenced building an ultra-[narrowband](#) wireless data network in the [San Francisco Bay Area](#) in 2014, the first business to achieve such a deployment in the U.S.<sup>[93][94]</sup> It subsequently announced it would set up a total of 4000 [base stations](#) to cover a total of 30 cities in the U.S. by the end of the 2016, making it the largest IoT network coverage provider in the country thus far.<sup>[95][96]</sup>

Another example of a large deployment is the one completed by New York Waterways in New York City to connect all their vessels and being able to monitor them live 24/7. The network was designed and engineered by [Fluidmesh](#) Networks, a Chicago-based company developing wireless networks for critical applications. The NYWW network is currently providing coverage on the Hudson River, East River, and Upper New York Bay. With the wireless network in place, NY Waterway is able to take control of its fleet and passengers in a way that was not previously possible. New applications can include security, energy and fleet management, digital signage, public Wi-Fi, paperless ticketing and others.<sup>[97]</sup>



# 25. Enabling Technologies

[https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)

There are many technologies that enable IOT. A key foundation piece is the network used to communicate between nodes of an IOT installation, a role that several wireless and/or wired technologies may fulfill.<sup>[121][122][123][124]</sup>

1. RFID and near-field communication – In the 2000s, RFID was the dominant technology. Later, NFC became dominant ([NFC](#)). NFC have become common in [smartphones](#) during the early 2010s, with uses such as reading NFC tags or for access to public transportation.<sup>[citation needed]</sup>
2. Rapid developments in the Optical technologies like [Li-Fi](#), Cisco's 40 Gbit/s bidirectional optical technology (BiDi<sup>[125]</sup>) may aid the development of IoT.
3. Optical tags and quick response codes – This is used for low cost tagging. Phone cameras decode QR code using image-processing techniques. In reality QR advertisement campaigns gives less turnout as users need to have another application to read [QR codes](#).
4. [Bluetooth low energy](#) – This is one of the latest tech. All newly releasing smartphones have [BLE](#) hardware in them. Tags based on BLE can signal their presence at a power budget that enables them to operate for up to one year on a lithium coin cell battery.
5. Low energy wireless IP networks – embedded radio in [system-on-a-chip](#) designs, lower power WiFi, sub-GHz radio in an [ISM band](#), often using a compressed version of [IPv6](#) called [6LowPAN](#).
6. [ZigBee](#) – This communication technology is based on the IEEE 802.15.4 2.4 GHz-band radio protocol to implement physical and MAC layer for low-rate wireless Private Area Networks. Some of its main characteristics like low power consumption, low data rate, low cost, and high message throughput make it an interesting IoT enabler technology.
7. [Z-Wave](#) – is a communication protocol that is mostly used in smart home applications. It uses a radio protocol in the 900 MHz-band.
8. [Thread](#) – Like ZigBee, this IoT communication technology relies on the IEEE 802.15.4 2.4 GHz-band radio protocol. A key difference is that its networking protocol is IPv6-compatible.
9. [LTE-Advanced](#) – LTE-A is a high-speed communication specification for mobile networks. Compared to its original LTE, LTE-A has been improved to have extended coverage, higher throughput and lower latency. One important application of this technology is Vehicle-to-Vehicle (V2V) communications.
10. [WiFi-Direct](#) – It is essentially WiFi for peer-to-peer communication without needing to have an access point. This feature attracts IoT applications to be built on top of WiFi-Direct to get benefit from the speed of WiFi while they experience lower latency.
11. [HomePlug](#) – This networking standard can be used to enable IOT communication over a home or building's power lines
12. [MoCA](#) – This networking standard can be used to enable IOT communication over CATV-



type coaxial cable

13. [Ethernet](#) – This general purpose networking standard can be used to enable IOT communication over twisted pair or fiber network links

## 26. Privacy and Security within the IoT

From [https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)

### Privacy, autonomy and control

[Philip N. Howard](#), a professor and author, writes that the internet of things offers immense potential for empowering citizens, making government transparent, and broadening information access. Howard cautions, however, that privacy threats are enormous, as is the potential for social control and political manipulation.<sup>[127]</sup>

The concern over the privacy was led many to consider the possibility that [Big Data](#) infrastructures such as the IoT and [Data Mining](#) are inherently incompatible with privacy.<sup>[128]</sup> Writer [Adam Greenfield](#) claims that these technologies are not only an invasion of public space but are also being used to perpetuate normative behavior, citing an instance of billboards with hidden cameras that tracked the demographics of passersby who stopped to read the advertisement.<sup>[129]</sup>

The Council of the Internet of Things compared the increased prevalence of [digital surveillance](#) due to the Internet of Things to the conceptual [panopticon](#) described by [Jeremy Bentham](#) in the 18th Century.<sup>[130]</sup> The assertion was defended by the works of French philosophers [Michel Foucault](#) and [Gilles Deleuze](#). Foucault wrote in his novel [Discipline and Punish: The Birth of the Prison](#) that the panopticon was a central element of the discipline society developed during the [Industrial Era](#).<sup>[131]</sup> Foucault also argued that the discipline systems established in factories and school reflected Bentham's vision of [panopticism](#).<sup>[131]</sup> In his 1992 paper "Postscripts on the Societies of Control," Delueze wrote that the discipline society had transitioned into a control society, with the [computer](#) replacing the [panopticon](#) as an instrument of discipline and control while still maintaining the qualities similar to that of panopticism.<sup>[132]</sup>

A research team of the [National Science Foundation](#) and [University of Arkansas at Little Rock](#) discovered that the privacy of households using smart home devices could be compromised by analyzing network traffic.<sup>[133][134]</sup>

Peter-Paul Verbeek, a professor of philosophy of technology at the [University of Twente](#), Netherlands, writes that technology already influences our moral decision making, which in turn affects human agency, privacy and autonomy. He cautions against viewing technology merely as a human tool and advocates instead to consider it as an active agent.<sup>[135]</sup>

Justin Brookman, of the [Center for Democracy and Technology](#), expressed concern regarding the impact of IoT on consumer privacy, saying that "There are some people in the commercial space who say, 'Oh, big data – well, let's collect everything, keep it around forever, we'll pay for somebody to think about security later.' The question is whether we want to have some sort of policy framework in place to limit that."<sup>[136]</sup>

[Tim O'Reilly](#) believes that the way companies sell the IoT devices on consumers are misplaced,

disputing the notion that the IoT is about gaining efficiency from putting all kinds of devices online and postulating that “IoT is really about human augmentation. The applications are profoundly different when you have sensors and data driving the decision-making.”<sup>[137]</sup>

Editorials at [WIRED](#) have also expressed concern, one stating “What you’re about to lose is your privacy. Actually, it’s worse than that. You aren’t just going to lose your privacy, you’re going to have to watch the very concept of privacy be rewritten under your nose.”<sup>[138]</sup>

The [American Civil Liberties Union](#) (ACLU) expressed concern regarding the ability of IoT to erode people’s control over their own lives. The ACLU wrote that “There’s simply no way to forecast how these immense powers – disproportionately accumulating in the hands of corporations seeking financial advantage and governments craving ever more control – will be used. Chances are Big Data and the Internet of Things will make it harder for us to control our own lives, as we grow increasingly transparent to powerful corporations and government institutions that are becoming more opaque to us.”<sup>[139]</sup>

Researchers have identified privacy challenges faced by all stakeholders in IoT domain, from the manufacturers and app developers to the consumers themselves, and examined the responsibility of each party in order to ensure user privacy at all times. Problems highlighted by the report<sup>[140]</sup> include:

- User consent – somehow, the report says, users need to be able to give informed consent to data collection. Users, however, have limited time and technical knowledge.
- Freedom of choice – both privacy protections and underlying standards should promote freedom of choice.
- Anonymity – IoT platforms pay scant attention to user anonymity when transmitting data, the researchers note. Future platforms could, for example, use TOR or similar technologies so that users can’t be too deeply profiled based on the behaviors of their “things”.

In response to rising concerns about privacy and [smart technology](#), in 2007 the [British Government](#) stated it would follow formal [Privacy by Design](#) principles when implementing their smart metering program. The program would lead to replacement of traditional [power meters](#) with smart power meters, which could track and manage energy usage more accurately.<sup>[141]</sup> However the [British Computer Society](#) is doubtful these principles were ever actually implemented.<sup>[142]</sup> In 2009 the [Dutch Parliament](#) rejected a similar smart metering program, basing their decision on privacy concerns. The Dutch program later revised and passed in 2011.<sup>[142]</sup>

## Security

Concerns have been raised that the internet of things is being developed rapidly without appropriate consideration of the profound security challenges involved<sup>[143]</sup> and the regulatory changes that might be necessary.<sup>[144]</sup> According to the Business Insider Intelligence Survey conducted in the last quarter of 2014, 39% of the respondents said that security is the biggest

concern in adopting internet-of-things technology.<sup>[145]</sup> In particular, as the internet of things spreads widely, cyber attacks are likely to become an increasingly physical (rather than simply virtual) threat.<sup>[146]</sup> In a January 2014 article in [Forbes](#), cybersecurity columnist [Joseph Steinberg](#) listed many Internet-connected appliances that can already “spy on people in their own homes” including televisions, kitchen appliances,<sup>[147]</sup> cameras, and thermostats.<sup>[148]</sup> Computer-controlled devices in automobiles such as brakes, engine, locks, hood and trunk releases, horn, heat, and dashboard have been shown to be vulnerable to attackers who have access to the onboard network. In some cases, vehicle computer systems are internet-connected, allowing them to be exploited remotely.<sup>[149]</sup> By 2008 security researchers had shown the ability to remotely control pacemakers without authority. Later hackers demonstrated remote control of insulin pumps<sup>[150]</sup> and implantable cardioverter defibrillators.<sup>[151]</sup> [David Pogue](#) wrote<sup>[152]</sup> that some recently published reports about hackers remotely controlling certain functions of automobiles were not as serious as one might otherwise guess because of various mitigating circumstances; such as the bug that allowed the hack having been fixed before the report was published, or that the hack required security researchers having physical access to the car prior to the hack to prepare for it.

The U.S. [National Intelligence Council](#) in an unclassified report maintains that it would be hard to deny “access to networks of sensors and remotely-controlled objects by enemies of the United States, criminals, and mischief makers... An open market for aggregated sensor data could serve the interests of commerce and security no less than it helps criminals and spies identify vulnerable targets. Thus, massively parallel [sensor fusion](#) may undermine social cohesion, if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search.”<sup>[153]</sup> In general, the intelligence community views internet of things as a rich source of data.<sup>[154]</sup>

As a response to increasing concerns over security, the Internet of Things Security Foundation (IoTSF) was launched on 23 September 2015. IoTSF has a mission to secure the internet of things by promoting knowledge and best practice. Its founding board is made from technology providers and telecommunications companies including BT, Vodafone, Imagination Technologies and Pen Test Partners.<sup>[155][156]</sup>

PART VII

CHAPTER 7: SECURITY, PRIVACY, AND  
ETHICS

## 27. Internet Privacy

From wikipedia: [https://en.wikipedia.org/wiki/Internet\\_privacy](https://en.wikipedia.org/wiki/Internet_privacy)

**Internet privacy** involves the right or mandate of personal [privacy](#) concerning the storing, repurposing, provision to third parties, and displaying of information pertaining to oneself via the [Internet](#). Internet privacy is a subset of [data privacy](#). Privacy concerns have been articulated from the beginnings of large scale computer sharing.<sup>[1]</sup>

Privacy can entail either [Personally Identifying Information](#) (PII) or non-PII information such as a site visitor's behavior on a website. PII refers to any information that can be used to identify an individual. For example, age and physical address alone could identify who an individual is without explicitly disclosing their name, as these two factors are unique enough to typically identify a specific person.

Some experts such as Steve Rambam, a private investigator specializing in Internet privacy cases, believe that privacy no longer exists; saying, "Privacy is dead – get over it".<sup>[2]</sup> In fact, it has been suggested that the "appeal of online services is to broadcast personal information on purpose."<sup>[3]</sup> On the other hand, in his essay *The Value of Privacy*, security expert [Bruce Schneier](#) says, "Privacy protects us from abuses by those in power, even if we're doing nothing wrong at the time of [surveillance](#)."<sup>[4][5]</sup>

### Levels of privacy<sup>[edit](#)</sup>

Internet and digital privacy are viewed differently from traditional expectations of privacy. Internet privacy is primarily concerned with protecting user information. Law Professor Jerry Kang explains that the term privacy expresses space, decision, and information.<sup>[6]</sup> In terms of space, individuals have an expectation that their physical spaces (i.e. homes, cars) not be intruded. Privacy within the realm of decision is best illustrated by the landmark case [Roe v. Wade](#). Lastly, information privacy is in regards to the collection of user information from a variety of sources, which produces great discussion.

The 1997 Information Infrastructure Task Force (IITF) created under [President Clinton](#) defined information privacy as "an individual's claim to control the terms under which personal information—information identifiable to the individual—is acquired, disclosed, and used."<sup>[1]</sup> At the end of the 1990s, with the rise of the internet, it became clear that the internet and companies would need to abide by new rules to protect individual's privacy. With the rise of the internet and mobile networks the salience of internet privacy is a daily concern for users.

People with only a casual concern for Internet privacy need not achieve total [anonymity](#). Internet users may protect their privacy through controlled disclosure of personal information. The revelation of IP addresses, non-personally-identifiable profiling, and similar information might become acceptable trade-offs for the convenience that users could otherwise lose using the workarounds needed to suppress such details rigorously. On the other hand, some people desire

much stronger privacy. In that case, they may try to achieve *Internet anonymity* to ensure privacy – use of the Internet without giving any third parties the ability to link the Internet activities to personally-identifiable information of the Internet user. In order to keep their information private, people need to be careful with what they submit to and look at online. When filling out forms and buying merchandise, that becomes tracked and because the information was not private, companies are now sending Internet users spam and advertising on similar products.

There are also several governmental organizations that protect individual's privacy and anonymity on the Internet, to a point. In an article presented by the [FTC](#), in October 2011, a number of pointers were brought to attention that helps an individual internet user avoid possible [identity theft](#) and other cyber-attacks. Preventing or limiting the usage of Social Security numbers online, being wary and respectful of emails including spam messages, being mindful of personal financial details, creating and managing strong passwords, and intelligent web-browsing behaviours are recommended, among others.<sup>[7]</sup>

Posting things on the Internet can be harmful or in danger of malicious attack. Some information posted on the Internet is permanent, depending on the terms of service, and [privacy policies](#) of particular services offered online. This can include comments written on blogs, pictures, and Internet sites, such as [Facebook](#) and [Twitter](#). It is absorbed into cyberspace and once it is posted, anyone can potentially find it and access it. Some employers may research a potential employee by searching online for the details of their online behaviours, possibly affecting the outcome of the success of the candidate.<sup>[8]</sup>

## Risks to Internet privacy<sup>[edit]</sup>

Companies are hired to watch what internet sites people visit, and then use the information, for instance by sending advertising based on one's browsing history. There are many ways in which people can divulge their personal information, for instance by use of “social media” and by sending bank and credit card information to various websites. Moreover, directly observed behaviour, such as browsing logs, search queries, or contents of the Facebook profile can be automatically processed to infer potentially more intrusive details about an individual, such as sexual orientation, political and religious views, race, substance use, intelligence, and personality.<sup>[9]</sup>

Those concerned about Internet privacy often cite a number of *privacy risks* – events that can compromise privacy – which may be encountered through Internet use.<sup>[10]</sup> These range from the gathering of statistics on users to more malicious acts such as the spreading of spyware and the exploitation of various forms of [bugs](#) (software faults).

Several social networking sites try to protect the personal information of their subscribers. On Facebook, for example, privacy settings are available to all registered users: they can block certain individuals from seeing their profile, they can choose their “friends”, and they can limit who has access to one's pictures and videos. Privacy settings are also available on other social networking sites such as Google Plus and Twitter. The user can apply such settings when providing personal information on the internet.



In late 2007 Facebook launched the Beacon program where user rental records were released on the public for friends to see. Many people were enraged by this breach in privacy, and the [Lane v. Facebook, Inc.](#) case ensued.<sup>[11]</sup>

Children and adolescents often use the Internet (including social media) in ways which risk their privacy: a cause for growing concern among parents. Young people also may not realise that all their information and browsing can and may be tracked while visiting a particular site, and that it is up to them to protect their own privacy. They must be informed about all these risks. For example, on Twitter, threats include shortened links that lead one to potentially harmful places. In their e-mail inbox, threats include email scams and attachments that get them to install malware and disclose personal information. On Torrent sites, threats include malware hiding in video, music, and software downloads. Even when using a smartphone, threats include geolocation, meaning that one's phone can detect where they are and post it online for all to see. Users can protect themselves by updating virus protection, using security settings, downloading patches, installing a firewall, screening e-mail, shutting down spyware, controlling [cookies](#), using encryption, fending off browser hijackers, and blocking pop-ups.<sup>[12][13]</sup>

However most people have little idea how to go about doing many of these things. How can the average user with no training be expected to know how to run their own network security (especially as things are getting more complicated all the time)? Many businesses hire professionals to take care of these issues, but most individuals can only do their best to learn about all this.<sup>[14]</sup>

In 1998, the Federal Trade Commission in the USA considered the lack of privacy for children on the Internet, and created the Children Online Privacy Protection Act (COPPA). COPPA limits the options which gather information from children and created warning labels if potential harmful information or content was presented. In 2000, Children's Internet Protection Act (CIPA) was developed to implement safe Internet policies such as rules<sup>[clarification needed]</sup>, and filter software. These laws, awareness campaigns, parental and adult supervision strategies and Internet filters can all help to make the Internet safer for children around the world.<sup>[15]</sup>

## HTTP cookies<sup>[edit]</sup>

Main article: [HTTP cookie](#)

An [HTTP cookie](#) is data stored on a user's computer that assists in automated access to websites or web features, or other [state](#) information required in complexity web sites. It may also be used for user-tracking by storing special usage history data in a cookie, and such cookies—for example, those used by [Google Analytics](#)—are called *tracking cookies*. Cookies are a common concern in the field of [Internet privacy](#). Although website developers most commonly use cookies for legitimate technical purposes, cases of abuse occur. In 2009, two researchers noted that social networking profiles could be connected to cookies, allowing the social networking profile to be connected to browsing habits.<sup>[16]</sup>

In the past, web sites have not generally made the user explicitly aware of the storing of

cookies, however **tracking cookies** and especially **third-party tracking cookies** are commonly used as ways to compile long-term records of individuals' browsing histories – a [privacy concern](#) that prompted European and US law makers to take action in 2011.<sup>[17][18]</sup> Cookies can also have implications for [computer forensics](#). In past years, most computer users were not completely aware of cookies, but recently, users have become conscious of possible detrimental effects of Internet cookies: a recent study done has shown that 58% of users have at least once, deleted cookies from their computer, and that 39% of users delete cookies from their computer every month. Since cookies are advertisers' main way of targeting potential customers, and some customers are deleting cookies, some advertisers started to use persistent [Flash cookies](#) and [zombie cookies](#), but modern browsers and anti-malware software can now block or detect and remove such cookies.

The original developers of cookies intended that only the website that originally distributed cookies to users could retrieve them, therefore returning only data already possessed by the website. However, in practice programmers can circumvent this restriction. Possible consequences include:

- the placing of a personally-identifiable tag in a browser to facilitate [web profiling](#) (see below), or,
- use of [cross-site scripting](#) or other techniques to steal information from a user's cookies.

Cookies do have benefits that many people may not know. One benefit is that for websites that one frequently visits that requires a password, cookies make it so they do not have to sign in every time. A cookie can also track one's preferences to show them websites that might interest them. Cookies make more websites free to use without any type of payment. Some of these benefits are also seen as negative. For example, one of the most common ways of theft is hackers taking one's user name and password that a cookie saves. While a lot of sites are free, they have to make a profit some how so they sell their space to advertisers. These ads, which are personalized to one's likes, can often freeze one's computer or cause annoyance. Cookies are mostly harmless except for third-party cookies.<sup>[19]</sup> These cookies are not made by the website itself, but by web banner advertising companies. These third-party cookies are so dangerous because they take the same information that regular cookies do, such as browsing habits and frequently visited websites, but then they give out this information to other companies.

Cookies are often associated with pop-up windows because these windows are often, but not always, tailored to a person's preferences. These windows are an irritation because they are often hard to close out of because the close button is strategically hidden in an unlikely part of the screen. In the worst cases, these pop-up ads can take over the screen and while trying to exit out of it, can take one to another unwanted website.

Cookies are seen so negatively because they are not understood and go unnoticed while someone is simply surfing the Internet. The idea that every move one makes while on the Internet is being watched, would frighten most users.<sup>[20]</sup>

Some users choose to disable cookies in their web browsers.<sup>[21]</sup> Such an action can reduce some privacy risks, but may severely limit or prevent the functionality of many websites. All significant web browsers have this disabling ability built-in, with no external program required. As an alternative, users may frequently delete any stored cookies. Some browsers (such as [Mozilla](#)

[Firefox](#) and [Opera](#)) offer the option to clear cookies automatically whenever the user closes the browser. A third option involves allowing cookies in general, but preventing their abuse. There are also a host of wrapper applications that will redirect cookies and cache data to some other location. Concerns exist that the privacy benefits of deleting cookies have been over-stated.<sup>[22]</sup>

The process of *profiling* (also known as “tracking”) assembles and analyzes several events, each attributable to a single originating entity, in order to gain information (especially patterns of activity) relating to the originating entity. Some organizations engage in the profiling of people’s web browsing, collecting the [URLs](#) of sites visited. The resulting profiles can potentially link with information that personally identifies the individual who did the browsing.

Some web-oriented marketing-research organizations may use this practice legitimately, for example: in order to construct profiles of ‘typical Internet users’. Such profiles, which describe average trends of large groups of Internet users rather than of actual individuals, can then prove useful for [market analysis](#). Although the aggregate data does not constitute a privacy violation, some people believe that the initial profiling does.

Profiling becomes a more contentious privacy issue when data-matching associates the profile of an individual with personally-identifiable information of the individual.

Governments and organizations may set up [honeypot](#) websites – featuring controversial topics – with the purpose of attracting and tracking unwary people. This constitutes a potential danger for individuals.

## Flash cookies[[edit](#)]

Main article: [Local shared object](#)

When some users choose to disable [HTTP cookie](#) to reduce privacy risks as noted, new types of cookies were invented: since cookies are advertisers’ main way of targeting potential customers, and some customers were deleting cookies, some advertisers started to use persistent Flash cookies and [zombie cookies](#). In a 2009 study, Flash cookies were found to be a popular mechanism for storing data on the top 100 most visited sites.<sup>[23]</sup> Another 2011 study of social media found that, “Of the top 100 web sites, 31 had at least one overlap between HTTP and Flash cookies.”<sup>[24]</sup> However, modern browsers and anti-malware software can now block or detect and remove such cookies.

Flash cookies, also known as [Local Shared Objects](#), work the same ways as normal cookies and are used by the [Adobe Flash Player](#) to store information at the user’s computer. They exhibit a similar privacy risk as normal cookies, but are not as easily blocked, meaning that the option in most browsers to not accept cookies does not affect Flash cookies. One way to view and control them is with browser extensions or add-ons. Flash cookies are unlike HTTP cookies in a sense that they are not transferred from the client back to the server. Web browsers read and write these cookies and can track any data by web usage.<sup>[25]</sup>

Although browsers such as Internet Explorer 8 and Firefox 3 have added a ‘Privacy Browsing’ setting, they still allow Flash cookies to track the user and operate fully. However, the Flash

player browser plugin can be disabled<sup>[26]</sup> or uninstalled,<sup>[27]</sup> and [Flash cookies can be disabled on a per-site or global basis](#). Adobe's Flash and (PDF) Reader are not the only browser plugins whose past [security](#) defects<sup>[28]</sup> have allowed [spyware](#) or [malware](#) to be installed: there have also been problems with Oracle's Java.<sup>[29]</sup>

## Evercookies<sup>[[edit](#)]</sup>

Main articles: [Zombie cookie](#) and [Evercookie](#)

[Evercookies](#), created by Samy Kamkar,<sup>[30][31]</sup> are JavaScript-based applications which produce cookies in a web browser that actively “resist” deletion by redundantly copying themselves in different forms on the user's machine (e.g., Flash Local Shared Objects, various HTML5 storage mechanisms, window.name caching, etc.), and resurrecting copies that are missing or expired. Evercookie accomplishes this by storing the cookie data in several types of storage mechanisms that are available on the local browser. It has the ability to store cookies in over ten types of storage mechanisms so that once they are on one's computer they will never be gone. Additionally, if evercookie has found the user has removed any of the types of cookies in question, it recreates them using each mechanism available.<sup>[32]</sup> Evercookies are one type of [zombie cookie](#). However, modern browsers and anti-malware software can now block or detect and remove such cookies.

## Photographs on the Internet<sup>[[edit](#)]</sup>



‘No photos’ tag at [Wikimania](#)

Today many people have [digital cameras](#) and post their photographs online, for example [street photography](#) practitioners do so for artistic purposes and [social documentary photography](#) practitioners do so to document the common people in everyday life. The people depicted in these photos might not want to have them appear on the Internet. Police arrest photos, considered public record in many jurisdictions, are often posted on the internet by numerous [online mug shot publishing sites](#).

Some organizations attempt to respond to this privacy-related concern. For example, the 2005

Wikimania conference required that photographers have the prior permission of the people in their pictures, albeit this made it impossible for photographers to practice [candid photography](#) and doing the same in a public place would violate the photographers' [free speech](#) rights. Some people wore a 'no photos' tag to indicate they would prefer not to have their photo taken.<sup>[[citation needed](#)]</sup> [Template:See above photo](#)

The Harvard Law Review published a short piece called "In The Face of Danger: Facial Recognition and Privacy Law", much of it explaining how "privacy law, in its current form, is of no help to those unwillingly tagged."<sup>[37]</sup> Any individual can be unwillingly tagged in a photo and displayed in a manner that might violate them personally in some way, and by the time Facebook gets to taking down the photo, many people will have already had the chance to view, share, or distribute it. Furthermore, traditional tort law does not protect people who are captured by a photograph in public because this is not counted as an invasion of privacy. The extensive Facebook privacy policy covers these concerns and much more. For example, the policy states that they reserve the right to disclose member information or share photos with companies, lawyers, courts, government entities, etc. if they feel it absolutely necessary. The policy also informs users that profile pictures are mainly to help friends connect to each other.<sup>[38]</sup> However, these, as well as other pictures, can allow other people to invade a person's privacy by finding out information that can be used to track and locate a certain individual. In an article featured in ABC News, it was stated that two teams of scientists found out that Hollywood stars could be giving up information about their private whereabouts very easily through pictures uploaded to the Internet. Moreover, it was found that pictures taken by some phones and tablets including [iPhones](#) automatically attach the [latitude](#) and [longitude](#) of the picture taken through [metadata](#) unless this function is manually disabled.<sup>[39]</sup>

Face recognition technology can be used to gain access to a person's private data, according to a new study. Researchers at Carnegie Mellon University combined image scanning, cloud computing and public profiles from social network sites to identify individuals in the offline world. Data captured even included a user's social security number.<sup>[40]</sup> Experts have warned of the privacy risks faced by the increased merging of our online and offline identities. The researchers have also developed an 'augmented reality' mobile app that can display personal data over a person's image captured on a smartphone screen.<sup>[41]</sup> Since these technologies are widely available, our future identities may become exposed to anyone with a smartphone and an Internet connection. Researchers believe this could force us to reconsider our future attitudes to privacy.

## 28. Computer Security

From wikipedia: [https://en.wikipedia.org/wiki/Computer\\_security](https://en.wikipedia.org/wiki/Computer_security)

**Computer security**, also known as **cyber security** or **IT security**, is the protection of [information systems](#) from theft or damage to the [hardware](#), the [software](#), and to the [information](#) on them, as well as from [disruption](#) or [misdirection](#) of the services they provide.<sup>[1]</sup>

It includes [controlling physical access](#) to the hardware, as well as protecting against harm that may come via [network access](#),<sup>[2]</sup> [data](#) and [code injection](#),<sup>[2]</sup> and due to malpractice by operators, whether [intentional](#), [accidental](#), or due to them [being tricked](#) into deviating from secure procedures.<sup>[3]</sup>

The field is of growing importance due to the increasing reliance on computer systems and the [Internet](#) in most societies,<sup>[4]</sup> [wireless networks](#) such as [Bluetooth](#) and [Wi-Fi](#) – and the growth of “[smart](#)” [devices](#), including [smartphones](#), [televisions](#) and tiny devices as part of the [Internet of Things](#).

### Vulnerabilities and attacks<sup>[edit]</sup>

Main article: [Vulnerability \(computing\)](#)

A vulnerability is a system susceptibility or flaw. Many vulnerabilities are documented in the [Common Vulnerabilities and Exposures](#) (CVE) database. An *exploitable* vulnerability is one for which at least one working attack or “[exploit](#)” exists.<sup>[5]</sup>

To secure a computer system, it is important to understand the attacks that can be made against it, and these [threats](#) can typically be classified into one of the categories below:

### Backdoors<sup>[edit]</sup>

A [backdoor](#) in a computer system, a [cryptosystem](#) or an algorithm, is any secret method of bypassing normal authentication or security controls. They may exist for a number of reasons, including by original design or from poor configuration. They may have been added by an authorized party to allow some legitimate access, or by an attacker for malicious reasons; but regardless of the motives for their existence, they create a vulnerability.



## Denial-of-service attack[\[edit\]](#)

[Denial of service attacks](#) are designed to make a machine or network resource unavailable to its intended users.<sup>[6]</sup> Attackers can deny service to individual victims, such as by deliberately entering a wrong password enough consecutive times to cause the victim account to be locked, or they may overload the capabilities of a machine or network and block all users at once. While a network attack from a single IP address can be blocked by adding a new firewall rule, many forms of [Distributed denial of service](#) (DDoS) attacks are possible, where the attack comes from a large number of points – and defending is much more difficult. Such attacks can originate from the [zombie computers](#) of [abotnet](#), but a range of other techniques are possible including [reflection and amplification attacks](#), where innocent systems are fooled into sending traffic to the victim.

## Direct-access attacks[\[edit\]](#)

An unauthorized user gaining physical access to a computer is most likely able to directly copy data from it. They may also compromise security by making [operating system](#) modifications, installing software [worms](#), [keyloggers](#), [covert listening devices](#) or using wireless mice.<sup>[7]</sup> Even when the system is protected by standard security measures, these may be able to be by-passed by booting another operating system or tool from a [CD-ROM](#) or other bootable media. [Disk encryption](#) and [Trusted Platform Module](#) are designed to prevent these attacks.

## Eavesdropping[\[edit\]](#)

[Eavesdropping](#) is the act of surreptitiously listening to a private conversation, typically between hosts on a network. For instance, programs such as [Carnivore](#) and [NarusInsight](#) have been used by the [FBI](#) and [NSA](#) to eavesdrop on the systems of [internet service providers](#). Even machines that operate as a closed system (i.e., with no contact to the outside world) can be eavesdropped upon via monitoring the faint [electro-magnetic](#) transmissions generated by the hardware; [TEMPEST](#) is a specification by the NSA referring to these attacks.

## Spoofing[\[edit\]](#)

[Spoofing](#), in general, is a fraudulent or malicious practice in which communication is sent from an unknown source disguised as a source known to the receiver. Spoofing is most prevalent in communication mechanisms that lack a high level of security.<sup>[8]</sup>



## Tampering[[edit](#)]

[Tampering](#) describes a malicious modification of products. So-called “[Evil Maid](#)” attacks and security services planting of surveillance capability into routers<sup>[9]</sup> are examples.

## Privilege escalation[[edit](#)]

[Privilege escalation](#) describes a situation where an attacker with some level of restricted access is able to, without authorization, elevate their privileges or access level. So for example a standard computer user may be able to fool the system into giving them access to restricted data; or even to “[become root](#)” and have full unrestricted access to a system.

## Phishing[[edit](#)]

[Phishing](#) is the attempt to acquire sensitive information such as usernames, passwords, and credit card details directly from users.<sup>[10]</sup> Phishing is typically carried out by [email spoofing](#) or [instant messaging](#), and it often directs users to enter details at a fake website whose look and feel are almost identical to the legitimate one. Preying on a victim’s trusting, phishing can be classified as a form of [social engineering](#).

## Clickjacking[[edit](#)]

[Clickjacking](#), also known as “UI redress attack” or “User Interface redress attack”, is a malicious technique in which an attacker tricks a user into clicking on a button or link on another webpage while the user intended to click on the top level page. This is done using multiple transparent or opaque layers. The attacker is basically “[hijacking](#)” the clicks meant for the top level page and routing them to some other irrelevant page, most likely owned by someone else. A similar technique can be used to hijack keystrokes. Carefully drafting a combination of stylesheets, iframes, buttons and text boxes, a user can be led into believing that they are typing the password or other information on some authentic webpage while it is being channeled into an invisible frame controlled by the attacker.

## Social engineering[[edit](#)]

Main article: [Social engineering \(security\)](#)

See also: [Category:Cryptographic attacks](#)

[Social engineering](#) aims to convince a user to disclose secrets such as passwords, card numbers, etc. by, for example, impersonating a bank, a contractor, or a customer.<sup>[11]</sup>

A popular and profitable cyber scam involves fake CEO emails sent to accounting and finance departments. In early 2016, the [FBI](#) reported that the scam has cost US businesses more than \$2bn in about two years.<sup>[12]</sup>

In May 2016, the [Milwaukee Bucks NBA](#) team was the victim of this type of cyber scam with a perpetrator impersonating the team's president [Peter Feigin](#), resulting in the handover of all the team's employees' 2015 [W-2](#) tax forms.<sup>[13]</sup>

## Systems at risk[[edit](#)]

Computer security is critical in almost any industry which uses computers. Currently, most electronic devices such as computers, laptops and cellphones come with built in firewall security software, but despite this, computers are not 100 percent accurate and dependable to protect our data (Smith, Grabosky & Urbas, 2004.) There are many different ways of hacking into computers. It can be done through a network system, clicking into unknown links, connecting to unfamiliar Wi-Fi, downloading software and files from unsafe sites, power consumption, electromagnetic radiation waves, and many more. However, computers can be protected through well built software and hardware. By having strong internal interactions of properties, software complexity can prevent software crash and security failure.<sup>[14]</sup>

## Financial systems[[edit](#)]

Web sites and apps that accept or store [credit card numbers](#), brokerage accounts, and [bank account](#) information are prominent hacking targets, because of the potential for immediate financial gain from transferring money, making purchases, or selling the information on the [black market](#).<sup>[15]</sup> In-store payment systems and [ATMs](#) have also been tampered with in order to gather customer account data and [PINs](#).

## Utilities and industrial equipment[\[edit\]](#)

Computers control functions at many utilities, including coordination of [telecommunications](#), the [power grid](#), [nuclear power plants](#), and valve opening and closing in water and gas networks. The Internet is a potential attack vector for such machines if connected, but the [Stuxnet](#) worm demonstrated that even equipment controlled by computers not connected to the Internet can be vulnerable to physical damage caused by malicious commands sent to industrial equipment (in that case [uranium enrichment](#) centrifuges) which are infected via [removable media](#). In 2014, the [Computer Emergency Readiness Team](#), a division of the [Department of Homeland Security](#), investigated 79 hacking incidents at energy companies.<sup>[16]</sup> Vulnerabilities in [smart meters](#) (many of which use local radio or cellular communications) can cause problems with billing fraud.<sup>[17]</sup>

## Aviation[\[edit\]](#)

The [aviation](#) industry is very reliant on a series of complex system which could be attacked.<sup>[18]</sup> A simple power outage at one airport can cause repercussions worldwide,<sup>[19]</sup> much of the system relies on radio transmissions which could be disrupted,<sup>[20]</sup> and controlling aircraft over oceans is especially dangerous because radar surveillance only extends 175 to 225 miles offshore.<sup>[21]</sup> There is also potential for attack from within an aircraft.<sup>[22]</sup>

The consequences of a successful attack range from loss of confidentiality to loss of system integrity, which may lead to more serious concerns such as exfiltration of data, network and [air traffic control](#) outages, which in turn can lead to airport closures, loss of aircraft, loss of passenger life, [damages on the ground](#) and to transportation infrastructure. A successful attack on a [military aviation](#) system that controls [munitions](#) could have even more serious consequences.

Europe has started to move towards centralised aviation network PENS ([Pan-European Network Service](#))<sup>[23]</sup> which do provide a common IP-based network service across the European region covering voice and data communication and later on even more with NewPENS,<sup>[24]</sup> similar USA has in NextGen program.<sup>[25]</sup>

## Consumer devices[\[edit\]](#)

Desktop computers and laptops are commonly infected with malware either to gather passwords or financial account information, or to construct a [botnet](#) to attack another target. [Smart phones](#), [tablet computers](#), [smart watches](#), and other [mobile devices](#) such as [Quantified Self](#) devices like [activity trackers](#) have also become targets and many of these have sensors such as cameras, microphones, GPS receivers, compasses, and [accelerometers](#) which could be exploited, and may collect personal information, including sensitive health information. Wifi, Bluetooth, and cell

phone networks on any of these devices could be used as attack vectors, and sensors might be remotely activated after a successful breach.<sup>[26]</sup>

[Home automation](#) devices such as the [Nest thermostat](#) are also potential targets.<sup>[26]</sup>

## Large corporations<sup>[edit]</sup>

Large corporations are common targets. In many cases this is aimed at financial gain through identity theft and involves [data breaches](#) such as the loss of millions of clients' credit card details by [Home Depot](#),<sup>[27]</sup> [Staples](#),<sup>[28]</sup> and [Target Corporation](#).<sup>[29]</sup> Medical records have been targeted for use in general identify theft, health insurance fraud, and impersonating patients to obtain prescription drugs for recreational purposes or resale.<sup>[30]</sup>

Not all attacks are financially motivated however; for example security firm [HBGary Federal](#) suffered a serious series of attacks in 2011 from hacktivist group [Anonymous](#) in retaliation for the firm's CEO claiming to have infiltrated their group,<sup>[31][32]</sup> and [Sony Pictures was attacked in 2014](#) where the motive appears to have been to embarrass with data leaks, and cripple the company by wiping workstations and servers.<sup>[33][34]</sup>

## Automobiles<sup>[edit]</sup>

If access is gained to a car's internal [controller area network](#), it is possible to disable the brakes and turn the steering wheel.<sup>[35]</sup> Computerized engine timing, [cruise control](#),[anti-lock brakes](#), seat belt tensioners, door locks, [airbags](#) and [advanced driver assistance systems](#) make these disruptions possible, and [self-driving cars](#) go even further.[Connected cars](#) may use wifi and bluetooth to communicate with onboard consumer devices, and the cell phone network to contact concierge and emergency assistance services or get navigational or entertainment information; each of these networks is a potential entry point for malware or an attacker.<sup>[35]</sup> Researchers in 2011 were even able to use a malicious [compact disc](#) in a car's stereo system as a successful attack vector,<sup>[36]</sup> and cars with built-in voice recognition or remote assistance features have onboard microphones which could be used for eavesdropping.

A 2015 report by U.S. Senator Edward Markey criticized manufacturers' security measures as inadequate, and also highlighted privacy concerns about driving, location, and diagnostic data being collected, which is vulnerable to abuse by both manufacturers and hackers.<sup>[37]</sup>

## Government<sup>[edit]</sup>

Government and [military](#) computer systems are commonly attacked by activists<sup>[38][39][40][41]</sup> and

foreign powers.<sup>[42][43][44][45]</sup> Local and regional government infrastructure such as [traffic light controls](#), police and intelligence agency communications, [personnel records](#), student records,<sup>[46]</sup> and financial systems are also potential targets as they are now all largely computerized. [Passports](#) and government [ID cards](#) that control access to facilities which use [RFID](#) can be vulnerable to [cloning](#).

## Internet of Things and physical vulnerabilities[\[edit\]](#)

The [Internet of Things](#) (IoT) is the network of physical objects such as devices, vehicles, and buildings that are [embedded](#) with [electronics](#), [software](#), [sensors](#), and [network connectivity](#) that enables them to collect and exchange data<sup>[47]</sup> – and concerns have been raised that this is being developed without appropriate consideration of the security challenges involved.<sup>[48][49]</sup>

While the IoT creates opportunities for more direct integration of the physical world into computer-based systems,<sup>[50][51]</sup> it also provides opportunities for misuse. In particular, as the Internet of Things spreads widely, cyber attacks are likely to become an increasingly physical (rather than simply virtual) threat.<sup>[52]</sup> If a front door's lock is connected to the Internet, and can be locked/unlocked from a phone, then a criminal could enter the home at the press of a button from a stolen or hacked phone. People could stand to lose much more than their credit card numbers in a world controlled by IoT-enabled devices. Thieves have also used electronic means to circumvent non-Internet-connected hotel door locks.<sup>[53]</sup>

[Medical devices](#) have either been successfully attacked or had potentially deadly vulnerabilities demonstrated, including both in-hospital diagnostic equipment<sup>[54]</sup> and implanted devices including [pacemakers](#)<sup>[55]</sup> and [insulin pumps](#).<sup>[56]</sup>

## Impact of security breaches[\[edit\]](#)

Serious financial damage has been caused by [security breaches](#), but because there is no standard model for estimating the cost of an incident, the only data available is that which is made public by the organizations involved. "Several computer security consulting firms produce estimates of total worldwide losses attributable to [virus](#) and [worm](#) attacks and to hostile digital acts in general. The 2003 loss estimates by these firms range from \$13 billion (worms and viruses only) to \$226 billion (for all forms of covert attacks). The reliability of these estimates is often challenged; the underlying methodology is basically anecdotal."<sup>[57]</sup>

However, reasonable estimates of the financial cost of security breaches can actually help organizations make rational investment decisions. According to the classic [Gordon-Loeb Model](#) analyzing the optimal investment level in information security, one can conclude that the amount a firm spends to protect information should generally be only a small fraction of the expected loss (i.e., the [expected value](#) of the loss resulting from a cyber/information [security breach](#)).<sup>[58]</sup>

## Attacker motivation[\[edit\]](#)

As with [physical security](#), the motivations for breaches of computer security vary between attackers. Some are thrill-seekers or [vandals](#), others are activists or criminals looking for financial gain. State-sponsored attackers are now common and well resourced, but started with amateurs such as [Markus Hess](#) who hacked for the [KGB](#), as recounted by [Clifford Stoll](#), in *[The Cuckoo's Egg](#)*.

A standard part of [threat modelling](#) for any particular system is to identify what might motivate an attack on that system, and who might be motivated to breach it. The level and detail of precautions will vary depending on the system to be secured. A home [personal computer](#), [bank](#), and [classified](#) military [network](#) face very different threats, even when the underlying technologies in use are similar.

## 29. Digital Rights

From wikipedia: [https://en.wikipedia.org/wiki/Digital\\_rights](https://en.wikipedia.org/wiki/Digital_rights) &

[https://en.wikipedia.org/wiki/Information\\_ethics](https://en.wikipedia.org/wiki/Information_ethics)

The term **digital rights** describes the [human rights](#) that allow individuals to access, use, create, and publish [digital media](#) or to access and use [computers](#), other [electronic devices](#), or [communications networks](#). The term is particularly related to the protection and realization of existing rights, such as the [right to privacy](#) or [freedom of expression](#), in the context of new digital technologies, especially the [Internet](#).<sup>[1]</sup> Internet access is recognized as a right by the laws of several countries.<sup>[2]</sup>

### Human rights and the Internet[\[edit\]](#)

A number of [human rights](#) have been identified as relevant with regard to the [Internet](#). These include [freedom of expression](#), data protection and [privacy](#) and [freedom of association](#). Furthermore, the [right to education](#) and [multilingualism](#), [consumer rights](#), and capacity building in the context of the [right to development](#) have also been identified.<sup>[3]</sup>

The [Internet](#) is a global public good that should be accessible to all and respectful of the rights of others, said an influential [Jesuit](#) magazine.

With repressive regimes restricting access to information and communications, democratic governments should work to guarantee access to the Internet and adopt general principles to ensure network use respects universal human rights said an editorial in *La Civiltà Cattolica*, a Jesuit journal reviewed by the Vatican before publication.

“What the law permits or prohibits offline must also be the case online,” said the editorial released Nov. 17.

The “only widespread international consensus” on online material to be censored regards child pornography and cyberterrorism, the article said.

The Jesuit journal said that with individuals abusing the [freedom of expression](#), with companies potentially exploiting computer users for financial gain and repressive regimes blocking information from their citizens, the world needs a “Charter of Human Rights for the Internet”.

The [Electronic Frontier Foundation](#) has criticized the [United States government](#) for considering during the [Megaupload](#) seizure process that people lose [property rights](#) by storing data on a cloud computing service.<sup>[4]</sup>



## Ensuring that access is broadly available and/or preventing unreasonable restrictions[\[edit\]](#)

Several countries have adopted laws that require the state to work to ensure that Internet access is broadly available and/or preventing the state from unreasonably restricting an individual's access to information and the Internet:

- [Costa Rica](#): A 30 July 2010 ruling by the Supreme Court of Costa Rica stated: “Without fear of equivocation, it can be said that these technologies [information technology and communication] have impacted the way humans communicate, facilitating the connection between people and institutions worldwide and eliminating barriers of space and time. At this time, access to these technologies becomes a basic tool to facilitate the exercise of fundamental rights and democratic participation (e-democracy) and citizen control, education, freedom of thought and expression, access to information and public services online, the right to communicate with government electronically and administrative transparency, among others. This includes the fundamental right of access to these technologies, in particular, the right of access to the Internet or World Wide Web.”<sup>[5]</sup>
- [Estonia](#): In 2000, the parliament launched a massive program to expand access to the countryside. The Internet, the government argues, is essential for life in the 21st century.<sup>[6]</sup>
- [Finland](#): By July 2010, every person in Finland was to have access to a one-megabit per second broadband connection, according to the [Ministry of Transport and Communications](#). And by 2015, access to a 100 Mbit/s connection.<sup>[7]</sup>
- [France](#): In June 2009, the [Constitutional Council](#), France’s highest court, declared access to the Internet to be a basic human right in a strongly-worded decision that struck down portions of the [HADOPI law](#), a law that would have tracked abusers and without judicial review and automatically cut off network access to those who continued to download illicit material after two warnings<sup>[8]</sup>
- [Greece](#): Article 5A of the [Constitution of Greece](#) states that all persons has a right to participate in the [Information Society](#) and that the state has an obligation to facilitate the production, exchange, diffusion, and access to electronically transmitted information.<sup>[9]</sup>
- [Spain](#): Starting in 2011, [Telefónica](#), the former state monopoly that holds the country’s “[universal service](#)” contract, has to guarantee to offer “reasonably” priced broadband of at least one megabyte per second throughout Spain.<sup>[10]</sup>

**Information ethics** has been defined as “the branch of ethics that focuses on the relationship between the creation, organization, dissemination, and use of information, and the ethical standards and moral codes governing human conduct in society”.<sup>[1]</sup> It provides a critical framework for considering moral issues concerning informational [privacy](#), moral agency (e.g. whether artificial agents may be moral), new environmental issues (especially how agents should behave in the [infosphere](#)), problems arising from the life-cycle (creation, collection, recording, distribution, processing, etc.) of information (especially ownership and copyright, [digital divide](#), and [digital](#)

rights). Information ethics is related to the fields of [computer ethics](#)<sup>[2]</sup> and the [philosophy of information](#).

Dilemmas regarding the life of information are becoming increasingly important in a society that is defined as “the information society”. Information transmission and literacy are essential concerns in establishing an ethical foundation that promotes fair, equitable, and responsible practices. Information ethics broadly examines issues related to ownership, access, privacy, security, and community.

