PART 1

Information Systems: Technologies and People

1

Components with Known Purposes: Technologies

In Greek mythology, when Theseus left to fight the Minotaur, his father Aegeus asked him to replace the black sail of his boat with a white one if he returned victorious. Just like components of an information system, Theseus and Aegeus were exchanging information through a clearly defined procedure. An information system is not a computer system. Organizations can see their information system supported by a computer system, but the information system cannot be reduced to a computer system. Individuals, the users of the computer system, are components of the information system: they also process, store and spread information, whether through the computer system or not. In this way, they themselves are also entry points likely to constitute the insider threats that this book addresses.

This chapter will discuss the technologies that have been used by human beings to support and secure information systems throughout history. From the decrease in transmission time to the massification of the quantities processed, the purposes of these technologies have evolved through the years and led to the explosion of a threat that is still part of every information system: the insider threat.

It is not our intention to focus on a history of the concept of information systems, but rather on a history of artifacts and technologies implemented by human beings to support and secure it. In fact, for authors such as Weizenbaum [WEI 84]: “the remaking of the world in the image of the computer started long before there were any electronic computers”. Thus, the reader will see how, over the years, these artifacts have pursued goals such as decreasing transmission time, decreasing processing time or the massification of quantities of information in an information system. Each time, these artifacts have revealed new threats to the information system’s security and the history that we offer in this chapter is intended to make the reader aware of the possibility of threats that do not come from the technological component of the information system. Indeed, since the beginning of time, the human component of the information system has constituted an insider threat, as this history will demonstrate.

1.1. Up to the end of the 19th Century: decreasing transmission time

In the second Century BC, the Greek Polybius developed a system for transmitting information over long distances in a few minutes where otherwise several hours of travel on horseback would have been necessary [LAU 77]. An operator showed or hid torches behind two walls in order to represent a letter of the alphabet (Figure 1.1). In fact, Polybius proposed dividing the alphabet into five groups of letters, with the result that only two “digits” were sufficient to represent the entire alphabet. Table 1.1 shows Polybius’ code: to represent an “A”, a torch was raised on the first wall and another on the second (first line and first column); to represent a "Ω", five torches were raised on the first wall and four on the second (fifth line and fourth column).

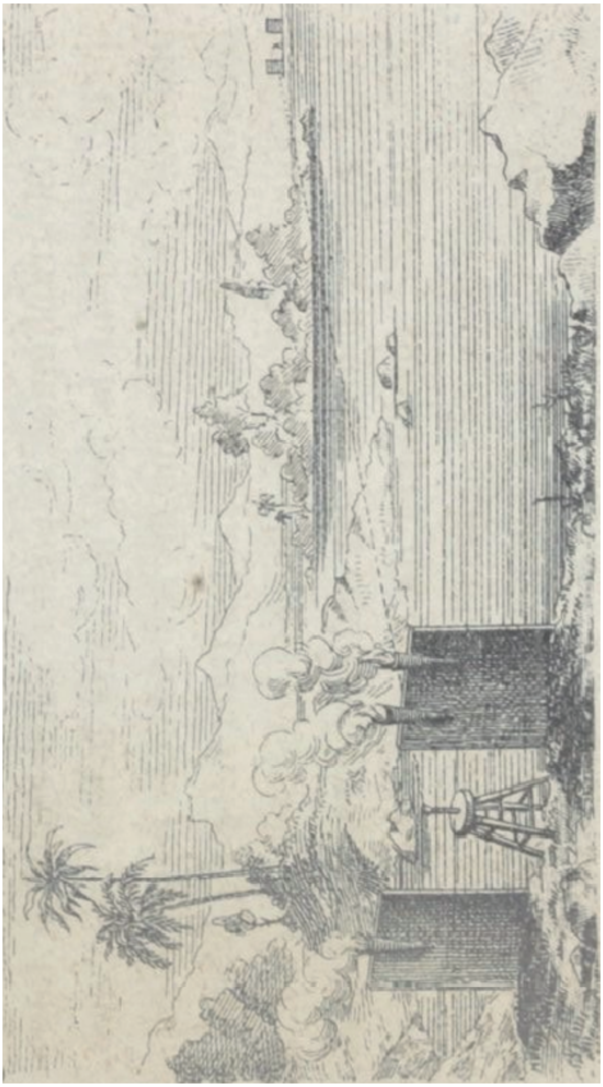


Figure 1.1. *Artifacts supporting an information system in the second Century BCE ([LAU 77], source: Bibliothèque Nationale de France)*