Information technology affects common issues such as copyright protection, intellectual freedom, accountability, privacy, and security. Many of these issues are difficult or impossible to resolve due to fundamental tensions between Western moral philosophies (based on rules, democracy, individual rights, and personal freedoms) and the traditional Eastern cultures (based on relationships, hierarchy, collective responsibilities, and social harmony).<sup>[3]</sup> The multi-faceted dispute between [Google](#) and the government of the [People's Republic of China](#) reflects some of these fundamental tensions.

Professional codes offer a basis for making ethical decisions and applying ethical solutions to situations involving information provision and use which reflect an organization's commitment to responsible information service. Evolving information formats and needs require continual reconsideration of ethical principles and how these codes are applied. Considerations regarding information ethics influence “personal decisions, professional practice, and [public policy](#)”.<sup>[4]</sup> Therefore, ethical analysis must provide a framework to take into consideration “many, diverse domains” (ibid.) regarding how information is distributed.

The main, peer-reviewed, academic journals reporting on information ethics are the [Journal of the Association for Information Systems](#), the flagship publication of the [Association for Information Systems](#), and [Ethics and Information Technology](#), published by Springer.

## PART VIII

# CHAPTER 8: NET NEUTRALITY AND THE DIGITAL DIVIDE

The Internet, and all the wonderful applications and programs that leverage it, are not readily available in all parts of the world. While adoption and access continues to grow, some are still left out. What impact does this have on the haves and have-nots? What about the level of access people around the world enjoy? In the United States, the vast majority of internet users have access to relatively high data speeds. What if you only had a connection equivalent to a dial-up modem, that you can only use a couple times a week? In addition to issues above (considered in our Digital Divide section), a newer issue of Net Neutrality has emerged over the last decade, that deals with how Internet Carriers (such as Comcast) can charge Internet users. To date, carriers have very little ability to charge users different rates (although phone carriers are different). If I watch 100 hours of streaming video a week on my Comcast connection, and my neighbor checks email once a day, we still pay the same. If Net Neutrality goes away, I may need to pay exponentially more money each month compared to what my neighbor pays for Internet service.

### *Learning Objectives*

After reading this chapter, you will be able to:

- Define and describe net neutrality.
- Define and describe the digital divide.
- Identify ways in which the digital divide impacts countries and Internet users across the globe.

## 30. Net Neutrality

### Net neutrality

From Wikipedia, [https://en.wikipedia.org/wiki/Net\\_neutrality](https://en.wikipedia.org/wiki/Net_neutrality)

**Net neutrality** is the [principle](#) that [Internet service providers](#) and governments regulating the Internet should treat all data on the [Internet](#) the same, not discriminating or charging differentially by user, content, website, platform, application, type of attached equipment, or mode of communication. The term was coined by [Columbia University media law](#) professor [Tim Wu](#) in 2003, as an extension of the longstanding concept of a [common carrier](#), which was used to describe the role of [telephone](#) systems.<sup>[1][2][3][4]</sup>

A widely cited example of a violation of net neutrality principles was when the Internet service provider [Comcast](#) was secretly slowing (colloquially called “[throttling](#)”) uploads from [peer-to-peer file sharing](#) (P2P) applications using forged packets.<sup>[5]</sup> Research suggests that a combination of [policy instruments](#) will help realize the range of valued political and economic objectives central to the network neutrality debate.<sup>[6]</sup> Combined with strong public opinion, this has led some governments to regulate [broadband](#) Internet services as a [public utility](#), similar to the way electricity, gas and water supply is regulated, along with limiting providers and regulating the options those providers can offer.<sup>[7]</sup>

### Discrimination by protocol

Discrimination by protocol is the favoring or blocking information based on aspects of the [communications protocol](#) that the computers are using to communicate.<sup>[18]</sup> In the US, a complaint was filed with the [Federal Communications Commission](#) against the cable provider, [Comcast](#), alleging they had illegally inhibited users of its high-speed Internet service from using popular file-sharing software, [Bit Torrent](#).<sup>[19]</sup> Comcast admitted no wrongdoing<sup>[20]</sup> in its proposed settlement of up to US\$16 dollars per share in December 2009.<sup>[21]</sup> However, a U.S. appeals court ruled in April 2010 that the FCC exceeded its authority when it sanctioned Comcast in 2008 for deliberately preventing some subscribers from using [peer-to-peer file-sharing](#) services to download large files. However, the FCC spokeswoman Jen Howard responded, “the court in no way disagreed with the importance of preserving a free and open Internet, nor did it close the door to other methods for achieving this important end [goal].”<sup>[22]</sup> In spite of the ruling in favor of Comcast, a study by *Measurement Lab* in October 2011 verified that Comcast had virtually stopped its BitTorrent throttling practices.<sup>[23][24]</sup>

## Discrimination by IP address

See also: [IP address blocking](#) and [Deep packet inspection](#)

During the 1990s, creating a non-neutral Internet was technically infeasible.<sup>[25]</sup> Originally developed to filter harmful [malware](#), the Internet security company [NetScreen Technologies](#) released network [firewalls](#) in 2003 with so-called [deep packet inspection](#) capabilities. Deep packet inspection helped make real-time discrimination between different kinds of data possible,<sup>[26]</sup> and is often used for [Internet censorship](#). In a practice called [zero-rating](#), companies will reimburse data use from certain addresses, favoring use of those services. Examples include [Facebook Zero](#)<sup>[27]</sup> and [Google Free Zone](#). These zero-rating practices are especially common in the [developing world](#).<sup>[28]</sup>

Sometimes Internet Service Providers (ISPs) will charge some companies, but not others, for the traffic they cause on the ISP's network. French telecom operator Orange, complaining that traffic from [YouTube](#) and other [Google](#) sites consists of roughly 50% of total traffic on the Orange network, made a deal with Google, in which they charge Google for the traffic incurred on the Orange network.<sup>[29]</sup> Some also thought that Orange's rival ISP Free throttled YouTube traffic. However, an investigation done by the French telecommunications regulatory body revealed that the network was simply congested during peak hours.<sup>[30]</sup>

## Favoring private networks

Proponents of net neutrality argue that without new regulations, Internet service providers would be able to favor their own private protocols over others. ISPs are able to encourage the use of specific services by utilizing private networks to discriminate what data is counted against bandwidth caps. For example, Comcast struck a deal with Microsoft that allowed users to stream television through the Xfinity app on their [Xbox 360s](#) without it affecting their bandwidth limit. However, utilizing other television [streaming](#) apps, such as [Netflix](#), [HBO Go](#), and [Hulu](#), counted towards the limit. Comcast denied that this infringed on net neutrality principles since “it runs its Xfinity for Xbox service on its own, private Internet protocol network.”<sup>[31]</sup>

## Peering discrimination

See also: [Peering](#)

There is some disagreement about whether “peering” is a net neutrality issue.<sup>[32]</sup> In the first quarter of 2014, streaming website Netflix reached an arrangement with ISP Comcast to improve the quality of its service to Netflix clients.<sup>[33]</sup> This arrangement was made in response to

increasingly slow connection speeds through Comcast over the course of 2013, where average speeds dropped by over 25% of their values a year before to an all-time low. After the deal was struck in January 2014, the Netflix speed index recorded a 66% increase in connection. [Netflix](#) agreed to a similar deal with [Verizon](#) in 2014 after Verizon [DSL](#) customers connection speed dropped to less than 1 Mbit/s early in the year. Netflix spoke out against this deal with a controversial statement delivered to all Verizon customers experiencing low connection speeds using the Netflix client.<sup>[34]</sup> This sparked an internal debate between the two companies that led to Verizon obtaining a [cease and desist](#) order on 5 June 2014 that forced Netflix to stop displaying this message.

# 31. Pros and Cons of Net Neutrality

From Wikipedia, [https://en.wikipedia.org/wiki/Net\\_neutrality](https://en.wikipedia.org/wiki/Net_neutrality)

## Arguments in favor

Proponents of net neutrality include [consumer advocates](#), [human rights](#) organizations such as [Article 19](#),<sup>[95]</sup> online companies and some technology companies.<sup>[96]</sup> Many major Internet application companies are advocates of neutrality. [Yahoo!](#), [Vonage](#),<sup>[97]</sup> [eBay](#), [Amazon](#),<sup>[98]</sup> [IAC/InterActiveCorp](#), [Microsoft](#), [Twitter](#), [Tumblr](#), [Etsy](#), [Daily Kos](#), [Greenpeace](#), along with many other companies and organizations, have also taken a stance in support of net neutrality.<sup>[99][100]</sup> [Cogent Communications](#), an international Internet service provider, has made an announcement in favor of certain net neutrality policies.<sup>[101]</sup> In 2008, Google published a statement speaking out against letting broadband providers abuse their market power to affect access to competing applications or content. They further equated the situation to that of the telephony market, where telephone companies are not allowed to control who their customers call or what those customers are allowed to say.<sup>[4]</sup> However, Google's support of net neutrality was called into question in 2014.<sup>[102]</sup> Several civil rights groups, such as the [ACLU](#), the [Electronic Frontier Foundation](#), [Free Press](#), and [Fight for the Future](#) support net neutrality.<sup>[103]</sup>

Individuals who support net neutrality include [World Wide Web](#) inventor [Tim Berners-Lee](#),<sup>[104]</sup> [Vinton Cerf](#),<sup>[105][106]</sup> [Lawrence Lessig](#),<sup>[107]</sup> [Robert W. McChesney](#), [Steve Wozniak](#), [Susan P. Crawford](#), [Marvin Ammori](#), [Ben Scott](#), [David Reed](#),<sup>[108]</sup> and U.S. President [Barack Obama](#).<sup>[109][110]</sup> On 10 November 2014, Obama recommended that the FCC reclassify broadband Internet service as a telecommunications service in order to preserve net neutrality.<sup>[111][112][113]</sup> On 12 November 2014, AT&T stopped build-out of their fiber network until it has "solid net neutrality rules to follow".<sup>[114]</sup> On 31 January 2015, [AP News](#) reported that the FCC will present the notion of applying ("with some caveats") [Title II \(common carrier\)](#) of the [Communications Act of 1934](#) and section 706 of the Telecommunications act of 1996<sup>[115]</sup> to the Internet in a vote expected on 26 February 2015.<sup>[116][117][118][119][120]</sup>

## Control of data

Supporters of net neutrality want to designate [cable companies](#) as [common carriers](#), which would require them to allow [Internet service providers](#) (ISPs) free access to cable lines, the same model used for [dial-up](#) Internet. They want to ensure that cable companies cannot screen, interrupt or filter Internet content without a [court order](#).<sup>[121]</sup> Common carrier status would give the FCC the power to enforce net neutrality rules.<sup>[122]</sup> [SaveTheInternet.com](#) accuses cable and

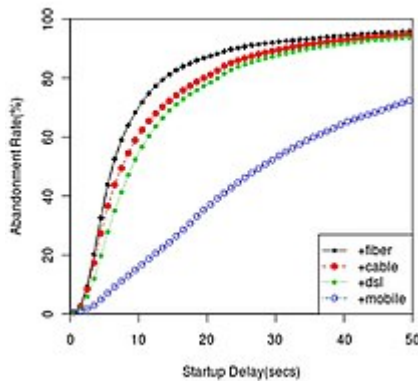


telecommunications companies of wanting the role of gatekeepers, being able to control which websites load quickly, load slowly, or don't load at all. According to SaveTheInternet.com these companies want to charge content providers who require guaranteed speedy data delivery – to create advantages for their own search engines, Internet phone services, and streaming video services – and slowing access or blocking access to those of competitors.<sup>[123]</sup> [Vinton Cerf](#), a co-inventor of the [Internet Protocol](#) and current vice president of Google argues that the Internet was designed without any authorities controlling access to new content or new services.<sup>[124]</sup> He concludes that the principles responsible for making the Internet such a success would be fundamentally undermined were broadband carriers given the ability to affect what people see and do online.<sup>[105]</sup> Cerf has also written about the importance of looking at problems like Net Neutrality through the a combination of the Internet's layered system and the multistakeholder model that governs it.<sup>[125]</sup> He shows how challenges can arise that can implicate Net Neutrality in certain infrastructure-based cases, such as when ISPs to enter into exclusive arrangements with large building owners, leaving the residents unable to exercise any choice in broadband provider.<sup>[126]</sup>

## Digital rights and freedoms

Proponents of net neutrality argue that a neutral net will foster free speech and lead to further democratic participation on the internet. Senator Al Franken from Minnesota fears that without new regulations, the major Internet Service Providers will use their position of power to stifle people's rights. He calls net neutrality the "First Amendment issue of our time."<sup>[127]</sup> By ensuring that all people and websites have equal access to each other, regardless of their ability to pay, proponents of net neutrality wish to prevent the need to pay for speech and the further centralization of media power. [Lawrence Lessig](#) and [Robert W. McChesney](#) argue that net neutrality ensures that the Internet remains a free and open technology, fostering democratic communication. Lessig and McChesney go on to argue that the monopolization of the Internet would stifle the diversity of independent news sources and the generation of innovative and novel web content.<sup>[107]</sup>

## User intolerance for slow-loading sites



Users with faster Internet connectivity (e.g., fiber) abandon a slow-loading video at a faster rate than users with slower Internet connectivity (e.g., cable or mobile).<sup>[128]</sup> A “fast lane” in the Internet can irrevocably decrease the user’s tolerance to the relative slowness of the “slow lane”.

Proponents of net neutrality invoke the human psychological process of adaptation where when people get used to something better, they would not ever want to go back to something worse. In the context of the Internet, the proponents argue that a user who gets used to the “fast lane” on the Internet would find the “slow lane” intolerable in comparison, greatly disadvantaging any provider who is unable to pay for the “fast lane”. Video providers Netflix<sup>[129]</sup> and Vimeo<sup>[130]</sup> in their comments to FCC in favor of net neutrality use the research<sup>[128]</sup> of S.S. Krishnan and [Ramesh Sitaraman](#) that provides the first quantitative evidence of adaptation to speed among online video users. Their research studied the patience level of millions of Internet video users who waited for a slow-loading video to start playing. Users who had a faster Internet connectivity, such as fiber-to-the-home, demonstrated less patience and abandoned their videos sooner than similar users with slower Internet connectivity. The results demonstrate how users can get used to faster Internet connectivity, leading to higher expectation of Internet speed, and lower tolerance for any delay that occurs. Author [Nicholas Carr](#)<sup>[131]</sup> and other social commentators<sup>[132][133]</sup> have written about the habituation phenomenon by stating that a faster flow of information on the Internet can make people less patient.

## Competition and innovation

Net neutrality advocates argue that allowing cable companies the right to demand a toll to guarantee quality or premium delivery would create an exploitative business model based on the ISPs position as [gatekeepers](#).<sup>[134]</sup> Advocates warn that by charging websites for access, network owners may be able to block competitor Web sites and services, as well as refuse access to those unable to pay.<sup>[107]</sup> According to Tim Wu, cable companies plan to reserve bandwidth for their

own television services, and charge companies a toll for priority service.<sup>[135]</sup> Proponents of net neutrality argue that allowing for preferential treatment of Internet traffic, or [tiered service](#), would put newer online companies at a disadvantage and slow innovation in online services.<sup>[96]</sup> [Tim Wu](#) argues that, without network neutrality, the Internet will undergo a transformation from a market ruled by innovation to one ruled by deal-making.<sup>[135]</sup> [SaveTheInternet.com](#) argues that net neutrality puts everyone on equal terms, which helps drive innovation. They claim it is a preservation of the way the internet has always operated, where the quality of websites and services determined whether they succeeded or failed, rather than deals with ISPs.<sup>[123]</sup> [Lawrence Lessig](#) and [Robert W. McChesney](#) argue that eliminating net neutrality would lead to the Internet resembling the world of cable TV, so that access to and distribution of content would be managed by a handful of massive, near monopolistic companies, though there are multiple service providers in each region. These companies would then control what is seen as well as how much it costs to see it. Speedy and secure Internet use for such industries as health care, finance, retailing, and gambling could be subject to large fees charged by these companies. They further explain that a majority of the great innovators in the history of the Internet started with little capital in their garages, inspired by great ideas. This was possible because the protections of net neutrality ensured limited control by owners of the networks, maximal competition in this space, and permitted innovators from outside access to the network. Internet content was guaranteed a free and highly competitive space by the existence of net neutrality.<sup>[107]</sup>

## Preserving Internet standards

Net neutrality advocates have sponsored legislation claiming that authorizing incumbent network providers to override transport and application layer separation on the Internet would signal the decline of fundamental Internet standards and international consensus authority. Further, the legislation asserts that bit-shaping the transport of application data will undermine the transport layer's designed flexibility.<sup>[136]</sup>

## Preventing pseudo-services

Alok Bhardwaj, founder of [Epic Privacy Browser](#), argues that any violations to network neutrality, realistically speaking, will not involve genuine investment but rather payoffs for unnecessary and dubious services. He believes that it is unlikely that new investment will be made to lay special networks for particular websites to reach end-users faster. Rather, he believes that non-net neutrality will involve leveraging quality of service to extract remuneration from websites that want to avoid being slowed down.<sup>[137][138]</sup>

# End-to-end principle

Main article: [End-to-end principle](#)

Some advocates say network neutrality is needed in order to maintain the end-to-end principle. According to [Lawrence Lessig](#) and [Robert W. McChesney](#), all content must be treated the same and must move at the same speed in order for net neutrality to be true. They say that it is this simple but brilliant end-to-end aspect that has allowed the Internet to act as a powerful force for economic and social good.<sup>[107]</sup> Under this principle, a neutral network is a [dumb network](#), merely passing packets regardless of the applications they support. This point of view was expressed by David S. Isenberg in his paper, “The Rise of the Stupid Network”. He states that the vision of an intelligent network is being replaced by a new network philosophy and architecture in which the network is designed for always-on use, not intermittence and scarcity. Rather than intelligence being designed into the network itself, the intelligence would be pushed out to the end-user’s device; and the network would be designed simply to deliver bits without fancy network routing or smart number translation. The data would be in control, telling the network where it should be sent. End-user devices would then be allowed to behave flexibly, as bits would essentially be free and there would be no assumption that the data is of a single data rate or data type.<sup>[139]</sup>

Contrary to this idea, the research paper titled *End-to-end arguments in system design* by Saltzer, Reed, and Clark<sup>[140]</sup> argues that [network intelligence](#) doesn’t relieve end systems of the requirement to check inbound data for errors and to rate-limit the sender, nor for a wholesale removal of intelligence from the network core.

## Arguments against

Opponents of net neutrality regulations include civil rights groups, economists, internet providers and technologists. Among corporations, opponents include [AT&T](#), [Verizon](#), [IBM](#), [Intel](#), [Cisco](#), [Nokia](#), [Qualcomm](#), [Broadcom](#), [Juniper](#), [dLink](#), [Wintel](#), [Alcatel-Lucent](#), [Corning](#), [Panasonic](#), [Ericsson](#), and others.<sup>[73][141][142]</sup> Notable technologists who oppose net neutrality include [Marc Andreessen](#), [Scott McNealy](#), [Peter Thiel](#), [David Farber](#), [Nicholas Negroponte](#), [Rajeev Suri](#), [Jeff Pulver](#), [John Perry Barlow](#), and [Bob Kahn](#).<sup>[143][144][145][146][147][148][149][150][151][152]</sup>

Nobel Prize-winning economist [Gary Becker](#)’s paper titled, “Net Neutrality and Consumer Welfare”, published by the *Journal of Competition Law & Economics*, alleges that claims by net neutrality proponents “do not provide a compelling rationale for regulation” because there is “significant and growing competition” among broadband access providers.<sup>[144][153]</sup> Google Chairman [Eric Schmidt](#) states that, while Google views that similar data types should not be discriminated against, it is okay to discriminate across different data types—a position that both Google and Verizon generally agree on, according to Schmidt.<sup>[154][155]</sup> According to the Journal, when President Barack Obama announced his support for strong net neutrality rules late in 2014, Schmidt told a top White House official the president was making a mistake.<sup>[155]</sup>

Several civil rights groups, such as the [National Urban League](#), [Jesse Jackson's Rainbow/PUSH](#), and [League of United Latin American Citizens](#), also oppose Title II net neutrality regulations,<sup>[156]</sup> who said that the call to regulate broadband Internet service as a utility would harm minority communities by stifling investment in undeserved areas.<sup>[157][158]</sup>

A number of other opponents created *Hands Off The Internet*,<sup>[159]</sup> a website created in 2006 to promote arguments against internet regulation. Principal financial support for the website came from AT&T, and members included [BellSouth](#), [Alcatel](#), [Cingular](#), and [Citizens Against Government Waste](#).<sup>[160][161][162][163][164]</sup>

[Robert Pepper](#), a senior managing director, global advanced technology policy, at [Cisco Systems](#), and former FCC chief of policy development, says: “The supporters of net neutrality regulation believe that more rules are necessary. In their view, without greater regulation, service providers might parcel out bandwidth or services, creating a bifurcated world in which the wealthy enjoy first-class Internet access, while everyone else is left with slow connections and degraded content. That scenario, however, is a false paradigm. Such an all-or-nothing world doesn’t exist today, nor will it exist in the future. Without additional regulation, service providers are likely to continue doing what they are doing. They will continue to offer a variety of broadband service plans at a variety of price points to suit every type of consumer”.<sup>[165]</sup> Computer scientist [Bob Kahn](#)<sup>[150]</sup> has said net neutrality is a slogan that would freeze innovation in the core of the Internet.<sup>[143]</sup>

Farber has written and spoken strongly in favor of continued research and development on core Internet protocols. He joined academic colleagues Michael Katz, [Christopher Yoo](#), and Gerald Faulhaber in an op-ed for the [Washington Post](#) strongly critical of network neutrality, essentially stating that while the Internet is in need of remodeling, congressional action aimed at protecting the best parts of the current Internet could interfere with efforts to build a replacement.<sup>[166]</sup>

## Reduction in innovation and investments

According to a letter to key Congressional and FCC leaders sent by 60 major ISP technology suppliers including IBM, Intel, Qualcomm, and Cisco, Title II regulation of the internet “means that instead of billions of broadband investment driving other sectors of the economy forward, any reduction in this spending will stifle growth across the entire economy. This is not idle speculation or fear mongering...Title II is going to lead to a slowdown, if not a hold, in broadband build out, because if you don’t know that you can recover on your investment, you won’t make it.”<sup>[73][167][168][169]</sup> According to the [Wall Street Journal](#), in one of Google’s few lobbying sessions with FCC officials, the company urged the agency to craft rules that encourage investment in broadband Internet networks—a position that mirrors the argument made by opponents of strong net neutrality rules, such as AT&T and Comcast.<sup>[155]</sup> Opponents of net neutrality argue that prioritization of bandwidth is necessary for future innovation on the Internet.<sup>[142]</sup> Telecommunications providers such as telephone and cable companies, and some technology companies that supply networking gear, argue telecom providers should have the ability to provide preferential treatment in the form of [tiered services](#), for example by giving online companies willing to pay the ability to transfer their data packets faster than other Internet traffic.<sup>[170]</sup> The

added revenue from such services could be used to pay for the building of increased broadband access to more consumers.<sup>[96]</sup>

Opponents say that net neutrality would make it more difficult for [Internet service providers](#) (ISPs) and other network operators to recoup their investments in broadband networks.<sup>[171]</sup> John Thorne, senior vice president and deputy general counsel of [Verizon](#), a [broadband](#) and [telecommunications](#) company, has argued that they will have no incentive to make large investments to develop advanced fibre-optic networks if they are prohibited from charging higher preferred access fees to companies that wish to take advantage of the expanded capabilities of such networks. Thorne and other ISPs have accused Google and [Skype](#) of freeloading or free riding for using a network of lines and cables the phone company spent billions of dollars to build.<sup>[142][172][173]</sup> [Marc Andreessen](#) states that “a pure net neutrality view is difficult to sustain if you also want to have continued investment in broadband networks. If you’re a large telco right now, you spend on the order of \$20 billion a year on [capex](#) [capital expenditure]. You need to know how you’re going to get a [return on that investment](#). If you have these pure net neutrality rules where you can never charge a company like Netflix anything, you’re not ever going to get a return on continued network investment — which means you’ll stop investing in the network. And I would not want to be sitting here 10 or 20 years from now with the same broadband speeds we’re getting today.”<sup>[174]</sup>

## Counterweight to server-side non-neutrality

Those in favor of forms of non-neutral tiered Internet access argue that the Internet is already not a level playing field: large companies achieve a performance advantage over smaller competitors by providing more and better-quality servers and buying high-bandwidth services. Should prices drop for lower levels of access, or access to only certain protocols, for instance, a change of this type would make Internet usage more neutral, with respect to the needs of those individuals and corporations specifically seeking differentiated tiers of service. Network expert<sup>[175]</sup> Richard Bennett has written, “A richly funded Web site, which delivers data faster than its competitors to the front porches of the Internet service providers, wants it delivered the rest of the way on an equal basis. This system, which Google calls broadband neutrality, actually preserves a more fundamental inequality.”<sup>[176]</sup>

## Broadband infrastructure

Proponents of net neutrality regulations say network operators have continued to under-invest in infrastructure.<sup>[177]</sup> However, according to Copenhagen Economics, US investment in telecom infrastructure is 50 percent higher than that of the European Union. As a share of GDP, The US’s broadband investment rate per GDP trails only the UK and South Korea slightly, but exceeds Japan, Canada, Italy, Germany, and France sizably.<sup>[178]</sup> On broadband speed, Akamai reported that the US



trails only South Korea and Japan among its major trading partners, and trails only Japan in the G-7 in both average peak connection speed and percentage of the population connection at 10 Mbit/s or higher, but are substantially ahead of most of its other major trading partners.<sup>[178]</sup>

The White House reported in June 2013 that U.S. connection speeds are “the fastest compared to other countries with either a similar population or land mass.”<sup>[179]</sup> Akamai’s report on “The State of the Internet” in the 2nd quarter of 2014 says “a total of 39 states saw 4K readiness rate more than double over the past year.” In other words, as ZDNet reports, those states saw a “major” increase in the availability of the 15Mbit/s speed needed for 4K video.<sup>[180]</sup> According to the [Progressive Policy Institute](#) and ITU data, the United States has the most affordable entry-level prices for fixed broadband in the OECD.<sup>[178][181]</sup>

In Indonesia, there is a very high number of Internet connections that are subjected to exclusive deals between the ISP and the building owner, and changing this dynamic could unlock much more consumer choice and higher speeds.<sup>[126]</sup> FCC Commissioner Ajit Pai and Federal Election Commission’s Lee Goldman wrote in a Politico piece in February 2015, “Compare Europe, which has long had utility-style regulations, with the United States, which has embraced a light-touch regulatory model. Broadband speeds in the United States, both wired and wireless, are significantly faster than those in Europe. Broadband investment in the United States is several multiples that of Europe. And broadband’s reach is much wider in the United States, despite its much lower population density.”<sup>[182]</sup>

## Significant and growing competition

A 2010 paper on net neutrality by Nobel Prize economist [Gary Becker](#) and his colleagues stated that “there is significant and growing competition among broadband access providers and that few significant competitive problems have been observed to date, suggesting that there is no compelling competitive rationale for such regulation.”<sup>[153]</sup> Becker and fellow economists Dennis Carlton and Hal Sidler found that “Between mid-2002 and mid-2008, the number of high-speed broadband access lines in the United States grew from 16 million to nearly 133 million, and the number of residential broadband lines grew from 14 million to nearly 80 million. Internet traffic roughly tripled between 2007 and 2009. At the same time, prices for broadband Internet access services have fallen sharply.”<sup>[153]</sup> The PPI reports that the profit margins of U.S. broadband providers are generally one-sixth to one-eighth of companies that use broadband (such as Apple or Google), contradicting the idea of monopolistic price-gouging by providers.<sup>[178]</sup>

## Broadband choice

A report by the [Progressive Policy Institute](#) in June 2014 argues that nearly every American can choose from at least 5-6 broadband internet service providers, despite claims that there are only a ‘small number’ of broadband providers.<sup>[178]</sup> Citing research from the FCC, the Institute wrote that



90 percent of American households have access to at least one wired and one wireless broadband provider at speeds of at least 4 [Mbit/s](#) (500 [kbyte/s](#)) downstream and 1 Mbit/s (125 kbyte/s) upstream and that nearly 88 percent of Americans can choose from at least two wired providers of broadband disregarding speed (typically choosing between a cable and telco offering). Further, three of the four national wireless companies report that they offer 4G LTE to between 250-300 million Americans, with the fourth (T-Mobile) sitting at 209 million and counting.<sup>[178]</sup> Similarly, the FCC reported in June 2008 that 99.8 percent of zip codes in the United States had two or more providers of high speed Internet lines available, and 94.6 percent of zip codes had four or more providers, as reported by University of Chicago economists Gary Becker, Dennis Carlton, and Hal Sider in a 2010 paper.<sup>[153]</sup>

When FCC Chairman Tom Wheeler redefined broadband from 4 Mbit/s to 25 Mbit/s (3.125 [MB/s](#)) or greater in January 2015, FCC commissioners Ajit Pai and Mike O'Reilly believed the redefinition was to set up the agency's intent to settle the net neutrality fight with new regulations. The commissioners argued that the stricter speed guidelines painted the broadband industry as less competitive, justifying the FCC's moves with Title II net neutrality regulations.<sup>[183]</sup>

## Deterring competition

FCC commissioner [Ajit Pai](#) states that the FCC completely brushes away the concerns of smaller competitors who are going to be subject to various taxes, such as state property taxes and general receipts taxes.<sup>[184]</sup> As a result, according to Pai, that does nothing to create more competition within the market.<sup>[184]</sup> According to Pai, the FCC's ruling to impose Title II regulations is opposed by the country's smallest private competitors and many municipal broadband providers.<sup>[185]</sup> In his dissent, Pai noted that 142 wireless ISPs (WISPs) said that FCC's new "regulatory intrusion into our businesses...would likely force us to raise prices, delay deployment expansion, or both." He also noted that 24 of the country's smallest ISPs, each with fewer than 1,000 residential broadband customers, wrote to the FCC stating that Title II "will badly strain our limited resources" because they "have no in-house attorneys and no budget line items for outside counsel." Further, another 43 municipal broadband providers told the FCC that Title II "will trigger consequences beyond the Commission's control and risk serious harm to our ability to fund and deploy broadband without bringing any concrete benefit for consumers or edge providers that the market is not already proving today without the aid of any additional regulation."<sup>[141]</sup>

## Potentially increased taxes

FCC commissioner [Ajit Pai](#), who opposed the net neutrality ruling, claims that the ruling issued by the FCC to impose Title II regulations explicitly opens the door to billions of dollars in new fees and taxes on broadband by subjecting them to the telephone-style taxes under the Universal Service Fund. Net neutrality proponent [Free Press](#) argues that, "the average potential

increase in taxes and fees per household would be far less” than the estimate given by net neutrality opponents, and that if there were to be additional taxes, the tax figure may be around \$4 billion. Under favorable circumstances, “the increase would be exactly zero.”<sup>[186]</sup> Meanwhile, the [Progressive Policy Institute](#) claims that Title II could trigger taxes and fees up to \$11 billion a year.<sup>[187]</sup> Financial website *Nerd Wallet* did their own assessment and settled on a possible \$6.25 billion tax impact, estimating that the average American household may see their tax bill increase \$67 annually.<sup>[187]</sup>

FCC spokesperson Kim Hart said that the ruling “does not raise taxes or fees. Period.”<sup>[187]</sup> However, the opposing commissioner, Ajit Pai, claims that “the plan explicitly opens the door to billions of dollars in new taxes on broadband...These new taxes will mean higher prices for consumers and more hidden fees that they have to pay.”<sup>[188]</sup> Pai explained that, “One avenue for higher bills is the new taxes and fees that will be applied to broadband. Here’s the background. If you look at your phone bill, you’ll see a ‘Universal Service Fee,’ or something like it. These fees — what most Americans would call taxes — are paid by Americans on their telephone service. They funnel about \$9 billion each year through the FCC. Consumers haven’t had to pay these taxes on their broadband bills because broadband has never before been a Title II service. But now it is. And so the Order explicitly opens the door to billions of dollars in new taxes.”<sup>[141]</sup>

## Prevent overuse of bandwidth

Since the early 1990s, Internet traffic has increased steadily. The arrival of picture-rich websites and [MP3s](#) led to a sharp increase in the mid-1990s followed by a subsequent sharp increase since 2003 as [video streaming](#) and [Peer-to-peer file sharing](#) became more common.<sup>[189][190]</sup> In reaction to companies including [YouTube](#), as well as smaller companies starting to offer free video content, using substantial amounts of bandwidth, at least one [Internet service provider](#) (ISP), [SBC Communications](#) (now [AT&T Inc.](#)), has suggested that it should have the right to charge these companies for making their content available over the provider’s network.<sup>[191]</sup>

Bret Swanson of the [Wall Street Journal](#) wrote in 2007 that the popular websites of that time, including YouTube, [MySpace](#), and blogs, were put at risk by net neutrality. He noted that, at the time, YouTube streamed as much data in three months as the world’s radio, cable and broadcast television channels did in one year, 75 [petabytes](#). He argued that networks were not remotely prepared to handle the amount of data required to run these sites. He also argued that net neutrality would prevent broadband networks from being built, which would limit available bandwidth and thus endanger innovation.<sup>[192]</sup> One example of these concerns was the “[series of tubes](#)” analogy, which was presented by US senator [Ted Stevens](#) during a committee hearing in the US senate in 2006.

## High costs to entry for cable broadband

According to a [Wired](#) magazine article by TechFreedom's Berin Szoka, Matthew Starr, and Jon Henke, local governments and public utilities impose the most significant barriers to entry for more cable broadband competition: "While popular arguments focus on supposed 'monopolists' such as big cable companies, it's government that's really to blame." The authors state that local governments and their public utilities charge ISPs far more than they actually cost and have the final say on whether an ISP can build a network. The public officials determine what requirements an ISP must meet to get approval for access to publicly owned "rights of way" (which lets them place their wires), thus reducing the number of potential competitors who can profitably deploy Internet service—such as AT&T's U-Verse, Google Fiber, and Verizon FiOS. Kickbacks may include municipal requirements for ISPs such as building out service where it isn't demanded, donating equipment, and delivering free broadband to government buildings.<sup>[193]</sup>

## Unnecessary regulations

According to [PayPal](#) founder and [Facebook](#) investor [Peter Thiel](#), "Net neutrality has not been necessary to date. I don't see any reason why it's suddenly become important, when the Internet has functioned quite well for the past 15 years without it.... Government attempts to regulate technology have been extraordinarily counterproductive in the past."<sup>[144]</sup> [Max Levchin](#), the other co-founder of PayPal, echoed similar statements, telling CNBC, "The Internet is not broken, and it got here without government regulation and probably in part because of lack of government regulation."<sup>[194]</sup> Opponents of new federal net neutrality policies point to the success of the internet as a sign that new regulations are not necessary. They argue that the freedom which websites, ISPs and consumers have had to settle their own disputes and compete through innovation is the reason why the internet has been such a rapid success. One of Congress's most outspoken critics of net neutrality regulations is Senator Ted Cruz from Texas, who points out that "innovation [on the internet] is happening without having to go to government and say 'Mother, may I?' What happens when the government starts regulating a service as a public utility is it calcifies everything and freezes it in place."<sup>[195]</sup> In regulating how the internet is provided, opponents argue that the government will hinder innovation on the web.

FCC Commissioner [Ajit Pai](#), who was one of the two commissioners who opposed the net neutrality proposal, criticized the FCC's ruling on internet neutrality, stating that the perceived threats from ISPs to deceive consumers, degrade content, or disfavor the content that they don't like are non-existent: "The evidence of these continuing threats? There is none; it's all anecdote, hypothesis, and hysteria. A small ISP in North Carolina allegedly blocked VoIP calls a decade ago. Comcast capped BitTorrent traffic to ease upload congestion eight years ago. Apple introduced Facetime over Wi-Fi first, cellular networks later. Examples this picayune and stale aren't enough to tell a coherent story about net neutrality. The bogeyman never had it so easy."<sup>[141]</sup> FCC Commissioner Mike O'Reilly, the other opposing commissioner, also claims that the ruling is

a solution to a hypothetical problem, “Even after enduring three weeks of spin, it is hard for me to believe that the Commission is establishing an entire Title II/net neutrality regime to protect against hypothetical harms. There is not a shred of evidence that any aspect of this structure is necessary. The D.C. Circuit called the prior, scaled-down version a ‘prophylactic’ approach. I call it guilt by imagination.”<sup>[196]</sup> In a [Chicago Tribune](#) article, FCC Commissioner Pai and [Joshua Wright](#) of the [Federal Trade Commission](#) argue that “the Internet isn’t broken, and we don’t need the president’s plan to ‘fix’ it. Quite the opposite. The Internet is an unparalleled success story. It is a free, open and thriving platform.”<sup>[74]</sup>

# 32. The Digital Divide

## The Digital Divide

From Wikipedia, [https://en.wikipedia.org/wiki/Digital\\_divide](https://en.wikipedia.org/wiki/Digital_divide)

A **digital divide** is an [economic](#) and [social inequality](#) with regard to access to, use of, or impact of [information and communication technologies](#)(ICT).<sup>[1]</sup> The divide within countries (such as the [digital divide in the United States](#)) may refer to inequalities between individuals, households, businesses, or geographic areas, usually at different [socioeconomic](#) levels or other demographic categories. The divide between differing countries or regions of the world is referred to as the [global digital divide](#),<sup>[1][2]</sup> examining this technological gap between developing and developed countries on an international scale.<sup>[3]</sup>

## Definitions and usage

The term *digital divide* describes a gap in terms of access to and usage of [information and communication technology](#). It was traditionally considered to be a question of having or not having access,<sup>[4]</sup> but with a global [mobile phone](#) penetration of over 95%,<sup>[5]</sup> it is becoming a relative inequality between those who have more and less bandwidth<sup>[6]</sup> and more or less skills.<sup>[7][8][9][10]</sup> Conceptualizations of the digital divide have been described as “who, with which characteristics, connects how to what”:<sup>[11]</sup>

- Who is the subject that connects: individuals, organizations, enterprises, schools, hospitals, countries, etc.
- Which characteristics or attributes are distinguished to describe the divide: income, education, age, geographic location, motivation, reason not to use, etc.
- How sophisticated is the usage: mere access, retrieval, interactivity, intensive and extensive in usage, innovative contributions, etc.
- To what does the subject connect: fixed or mobile, Internet or telephony, digital TV, broadband, etc.

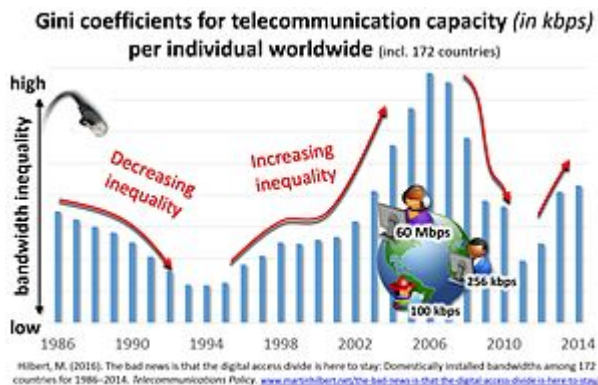
Different authors focus on different aspects, which leads to a large variety of definitions of the digital divide. “For example, counting with only 3 different choices of subjects (individuals, organizations, or countries), each with 4 characteristics (age, wealth, geography, sector), distinguishing between 3 levels of digital adoption (access, actual usage and effective adoption), and 6 types of technologies (fixed phone, mobile... Internet...), already results in  $3 \times 4 \times 3 \times 6 = 216$

different ways to define the digital divide. Each one of them seems equally reasonable and depends on the objective pursued by the analyst”.<sup>[11]</sup>

## Means of connectivity

### Infrastructure

The infrastructure by which individuals, households, businesses, and communities connect to the Internet address the physical mediums that people use to connect to the Internet such as desktop computers, laptops, basic mobile phones or [smart phones](#), iPods or other MP3 players, gaming consoles such as Xbox or PlayStation, electronic book readers, and tablets such as iPads.<sup>[12]</sup>



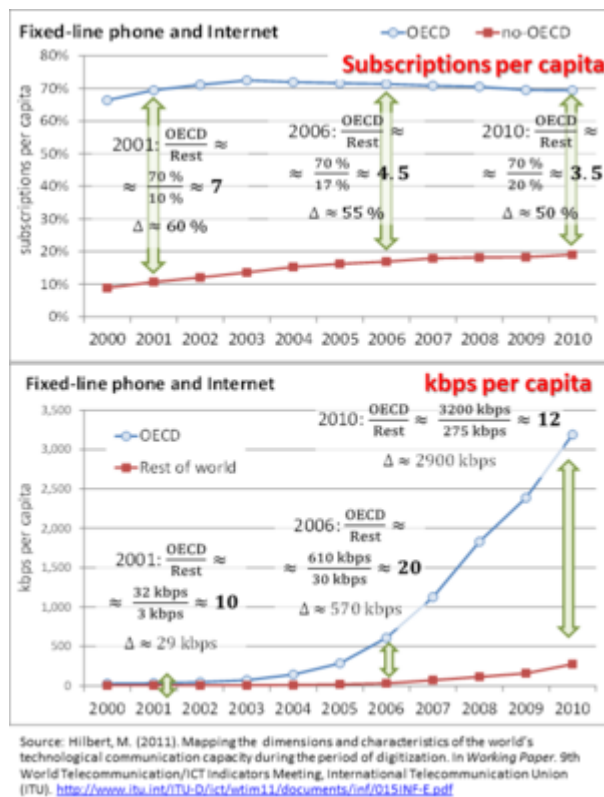
The digital divide measured in terms of bandwidth is not closing, but fluctuating up and down. Gini coefficients for telecommunication capacity (in kbit/s) among individuals worldwide.<sup>[13]</sup>

Traditionally the nature of the divide has been measured in terms of the existing numbers of subscriptions and digital devices. Given the increasing number of such devices, some have concluded that the digital divide among individuals has increasingly been closing as the result of a natural and almost automatic process.<sup>[4][14]</sup> Others point to persistent lower levels of connectivity among women, racial and ethnic minorities, people with lower incomes, rural residents, and less educated people as evidence that addressing inequalities in access to and use of the medium will require much more than the passing of time.<sup>[7][15][16]</sup> Recent studies have measured the digital divide not in terms of technological devices, but in terms of the existing bandwidth per individual (in kbit/s per capita).<sup>[6][13]</sup> As shown in the Figure on the side, the digital divide in kbit/s is not monotonically decreasing, but re-opens up with each new innovation. For example, “the massive diffusion of narrow-band Internet and mobile phones during the late 1990s” increased digital inequality, as well as “the initial introduction of broadband DSL and cable modems during 2003–2004 increased levels of inequality”.<sup>[6]</sup> This is because a new kind of connectivity is never introduced instantaneously and uniformly to society as a whole at once, but diffuses slowly



through social networks. As shown by the Figure, during the mid-2000s, communication capacity was more unequally distributed than during the late 1980s, when only fixed-line phones existed. The most recent increase in digital equality stems from the massive diffusion of the latest digital innovations (i.e. fixed and mobile broadband infrastructures, e.g. 3G and fiber optics FTTH).<sup>[17]</sup> Measurement methodologies of the digital divide, and more specifically an Integrated Iterative Approach General Framework (Integrated Contextual Iterative Approach – ICI) and the digital divide modeling theory under measurement model DDG (Digital Divide Gap) are used to analyze the gap existing between developed and developing countries, and the gap among the 27 members-states of the European Union.<sup>[18][19]</sup>

### *The bit as the unifying variable*



Fixed-line phone and Internet 2000–2010: subscriptions (top) and kbit/s (bottom) per capita<sup>[20]</sup>

Instead of tracking various kinds of digital divides among fixed and mobile phones, narrow- and broadband Internet, digital TV, etc., it has recently been suggested to simply measure the amount of kbit/s per actor.<sup>[6][13][21][22]</sup> This approach has shown that the digital divide in kbit/s per capita is actually widening in relative terms: “While the average inhabitant of the developed world counted with some 40 kbit/s more than the average member of the information society in developing countries in 2001, this gap grew to over 3 Mbit/s per capita in 2010.”<sup>[22]</sup> The upper graph of the Figure on the side shows that the divide between developed and developing countries



has been diminishing when measured in terms of subscriptions per capita. In 2001, fixed-line telecommunication penetration reached 70% of society in developed [OECD](#) countries and 10% of the developing world. This resulted in a ratio of 7 to 1 (divide in relative terms) or a difference of 60% (divide in measured in absolute terms). During the next decade, fixed-line penetration stayed almost constant in OECD countries (at 70%), while the rest of the world started a catch-up, closing the divide to a ratio of 3.5 to 1. The lower graph shows the divide not in terms of ICT devices, but in terms of kbit/s per inhabitant. While the average member of developed countries counted with 29 kbit/s more than a person in developing countries in 2001, this difference got multiplied by a factor of one thousand (to a difference of 2900 kbit/s). In relative terms, the fixed-line capacity divide was even worse during the introduction of broadband Internet at the middle of the first decade of the 2000s, when the OECD counted with 20 times more capacity per capita than the rest of the world.<sup>[6]</sup> This shows the importance of measuring the divide in terms of kbit/s, and not merely to count devices. The International Telecommunications Union concludes that “the bit becomes a unifying variable enabling comparisons and aggregations across different kinds of communication technologies”.<sup>[23]</sup>

## Skills and digital literacy

However, research shows that the digital divide is more than just an access issue and cannot be alleviated merely by providing the necessary equipment. There are at least three factors at play: information accessibility, information utilization and information receptiveness. More than just accessibility, individuals need to know how to make use of the information and communication tools once they exist within a community.<sup>[24]</sup> Information professionals have the ability to help bridge the gap by providing reference and information services to help individuals learn and utilize the technologies to which they do have access, regardless of the economic status of the individual seeking help.<sup>[25]</sup>

## Location

Internet connectivity can be utilized at a variety of locations such as homes, offices, schools, libraries, public spaces, Internet cafe and others. There are also varying levels of connectivity in rural, suburban, and urban areas.<sup>[26][27]</sup>

## Applications

[Common Sense Media](#), a nonprofit group based in San Francisco, surveyed almost 1,400 parents

and reported in 2011 that 47 percent of families with incomes more than \$75,000 had downloaded [apps](#) for their children, while only 14 percent of families earning less than \$30,000 had done so.<sup>[28]</sup>

## Reasons and correlating variables

The gap in a digital divide may exist for a number of reasons. Obtaining access to ICTs and using them actively has been linked to a number of demographic and socio-economic characteristics: among them income, education, race, gender, geographic location (urban-rural), age, skills, awareness, political, cultural and psychological attitudes.<sup>[29][30][31][32][33][34][35][36]</sup> [Multiple regression](#) analysis across countries has shown that income levels and educational attainment are identified as providing the most powerful explanatory variables for ICT access and usage.<sup>[37]</sup> Evidence was found that caucasians are much more likely than non-caucasians to own a computer as well as have access to the Internet in their homes. As for geographic location, people living in urban centers have more access and show more usage of computer services than those in rural areas. Gender was previously thought to provide an explanation for the digital divide, many thinking ICT were male gendered, but controlled statistical analysis has shown that income, education and employment act as [confounding variables](#) and that women with the same level of income, education and employment actually embrace ICT more than men (see [Women and ICT4D](#)).<sup>[38]</sup>

One telling fact is that “as income rises so does Internet use [...]”, strongly suggesting that the digital divide persists at least in part due to income disparities.<sup>[39]</sup> Most commonly, a digital divide stems from poverty and the economic barriers that limit resources and prevent people from obtaining or otherwise using newer technologies.

In research, while each explanation is examined, others must be controlled in order to eliminate [interaction effects](#) or [mediating variables](#),<sup>[29]</sup> but these explanations are meant to stand as general trends, not direct causes. Each component can be looked at from different angles, which leads to a myriad of ways to look at (or define) the digital divide. For example, measurements for the intensity of usage, such as incidence and frequency, vary by study. Some report usage as access to Internet and ICTs while others report usage as having previously connected to the Internet. Some studies focus on specific technologies, others on a combination (such as [Infostate](#), proposed by [Orbicom-UNESCO](#), the [Digital Opportunity Index](#), or [ITU's ICT Development Index](#)). Based on different answers to the questions of who, with which kinds of characteristics, connects how and why, to what there are hundreds of alternatives ways to define the digital divide.<sup>[11]</sup> “The new consensus recognizes that the key question is not how to connect people to a specific network through a specific device, but how to extend the expected gains from new ICTs”.<sup>[40]</sup> In short, the desired impact and “the end justifies the definition” of the digital divide.<sup>[11]</sup>

## Economic gap in the United States

During the mid-1990s the US Department of Commerce, National Telecommunications & Information Administration (NTIA) began publishing reports about the Internet and access to and usage of the resource. The first of three reports is entitled “Falling Through the Net: A Survey of the ‘Have Nots’ in Rural and Urban America” (1995),<sup>[41]</sup> the second is “Falling Through the Net II: New Data on the Digital Divide” (1998),<sup>[42]</sup> and the final report “Falling Through the Net: Defining the Digital Divide” (1999).<sup>[43]</sup> The NTIA’s final report attempted to clearly define the term digital divide; “the digital divide—the divide between those with access to new technologies and those without—is now one of America’s leading economic and civil rights issues. This report will help clarify which Americans are falling further behind, so that we can take concrete steps to redress this gap.”<sup>[43]</sup> Since the introduction of the NTIA reports, much of the early, relevant literature began to reference the NTIA’s digital divide definition. The digital divide is commonly defined as being between the “haves” and “have-nots.”<sup>[43][44]</sup>

## Overcoming the divide

See also: [Information and communication technologies for development](#)

An individual must be able to connect in order to achieve enhancement of social and [cultural capital](#) as well as achieve mass economic gains in productivity. Therefore, access is a necessary (but not sufficient) condition for overcoming the digital divide. Access to ICT meets significant challenges that stem from income restrictions. The borderline between ICT as a [necessity good](#) and ICT as a [luxury good](#) is roughly around the “magical number” of US\$10 per person per month, or US\$120 per year,<sup>[37]</sup> which means that people consider ICT expenditure of US\$120 per year as a basic necessity. Since more than 40% of the world population lives on less than US\$2 per day, and around 20% live on less than US\$1 per day (or less than US\$365 per year), these income segments would have to spend one third of their income on ICT ( $120/365 = 33\%$ ). The global average of ICT spending is at a mere 3% of income.<sup>[37]</sup> Potential solutions include driving down the costs of ICT, which includes low cost technologies and shared access through [Telecentres](#).

Furthermore, even though individuals might be capable of accessing the Internet, many are thwarted by barriers to entry such as a lack of means to infrastructure or the inability to comprehend the information that the Internet provides. Lack of adequate infrastructure and lack of knowledge are two major obstacles that impede mass connectivity. These barriers limit individuals’ capabilities in what they can do and what they can achieve in accessing technology. Some individuals have the ability to connect, but they do not have the knowledge to use what information ICTs and Internet technologies provide them. This leads to a focus on capabilities and skills, as well as awareness to move from mere access to effective usage of ICT.<sup>[8]</sup>

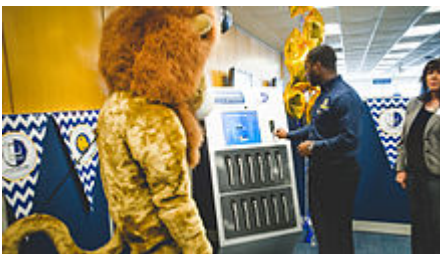
The [United Nations](#) is aiming to raise awareness of the divide by way of the [World Information Society Day](#) which has taken place yearly since May 17, 2006.<sup>[45]</sup> It also set up the Information and

Communications Technology (ICT) Task Force in November 2001.<sup>[46]</sup> Later [UN](#) initiatives in this area are the [World Summit on the Information Society](#), which was set up in 2003, and the [Internet Governance Forum](#), set up in 2006.

In the year 2000, the [United Nations Volunteers \(UNV\) programme](#) launched its Online Volunteering service,<sup>[47]</sup> which uses ICT as a vehicle for and in support of volunteering. It constitutes an example of a volunteering initiative that effectively contributes to bridge the digital divide. ICT-enabled volunteering has a clear added value for development. If more people collaborate online with more development institutions and initiatives, this will imply an increase in person-hours dedicated to development cooperation at essentially no additional cost. This is the most visible effect of online volunteering for human development.<sup>[48]</sup>

Social media websites serve as both manifestations of and means by which to combat the digital divide. The former describes phenomena such as the divided users demographics that make up sites such as Facebook and Myspace or Word Press and Tumblr. Each of these sites host thriving communities that engage with otherwise marginalized populations. An example of this is the large online community devoted to Afrofuturism, a discourse that critiques dominant structures of power by merging themes of science fiction and blackness. Social media brings together minds that may not otherwise meet, allowing for the free exchange of ideas and empowerment of marginalized discourses.

## Libraries



A laptop lending kiosk at [Texas A&M University-Commerce](#)'s Gee Library

Attempts to bridge the digital divide include a program developed in Durban, South Africa, where very low access to technology and a lack of documented cultural heritage has motivated the creation of an “online indigenous digital library as part of public library services.”<sup>[49]</sup> This project has the potential to narrow the digital divide by not only giving the people of the Durban area access to this digital resource, but also by incorporating the community members into the process of creating it.

Another attempt to narrow the digital divide takes the form of [One Laptop Per Child](#) (OLPC).<sup>[50]</sup> This organization, founded in 2005, provides inexpensively produced “XO” laptops (dubbed the “\$100 laptop”, though actual production costs vary) to children residing in poor and isolated regions within developing countries. Each laptop belongs to an individual child and provides a gateway to digital learning and Internet access. The XO laptops are specifically designed to

withstand more abuse than higher-end machines, and they contain features in context to the unique conditions that remote villages present. Each laptop is constructed to use as little power as possible, have a sunlight-readable screen, and is capable of automatically networking with other XO laptops in order to access the Internet—as many as 500 machines can share a single point of access.<sup>[50]</sup>

To address the divide The Gates Foundation began the Gates Library Initiative. The Gates Foundation focused on providing more than just access, they placed computers and provided training in libraries. In this manner if users began to struggle while using a computer, the user was in a setting where assistance and guidance was available. Further, the Gates Library Initiative was “modeled on the old-fashioned life preserver: The support needs to be around you to keep you afloat.”<sup>[9]</sup>

In nations where poverty compounds effects of the digital divide, programs are emerging to counter those trends. Prior conditions in Kenya—lack of funding, language and technology illiteracy contributed to an overall lack of computer skills and educational advancement for those citizens. This slowly began to change when foreign investment began. In the early 2000s, The Carnegie Foundation funded a revitalization project through the Kenya National Library Service (KNLS). Those resources enabled public libraries to provide information and communication technologies (ICT) to their patrons. In 2012, public libraries in the Busia and Kibera communities introduced technology resources to supplement curriculum for primary schools. By 2013, the program expanded into ten schools.<sup>[51]</sup>

## Effective use

[Community Informatics](#) (CI) provides a somewhat different approach to addressing the digital divide by focusing on issues of “use” rather than simply “access”. CI is concerned with ensuring the opportunity not only for ICT access at the community level but also, according to [Michael Gurstein](#), that the means for the “effective use” of ICTs for community betterment and empowerment are available.<sup>[52]</sup> Gurstein has also extended the discussion of the digital divide to include issues around access to and the use of “open data” and coined the term “data divide” to refer to this issue area.<sup>[53]</sup>

## Implications

### Social capital

Once an individual is connected, Internet connectivity and ICTs can enhance his or her future social and cultural capital. [Social capital](#) is acquired through repeated interactions with other

individuals or groups of individuals. Connecting to the Internet creates another set of means by which to achieve repeated interactions. ICTs and Internet connectivity enable repeated interactions through access to social networks, chat rooms, and gaming sites. Once an individual has access to connectivity, obtains infrastructure by which to connect, and can understand and use the information that ICTs and connectivity provide, that individual is capable of becoming a “digital citizen.”<sup>[29]</sup>

## Criticisms

### Knowledge divide

Since gender, age, racial, income, and educational gaps in the digital divide have lessened compared to past levels, some researchers suggest that the digital divide is shifting from a gap in access and connectivity to ICTs to a [knowledge divide](#).<sup>[54]</sup> A knowledge divide concerning technology presents the possibility that the gap has moved beyond access and having the resources to connect to ICTs to interpreting and understanding information presented once connected.<sup>[55]</sup>

### Second-level digital divide

The second-level digital divide, also referred to as the production gap, describes the gap that separates the consumers of content on the Internet from the producers of content.<sup>[56]</sup> As the technological digital divide is decreasing between those with access to the Internet and those without, the meaning of the term digital divide is evolving.<sup>[54]</sup> Previously, digital divide research has focused on accessibility to the Internet and Internet consumption. However, with more and more of the population with access to the Internet, researchers are examining how people use the Internet to create content and what impact socioeconomics are having on user behavior.<sup>[10][57]</sup> New applications have made it possible for anyone with a computer and an Internet connection to be a creator of content, yet the majority of user generated content available widely on the Internet, like public blogs, is created by a small portion of the Internet using population. [Web 2.0](#) technologies like Facebook, YouTube, Twitter, and Blogs enable users to participate online and create content without having to understand how the technology actually works, leading to an ever increasing digital divide between those who have the skills and understanding to interact more fully with the technology and those who are passive consumers of it.<sup>[56]</sup> Many are only nominal content creators through the use of Web 2.0, posting photos and status updates on Facebook, but not truly interacting with the technology.

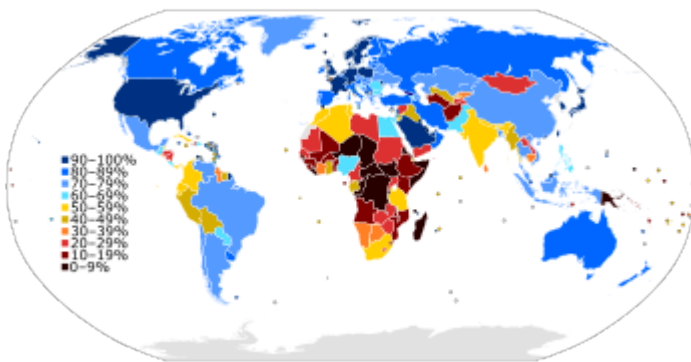
Some of the reasons for this production gap include material factors like the type of Internet



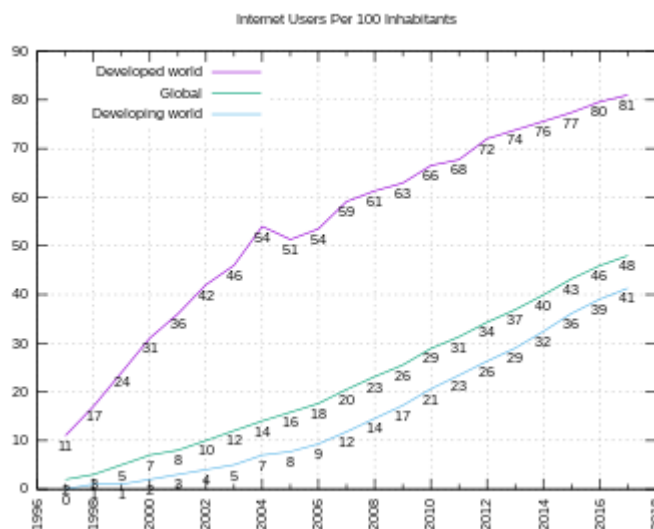
connection one has and the frequency of access to the Internet. The more frequently a person has access to the Internet and the faster the connection, the more opportunities they have to gain the technology skills and the more time they have to be creative.<sup>[58]</sup>

Other reasons include cultural factors often associated with class and socioeconomic status. Users of lower socioeconomic status are less likely to participate in content creation due to disadvantages in education and lack of the necessary free time for the work involved in blog or web site creation and maintenance.<sup>[58]</sup> Additionally, there is evidence to support the existence of the second-level digital divide at the K-12 level based on how educators' use technology for instruction.<sup>[59]</sup> Schools' economic factors have been found to explain variation in how teachers use technology to promote higher-order thinking skills.<sup>[59]</sup>

## The global digital divide



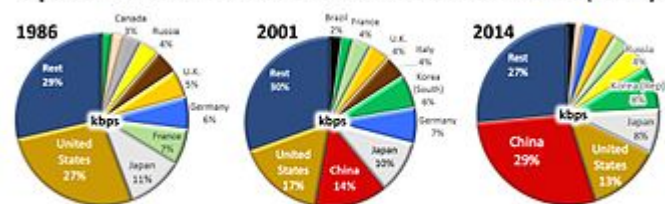
**Internet users in 2012 as a percentage of a country's population**Source: [International Telecommunications Union](#).<sup>[5]</sup>



**Internet users per 100 inhabitants**Source: [International Telecommunications Union](#).<sup>[60][61]</sup>



### Top 10 countries with most installed bandwidth (in kbps)



Hilbert, M. (2016). The bad news is that the digital access divide is here to stay: Domestically installed bandwidths among 172 countries for 1986–2014. Telecommunications Policy. [www.martinhilbert.net/the-bad-news-is-that-the-digital-access-divide-is-here-to-stay/](http://www.martinhilbert.net/the-bad-news-is-that-the-digital-access-divide-is-here-to-stay/)

Global bandwidth concentration: 3 countries have almost 50 %; 10 countries almost 75 %<sup>[13]</sup>

### Worldwide Internet users

	2005	2010	2014 <sup>a</sup>
<b>World population</b> <sup>[62]</sup>	6.5 billion	6.9 billion	7.2 billion
<b>Not using the Internet</b>	84%	70%	60%
<b>Using the Internet</b>	16%	30%	40%
<b>Users in the developing world</b>	8%	21%	32%
<b>Users in the developed world</b>	51%	67%	78%

<sup>a</sup> Estimate.

Source: [International Telecommunications Union](http://www.itu.int).<sup>[63]</sup>

### Internet users by region

	2005	2010	2014 <sup>a</sup>
<b>Africa</b>	2%	10%	19%
<b>Americas</b>	36%	49%	65%
<b>Arab States</b>	8%	26%	41%
<b>Asia and Pacific</b>	9%	23%	32%
<b>Commonwealth of Independent States</b>	10%	34%	56%
<b>Europe</b>	46%	67%	75%

<sup>a</sup> Estimate.

Source: [International Telecommunications Union](http://www.itu.int).<sup>[63]</sup>

### Mobile broadband Internet subscriptions in 2012

as a percentage of a country's population Source: [International Telecommunications Union](http://www.itu.int).<sup>[64]</sup>

### Worldwide broadband subscriptions

	2007	2010	2014 <sup>a</sup>
<b>World population</b> <sup>[62]</sup>	6.6 billion	6.9 billion	7.2 billion
<b>Fixed broadband</b>	5%	8%	10%
Developing world	2%	4%	6%
Developed world	18%	24%	27%
<b>Mobile broadband</b>	4%	11%	32%
Developing world	1%	4%	21%
Developed world	19%	43%	84%

<sup>a</sup> Estimate.

Source: [International Telecommunications Union](#).<sup>[63]</sup>

### **Broadband subscriptions by region**

<b>Fixed subscriptions:</b>	<b>2007</b>	<b>2010</b>	<b>2014<sup>a</sup></b>
Africa	0.1%	0.2%	0.4%
Americas	11%	14%	17%
Arab States	1%	2%	3%
Asia and Pacific	3%	6%	8%
Commonwealth of Independent States	2%	8%	14%
Europe	18%	24%	28%
<b>Mobile subscriptions:</b>	<b>2007</b>	<b>2010</b>	<b>2014<sup>a</sup></b>
Africa	0.2%	2%	19%
Americas	6%	23%	59%
Arab States	0.8%	5%	25%
Asia and Pacific	3%	7%	23%
Commonwealth of Independent States	0.2%	22%	49%
Europe	15%	29%	64%

<sup>a</sup> Estimate.

Source: [International Telecommunications Union](#).<sup>[63]</sup>

The global digital divide describes global disparities, primarily between [developed](#) and [developing countries](#), in regards to access to computing and information resources such as the [Internet](#) and the opportunities derived from such access.<sup>[65]</sup> As with a smaller [unit of analysis](#), this gap describes an inequality that exists, referencing a global scale.

The Internet is expanding very quickly, and not all countries—especially developing

countries—are able to keep up with the constant changes. The term “digital divide” doesn’t necessarily mean that someone doesn’t have technology; it could mean that there is simply a difference in technology. These differences can refer to, for example, high-quality computers, fast Internet, technical assistance, or telephone services. The difference between all of these is also considered a gap.

In fact, there is a large inequality worldwide in terms of the distribution of installed telecommunication bandwidth. In 2014 only 3 countries (China, US, Japan) host 50% of the globally installed bandwidth potential (see pie-chart Figure on the right).<sup>[13]</sup> This concentration is not new, as historically only 10 countries have hosted 70–75% of the global telecommunication capacity (see Figure). The U.S. lost its global leadership in terms of installed bandwidth in 2011, being replaced by China, which hosts more than twice as much national bandwidth potential in 2014 (29% versus 13% of the global total).<sup>[13]</sup>

## Versus the digital divide

The global digital divide is a special case of the digital divide, the focus is set on the fact that “Internet has developed unevenly throughout the world”<sup>[33]:681</sup> causing some countries to fall behind in technology, education, labor, democracy, and tourism. The concept of the digital divide was originally popularized in regard to the disparity in Internet access between rural and urban areas of the United States of America; the *global* digital divide mirrors this disparity on an international scale.

The global digital divide also contributes to the inequality of access to goods and services available through technology. Computers and the Internet provide users with improved education, which can lead to higher wages; the people living in nations with limited access are therefore disadvantaged.<sup>[66]</sup> This global divide is often characterized as falling along what is sometimes called the [north-south divide](#) of “northern” wealthier nations and “southern” poorer ones.

## PART IX

# CHAPTER 9: DESIGN

This chapter is the first of two chapters focused on design. Design is something that many of us take for granted, but it's something we encounter every day. The classroom we use each week? Someone (or many someones) designed this room, from the blueprints, to construction, to furnishings and technology, and so on. We often recognize bad design quickly; it confuses or disorients us. Good design goes unnoticed by many. The next two chapters attempt to provide you with a variety of design 'lenses' which to view the world, to help you recognize good design, and also apply good design principles to your future endeavors.

### *Learning Objectives*

After reading this chapter, you will be able to:

- Describe design.
- Define and describe human-computer interaction.

# 33. Introduction to Design

**Design** is the creation of a [plan](#) or [convention](#) for the construction of an object, system or measurable human interaction (as in [architectural blueprints](#), [engineering drawings](#), [business processes](#), [circuit diagrams](#), and [sewing patterns](#)).<sup>[1]</sup> Design has different connotations in different fields (see [design disciplines](#) below). In some cases, the direct construction of an object (as in [pottery](#), [engineering](#), [management](#), [coding](#), and [graphic design](#)) is also considered to be design.

Designing often necessitates considering the [aesthetic](#), [functional](#), economic, and sociopolitical dimensions of both the design object and design process. It may involve considerable [research](#), [thought](#), [modeling](#), interactive [adjustment](#), and re-design. Meanwhile, diverse kinds of objects may be designed, including [clothing](#), [graphical user interfaces](#), [skyscrapers](#), [corporate identities](#), [business processes](#), and even methods of designing.<sup>[2]</sup>

Thus “design” may be a substantive referring to a categorical abstraction of a created thing or things (the design of something), or a verb for the process of creation, as is made clear by grammatical context.

## Design as a process

Substantial disagreement exists concerning how designers in many fields, whether amateur or professional, alone or in teams, produce designs. Dorst and Dijkhuis argued that “there are many ways of describing design processes” and discussed “two basic and fundamentally different ways”,<sup>[9]</sup> both of which have several names. The prevailing view has been called “The Rational Model”,<sup>[10]</sup> “Technical Problem Solving”,<sup>[11]</sup> and “The Reason-Centric Perspective”.<sup>[12]</sup> The alternative view has been called “Reflection-in-Action”,<sup>[11]</sup> “Evolutionary Design”,<sup>[8]</sup> “co-evolution”,<sup>[13]</sup> and “The Action-Centric Perspective”.<sup>[12]</sup>

## The Rational Model

The Rational Model was independently developed by [Simon](#)<sup>[14]</sup> and Pahl and Beitz.<sup>[15]</sup> It posits that:

1. designers attempt to [optimize](#) a design candidate for known [constraints](#) and [objectives](#),
2. the design process is plan-driven,
3. the design process is understood in terms of a discrete sequence of stages.

The Rational Model is based on a [rationalist philosophy](#)<sup>[10]</sup> and underlies the [waterfall model](#),<sup>[16]</sup> [systems development life cycle](#),<sup>[17]</sup> and much of the [engineering design](#) literature.<sup>[18]</sup> According

to the rationalist philosophy, design is informed by research and knowledge in a predictable and controlled manner. Technical rationality is at the center of the process.<sup>[citation needed]</sup>

### *Example sequence of stages*

Typical stages consistent with The Rational Model include the following.

- Pre-production design
  - [Design brief](#) or [Parti pris](#) – an early (often the beginning) statement of design goals
  - [Analysis](#) – analysis of current design goals
  - [Research](#) – investigating similar design solutions in the field or related topics
  - [Specification](#) – specifying requirements of a design solution for a product ([product design specification](#))<sup>[19]</sup> or service.
  - [Problem solving](#) – [conceptualizing](#) and [documenting](#) design solutions
  - [Presentation](#) – presenting design solutions
- Design during production
  - [Development](#) – continuation and improvement of a designed solution
  - Testing – [in situ](#) testing a designed solution
- Post-production design feedback for future designs
  - [Implementation](#) – introducing the designed solution into the environment
  - [Evaluation](#) and [conclusion](#) – summary of process and results, including [constructive criticism](#) and suggestions for future improvements
- Redesign – any or all stages in the design process repeated (with corrections made) at any time before, during, or after production.

Each stage has many associated [best practices](#).<sup>[20]</sup>

### *Criticism of the Rational Model*

The Rational Model has been widely criticized on two primary grounds

1. Designers do not work this way – extensive empirical evidence has demonstrated that designers do not act as the rational model suggests.<sup>[21]</sup>
2. Unrealistic assumptions – goals are often unknown when a design project begins, and the requirements and constraints continue to change.<sup>[22]</sup>

# The Action-Centric Model

The Action-Centric Perspective is a label given to a collection of interrelated concepts, which are antithetical to The Rational Model.<sup>[12]</sup> It posits that:

1. designers use [creativity](#) and [emotion](#) to generate design candidates,
2. the design process is [improvised](#),
3. no universal sequence of stages is apparent – analysis, design and implementation are contemporary and inextricably linked<sup>[12]</sup>

The Action-Centric Perspective is based on an [empiricist philosophy](#) and broadly consistent with the [Agile approach](#)<sup>[23]</sup> and amethodical development.<sup>[24]</sup> Substantial empirical evidence supports the veracity of this perspective in describing the actions of real designers.<sup>[21]</sup> Like the Rational Model, the Action-Centric model sees design as informed by research and knowledge. However, research and knowledge are brought into the design process through the judgment and common sense of designers – by designers “thinking on their feet” – more than through the predictable and controlled process stipulated by the Rational Model. Designers’ context-dependent experience and professional judgment take center stage more than technical rationality.<sup>[citation needed]</sup>

## *Descriptions of design activities*

At least two views of design activity are consistent with the Action-Centric Perspective. Both involve three basic activities.

In the [Reflection-in-Action paradigm](#), designers alternate between “[framing](#)”, “making moves”, and “evaluate moves.” “Framing” refers to conceptualizing the problem, i.e., defining goals and objectives. A “move” is a tentative design decision. The evaluation process may lead to further moves in the design.<sup>[11]</sup>

In the Sensemaking-Coevolution-Implementation Framework, designers alternate between its three titular activities. [Sensemaking](#) includes both framing and evaluating moves. Implementation is the process of constructing the design object. Coevolution is “the process where the design agent simultaneously refines its mental picture of the design object based on its mental picture of the context, and vice versa.”<sup>[25]</sup>

The concept of the Design Cycle is understood as a circular time structure,<sup>[26]</sup> which may start with the thinking of an idea, then expressing it by the use of visual and/or verbal means of communication (design tools), the sharing and perceiving of the expressed idea, and finally starting a new cycle with the critical rethinking of the perceived idea. Anderson points out that this concept emphasizes the importance of the means of expression, which at the same time are means of perception of any design ideas.<sup>[27]</sup>



# Approaches to design

A design approach is a general philosophy that may or may not include a guide for specific methods. Some are to guide the overall goal of the design. Other approaches are to guide the tendencies of the designer. A combination of approaches may be used if they don't conflict.

Some popular approaches include:

- [Socio-Technical System design](#) a philosophy and tools for participative designing of work arrangements and supporting processes – for organizational purpose, quality, safety, economics and customer requirements in core work processes, the quality of peoples experience at work and the needs of society
- [KISS principle](#), (Keep it Simple Stupid), which strives to eliminate unnecessary complications.
- [There is more than one way to do it](#) (TIMTOWTDI), a philosophy to allow multiple methods of doing the same thing.
- [Use-centered design](#), which focuses on the goals and tasks associated with the use of the artifact, rather than focusing on the end user.
- [User-centered design](#), which focuses on the needs, wants, and limitations of the end user of the designed artifact.
- [Critical design](#) uses designed artifacts as an embodied critique or commentary on existing values, morals, and practices in a culture.
- [Service design](#) designing or organizing the experience around a product, the service associated with a product's use.
- [Transgenerational design](#), the practice of making products and environments compatible with those physical and sensory impairments associated with human aging, which limit major activities of daily living.
- Speculative design, the speculative design process doesn't necessarily define a specific problem to solve, but establishes a provocative starting point from which a design process emerges. The result is an evolution of fluctuating iteration and reflection using designed objects to provoke questions and stimulate discussion in academic and research settings.

## Methods of designing

Main article: [Design methods](#)

Design methods is a broad area that focuses on:

- [Exploring](#) possibilities and constraints by focusing critical thinking skills to research and define problem spaces for existing [products](#) or [services](#)—or the creation of new categories; (see also [Brainstorming](#))
- [Redefining](#) the specifications of design solutions which can lead to better guidelines for

traditional design activities (graphic, industrial, architectural, etc.);

- [Managing](#) the process of exploring, defining, creating artifacts continually over time
- [Prototyping](#) possible scenarios, or solutions that incrementally or significantly improve the inherited situation
- Trendspotting; understanding the trend process.

# 34. Human-computer Interaction

**Human-computer interaction** (commonly referred to as **HCI**) researches the design and use of computer technology, focused on the interfaces between people ([users](#)) and computers. Researchers in the field of HCI both *observe* the ways in which humans interact with computers and *design* technologies that let humans interact with computers in novel ways.

As a field of research, human-computer interaction is situated at the intersection of [computer science](#), [behavioral sciences](#), [design](#), [media studies](#), and [several other fields of study](#). The term was popularized by [Stuart K. Card](#), [Allen Newell](#), and [Thomas P. Moran](#) in their seminal 1983 book, *The Psychology of Human-Computer Interaction*, although the authors first used the term in 1980<sup>[1]</sup> and the first known use was in 1975.<sup>[2]</sup> The term connotes that, unlike other tools with only limited uses (such as a hammer, useful for driving nails but not much else), a computer has many uses and this takes place as an open-ended dialog between the user and the computer. The notion of dialog likens human-computer interaction to human-to-human interaction, an analogy which is crucial to theoretical considerations in the field.<sup>[3][4]</sup>

## Introduction

Humans interact with computers in many ways; and the interface between humans and the computers they use is crucial to facilitating this [interaction](#). Desktop applications, internet browsers, handheld computers, and computer kiosks make use of the prevalent [graphical user interfaces](#) (GUI) of today.<sup>[5]</sup> Voice user interfaces (VUI) are used for speech recognition and synthesising systems, and the emerging multi-modal and gestalt User Interfaces (GUI) allow humans to engage with embodied character agents in a way that cannot be achieved with other interface paradigms. The growth in human-computer interaction field has been in quality of interaction, and in different branching in its history. Instead of designing regular interfaces, the different research branches have had different focus on the concepts of multimodality rather than unimodality, intelligent adaptive interfaces rather than command/action based ones, and finally active rather than passive interfaces<sup>[citation needed]</sup>

The [Association for Computing Machinery](#) (ACM) defines human-computer interaction as “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them”.<sup>[5]</sup> An important facet of HCI is the securing of user satisfaction (or simply End User Computing Satisfaction). “Because human-computer interaction studies a human and a machine in communication, it draws from supporting knowledge on both the machine and the human side. On the machine side, techniques in [computer graphics](#), [operating systems](#), [programming languages](#), and development environments are relevant. On the human side, [communication theory](#), [graphic](#) and [industrial design](#) disciplines, [linguistics](#), [social sciences](#), [cognitive psychology](#), [social psychology](#), and [human factors](#) such as [computer user satisfaction](#) are relevant. And, of course,

engineering and design methods are relevant.”<sup>[5]</sup> Due to the multidisciplinary nature of HCI, people with different backgrounds contribute to its success. HCI is also sometimes termed *human-machine interaction* (HMI), *man-machine interaction* (MMI) or *computer-human interaction* (CHI).

Poorly designed [human-machine interfaces](#) can lead to many unexpected problems. A classic example of this is the [Three Mile Island accident](#), a nuclear meltdown accident, where investigations concluded that the design of the human-machine interface was at least partly responsible for the disaster.<sup>[6][7][8]</sup> Similarly, accidents in aviation have resulted from manufacturers’ decisions to use non-standard [flight instrument](#) or throttle quadrant layouts: even though the new designs were proposed to be superior in basic human-machine interaction, pilots had already ingrained the “standard” layout and thus the conceptually good idea actually had undesirable results.

Leading academic research centers include CMU’s [Human-Computer Interaction Institute](#), [GVU Center at Georgia Tech](#), and the [University of Maryland Human-Computer Interaction Lab](#).

## Goals

Human-computer interaction studies the ways in which humans make, or don’t make, use of computational artifacts, systems and infrastructures. In doing so, much of the research in the field seeks to *improve* human-computer interaction by improving the *usability* of computer interfaces.<sup>[9]</sup> How usability is to be precisely understood, how it relates to other social and cultural values and when it is, and when it may not be a desirable property of computer interfaces is increasingly debated.<sup>[10][11]</sup>

Much of the research in the field of human-computer interaction takes an interest in:

- Methods for designing novel computer interfaces, thereby optimizing a design for a desired property such as, e.g., learnability or efficiency of use.
- Methods for implementing interfaces, e.g., by means of [software libraries](#).
- Methods for evaluating and comparing interfaces with respect to their usability and other desirable properties.
- Methods for studying human computer use and its sociocultural implications more broadly.
- Models and theories of human computer use as well as conceptual frameworks for the design of computer interfaces, such as, e.g., [cognitivist](#) user models, [Activity Theory](#) or [ethnomethodological](#) accounts of human computer use.<sup>[12]</sup>
- Perspectives that critically reflect upon the values that underlie computational design, computer use and HCI research practice.<sup>[13]</sup>

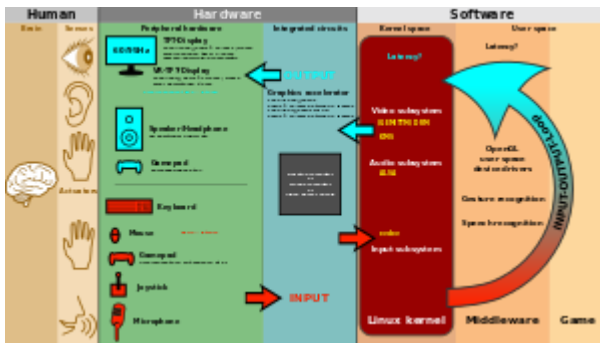
Visions of what researchers in the field seek to achieve vary. When pursuing a cognitivist perspective, researchers of HCI may seek to align computer interfaces with the mental model that humans have of their activities. When pursuing a post-cognitivist perspective, researchers of

HCI may seek to align computer interfaces with existing social practices or existing sociocultural values.

Researchers in HCI are interested in developing new design methodologies, experimenting with new devices, prototyping new software and hardware systems, exploring new interaction paradigms, and developing models and theories of interaction.

## Design

## Principles



The user interacts directly with hardware for the human *input* and *output* such as [displays](#), e.g. through a [graphical user interface](#). The user interacts with the computer over this software interface using the given [input and output](#) (I/O) hardware.

Software and hardware must be matched, so that the processing of the user input is fast enough, the [latency](#) of the computer output is not disruptive to the [workflow](#).

When evaluating a current [user interface](#), or designing a new user interface, it is important to keep in mind the following experimental design principles:

- Early focus on user(s) and task(s): Establish how many users are needed to perform the task(s) and determine who the appropriate users should be; someone who has never used the interface, and will not use the interface in the future, is most likely not a valid user. In addition, define the task(s) the users will be performing and how often the task(s) need to be performed.
- [Empirical](#) measurement: Test the interface early on with real users who come in contact with the interface on a daily basis. Keep in mind that results may vary with the performance level of the user and may not be an accurate depiction of the typical human-computer interaction. Establish quantitative [usability](#) specifics such as: the number of users performing the task(s), the time to complete the task(s), and the number of errors made during the task(s).
- [Iterative design](#): After determining the users, tasks, and empirical measurements to include,

perform the following iterative design steps:

1. Design the user interface
2. Test
3. Analyze results
4. Repeat

Repeat the iterative design process until a sensible, user-friendly interface is created.<sup>[14]</sup>

## Methodologies

A number of diverse methodologies outlining techniques for human-computer [interaction design](#) have emerged since the rise of the field in the 1980s. Most design methodologies stem from a model for how users, designers, and technical systems interact. Early methodologies, for example, treated users' cognitive processes as predictable and quantifiable and encouraged design practitioners to look to cognitive science results in areas such as memory and attention when designing user interfaces. Modern models tend to focus on a constant feedback and conversation between users, designers, and engineers and push for technical systems to be wrapped around the types of experiences users want to have, rather than wrapping [user experience](#) around a completed system.

- [Activity theory](#): used in HCI to define and study the context in which human interactions with computers take place. Activity theory provides a framework to reason about actions in these contexts, analytical tools with the format of checklists of items that researchers should consider, and informs [design of interactions](#) from an activity-centric perspective.<sup>[15]</sup>
- [User-centered design](#): user-centered design (UCD) is a modern, widely practiced design philosophy rooted in the idea that users must take center-stage in the design of any computer system. Users, designers and technical practitioners work together to articulate the wants, needs and limitations of the user and create a system that addresses these elements. Often, user-centered design projects are informed by [ethnographic](#) studies of the environments in which users will be interacting with the system. This practice is similar but not identical to [participatory design](#), which emphasizes the possibility for end-users to contribute actively through shared design sessions and workshops.
- [Principles of user interface design](#): these are seven principles of [user interface](#) design that may be considered at any time during the design of a user interface in any order: tolerance, simplicity, visibility, affordance, consistency, structure and feedback.<sup>[16]</sup>
- [Value sensitive design](#): Value Sensitive Design (VSD) is a method for building technology that account for the values of the people who use the technology directly, as well as those who the technology affects, either directly or indirectly. VSD uses an iterative design process that involves three types of investigations: conceptual, empirical and technical. Conceptual investigations aim at understanding and articulating the various stakeholders of the

technology, as well as their values and any values conflicts that might arise for these stakeholders through the use of the technology. Empirical investigations are qualitative or quantitative design research studies used to inform the designers' understanding of the users' values, needs, and practices. Technical investigations can involve either analysis of how people use related technologies, or the design of systems to support values identified in the conceptual and empirical investigations.<sup>[17]</sup>

## Human–computer interface

Main article: [User interface](#)

The human–computer interface can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the *loop of interaction*. The loop of interaction has several aspects to it, including:

- **Visual Based:** The visual based human computer inter-action is probably the most widespread area in HCI research.
- **Audio Based:** The audio based interaction between a computer and a human is another important area of in HCI systems. This area deals with information acquired by different audio signals.
- **Task environment:** The conditions and goals set upon the user.
- **Machine environment:** The environment that the computer is connected to, e.g. a laptop in a college student's dorm room.
- **Areas of the interface:** Non-overlapping areas involve processes of the human and computer not pertaining to their interaction. Meanwhile, the overlapping areas only concern themselves with the processes pertaining to their interaction.
- **Input flow:** The flow of information that begins in the task environment, when the user has some task that requires using their computer.
- **Output:** The flow of information that originates in the machine environment.
- **Feedback:** Loops through the interface that evaluate, moderate, and confirm processes as they pass from the human through the interface to the computer and back.
- **Fit:** This is the match between the computer design, the user and the task to optimize the human resources needed to accomplish the task.

Topics in HCI include:



## User customization

[End-user development](#) studies how ordinary users could routinely tailor applications to their own needs and use this power to invent new applications based on their understanding of their own domains. With their deeper knowledge of their own knowledge domains, users could increasingly be important sources of new applications at the expense of generic systems programmers (with systems expertise but low domain expertise).

## Embedded computation

Computation is passing beyond computers into every object for which uses can be found. Embedded systems make the environment alive with little computations and automated processes, from computerized cooking appliances to lighting and plumbing fixtures to window blinds to automobile braking systems to greeting cards. To some extent, this development is already taking place. The expected difference in the future is the addition of networked communications that will allow many of these embedded computations to coordinate with each other and with the user. [Human interfaces](#) to these embedded devices will in many cases be very different from those appropriate to workstations.

## Augmented reality

A common staple of science fiction, augmented reality refers to the notion of layering relevant information into our vision of the world. Existing projects show real-time statistics to users performing difficult tasks, such as manufacturing. Future work might include augmenting our social interactions by providing additional information about those we converse with.

## Social computing

In recent years, there has been an explosion of social science research focusing on interactions as the unit of analysis. Much of this research draws from psychology, social psychology, and sociology. For example, one study found out that people expected a computer with a man's name to cost more than a machine with a woman's name.<sup>[20]</sup> Other research finds that individuals perceive their interactions with computers more positively than humans, despite behaving the same way towards these machines.<sup>[21]</sup>

## Knowledge-driven human-computer interaction

In human and computer interactions, there usually exists a semantic gap between human and computer's understandings towards mutual behaviors. [Ontology \(information science\)](#), as a formal representation of domain-specific knowledge, can be used to address this problem, through solving the semantic ambiguities between the two parties. [\[22\]](#)

# 35. Cognitive Science & Artificial Intelligence

**Cognitive science** is the interdisciplinary, [scientific](#) study of the [mind](#) and its processes.<sup>[2]</sup> It examines the nature, the tasks, and the functions of [cognition](#). Cognitive scientists study intelligence and behavior, with a focus on how nervous systems represent, process, and transform information. Mental faculties of concern to cognitive scientists include [perception](#), [language](#), [memory](#), [attention](#), [reasoning](#), and [emotion](#); to understand these faculties, cognitive scientists borrow from fields such as [psychology](#), [artificial intelligence](#), [philosophy](#), [neuroscience](#), [linguistics](#), and [anthropology](#).<sup>[3]</sup> The typical analysis of cognitive science span many levels of organization, from learning and decision to logic and planning; from [neural](#) circuitry to modular brain organization. The fundamental concept of cognitive science is that “thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures.”<sup>[3]</sup>

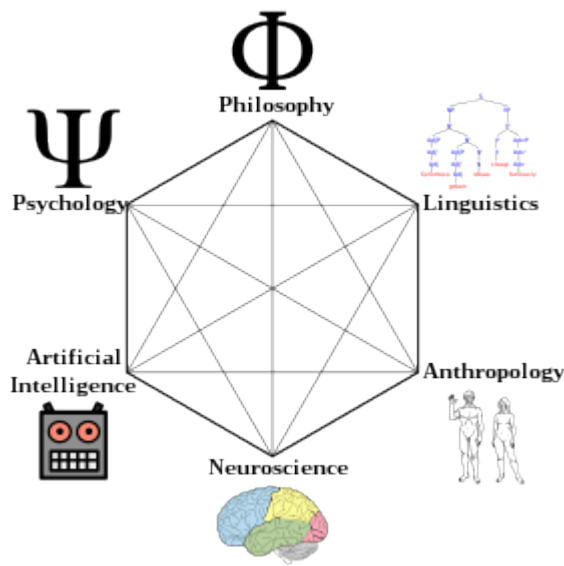


Figure illustrating the fields that contributed to the birth of cognitive science, including [linguistics](#), [neuroscience](#), [artificial intelligence](#), [philosophy](#), [anthropology](#), and [psychology](#).<sup>[1]</sup>

# Principles

## Levels of analysis

A central tenet of cognitive science is that a complete understanding of the mind/brain cannot be attained by studying only a single level. An example would be the problem of remembering a phone number and recalling it later. One approach to understanding this process would be to study behavior through direct observation, or [naturalistic observation](#). A person could be presented with a phone number and be asked to recall it after some delay of time. Then, the accuracy of the response could be measured. Another approach to measure cognitive ability would be to study the firings of individual [neurons](#) while a person is trying to remember the phone number. Neither of these experiments on its own would fully explain how the process of remembering a phone number works. Even if the technology to map out every neuron in the brain in real-time were available, and it were known when each neuron was firing, it would still be impossible to know how a particular firing of neurons translates into the observed behavior. Thus, an understanding of how these two levels relate to each other is imperative. *The Embodied Mind: Cognitive Science and Human Experience* says, “the new sciences of the mind need to enlarge their horizon to encompass both lived human experience and the possibilities for transformation inherent in human experience.”<sup>[4]</sup> This can be provided by a functional level account of the process. Studying a particular phenomenon from multiple levels creates a better understanding of the processes that occur in the brain to give rise to a particular behavior. [Marr](#)<sup>[5]</sup> gave a famous description of three levels of analysis:

1. the *computational theory*, specifying the goals of the computation;
2. *representation and algorithms*, giving a representation of the inputs and outputs and the algorithms which transform one into the other; and
3. the *hardware implementation*, how algorithm and representation may be physically realized.

(See also the entry on [functionalism](#).)

## Interdisciplinary nature

Cognitive science is an interdisciplinary field with contributors from various fields, including [psychology](#), [neuroscience](#), [linguistics](#), [philosophy of mind](#), [computer science](#), [anthropology](#), [sociology](#), and [biology](#). Cognitive scientists work collectively in hope of understanding the mind and its interactions with the surrounding world much like other sciences do. The field regards itself as compatible with the physical sciences and uses the [scientific method](#) as well as [simulation](#) or [modeling](#), often comparing the output of models with aspects of human cognition. Similarly to

the field of psychology, there is some doubt whether there is a unified cognitive science, which have led some researchers to prefer ‘cognitive sciences’ in plural.<sup>[6]</sup>

Many, but not all, who consider themselves cognitive scientists hold a [functionalist](#) view of the mind—the view that mental states and processes should be explained by their function – what they do. According to the [multiple realizability](#) account of functionalism, even non-human systems such as robots and computers can be ascribed as having cognition.

## Artificial intelligence

“AI” redirects here. For other uses, see [AI](#) and [Artificial intelligence \(disambiguation\)](#).

**Artificial intelligence (AI)** is [intelligence](#) exhibited by [machines](#). In [computer science](#), an ideal “intelligent” machine is a flexible [rational agent](#) that perceives its environment and takes actions that maximize its chance of success at some goal.<sup>[1]</sup> Colloquially, the term “artificial intelligence” is applied when a machine mimics “cognitive” functions that humans associate with other [human minds](#), such as “learning” and “problem solving”.<sup>[2]</sup> As machines become increasingly capable, facilities once thought to require intelligence are removed from the definition. For example, [optical character recognition](#) is no longer perceived as an exemplar of “artificial intelligence” having become a routine technology.<sup>[3]</sup> Capabilities still classified as AI include advanced [Chess](#) and [Go](#) systems and [self-driving cars](#).

AI research is divided into subfields<sup>[4]</sup> that focus on specific [problems](#) or on specific [approaches](#) or on the use of a particular [tool](#) or towards satisfying particular [applications](#).

The central problems (or goals) of AI research include [reasoning](#), [knowledge](#), [planning](#), [learning](#), [natural language processing](#) (communication), [perception](#) and the ability to move and manipulate objects.<sup>[5]</sup> [General intelligence](#) is among the field’s long-term goals.<sup>[6]</sup> Approaches include [statistical methods](#), [computational intelligence](#), [soft computing](#)(e.g. [machine learning](#)), and [traditional symbolic AI](#). Many tools are used in AI, including versions of [search and mathematical optimization](#), [logic](#), [methods based on probability and economics](#). The AI field draws upon [computer science](#), [mathematics](#), [psychology](#), [linguistics](#), [philosophy](#), [neuroscience](#) and [artificial psychology](#).

The field was founded on the claim that [human intelligence](#) “can be so precisely described that a machine can be made to simulate it.”<sup>[7]</sup> This raises philosophical arguments about the nature of the [mind](#) and the ethics of creating artificial beings endowed with human-like intelligence, issues which have been explored by [myth](#), [fiction](#) and [philosophy](#) since [antiquity](#).<sup>[8]</sup> Attempts to create artificial intelligence has experienced many [setbacks](#), including the [ALPAC report](#) of 1966, the abandonment of [perceptrons](#) in 1970, [the Lighthill Report](#) of 1973 and the [collapse of the Lisp machine market](#) in 1987. In the twenty-first century AI techniques became an essential part of the [technology industry](#), helping to solve many challenging problems in computer science.<sup>[9]</sup>

PART X

# CHAPTER 10: DESIGN METHODOLOGIES

# 36. Introduction to Design Thinking

from wikipedia: [https://en.wikipedia.org/wiki/Design\\_thinking](https://en.wikipedia.org/wiki/Design_thinking)

**Design thinking** refers to design-specific cognitive activities that designers apply during the process of designing.<sup>[1]</sup>

Design thinking is a methodology not exclusive for designers, that helps people understand and develop creative ways to solve an specific issue, generally business oriented.

## Origins of the term<sup>[edit]</sup>

For more details on the history of the term, see [§ History](#).