	1	2	3	4	5
1	Α	Β	Γ	Δ	Ε
2	Ζ	Η	Θ	Ι	Κ
3	Λ	Μ	Ν	Ξ	Ο
4	Π	Ρ	Σ	Τ	Υ
5	Φ	Χ	Ψ	Ω	

Table 1.1. *Polybius' code*

Independently of any artifact, an individual, from the moment he/she exchanges information, places himself/herself in an information system in which he/she is a component. In this way, the author, while writing this book, is part of an information system and the reader, when he or she reads these words, is within an information system. Information systems are everywhere and very often it has been military motivations that have motivated humanity to perfect them, thus raising the question of the security of such systems.

Indeed, talking is a natural process for human beings who are able to comprehend the risks inherent in the security of the information that spreads when they talk. For example, a child knows that he/she risks being overheard. If we can imagine what dangers might threaten a messenger on horseback in Ancient Greece, it is also possible to see security breaches in Polybius' information system: everyone has access to the information being transmitted. This awareness of security flaws is not natural for human beings insofar as the means of communication is not natural. The same thing is true when information systems within organizations are increasingly supported by digital artifacts.

From the moment it is supported by an artifact, an information system presents security flaws that we are not naturally aware of.

Although artifacts can give a false impression of security and lead to flaws that individuals must be made aware of, the fact remains that natural forms of communication can also lead to flaws that individuals must be made aware of.

Polybius perfected his system very quickly with the help of a password: one starts to fill in the square (Table 1.1) with the letters of this password and then completes it with the remaining letters of the alphabet. At the time, the message was indecipherable without the password. This kind of encryption with monoalphabetic substitution is easily decipherable today with an analysis of how frequently letters appear in a language. In French, for example, the letter "e" is the most frequently used.

There are documents attesting to the existence of systems comparable to Polybius', although simpler, used by the ancient people of Europe and Asia. For example, the Roman army established telecommunication stations along Roman roads [LAU 77]. Trajan's column in Rome provides a visual representation of these observation turrets equipped with torches (Figure 1.2). In China, the Great Wall was equipped with fires used to signal an attack. Brick cones full of wood and straw also served to create smoke to announce the arrival or retreat or enemy troops.

Figure 1.2. *Artifacts supporting the Roman army's information system in the first Century*

In the Middle Ages, the Romans' system fell into disuse in Europe while in Constantinople, signal lights remained in use for signaling Muslim incursions. Progress in physics in the 16th and 17th Centuries rekindled the idea of systems that could transmit information over distances at "great speed". In France in 1705, the Royal Academy of Sciences wrote the following about the system of physicist and academician Guillaume Amontons:

> "[Amontons' system] consists of having several people in consecutive posts who, by means of telescopes, having seen certain signals from the previous post, transmit them to the following one, and so on, and these different signals are the letters in an alphabet whose code is known in Paris and in Rome. Most of the telescopes cover the distance between the posts, whose number must be as low as possible; and the same way the second post sends signals to the third as soon as they see the first post sending it, the news is sent from Paris to Rome in as little time as it took to send the signals in Paris". [FON 05, p. 152]

The telegraph of the Chappe brothers (Figure 1.3) followed at the end of the 18th Century and was the first telecommunications network with a national scope. By defining the conventions and vocabularies, the Chappe brothers made it possible to link very precise signals to specific dispatches especially applying to the army. Figuier [FIG 68] explains how it works:

> "The telegraph itself, or the part of the machine which creates the signals (fig. [1.3]), is made up of three mobile branches: a main branch AB, 4 meters long called the *regulator* and two small

> branches 1 meter long, AC, BD, called *indicators*, or *wings*. Two iron counterweights *p*, *p'* attached to a rod of the same metal, balance the weight of the *wings*, and making it possible to move with very little effort. These rods are somewhat thin so they are not visible from a distance. The regulator is secured in the middle to a pole or at a height, that elevates above the roof of the hut in which the observation post is located". [FIG 68, p. 51]

The key to the vocabulary changed frequently to keep the system secure and its use was then dedicated to military communications during the French Revolution. Some clandestine systems were nevertheless dismantled in the years 1833–1834, while businessmen wanted access to a telecommunications network for commercial purposes. In 1837, a law was passed giving the French state a monopoly on the transmission of information by telegraph or any forthcoming means of transmission. In France, only the French government could use, manage and install the means of transmission of information for 150 years. This was known as the Post, Telegraphs and Telephones (PTT) monopoly.