The notion of design as a “way of thinking” in [the sciences](#) can be traced to [Herbert A. Simon](#)’s 1969 book *The Sciences of the Artificial*,<sup>[2]</sup> and in [design engineering](#) to Robert McKim’s 1973 book *Experiences in Visual Thinking*.<sup>[3]</sup> Peter Rowe’s 1987 book *Design Thinking*, which described methods and approaches used by architects and urban planners, was a significant early usage of the term in the design research literature.<sup>[4]</sup> [Rolf Faste](#) expanded on McKim’s work at [Stanford University](#) in the 1980s and 1990s,<sup>[5][6]</sup> teaching “design thinking as a method of creative action.”<sup>[7]</sup> Design thinking was adapted for business purposes by Faste’s Stanford colleague [David M. Kelley](#), who founded [IDEO](#) in 1991.<sup>[8]</sup> [Richard Buchanan](#)’s 1992 article “Wicked Problems in Design Thinking” expressed a broader view of design thinking as addressing intractable human concerns through design.<sup>[9]</sup>



Design thinking example video

## Solution-based thinking<sup>[edit]</sup>

Design thinking is a formal method for practical, [creative](#) resolution of problems and creation of solutions, with the intent of an improved future result. In this regard it is a form of solution-based, or solution-focused thinking – starting with a goal (a better future situation) instead of solving a specific problem. By considering both present and future conditions and parameters of



the problem, alternative solutions may be explored simultaneously. [Nigel Cross](#) asserted that this type of thinking most often happens in the built, or artificial, environment (as in artifacts).<sup>[10]</sup>

This approach differs from the analytical [scientific method](#), which begins by thoroughly defining all parameters of a problem to create a solution. Design thinking identifies and investigates with known and ambiguous aspects of the current situation to discover hidden parameters and open alternative paths that may lead to the goal. Because design thinking is [iterative](#), intermediate “solutions” are also potential starting points of alternative paths, including redefining of the initial problem.

## Bryan Lawson – architects vs. scientists[\[edit\]](#)

In 1972 psychologist, architect and design researcher Bryan Lawson conducted an empirical study to investigate the difference between problem-focused solvers and solution-focused solvers. He took two groups of students – final year students in architecture and post-graduate science students – and asked them to create one-layer structures from a set of colored blocks. The perimeter of the structure had to optimize either the red or the blue color; however, there were unspecified rules governing the placement and relationship of some of the blocks. Lawson found that:

The scientists adopted a technique of trying out a series of designs which used as many different blocks and combinations of blocks as possible as quickly as possible. Thus they tried to maximise the information available to them about the allowed combinations. If they could discover the rule governing which combinations of blocks were allowed they could then search for an arrangement which would optimise the required colour around the layout. *[problem-focused]* By contrast, the architects selected their blocks in order to achieve the appropriately coloured perimeter. If this proved not to be an acceptable combination, then the next most favourably coloured block combination would be substituted and so on until an acceptable solution was discovered. *[solution-focused]*  
– BRYAN LAWSON, HOW DESIGNERS THINK<sup>[11]</sup>

[Nigel Cross](#) concluded that Lawson’s studies suggested that scientists problem solve by analysis, while designers problem solve by synthesis.<sup>[10]</sup> Kelley and Brown argue that design thinking uses both analysis and synthesis.<sup>[citation needed]</sup>

## Analysis and synthesis[\[edit\]](#)

The terms analysis and synthesis come from (classical) Greek and mean literally “to loosen up” and “to put together” respectively. In general, analysis is defined as the procedure by which we

break down an intellectual or substantial whole into parts or components. Synthesis is defined as the opposite procedure: to combine separate elements or components in order to form a coherent whole. However, analysis and synthesis, as scientific methods, always go hand in hand; they complement one another. Every synthesis is built upon the results of a preceding analysis, and every analysis requires a subsequent synthesis in order to verify and correct its results.<sup>[12]</sup>

## Divergent thinking versus convergent thinking<sup>[edit]</sup>

Design thinking employs [divergent thinking](#) as a way to ensure that many possible solutions are explored in the first instance, and then [convergent thinking](#) as a way to narrow these down to a final solution. Divergent thinking is the ability to offer different, unique or variant ideas adherent to one theme while convergent thinking is the ability to find the “correct” solution to the given problem. Design thinking encourages divergent thinking to ideate many solutions (possible or impossible) and then uses convergent thinking to prefer and realize the best resolution.

## Design thinking as a process for problem-solving<sup>[edit]</sup>

Unlike [analytical](#) thinking, design thinking includes “building up” ideas, with few, or no, limits on breadth during a “brainstorming” phase.<sup>[13]</sup> This helps reduce fear of failure in the participant(s) and encourages input and participation from a wide variety of sources in the ideation phases. The phrase “[thinking outside the box](#)” has been coined to describe one goal of the brainstorming phase and is encouraged, since this can aid in the discovery of hidden elements and ambiguities in the situation and discovering potentially faulty assumptions.

One version of the design thinking process has seven stages: *define, research, ideate, prototype, choose, implement, and learn*.<sup>[2]</sup> Within these seven steps, problems can be framed, the right questions can be asked, more ideas can be created, and the best answers can be chosen. The steps aren’t linear; can occur simultaneously and be repeated. A simpler expression of the process is Robert McKim’s phrase “Express-Test-Cycle”.<sup>[3]</sup> An alternative five-phase description of the process is described by [Christoph Meinel](#) and Larry Leifer: *(re)defining the problem, needfinding and benchmarking, ideating, building, testing*.<sup>[14]</sup> Yet another way to look at it is [Shewhart](#)’s “Plan-Do-Study-Act” [PDSA](#) cycle.

Although design is always influenced by individual preferences, the design thinking method shares a common set of traits, mainly: creativity, [ambidextrous](#) thinking, [teamwork](#), [user-centeredness](#) ([empathy](#)), [curiosity](#) and [optimism](#).<sup>[6]</sup> These traits are exemplified by design thinking methods in “[serious play](#)”.

The path through these process steps is not strictly circular. Meinel and Leifer state: “While the stages are simple enough, the adaptive expertise required to choose the right inflection points and appropriate next stage is a high order intellectual activity that requires practice and is learnable.”<sup>[14]</sup>

## Attributes of design thinking[\[edit\]](#)

## Principles[\[edit\]](#)

Christoph Meinel and Larry Leifer assert that there are four principles to design thinking:[\[14\]](#)

- The human rule – all design activity is ultimately social in nature
- The ambiguity rule – design thinkers must preserve ambiguity
- The re-design rule – all design is re-design
- The tangibility rule – making ideas tangible always facilitates communication

## Wicked problems[\[edit\]](#)

Design thinking is especially useful when addressing what [Horst Rittel](#) referred to as [wicked problems](#), which are ill-defined or tricky (as opposed to wicked in the sense of [malicious](#)).[\[15\]](#) With ill-defined problems, both the problem and the solution are unknown at the outset of the problem-solving exercise. This is as opposed to “tame” or “well-defined” problems where the problem is clear, and the solution is available through some technical knowledge.[\[16\]](#)

For wicked problems, the general thrust of the problem may be clear, however considerable time and effort is spent in order to clarify the requirements. A large part of the problem solving activity, then, consists of problem definition and [problem shaping](#).[\[17\]](#)

## The “a-ha moment”[\[edit\]](#)

The “a-ha moment” is the moment where there is suddenly a clear forward path.[\[18\]](#) It is the point in the cycle where synthesis and divergent thinking, analysis and convergent thinking, and the nature of the problem all come together and an appropriate resolution has been captured. Prior to this point, the process may seem nebulous, hazy and inexact. At this point, the path forward is so obvious that in retrospect it seems odd that it took so long to recognize it. After this point, the focus becomes more and more clear as the final product is constructed.[\[19\]](#)

## Methods and process[\[edit\]](#)

*Design methods* and *design process* are often used interchangeably, but there are significant differences between the two.

[Design methods](#) are techniques, rules, or ways of doing things that someone uses within a design discipline. Methods for design thinking include [interviewing](#), creating [user profiles](#), looking at other existing solutions, creating [prototypes](#), [mind mapping](#), asking questions like the [five whys](#), and situational analysis.

Because of design thinking's parallel nature, there are many different paths through the phases. This is part of the reason design thinking may seem to be “fuzzy” or “ambiguous” when compared to more [analytical](#), [Cartesian](#) methods of science and engineering.

Some early design processes stemmed from [soft systems methodology](#) in the 1960s. Koberg and Bagnall wrote *The All New Universal Traveller* in 1972 and presented a circular, seven-step process to problem-solving. These seven steps could be done lineally or in feed-back loops.<sup>[20]</sup> Stanford's d.school developed an updated seven step process in 2007.<sup>[21]</sup> Other expressions of design processes have been proposed, including a three-step simplified triangular process (or the six-part, less simplified pyramid) by Bryan Lawson.<sup>[11]</sup> Hugh Dubberly's free e-book *How Do You Design: A Compendium of Models* summarizes a large number of design process models.<sup>[22]</sup>

Design thinking calls for considering the given user case from various perspectives, empathizing with users, and addressing various stakeholders.<sup>[citation needed]</sup>

## The use of visual analogy in design thinking and learning[\[edit\]](#)

Ill-defined problems often contain higher-order and obscure relationships. Design thinking can address these through the use of [analogies](#). An understanding of the expected results, or lack of domain-related knowledge for the task, may be developed by correlating different internal representations, such as images, to develop an understanding of the obscure or ill-defined elements of the situation. The process involves several complex cognitive mechanisms, as the design task often has elements in multiple cognitive domains—visual, mathematical, auditory or tactile—requiring the usage of multiple “languages”, like [visual thinking](#).

## Differences from science and humanities[\[edit\]](#)

Although many design fields have been categorized as lying between Science and the Arts and Humanities, design may be seen as its own distinct way of understanding the world, based on solution-based problem solving, problem shaping, synthesis, and appropriateness in the built environment.

One of the first [design science](#) theorists, [John Chris Jones](#), postulated that design was different

than the arts, sciences and mathematics in the 1970s. In response to the question “Is designing an art, a science or a form of mathematics?” Jones responded:

The main point of difference is that of *timing*. Both artists and scientists operate on the physical world as it exists in the *present* (whether it is real or symbolic), while mathematicians operate on abstract relationships that are independent of historical *time*. Designers, on the other hand, are forever bound to treat as real that which exists only in an imagined *future* and have to specify ways in which the *foreseen* thing can be made to exist.

— [JOHN CHRIS JONES](#), DESIGN METHOD<sup>[23]</sup>

Design can be seen as its own culture in education, with its own methods and ways of thinking, which can be systematically taught in both K-12 and higher education. [Nigel Cross](#) set out to show the differences between the humanities, the sciences, and design in his paper “Designerly Ways of Knowing”. He observed that:<sup>[10]</sup>

*The phenomenon of study in each culture is*

- in the sciences: the natural world
- in the humanities: human experience
- in design: the artificial world

*The appropriate methods in each culture are*

- in the sciences: controlled experiment, classification, analysis
- in the humanities: analogy, metaphor, evaluation
- in design: modeling, pattern-forming, synthesis

*The values of each culture are*

- in the sciences: objectivity, rationality, neutrality, and a concern for “truth”
- in the humanities: subjectivity, imagination, commitment, and a concern for “justice”
- in design: practicality, ingenuity, empathy, and a concern for “appropriateness”

## The languages of design<sup>[edit]</sup>

Conventionally, designers communicate mostly in [visual or object languages](#).<sup>[10][24]</sup> Symbols, signs, and metaphors are used through the medium of sketching, diagrams and technical drawings to translate abstract requirements into concrete objects. The way designers communicate, then, is through understanding this way of coding design requirements in order to produce built products.<sup>[25]</sup>

## Design thinking in business[\[edit\]](#)

Design thinking has two common interpretations in the business world:[\[citation needed\]](#)

1. Designers bringing their methods into business by either taking part themselves in business process, or training business people to use design methods
2. Designers achieving innovative outputs or products (for example, the [iPod](#))

The first interpretation has been described by Tim Brown, CEO of [IDEO](#), at a [TED](#) lecture,[\[26\]](#) though his blog[\[27\]](#) also considers the second interpretation.

The limits of the first kind of design thinking in business are also being explored. Not all problems yield to design thinking alone, where it may be a “temporary fix”.[\[28\]](#) Design thinking companies including [IDEO](#) and [Sense Worldwide](#) are responding to this by building business thinking capabilities.[\[29\]](#)

Tim Brown has argued that design thinking is now widely, but sporadically, used in business. He argues that competitive advantage comes from sustained use of design thinking, from becoming “masters of the art.”[\[30\]](#)

In organization and management theory, design thinking forms part of the Architecture/Design/Anthropology (A/D/A) paradigm, which characterizes innovative, human-centered enterprises. This paradigm also focuses on a collaborative and iterative style of work and an [abductive](#) mode of thinking, compared to practices associated with the more traditional Mathematics/Economics/Psychology (M/E/P) management paradigm.[\[31\]](#)

A study by the [London Business School](#) found that for every percent of sales invested in product design, profits rose by an average of 3 to 4 percent.[\[32\]](#)

## Design thinking in education[\[edit\]](#)

Design thinking has been suggested for use in schools in a variety of curricular ways,[\[33\]\[34\]\[35\]](#) as well as for redesigning student spaces and school systems.[\[36\]](#)

Design thinking in education typically takes three forms: helping school administrators solve institution-based problems, aiding educators develop more creative lesson plans, and engendering design thinking skills in students.

There are currently many researchers exploring the intersection of design thinking and education.[\[37\]](#) The REDLab group, from [Stanford University](#)’s Graduate School of Education, conducts research into design thinking in K-12, secondary, and post-secondary settings.[\[38\]](#) The Hasso Plattner Design Thinking Research Program is a collaborative program between [Stanford University](#) and the [Hasso Plattner Institute](#) from [Potsdam](#), Germany.[\[37\]\[39\]](#) The Hasso Plattner Design Thinking Research Program’s mission is to “apply rigorous academic methods to understand how and why design thinking innovation works and fails.”[\[39\]](#)



[SPJIMR](#), a top B-school in India, offers a road map to build design thinking culture in the organisation and has implemented the approach across its different management programs.

In addition to enriching curriculum and expanding student perspectives, design thinking can also benefit educators. Researchers have proposed that design thinking can enable educators to integrate technology into the classroom.<sup>[40]</sup>

Design thinking as a viable curricular and systemic reform program is increasingly being recognized by educators. “Much of today’s education system guides students toward finding the correct answers to fill-in-the blanks on standardized tests, as this kind of instruction facilitates streamlined assessments to measure success or failure... It is critical that, particularly in under-served schools this model of learning does not continue to prevail. Students need both the skills and the tools to participate in a society where problems are increasingly complex and nuanced understandings are vital.”<sup>[41]</sup>

### **Uses in K-12 education**

In the K-12 arena, design thinking is employed to promote creative thinking, teamwork, and student responsibility for learning. The non profit Tools at Schools aims to expose students, educators, and schools to design thinking. The organization does this by facilitating a relationship between a school and a manufacturing company. Over a minimum of six months, representatives from the manufacturing company teach students the principles of design and establish the kind of product to be designed.<sup>[42]</sup> The students collaborate to design a prototype that the manufacturer produces.<sup>[42]</sup> Once the prototype arrives, the students must promote the product and support the ideas that lead to its design.<sup>[42]</sup>

An example of the Tools at Schools partnership is the redesign of school equipment by 8th grade students at [The School at Columbia University](#). The students were divided into groups and asked to redesign a locker, chair, or a desk to better suit the needs of 21st century pupils.<sup>[43]</sup> The students’ final products were displayed at the [International Contemporary Furniture Fair](#) where they demonstrated their product to fair attendees and industry professionals.<sup>[43]</sup> Overall Tools at Schools not only introduces students to the design process, it exposes them to the design profession through their interactions with designers and manufacturers.<sup>[43]</sup> Since the students work together in groups, design thinking in education also encourages collaborative learning.

Another organization that works with integrating design thinking for students is the corporation NoTosh. NoTosh has a Design Thinking School to teach instructors how to implement design thinking into their curriculum. One of the design thinking techniques NoTosh adopted from the corporate world and applied to education is hexagonal thinking. Hexagonal thinking consists of gathering cut-outs in hexagon shapes and writing a concept or fact on each one. Students then connect the hexagons by laying related ideas or facts together. The visual representation of relationships helps students better conceptualize [wicked problems](#).<sup>[44]</sup> Another concrete example of design thinking in action is NoTosh’s “Googleable vs NonGoogleable Questions” exercise.<sup>[44]</sup> Given a specific topic, students brainstorm questions on that issue and divide their questions into “Googleable and NonGoogleable.”<sup>[44]</sup> Students research the Googleable questions and present their findings to the class while the NonGoogleable questions are used to create a project.<sup>[44]</sup>

### **Stanford University’s Taking Design Thinking to Schools Initiative**

Apart from non profit entities and corporations, research universities are also involved in



deploying design thinking curriculum to K-12 schools. Part of [Stanford University](#)'s efforts to incorporate design thinking in education into a hands-on setting is the Taking Design Thinking to Schools initiative. The Stanford School of Education and d.school partner with K-12 teachers in the [Palo Alto](#) area to discover ways to apply design thinking in an educational setting.<sup>[45]</sup> “Teachers and students engage in hands-on design challenges that focus on developing empathy, promoting a bias towards action, encouraging ideation, developing metacognitive awareness and fostering active problem solving.”<sup>[45]</sup>

Taking Design Thinking to Schools identifies the following design thinking process:

- *Understand*: students explore the topic through research and develop familiarity with the subject matter
- *Observe*: this phase consists of students taking note of their environment, which includes physical surroundings and human interactions; students gather more information about peoples' actions and possible motivation through discussion
- *Point of view*: students consider alternate points of views to better understand the problem and to inform their ideas in the next phase
- *Ideate*: this phase consists of students brainstorming ideas without criticism or inhibition. In this phase, the focus is on generating lots of ideas with an emphasis on creativity and enjoying the process.
- *Prototype*: in this phase students create quick prototypes to investigate ideas generated during the ideation phase
- *Test*: students test their ideas in a repetitive fashion and determine which aspects of the design are effective and which could be improved.<sup>[45]</sup>

By employing this process, the Stanford team and Taking Design Thinking to Schools participants collaborate to develop coursework that students will find engrossing and “hands-on.”<sup>[45]</sup> Thus, the program at Stanford combines both design thinking for teachers who must create alternative curriculum and students who must complete the design thinking-based projects.

### **The K12 Lab at Stanford**

The K12 Lab network is a part of the [Stanford University](#) d.school and according to its website its mission is to “inspire and develop the creative confidence of educators and support edu innovators catalyzing new models for teaching and learning.”<sup>[46]</sup> The K12 Lab Network publishes a wiki with information on creating design challenges for K-12 schools. The wiki provides tools for thinking about design challenges as well as criteria for implementing design challenges.<sup>[47]</sup>

### **The Design Thinking for Educators toolkit**

The Design Thinking for Educators toolkit was developed in 2011 by the design firm IDEO in partnership with the PreK-12 independent school [Riverdale Country School](#).<sup>[48]</sup> The Design Thinking for Educators toolkit that is currently offered to the public for free download is the second version.<sup>[49]</sup> The Design Thinking for Educators toolkit is a comprehensive resource for educators to use, which includes a “walk-through of the design thinking process complete with examples and a downloadable workbook.”<sup>[50]</sup> The toolkit has been used in academic research to

aid in the creation of an “iPad learning Ecosystem”.<sup>[51]</sup> to help design a program to aid at-risk youth in the transition from elementary to secondary school,<sup>[51]</sup> as well as to redesign libraries.<sup>[50]</sup>

## **AIGA**

[AIGA](#) has implemented a movement, DesignEd K12, to take designing thinking to schools. This movement is guided by volunteers and there is not a specific program to follow; instead volunteer designers introduce students to the design field and consequently, design thinking. DesignEd K12 intends to motivate students to use design thinking to solve problems; to create a network where designers, students, and educational professionals share best practices; to shape a recommended approach to teaching design; and to cultivate a passion for design among young people.<sup>[52]</sup> Across the nation, many of AIGA's chapters are working with school districts. The programs range in scope; some mentor students who have shown an interest in design, while other programs offer students the opportunity to explore design and participate in design thinking projects within scheduled classed or through an after-school activity.<sup>[52]</sup>

## **Uses in higher education**

Design thinking is currently being taught in “workshops, supplemental training, courses, or degree programs” in over 60 universities and colleges.<sup>[53]</sup> Design thinking is used by colleges as a way to instruct students on the phases of design, and to help develop innovative solutions to existing problems.<sup>[53]</sup> The d.school at [Stanford University](#) is a well-known design thinking program in higher education, with students from Stanford's departments of engineering, medicine, business, law, and education utilizing the d.school to develop innovative solutions to problems.<sup>[54]</sup> The [University of Kentucky](#) also has formalized instruction on design thinking through its dLab. The dLab serves a multitude of functions from helping schools resolve their issues with design thinking to conducting empirical experiments on design thinking to collaborating with outside organizations to provide issues that plague their organization.<sup>[55]</sup> [Radford University](#), located in Radford, Virginia, currently offers a [Master of Fine Arts](#) (MFA) degree in design thinking.<sup>[44]</sup> The MFA degree offered is a completely online degree that emphasizes design thinking, design history, design research, design management, and design doing.<sup>[56]</sup>

The [Johns Hopkins University](#) Carey Business School and the [Maryland Institute College of Art](#) began offering an MBA/MA in design leadership in 2012.<sup>[57]</sup> Students simultaneously earn a master of arts degree in design leadership from an art school as well as an MBA from a research institution.

## **Obstacles to implementing design thinking in schools**

The accountability to succeed on high-stakes standardized tests in K-12 environments prevents the implementation of design thinking curriculum. Educators feel that focusing on classic curriculum will better prepare their students to perform well on these exams.<sup>[41]</sup> Resistance to design thinking also springs from concerns about the appropriateness of applying design thinking to an educational setting. It has been argued that design thinking is best applied by professionals who know a field well.<sup>[58]</sup> Therefore, K-12 students who are limited by their reduced understanding of both the field and their still developing intellectual capacities may not be best suited to design thinking activities.<sup>[58]</sup>

Another more subtle obstacle to design thinking in schools may come from members of the

academic community who believe design thinking should remain in the milieu of avant-garde companies.<sup>[59]</sup> Other issues that may prevent the implementation of design thinking in scholastic settings may be a lack of awareness of the field, educators' uncertainty in implementing new approaches to teaching, and lack of institutional support.

Even for institutions that see the value of design thinking, there is the issue of implementing these new approaches to education successfully. Admittedly “creating an effective thinking and successful team learning experience is a sticky wicked problem.”<sup>[53]</sup>

## Design thinking in teaching and learning through ICT<sup>[[edit](#)]</sup>

The integration of ICT into teaching and learning presents many challenges that go beyond issues dealing with technical implementation. Some researchers have already claimed the limited effects of ICT adoption in learning;<sup>[60][61][62]</sup> Considering the emphasis and the investment that has been placed on the use of ICT in formal learning settings (schools and higher education institutions) it is important to identify where the problems are. In this regard, some voices of the educational community focus on the methods used for integrating ICT in teaching and learning;<sup>[63][64]</sup> In this sense, the adoption of a design thinking mindset is regarded as a promising strategy to develop holistic solutions.

Design thinking in teaching and learning through ICT can be considered as similar activities. First, it's important to acknowledge that the type of problems faced by the educational community when adopting learning technology are unique, ill-defined and do not have clear solutions;<sup>[65][66]</sup> This definition corresponds very well to the term wicked problems used by the design community.<sup>[67]</sup> Secondly, similarly to what happens in design, the diversity of actors brings another layer of complexity that should be recognized. In this regard, collaboration between different stakeholders during the design process is another key issue that could contribute to develop more meaningful technologies for learning;<sup>[63][64][68]</sup>

Design thinking has been outlined as a meaningful approach for facing wicked problems.<sup>[9]</sup> The adoption of a design mindset helps understand that there can be many solutions for a given situation and that any design requires testing. From this perspective, bringing design thinking to learning design and design expertise to the development process of technological learning solutions can contribute to the creation of more holistic solutions in learning through ICT.<sup>[69]</sup>

## 37. Maker Culture

from wikipedia: [https://en.wikipedia.org/wiki/Maker\\_culture](https://en.wikipedia.org/wiki/Maker_culture)

The **maker culture** is a contemporary [culture](#) or [subculture](#) representing a technology-based extension of [DIY culture](#)<sup>[citation needed]</sup> that intersects with [hacker culture](#) (which is less concerned with physical objects as it focuses on software) and revels in the creation of new devices as well as [tinkering](#) with existing ones. The maker culture in general supports [open-source hardware](#). Typical interests enjoyed by the maker culture include engineering-oriented pursuits such as [electronics](#), [robotics](#), [3-D printing](#), and the use of [Computer Numeric Control](#) tools, as well as more traditional activities such as [metalworking](#), [woodworking](#), and, mainly, its predecessor, the traditional [arts and crafts](#). The subculture stresses a cut-and-paste approach to standardized hobbyist [technologies](#), and encourages cookbook re-use of designs published on websites and maker-oriented publications.<sup>[1][2]</sup> There is a strong focus on using and learning practical skills and applying them to reference designs.<sup>[3]</sup>

### Philosophical emphasis<sup>[edit]</sup>

Maker culture emphasizes learning-through-doing ([active learning](#)) in a social environment. Maker culture emphasizes informal, networked, peer-led, and shared learning motivated by fun and self-fulfillment.<sup>[4]</sup> Maker culture encourages novel applications of technologies, and the exploration of intersections between traditionally separate domains and ways of working including metal-working, calligraphy, film making, and computer programming. Community interaction and knowledge sharing are often mediated through networked technologies, with websites and social media tools forming the basis of knowledge repositories and a central channel for information sharing and exchange of ideas, and focused through social meetings in shared spaces such as hackspaces. Maker culture has attracted the interest of educators concerned about students' disengagement from STEM subjects (science, technology, engineering and mathematics) in formal educational settings. Maker culture is seen as having the potential to contribute to a more participatory approach and create new pathways into topics that will make them more alive and relevant to learners.

Some say that the maker movement is a reaction to the de-valuing of physical exploration and the growing sense of disconnection with the physical world in modern cities.<sup>[5]</sup> Other scholars including Raymond Malewitz and [Charles Jencks](#) have examined the [Utopian](#) vision of Maker culture, which they link to myths of [rugged individualism](#), the possibility of a [counterculture](#) and [libertarianism](#)<sup>[6][7]</sup> Many products produced by the maker communities have a focus on [health](#) (food), [sustainable development](#), [environmentalism](#), local [culture](#) and can from that point of view also be seen as a negative response to [disposables](#), [globalised mass production](#), the power of [chain stores](#), [multinationals](#) and [consumerism](#).

In reaction to the rise of maker culture, [Barack Obama](#) pledged to open several national [research](#)

and development facilities to the public.<sup>[5]</sup> In addition the U.S. federal government renamed one of their national centers “[America Makes](#)”.<sup>[8]</sup>

The maker movement is a social movement with an [artisan](#) spirit in which the methods of [digital fabrication](#)—previously the exclusive domain of institutions—have become accessible at a personal scale, following a logical and economic progression similar to the transition from minicomputers to personal computers in the [microcomputer revolution](#) of the 1970s.<sup>[9]</sup> In 2005, Dale Dougherty launched [Make](#) magazine to serve the growing community, followed by the 2006 launch of [Maker Faire](#).<sup>[10]</sup> The term, coined by Dougherty, grew into a full-fledged industry based on the growing number of DIYers who want to build something rather than buy it.

Spurred primarily by the advent of [RepRap 3D printing](#) for the fabrication of [prototypes](#), declining cost and broad adoption have opened up new realms of [innovation](#). As it has become cost effective to make just one item for prototyping (or a small number of household items),<sup>[11]</sup> this approach can be depicted as personal fabrication for “a market of one person”.<sup>[9]</sup>

## Makerspaces<sup>[edit]</sup>

Main articles: [Hackerspace](#) and [Fablab](#)

The rise of the maker culture is closely associated with the rise of hackerspaces, Fab Labs and other “maker spaces”, of which there are now many around the world, including over 100 each in Germany and the United States.<sup>[12]</sup> Hackerspaces allow like-minded individuals to share ideas, tools, and skillsets.<sup>[13][14]</sup> Some notable hackerspaces which have been linked with the maker culture include [Urban Workshop](#), [Noisebridge](#), [NYC Resistor](#), [A2 Mech Shop](#), [Pumping Station: One](#), [Artisan’s Asylum](#),<sup>[15]</sup> [danger!awesome](#),<sup>[16]</sup> and [TechShop](#). In addition, those who identify with the subculture can be found at more traditional universities with a technical orientation, such as [MIT](#) and [Carnegie Mellon](#) (specifically around “[shop](#)” areas like the MIT Hobby Shop and CMU Robotics Club). As maker culture becomes more popular, hackerspaces and Fab Labs are becoming more common in universities<sup>[17]</sup> and public libraries. The federal government has started adopting the concept of fully open makerspaces within its agencies, the first of which (SpaceShop Rapid Prototyping Lab) resides at [NASA Ames Research Center](#).<sup>[18]</sup> In Europe the popularity of the labs is more prominent than in the US: about three times more labs exist there.<sup>[19]</sup>

Outside Europe and the US, the maker culture is also on the rise, with several hacker or makerspaces being landmarks in their respective cities’ entrepreneurial and educational landscape. More precisely: [HackerspaceSG](#) in Singapore has been set up by the team now leading the city-state (and, arguably, South-East Asia’s) most prominent accelerator [JFDI.Asia](#). Lambda Labs in Beirut is recognized as a hackerspace where people can collaborate freely, in a city often divided by its different ethnic and religious groups.<sup>[20]</sup> Xinechian <sup>[21]</sup> in Shanghai is China’s first hackerspace, which allows for innovation and collaboration in a country known for its strong internet censorship.

With the rise of cities, which will host 60% of mankind by 2030, hackerspaces, fablabs and makerspaces will likely gain traction, as they are places for local entrepreneurs to gather and

collaborate, providing local solutions to environmental, social or economical issues.<sup>[22]</sup> The [Institute for the Future](#) has launched in this regard Maker Cities, as “an open and collaborative online game, to generate ideas about how citizens are changing work, production, governance, learning, well-being, and their neighborhoods, and what this means for the future”.<sup>[23]</sup>

Cuba will host the first international Open Technology 4 Life Workshop inviting American Makers to collaborate with Cuban Makers in January 2016 in Havana.<sup>[24]</sup>

Over the same time frame, [makerspaces](#) have started to spring up. Though desktop machines and inexpensive tools for the home have made many projects possible, some still require industrial equipment that's not accessible to the typical maker. Makerspaces — TechShop is probably the best-known, with multiple locations around the U.S. — tend to be a community-based industrial space that operate on a membership plan, somewhat like a gym.

## Tools and hardware[\[edit\]](#)

See also: [Free hardware](#)

[3D printers](#) and [3D scanners](#),<sup>[26]</sup> [microcontrollers](#),<sup>[27]</sup> [drones](#),<sup>[28]</sup> [DIY electronics](#) like [littleBits](#),<sup>[29]</sup> are just some of the tools that are helping grow the movement. They're growing less expensive — in some cases, they're already very reasonable — and getting smaller. But this combined with the cloud and the openness in hardware and software give the biggest advance to the maker culture.

The cloud itself is a basic tool in service of the maker movement, enabling increased collaboration, digital workflow, distributed manufacturing (i.e., the download of files that translate directly into objects via a digitized manufacturing process) and [collaborative economy](#). This, combined with the [Open source](#) movement, initially focused on software, has been expanding into [open-source hardware](#), assisted by easy access to online plans (in the cloud) and licensing agreements.

Programmable microcontrollers and microcomputers like the [Arduino](#), [Raspberry Pi](#), [BeagleBone Black](#), and Intel's Galileo and Edison controllers, are easy to program and enable connected devices, and some open source. Combined with the [cloud](#), they're helping create the [Internet of Things](#).

A very important tool for the Maker culture, the additive manufacturing, like [3D printing](#)<sup>[30]</sup> (including machining, like CNC milling and routing) have moved to the desktop. This combines with the open hardware in the cloud for open-source 3D printing. Also combines with DIY open-source microelectronics to create autoreplicant 3d printers, as [RepRap](#).

## Other Types of Making[\[edit\]](#)

Maker culture involves many types of making – this section reviews some of the major types.



## Amateur Scientific Equipment[\[edit\]](#)

This involves making scientific instruments for [citizen science](#) or [open source labs](#).<sup>[31]</sup> With the advent of low-cost digital manufacturing it is becoming increasingly common for scientists as well as amateurs to fabricate their own scientific apparatuses from open source hardware designs.<sup>[32][33]</sup>

## Clothes[\[edit\]](#)

See also: [Ravelry](#)

Clothes can include sew and no-sew DIY hacks.<sup>[34][35][36]</sup>

Clothing can also include knitted or crocheted clothing and accessories. Some knitters may use knitting machines with varying degrees of automatic patterning. Fully electronic knitting machines can be interfaced to computers running computer-aided design software. Arduino boards have been interfaced to electronic knitting machines to further automate the process.<sup>[37]</sup>

[Free People](#), a popular clothing retailer for young women, often hosts craft nights inside the doors of its Anthropologie locations.<sup>[38]</sup>

## Biology, food and composting[\[edit\]](#)

Examples of maker culture in food production include [baking](#), [homebrewing](#), [winemaking](#), [vegoil](#), [pickling](#), [sausage](#), [cheesemaking](#), [yogurt](#) and [pastry](#) production.

This can also extend into [urban agriculture](#), [composting](#) and [synthetic biology](#).<sup>[39]</sup>

## Organic cosmetics[\[edit\]](#)

See also: [Organic movement](#)

Maker [cosmetics](#) includes [parfums](#), [creams](#), [lotions](#), [gels](#) and [shampoos](#).

Tool kits for maker cosmetics can include<sup>[40]</sup> [beakers](#) (250 and 400 ml), [digital scales](#), [laboratory thermometers](#) (if possible, from -20 to 110 °C), [pH paper](#), [glass rods](#), plastic [spatulas](#), and [spray](#) to disinfect with alcohol.

[Parfums](#) can be done at home using (96°) [ethanol](#) (also in the form of [vodka](#) or [Everclear](#)), [essential oils](#) or [fragrance oils](#), [infused oils](#), even [flavour extracts](#) (such as pure [vanilla extract](#)), [distilled](#) or [spring water](#) and [glycerine](#). Tools [glass bottles](#), [glass jar](#), [measuring cup](#)/[measuring](#)



[spoons](#), a [dropper](#), [funnel](#) and [aluminum foil](#) or [wrapping paper](#), if you are using clear glass bottles.<sup>[41]</sup>

## Music making[\[edit\]](#)

The concept of homemade and experimental instruments in music has its roots prior to the maker movement, from complicated experiments with figures such as [Reed Ghazala](#) and [Michel Waisvisz](#) pioneering early [circuit bending](#) techniques to simple projects such as the [Cigar Box Guitar](#). [Bart Hopkin](#) published the magazine [Experimental Musical Instruments](#) for 15 years followed by a series of books about instrument building. Organizations such as [Zvex](#), [WORM](#), [STEIM](#), [Death by Audio](#), and [Casper Electronics](#) cater to the do-it-yourself audience, while musicians like [Nicolas Collins](#) and [Yuri Landman](#) create and perform with custom made and experimental instruments.

## Tool making[\[edit\]](#)

Makers can also make or fabricate their own tools.<sup>[42]</sup> This includes [knives](#), [hand tools](#), [lathes](#), [3-D printers](#), [wood working](#) tools,<sup>[43]</sup> etc.

## Vehicles[\[edit\]](#)

A [kit car](#), also known as a “component car”, is an automobile that is available as a set of parts that a manufacturer sells and the buyer himself then assembles into a functioning car.

[Car tuning](#) can include [electric vehicle conversion](#).

## Media[\[edit\]](#)

Some media outlets associated with the subculture include [MAKE](#) (a magazine published since 2005 by [O'Reilly Media](#)), [Wamungo](#) and the popular weblog [Boing Boing](#). Boing Boing editor [Cory Doctorow](#) has written a novel, [Makers](#), which he describes as being “a book about people who hack hardware, business-models, and living arrangements to discover ways of staying alive and happy even when the economy is falling down the toilet”.<sup>[44]</sup> In 2016 Intel sponsored a reality TV show – America’s Greatest Makers – where 24 teams of Makers compete for \$1 million.

# 38. Experience Design

From Wikipedia: [https://en.wikipedia.org/wiki/User\\_experience\\_design](https://en.wikipedia.org/wiki/User_experience_design)

**User experience design (UX, UXD, UED or XD)** is the process of enhancing user satisfaction by improving the [usability](#), [accessibility](#), and pleasure provided in the interaction between the user and the product.<sup>[1]</sup> User experience design encompasses traditional [human-computer interaction](#) (HCI) design, and extends it by addressing all aspects of a product or service as perceived by users.<sup>[2]</sup>

## Elements

User experience design includes elements of [interaction design](#), [information architecture](#), [user research](#), and other disciplines, and is concerned with all facets of the overall experience delivered to users. Following is a short analysis of its constituent parts.

## Visual design

Visual design, also commonly known as [graphic design](#), [user interface design](#), [communication design](#), and [visual communication](#), represents the aesthetics or [look-and-feel](#) of the front end of any [user interface](#). Graphic treatment of interface elements is often perceived as the visual design. The purpose of visual design is to use visual elements like colors, images, and symbols to convey a message to its audience. Fundamentals of [Gestalt psychology](#) and [visual perception](#) give a cognitive perspective on how to create effective visual communication.<sup>[6]</sup>

## Information architecture

Information architecture is the art and science of structuring and organizing the information in products and services to support [usability](#) and [findability](#).

In the context of information architecture, information is separate from both knowledge and data, and lies nebulously between them. It is information about objects.<sup>[citation needed]</sup> The objects can range from websites, to software applications, to images et al. It is also concerned with [metadata](#): terms used to describe and represent content objects such as documents, people, process, and organizations.

## *Structuring, organization, and labeling*

[Structuring](#) is reducing information to its basic building units and then relating them to each other. Organization involves grouping these units in a distinctive and meaningful manner. Labeling means using appropriate wording to support easy navigation and findability.

## *Finding and managing*

Findability is the most critical success factor for information architecture.<sup>[[citation needed](#)]</sup> If users are not able to find required information without browsing, searching or asking, then the findability of the information architecture fails. Navigation needs to be clearly conveyed to ease finding of the contents.

## Interaction design

Main article: [Interaction design](#)

There are many key factors to understanding interaction design and how it can enable a pleasurable end user experience. It is well recognized <sup>[[clarification needed](#)]</sup> that building great user experience requires interaction design to play a pivotal role in helping define what works best for the users. High demand for improved user experiences and strong focus on the end-users have made interaction designers critical in conceptualizing design that matches [user expectations](#) and standards of the latest UI patterns and components. While working, interaction designers take several things in consideration. A few of them are:<sup>[7]</sup>

- Creating the layout of the interface
- Defining interaction patterns best suited in the context
- Incorporating user needs collected during user research into the designs
- Features and information that are important to the user
- Interface behavior like drag-drop, selections, and mouse-over actions
- Effectively communicating strengths of the system
- Making the interface intuitive by building affordances
- Maintaining consistency throughout the system.

In the last few years, the role of interaction designer has shifted from being just focused on specifying UI components and communicating them to the engineers to a situation now where designers have more freedom to design contextual interfaces which are based on helping meet the user needs.<sup>[8]</sup> Therefore, User Experience Design evolved into a multidisciplinary design

branch that involves multiple technical aspects from [motion graphics design](#) and [animation](#) to [programming](#).

## Usability

Main article: [Usability](#)

Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.<sup>[9]</sup>

Usability is attached with all tools used by humans and is extended to both digital and non-digital devices. Thus, it is a subset of user experience but not wholly contained. The section of usability that intersects with user experience design is related to humans' ability to use a system or application. Good usability is essential to a positive user experience but does not alone guarantee it.<sup>[10]</sup>

## *Accessibility*

Main article: [Accessibility](#)

Accessibility of a system describes its ease of reach, use and understanding. In terms of user experience design it can also be related to the overall comprehensibility of the information and features. It contributes to shorten the learning curve attached with the system. Accessibility in many contexts can be related to the ease of use for people with disabilities and comes under usability.<sup>[11]</sup>

## Human–computer interaction

Main article: [Human-computer interaction](#)

Human–computer interaction is concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.<sup>[12]</sup>

Human–computer interaction is the main contributor to user experience design because of its emphasis on human performance rather than mere usability. It provides key research findings which inform the improvement of systems for the people. Human–computer interaction extends its study towards more integrated interactions, such as tangible interactions, which is generally not covered in the practice of user experience. User experience cannot be manufactured or

designed; it has to be incorporated in the design. Understanding the user's emotional quotient plays a key role while designing a user experience. The first step while designing the user experience is determining the reason a visitor will be visiting the website or use the application in question. Then the user experience can be designed accordingly.

## Design

Main article: [Design](#)

User experience design incorporates most or all of the above disciplines to positively impact the overall experience a person has with a particular interactive system and its provider. User experience design most frequently defines a sequence of interactions between a user (individual person) and a system, virtual or physical, designed to meet or support user needs and goals, primarily, while also satisfying systems requirements and organizational objectives.

Typical outputs include:

- [Persona](#) (an archetypal user for whom the product or service is being designed)
- [Wireframes](#) (screen blueprints or [storyboards](#))
- [Prototypes](#) (for interactive or in-the-mind simulation)
- Written specifications (describing the behavior or design)
- Site audit (usability study of existing assets)
- Flows and navigation maps
- User stories or scenarios
- Sitemaps and content inventory
- High-fidelity visual mockups (precise visual layout and design of the expected product or interface)

## General design process

While designing a product or service for a client, it is of utmost importance that the designers are on the same page as the client. All the information collected, plans made, design executed will reflect on the final product. Rigorous analysis must be done before proceeding to the design stage and then numerous testings done to optimize the site as per best standards so that the competitive edge is maintained. Leading Digital marketing companies combine three elements to provide the best responsive product to the customer. These are:

1. Researching about the [target audience](#)
2. Understanding the company's business goals
3. And most importantly apply out of the box thinking.

[Brainstorming](#) and testing ultimately leads them to finalize the design for their customers. Let's have a detailed look at the step by step process of product design:

- Collecting information about the problem

The UX designer needs to find out as much as they can about people, processes, and products before the design phase. Designers can do this by meeting with the clients or business stakeholders frequently to know what their requirements are, or by conducting interviews with users in their home or work spaces. This kind of qualitative [research](#) helps designers create products and services that better serve user needs.

- Getting ready to design

After research, the designer must make sense of the data they've collected. Typically this is done through modeling of the users and their environments. User modeling or [personas](#) are composite archetypes based on behavior patterns uncovered during research. Personas provide designers a precise way of thinking and communicating about how groups of users behave, how they think, what they want to accomplish and why.<sup>[13]</sup> Once created, personas help the designer to understand the users' goals in specific contexts, which is particularly useful during ideation and for validating design concepts. Other types of models include work flow models, artifact models, and physical models.

- Design

When the designer has a firm grasp on the user's needs and goals, they begin to sketch out the interaction framework (also known as [wireframes](#)). This stage defines the high-level structure of screen layouts, as well as the product's flow, behavior, and organization. There are many kinds of materials that can be involved in during this iterative phase, from whiteboards to paper prototypes. As the interaction framework establishes an overall structure for product behavior, a parallel process focused on the visual and industrial designs. The visual design framework defines the experience attributes, visual language, and the visual style.<sup>[14]</sup>

Once a solid and stable framework is established, wireframes are translated from sketched storyboards to full-resolution screens that depict the user interface at the pixel level. At this point, it's critical for the programming team to collaborate closely with the designer. Their input is necessary to creating a finished design that can and will be built while remaining true to the concept.

- Test and iterate

Usability testing is carried out through prototypes. The target users are given various tasks to perform on the prototypes. Any issues or problems faced by the users are collected as field notes and these notes are used to make changes in the design and reiterate the testing phase.<sup>[15]</sup> Usability testing is, at its core, a means to "evaluate, not create".<sup>[16]</sup>

## UX Deliverables

UX designers' main goal is to solve the end-users' problems, and thus the ability to communicate the design to stakeholders and developers is critical to the ultimate success of the design. Regarding UX specification documents, these requirements depend on the client or the organization involved in designing a product. The four major deliverables are: a title page, an introduction to the feature, wireframes and a version history.<sup>[17]</sup> Depending on the type of project, the specification documents can also include flow models, cultural models, personas, user stories, scenarios and any prior user research. Documenting design decisions, in the form of annotated wireframes, gives the developer the necessary information they may need to successfully code the project.



## 39. Augmented Reality

From Wikipedia: [https://en.wikipedia.org/wiki/Augmented\\_reality](https://en.wikipedia.org/wiki/Augmented_reality)

**Augmented reality (AR)** is an interactive experience of a real-world environment where the objects that reside in the real-world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including [visual](#), [auditory](#), [haptic](#), [somatosensory](#) and [olfactory](#).<sup>[1][2]</sup> The overlaid sensory information can be constructive (i.e. additive to the natural environment), or destructive (i.e. masking of the natural environment).<sup>[3]</sup> This experience is seamlessly interwoven with the physical world such that it is perceived as an [immersive](#) aspect of the real environment.<sup>[3]</sup> In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas [virtual reality](#) completely replaces the user's real-world environment with a simulated one.<sup>[4][5]</sup> Augmented reality is related to two largely synonymous terms: [mixed reality](#) and [computer-mediated reality](#).

The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment. The earliest functional AR systems that provided immersive mixed reality experiences for users were invented in the early 1990s, starting with the [Virtual Fixtures](#) system developed at the U.S. Air Force's [Armstrong Laboratory](#) in 1992.<sup>[3][6][7]</sup> Commercial augmented reality experiences were first introduced in entertainment and gaming businesses. Subsequently, augmented reality applications have spanned commercial industries such as education, communications, medicine, and entertainment. In education, content may be accessed by scanning or viewing an image with a mobile device or by using markerless AR techniques.<sup>[8][9]</sup> An example relevant to the construction industry is an AR helmet for construction workers which displays information about construction sites.

Augmented reality is used to enhance natural environments or situations and offer perceptually enriched experiences. With the help of advanced AR technologies (e.g. adding [computer vision](#), incorporating AR cameras into smartphone applications and [object recognition](#)) the information about the surrounding real world of the user becomes [interactive](#) and digitally manipulated. Information about the environment and its objects is overlaid on the real world. This information can be virtual<sup>[10][11][12][13]</sup> or real, e.g. seeing other real sensed or measured information such as electromagnetic radio waves overlaid in exact alignment with where they actually are in space.<sup>[14][15][16]</sup> Augmented reality also has a lot of potential in the gathering and sharing of tacit knowledge. Augmentation techniques are typically performed in real time and in semantic contexts with environmental elements. Immersive perceptual information is sometimes combined with supplemental information like scores over a live video feed of a sporting event. This combines the benefits of both augmented reality technology and [heads up display](#) technology (HUD).

# Applications

Augmented reality has many applications. First used for military, industrial, and medical applications, it has also been applied to commercial and entertainment areas.<sup>[73]</sup>

## Literature

In 2011, there were works using AR poetry made by [ni\\_ka](#) from the [Sekai Camera](#) in Japan, Tokyo. The rose of these works come from [Paul Celan](#), “[Die Niemandsrose](#)“, and express the mourning of 3.11, [2011 Tōhoku earthquake and tsunami](#).<sup>[74][75][76][77]</sup>

## Archaeology

AR can be used to aid archaeological research, by augmenting archaeological features onto the modern landscape, enabling archaeologists to formulate conclusions about site placement and configuration.<sup>[78]</sup>

Another application given to AR in this field is the possibility for users to rebuild ruins, buildings, landscapes or even ancient characters as they formerly existed.<sup>[79][80][81]</sup>

## Architecture



Meta 2 used for collaborative design

AR can aid in visualizing building projects. Computer-generated images of a structure can be superimposed into a real life local view of a property before the physical building is constructed there; this was demonstrated publicly by [Trimble Navigation](#) in 2004. AR can also be employed within an architect’s work space, rendering into their view animated 3D visualizations of their 2D drawings. Architecture sight-seeing can be enhanced with AR applications allowing users

viewing a building's exterior to virtually see through its walls, viewing its interior objects and layout. <sup>[82][83][84]</sup>

## Visual art

AR technology has helped disabled individuals create visual art by using [eye tracking](#) to translate a user's eye movements into drawings on a screen. <sup>[85]</sup> An item such as a commemorative coin can be designed so that when scanned by an AR-enabled device it displays additional objects and layers of information that were not visible in a real world view of it. <sup>[86][87]</sup> In 2013, L'Oreal used CrowdOptic technology to create an augmented reality at the seventh annual Luminato Festival in Toronto, Canada. <sup>[31]</sup>

AR in visual art opens the possibility of multidimensional experiences and interpretations of reality. Augmenting people, objects, and landscapes is becoming an art form in itself. In 2011, artist Amir Bardaran's *Frenchising the Mona Lisa* infiltrates Da Vinci's painting using an AR mobile application called Junaio. Aim a Junaio loaded smartphone camera at any image of the Mona Lisa and watch as Leonardo's subject places a scarf made of a French flag around her head. <sup>[88]</sup> The AR app allows the user to train his or her smartphone on Da Vinci's *Mona Lisa* and watch the mysterious Italian lady loosen her hair and wrap a French flag around her in the form a (currently banned) Islamic *hijab*. <sup>[89]</sup>

[iGreet's](#) augmented reality greeting card suddenly becomes alive and hidden digital content appears when being viewed through the app.