The telegraph became electric, then was used with the Morse alphabet and subsequently the telephone appeared, with each change accompanied by a question that the reader must keep in mind: these forms of media made it possible to exchange information, certainly, but how to ensure the security of the information system that they support?

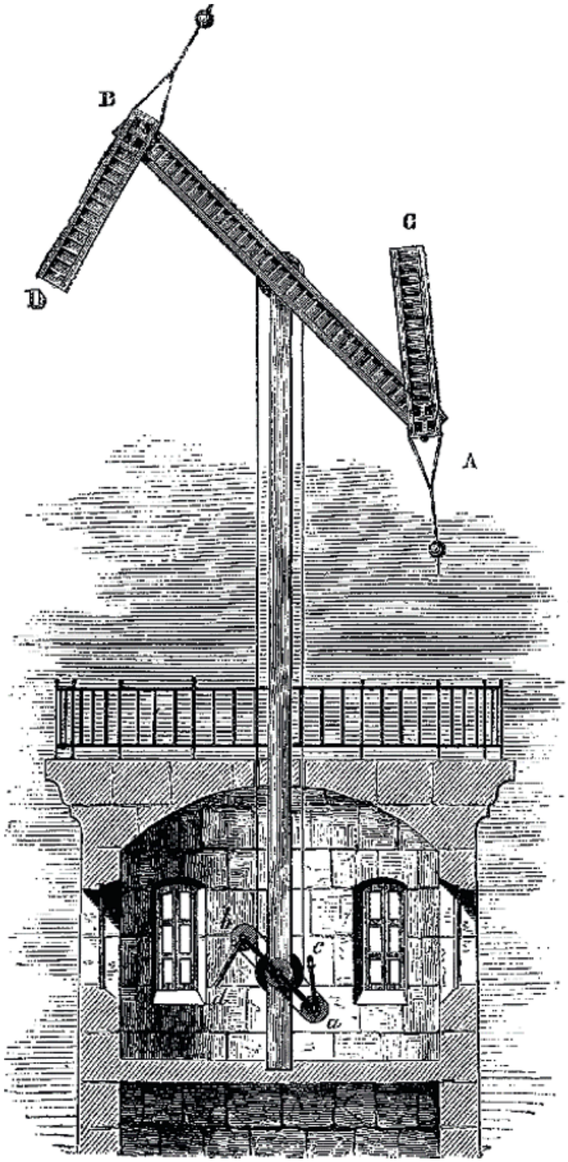


Figure 1.3. *Chappe's Telegraph (source: [FIG 68]), an artifact supporting the information system of the French State in the 19th Century*

Indeed, when governed by rigor and military discipline, the information system sees its components work according to strict and well-defined procedures. Yet, the industrial revolution went hand in hand with the liberalization of means of communication in the second half of the 19th Century. Moreover, the information system of organizations, until then confined to memoranda, account books and letters, saw the introduction of new components supported by Information and Communication Technologies. Whether it is a telegram, a telephone call, a fax or an e-mail, the question of the security of the artifacts supporting the information system arises. The question – the one which is the subject of this book – of insider threats that the employees, the human component of the information system can constitute, arises again: are they liable to spread, even unintentionally, information to someone other than its intended recipient?

In an 1878 *Instruction Manual for the Domestic Use of the Bell Telephone*, we can read that "telephones can serve to establish communications between two or several rooms in a house or any building, whether for purely domestic needs, or for commercial, industrial or administrative uses" [ROO 78, p. 1]. It becomes possible to talk remotely. The transmission time for information is reduced to the time it takes to speak the words themselves. From the point of view of information system's security, when speaking on the telephone it seems as if the natural character of this medium of transmitting information minimizes the insider threat and the risk of attacks from the human component of the information system. Indeed, unlike the torches in Polybius' system (Figure 1.1) or the Chappe brothers' telegraph (Figure 1.3), human beings naturally learn to communicate by voice. The artifact that is the telephone provides a feeling of security insofar as the interlocutor is known. Nevertheless, an attack can consist of pretending to be this interlocutor. Once again, the presence of an artifact supporting the information system leads to a false impression of security that we must be aware of. The observations that we have been able to make in the field and which are presented in the second part of this book show that independently of the object used, the human component of the information system is always susceptible to be the target of attacks.