## Greeting cards

AR technology has been used in conjunction with greeting cards. They can be implemented with digital content which users are able to discover by viewing the illustrations with certain mobile applications or devices using augmented reality technology. The digital content could be 2D & 3D animations, standard video and 3D objects with which the users can interact.

In 2015, the Bulgarian startup [iGreet](#) developed its own AR technology and used it to make the first premade "live" greeting card. It looks like traditional paper card, but contains hidden digital content which only appears when users scan the greeting card with the iGreet app. <sup>[90][91]</sup>

## Commerce

### View Description image 1

AR can enhance product previews such as allowing a customer to view what's inside a product's packaging without opening it.<sup>[92]</sup> AR can also be used as an aid in selecting products from a catalog or through a kiosk. Scanned images of products can activate views of additional content such as customization options and additional images of the product in its use.<sup>[93][94]</sup> AR is used to integrate print and video marketing. Printed marketing material can be designed with certain “trigger” images that, when scanned by an AR enabled device using image recognition, activate a video version of the promotional material. A major difference between Augmented Reality and straight forward image recognition is that you can overlay multiple media at the same time in the view screen, such as social media share buttons, in-page video even audio and 3D objects. Traditional print only publications are using Augmented Reality to connect many different types of media.<sup>[95][96][97][98][99]</sup>

## Construction

With the continual improvements to [GPS](#) accuracy, businesses are able to use augmented reality to visualize [georeferenced](#) models of construction sites, underground structures, cables and pipes using mobile devices.<sup>[100]</sup> Augmented reality is applied to present new projects, to solve on-site construction challenges, and to enhance promotional materials.<sup>[101]</sup> Examples include the [Daqri](#) Smart Helmet, an Android-powered hard hat used to create augmented reality for the industrial worker, including visual instructions, real time alerts, and 3D mapping.<sup>[102]</sup>

Following the [Christchurch earthquake](#), the University of Canterbury released, CityViewAR, which enabled city planners and engineers to visualize buildings that were destroyed in the earthquake.<sup>[103]</sup> Not only did this provide planners with tools to reference the previous [cityscape](#), but it also served as a reminder to the magnitude of the devastation caused, as entire buildings were demolished.

## Education



[App iSkull](#), an augmented human skull for education ([iOS](#) OS)

[App iWow](#), a mobile device based augmented reality enhanced world globe

Augmented reality applications can complement a standard curriculum. Text, graphics, video and audio can be superimposed into a student's real time environment. Textbooks, flashcards and other educational reading material can contain embedded "[markers](#)" that, when scanned by an AR device, produce supplementary information to the student rendered in a multimedia format.<sup>[104][105][106]</sup> Students can participate interactively with computer generated simulations of historical events, exploring and learning details of each significant area of the event site.<sup>[107]</sup> On higher education, there are some applications that can be used. For instance, Construct3D, a Studierstube system, allows students to learn mechanical engineering concepts, math or geometry. This is an active learning process in which students learn to learn with technology.<sup>[108]</sup> AR can aid students in understanding chemistry by allowing them to visualize the spatial structure of a molecule and interact with a virtual model of it that appears, in a camera image, positioned at a marker held in their hand.<sup>[109]</sup> It can also enable students of physiology to visualize different systems of the human body in three dimensions.<sup>[110]</sup> Augmented reality technology also permits learning via remote collaboration, in which students and instructors not at the same physical location can share a common virtual learning environment populated by virtual objects and learning materials and interact with another within that setting.<sup>[111]</sup>

This resource could also be of advantage in Primary School. Children can learn through experiences, and visuals can be used to help them learn. For instance, they can learn new knowledge about astronomy, which can be difficult to understand, and children might better understand the solar system when using AR devices and being able to see it in 3D. Further, learners could change the illustrations in their science books by using this resource.

For teaching anatomy, teachers could visualize bones and organs using augmented reality to display them on the body of a person.<sup>[citation needed]</sup>

Mobile apps using augmented reality are emerging in the classroom. The [mix](#) of real life and virtual reality displayed by the apps using the mobile phone's camera allows information to be manipulated and seen like never before. Many such apps have been designed to create a highly engaging environment and transform the learning experience. Examples of the mobile apps, that

leverage augmented reality to aid learning, include SkyView for studying astronomy<sup>[112]</sup> and AR Circuits for building simple electric circuits.<sup>[113]</sup>

## Emergency management / search and rescue



LandForm+ is a geographic augmented reality system used for search and rescue, and emergency management.

Augmented reality systems are used in public safety situations – from super storms to suspects at large. Two interesting articles from *Emergency Management* magazine discuss the power of the technology for emergency management. The first is “Augmented Reality–Emerging Technology for Emergency Management” by Gerald Baron.<sup>[114]</sup> Per Adam Crowe: “Technologies like augmented reality (ex: Google Glass) and the growing expectation of the public will continue to force professional emergency managers to radically shift when, where, and how technology is deployed before, during, and after disasters.”<sup>[115]</sup>

Another example, a search aircraft is looking for a lost hiker in rugged mountain terrain. Augmented reality systems provide aerial camera operators with a geographic awareness of forest road names and locations blended with the camera video. As a result, the camera operator is better able to search for the hiker knowing the geographic context of the camera image. Once found, the operator can more efficiently direct rescuers to the hiker’s location.<sup>[116]</sup>

## Everyday



30 years of Augmediated Reality in everyday life.

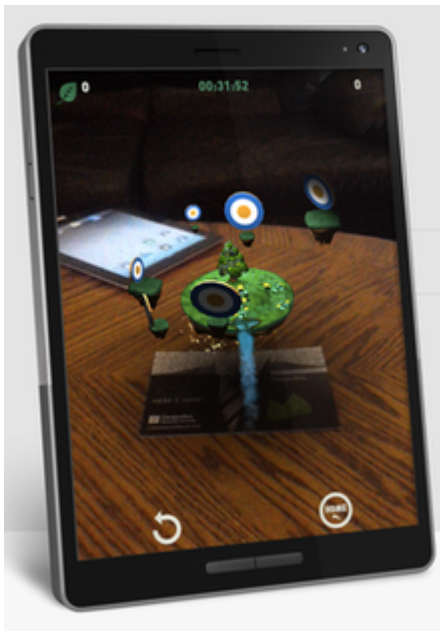
Since the 1970s and early 1980s, [Steve Mann](#) has been developing technologies meant for everyday use i.e. “horizontal” across all applications rather than a specific “vertical” market. Examples include Mann’s “EyeTap Digital Eye Glass”, a general-purpose seeing aid that does dynamic-range

management (HDR vision) and overlays, underlays, simultaneous augmentation and diminishment (e.g. diminishing the electric arc while looking at a welding torch).<sup>[117]</sup>

## Video games

Lyteshot in action

See also: [List of augmented reality software – Games](#)



[Merchlar](#)'s mobile game *Get On Target* uses a trigger image as [fiducial marker](#)

Augmented reality allows video game players to experience digital game play in a real world environment. Companies and platforms like [Niantic](#) and [LyteShot](#) emerged as augmented reality gaming creators.<sup>[118][119]</sup> Niantic is notable for releasing the record-breaking [Pokémon Go](#) game.<sup>[120]</sup>

## Industrial design

Main article: [Industrial Augmented Reality](#)

AR can help industrial designers experience a product's design and operation before completion. Volkswagen uses AR for comparing calculated and actual crash test imagery.<sup>[121]</sup> AR can be used



to visualize and modify a car body structure and engine layout. AR can also be used to compare digital mock-ups with physical mock-ups for finding discrepancies between them. <sup>[122][123]</sup>

## Medical

Since 2005, a device that films subcutaneous veins, processes and projects the image of the veins onto the skin has been used to locate veins. This device is called a [near-infrared vein finder](#). <sup>[124][125]</sup>

Augmented Reality can provide the surgeon with information, which are otherwise hidden, such as showing the heartbeat rate, the blood pressure, the state of the patient's organ, etc. AR can be used to let a doctor look inside a patient by combining one source of images such as an [X-ray](#) with another such as video.

Examples include a virtual [X-ray](#) view based on prior [tomography](#) or on real time images from [ultrasound](#) and [confocal microscopy](#) probes, <sup>[126]</sup> visualizing the position of a tumor in the video of an [endoscope](#), <sup>[127]</sup> or radiation exposure risks from X-ray imaging devices. <sup>[128][129]</sup> AR can enhance viewing a [fetus](#) inside a mother's [womb](#). <sup>[130]</sup> It has been also used for cockroach phobia treatment. <sup>[131]</sup> Also, patients wearing augmented reality glasses can be reminded to take medications. <sup>[132]</sup>

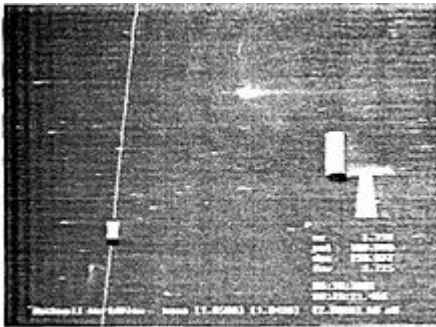
## Beauty

In 2014 the company [L'Oreal Paris](#) started developing a smartphone and tablet application called "Makeup Genius", which lets users try out make-up and beauty styles utilizing the front-facing camera of the endpoint and its display. <sup>[133]</sup>

## Spatial immersion and interaction

Augmented reality applications, running on handheld devices utilized as virtual reality headsets, can also digitalize human presence in space and provide a computer generated model of them, in a virtual space where they can interact and perform various actions. Such capabilities are demonstrated by "project Anywhere" developed by a post graduate student at ETH Zurich, which was dubbed as an "out-of-body experience" <sup>[6][7][8]</sup>.

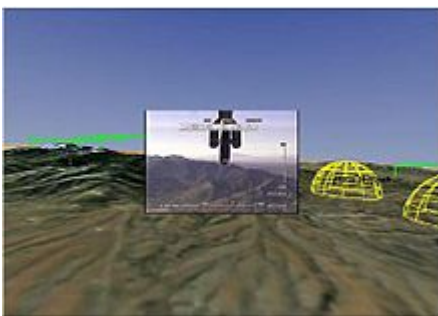
## Military



Rockwell WorldView Console showing space surveillance telescope video map overlay of satellite flight tracks from a 1993 paper.

In combat, AR can serve as a networked communication system that renders useful battlefield data onto a soldier's goggles in real time. From the soldier's viewpoint, people and various objects can be marked with special indicators to warn of potential dangers. Virtual maps and 360° view camera imaging can also be rendered to aid a soldier's navigation and battlefield perspective, and this can be transmitted to military leaders at a remote command center.<sup>[134]</sup>

An interesting application of AR occurred when Rockwell International created video map overlays of satellite and orbital debris tracks to aid in space observations at Air Force Maui Optical System. In their 1993 paper “Debris Correlation Using the Rockwell WorldView System” the authors describe the use of map overlays applied to video from space surveillance telescopes. The map overlays indicated the trajectories of various objects in geographic coordinates. This allowed telescope operators to identify satellites, and also to identify – and catalog – potentially dangerous space debris.<sup>[135]</sup>



Screen capture of SmartCam3D in picture in picture (PIP) mode. This helps sensor operators maintain a broader situation awareness than a telescopic camera “soda-straw”. It was shown to essentially double the speed at which points can be located on the ground.

Starting in 2003 the US Army integrated the SmartCam3D augmented reality system into the Shadow Unmanned Aerial System to aid sensor operators using telescopic cameras to locate people or points of interest. The system combined both fixed geographic information including street names, points of interest, airports and railroads with live video from the camera system.

The system offered “picture in picture” mode that allows the system to show a synthetic view of the area surrounding the camera’s field of view. This helps solve a problem in which the field of view is so narrow that it excludes important context, as if “looking through a soda straw”. The system displays real-time friend/foe/neutral location markers blended with live video, providing the operator with improved situation awareness.

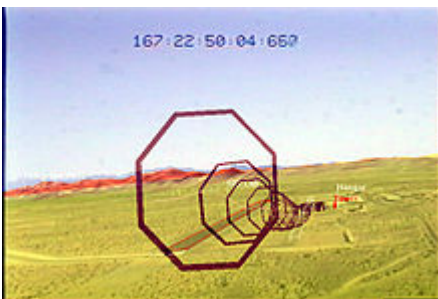
Researchers at USAF Research Lab (Calhoun, Draper et al.) found an approximately two-fold increase in the speed at which UAV sensor operators found points of interest using this technology.<sup>[136]</sup> This ability to maintain geographic awareness quantitatively enhances mission efficiency. The system is in use on the US Army RQ-7 Shadow and the MQ-1C Gray Eagle Unmanned Aerial Systems.

## Navigation

See also: [Automotive navigation system](#)



[Augmented reality map](#) on iPhone



LandForm video map overlay marking runways, road, and buildings during 1999 helicopter flight test.

AR can augment the effectiveness of navigation devices. Information can be displayed on an automobile's windshield indicating destination directions and meter, weather, terrain, road conditions and traffic information as well as alerts to potential hazards in their path. [\[137\]](#)[\[138\]](#)[\[139\]](#) Aboard maritime vessels, AR can allow bridge watch-standers to continuously monitor important information such as a ship's heading and speed while moving throughout the bridge or performing other tasks. [\[140\]](#)

The NASA X-38 was flown using a Hybrid Synthetic Vision system that overlaid map data on video to provide enhanced navigation for the spacecraft during flight tests from 1998 to 2002. It used the LandForm software and was useful for times of limited visibility, including an instance when the video camera window frosted over leaving astronauts to rely on the map overlays. [\[141\]](#) The LandForm software was also test flown at the Army Yuma Proving Ground in 1999. In the photo at right one can see the map markers indicating runways, air traffic control tower, taxiways, and hangars overlaid on the video. [\[142\]](#)

## Office workplace

AR can help facilitate collaboration among distributed team members in a work force via conferences with real and virtual participants. AR tasks can include brainstorming and discussion meetings utilizing common visualization via touch screen tables, interactive digital whiteboards, shared design spaces, and distributed control rooms. [\[143\]](#)[\[144\]](#)[\[145\]](#)

## Sports and entertainment

AR has become common in sports telecasting. Sports and entertainment venues are provided with see-through and overlay augmentation through tracked camera feeds for enhanced viewing by the audience. Examples include the yellow “[first down](#)” line seen in television broadcasts of [American football](#) games showing the line the offensive team must cross to receive a first down. AR is also used in association with football and other sporting events to show commercial advertisements overlaid onto the view of the playing area. Sections of [rugby](#) fields and [cricket](#) pitches also display sponsored images. Swimming telecasts often add a line across the lanes to indicate the position of the current record holder as a race proceeds to allow viewers to compare the current race to the best performance. Other examples include hockey puck tracking and annotations of racing car performance and snooker ball trajectories. [\[58\]](#)[\[146\]](#)

AR can enhance concert and theater performances. For example, artists can allow listeners to augment their listening experience by adding their performance to that of other bands/groups of users. [\[147\]](#)[\[148\]](#)[\[149\]](#)

The gaming industry has benefited a lot from the development of this technology. A number of games have been developed for prepared indoor environments. Early AR games also include AR air hockey, collaborative combat against virtual enemies, and AR-enhanced pool games. A significant number of games incorporate AR in them and the introduction of the smartphone has made a bigger impact. [\[150\]](#)[\[151\]](#)

## Task support

Complex tasks such as assembly, maintenance, and surgery can be simplified by inserting additional information into the field of view. For example, labels can be displayed on parts of a system to clarify operating instructions for a mechanic who is performing maintenance on the system. [\[152\]](#)[\[153\]](#) Assembly lines gain many benefits from the usage of AR. In addition to Boeing, BMW and Volkswagen are known for incorporating this technology in their assembly line to improve their manufacturing and assembly processes. [\[154\]](#)[\[155\]](#)[\[156\]](#) Big machines are difficult to maintain because of the multiple layers or structures they have. With the use of AR the workers can complete their job in a much easier way because AR permits them to look through the machine as if it was with x-ray, pointing them to the problem right away. [\[157\]](#)

## Television

Weather visualizations were the first application of augmented reality to television. It has now become common in weathercasting to display full motion video of images captured in real-time from multiple cameras and other imaging devices. Coupled with 3D graphics symbols and mapped to a common virtual geo-space model, these animated visualizations constitute the first true application of AR to TV.

Augmented reality has also become common in sports telecasting. Sports and entertainment venues are provided with see-through and overlay augmentation through tracked camera feeds for enhanced viewing by the audience. Examples include the yellow “first down” line seen in television broadcasts of American football games showing the line the offensive team must cross to receive a first down. AR is also used in association with football and other sporting events to show commercial advertisements overlaid onto the view of the playing area. Sections of rugby fields and cricket pitches also display sponsored images. Swimming telecasts often add a line across the lanes to indicate the position of the current record holder as a race proceeds to allow viewers to compare the current race to the best performance. Other examples include hockey puck tracking and annotations of racing car performance and snooker ball trajectories. [\[158\]](#)[\[159\]](#)

Augmented reality is starting to allow Next Generation TV viewers to interact with the programs they are watching. They can place objects into an existing program and interact with these objects, such as moving them around. Avatars of real persons in real time who are also watching the same program. [\[160\]](#)

## Tourism and sightseeing

Augmented reality applications can enhance a user's experience when traveling by providing real time informational displays regarding a location and its features, including comments made by previous visitors of the site. AR applications allow tourists to experience simulations of historical events, places and objects by rendering them into their current view of a landscape. [\[161\]](#)[\[162\]](#)[\[163\]](#) AR applications can also present location information by audio, announcing features of interest at a particular site as they become visible to the user. [\[164\]](#)[\[165\]](#)[\[166\]](#)

## Translation

AR systems can interpret foreign text on signs and menus and, in a user's augmented view, re-display the text in the user's language. Spoken words of a foreign language can be translated and displayed in a user's view as printed subtitles. [\[167\]](#)[\[168\]](#)[\[169\]](#)



## 40. Virtual Reality

From Wikipedia: [https://en.wikipedia.org/wiki/Virtual\\_reality](https://en.wikipedia.org/wiki/Virtual_reality)

**Virtual reality (VR)** is a [simulated](#) experience that can be similar to or completely different from the real world. [Applications of virtual reality](#) can include entertainment (i.e. gaming) and educational purposes (i.e. medical or military training). Other, distinct types of VR style technology include [augmented reality](#) and [mixed reality](#).

Currently standard virtual reality systems use either [virtual reality headsets](#) or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a [head-mounted display](#) with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates [auditory](#) and [video feedback](#), but may also allow other types of sensory and force feedback through [haptic technology](#).

### Concerns and challenges

There are certain health and safety considerations of virtual reality. For example, a number of unwanted symptoms have been caused by prolonged use of virtual reality,<sup>[78]</sup> and these may have slowed proliferation of the technology. Most virtual reality systems come with consumer warnings. In addition, there are social, conceptual, and philosophical considerations with virtual reality. What the phrase “virtual reality” means or refers to, is not always unambiguous. In the book *The Metaphysics of Virtual Reality* by [Michael R. Heim](#), seven different concepts of virtual reality are identified: simulation, interaction, artificiality, immersion, [telepresence](#), [full-body immersion](#), and network communication. There has been an increase in interest in the potential social impact of new technologies, such as virtual reality. In the book *Infinite Reality: Avatars, Eternal Life, New Worlds, and the Dawn of the Virtual Revolution*, Blascovich and Bailenson review the literature on the psychology and sociology behind life in virtual reality.

Mychilo S. Cline's book *Power, Madness, and Immortality: The Future of Virtual Reality*, argues that virtual reality will lead to a number of important changes in human life and activity.<sup>[79]</sup> He argues that virtual reality will be integrated into daily life and activity, and will be used in various human ways. Another such speculation has been written up on how to reach ultimate happiness via virtual reality.<sup>[80]</sup> He also argues that techniques will be developed to influence human behavior, [interpersonal communication](#), and [cognition](#).<sup>[81]</sup> As we spend more and more time in virtual space, there would be a gradual “migration to virtual space”, resulting in important changes in economics, worldview, and culture.<sup>[82]</sup> Philosophical implications of VR are discussed in books, including [Philip Zhai](#)'s *Get Real: A Philosophical Adventure in Virtual Reality* (1998) and *Digital Sensations: Space, Identity and Embodiment in Virtual Reality* (1999), written by Ken Hillis.



Virtual reality technology faces a number of challenges, most of which involve [motion sickness](#) and technical matters. Users might become disoriented in a purely virtual environment, causing balance issues; computer latency might affect the simulation, providing a less-than-satisfactory end-user experience; the complicated nature of head-mounted displays and input systems such as specialized gloves and boots may require specialized training to operate, and navigating the non-virtual environment (if the user is not confined to a limited area) might prove dangerous without external sensory information. In January 2014, [Michael Abrash](#) gave a talk on VR at Steam Dev Days.<sup>[83]</sup> He listed all the requirements necessary to establish [presence](#) and concluded that a great VR system will be available in 2015 or soon after. While the visual aspect of VR is close to being solved, he stated that there are other areas of VR that need solutions, such as 3D audio, haptics, body tracking, and input. However, [3D audio effects](#) exist in games and simulate the [head-related transfer function](#) of the listener (especially using headphones). Examples include [Environmental Audio Extensions](#) (EAX), [DirectSound](#) and [OpenAL](#). VR audio developer [Varun Nair](#) points out that from a design perspective, sound for VR is still very much an open book. Many of the game audio design principles, especially those related to [FPS](#) games, crumble in virtual reality. He encourages more [sound designers](#) to get involved in virtual reality audio to experiment and push VR audio forward.<sup>[84]</sup> There have been rising concerns that with the advent of virtual reality, some users may experience [virtual reality addiction](#).<sup>[85]</sup>

## History

### Before the 1950s

The Sensorama was released in the 1950s.



[View-Master](#), a stereoscopic visual simulator, was introduced in 1939.

The first references to the concept of virtual reality came from [science fiction](#). [Stanley G.](#)

[Weinbaum](#)'s 1935 short story "Pygmalion's Spectacles" <sup>[6]</sup> describes a goggle-based virtual reality system with holographic recording of fictional experiences, including smell and touch. Virtual reality in modern meaning was popularized by [Jaron Lanier](#) through his company [VPL Research](#), which held many of the mid-1980s VR patents. VPL developed the first head-mounted display (HMD), the EyePhone, and introduced the Haptic Input [DataGlove](#).<sup>[7]</sup>

## 1950–1970

[Morton Heilig](#) wrote in the 1950s of an "Experience Theatre" that could encompass all the senses in an effective manner, thus drawing the viewer into the onscreen activity. He built a prototype of his vision dubbed the [Sensorama](#) in 1962, along with five short films to be displayed in it while engaging multiple senses (sight, sound, smell, and touch). Predating digital computing, the Sensorama was a [mechanical device](#), which reportedly still functions today. Around the same time, [Douglas Engelbart](#) used computer screens as both input and output devices. In 1968, [Ivan Sutherland](#), with the help of his student [Bob Sproull](#), created what is widely considered to be the first virtual reality and [augmented reality](#) (AR) [head-mounted display](#) (HMD) system. It was primitive both in terms of [user interface](#) and [realism](#), and the HMD to be worn by the user was so heavy that it had to be suspended from the ceiling. The graphics comprising the virtual environment were simple [wire-frame model](#) rooms. The formidable appearance of the device inspired its name, [The Sword of Damocles](#).

1970–1990



[Battlezone](#), an arcade video game from 1980, used 3D vector graphics to immerse the player in a VR world.(Atari).

Also notable among the earlier [hypermedia](#) and virtual reality systems was the [Aspen Movie Map](#), which was created at [MIT](#) in 1978. The program was a crude virtual simulation of [Aspen, Colorado](#) in which users could wander the streets in one of three modes: summer, winter, and polygons. The first two were based on photographs—the researchers actually photographed every possible movement through the city’s street grid in both seasons—and the third was a basic 3-D model of the city. Atari founded a research lab for virtual reality in 1982, but the lab was closed after two years due to Atari Shock ([North American video game crash of 1983](#)). However, its hired employees, such as Tom Zimmerman, Scott Fisher, Jaron Lanier and Brenda Laurel, kept their research and development on VR-related technologies. By the 1980s the term “virtual reality” was popularized by [Jaron Lanier](#), one of the modern pioneers of the field. Lanier had founded the company [VPL Research](#) in 1985. VPL Research has developed several VR devices like the Data Glove, the Eye Phone, and the Audio Sphere. VPL licensed the Data Glove technology to Mattel, which used it to make an accessory known as the Power Glove. While the Power Glove was hard to use and not popular, at US\$75, it was early affordable VR device.

During this time, virtual reality was not well known, though it did receive media coverage in the late 1980s. Most of its popularity came from marginal cultures, like [cyberpunks](#), who viewed the technology as a potential means for social change, and drug culture, who praised virtual reality not only as a new art form, but as an entirely new frontier.<sup>[8]</sup> The concept of virtual reality was popularized in mass media by movies such as [Brainstorm](#) (1983) and [The Lawnmower Man](#). The

VR research boom of the 1990s was accompanied by the non-fiction book *Virtual Reality* (1991) by [Howard Rheingold](#).<sup>[9]</sup> The book served to demystify the subject, making it more accessible to researchers outside of the computer sphere and sci-fi enthusiasts.

Once the industry began to attract media coverage, some even compared the innovations in virtual reality to the Wright Brothers' pioneering invention of the airplane.<sup>[10]</sup> In 1990, Jonathan Waldern, a VR Ph.D, demonstrates “[Virtuality](#)” at the Computer Graphics 90 exhibition staged at London's Alexandra Palace. This new system was an arcade machine that would use a [virtual reality headset](#) to immerse players. *CyberEdge* and *PCVR*, two VR industry magazines, started to publish in the early 1990s. However, most ideas about VR remained theoretical due to the limited computing power available at the time. The extremely high cost of the technology made it impossible for consumers to adopt. When the Internet became widely available, this became the technology focus for most people. The VR industry mainly provided VR devices for medical, flight simulation, automobile industry design, and military training purposes from 1970 to 1990.

## 1990–2000

In 1991, [Sega](#) announced the [Sega VR](#) headset for [arcade games](#) and the [Mega Drive](#) console. It used [LCD](#) screens in the visor, stereo headphones, and inertial sensors that allowed the system to [track](#) and react to the movements of the user's head.<sup>[11]</sup> In the same year, [Virtuality](#) launched and went on to become the first mass-produced, networked, multiplayer VR entertainment system. It was released in many countries, including a dedicated VR arcade at [Embarcadero Center](#) in [San Francisco](#). Costing up to \$73,000 per multi-pod Virtuality system, they featured headsets and exoskeleton gloves that gave one of the first “immersive” VR experiences.<sup>[12]</sup> Antonio Medina, a MIT graduate and NASA scientist, designed a virtual reality system to “drive” Mars rovers from Earth in apparent real time despite the substantial delay of Mars-Earth-Mars signals. The system, termed “Computer-Simulated Teleoperation” as published by Rand, is an extension of virtual reality.<sup>[13]</sup>

In 1991, [Carolina Cruz-Neira](#), [Daniel J. Sandin](#) and [Thomas A. DeFanti](#) from the [Electronic Visualization Laboratory](#) created the [first cubic immersive room](#), replacing goggles by a multi-projected environment where people can see their body and other people around. In that same year, [Computer Gaming World](#) predicted “Affordable VR by 1994”.<sup>[14]</sup> By 1994, Sega released the [Sega VR-1](#) motion simulator [arcade attraction](#),<sup>[15][16]</sup> in [SegaWorld amusement arcades](#). It was able to track head movement and featured [3D polygon graphics](#) in [stereoscopic 3D](#), powered by the [Sega Model 1 arcade system board](#).<sup>[17]</sup> Also in 1994 Apple released QuickTime VR. A widely available product for interacting with VR models.

A year later, the artist [Maurice Benayoun](#) created the first VR artwork connecting in real time 2 continents: the “Tunnel under the Atlantic” between the [Pompidou Centre](#) in Paris and the Museum of Contemporary Art in [Montreal](#). The installation included dynamic real time 3d modeling, video chat, spatialized sound and AI content management. The [Virtual Boy](#) was created by [Nintendo](#) and was released in Japan on July 21, 1995 and in North America on August 15, 1995.<sup>[18]</sup> Also in 1995, a group in Seattle created public demonstrations of a “[CAVE-like](#)” 270 degree

immersive projection room called the Virtual Environment Theater, produced by entrepreneurs Chet Dagit and Bob Jacobson.<sup>[19]</sup> Then in 1996 the same system was shown in tradeshow exhibits sponsored by [Netscape](#) Communications, and championed by Jim Barksdale, for the first time showing VR connected to the Internet with World Wide Web content feeds embedded in [VRML](#) 3D virtual world models. Forte released the [VFX1](#), a PC-powered virtual reality headset in 1995, which was supported by games including [Descent](#), [Star Wars: Dark Forces](#), [System Shock](#) and [Quake](#). In 1999, entrepreneur [Philip Rosedale](#) formed [Linden Lab](#) with an initial focus on the development of hardware that would enable computer users to be fully immersed in a 360 degree virtual reality experience. In its earliest form, the company struggled to produce a commercial version of “The Rig,” which was realized in prototype form as a clunky steel contraption with several computer monitors that users could wear on their shoulders.<sup>[20]</sup> That vision soon morphed into the software-based, 3D virtual world [Second Life](#).



A 2013 developer version of [Oculus Rift](#) from [Oculus VR](#), a company [Facebook](#) acquired in 2014 for \$2 billion

2000–2016



The affordable and accessible [Google Cardboard](#) standard.

In 2001, SAS3 or SAS Cube became the first PC based cubic room, developed by Z-A Production ([Maurice Benayoun](#), David Nahon), Barco, Clarté, installed in Laval France in April 2001. The SAS library gave birth to Virtools VRPack. By 2007, [Google](#) introduced [Street View](#), a service that shows

panoramic views of an increasing number of worldwide positions such as roads, indoor buildings and rural areas. It also features a stereoscopic 3D mode, introduced in 2010.<sup>[21]</sup> In 2010, [Palmer Luckey](#), who later went on to found [Oculus VR](#), designed the first prototype of the [Oculus Rift](#). This prototype, built on a shell of another virtual reality headset, displayed only 2-D images and was noticeably cumbersome to wear. However, it boasted a 90-degree field of vision that was previously unseen anywhere in the market at the time. This initial design would later serve as a basis from which the later designs came.<sup>[22]</sup>

In 2013, [Nintendo](#) filed a [patent](#) for the concept of using VR technology to produce a more realistic [3D effect](#) on a 2D television. A camera on the TV tracks the viewer's location relative to the TV, and if the viewer moves, everything on the screen reorients itself appropriately. "For example, if you were looking at a forest, you could shift your head to the right to discover someone standing behind a tree."<sup>[23]</sup> In July 2013, Guild Software's [Vendetta Online](#) was widely reported as the first [MMORPG](#) to support the [Oculus Rift](#),<sup>[24][25]</sup> making it potentially the first persistent online world with native support for a consumer virtual reality headset. Since 2013, there have been several virtual reality devices that seek to enter the market to complement Oculus Rift to enhance the game experience. One, [Virtuix Omni](#), is based on the ability to move in a three dimensional environment through an omnidirectional treadmill.

On March 25, 2014, [Facebook](#) purchased a company that makes virtual reality headsets, [Oculus VR](#), for \$2 billion.<sup>[26]</sup> [Sony](#) announces Project Morpheus (its code name for [PlayStation VR](#)), a virtual reality headset for the [PlayStation 4](#).<sup>[27]</sup> Google announces [Cardboard](#), a do-it-yourself stereoscopic viewer for smartphones. The user places her smartphone in the cardboard holder, which she wears on her head. In 2015, the Kickstarter campaign for Gloveone, a pair of gloves providing motion tracking and haptic feedback, was successfully funded, with over \$150,000 in contributions.<sup>[28]</sup>

In February–March 2015, [HTC](#) partnered with [Valve Corporation](#) announced their virtual reality headset [HTC Vive](#) and controllers, along with their tracking technology called Lighthouse, which utilizes "base stations" mounted to the wall above the user's head in the corners of a room for positional tracking of the Vive headset and its motion controllers using infrared light.<sup>[29][30][31][32]</sup> The company announced its plans to release the Vive to the public in April 2016 on December 8, 2015.<sup>[33][34]</sup> Units began shipping on April 5, 2016.<sup>[35]</sup>

In July 2015, [OnePlus](#) became the first company to launch a product using virtual reality.<sup>[36]</sup> They used VR as the platform to launch their second flagship device the OnePlus 2, first viewable using an app on the Google Play Store,<sup>[37]</sup> then on YouTube.<sup>[38]</sup> The launch was viewable using OnePlus Cardboard, based on the Google's own Cardboard platform. The whole VR launch had a runtime of 33 minutes, and was viewable in all countries. Also in 2015, [Jaunt](#), a startup company developing cameras and a [cloud](#) distribution platform, whose content will be accessible using an [app](#), reached \$100 million in funding from such sources as [Disney](#) and [Madison Square Garden](#).<sup>[39]</sup> On April 27, 2016, [Mojang](#) announced that [Minecraft](#) is now playable on the [Gear VR](#).<sup>[40]</sup> Minecraft is still being developed for the [Oculus Rift](#) headset but a separate version was released to the Oculus Store for use with the Gear VR. This version is similar to the Pocket Edition of Minecraft.



## Use

### Education and training



[U.S. Navy](#) personnel using a VR parachute training simulator.

Research is being done on learning in virtual reality, as its immersive qualities may enhance learning. VR is used by trainers to provide learners with a virtual environment where they can develop their skills without the real-world consequences of failing. [Thomas A. Furness III](#) was one of the first to develop the use of VR for military training when, in 1982, he presented the Air Force with his first working model of a virtual flight simulator he called the Visually Coupled Airborne Systems Simulator (VCASS). By the time he started his work on VCASS, aircraft were becoming increasingly complicated to handle and virtual reality provided a better solution to previous training methods. Furness attempted to incorporate his knowledge of human visual and auditory processing to create a virtual interface that was more intuitive to use. The second phase of his project, which he called the “Super Cockpit,” was even more advanced, with high resolution graphics (for the time) and a responsive display. Furness is often credited as a pioneer in virtual reality for this research.<sup>[8]</sup> VR plays an important role in combat training for the military. It allows the recruits to train under a controlled environment where they are to respond to different types of combat situations. A fully immersive virtual reality that uses [head-mounted display](#) (HMD), data suits, data glove, and VR weapon are used to train for combat. This setup allows the training’s reset time to be cut down, and allows more repetition in a shorter amount of time. The fully immersive training environment allows the soldiers to train through a wide variety of terrains, situations and scenarios.<sup>[41]</sup>

VR is also used in flight simulation for the Air Force where people are trained to be pilots. The simulator would sit on top of a hydraulic lift system that reacts to the user inputs and events. When the pilot steer the aircraft, the module would turn and tilt accordingly to provide [haptic feedback](#). The flight simulator can range from a fully enclosed module to a series of computer monitors providing the pilot’s point of view. The most important reasons on using simulators over learning with a real aircraft are the reduction of transference time between land training and real flight, the safety, economy and absence of pollution.<sup>[42]</sup> By the same token, virtual driving simulations are used to train tank drivers on the basics before allowing them to operate the real vehicle.<sup>[43]</sup> Finally, the same goes for truck driving simulators, in which Belgian firemen are for

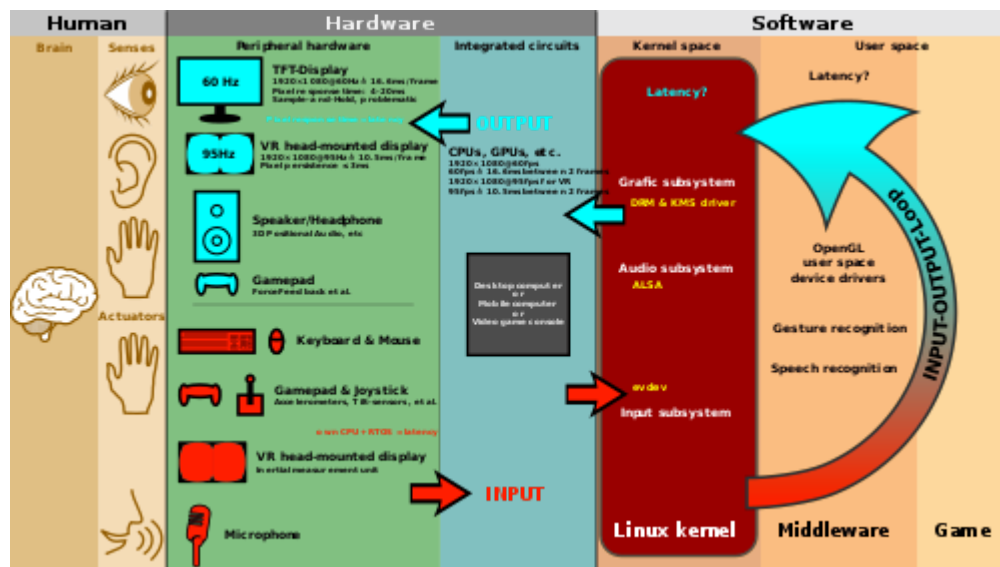


example trained to drive in a way that prevents as much damage as possible. As these drivers often have less experience than other truck drivers, virtual reality training allows them to compensate this. In the near future, similar projects are expected for all drivers of priority vehicles, including the police.<sup>[44]</sup>

Medical personnel are able to train through VR to deal with a wider variety of injuries.<sup>[45]</sup> An experiment was performed by sixteen surgical residents where eight of them went through [laparoscopic cholecystectomy](#) through VR training. They then came out 29% faster at [gallbladder](#) dissection than the controlled group.<sup>[46]</sup> With the increased commercial availability of certified training programs for basic skills training in VR environments, students have the ability to familiarize themselves with necessary skills in a corrective and repetitive environment; VR is also proven to help students familiarize themselves with skills not specific to any particular procedure.<sup>[47]</sup> VR application was used to train road crossing skills in children. It proved to be rather successful. However some students with autistic spectrum disorders after such training might be unable to distinguish virtual from real. As a result, they may attempt quite dangerous road crossings.<sup>[48]</sup>

## Video games

[Playstation VR](#) headset used in video games



Paramount for the [immersion](#) into **virtual reality** are a high [frame rate](#) (at least 95 fps), as well as a low [latency](#). Furthermore, a pixel persistence lower than 3 [ms](#) is required, because if not, users will feel sick when moving their head around.

The use of graphics, sound and input technology in [video games](#) can be incorporated into VR.

Several Virtual Reality head mounted displays (HMD) were released for gaming during the early-mid 1990s. These included the [Virtual Boy](#) developed by [Nintendo](#), the iGlasses developed by Virtual I-O, the Cybermaxx developed by Victormaxx and the [VFX1 Headgear](#) developed by [Forte Technologies](#). Other modern examples of narrow VR for gaming include the [Wii Remote](#), the [Kinect](#), and the [PlayStation Move/PlayStation Eye](#), all of which track and send motion input of the players to the game console somewhat accurately. Several companies are working on a new generation of VR headsets: [Oculus Rift](#) is a head-mounted display for gaming purposes developed by [Oculus VR](#), an American technology company that was acquired for US\$2 billion by Facebook in 2014. One of its rivals was named by [Sony](#) as [PlayStation VR](#) (codenamed Morpheus), which requires a PS4 instead of a PC to run. In 2015, [Valve Corporation](#) announced their partnership with [HTC](#) to make a VR headset capable of tracking the exact position of its user in a 4.5 by 4.5 meters area, the [HTC Vive](#).<sup>[49]</sup> All these virtual reality headsets are tethered headsets that use special curved lenses to magnify and stretch a 5.7-inch screen (in the case of Morpheus) across the field of vision. There are more gaming VR headsets in development, each with its own special abilities. [StarVR](#) offers a 210° field of view, whereas [FOVE](#) tracks the position of your eyes as an input method.<sup>[50]</sup>

## Fine arts

[David Em](#) was the first fine artist to create navigable virtual worlds in the 1970s.<sup>[51]</sup> His early work was done on mainframes at [Information International, Inc.](#), [Jet Propulsion Laboratory](#), and [California Institute of Technology](#). [Jeffrey Shaw](#) explored the potential of VR in fine arts with early works like *Legible City* (1989), *Virtual Museum* (1991), and *Golden Calf* (1994). Canadian artist [Char Davies](#) created immersive VR art pieces *Osmose* (1995) and *Ephémère* (1998). [Maurice Benayoun](#)'s work introduced metaphorical, philosophical or political content, combining VR, network, generation and intelligent agents, in works like *Is God Flat?* (1994), *"Is the Devil Curved?"* (1995), *The Tunnel under the Atlantic* (1995), and *World Skin, a Photo Safari in the Land of War* (1997). Other pioneering artists working in VR have include [Knowbotic Research](#), [Rebecca Allen](#) and [Perry Hoberman](#).<sup>[52]</sup>

## Engineering

The use of 3D [computer-aided design](#) (CAD) data was limited by 2D monitors and paper printouts until the mid-to-late 1990s, when projectors, 3D tracking, and computer technology enabled a renaissance in the use 3D CAD data in virtual reality environments. With the use of active shutter glasses and multi-surface projection units immersive engineering was made possible by companies like VRcom and [IC.IDO](#). Virtual reality has been used in automotive, aerospace, and ground transportation original equipment manufacturers (OEMs) in their product engineering and manufacturing engineering . Virtual reality adds more dimensions to [virtual prototyping](#),

product building, assembly, service, performance use-cases. This enables engineers from different disciplines to view their in the final product. Immersive engineering enables management and investors to see virtual prototypes prior to the availability of any physical prototypes.

## Heritage and archaeology

The first use of a VR presentation in a heritage application was in 1994, when a museum visitor interpretation provided an interactive “walk-through” of a 3D reconstruction of [Dudley Castle](#) in England as it was in 1550. This consisted of a computer controlled laserdisc-based system designed by British-based engineer Colin Johnson. The system was featured in a conference held by the British Museum in November 1994, and in the subsequent technical paper, *Imaging the Past – Electronic Imaging and Computer Graphics in Museums and Archaeology*.<sup>[53]</sup> Virtual reality enables heritage sites to be recreated extremely accurately, so that the recreations can be published in various media.<sup>[54]</sup> The original sites are often inaccessible to the public or, due to the poor state of their preservation, hard to picture.<sup>[55]</sup> This technology can be used to develop virtual replicas of caves, natural environment, old towns, monuments, sculptures and archaeological elements.<sup>[56]</sup>

## Architectural design



A visitor at Mozilla Berlin Hackshibition trying Oculus Rift virtual reality experience on Firefox.

One of the first recorded uses of virtual reality in architecture was in the late 1980s when the University of North Carolina modeled its Sitterman Hall, home of its computer science department, in a virtual environment.<sup>[10]</sup> Several companies, including IrisVR and Floored, Inc., provide software or services that allow architectural design firms and various clients in the real estate industry to tour virtual models of proposed building designs. IrisVR currently provides software that allows users to convert design files created in CAD programs like SketchUp and Revit into files viewable with an Oculus Rift, HTC Vive, or a smartphone “in one click,” without the need for complex tiered workflows or knowledge of game engines such as Unity3D.<sup>[57]</sup> Floored, meanwhile, manually constructs and refines Rift-viewable 3D models in-house from either CAD files for un-built designs or physical scans of already built, brick-and-mortar buildings, and

provides clients with access to its own viewing software, which can be used with either an Oculus Rift or a standard 2D web browser, afterward. <sup>[58]</sup>

VR software products like these can provide a number of benefits to architects and their clients. During the design process, architects can use VR to experience the designs they are working on before they are built. Seeing a design in VR can give architect a correct sense of scale and proportion. <sup>[59]</sup> Having an interactive VR model also eliminates the need to make physical miniatures to demonstrate a design to clients or the public. Later on, after a building is constructed, developers and owners can create a VR model of a space that allows potential buyers or tenants to tour a space in VR, even if real-life circumstances make a physical tour unfeasible. For instance, if the owner of an apartment building has a VR model of a space while the building is under construction, she can begin showing and renting the units before they are even ready to be occupied. Furthermore, this sort of showing can be conducted over any distance, as long as the potential customer has access to a VR setup (or, even, with the help of [Google Cardboard](#) or a similar phone-based VR headset, nothing but a smartphone.)

## Urban design



A land development plan using Prefurbia, a 4th generation design system.

In 2010, 3D virtual reality was beginning to be used for urban regeneration, planning and transportation projects. <sup>[60]</sup> In 2007, development began on a virtual reality software which took design coordinate geometry used by land surveyors and civil engineers and incorporated precision spatial information created automatically by the lines and curves typically shown on subdivision plats and land surveying plans. These precise spatial areas cross referenced color and texture to an item list. The item list contained a set of controls for [3D rendering](#), such as water reflective surfaces or building height. The land surface in software to create a contour map uses a digital terrain model (DTM). By 2010, prototype software was developed for LandMentor, a technology to automate the process leading from design to virtualization. The first beta users in 2011 were able drape the design or survey data over the digital terrain to create data structures that were passed into a video game engine. The engine was able to create a virtual interactive world. The software was improved to implement 3D models from other free or commercially sold software to create a more realistic virtual reality. <sup>[citation needed]</sup>



A streetscape with homes, showing architectural shaping and blending

## Therapy

Main article: [Virtual reality therapy](#)

The primary use of VR in a therapeutic role is its application to various forms of exposure therapy, including [phobia](#) treatments.

## Theme parks

Since 2015, virtual reality has been installed onto a number of roller coasters, including [Galactica](#) at [Alton Towers](#), [The New Revolution](#) at [Six Flags Magic Mountain](#) and [Alpenexpress](#) at [Europapark](#), amongst others.

## Concerts



Assembled Google Cardboard VR

In [Oslo Spektrum](#) on May the 3rd 2016, Norwegian pop band [a-ha](#) cleared away their normal stage-production to give room for a very different concert performance in collaboration with Void, a [Norwegian computational](#) design studio working in the intersection between [design](#), [architecture](#),

[art](#) and [technology](#). The collaboration resulted in a unique one-of-a-kind concert with advanced [scenography](#) using 360 virtual reality technology. It used [movement sensors](#) that reacted to the band members' movements, voices and instruments. [3D cameras](#), 20000 lines of codes, 1000 square meters of projection film and massive projectors was set up into a visual show that made the [Oslo Spektrum](#) arena in [Oslo, Norway](#) into a light installation and visual experience that unfolded live for the audience instead of a pre programmed sequence. The stereoscopic VR-experience was made available for Android users directly through a YouTube app and also made available for iPhone users and other platforms.<sup>[61][62][63]</sup>

## Retail

[Lowe's](#), [IKEA](#) and [Wayfair](#) and other retailers have developed systems that allow their products to be seen in virtual reality, to give consumers a better idea of how the product will fit into their home, or to allow the consumer to get a better look at the product from home.<sup>[64]</sup> Consumers looking at digital photos of the products can “turn” the product around virtually, and see it from the side or the back. This enables customers to get a better sense of how a product looks and about its features, than with the typical single picture used in traditional paper catalogues.

## Charity

Non-profit organisations such as [Amnesty International](#), [UNICEF](#), and [World Wide Fund for Nature](#) (WWF) have started using virtual reality to bring potential supporters closer to their work, effectively bringing distant social, political and environmental issues and projects to members of the public in immersive ways not possible with traditional media. Panoramic 360 views of conflict in Syria<sup>[65]</sup> and face to face encounters with CGI tigers in Nepal<sup>[66]</sup> have been used in experiential activations and shared online to both educate and gain financial support for such charitable work.

## Film

Many companies, including [GoPro](#), [Nokia](#), [Samsung](#), [Ricoh](#) and [Nikon](#), develop [omnidirectional cameras](#), also known as 360-degree cameras or VR cameras, that have the ability to record in all directions.<sup>[67]</sup> These cameras are used to create images and videos that can be viewed in VR. (See [VR photography](#).) Films produced for VR permit the audience to view the entire environment in every scene, creating an interactive viewing experience. Production companies, such as [Fox Searchlight Pictures](#) and [Skybound](#), utilize VR cameras to produce films that are interactive in VR. Fox Searchlight, Oculus and [Samsung Gear VR](#) collaborated on a project titled

“Wild – The Experience”, starring Reese Witherspoon. The VR film was presented at the [Consumer Electronics Show](#) as well as the [Sundance Film Festival](#) in January 2015.<sup>[68]</sup> On December 8, 2015, the production company [Skybound](#) announced their VR thriller titled “Gone”. In collaboration with the VR production company WEVR, and [Samsung Gear VR](#), the 360-degree video series was released on January 20, 2016.<sup>[69][70]</sup>

## Media

Media companies such as [Paramount Pictures](#), and [Disney](#) have applied VR into marketing campaigns creating interactive forms of media. In October 2014 Paramount Pictures, in collaboration with the media production company [Framestore](#), created a VR experience utilizing the [Oculus](#) DK2. The experience was dubbed a “time sensitive adventure in space” that took place in a portion of the Endurance space ship from the film “Interstellar.” The experience was available to the public at limited AMC theater locations.<sup>[71][72]</sup> In May 2016, Disney released a VR experience titled Disney Movies VR on Valve Corporation’s [Steam](#) software, free for download. The experience allows users to interact with the characters and worlds from the Disney, Marvel, and Lucasfilm universes.<sup>[73]</sup>



## PART XI

# CHAPTER 11: INTERFACES

Whenever someone interacts with a computer system, they interact through the use of an interface. This chapter looks at interfaces in a broad context, then focuses specifically on graphical user interfaces leveraged through computers.

### *Learning Objectives*

After reading this lesson, you will be able to:

- Describe and define interfaces.
- Describe good interface design principles.
- Define graphical user interfaces, and identify elements of a GUI.

# 4I. User Interfaces

## User interface

from [https://en.wikipedia.org/wiki/User\\_interface](https://en.wikipedia.org/wiki/User_interface)



Example of a [tangible user interface](#).

The **user interface (UI)**, in the [industrial design](#) field of [human-machine interaction](#), is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the operators' [decision-making](#) process. Examples of this broad concept of user interfaces include the interactive aspects of computer [operating systems](#), hand [tools](#), [heavy machinery](#) operator controls, and [process](#) controls. The design considerations applicable when creating user interfaces are related to or involve such disciplines as [ergonomics](#) and [psychology](#).

Generally, the goal of [user interface design](#) is to produce a user interface which makes it easy (self-explanatory), efficient, and enjoyable (user-friendly) to operate a machine in the way which produces the desired result. This generally means that the operator needs to provide minimal input to achieve the desired output, and also that the machine minimizes undesired outputs to the human.

With the increased use of [personal computers](#) and the relative decline in societal awareness of [heavy machinery](#), the term user interface is generally assumed to mean the [graphical user interface](#), while industrial control panel and machinery control design discussions more commonly refer to human-machine interfaces.

Other terms for user interface are **man-machine interface (MMI)** and when the machine in question is a computer **human-computer interface**.

# Overview



A [graphical user interface](#) following the [desktop metaphor](#).

The user interface or *human-machine interface* is the part of the machine that handles the human-machine interaction. Membrane switches, rubber keypads and touchscreens are examples of the physical part of the Human Machine Interface which we can see and touch.

In complex systems, the human-machine interface is typically computerized. The term *human-computer interface* refers to this kind of system. In the context of computing the term typically extends as well to the software dedicated to control the physical elements used for [human-computer interaction](#).

The engineering of the human-machine interfaces is enhanced by considering [ergonomics](#) ([human factors](#)). The corresponding disciplines are [human factors engineering](#) (HFE) and [usability engineering](#) (UE), which is part of [systems engineering](#).

Tools used for incorporating human factors in the interface design are developed based on knowledge of [computer science](#), such as [computer graphics](#), [operating systems](#), [programming languages](#). Nowadays, we use the expression [graphical user interface](#) for human-machine interface on computers, as nearly all of them are now using graphics.

## Interface design

Primary methods used in the interface design include prototyping and simulation.

Typical human-machine interface design consists of the following stages: interaction specification, interface software specification and prototyping:

- Common practices for interaction specification include [user-centered design](#), [persona](#), [activity-oriented design](#), [scenario-based design](#), [resiliency design](#).
- Common practices for interface software specification include [use cases](#), [constrain enforcement](#) by [interaction protocols](#) (intended [to avoid use errors](#)).
- Common practices for prototyping are based on interactive design based on libraries of interface elements (controls, decoration, etc.).

# Quality

All great interfaces share eight qualities or characteristics:

1. **Clarity** The interface avoids ambiguity by making everything clear through language, flow, hierarchy and metaphors for visual elements.
2. **Concision**<sup>[11]</sup> It's easy to make the interface clear by over-clarifying and labeling everything, but this leads to interface bloat, where there is just too much stuff on the screen at the same time. If too many things are on the screen, finding what you're looking for is difficult, and so the interface becomes tedious to use. The real challenge in making a great interface is to make it concise and clear at the same time.
3. **Familiarity**<sup>[12]</sup> Even if someone uses an interface for the first time, certain elements can still be familiar. Real-life metaphors can be used to communicate meaning.
4. **Responsiveness**<sup>[13]</sup> A good interface should not feel sluggish. This means that the interface should provide good feedback to the user about what's happening and whether the user's input is being successfully processed.
5. **Consistency**<sup>[14]</sup> Keeping your interface consistent across your application is important because it allows users to recognize usage patterns.
6. **Aesthetics** While you don't need to make an interface attractive for it to do its job, making something look good will make the time your users spend using your application more enjoyable; and happier users can only be a good thing.
7. **Efficiency** Time is money, and a great interface should make the user more productive through shortcuts and good design.
8. **Forgiveness** A good interface should not punish users for their mistakes but should instead provide the means to remedy them.

## Principle of least astonishment

The [principle of least astonishment](#) (POLA) is a general principle in the design of all kinds of interfaces. It is based on the idea that human beings can only pay full attention to one thing at one time,<sup>[15]</sup> leading to the conclusion that novelty should be minimized.

# Types



HP Series 100 HP-150 Touchscreen

- **Direct manipulation interface** is the name of a general class of user interfaces that allow users to manipulate objects presented to them, using actions that correspond at least loosely to the physical world.
- **Graphical user interfaces** (GUI) accept input via devices such as a computer keyboard and mouse and provide articulated [graphical](#) output on the [computer monitor](#). There are at least two different principles widely used in GUI design: [Object-oriented user interfaces](#) (OOUIs) and [application](#) oriented interfaces.<sup>[16]</sup>
- **Web-based user interfaces** or **web user interfaces** (WUI) that accept input and provide output by generating [web pages](#) which are transmitted via the [Internet](#) and viewed by the user using a [web browser](#) program. Newer implementations utilize [PHP](#), [Java](#), [JavaScript](#), [AJAX](#), [Apache Flex](#), [.NET Framework](#), or similar technologies to provide real-time control in a separate program, eliminating the need to refresh a traditional HTML based web browser. Administrative web interfaces for web-servers, servers and networked computers are often called [control panels](#).
- **Touchscreens** are displays that accept input by touch of fingers or a [stylus](#). Used in a growing amount of [mobile devices](#) and many types of [point of sale](#), industrial processes and machines, self-service machines etc.
- **Command line interfaces**, where the user provides the input by typing a [command string](#) with the computer keyboard and the system provides output by printing text on the computer monitor. Used by programmers and system administrators, in engineering and scientific environments, and by technically advanced personal computer users.
- **Touch user interface** are graphical user interfaces using a [touchpad](#) or touchscreen display as a combined input and output device. They supplement or replace other forms of output with [haptic](#) feedback methods. Used in computerized [simulators](#) etc.
- **Hardware interfaces** are the physical, spatial interfaces found on products in the real world from toasters, to car dashboards, to airplane cockpits. They are generally a mixture of knobs, buttons, sliders, switches, and touchscreens.
- **Attentive user interfaces** manage the user [attention](#) deciding when to interrupt the user, the kind of warnings, and the level of detail of the messages presented to the user.

- **Batch interfaces** are non-interactive user interfaces, where the user specifies all the details of the *batch job* in advance to [batch processing](#), and receives the output when all the processing is done. The computer does not prompt for further input after the processing has started.
- **Conversational interfaces** enable users to command the computer with plain text English (e.g., via text messages, or chatbots) or voice commands, instead of graphic elements. These interfaces often emulate human-to-human conversations. <sup>[17]</sup>
- **Conversational interface agents** attempt to personify the computer interface in the form of an animated person, robot, or other character (such as Microsoft's Clippy the paperclip), and present interactions in a conversational form.
- **Crossing-based interfaces** are graphical user interfaces in which the primary task consists in crossing boundaries instead of pointing.
- **Gesture interfaces** are graphical user interfaces which accept input in a form of hand [gestures](#), or [mouse gestures](#) sketched with a computer mouse or a [stylus](#).
- **Holographic user interfaces** provide input to electronic or electro-mechanical devices by passing a finger through reproduced holographic images of what would otherwise be tactile controls of those devices, floating freely in the air, detected by a wave source and without tactile interaction.
- **Intelligent user interfaces** are human-machine interfaces that aim to improve the efficiency, effectiveness, and naturalness of human-machine interaction by representing, reasoning, and acting on models of the user, domain, task, discourse, and media (e.g., graphics, natural language, gesture).
- **Motion tracking interfaces** monitor the user's body motions and translate them into commands, currently being developed by Apple. <sup>[18]</sup>
- **Multi-screen interfaces**, employ multiple displays to provide a more flexible interaction. This is often employed in computer game interaction in both the commercial arcades and more recently the handheld markets.
- **Non-command user interfaces**, which observe the user to infer his / her needs and intentions, without requiring that he / she formulate explicit commands.
- **Object-oriented user interfaces (OOUI)** are based on [object-oriented programming](#) metaphors, allowing users to [manipulate](#) simulated objects and their properties.
- **Reflexive user interfaces** where the users control and redefine the entire system via the user interface alone, for instance to change its [command verbs](#). Typically this is only possible with very rich graphic user interfaces.
- **Search interface** is how the [search box](#) of a site is displayed, as well as the visual representation of the search results.
- **Tangible user interfaces**, which place a greater emphasis on touch and physical environment or its element.
- **Task-focused interfaces** are user interfaces which address the [information overload](#) problem of the [desktop metaphor](#) by making tasks, not files, the primary unit of interaction.
- **Text-based user interfaces** are user interfaces which output a text. TUIs can either contain a [command-line interface](#) or a text-based [WIMP](#) environment.
- **Voice user interfaces**, which accept input and provide output by generating voice prompts. The user input is made by pressing keys or buttons, or responding verbally to the interface.

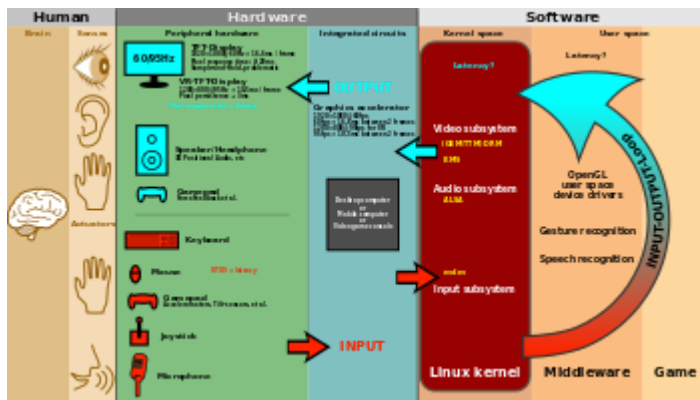
- **[Natural-language interfaces](#)** – Used for search engines and on webpages. User types in a question and waits for a response.
- **Zero-input interfaces** get inputs from a set of sensors instead of querying the user with input dialogs.
- **[Zooming user interfaces](#)** are graphical user interfaces in which information objects are represented at different levels of scale and detail, and where the user can change the scale of the viewed area in order to show more detail.



# 42. User Interface Design

## User interface design

from [https://en.wikipedia.org/wiki/User\\_interface\\_design](https://en.wikipedia.org/wiki/User_interface_design)



The graphical user interface is presented (displayed) on the computer screen. It is the result of processed user input and usually the primary interface for human-machine interaction. The [touch user interfaces](#) popular on small mobile devices are an overlay of the visual output to the visual input.

**User interface design (UI)** or **user interface engineering** is the [design](#) of [user interfaces](#) for [machines](#) and [software](#), such as [computers](#), [home appliances](#), [mobile devices](#), and other [electronic devices](#), with the focus on maximizing [usability](#) and the [user experience](#). The goal of user interface design is to make the user's interaction as simple and efficient as possible, in terms of accomplishing user goals ([user-centered design](#)).

Good user interface design facilitates finishing the task at hand without drawing unnecessary attention to itself. [Graphic design](#) and [typography](#) are utilized to support its [usability](#), influencing how the user performs certain interactions and improving the aesthetic appeal of the design; design aesthetics may enhance or detract from the ability of users to use the functions of the interface.<sup>[1]</sup> The design process must balance technical functionality and visual elements (e.g., [mental model](#)) to create a system that is not only operational but also usable and adaptable to changing user needs.

Interface design is involved in a wide range of projects from computer systems, to cars, to commercial planes; all of these projects involve much of the same basic human interactions yet also require some unique skills and knowledge. As a result, designers tend to specialize in certain types of projects and have skills centered on their expertise, whether that be [software design](#), user research, [web design](#), or [industrial design](#).

## Processes

User interface design requires a good understanding of user needs. There are several phases and processes in the user interface design, some of which are more demanded upon than others, depending on the project.<sup>[2]</sup> (Note: for the remainder of this section, the word *system* is used to denote any project whether it is a [website](#), [application](#), or [device](#).)

- **Functionality requirements gathering** – assembling a list of the functionality required by the system to accomplish the goals of the project and the potential needs of the users.
- **User and task analysis** – a form of [field research](#), it's the analysis of the potential users of the system by studying how they perform the tasks that the design must support, and conducting interviews to elucidate their goals.<sup>[3]</sup> Typical questions involve:
  - What would the user want the system to do?
  - How would the system fit in with the user's normal [workflow](#) or daily activities?
  - How technically savvy is the user and what similar systems does the user already use?
  - What interface look & feel styles appeal to the user?
- **Information architecture** – development of the process and/or information flow of the system (i.e. for phone tree systems, this would be an option tree flowchart and for web sites this would be a site flow that shows the hierarchy of the pages).
- **Prototyping** – development of [wire-frames](#), either in the form of [paper prototypes](#) or simple interactive screens. These prototypes are stripped of all look & feel elements and most content in order to concentrate on the interface.
- **Usability inspection** – letting an evaluator inspect a user interface. This is generally considered to be cheaper to implement than usability testing (see step below), and can be used early on in the development process since it can be used to evaluate prototypes or specifications for the system, which usually can't be tested on users. Some common usability inspection methods include [cognitive walkthrough](#), which focuses the simplicity to accomplish tasks with the system for new users, [heuristic evaluation](#), in which a set of heuristics are used to identify usability problems in the UI design, and [pluralistic walkthrough](#), in which a selected group of people step through a task scenario and discuss usability issues.
- **Usability testing** – testing of the prototypes on an actual user—often using a technique called [think aloud protocol](#) where you ask the user to talk about their thoughts during the experience. User interface design testing allows the designer to understand the reception of the design from the viewer's standpoint, and thus facilitates creating successful applications.
- **Graphical user interface design** – actual [look and feel](#) design of the final [graphical user interface](#) (GUI). It may be based on the findings developed during the user research, and refined to fix any usability problems found through the results of testing.<sup>[4]</sup>

# Requirements

The dynamic characteristics of a system are described in terms of the dialogue requirements contained in seven principles of part 10 of the ergonomics standard, the [ISO 9241](#). This standard establishes a framework of ergonomic “principles” for the dialogue techniques with high-level definitions and illustrative applications and examples of the principles. The principles of the dialogue represent the dynamic aspects of the interface and can be mostly regarded as the “feel” of the interface. The seven dialogue principles are:

- Suitability for the task: the dialogue is suitable for a task when it supports the user in the effective and efficient completion of the task.
- Self-descriptiveness: the dialogue is self-descriptive when each dialogue step is immediately comprehensible through feedback from the system or is explained to the user on request.
- Controllability: the dialogue is controllable when the user is able to initiate and control the direction and pace of the interaction until the point at which the goal has been met.
- Conformity with user expectations: the dialogue conforms with user expectations when it is consistent and corresponds to the user characteristics, such as task knowledge, education, experience, and to commonly accepted conventions.
- Error tolerance: the dialogue is error tolerant if despite evident errors in input, the intended result may be achieved with either no or minimal action by the user.
- Suitability for individualization: the dialogue is capable of individualization when the interface software can be modified to suit the task needs, individual preferences, and skills of the user.
- Suitability for learning: the dialogue is suitable for learning when it supports and guides the user in learning to use the system.

The concept of usability is defined of the [ISO 9241](#) standard by effectiveness, efficiency, and satisfaction of the user. Part 11 gives the following definition of usability:

- Usability is measured by the extent to which the intended goals of use of the overall system are achieved (effectiveness).
- The resources that have to be expended to achieve the intended goals (efficiency).
- The extent to which the user finds the overall system acceptable (satisfaction).

Effectiveness, efficiency, and satisfaction can be seen as quality factors of usability. To evaluate these factors, they need to be decomposed into sub-factors, and finally, into usability measures.

The information presentation is described in Part 12 of the [ISO 9241](#) standard for the organization of information (arrangement, alignment, grouping, labels, location), for the display of graphical objects, and for the coding of information (abbreviation, color, size, shape, visual cues) by seven attributes. The “attributes of presented information” represent the static aspects of the interface and can be generally regarded as the “look” of the interface. The attributes are detailed in

the recommendations given in the standard. Each of the recommendations supports one or more of the seven attributes. The seven presentation attributes are:

- Clarity: the information content is conveyed quickly and accurately.
- Discriminability: the displayed information can be distinguished accurately.
- Conciseness: users are not overloaded with extraneous information.
- Consistency: a unique design, conformity with user's expectation.
- Detectability: the user's attention is directed towards information required.
- Legibility: information is easy to read.
- Comprehensibility: the meaning is clearly understandable, unambiguous, interpretable, and recognizable.

The user guidance in Part 13 of the [ISO 9241](#) standard describes that the user guidance information should be readily distinguishable from other displayed information and should be specific for the current context of use. User guidance can be given by the following five means:

- Prompts indicating explicitly (specific prompts) or implicitly (generic prompts) that the system is available for input.
- Feedback informing about the user's input timely, perceptible, and non-intrusive.
- Status information indicating the continuing state of the application, the system's hardware and software components, and the user's activities.
- Error management including error prevention, error correction, user support for error management, and error messages.
- On-line help for system-initiated and user initiated requests with specific information for the current context of use.

## Research

User interface design has been a topic of considerable research, including on its [aesthetics](#).<sup>[5]</sup> Standards have been developed as far back as the 1980s for defining the usability of software products. One of the structural bases has become the IFIP user interface reference model. The model proposes four dimensions to structure the user interface:

- The input/output dimension (the look)
- The dialogue dimension (the feel)
- The technical or functional dimension (the access to tools and services)
- The organizational dimension (the communication and co-operation support)

This model has greatly influenced the development of the international standard [ISO 9241](#) describing the interface design requirements for usability. The desire to understand application-specific UI issues early in software development, even as an application was being developed, led

to research on GUI rapid prototyping tools that might offer convincing simulations of how an actual application might behave in production use.<sup>[6]</sup> Some of this research has shown that a wide variety of programming tasks for GUI-based software can, in fact, be specified through means other than writing program code.<sup>[7]</sup>

Research in recent years is strongly motivated by the increasing variety of devices that can, by virtue of [Moore's law](#), host very complex interfaces.<sup>[8]</sup>

Research has also been conducted on generating user interfaces automatically, to match a user's level of ability for different levels of interaction.<sup>[9]</sup>

At the moment, in addition to traditional prototypes the literature proposes new solutions, such as an experimental mixed prototype based on a configurable physical prototype that allow to achieve a complete sense of touch, thanks to the physical mock-up, and a realistic visual experience, thanks to the superimposition of the virtual interface on the physical prototype with Augmented Reality techniques.<sup>[10]</sup>

# 43. Graphical User Interfaces

## Graphical user interface

from [https://en.wikipedia.org/wiki/Graphical\\_user\\_interface](https://en.wikipedia.org/wiki/Graphical_user_interface)  
“GUI” redirects here. For other uses, see [Gui \(disambiguation\)](#).



A Unix-based [X Window System](#) desktop

In [computer science](#), a **graphical user interface** (GUI [/ɡ ʊ iː/](#)), is a type of [user interface](#) that allows [users](#) to [interact with electronic devices](#) through graphical [icons](#) and visual indicators such as [secondary notation](#), instead of [text-based user interfaces](#), typed command labels or text navigation. GUIs were introduced in reaction to the perceived steep [learning curve](#) of [command-line interfaces](#) (CLIs),<sup>[1][2][3]</sup> which require commands to be typed on a [computer keyboard](#).

The actions in a GUI are usually performed through [direct manipulation](#) of the graphical elements.<sup>[4]</sup> Beyond computers, GUIs are used in many handheld [mobile devices](#) such as [MP3 players](#), portable media players, gaming devices, [smartphones](#) and smaller household, office and industrial equipment. The term GUI tends not to be applied to other lower-[display resolution types of interfaces](#), such as [video games](#) (where *head-up display* ([HUD](#))<sup>[5]</sup> is preferred), or not restricted to flat screens, like [volumetric displays](#)<sup>[6]</sup> because the term is restricted to the scope of two-dimensional display screens able to describe generic information, in the tradition of the [computer science](#) research at the Xerox Palo Alto Research Center ([PARC](#)).

**Graphical user interface elements** are those elements used by [graphical user interfaces](#) (GUIs) to offer a consistent [visual language](#) to represent information stored in computers. These make it easier for people with few computer skills to work with and use computer software.

This article explains the most common elements of visual language interfaces found in the [WIMP](#) (“window, icon, menu, pointer”) paradigm, although many are also used at other graphical [post-WIMP](#) interfaces. These elements are usually embodied in an interface using a [widget toolkit](#) or [desktop environment](#).

## Structural elements

Graphical user interfaces use visual conventions to represent the generic information shown. Some conventions are used to build the structure of the static elements on which the user can interact, and define the appearance of the interface.

## Window

Main article: [Window \(computing\)](#)

A window is an area on the screen that displays information, with its contents being displayed independently from the rest of the screen. An example of a window is what appears on the screen when the “My Documents” [icon](#) is clicked in the [Windows Operating System](#). It is easy for a user to manipulate a window: it can be shown and hidden by clicking on an icon or [application](#), and it can be moved to any area by dragging it (that is, by clicking in a certain area of the window – usually the title bar along the tops – and keeping the pointing device’s button pressed, then moving the pointing device). A window can be placed in front or behind another window, its size can be adjusted, and scrollbars can be used to navigate the sections within it. Multiple windows can also be open at one time, in which case each window can display a different application or file – this is very useful when working in a multitasking environment. The system memory is the only limitation to the number of windows that can be open at once. There are also many types of specialized windows.<sup>[1]</sup>

- A **container window** is a window that is opened while invoking the icon of a mass storage device, or directory or folder and which is presenting an ordered list of other icons that could be again some other directories, or data files or maybe even executable programs. All modern container windows could present their content on screen either acting as browser windows or text windows. Their behaviour can automatically change according to the choices of the single users and their preferred approach to the graphical user interface.
- A [browser window](#) allows the user to move forward and backwards through a sequence of documents or [web pages](#). [Web browsers](#) are an example of these types of windows.
- **Text terminal** windows are designed for embedding interaction with [text user interfaces](#) within the overall graphical interface. [MS-DOS](#) and [UNIX](#) consoles are examples of these types of windows.
- A **child window** opens automatically or as a result of a user activity in a parent window. [Pop-up windows](#) on the [Internet](#) can be child windows.
- A **message window**, or [dialog box](#), is a type of child window. These are usually small and basic windows that are opened by a program to display information to the user and/or get information from the user. They usually have a button that must be pushed before the program can be resumed.



# Menus

Menus allow the user to execute commands by selecting from a list of choices. Options are selected with a mouse or other pointing device within a GUI. A keyboard may also be used. Menus are convenient because they show what commands are available within the [software](#). This limits the amount of documentation the user reads to understand the software. <sup>[2]</sup>

- A [menu bar](#) is displayed horizontally across the top of the screen and/or along the tops of some or all windows. A pull-down menu is commonly associated with this menu type. When a user clicks on a menu option the pull-down menu will appear. <sup>[3][4]</sup>
- A [menu](#) has a visible title within the menu bar. Its contents are only revealed when the user selects it with a pointer. The user is then able to select the items within the pull-down menu. When the user clicks elsewhere the content of the menu will disappear. <sup>[5]</sup>
- A [context menu](#) is invisible until the user performs a specific mouse action, like pressing the right mouse button. When the software-specific mouse action occurs the menu will appear under the cursor. <sup>[3]</sup>
- [Menu extras](#) are individual items within or at the side of a menu.

# Icons

An [icon](#) is a small picture that represents objects such as a file, program, web page, or command. They are a quick way to execute commands, open documents, and run programs. Icons are also very useful when searching for an object in a browser list, because in many operating systems all documents using the same extension will have the same icon.

# Controls (or widgets)

Main article: [Graphical control element](#)

Interface elements known as [graphical control elements](#), **controls** or **widgets** are [software components](#) that a computer user interacts with through [direct manipulation](#) to read or edit information about an application. Each widget facilitates a specific user-computer interaction. Structuring a user interface with [Widget toolkits](#) allow developers to reuse code for similar tasks, and provides users with a common language for interaction, maintaining consistency throughout the whole information system.

Common uses for widgets involve the display of collections of related items (such as with various [list](#) and [canvas](#) controls), initiation of actions and processes within the interface ([buttons](#) and

[menus](#)), [navigation](#) within the [space](#) of the information system ([links](#), [tabs](#) and [scrollbars](#)), and representing and manipulating data values ([labels](#), [check boxes](#), [radio buttons](#), [sliders](#), [spinners](#)...)

## Tabs

A [tab](#) is typically a rectangular small box which usually contains a text label or graphical icon associated with a view pane. When activated the view pane, or window, displays widgets associated with that tab; groups of tabs allow the user to switch quickly between different widgets. This is used in the web browsers [Firefox](#), [Internet Explorer](#), [Konqueror](#), [Opera](#), and [Safari](#). With these browsers, you can have multiple web pages open at once in one window, and quickly navigate between them by clicking on the tabs associated with the pages. Tabs are usually placed in groups at the top of a window, but may also be grouped on the side or bottom of a window. Tabs are also present in the settings panes of many applications. Windows for example uses tabs in most of its control panel dialogues.

## Interaction elements

Some common [idioms](#) for interaction have evolved in the visual language used in GUIs. Interaction elements are interface objects that represent the state of an ongoing operation or transformation, either as visual reminders of the user [intent](#) (such as the pointer), or as [affordances](#) showing places where the user may interact.

## Cursor

Main article: [Cursor \(computers\)](#)

A cursor is an indicator used to show the position on a computer monitor or other display device that will respond to input from a text input or pointing device.

### *Pointer*

Main article: [Pointer \(computing WIMP\)](#)

The pointer echoes movements of the [pointing device](#), commonly a [mouse](#) or [touchpad](#). The

pointer is the place where actions take place that are initiated through [direct manipulation gestures](#) such as [click](#), [touch](#) and [drag](#).

### *Insertion point*

The caret, [text cursor](#) or *insertion point* represents the point of the user interface where the [focus](#) is located. It represents the object that will be used as the default subject of user-initiated [commands](#) such as writing text, starting a [selection](#) or a [copy-paste](#) operation through the keyboard.

### Selection

A [selection](#) is a list of items on which user operations will take place. The user typically adds items to the list manually, although the computer may create a selection automatically.

### Adjustment handle

A [handle](#) is an indicator of a starting point for a [drag and drop](#) operation. Usually the pointer shape changes when placed on the handle, showing an icon that represents the supported drag operation.

## PART XII

# CHAPTER 12: DISRUPTIVE INNOVATION

Technologies are difficult to predict. What will be successful in the marketplace? Why do some technologies that are better designed fail, while poorly designed technologies succeed? Some technologies are classified as 'disruptive', but disruption is often more about business models that take advantage of technology in new ways.

### *Learning Objectives*

After reading this chapter, you will be able to:

- Describe disruptive innovation, and how it relates to technology.
- Describe how convergence and divergence relate to technology.

# 44. Disruptive Innovation

From: [https://en.wikipedia.org/wiki/Disruptive\\_innovation](https://en.wikipedia.org/wiki/Disruptive_innovation)

A **disruptive innovation** is an [innovation](#) that creates a new [market](#) and [value network](#) and eventually disrupts an existing market and value network, displacing established market leading firms, products and alliances. The term was defined and phenomenon analyzed by [Clayton M. Christensen](#) beginning in 1995.<sup>[2]</sup> In the early 2000s, “significant societal impact” has also been used as an aspect of disruptive innovation.<sup>[3]</sup>

Not all innovations are disruptive, even if they are revolutionary. For example, the first [automobiles](#) in the late 19th century were not a disruptive innovation, because early automobiles were expensive luxury items that did not disrupt the market for [horse-drawn vehicles](#). The market for transportation essentially remained intact until the debut of the lower-priced [Ford Model T](#) in 1908.<sup>[4]</sup> The *mass-produced* automobile was a disruptive innovation, because it changed the transportation market, whereas the first thirty years of automobiles did not.

Disruptive innovations tend to be produced by outsiders and [entrepreneurs](#), rather than existing market-leading companies. The business environment of market leaders does not allow them to pursue disruptive innovations when they first arise, because they are not profitable enough at first and because their development can take scarce resources away from sustaining innovations (which are needed to compete against current competition).<sup>[5]</sup> A disruptive process can take longer to develop than by the conventional approach and the risk associated to it is higher than the other more incremental or evolutionary forms of innovations, but once it is deployed in the market, it achieves a much faster penetration and higher degree of impact on the established markets.<sup>[3]</sup>

## History and usage of the term

The term **disruptive technologies** was coined by [Clayton M. Christensen](#) and introduced in his 1995 article *Disruptive Technologies: Catching the Wave*,<sup>[6]</sup> which he cowrote with Joseph Bower. The article is aimed at management executives who make the funding or purchasing decisions in companies, rather than the research community. He describes the term further in his book [The Innovator's Dilemma](#).<sup>[7]</sup> *Innovator's Dilemma* explored the cases of the disk drive industry (which, with its rapid generational change, is to the study of business what fruit flies are to the study of genetics, as Christensen was advised in the 1990s<sup>[8]</sup>) and the excavating equipment industry (where [hydraulic actuation](#) slowly displaced cable-actuated movement). In his sequel with Michael E. Raynor, *The Innovator's Solution*,<sup>[9]</sup> Christensen replaced the term *disruptive technology* with *disruptive innovation* because he recognized that few technologies are intrinsically disruptive or sustaining in character; rather, it is the *business model* that the technology enables that creates the disruptive impact. However, Christensen's evolution from a technological focus to a business-modelling focus is central to understanding the evolution of

business at the market or industry level. Christensen and Mark W. Johnson, who cofounded the management consulting firm [Innosight](#), described the dynamics of “business model innovation” in the 2008 [Harvard Business Review](#) article “Reinventing Your Business Model”.<sup>[10]</sup> The concept of disruptive technology continues a long tradition of identifying radical technical change in the study of [innovation](#) by economists, and the development of tools for its management at a firm or policy level.

In the late 1990s, the automotive sector began to embrace a perspective of “constructive disruptive technology” by working with the consultant David E. O’Ryan, whereby the use of current off-the-shelf technology was integrated with newer innovation to create what he called “an unfair advantage”. The process or technology change as a whole had to be “constructive” in improving the current method of manufacturing, yet disruptively impact the whole of the business case model, resulting in a significant reduction of waste, energy, materials, labor, or legacy costs to the user.

In keeping with the insight that what matters economically is the business model, not the technological sophistication itself, Christensen’s theory explains why many disruptive innovations are not “advanced technologies”, which the technology mudslide hypothesis would lead one to expect. Rather, they are often novel combinations of existing off-the-shelf components, applied cleverly to a small, fledgling value network.

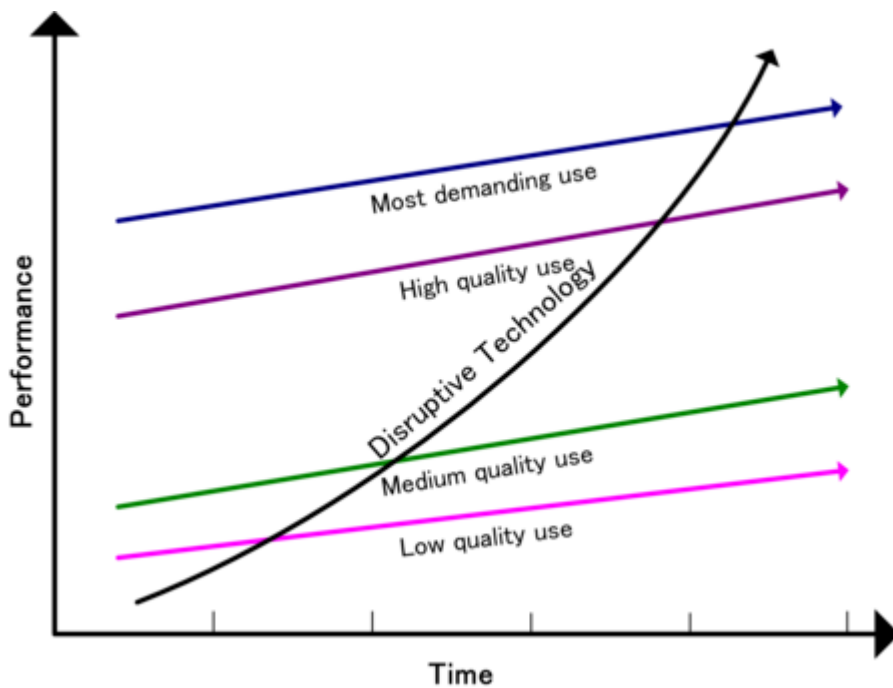
## Theory

Christensen defines a disruptive innovation as a product or service designed for a new set of customers.

“Generally, disruptive innovations were technologically straightforward, consisting of off-the-shelf components put together in a product architecture that was often simpler than prior approaches. They offered less of what customers in established markets wanted and so could rarely be initially employed there. They offered a different package of attributes valued only in emerging markets remote from, and unimportant to, the mainstream.”<sup>[11]</sup>

Christensen argues that disruptive innovations can hurt successful, well-managed companies that are responsive to their customers and have excellent research and development. These companies tend to ignore the markets most susceptible to disruptive innovations, because the markets have very tight profit margins and are too small to provide a good growth rate to an established (sizable) firm.<sup>[12]</sup> Thus, disruptive technology provides an example of an instance when the common business-world advice to “[focus on the customer](#)” (or “stay close to the customer”, or “listen to the customer”) can be strategically counterproductive.

While Christensen argued that disruptive innovations can hurt successful, well-managed companies, O’Ryan countered that “constructive” integration of existing, new, and forward-thinking innovation could improve the economic benefits of these same well-managed companies, once decision-making management understood the systemic benefits as a whole.



How low-end disruption occurs over time.

Christensen distinguishes between “low-end disruption”, which targets customers who do not need the full performance valued by customers at the high end of the market, and “new-market disruption”, which targets customers who have needs that were previously unserved by existing incumbents.<sup>[13]</sup>

“Low-end disruption” occurs when the rate at which products improve exceeds the rate at which customers can adopt the new performance. Therefore, at some point the performance of the product overshoots the needs of certain customer segments. At this point, a disruptive technology may enter the market and provide a product that has lower performance than the incumbent but that exceeds the requirements of certain segments, thereby gaining a foothold in the market.

In low-end disruption, the disruptor is focused initially on serving the least profitable customer, who is happy with a good enough product. This type of customer is not willing to pay premium for enhancements in product functionality. Once the disruptor has gained a foothold in this customer segment, it seeks to improve its profit margin. To get higher profit margins, the disruptor needs to enter the segment where the customer is willing to pay a little more for higher quality. To ensure this quality in its product, the disruptor needs to innovate. The incumbent will not do much to retain its share in a not-so-profitable segment, and will move up-market and focus on its more attractive customers. After a number of such encounters, the incumbent is squeezed into smaller markets than it was previously serving. And then, finally, the disruptive technology meets the demands of the most profitable segment and drives the established company out of the market.

“New market disruption” occurs when a product fits a new or emerging market segment that is not being served by existing incumbents in the industry.

The extrapolation of the theory to all aspects of life has been challenged,<sup>[14][15]</sup> as has the methodology of relying on selected case studies as the principal form of evidence.<sup>[14]</sup> [Jill Lepore](#)



points out that some companies identified by the theory as victims of disruption a decade or more ago, rather than being defunct, remain dominant in their industries today (including [Seagate Technology](#), [U.S. Steel](#), and [Bucyrus](#)).<sup>[14]</sup> Lepore questions whether the theory has been oversold and misapplied, as if it were able to explain everything in every sphere of life, including not just business but education and public institutions.<sup>[14]</sup>

## Disruptive technology

In 2009, [Milan Zeleny](#) described high technology as disruptive technology and raised the question of what is being disrupted. The answer, according to Zeleny, is the *support network* of high technology.<sup>[16]</sup> For example, introducing electric cars disrupts the support network for gasoline cars (network of gas and service stations). Such disruption is fully expected and therefore effectively resisted by support net owners. In the long run, high (disruptive) technology bypasses, upgrades, or replaces the outdated support network.

Technology, being a form of social relationship<sup>[citation needed]</sup>, always evolves. No technology remains fixed. Technology starts, develops, persists, mutates, stagnates, and declines, just like living [organisms](#).<sup>[17]</sup> The evolutionary life cycle occurs in the use and development of any technology. A new high-technology core emerges and challenges existing [technology support nets](#) (TSNs), which are thus forced to coevolve with it. New versions of the core are designed and fitted into an increasingly appropriate TSN, with smaller and smaller high-technology effects. High technology becomes regular technology, with more efficient versions fitting the same support net. Finally, even the efficiency gains diminish, emphasis shifts to product tertiary attributes (appearance, style), and technology becomes TSN-preserving appropriate technology. This technological equilibrium state becomes established and fixated, resisting being interrupted by a technological mutation; then new high technology appears and the cycle is repeated.

Regarding this evolving process of technology, [Christensen](#) said:

“The technological changes that damage established companies are usually not radically new or difficult from a technological point of view. They do, however, have two important characteristics: First, they typically present a different package of performance attributes—ones that, at least at the outset, are not valued by existing customers. Second, the performance attributes that existing customers do value improve at such a rapid rate that the new technology can later invade those established markets.”<sup>[18]</sup>

[Joseph Bower](#)<sup>[19]</sup> explained the process of how disruptive technology, through its requisite support net, dramatically transforms a certain industry.

“When the technology that has the potential for revolutionizing an industry emerges, established companies typically see it as unattractive: it’s not something their mainstream customers want, and its projected profit margins aren’t sufficient to cover big-company cost structure. As a result, the new technology tends to get ignored in favor of what’s

currently popular with the best customers. But then another company steps in to bring the innovation to a new market. Once the disruptive technology becomes established there, smaller-scale innovation rapidly raise the technology's performance on attributes that mainstream customers' value."<sup>[20]</sup>

The automobile was high technology with respect to the horse carriage; however, it evolved into technology and finally into appropriate technology with a stable, unchanging TSN. The main high-technology advance in the offing is some form of [electric car](#)—whether the energy source is the sun, hydrogen, water, air pressure, or traditional charging outlet. Electric cars preceded the gasoline automobile by many decades and are now returning to replace the traditional gasoline automobile.

[Milan Zeleny](#) described the above phenomenon.<sup>[21]</sup> He also wrote that:

“Implementing high technology is often resisted. This resistance is well understood on the part of active participants in the requisite TSN. The electric car will be resisted by gas-station operators in the same way automated teller machines (ATMs) were resisted by bank tellers and automobiles by horsewhip makers. Technology does not qualitatively restructure the TSN and therefore will not be resisted and never has been resisted. Middle management resists business process reengineering because BPR represents a direct assault on the support net (coordinative hierarchy) they thrive on. Teamwork and multi-functionality is resisted by those whose TSN provides the comfort of narrow specialization and command-driven work.”<sup>[22]</sup>

## Practical example of disruption

In the practical world, the popularization of [personal computers](#) illustrates how knowledge contributes to the ongoing technology innovation. The original centralized concept (one computer, many persons) is a knowledge-defying idea of the prehistory of computing, and its inadequacies and failures have become clearly apparent. The era of personal computing brought powerful computers “on every desk” (one person, one computer). This short transitional period was necessary for getting used to the new computing environment, but was inadequate from the vantage point of producing knowledge. Adequate knowledge creation and management come mainly from networking and distributed computing (one person, many computers). Each person's computer must form an access point to the entire computing landscape or ecology through the Internet of other computers, databases, and mainframes, as well as production, distribution, and retailing facilities, and the like. For the first time, technology empowers individuals rather than external hierarchies. It transfers influence and power where it optimally belongs: at the [loci](#) of the useful knowledge. Even though hierarchies and bureaucracies do not innovate, free and empowered individuals do; knowledge, innovation, spontaneity, and self-reliance are becoming increasingly valued and promoted.<sup>[25]</sup>

# 45. Technological Divergence

From [https://en.wikipedia.org/wiki/Technological\\_convergence](https://en.wikipedia.org/wiki/Technological_convergence)

**Technological convergence** is the tendency that as [technology changes](#), different technological systems sometimes evolve toward performing similar tasks. Digital convergence refers to the convergence of four industries into one conglomerate, ITTCE ([Information Technologies](#), [Telecommunication](#), [Consumer Electronics](#), and [Entertainment](#)). Previously separate technologies such as voice (and telephony features), data (and productivity applications), and video can now share resources and interact with each other synergistically. Telecommunications convergence (also called “network convergence”) describes emerging [telecommunications](#) technologies, and [network architecture](#) used to migrate multiple communications services into a single network.<sup>[1]</sup> Specifically this involves the converging of previously distinct media such as [telephony](#) and [data communications](#) into common interfaces on single devices, such as most smart phones can make phone calls and search the web.

Media convergence is the interlinking of computing and other information technologies, media content, media companies and communication networks that have arisen as the result of the evolution and popularization of the Internet as well as the activities, products and services that have emerged in the digital media space. Many experts<sup>[who?]</sup> view this as simply being the tip of the iceberg, as all facets of institutional activity and social life such as business, government, art, journalism, health, and education are increasingly being carried out in these digital media spaces across a growing network of [information and communication technology](#) devices. Also included in this topic is the basis of computer networks, wherein many different operating systems are able to communicate via different [protocols](#). This could be a prelude to [artificial intelligence](#) networks on the Internet eventually leading to a powerful [superintelligence](#)<sup>[2]</sup> via a [technological singularity](#).

Convergent services, such as [VoIP](#), [IPTV](#), [Smart TV](#), and others, tend to replace the older technologies and thus can [disrupt markets](#). IP-based convergence is inevitable and will result in new service and new demand in the market.<sup>[3]</sup> When the old technology converges into the public-owned common, IP based services become access-independent or less dependent. The old service is access-dependent.<sup>[4]</sup> Educational institutions and modern Universities have started developing courses leading to specialized degrees.<sup>[5]</sup>

## Definitions



A converged mechanical tool, the multitool. Within one device, it provides many tools.

Siddhartha Menon defines convergence, in his *Policy initiative Dilemmas on Media Convergence: A Cross National Perspective*, as integration and digitalization. Integration, here, is defined as “a process of transformation measure by the degree to which diverse media such as phone, data broadcast and information technology infrastructures are combined into a single seamless all purpose network architecture platform”.<sup>[6]</sup> Digitalization is not so much defined by its physical infrastructure, but by the content or the medium. [Jan van Dijk](#) suggests that “digitalization means breaking down signals into bytes consisting of ones and zeros”.<sup>[7][8]</sup> Convergence is defined by Blackman, 1998, as a trend in the evolution of technology services and industry structures.<sup>[9]</sup> Convergence is later defined more specifically as the coming together of telecommunications, computing and broadcasting into a single digital bit-stream.<sup>[10][11][12]</sup> Mueller stands against the statement that convergence is really a takeover of all forms of media by one technology: digital computers.<sup>[13][14]</sup>

## History

Example of convergent devices, 2010s-era smartphones, which can be used for phone calls, text messages, email, surfing the Internet, watching digital videos, paying bills online and so on.

Communication networks were designed to carry different types of information independently. The older media, such as television and radio, are broadcasting networks with passive audiences. Convergence of telecommunication technology permits the manipulation of all forms of information, voice, data, and video. Telecommunication has changed from a world of scarcity to one of seemingly limitless capacity. Consequently, the possibility of audience interactivity morphs the passive audience into an engaged audience.<sup>[15]</sup> The historical roots of convergence can be traced back to the emergence of [mobile telephony](#) and the [Internet](#), although the term properly applies only from the point in marketing history when fixed and mobile telephony began to be

offered by operators as joined products. Fixed and mobile operators were, for most of the 1990s, independent companies. Even when the same organization marketed both products, these were sold and serviced independently.

In the 1990s an implicit and often explicit assumption was that new media was going to replace the old media and Internet was going to replace broadcasting. In Nicholas Negroponte's [Being Digital](#), Negroponte predicts the collapse of broadcast networks in favor of an era of narrow-casting. He also suggests that no government regulation can shatter the [media conglomerate](#). "The monolithic empires of mass media are dissolving into an array of cottage industries.... Media barons of today will be grasping to hold onto their centralized empires tomorrow.... The combined forces of technology and human nature will ultimately take a stronger hand in plurality than any laws Congress can invent."<sup>[16]</sup> The new media companies claimed that the old media would be absorbed fully and completely into the orbit of the emerging technologies. [George Gilder](#) dismisses such claims saying, <sup>[clarification needed]</sup> "The computer industry is converging with the television industry in the same sense that the automobile converged with the horse, the TV converged with the nickelodeon, the word-processing program converged with the typewriter, the CAD program converged with the drafting board, and digital desktop publishing converged with the Linotype machine and the letterpress." Gilder believes that computers had come not to transform mass culture but to destroy it.