At the end of the 19th Century, the information system integrated a human component, certainly, but also increasingly integrated components supported by artifacts, that is to say man-made products: from the Latin *arte factus* "made with art". Whether they are signals from torches, smokes signals, telegrams or telephones, these artifacts are meant to decrease the transmission time of the information within the information system. Figure 1.4 shows how the artifacts likely to support information systems in the year 2000 were envisioned in 1910.

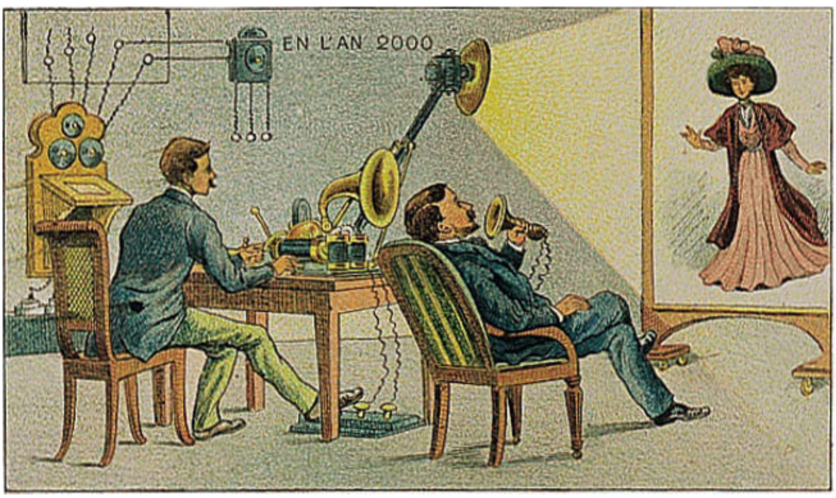


Figure 1.4. *"Correspondence Cinéma – Phono – Télégraphique": artifacts supporting an information system in the year 2000, as seen in 1910 by Villemard (source: Bibliothèque Nationale de France)*

1.2. From the end of the 19th Century: decreasing processing time

In an information system, information is transmitted, certainly, but it is also processed. Traditional information processing techniques have evolved within organizations, particularly at the end of the 19th Century [DAN 01]. Whether they are accounting related, administrative, or commercial in nature, the quantities of information processed have become larger and larger, in fact lengthening the processing time. Managing prices, estimating and distributing costs, evaluating profits and controlling stocks are so much information processing that is likely to take a long time once large quantities of information need to be processed.

The United States Constitution of 1787 stipulated that every 10 years, a census of the nation's free people and slaves had to be taken. The young nation went from 3.9 million people at the time of the first census in 1790 to 76 million in 1900, while the length of the census reports went from 56 pages in 1790 to 26,408 pages in 1890. For each census, a new census bureau would open and then be closed after having issued its report, resulting in a lack of continuity and legibility of statistics from one census report to another [HEI 09, p. 15]. High turnover, combined with sporadic funding, led to the use of punch cards (Figure 1.5) in carrying out the 1890 census with unprecedented efficiency and precision.