Media companies put Media Convergence back to their agenda, after the [dot-com bubble](#) burst. Erstwhile Knight Ridder promulgated concept of portable magazines, newspaper, and books in 1994.<sup>[17]</sup> "Within news corporations it became increasingly obvious that an editorial model based on mere replication in the internet of contents that had previously been written for print newspapers, radio, or television was no longer sufficient."<sup>[18]</sup> The rise of digital communication in the late 20th century has made it possible for media organizations (or individuals) to deliver text, audio, and video material over the same wired, wireless, or fiber-optic connections. At the same time, it inspired some media organizations to explore multimedia delivery of information. This digital convergence of news media, in particular, was called "Mediamorphosis" by researcher Roger Fidler <sup>[1]</sup>, in his 1997 book by that name. Today, we are surrounded by a multi-level convergent media world where all modes of communication and information are continually reforming to adapt to the enduring demands of technologies, "changing the way we create, consume, learn and interact with each other".<sup>[19]</sup>

## Appliances

Some media observers expect that we will eventually access all media content through one device, or "black box".<sup>[25]</sup> As such, media business practice has been to identify the next "black box" to invest in and provide media for. This has caused a number of problems. Firstly, as "black boxes" are invented and abandoned, the individual is left with numerous devices that can perform the same task, rather than one dedicated for each task. For example, one may own both a computer and a video games console, subsequently owning two DVD players. This is contrary to the streamlined goal of the "black box" theory, and instead creates clutter.<sup>[26]</sup> Secondly, technological convergence

tends to be experimental in nature. This has led to consumers owning technologies with additional functions that are harder, if not impractical, to use rather than one specific device. Many people would only watch the TV for the duration of the meal's cooking time, or whilst in the kitchen, but would not use the microwave as the household TV. These examples show that in many cases technological convergence is unnecessary or unneeded.

Furthermore, although consumers primarily use a specialized media device for their needs, other “black box” devices that perform the same task can be used to suit their current situation. As a 2002 Cheskin Research report explained: “...Your email needs and expectations are different whether you're at home, work, school, commuting, the airport, etc., and these different devices are designed to suit your needs for accessing content depending on where you are- your situated context.” Despite the creation of “black boxes”, intended to perform all tasks, the trend is to use devices that can suit the consumer's physical position.<sup>[27]</sup> Due to the variable utility of portable technology, convergence occurs in high end mobile devices. They incorporate multimedia services, GPS, Internet access, and mobile telephony into a single device, heralding the rise of what has been termed the “smart phone,” a device designed to remove the need to carry multiple devices. Convergence of media occurs when multiple products come together to form one product with the advantages of all of them, also known as the black box. This idea of one technology, concocted by [Henry Jenkins](#), has become known more as a fallacy because of the inability to actually put all technical pieces into one. For example, while people can have e-mail and Internet on their phone, they still want full computers with Internet and e-mail in addition. Mobile phones are a good example, in that they incorporate [digital cameras](#), mp3 players, [voice recorders](#), and other devices. This type of convergence is popular.<sup>[citation needed]</sup> For the consumer, it means more features in less space; for [media conglomerates](#) it means remaining competitive.

However, convergence has a downside. Particularly in initial forms, converged devices are frequently less functional and reliable than their component parts (e.g., a mobile phone's web browser may not render some web pages correctly, due to not supporting certain rendering methods, such as the [iPhone](#) browser not supporting [Flash](#) content). As the number of functions in a single device escalates, the ability of that device to serve its original function decreases.<sup>[28]</sup> As Rheingold asserts, technological convergence holds immense potential for the “improvement of life and liberty in some ways and (could) degrade it in others”.<sup>[29]</sup> He believes the same technology has the potential to be “used as both a weapon of social control and a means of resistance”.<sup>[29]</sup> Since technology has evolved in the past ten years or so, companies are beginning to converge technologies to create demand for new products. This includes phone companies integrating [3G](#) and [4G](#) on their phones. In the mid 20th century, television converged the technologies of movies and radio, and television is now being converged with the mobile phone industry and the Internet. Phone calls are also being made with the use of personal computers. Converging technologies combine multiple technologies into one. Newer mobile phones feature cameras, and can hold images, videos, music, and other media. Manufacturers now integrate more advanced features, such as video recording, GPS receivers, data storage, and security mechanisms into the traditional cellphone.



## Internet

The role of the [internet](#) has changed from its original use as a communication tool to provide easier and faster access to information, mainly through a [broadband](#) connection. The television, radio and newspapers were the world's mediums for accessing news and entertainment; now, all three mediums have converged into one, and people all over the world can read and hear news and other information on the Internet. The convergence of the internet and conventional TV become popular in the 2010s, through [smart TV](#), also sometimes referred to as “Connected TV” or “Hybrid TV”, (not to be confused with [IPTV](#), [Internet TV](#), or with [Web TV](#)). Smart TV is used to describe the current trend of integration of the Internet and [Web 2.0](#) features into modern [television sets](#) and [set-top boxes](#), as well as the technological convergence between computers and these television sets or set-top boxes. These new [devices](#) most often also have a much higher focus on [online interactive media](#), [Internet TV](#), [over-the-top content](#), as well as [on-demand streaming media](#), and less focus on traditional [broadcast](#) media like previous generations of [television sets](#) and [set-top boxes](#) always have had.<sup>[30]</sup>

## In the marketplace

Convergence is a global marketplace dynamic in which different companies and sectors are being brought together, both as competitors and collaborators, across traditional boundaries of industry and technology. In a world dominated by convergence, many traditional products, services and types of companies will become less relevant, but a stunning array of new ones is possible. An array of technology developments act as accelerators of convergence, including mobility, analytics, cloud, digital and social networks. As a disruptive force, convergence is a threat to the unprepared, but a tremendous growth opportunity for companies that can out-innovate and out-execute their ever-expanding list of competitors under dramatically new marketplace rules. With convergence, lines are blurred as companies diversify outside of their original markets. For instance, mobile services are increasingly an important part of the automobile; chemicals companies work with agribusiness; device manufacturers sell music, video and books; booksellers become consumer device companies; search and advertising companies become telecommunications companies (“telcos”); media companies act like telcos and vice versa; retailers act like financial services companies and vice versa; cosmetics companies work with pharmaceutical companies; and more. Mobile phone usage broadens dramatically, enabling users to make payments online, watch videos, or even adjusting their home thermostat while away at work.

## Emerging trends

[Network neutrality](#) has emerged as an issue. Wu and Lessig (2004) set out two reasons to adapt



neutral network model for computer networks. First, “a neutral network eliminates the risk of future discrimination, providing more incentive to invest in broadband application development.” Second, “neutral network facilitates fair competition among application, no bias between applications.”<sup>[58]</sup> The two reasons also coincide with FCC’s interest to stimulate investment and enhance innovation in broadband technology and services.<sup>[59][60]</sup> Despite regulatory efforts of deregulation, privatization, and liberalization, the infrastructure barrier has been a negative factor in achieving effective competition. “Kim et al. argues that IP dissociates the telephony application from the infrastructure and Internet telephony is at the forefront of such dissociation .”<sup>[61]</sup> The neutrality of the network is very important for fair competition.<sup>[62]</sup> As the former FCC Charman [Michael Powell](#) put it: “From its inception, the Internet was designed, as those present during the course of its creating will tell you, to prevent government or a corporation or anyone else from controlling it. It was designed to defeat [discrimination](#) against users, ideas and technologies”<sup>[63]</sup> Because of these reasons, Shin concludes that regulator should make sure to regulate application and infrastructure separately.

The layered model was first proposed by Solum and Chug, Sicker, and Nakahata. Sicker, Warbach and Witt have supported using a layered model to regulate the telecommunications industry with the emergence of convergence services. Many researchers have different layered approach, but they all agree that the emergence of convergent technology will create challenges and ambiguities for regulations.<sup>[3]</sup> The key point of the layered model is that it reflects the reality of network architecture, and current business model.<sup>[64]</sup> The layered Model consists of 1. Access Layer – where the physical infrastructure resides: copper wires, cable, or fiber optic. 2. transport layer – the provider of service. 3. Application layer – the interface between the data and the users. 4. content layer – the layer which users see.<sup>[64]</sup> In *Convergence Technologies and the Layered Policy Model: Implication for Regulating Future Communications*, Shin combines the Layered Model and Network Neutrality as the principle to regulate the future convergent Media Industry.<sup>[65]</sup>

PART XIII

# CHAPTER 13: BUSINESS MODELS

# 46. Business Models

From wikipedia.org: [https://en.wikipedia.org/wiki/Business\\_model](https://en.wikipedia.org/wiki/Business_model)

A **business model** is an “abstract representation of an organization, be it conceptual, textual, and/or graphical, of all core interrelated architectural, co-operational, and financial arrangements designed and developed by an organization presently and in the future, as well as all core products and/or services the organization offers, or will offer, based on these arrangements that are needed to achieve its strategic goals and objectives.”<sup>[1][2]</sup> This definition by Al-Debei, El-Haddadeh and Avison (2008) indicates that [value proposition](#), value architecture (the organizational infrastructure and technological architecture that allows the movement of products, services, and information), value finance (modeling information related to total cost of ownership, pricing methods, and revenue structure), and [value network](#) articulate the primary constructs or dimensions of business models.<sup>[3]</sup>

A business model describes the [rationale](#) of how an [organization](#) creates, delivers, and captures value,<sup>[4]</sup> in economic, social, cultural or other contexts. The process of business model construction is part of [business strategy](#).

In theory and practice, the term *business model* is used for a broad range of informal and formal descriptions to represent core aspects of a [business](#), including purpose, [business process](#), target customers, offerings, strategies, infrastructure, organizational structures, sourcing, trading practices, and operational processes and policies including culture. The literature has provided very diverse interpretations and definitions of a business model. A systematic review and analysis of manager responses to a survey defines business models as the design of organizational structures to enact a commercial opportunity.<sup>[5]</sup> Further extensions to this design logic emphasize the use of narrative or coherence in business model descriptions as mechanisms by which entrepreneurs create extraordinarily successful [growth firms](#).<sup>[6]</sup>

Business models are used to describe and classify businesses, especially in an entrepreneurial setting, but they are also used by managers inside companies to explore possibilities for future development. Well-known business models can operate as “recipes” for creative managers.<sup>[7]</sup> Business models are also referred to in some instances within the context of accounting for purposes of public reporting.

## Categorization of business models

From about 2012, some research and experimentation has theorized about a so-called “liquid business model”.<sup>[12][13]</sup>

## V<sup>4</sup> BM framework

Al-Debei and Avison (2010) **V<sup>4</sup> BM Framework** – four main dimensions encapsulating sixteen elements: Value Proposition, Value Architecture, Value Network, and Value Finance<sup>[3]</sup>

- **Value Proposition:** This dimension implies that a BM should include a description of the products/services a digital organization offers, or will offer, along with their related information. Furthermore, the BM needs also to describe the value elements incorporated within the offering, as well as the nature of targeted market segment(s) along with their preferences.
- **Value Architecture:** portrays the concept as a holistic structural design of an organization, including its technological architecture, organizational infrastructure, and their configurations.
- **Value Network:** depicts the cross-company or inter-organization perspective towards the concept and has gained much attention in the BM literature.
- **Value Finance:** depicts information related to costing, pricing methods, and revenue structure

## Shift from pipes to platforms

[Sangeet Paul Choudary](#) (2013) distinguishes between two broad families of business models in an article in [Wired magazine](#).<sup>[14]</sup> Choudary contrasts pipes (linear business models) with platforms (networked business models). In the case of pipes, firms create goods and services, push them out and sell them to customers. Value is produced upstream and consumed downstream. There is a linear flow, much like water flowing through a pipe. Unlike pipes, platforms do not just create and push stuff out. They allow users to create and consume value.

In an op-ed on MarketWatch,<sup>[15]</sup> Choudary, [Van Alstyne](#) and [Parker](#) further explain how business models are moving from pipes to platforms, leading to disruption of entire industries.

## Platform business models

There are three elements to a successful platform business model.<sup>[16]</sup> The *Toolbox* creates connection by making it easy for others to plug into the platform. This infrastructure enables interactions between participants. The *Magnet* creates pull that attracts participants to the platform. For transaction platforms, both producers and consumers must be present to achieve critical mass. The *Matchmaker* fosters the flow of value by making connections between producers and consumers. Data is at the heart of successful matchmaking, and distinguishes platforms from other business models.

Chen (2009) stated that the business model has to take into account the capabilities of [Web 2.0](#), such as [collective intelligence](#), network effects, [user-generated content](#), and the possibility of [self-improving](#) systems. He suggested that the [service industry](#) such as the airline, traffic, transportation, hotel, restaurant, information and communications technology and online gaming industries will be able to benefit in adopting business models that take into account the characteristics of Web 2.0. He also emphasized that Business Model 2.0 has to take into account not just the technology effect of Web 2.0 but also the networking effect. He gave the example of the success story of [Amazon](#) in making huge revenues each year by developing an open platform that supports a community of companies that re-use Amazon's on-demand commerce services.<sup>[17]</sup><sup>[need quotation to verify]</sup>

## Applications

[Malone](#) et al.<sup>[18]</sup> found that some business models, as defined by them, indeed performed better than others in a dataset consisting of the largest U.S. firms, in the period 1998 through 2002, while they did not prove whether the existence of a business model mattered.

In the context of the Software-Cluster, which is funded by the German Federal Ministry of Education and Research, a business model wizard<sup>[19]</sup> for software companies has been developed. It supports the design and analysis of software business models. The tool's underlying concept and data were published in various<sup>[citation needed]</sup> scientific publications.

The concept of a business model has been incorporated into certain [accounting](#) standards. For example, the [International Accounting Standards Board](#) (IASB) utilizes an “entity's business model for managing the financial assets” as a criterion for determining whether such assets should be measured at [amortized cost](#) or at [fair value](#) in its [financial instruments](#) accounting standard, [IFRS 9](#).<sup>[20][21][22][23]</sup> In their 2013 proposal for accounting for financial instruments, the [Financial Accounting Standards Board](#) also proposed a similar use of business model for classifying financial instruments.<sup>[24]</sup> The concept of business model has also been introduced into the accounting of [deferred taxes](#) under [International Financial Reporting Standards](#) with 2010 amendments to IAS 12 addressing deferred taxes related to investment property.<sup>[25][26][27]</sup>

Both IASB and FASB have proposed using the concept of business model in the context of reporting a lessor's [lease](#) income and lease expense within their joint project on accounting for leases.<sup>[28][29][30][31][32]</sup> In its 2016 lease accounting model, [IFRS 16](#), the IASB chose not to include a criterion of “stand alone utility” in its lease definition because “entities might reach different conclusions for contracts that contain the same rights of use, depending on differences between customers' resources or suppliers' business models.”<sup>[33]</sup> The concept has also been proposed as an approach for determining the measurement and classification when accounting for [insurance contracts](#).<sup>[34][35]</sup> As a result of the increasing prominence the concept of business model has received in the context of financial reporting, the [European Financial Reporting Advisory Group](#) (EFRAG), which advises the [European Union](#) on endorsement of financial reporting standards, commenced a project on the “Role of the Business Model in Financial Reporting” in 2011.<sup>[36]</sup>

## Examples of business models

In the early history of business models it was very typical to define business model types such as bricks-and-mortar or e-broker. However, these types usually describe only one aspect of the business (most often the revenue model). Therefore, more recent literature on business models concentrate on describing a business model as a whole, instead of only the most visible aspects.

The following examples provide an overview for various business model types that have been in discussion since the invention of term *business model*:

- [Bricks and clicks business model](#)

Business model by which a company integrates both [offline \(bricks\)](#) and [online \(clicks\)](#) presences. One example of the bricks-and-clicks model is when a chain of stores allows the user to order products online, but lets them pick up their order at a local store.

- [Collective business models](#)

Business system, organization or association typically composed of relatively large numbers of [businesses](#), tradespersons or [professionals](#) in the same or related fields of endeavor, which pools [resources](#), shares information or provides other benefits for their members. For example, a [science park](#) or high-tech campus provides shared resources (e.g. cleanrooms and other lab facilities) to the firms located on its premises, and in addition seeks to create an innovation community among these firms and their employees.<sup>[44]</sup>

- [Cutting out the middleman](#) model

The removal of [intermediaries](#) in a [supply chain](#): “cutting out the middleman”. Instead of going through traditional distribution channels, which had some type of intermediate (such as a [distributor](#), [wholesaler](#), broker, or [agent](#)), companies may now deal with every customer directly, for example via the Internet.

- [Direct sales model](#)

Direct selling is [marketing](#) and selling products to consumers directly, away from a fixed retail location. Sales are typically made through [party plan](#), one-to-one demonstrations, and other personal contact arrangements. A text book definition is: “The direct personal presentation, demonstration, and sale of products and services to consumers, usually in their homes or at their jobs.”<sup>[45]</sup>

- Distribution business models, various
- [Value-added reseller](#) model

Value Added Reseller is a model where a business makes something which is resold by other businesses but with modifications which add value to the original product or service. These modifications or additions are mostly industry specific in nature and are essential for the distribution. Businesses going for a VAR model have to develop a VAR network. It is one of the latest collaborative business models which can help in faster development cycles and is adopted by many Technology companies especially software.

- [Fee in, free out](#)

Business model which works by charging the first client a fee for a service, while offering that service free of charge to subsequent clients.

- [Franchise](#)

Franchising is the practice of using another firm's successful business model. For the franchisor, the franchise is an alternative to building 'chain stores' to *distribute* goods and avoid investment and liability over a chain. The franchisor's success is the success of the franchisees. The franchisee is said to have a greater incentive than a direct employee because he or she has a direct stake in the business.

- Sourcing business model

A Sourcing Business Model is a type of business model that is applied specifically to business relationships where more than one party needs to work with another party to be successful. It is the combination of two concepts: the contractual relationship framework a company uses with its supplier (transactional, relational, investment based), and the economic model used (transactional, output or outcome-based).

- [Freemium business model](#)

Business model that works by offering basic Web services, or a basic downloadable digital product, for free, while charging a premium for advanced or special features.<sup>[46]</sup>

- [Pay what you can](#) (PWYC) is a [non-profit](#) or [for-profit](#) business model which does not depend on set prices for its goods, but instead asks customers to pay what they feel the product or service is worth to them.<sup>[47][48][49]</sup> It is often used as a promotional tactic,<sup>[50]</sup> but can also be the regular method of doing business. It is a variation on the [gift economy](#) and cross-subsidization, in that it depends on [reciprocity](#) and trust to succeed.

“[Pay what you want](#)” (PWYW) is sometimes used synonymously, but “pay what you can” is often more oriented to charity or socially oriented uses, based more on *ability* to pay, while “pay what you want” is often more broadly oriented to perceived value in combination with willingness and ability to pay.



## 47. Entrepreneurship

**Entrepreneurship** has traditionally been defined as the process of designing, launching and running a new [business](#), which typically begins as a [small business](#), such as a [startup company](#), offering a product, process or service for sale or hire.<sup>[1]</sup> It has been defined as the “...capacity and willingness to develop, organize, and manage a business venture along with any of its risks in order to make a [profit](#).”<sup>[2]</sup> While definitions of entrepreneurship typically focus on the launching and running of businesses, due to the high [risks](#) involved in launching a start-up, a significant proportion of businesses have to close, due to a “...lack of funding, bad business decisions, an economic crisis – or a combination of all of these”<sup>[3]</sup> or due to lack of market demand. In the 2000s, the definition of “entrepreneurship” has been expanded to explain how and why some individuals (or teams) identify opportunities, evaluate them as viable, and then decide to exploit them, whereas others do not,<sup>[4]</sup> and, in turn, how entrepreneurs use these opportunities to develop new products or services, launch new firms or even new industries and create wealth.<sup>[5]</sup>

Traditionally, an **entrepreneur** has been defined as “a person who organizes and manages any enterprise, especially a business, usually with considerable initiative and [risk](#).”<sup>[6]</sup> Rather than working as an [employee](#), an entrepreneur runs a [small business](#) and assumes all the risk and reward of a given business venture, idea, or good or service offered for sale. The entrepreneur is commonly seen as a business leader and [innovator](#) of new ideas and business processes.”<sup>[7]</sup> Entrepreneurs tend to be good at perceiving new business opportunities and they often exhibit positive [biases](#) in their perception (i.e., a bias towards finding new possibilities and seeing unmet market needs) and a pro-risk-taking attitude that makes them more likely to exploit the opportunity.<sup>[8][9]</sup> “Entrepreneurial spirit is characterized by innovation and risk-taking.”<sup>[2]</sup> While entrepreneurship is often associated with new, small, for-profit start-ups, entrepreneurial behavior can be seen in small-, medium- and large-sized firms, new and established firms and in for-profit and not-for-profit organizations, including voluntary sector groups, [charitable organizations](#) and [government](#).<sup>[10]</sup> For example, in the 2000s, the field of [social entrepreneurship](#) has been identified, in which entrepreneurs combine business activities with humanitarian, environmental or community goals.

An entrepreneur is typically in control of a commercial undertaking, directing the [factors of production](#)—the [human](#), [financial](#) and material resources—that are required to exploit a business opportunity. They act as the manager and oversee the launch and growth of an enterprise. Entrepreneurship is the process by which an individual (or team) identifies a business opportunity and acquires and deploys the necessary resources required for its exploitation. The exploitation of entrepreneurial opportunities may include actions such as developing a [business plan](#), hiring the [human resources](#), acquiring financial and material resources, providing [leadership](#), and being responsible for the venture’s success or failure.<sup>[11]</sup> Economist [Joseph Schumpeter](#) (1883–1950) stated that the role of the entrepreneur in the economy is “[creative destruction](#)”—launching innovations that simultaneously destroy old industries while ushering in new industries and approaches. For Schumpeter, the changes and “dynamic [disequilibrium](#) brought on by the innovating entrepreneur ... [are] the ‘norm’ of a healthy [economy](#).”<sup>[12]</sup>

Entrepreneurship typically operates within an [entrepreneurship ecosystem](#) which often includes government programs and services that promote entrepreneurship and support entrepreneurs and start-ups; non-governmental organizations such as small business associations and organizations that offer advice and mentoring to entrepreneurs (e.g., through entrepreneurship centers or websites); small business [advocacy organizations](#) that lobby the government for increased support for entrepreneurship programs and more small business-friendly laws and regulations; entrepreneurship resources and facilities (e.g., [business incubators](#) and [seed accelerators](#)); entrepreneurship education and training programs offered by schools, colleges and universities; and financing (e.g., bank loans, [venture capital financing](#), [angel investing](#), and government and private foundation grants). The strongest entrepreneurship ecosystems are those found in top entrepreneurship hubs such as [Silicon Valley](#), [New York City](#), [Boston](#), [Singapore](#) and other such locations where there are [clusters](#) of leading high-tech firms, top [research universities](#), and venture capitalists.<sup>[13]</sup> In the 2010s, entrepreneurship can be studied in college or university as part of the disciplines of [management](#) or [business administration](#).

## Definition



[Sean John Combs](#) is an American record producer, rapper and entrepreneur.

The term *entrepreneur* is defined as an individual who organizes or operates a business or businesses. Credit for coining this term generally goes to the French economist [Jean-Baptiste Say](#). However, the Irish-French economist [Richard Cantillon](#) defined the term first<sup>[31]</sup> in his *Essai sur la Nature du Commerce en Général*, or *Essay on the Nature of Trade in General*, a book [William Stanley Jevons](#) considered the “cradle of political economy”.<sup>[32]</sup> Cantillon used the term differently; biographer Anthony Breer noted that Cantillon saw the entrepreneur as a risk-taker while Say considered the entrepreneur a “planner”. Cantillon defined the term as a person who pays a certain price for a product and resells it at an uncertain price: “making decisions about obtaining and

using the resources while consequently admitting the risk of enterprise.” The word first appeared in the French dictionary entitled “Dictionnaire Universel de Commerce” compiled by Jacques des Bruslons and published in 1723.<sup>[33]</sup>

## Relationship between small business and entrepreneurship

The term “entrepreneur” is often conflated with the term “[small business](#)” or used interchangeably with this term. While most entrepreneurial ventures start out as a small business, not all small businesses are entrepreneurial in the strict sense of the term. Many small businesses are sole proprietor operations consisting solely of the owner, or they have a small number of employees, and many of these small businesses offer an existing product, process or service, and they do not aim at growth. In contrast, entrepreneurial ventures offer an innovative product, process or service, and the entrepreneur typically aims to scale up the company by adding employees, seeking international sales, and so on, a process which is financed by [venture capital](#) and [angel investments](#). Successful entrepreneurs have the ability to lead a business in a positive direction by proper planning, to adapt to changing environments and understand their own strengths and weakness.<sup>[34]</sup>

## Entrepreneurial behaviours

British entrepreneur [Karren Brady](#) has an estimated net worth of \$123 million<sup>[46]</sup>

The entrepreneur is commonly seen as an innovator – a designer of new ideas and business processes.<sup>[47]</sup> Management skill and strong team building abilities are often perceived as essential leadership attributes for successful entrepreneurs.<sup>[48]</sup> Political economist [Robert Reich](#) considers leadership, management ability, and [team-building](#) to be essential qualities of an entrepreneur.<sup>[49][50]</sup>

# Risk-taking



[Dell](#) Women's Entrepreneur [Network](#) event in New York City, May 2013

Theorists [Frank Knight](#)<sup>[51]</sup> and [Peter Drucker](#) defined entrepreneurship in terms of risk-taking. The entrepreneur is willing to put his or her career and financial security on the line and take risks in the name of an idea, spending time as well as capital on an uncertain venture. Knight classified three types of uncertainty:

- [Risk](#), which is measurable statistically (such as the probability of drawing a red color ball from a jar containing 5 red balls and 5 white balls)
- [Ambiguity](#), which is hard to measure statistically (such as the probability of drawing a red ball from a jar containing 5 red balls but an unknown number of white balls)
- [True uncertainty](#) or Knightian uncertainty, which is impossible to estimate or predict statistically (such as the probability of drawing a red ball from a jar whose contents are entirely unknown)

Entrepreneurship is often associated with true uncertainty, particularly when it involves the creation of a novel good or service, for a market that did not previously exist, rather than when a venture creates an incremental improvement to an existing product or service. A 2014 study at ETH Zürich found that compared with typical managers, entrepreneurs showed higher decision-making efficiency, and a stronger activation in regions of frontopolar cortex (FPC) previously associated with explorative choice.<sup>[52]</sup>

## 48. Startup Companies

From wikipedia: [https://en.wikipedia.org/wiki/Startup\\_company](https://en.wikipedia.org/wiki/Startup_company)

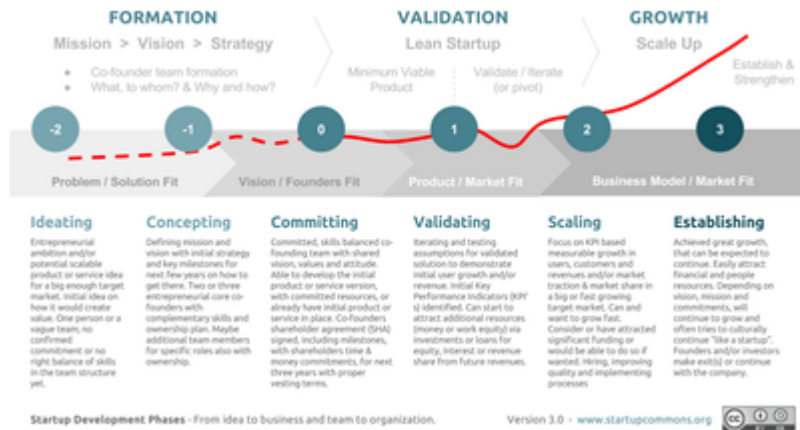
A **startup company** (**startup** or **start-up**) is an [entrepreneurial venture](#) which is typically a newly emerged, fast-growing [business](#) that aims to meet a marketplace need by developing or offering an innovative product, process or service. A startup is usually a [company](#) such as a [small business](#), a [partnership](#) or an organization designed to rapidly develop [scalable business model](#).<sup>[1]</sup> Often, startup companies deploy technologies, such as [Internet](#), [e-commerce](#), computers, telecommunications, or [robotics](#). These companies are generally involved in the design and implementation of the [innovative](#) processes of the [development](#), validation and research for target [markets](#).<sup>[2]</sup> While start-ups do not all operate in technology realms, the term became internationally widespread during the [dot-com bubble](#) in the late 1990s, when a great number of [Internet-based companies](#) were founded.<sup>[3]</sup>

The exact definition of “startup” is widely debated. However at their core, most definitions are similar to what the [U.S. Small Business Administration](#) describes as a “business that is typically technology oriented and has high growth potential”.<sup>[4]</sup> The reference to “growth potential” may mean growth in revenues, number of employees, or both, or to the scaling up of a business to offer its goods or services to a wider or larger market. One popular definition by entrepreneur-mentor [Steve Blank](#) and Bob Dorf defines a startup as an “organization formed to search for a repeatable and scalable business model.” In this case “search” is intended to differentiate established late-stage startups from traditional small businesses, such as a restaurant opening up a mature market. The latter implements a well-known existing business strategy whereas a startup explores an unknown or innovative business model in order to [disrupt](#) existing markets, as in the case of the online merchant [Amazon](#), the “app”-based ride service [Uber](#) or the [search engine Google](#), each of which pioneered the development of their respective market categories. Blank and Dorf add that startups are *not* smaller versions of larger companies: a startup is a *temporary* organization designed to *search* for a [product/market fit](#) and a business model, while in contrast, a large company is a *permanent* organization that has already achieved a product/market fit and is designed to *execute* a well-defined, fully validated, well-tested, proven, verified, stable, clear, unambiguous, repeatable and scalable business model. Blank and Dorf further say that a startup essentially goes [from failure to failure](#) in an effort to learn from each failure and discover what does not work in the process of searching for a repeatable, [high growth](#) business model.<sup>[3][5][6][7]</sup>

[Paul Graham](#) states that “a startup is a company designed to grow fast. Being newly founded does not in itself make a company a startup. Nor is it necessary for a startup to work on technology, or take [venture funding](#), or have some sort of “[exit](#)”. The only essential thing is growth. Everything else we associate with startups follows from growth.” Graham added that an [entrepreneur](#) starting a startup is committing to solve a harder type of problem than ordinary businesses do. “You’re committing to search for one of the rare ideas that generates rapid growth.”<sup>[8]</sup> [Aswath Damodaran](#) states that the value of a startup firm “rests entirely on its future growth potential.” His definition emphasizes the stage of development rather than the structure of the company or its respective industry. Consequently, he attributes certain characteristics to a

startup which include, but are not limited to, its lack of history and past financial statements, its dependency on [private equity](#), and its statistically small rate of survival.<sup>[9]</sup>

## Evolution



### Startup development phases

Startup companies can come in all forms and sizes. Some of the critical tasks are to build a co-founder team to secure key skills, know-how, financial resources and other elements to conduct research on the [target market](#). Typically, a startup will begin by building a first [minimum viable product](#) (MVP), a [prototype](#), to validate, assess and develop the new ideas or business concepts. In addition, startups founders do research to deepen their understanding of the ideas, technologies or business concepts and their commercial potential.<sup>[10]</sup> A [Shareholders' agreement](#) (SHA) is often agreed early on to confirm the commitment, ownership and contributions of the founders and investors and to deal with the [intellectual properties](#) and [assets](#) that may be generated by the startup. Business models for startups are generally found via a "bottom-up" or "top-down" approach. A company may cease to be a startup as it passes various milestones,<sup>[11]</sup> such as becoming publicly traded on the [stock market](#) in an [Initial Public Offering](#) (IPO), or ceasing to exist as an independent entity via a [merger](#) or [acquisition](#). Companies may also fail and cease to operate altogether, an outcome that is very likely for startups, given that they are developing disruptive innovations which may not function as expected and for which there may not be market demand, even when the product or service is finally developed. Given that startups operate in high-risk sectors, it can also be hard to attract investors to support the product/service development or attract buyers.

The size and maturity of the [startup ecosystem](#) where the startup is launched and where it grows have an effect on the volume and success of the startups. The startup ecosystem consists of the individuals ([entrepreneurs](#), [venture capitalists](#), [Angel investors](#), [mentors](#)); institutions and organizations (top research universities and institutes, business schools and entrepreneurship programs operated by universities and colleges, non-profit entrepreneurship support



organizations, government entrepreneurship programs and services, [Chambers of commerce](#) [business incubators](#) and [business accelerators](#) and top-performing entrepreneurial firms and start-ups. A region with all of these elements is considered to be a “strong” entrepreneurship ecosystem. Some of the most famous entrepreneurial ecosystems are [Silicon Valley](#) in California, where major computer and Internet firms and top universities such as [Stanford University](#) create a stimulating start-up environment, [Boston](#) (where [Massachusetts Institute of Technology](#) is located) and [Berlin](#), home of [WISTA](#) (a top research area), numerous [creative industries](#), leading entrepreneurs and start-up firms.

Investors are generally most attracted to those new companies distinguished by their strong co-founding team, a balanced “risk/reward” profile (in which high risk due to the untested, disruptive innovations is balanced out by high potential returns) and “scalability” (the likelihood that a start-up can expand its operations by serving more markets or more customers). Attractive startups generally have lower “[bootstrapping](#)” (self-funding of startups by the founders) costs, higher risk, and higher potential [return on investment](#). Successful startups are typically more scalable than an established business, in the sense that the startup has the potential to grow rapidly with a limited investment of capital, labor or land.<sup>[12]</sup> Timing has often been the single most important factor for biggest startup successes,<sup>[13]</sup> while at the same time it’s identified to be one of the hardest things to master by many serial entrepreneurs and investors.<sup>[14]</sup>

Startups have several options for funding. [Venture capital](#) firms and [angel investors](#) may help startup companies begin operations, exchanging [seed money](#) for an [equity](#) stake in the firm. Venture capitalists and angel investors provide financing to a range of startups (a portfolio), with the expectation that a very small number of the start-ups will become viable and make money. In practice though, many startups are initially funded by the founders themselves using “[bootstrapping](#)“, in which loans or monetary gifts from friends and family are combined with savings and [credit card](#) debt to finance the venture. [Factoring](#) is another option, though it is not unique to startups. Other funding opportunities include various forms of [crowdfunding](#), for example [equity crowdfunding](#),<sup>[15]</sup> in which the startup seeks funding from a large number of individuals, typically by pitching their idea on the [Internet](#)

## Culture





An strong [startup ecosystem](#) is vital to a thriving local entrepreneurial culture.

Startup founders often have a more casual or offbeat attitude in their dress, office space and marketing, as compared to traditional corporations. Startup founders in the 2010s may wear [hoodies](#), [sneakers](#) and other casual clothes to business meetings. Some startups have recreational facilities in their offices, such as [pool tables](#), [ping pong](#) tables and [pinball machines](#), which are used to create an attractive, fun work environment, stimulate team development and team spirit, and encourage creativity. Some of the casual approaches, such as the use of “flat” organizational structures, in which regular employees can talk with the founders and chief executive officers informally, are done to promote efficiency in the workplace, which is needed to get their business off the ground<sup>[citation needed]</sup>. In a 1960 study, [Douglas McGregor](#) stressed that punishments and rewards for uniformity in the workplace are not necessary, because some people are born with the motivation to work without incentives.<sup>[18]</sup> Some startups do not use a strict [command and control](#) hierarchical structure, with executives, managers, supervisors and employees. Some startups offer employees [stock options](#), to increase their “buy in” into the start up (as these employees stand to gain if the company does well). This removal of stressors allows the workers and researchers in the startup to focus less on the work environment around them, and more on achieving the task at hand, giving them the potential to achieve something great for their company.

This culture today has evolved to include larger companies aiming at acquiring the bright minds driving startups. [Google](#), amongst other companies, has made strides to make purchased startups and their workers feel at home in their offices, even letting them bring their dogs to work.<sup>[19]</sup> The main goal behind all changes to the culture of the startup workplace, or a company hiring workers from a startup to do similar work, is to make the people feel as comfortable as possible so they can have the best performance in the office<sup>[citation needed]</sup>. Some companies even try to hide how large they are to capture a particular demographic, as is the case with Heineken recently.<sup>[20]</sup>

## Trends and obstacles

If a company's value is based on its technology, it is often equally important for the business owners to obtain intellectual property protection for their idea. The news magazine [The Economist](#) estimated that up to 75% of the value of US public companies is now based on their intellectual property (up from 40% in 1980).<sup>[43]</sup> Often, 100% of a small startup company's value is based on its intellectual property. As such, it is important for technology-oriented startup companies to develop a sound strategy for protecting their intellectual capital as early as possible.<sup>[44]</sup> Startup companies, particularly those associated with new technology, sometimes produce huge returns to their creators and investors—a recent example of such is Google, whose creators became billionaires through their stock ownership and options. However, the failure rate of startup companies is very high.<sup>[45]</sup> One common reason for failure is that startup companies can run out of funding, without securing their next round of investment or before becoming profitable enough to pay their staff. When this happens, it can leave employees without paychecks. Sometimes these

companies are purchased by other companies, if they are deemed to be viable, but oftentimes they leave employees with very little recourse to recoup lost income for worked time.<sup>[46]</sup>

Although there are startups created in all types of businesses, and all over the world, some locations and business sectors are particularly associated with startup companies. The internet bubble of the late 1990s was associated with huge numbers of internet startup companies, some selling the technology to provide internet access, others using the internet to provide services. Most of this startup activity was located in the most well known startup ecosystem – [Silicon Valley](#), an area of northern California renowned for the high level of startup company activity:

The spark that set off the explosive boom of “Silicon startups” in Stanford Industrial Park was a personal dispute in 1957 between employees of Shockley Semiconductor and the company’s namesake and founder, Nobel laureate and co-inventor of the transistor William Shockley... (His employees) formed Fairchild Semiconductor immediately following their departure...

After several years, Fairchild gained its footing, becoming a formidable presence in this sector. Its founders began leaving to start companies based on their own latest ideas and were followed on this path by their own former leading employees... The process gained momentum and what had once began in a Stanford’s research park became a veritable startup avalanche... Thus, over the course of just 20 years, a mere eight of Shockley’s former employees gave forth 65 new enterprises, which then went on to do the same...<sup>[47]</sup>

Start-up advocates are also trying to build a community of tech start-ups in New York City with organizations like NY Tech Meet Up<sup>[48]</sup> and Built in NYC.<sup>[49]</sup> In the early 2000s, the patent assets of failed startup companies are being purchased by what are derogatorily known as [patent trolls](#), who then take the patents from the companies and assert those patents against companies that might be infringing the technology covered by the patent.<sup>[50]</sup>

## 49. How do you start a Startup?

From wikipedia: [https://en.wikipedia.org/wiki/Startup\\_company](https://en.wikipedia.org/wiki/Startup_company)

[https://en.wikipedia.org/wiki/Venture\\_capital](https://en.wikipedia.org/wiki/Venture_capital)

[https://en.wikipedia.org/wiki/Angel\\_investor](https://en.wikipedia.org/wiki/Angel_investor)

<https://en.wikipedia.org/wiki/Crowdfunding>

### Startup investing

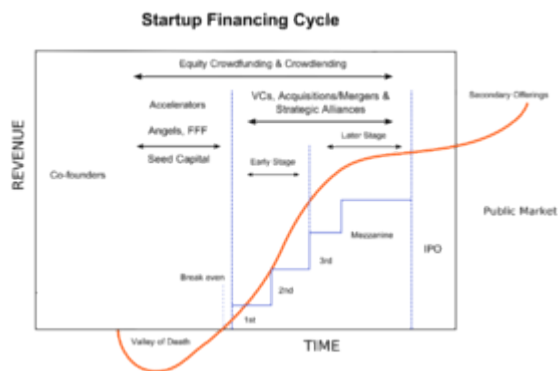


Diagram of the typical financing cycle for a startup company.

Startup investing is the action of making an investment in an early-stage company (the startup company). Beyond founders' own contributions, some startups raise additional investment at some or several stages of their growth. Not all startups trying to raise investments are successful in their fundraising. The solicitation of funds became easier for startups as result of the [JOBS Act](#).<sup>[24][25][26][27]</sup> Prior to the advent of [equity crowdfunding](#), a form of online investing that has been legalized in several nations, startups did not advertise themselves to the general public as investment opportunities until and unless they first obtained approval from regulators for an [initial public offering](#) (IPO) that typically involved a listing of the startup's securities on a [stock exchange](#). Today, there are many alternative forms of IPO commonly employed by startups and startup promoters that do not include an exchange listing, so they may avoid certain regulatory compliance obligations, including mandatory periodic disclosures of financial information and factual [discussion of business conditions by management](#) that investors and potential investors routinely receive from registered public companies.<sup>[28]</sup>

## Investing rounds

When investing in a startup, there are different types of stages in which the investor can participate. The first round is called seed round. The seed round generally is when the startup is still in the very early phase of execution when their product is still in the prototype phase. At this level angel investors will be the ones participating. The next round is called [Series A](#). At this point the company already has traction and may be making revenue. In Series A rounds venture capital firms will be participating alongside angels or [super angel](#) investors. The next rounds are [Series B](#), C, and D. These three rounds are the ones leading towards the IPO. Venture capital firms and [private equity](#) firms will be participating.<sup>[33]</sup>

## Investing online

The first known investment-based [crowdfunding](#) platform for startups was launched in Feb. 2010 by Grow VC,<sup>[34]</sup> followed by the first US. based company [ProFounder](#) launching model for startups to raise investments directly on the site,<sup>[35]</sup> but ProFounder later decided to shut down its business due regulatory reasons preventing them from continuing,<sup>[36]</sup> having launched their model for US. markets prior to JOBS Act. With the positive progress of the JOBS Act for crowd investing in US., equity crowdfunding platforms like [SeedInvest](#) and [CircleUp](#) started to emerge in 2011 and platforms such as [investiere](#), [Companisto](#) and [Seedrs](#) in Europe and [OurCrowd](#) in Israel. The idea of these platforms is to streamline the process and resolve the two main points that were taking place in the market. The first problem was for startups to be able to access capital and to decrease the amount of time that it takes to close a round of financing. The second problem was intended to increase the amount of deal flow for the investor and to also centralize the process.<sup>[37][38][39]</sup>

**Venture capital (VC)** is a type of [private equity](#),<sup>[4]</sup> a form of financing that is provided by firms or funds to [small, early-stage, emerging firms](#) that are deemed to have high growth potential, or which have demonstrated high growth (in terms of number of employees, annual revenue, or both). Venture capital firms or funds invest in these early-stage companies in exchange for [equity](#)—an ownership stake—in the companies they invest in. Venture capitalists take on the risk of financing risky start-ups in the hopes that some of the firms they support will become successful. The start-ups are usually based on an [innovative technology](#) or [business model](#) and they are usually from the [high technology](#) industries, such as [information technology](#) (IT), [social media](#) or [biotechnology](#).

The typical venture capital investment occurs after an initial “[seed funding](#)” round. The first round of institutional venture capital to fund growth is called the [Series A round](#). Venture capitalists provide this financing in the interest of generating a [return](#) through an eventual “exit” event, such as the company selling shares to the public for the first time in an [Initial public offering](#) (IPO) or doing a [merger and acquisition](#) (also known as a “trade sale”) of the company.

In addition to [angel investing](#), [equity crowdfunding](#) and other [seed funding](#) options, venture

capital is attractive for new companies with limited operating history that are too small to raise [capital](#) in the [public markets](#) and have not reached the point where they are able to secure a [bank loan](#) or complete a [debt offering](#). In exchange for the high [risk](#) that venture capitalists assume by investing in smaller and early-stage companies, venture capitalists usually get significant control over company decisions, in addition to a significant portion of the companies' ownership (and consequently value). Companies like Uber, Airbnb, Flipkart, ReviewAdda, Xiaomi & Didi Chuxing are highly valued startups, where venture capitalists contribute more than financing to these early-stage firms; they also often provide strategic advice to the firm's executives on its [business model](#) and marketing strategies.

Venture capital is also a way in which the private and public sectors can construct an institution that systematically creates [business networks](#) for the new firms and industries, so that they can progress and develop. This institution helps identify promising new firms and provide them with finance, technical expertise, [mentoring](#), marketing “know-how”, and [business models](#). Once integrated into the business network, these firms are more likely to succeed, as they become “nodes” in the search networks for designing and building products in their domain.<sup>[2]</sup> However, venture capitalists' decisions are often biased, exhibiting for instance overconfidence and illusion of control, much like entrepreneurial decisions in general.<sup>[3]</sup>

An **angel investor** or **angel** (also known as a **business angel**, **informal investor**, **angel funder**, **private investor**, or **seed investor**) is an affluent individual who provides capital for a business [start-up](#), usually in exchange for [convertible debt](#) or [ownership equity](#). A small but increasing number of angel investors invest online through [equity crowdfunding](#) or organize themselves into **angel groups** or **angel networks** to share research and pool their [investment capital](#), as well as to provide advice to their portfolio companies.<sup>[1]</sup>

**Crowdfunding** is the practice of funding a project or venture by raising monetary contributions from a large number of people. Crowdfunding is a form of [crowdsourcing](#) and of [alternative finance](#). In 2015, it was estimated that worldwide over US\$34 billion was raised this way.<sup>[1][2]</sup>

Although the concept can also be executed through mail-order subscriptions, benefit events, and other methods, it is now often performed via [Internet](#)-mediated registries.<sup>[3]</sup> This modern crowdfunding model is generally based on three types of actors: the project initiator who proposes the idea and/or project to be funded, individuals or groups who support the idea, and a moderating organization (the “platform”) that brings the parties together to launch the idea.<sup>[4]</sup>

Crowdfunding has been used to fund a wide range for-profit [entrepreneurial ventures](#) such as artistic and creative projects, medical expenses, travel, or community-oriented [social entrepreneurship](#) projects.

## PART XIV

# CHAPTER 14: THE DYNAMICS OF DIGITAL WORK

Working digitally is the new norm, as the vast majority of organizations now leverage telecommuting and virtual teams throughout the organization. While virtual teams play an increasingly important role in the future of work, it is important to understand how people can work efficiently when working virtually, as well as some strategies for maintaining a highly collaborative, productive work culture when co-workers may not be physically present.

### *Learning Objectives*

After reading this chapter, you should be able to:

- Define virtual team, and identify advantages and disadvantages of using virtual teams.
- Identify various types of technologies that can help facilitate virtual team work.
- Describe good brainstorming practices.

# 50. Working Virtually

from [https://en.wikipedia.org/wiki/Virtual\\_team](https://en.wikipedia.org/wiki/Virtual_team)

A **virtual team** (also known as a **geographically dispersed team**, **distributed team**, or **remote team**<sup>[1]</sup>) usually refers to a group of individuals who work together from different geographic locations and rely on [communication technology](#)<sup>[2]</sup> such as email, FAX, and video or voice conferencing services in order to collaborate. The term can also refer to groups or teams that work together asynchronously or across organizational levels. Powell, Piccoli and Ives (2004) define virtual teams as “groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks.”<sup>[3]</sup> Ale Ebrahim, N., Ahmed, S. & Taha, Z. (2009) expanded the definition adding that virtual teams are usually small, temporary groups consisting of [knowledge workers](#).<sup>[4]</sup>

Members of virtual teams [communicate electronically](#) and may never meet [face-to-face](#). Virtual teams are made possible by a proliferation of [fiber optic technology](#) that has significantly increased the scope of off-site [communication](#).<sup>[5]</sup> Virtual teams allow companies to procure the best talent without geographical restrictions.<sup>[5]</sup> According to Hambley, O’Neil, & Kline (2007), “virtual teams require new ways of working across boundaries through systems, processes, technology, and people, which requires effective leadership... despite the widespread increase in virtual teamwork, there has been relatively little focus on the role of virtual team leaders.”<sup>[6]</sup>

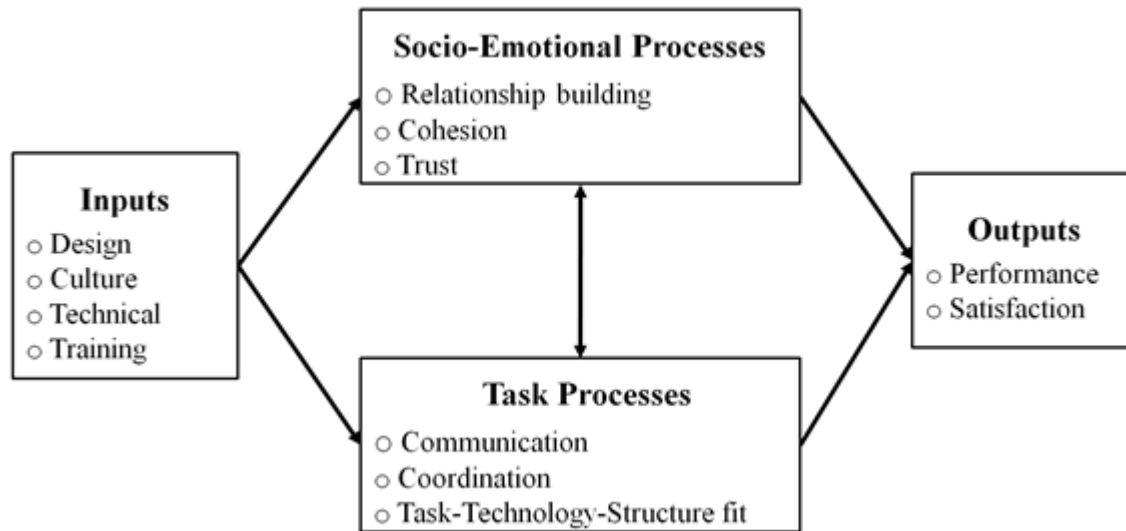
## Model

There are three main aspects to a virtual team – purpose, people and links.<sup>[7]</sup> While purpose is an important aspect for all [organizations](#), it’s the most critical aspect for virtual teams; purpose is what holds a virtual team together. Virtual teams do not have [hierarchy](#) or any other common structures because they may not be from the same organization, and purpose here brings and holds the team together.<sup>[7]</sup> Purpose is generally translated into certain action steps for people to work on with a defined structure consisting of common goals, individual tasks and results.<sup>[7]</sup> A number of factors may affect the performance of members of a virtual team. For example, team members with a higher degree of focused attention and aggregate lower levels of temporal dissociation (or [flow](#)) may have higher performance. Further, members with higher degrees of attention focus may prefer asynchronous communication channels, while those with low levels of flow may prefer synchronous communication channels.<sup>[8]</sup>



## Structure

Powell, Piccoli and Ives<sup>[9]</sup> found and investigated 43 articles about virtual teams and concluded that the current research have found four main focus areas of it.



## Inputs

**Design** of a virtual team means simply that forming a VT should be planned. This means structuring the interactions; what kind of communication tools are used, how much face-to-face time will be possible, etc. Research has found that team building exercises,<sup>[10]</sup> the establishment of shared norms (Sarker et al., 2001, p. 50) and the establishment of a clear team structure<sup>[11]</sup> helps the team to succeed.<sup>[12]</sup> Kirkman et al.<sup>[13]</sup> found empirically that having more face-to-face meetings improved the empowerment of virtual teams, which leads to better learning. Numerous communication problems can be diverted by creating shared knowledge databases in order to allow all the team members to have the same information and to know that others have it, too.<sup>[14]</sup> As an added bonus, shared knowledge databases also share the same language and mental models, which are substitutes for the all important face-to-face time. Furthermore, shared mental models can be focused through designing, requiring the teams to create goals and strategies. This has been shown clearly to improve the teams<sup>[15]</sup>

With **cultural differences** also coordination problems and obstacles to effective communication can be involved.<sup>[16]</sup> These problems may be solved by actively understanding and accepting differences in cultures.<sup>[17]</sup>

The **technical expertise** of a team seems to have a positive effect on the team's performance and the satisfaction of belonging to the team.<sup>[18]</sup> At the same time, high trust is found to develop.<sup>[19]</sup> On the other hand, "the relationship between technology and task performance is found to be more

dependent on experience with technology and with group membership than the type of task on which the group was working”.[20]

Diverse technological skills can create conflict among the team.[21] This is why teams should have consistent **training** to improve team performance.[22] For instance, mentoring is a good way to make personal ties to more experienced virtual team professionals.[23] According to Tan et al.,[24] consistent training fosters cohesiveness, trust, teamwork, commitment to team goals, individual satisfaction and higher perceived decision quality. In their article, they taught a communication technique called the dialogue technique. It is created through three stages: small talk, sharing mental models and norm building.

The overall results found that more virtual teams exhibit higher task conflict and lower communication frequency, knowledge sharing, performance, and satisfaction. Although these findings are consistent with previous research, their results suggest that the results do not generalize to all types of teams and methodological approaches.[25]

Virtualness has a different effect on teams depending on the **length of team duration**. For short-term teams, leaner media, misattributions, and subgroups all potentially contribute to less effective teams. In longer-term teams, members make fewer misattributions to a person as they interact with each other over a longer time frame and develop relationships. Also, over longer time spans teammates build a group identity that helps them to overcome differences. There aren't any negative effects on team performance or satisfaction, and team conflict actually decreased as the degree of virtualness increased. Although there was a negative effect on communication frequency and knowledge sharing, the effect was much less in long-term teams compared to short-term teams.[25]

Virtualness also has varying influence on teams depending on how the virtualness is measured as well as the length of time that a team is working together. The negative effects that effect short-term teams disappeared for longer term teams. Their results also showed that there are different effects on virtualness depending on what type of analysis is used (individual or group) and the methods (experiments or surveys) of virtual work.[25]

## Socio-emotional processes

This section introduces the emotional problems involved and mitigation tactics needed to achieve cohesion and trust among team members. Overall, the research about this reports “a positive link between socio-emotional process and outcomes of the virtual team project.”[26] Because of geographical distribution, face-to-face time occurs only rarely. This, according to research, results in weaker social links between team-mates and leads the team to be more task-focused than socially focused.[27] If face-to-face meetings are feasible, meetings should be held as much as possible at the beginning of the team formation in order to bring team-mates closer and form interpersonal bonds. These meetings should focus more on **relationship building** than on actual business.[28] However, with socializing different cultural preferences have to be remembered.[29] If face-to-face meetings are not possible or feasible to the desired extent, other approaches can be applied. Social-bonding can be done partially via electronic communication tools. Jarvenpaa

and Leidner's<sup>[30]</sup> study found that if teams communicate more socially they achieve higher trust and better social and emotional relationships. Leaders can help foster relationship building and general team building in many ways, e.g. by providing continuous feedback, listening to team members' opinions and suggestions, clearly stating the team member roles and having consistency in their leadership style.<sup>[31]</sup>

**Cohesion** means the sense of unity in a team. Cohesion is important to virtual teams, and is associated with better performance<sup>[32]</sup> and greater satisfaction.<sup>[33]</sup> Cohesion, and trust are very important in fostering team effectiveness. It has been found that [collaborative technologies](#) take away from the development of cohesion within Virtual Teams and that traditional teams have higher level of team cohesiveness.<sup>[34]</sup> Another study has found that although virtual teams may start with low cohesion, over time they exchange enough social information to develop strong cohesion.<sup>[35]</sup> In comparing men and women's perception of cohesion in virtual teams, Lind (1999) found that both women in virtual teams and men in traditional teams perceived greater team cohesiveness than men in virtual teams. However, virtual teams have difficulty attaining cohesion.<sup>[36]</sup> Research on socio-emotional development in virtual teams has centered on relationship building, specifically team cohesion and trust. Relationship building deals with interactions that increase inclusiveness. Socio-emotional processes and outcomes of virtual team projects are closely related, as virtual teams need to meet the socio-emotional needs of virtual team members in order to be successful.<sup>[37]</sup>

**Trust** is particularly problematic subject with virtual teams, because it is arguable whether people can be expected to trust each other if they have never met face-to-face.<sup>[38]</sup> Furthermore, trust is noted to be crucial in successful teams, but usually there is not much time to build it little by little because often the teams are short-lived in projects. Jarvenpaa and Leidner<sup>[39]</sup> describe a mechanism of how people solve the trust problem in a short time. It is called the [swift trust paradigm](#) and it suggests that team members assume from the beginning that the other team members are trustworthy. They adjust that assumption during the lifetime of the team. Jarvenpaa and Leidner<sup>[39]</sup> also researched the differences between teams that had a high level of trust in the beginning and teams with a high amount of trust in the end and compared them. To achieve high trust early in the group's life, the team had social and enthusiastic communication and they coped well with technical uncertainty and took individual initiatives. The groups that enjoyed trust later had predictable communication, timely responses, positive leadership and the ability to move from social communication to task-focused communication.<sup>[30]</sup> The integrity of other team members is important in the development of trust, and perceptions of other members' benevolence supports the maintenance of trust over time.<sup>[40]</sup> Face-to-face meetings during the beginning stages for a team, before they become virtual, helps to develop strong trust.

## Task processes

Task processes are actions that team members carry out in order to accomplish their goal and complete their project. The three main parts to task processes are communication, coordination and task-technology-structure fit.

**Communication** is one of the most crucial things in virtual teams. Communication is vital to the success of the virtual team and it is crucial that the team is a group of excellent communicators with the proper technology for the best levels of communication.<sup>[41]</sup> It starts from selecting excellent communicators for the team members and the right technology for them to use.<sup>[42]</sup> Virtual communication technologies cause many difficulties in effective team communication, such as time delays, common reference frames, differences of interpretation, and assurance of participation for remote team members.<sup>[43]</sup> Some empirically found challenges in successful communication in virtual teams are failure to communicate due to wrong or lacking contextual information, unevenly distributed information, interpretation of the meaning of silence and technical problems.<sup>[44]</sup> Nonverbal communication, which is vital for team communication, is also missing in virtual teams.<sup>[45]</sup> Traditional teams communicate more effectively than virtual teams.<sup>[46]</sup> Difficulties often arise when some team members are co-located while others are geographically distant. There is an assumption that co-located team members communicate with each other about information that is not communicated to the distant member, which can cause friction between members.<sup>[47]</sup> Leadership and cultural differences also substantially affect the effectiveness of communication.<sup>[48]</sup> The frequency and predictability of communication and how much feedback is provided regularly improves the effectiveness of communication, which leads to greater team trust and improves team performance.<sup>[49]</sup> On the other hand, inconsistent and infrequent communication reduces the coordination and success of virtual teams.<sup>[50]</sup> One common reason is that some team members leave for a short amount of time without communicating their absence to other members.<sup>[51]</sup> However, virtual teams are found to communicate more frequently than normal teams<sup>[52]</sup> and female-only virtual teams have higher communication than male-only or combined gender virtual teams.<sup>[53]</sup> Higher effective communication is shown to improve cultural understanding.<sup>[54]</sup>

Inequalities of hierarchy within the group are reduced via email communication and also make it easier to access higher level employees due to the difficulty of scheduling face to face meetings. However, minority members are more likely to express their opinions in anonymous conditions, though their opinions are more accepted in face-to-face conditions.<sup>[55]</sup> Computer-Mediated Communication (CMC) groups create hierarchies that try to preserve the status quota.<sup>[56]</sup> In-group and out-group biases were found in student groups by Cramton (2001). Lateral communication in virtual teams can be important to a team's ability to adapt and change, especially when moving from co-location to Virtual Teams.<sup>[57]</sup> Lateral communication can be improved by creating a flatter reporting structure and hierarchy as well as by using computer mediated communication tools.<sup>[58]</sup>

The extensive reliance on communication technology leads to reduced effect and difficulties in management compared to the traditional teams.<sup>[59]</sup> Researchers have found some solutions for these problems. One company has created a reward system for team cooperation to encourage people to actively and accurately communicate.<sup>[60]</sup> On the other hand, according to Pink's<sup>[61]</sup> research on rewarding creativity, rewarding communication is not a sustainable way to encourage cooperation. In another company, they emphasized the need to debate as well as merely share information.<sup>[62]</sup> Predictability and feedback also frequently improve communication effectiveness, creating trust and better team performance.<sup>[42]</sup> In addition, in one study researchers tested the question of whether adding video to electronic communication helps to explain a detailed task (a map route) to another person.<sup>[63]</sup> They found that for native speaker pairs it did not bring any

additional benefits, but for non-native speaker pairs it brought significant improvement to the task.<sup>[64]</sup>

**Coordination** is how much combined effort exists between various parts of an organization and how consistent and coherent they are.<sup>[65]</sup> Coordination is positively associated with virtual team performance.<sup>[66]</sup> However, it is difficult for virtual teams to coordinate across time zones, cultural divides and divergent mental models.<sup>[67]</sup> The development of a type of collaboration norms within the team are necessary for a team to meld team members' contributions.<sup>[68]</sup> Face-to-face meetings are especially helping in leading a successful project.<sup>[69]</sup> If face-to-face meetings are not possible, a formal protocol for communication training improves both coordination and collaboration activities.<sup>[70]</sup> Minimizing cultural barriers also improves coordination between team members.<sup>[71]</sup> It is, naturally, more difficult to coordinate virtual teams in different time zones, cultures and mental models. Collaboration norms have to develop for the team to function well.<sup>[72]</sup> As mentioned before, periodical face-to-face meetings are a good way to form relationships and also a good vehicle to coordinate activities and to drive the project forward.<sup>[73]</sup> When face-to-face meetings are not feasible, one alternative is to develop coordination protocols with communication training.<sup>[74]</sup> Ramesh and Dennis<sup>[75]</sup> have suggested standardizing the team "s inputs, processes and/or outputs. This should help the team to coordinate and help the other party.

The **task-technology-structure** fit examines "the possible fit between various technologies available...";<sup>[72]</sup> Studies have hypothesized that the technology fit depends on individual preferences, e.g. experience of use and the urgency of the task;<sup>[28][73]</sup> The technology used is dependent on personal preference, previous experience with the technology, ease of use, need for documenting project activities, and how urgent the task is.<sup>[76][77][78]</sup> found that face-to-face meetings or phone calls are suitable for ambiguous tasks, managing conflicts, managing external resources, brainstorming and strategic talks. Electronic communication is more suitable for more structured tasks such as routine analysis, examining design tradeoffs and monitoring project status. Interestingly, in their study the team first adjusted their organization to the technology at hand, but later also adjusted the technology to their organization.

## Outputs

Output in virtual teams means all the things that come out of the work processes of the team.

"Decision quality" is one of the outputs of virtual teams. The majority of research has not found significant evidence of difference between the decision quality of virtual and traditional teams and the number of ideas that were generated.<sup>[79]</sup> However Chidambaram & Bostrom (1993) found that virtual teams generate more ideas compared to traditional teams. As there are many constraints with working virtually, virtual teams require a longer time to reach a decision<sup>[80]</sup>

When comparing "the performance" of traditional and virtual teams, the results are mixed. Some studies find traditional teams and some virtual teams to be better. The majority of studies have found the teams to be about at the same level.<sup>[81]</sup> Powell, Piccoli and Ives<sup>[82]</sup> list many studies that have found different factors, which make virtual teams successful. The found factors are:

- Training
- Strategy/goal setting
- Developing shared language
- Team building
- Team cohesiveness
- Communication
- Coordination and commitment of the teams
- The appropriate task-technology fit
- Competitive and collaborative conflict behaviors (conversely, the same study found that avoidance and compromise conflict behavior had a negative impact)

The results from different student studies are mixed concerning working in a virtual team.<sup>[82]</sup> Tan et al.<sup>[83]</sup> found that teams which used their dialogue technique were more **satisfied** with decisions made in the team. One study found that a traditional team started out more satisfied than a virtual team. Then, in less than a year, the satisfaction of the virtual team rose and exceeded the satisfaction of the traditional team.<sup>[84]</sup> Women are more satisfied than men with virtual teams<sup>[85]</sup> and are also more satisfied compared to women in traditional teams. Team members that are more satisfied were more likely to have had training<sup>[86]</sup> and used more communication methods<sup>[87]</sup> compared to unsatisfied team members.

## Advantages

Cultural diversity has been shown to affect group decision-making, and some of it can be positive for the team.<sup>[93]</sup> Combined with collaborative [conflict management](#), groups of individuals from different cultural perspectives are more likely to actively participate in group decision making.<sup>[94]</sup> The differing backgrounds and experiences of these group members also encourage creativity and create conflicting viewpoints, which make it more likely that multiple options are explored and considered. The other side of this same coin is that virtual teams create a more equal workplace, discouraging age, race, and disability discrimination by forcing individuals to interact with others whose differences challenge their assumptions. Physically disadvantaged employees are also able to participate more in teams where communication is virtual, where they may not have previously been able due to physical limitations of an office or other workspace.<sup>[95]</sup>

Virtual teams are required to use technologies to communicate that have the side effect of mitigating some problems of [cultural diversity](#).<sup>[93]</sup> For instance, email as a medium of communication does not transfer accents and carries fewer noticeable verbal language differences than voice communication. Cultural barriers are not removed from the team, they are instead shielded from view in situations where they are irrelevant. In fact, simply understanding the diversity within a team and working on ways around that can strengthen the relationship between team members of different cultures.<sup>[96]</sup>

Virtual teams save travel time and cost, significant expenses for businesses with multiple locations or having clients located in multiple places. They also reduce disruption in the normal



workday by not requiring an individual to physically leave their workspace.<sup>[95]</sup> This improved efficiency can also directly translate to saved costs for a company.

A company is able to recruit from a larger pool of employees if using virtual teams, as people are increasingly unwilling to relocate for new jobs. A growing amount of talent would otherwise be unobtainable without the employee traveling often. The use of virtual teams also allows the employee to participate in multiple projects within the company that are located on different sites.<sup>[95]</sup> This in turn helps the company by allowing them to reuse existing resources so that they are not required to hire a new employee to do the same job.

## Disadvantages

It is common that cultural differences will come up in global teams. Cultural diversity also impairs communication, often due to language barriers and cultural mismatches in the workplace.<sup>[93]</sup>

Satisfaction among the team members of a virtual team has been shown to be less positive than satisfaction among face-to-face teams. This drop in satisfaction is in part because it is more difficult to build trust without face-to-face communications,<sup>[97]</sup> a necessary part of high-performing virtual teams.<sup>[98]</sup> However, effective management and adherence to proper goal setting principles specific to the nature of work virtual teams require can lead to improved team effectiveness.<sup>[97]</sup> If a team and its corresponding management is not prepared for the challenges of a virtual team, this will be difficult to achieve.

[Transactive memory](#) rarely exists in virtual teams, and even when it does it is often not transferred to new members and contextual knowledge is not kept or well documented.<sup>[99]</sup> Development of this type of [common ground](#) is particularly difficult on virtual teams due to the indirect methods and low frequency of communication. While teams that meet in person can develop this naturally, virtual teams will often have to create it artificially and ahead of time.<sup>[97]</sup>

Virtual teams also highlight a generational gap, as may older executive and senior managers will not have as much experience with computer technology as their younger counterparts.<sup>[95][100]</sup> These senior members must then make an extra effort to catch up to the younger generation and understand this new way of communicating.

Another problem unique to virtual teams is that of differing time zones. A part of the team on one side of the world may be asleep during another part's normal workday, and the group has to work around this. [Asynchronous communication](#) tends to be more difficult to manage and requires much greater coordination than [synchronous communication](#).<sup>[94][95]</sup>

Team leaders will need more training, specifically in [delegation](#). Given that, team members need to be able to share leadership responsibilities and training programs ought to be developed in recognition and support of that.<sup>[101]</sup> A contribution to this problem is that few companies have extensive expertise in how to operate and engage in virtual teams, and they create them without understanding how they differ from regular teams.<sup>[95]</sup>



# 51. Collaborative Software

From wikipedia: [https://en.wikipedia.org/wiki/Collaborative\\_software](https://en.wikipedia.org/wiki/Collaborative_software)

**Collaborative software** or **groupware** is an [application software](#) designed to help people involved in a common task to achieve their goals. One of the earliest definitions of collaborative software is ‘intentional group processes plus software to support them.’<sup>[1]</sup>

Collaborative software is a broad concept that overlaps considerably with [computer-supported cooperative work](#) (CSCW). According to Carstensen and Schmidt (1999)<sup>[2]</sup> groupware is part of CSCW. The authors claim that CSCW, and thereby groupware, addresses “how collaborative activities and their coordination can be supported by means of computer systems.” Software products such as email, calendaring, [text chat](#), [wiki](#), and [bookmarking](#) belong to this category whenever used for group work,<sup>[citation needed]</sup> whereas the more general term [social software](#) applies to systems used outside the workplace, for example, [online dating services](#) and [social networking sites](#) like [Twitter](#) and [Facebook](#).

The use of collaborative software in the work space creates a [collaborative working environment](#) (CWE).

Finally, collaborative software relates to the notion of [collaborative work systems](#), which are conceived as any form of human organization that emerges any time that collaboration takes place, whether it is formal or informal, intentional or unintentional.<sup>[3]</sup> Whereas the groupware or collaborative software pertains to the technological elements of computer-supported cooperative work, collaborative work systems become a useful analytical tool to understand the behavioral and organizational variables that are associated to the broader concept of CSCW.<sup>[4][5]</sup>

## Origins

See also: [MUD](#)

[Douglas Engelbart](#) first envisioned collaborative computing in 1951 and documented his vision in 1962,<sup>[6]</sup> with [working prototypes](#) in full operational use by his research team by the mid-1960s,<sup>[7]</sup> and held the first public demonstration of his work in 1968 in what is now referred to as “[The Mother of All Demos](#).”<sup>[8]</sup> The following year, Engelbart’s lab was hooked into the [ARPANET](#), the first computer network, enabling them to extend services to a broader userbase. See also [Intelligence Amplification Section 4: Douglas Engelbart](#), [ARPANET](#) Section on [ARPANET Deployed](#), and the Doug Engelbart Archive Collection.

Online collaborative gaming software began between early networked computer users. In 1975, [Will Crowther](#) created [Colossal Cave Adventure](#) on a [DEC PDP-10](#) computer. As internet connections grew, so did the numbers of users and multi-user games. In 1978 [Roy Trubshaw](#), a student at Essex University in the United Kingdom, created the game MUD (Multi-User Dungeon).

The US Government began using truly collaborative applications in the early 1990s.<sup>[9]</sup> One of the

first robust applications was the Navy's Common Operational Modeling, Planning and Simulation Strategy (COMPASS).<sup>[10]</sup> The COMPASS system allowed up to 6 users created point-to-point connections with one another; the collaborative session only remained while at least one user stayed active, and would have to be recreated if all six logged out. MITRE improved on that model by hosting the collaborative session on a server that each user logged into. Called the Collaborative Virtual Workstation (CVW), this allowed the session to be set up in a virtual file cabinet and virtual rooms, and left as a persistent session that could be joined later.<sup>[11]</sup>

In 1996, [Pavel Curtis](#), who had built MUDs at [PARC](#), created PlaceWare, a server that simulated a one-to-many auditorium, with side chat between “seat-mates”, and the ability to invite a limited number of audience members to speak. In 1997, engineers at [GTE](#) used the PlaceWare engine in a commercial version of MITRE's CVW, calling it InfoWorkSpace (IWS). In 1998, IWS was chosen as the military standard for the standardized Air Operations Center.<sup>[12]</sup> The IWS product was sold to [General Dynamics](#) and then later to Ezenia.<sup>[13]</sup>

## Groupware

Collaborative software was originally designated as *groupware* and this term can be traced as far back as the late 1980s, when Richman and Slovak (1987)<sup>[14]</sup> wrote:

“Like an electronic sinew that binds teams together, the new *groupware* aims to place the computer squarely in the middle of communications among managers, technicians, and anyone else who interacts in groups, revolutionizing the way they work.”

Even further back, in 1978 Peter and Trudy Johnson-Lenz coined the term groupware; their initial 1978 definition of groupware was, “intentional group processes plus software to support them.” Later in their article they went on to explain groupware as “computer-mediated culture... an embodiment of social organization in hyperspace.” Groupware integrates co-evolving human and tool systems, yet is simply a single system.<sup>[1]</sup>

In the early 1990s the first commercial groupware products were delivered, and big companies such as [Boeing](#) and [IBM](#) started using electronic meeting systems for key internal projects. [Lotus Notes](#) appeared as a major example of that product category, allowing remote group collaboration when the internet was still in its infancy. Kirkpatrick and Losee (1992)<sup>[15]</sup> wrote then:

“If GROUPWARE really makes a difference in productivity long term, the very definition of an office may change. You will be able to work efficiently as a member of a group wherever you have your computer. As computers become smaller and more powerful, that will mean anywhere.”

## Design and implementation issues

The complexity of groupware development is still an issue. One reason for this is the socio-technical dimension of groupware. Groupware designers do not only have to address technical issues (as in traditional software development) but also consider the organizational aspects [\[16\]](#) and the social group processes that should be supported with the groupware application. Some examples for issues in groupware development are:

- Persistence is needed in some sessions. Chat and voice communications are routinely non-persistent and evaporate at the end of the session. Virtual room and online file cabinets can persist for years. The designer of the collaborative space needs to consider the information duration needs and implement accordingly.
- Authentication has always been a problem with groupware. When connections are made point-to-point, or when log-in registration is enforced, it's clear who is engaged in the session. However, audio and unmoderated sessions carry the risk of unannounced 'lurkers' who observe but do not announce themselves or contribute. [\[17\]\[18\]](#)
- Until recently, bandwidth issues at fixed location limited full use of the tools. These are exacerbated with mobile devices.
- Multiple input and output streams bring concurrency issues into the groupware applications.
- Motivational issues are important, especially in settings where no pre-defined group process was in place.
- Closely related to the motivation aspect is the question of reciprocity. [Ellis](#) and others [\[19\]](#) have shown that the distribution of efforts and benefits has to be carefully balanced in order to ensure that all required group members really participate.

One approach for addressing these issues is the use of design patterns for groupware design. [\[20\]](#) The patterns identify recurring groupware design issues and discuss design choices in a way that all stakeholders can participate in the groupware development process.

## Groupware and levels of collaboration

Groupware can be divided into three categories depending on the level of [collaboration](#). [\[21\]\[22\]](#)

1. **Communication** can be thought of as unstructured interchange of information. A phone call or an [IM](#) Chat discussion are examples of this.
2. **Conferencing** (or collaboration level, as it is called in the academic papers that discuss these levels) refers to interactive work toward a shared goal. Brainstorming or voting are examples of this.
3. **Co-ordination** refers to complex interdependent work toward a shared goal. A good metaphor for understanding this is to think about a sports team; everyone has to contribute

the right play at the right time as well as adjust their play to the unfolding situation – but everyone is doing something different – in order for the team to win. That is complex interdependent work toward a shared goal: collaborative management.

## Collaborative management (coordination) tools

Collaborative management tools facilitate and manage group activities. Examples include:

- [Electronic calendars](#) (also called [time management](#) software) – schedule events and automatically notify and remind group members
- [Project management](#) systems – schedule, track, and chart the steps in a project as it is being completed
- [Online proofing](#) – share, review, approve, and reject web proofs, artwork, photos, or videos between designers, customers, and clients
- [Workflow systems](#) – collaborative management of tasks and documents within a knowledge-based business process
- [Knowledge management systems](#) – collect, organize, manage, and share various forms of information
- [Enterprise bookmarking](#) – collaborative bookmarking engine to tag, organize, share, and search enterprise data
- [Prediction markets](#) – let a group of people predict together the outcome of future events
- [Extranet](#) systems (sometimes also known as ‘project extranets’) – collect, organize, manage and share information associated with the delivery of a project (e.g.: the construction of a building)
- [Social software](#) systems – organize social relations of groups
- [Online spreadsheets](#) – collaborate and share structured data and information
- [Client portals](#) – interact and share with your clients in a private online environment<sup>[23]</sup>

## Collaborative software and human interaction

The design intent of collaborative software (groupware) is to transform the way documents and [rich media](#) are shared in order to enable more effective team collaboration.

Collaboration, with respect to information technology, seems to have several definitions. Some are defensible but others are so broad they lose any meaningful application. Understanding the differences in human interactions is necessary to ensure the appropriate technologies are employed to meet interaction needs.

There are three primary ways in which humans interact: conversations, transactions, and collaborations.

*Conversational interaction* is an exchange of information between two or more participants

where the primary purpose of the interaction is discovery or relationship building. There is no central entity around which the interaction revolves but is a free exchange of information with no defined constraints generally focused on personal experiences.<sup>[24]</sup> Communication technology such as telephones, [instant messaging](#), and e-mail are generally sufficient for conversational interactions.

*Transactional interaction* involves the exchange of transaction entities where a major function of the transaction entity is to alter the relationship between participants.

In *collaborative interactions* the main function of the participants' relationship is to alter a collaboration entity (i.e., the converse of transactional).

## 52. Brainstorming

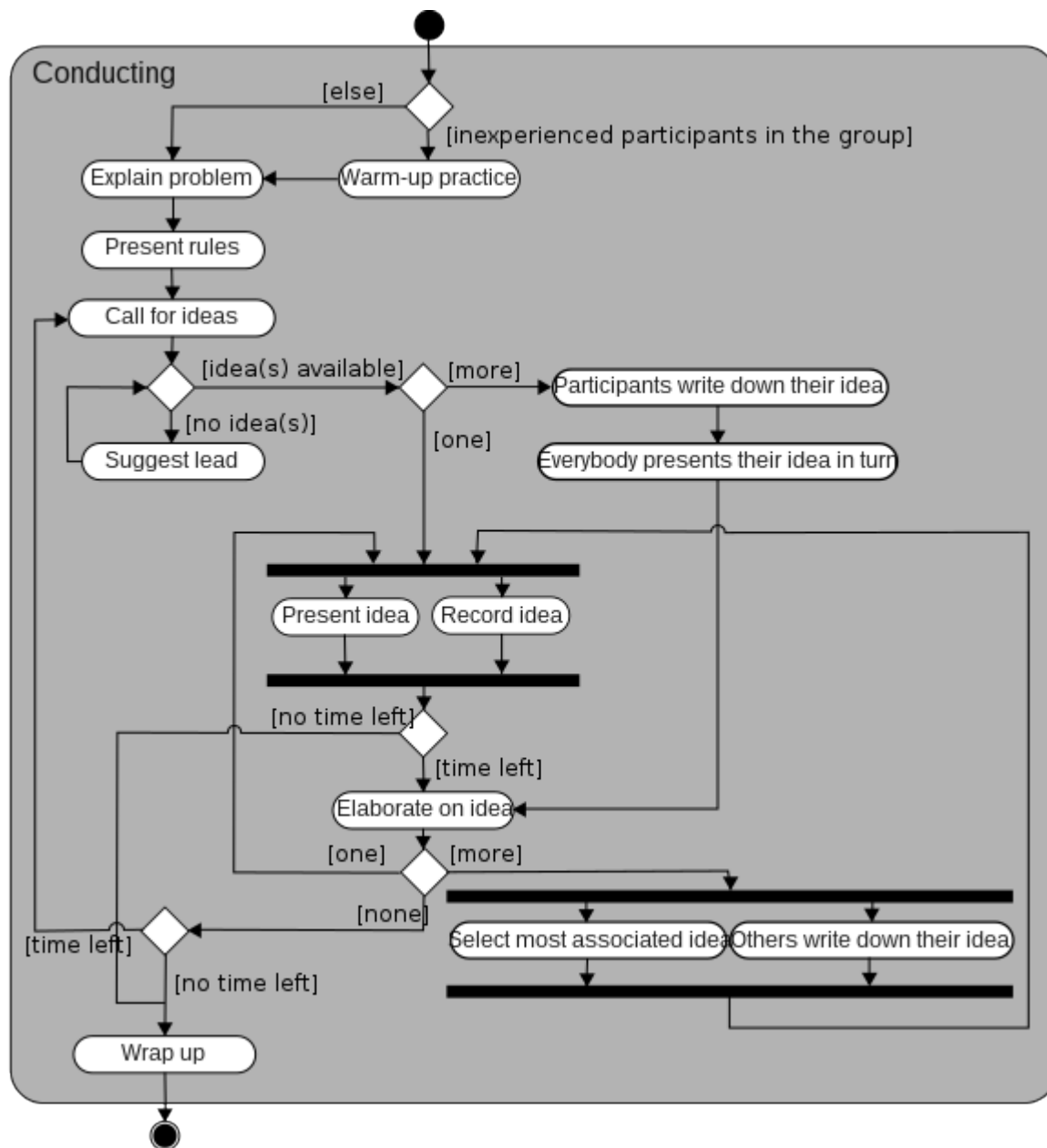
**Brainstorming** is a [group creativity technique](#) by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members.

The term was popularized by [Alex Faickney Osborn](#) in the 1953 book *Applied Imagination*.

### Origin

Advertising executive [Alex F. Osborn](#) began developing methods for [creative problem-solving](#) in 1939. He was frustrated by employees' inability to develop creative ideas individually for ad campaigns. In response, he began hosting group-thinking sessions and discovered a significant improvement in the quality and quantity of ideas produced by employees. Osborn outlined his method in the 1948 book *Your Creative Power* in chapter 33, "How to Organize a Squad to Create Ideas".<sup>[1]</sup>

## Osborn's method



Conducting a brainstorming activity

[Osborn](#) claimed that two principles contribute to “ideative efficacy,” these being :

1. Defer judgment,
2. Reach for quantity.<sup>[2]</sup>

Following these two principles were his four general rules of brainstorming, established with intention to :



- reduce social inhibitions among group members.
  - stimulate idea generation.
  - increase overall creativity of the group.
1. **go for quantity:** This rule is a means of enhancing divergent production, aiming to facilitate problem solving through the maxim *quantity breeds quality*. The assumption is that the greater the number of ideas generated, the bigger the chance of producing a radical and effective solution.
  2. **Withhold criticism:** In brainstorming, [criticism](#) of ideas generated should be put 'on hold'. Instead, participants should focus on extending or adding to ideas, reserving criticism for a later 'critical stage' of the process. By suspending judgment, participants will feel free to generate unusual ideas.
  3. **Welcome wild ideas:** To get a good long list of suggestions, wild ideas are encouraged. They can be generated by looking from new perspectives and suspending assumptions. These new ways of thinking might give you better solutions.
  4. **Combine and improve ideas:** As suggested by the slogan "1+1=3". It is believed to stimulate the building of ideas by a process of [association](#).<sup>[2]</sup>

## Applications

Osborn notes that brainstorming should address a specific question; he held that sessions addressing multiple questions were inefficient.

Further, the problem must require the generation of ideas rather than judgment; he uses examples such as generating possible names for a product as proper brainstorming material, whereas analytical judgments such as whether or not to marry do not have any need for brainstorming.<sup>[2]</sup>

## Groups

Osborn envisioned groups of around 12 participants, including both experts and novices. Participants are encouraged to provide wild and unexpected answers. Ideas receive no criticism or discussion. The group simply provides ideas that might lead to a solution and apply no analytical judgment as to the feasibility. The judgments are reserved for a later date.<sup>[2]</sup>

## Variations

### Nominal group technique

Main article: [nominal group technique](#)

Participants are asked to write their ideas anonymously. Then the facilitator collects the ideas and the group votes on each idea. The vote can be as simple as a show of hands in favor of a given idea. This process is called distillation.

After distillation, the top ranked ideas may be sent back to the group or to subgroups for further brainstorming. For example, one group may work on the color required in a product. Another group may work on the size, and so forth. Each group will come back to the whole group for ranking the listed ideas. Sometimes ideas that were previously dropped may be brought forward again once the group has re-evaluated the ideas.

It is important that the facilitator be trained in this process before attempting to facilitate this technique. The group should be primed and encouraged to embrace the process. Like all team efforts, it may take a few practice sessions to train the team in the method before tackling the important ideas.

### Group passing technique

Each person in a circular group writes down one idea, and then passes the piece of paper to the next person, who adds some thoughts. This continues until everybody gets his or her original piece of paper back. By this time, it is likely that the group will have extensively elaborated on each idea.

The group may also create an “idea book” and post a distribution list or routing slip to the front of the book. On the first page is a description of the problem. The first person to receive the book lists his or her ideas and then routes the book to the next person on the distribution list. The second person can log new ideas or add to the ideas of the previous person. This continues until the distribution list is exhausted. A follow-up “read out” meeting is then held to discuss the ideas logged in the book. This technique takes longer, but it allows individuals time to think deeply about the problem.

### Team idea mapping method

This method of brainstorming works by the method of [association](#). It may improve collaboration

and increase the quantity of ideas, and is designed so that all attendees participate and no ideas are rejected.

The process begins with a well-defined topic. Each participant brainstorms individually, then all the ideas are merged onto one large idea map. During this consolidation phase, participants may discover a common understanding of the issues as they share the meanings behind their ideas. During this sharing, new ideas may arise by the association, and they are added to the map as well. Once all the ideas are captured, the group can prioritize and/or take action.<sup>[3]</sup>

## Directed brainstorming

Directed brainstorming is a variation of electronic brainstorming (described below). It can be done manually or with computers. Directed brainstorming works when the solution space (that is, the set of criteria for evaluating a good idea) is known prior to the session. If known, those criteria can be used to constrain the [Ideation](#) process intentionally.

In directed brainstorming, each participant is given one sheet of paper (or electronic form) and told the brainstorming question. They are asked to produce one response and stop, then all of the papers (or forms) are randomly swapped among the participants. The participants are asked to look at the idea they received and to create a new idea that improves on that idea based on the initial criteria. The forms are then swapped again and respondents are asked to improve upon the ideas, and the process is repeated for three or more rounds.

In the laboratory, directed brainstorming has been found to almost triple the productivity of groups over electronic brainstorming.<sup>[4]</sup>

## Guided brainstorming

A guided brainstorming session is time set aside to brainstorm either individually or as a collective group about a particular subject under the constraints of perspective and time. This type of brainstorming removes all cause for conflict and constrains conversations while stimulating critical and creative thinking in an engaging, balanced environment.

Participants are asked to adopt different mindsets for pre-defined period of time while contributing their ideas to a central [mind map](#) drawn by a pre-appointed scribe. Having examined a multi-perspective point of view, participants seemingly see the simple solutions that collectively create greater growth. Action is assigned individually.

Following a guided brainstorming session participants emerge with ideas ranked for further brainstorming, research and questions remaining unanswered and a prioritized, assigned, actionable list that leaves everyone with a clear understanding of what needs to happen next and the ability to visualize the combined future focus and greater goals of the group.

## Individual brainstorming

“Individual brainstorming” is the use of brainstorming in solitary situations. It typically includes such techniques as [free writing](#), free speaking, word association, and drawing a [mind map](#), which is a visual note taking technique in which people diagram their thoughts. Individual brainstorming is a useful method in [creative writing](#) and has been shown to be superior to traditional group brainstorming.<sup>[5][6]</sup>

## Question brainstorming

This process involves brainstorming the *questions*, rather than trying to come up with immediate answers and short term solutions. Theoretically, this technique should not inhibit participation as there is no need to provide solutions. The answers to the questions form the framework for constructing future action plans. Once the list of questions is set, it may be necessary to prioritize them to reach to the best solution in an orderly way.<sup>[7]</sup>

“Questorming” is another term for this mode of inquiry.<sup>[8]</sup>

## Electronic brainstorming (EBS)

See also: [Brainstorming software](#) and [Electronic meeting system](#)

Although the brainstorming can take place online through commonly available technologies such as email or interactive web sites, there have also been many efforts to develop customized computer software that can either replace or enhance one or more manual elements of the brainstorming process.

Early efforts, such as GroupSystems at University of Arizona<sup>[9]</sup> or Software Aided Meeting Management (SAMM) system at the University of Minnesota,<sup>[10]</sup> took advantage of then-new computer networking technology, which was installed in rooms dedicated to computer supported meetings. When using these [electronic meeting systems](#) (EMS, as they came to be called), group members simultaneously and independently entered ideas into a computer terminal. The software collected (or “pools”) the ideas into a list, which could be displayed on a central projection screen (anonymized if desired). Other elements of these EMSs could support additional activities such as categorization of ideas, elimination of duplicates, assessment and discussion of prioritized or controversial ideas. Later EMSs capitalized on advances in computer networking and internet protocols to support asynchronous brainstorming sessions over extended periods of time and in multiple locations

Introduced along with the EMS by Nunamaker and colleagues at University of Arizona<sup>[9]</sup> was electronic brainstorming (EBS). By utilizing customized computer software for groups (*group*

decision support systems or groupware), EBS can replace face-to-face brainstorming.<sup>[22]</sup> An example of groupware is the *GroupSystems*, a software developed by University of Arizona.<sup>[9]</sup> After an idea discussion has been posted on *GroupSystems*, it is displayed on each group member's computer. As group members simultaneously type their comments on separate computers, those comments are anonymously pooled and made available to all group members for evaluation and further elaboration.<sup>[9]</sup>

Compared to face-to-face brainstorming, not only does EBS enhanced efficiency by eliminating travelling and turn-taking during group discussions, it also excluded several psychological constraints associated with face-to-face meetings. Identified by Gallupe and colleagues,<sup>[23]</sup> both production blocking (reduced idea generation due to turn-taking and forgetting ideas in face-to-face brainstorming) and evaluation apprehension (a general concern experienced by individuals for how others in the presence are evaluating them) are reduced in EBS.<sup>[22]</sup> These positive psychological effects increase with group size.<sup>[3]</sup> A perceived advantage of EBS is that all ideas can be archived electronically in their original form, and then retrieved later for further thought and discussion. EBS also enables much larger groups to brainstorm on a topic than would normally be productive in a traditional brainstorming session.<sup>[4]</sup>

Computer supported brainstorming may overcome some of the challenges faced by traditional brainstorming methods. For example, ideas might be “pooled” automatically, so that individuals do not need to wait to take a turn, as in verbal brainstorming. Some software programs show all ideas as they are generated (via chat room or e-mail). The display of ideas may cognitively stimulate brainstormers, as their attention is kept on the flow of ideas being generated without the potential distraction of social cues such as facial expressions and verbal language.<sup>[3]</sup> EBS techniques have been shown to produce more ideas and help individuals focus their attention on the ideas of others better than a brainwriting technique (participants write individual written notes in silence and then subsequently communicate them with the group).<sup>[3]</sup> The production of more ideas has been linked to the fact that paying attention to others' ideas leads to non-redundancy, as brainstormers try to avoid to replicate or repeat another participant's comment or idea. Conversely, the production gain associated with EBS was less found in situations where EBS group members focused too much on generating ideas that they ignored ideas expressed by others. The production gain associated with *GroupSystem* users' attentiveness to ideas expressed by others has been documented by Dugosh and colleagues.<sup>[21]</sup> EBS group members who were instructed to attend to ideas generated by others outperformed those who were not in terms of creativity.

According to a meta-analysis comparing EBS to face-to-face brainstorming conducted by DeRosa and colleagues<sup>[20]</sup>, EBS has been found to enhance both the production of non-redundant ideas and the quality of ideas produced. Despite the advantages demonstrated by EBS groups, EBS group members reported less satisfaction with the brainstorming process compared to face-to-face brainstorming group members.

Some web-based brainstorming techniques allow contributors to post their comments anonymously through the use of avatars. This technique also allows users to log on over an extended time period, typically one or two weeks, to allow participants some “soak time” before posting their ideas and feedback. This technique has been used particularly in the field of new product development, but can be applied in any number of areas requiring collection and evaluation of ideas.<sup>[citation needed]</sup>

Some limitations of EBS include the fact that it can flood people with too many ideas at one time that they have to attend to, and people may also compare their performance to others by analyzing how many ideas each individual produces (social matching).<sup>[citation needed]</sup>

## Incentives

Some research indicates that incentives can augment creative processes. Participants were divided into three conditions. In Condition I, a flat fee was paid to all participants. In the Condition II, participants were awarded points for every unique idea of their own, and subjects were paid for the points that they earned. In Condition III, subjects were paid based on the impact that their idea had on the group; this was measured by counting the number of group ideas derived from the specific subject's ideas. Condition III outperformed Condition II, and Condition II outperformed Condition I at a statistically significant level for most measures. The results demonstrated that participants were willing to work far longer to achieve unique results in the expectation of compensation.<sup>[11]</sup>

## Challenges to effective group brainstorming

A good deal of research refutes Osborn's claim that group brainstorming could generate more ideas than individuals working alone.<sup>[6]</sup> For example, in a review of 22 studies of group brainstorming, Michael Diehl and [Wolfgang Stroebe](#) found that, overwhelmingly, groups brainstorming together produce fewer ideas than individuals working separately.<sup>[12]</sup> However, this conclusion is brought into question by a subsequent review of 50 studies by Scott G. Isaksen showed that a misunderstanding of the tool, and weak application of the methods (including lack of facilitation), and the artificiality of the problems and groups undermined most such studies, and the validity of their conclusions.<sup>[13]</sup>

Several factors can contribute to a loss of effectiveness in group brainstorming.

### **Blocking:**

Main article: [Production blocking](#)

Because only one participant may give an idea at any one time, other participants might forget the idea they were going to contribute or not share it because they see it as no longer important or relevant.<sup>[14]</sup> Further, if we view brainstorming as a cognitive process in which “a participant generates ideas (generation process) and stores them in short-term memory (memorization process) and then eventually extracts some of them from its short-term memory to express them (output process)”, then blocking is an even more critical challenge because it may also inhibit a person's train of thought in generating their own ideas and remembering them.<sup>[15]</sup>

**Collaborative fixation:** Exchanging ideas in a group may reduce the number of domains that a group explores for additional ideas. Members may also conform their ideas to those of other

members, decreasing the novelty or variety of ideas, even though the overall number of ideas might not decrease. [\[16\]](#)

**Evaluation apprehension:** Evaluation apprehension was determined to occur only in instances of personal evaluation. If the assumption of collective assessment were in place, real-time judgment of ideas, ostensibly an induction of evaluation apprehension, failed to induce significant variance. [\[6\]](#)[\[17\]](#)

**Free-riding:** Individuals may feel that their ideas are less valuable when combined with the ideas of the group at large. Indeed, Diehl and Stroebe demonstrated that even when individuals worked alone, they produced fewer ideas if told that their output would be judged in a group with others than if told that their output would be judged individually. However, experimentation revealed free riding as only a marginal contributor to productivity loss, and type of session (i.e., real vs. nominal group) contributed much more. [\[6\]](#)

**Personality characteristics:** Extroverts have been shown to outperform introverts in computer mediated groups. Extroverts also generated more unique and diverse ideas than introverts when additional methods were used to stimulate idea generation, such as completing a small related task before brainstorming, or being given a list of the classic rules of brainstorming. [\[18\]](#)

**Social matching:** One phenomenon of group brainstorming is that participants will tend to alter their rate of productivity to match others in the group. This can lead to participants generating fewer ideas in a group setting than they would individually because they will decrease their own contributions if they perceive themselves to be more productive than the group average. On the other hand, the same phenomenon can also increase an individual's rate of production to meet the group average. [\[12\]](#)[\[19\]](#)