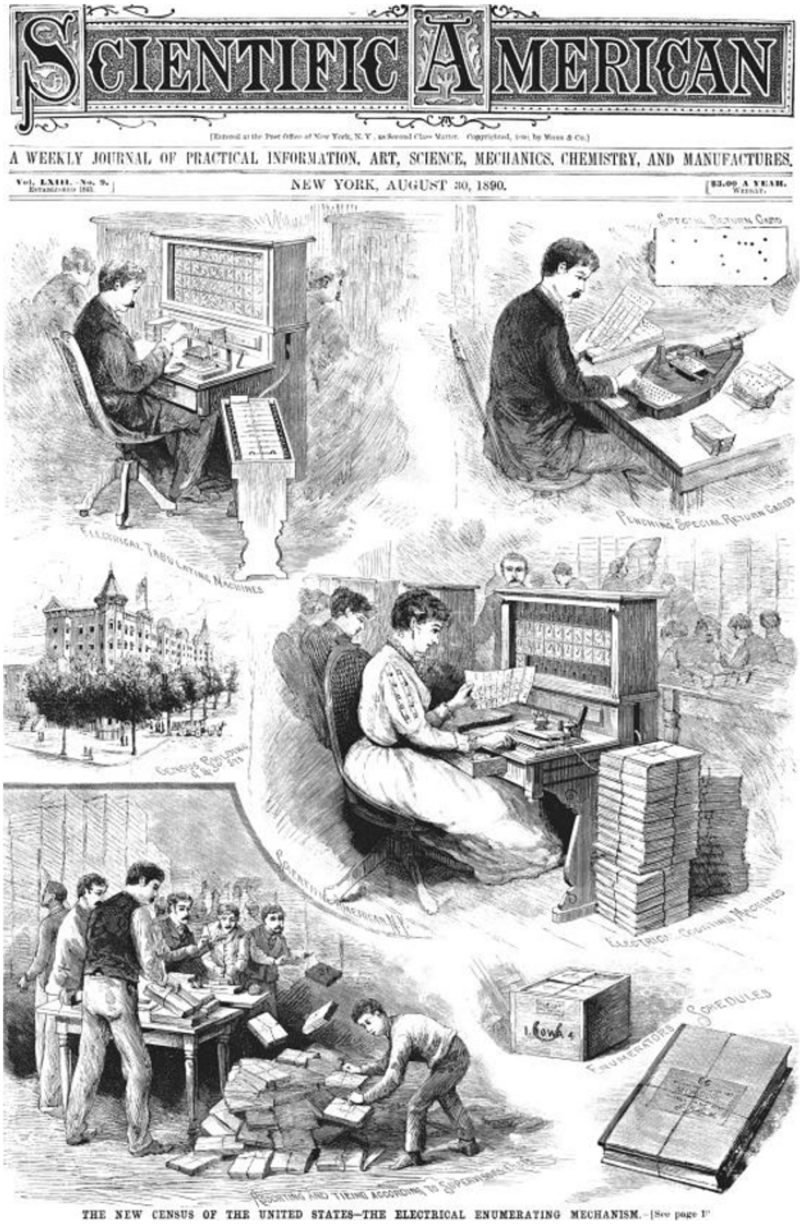
Before World War I, manufacturers had begun to collect more and more information. Because businesses had been predominantly small before then, formal demand for information was almost nonexistent. Not only (1) was information accessible directly through observation, but also (2) the decisions a small business needed to make in a stable economy were relatively simple.

Starting in the 1920s, tabulating machines with punch cards were used all over the world to reduce the processing time for information [MUR 10]. The opening of new markets, national and international, as well as technological innovations, made the type of decisions managers had to make more complex, while they saw the processing of information as the source of key indicators. In addition, new systems were tested for using this information and benefitting from it in a changing economy. For Levenstein [LEV 98, p. 2]:

> "Firms adopted technologies, organizational structures, and information systems to adapt to and take advantage of these new possibilities".

The demand for artifacts making it possible to process information more and more quickly came in particular from an increase in the size and number of very capitalistic businesses [LEV 98, p. 14]. The principal demand involved production rather than transactions. It entailed measuring, recording and processing what was happening internally within the business rather than in the outside world. This information was then used at different levels of the business to help decision making.

However, surviving in a competitive mass market requires a mastery of costs and margins as well as a rapid response that was adapted to client preferences and variations in the market. Thus, attention was also paid to transactions. In 1949, the British agri-food company J. Lyons was one of the first in the world to use a computer to support its information system. This business, which had no experience in electronics or computer science, designed and built the LEO I, the first stored program computer used by a private enterprise [LAN 00, p. 16].



SCIENTIFIC AMERICAN

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Vol. LXIII.—No. 9. Established 1845. | NEW YORK, AUGUST 30, 1890. | $3.00 A YEAR. WEEKLY.

THE NEW CENSUS OF THE UNITED STATES—THE ELECTRICAL ENUMERATING MECHANISM.—[See page 1

Figure 1.5. *First page of the August 30, 1890 Scientific American showing how the artifacts supporting an information system made it possible to reduce processing time*

Despite a large number of daily transactions, Lyons was making an extremely low average profit, around a fraction of a penny [LAN 00, p. 17]. In 1923, the top management decided to recruit John Simmons, a statistician, who would later say:

> "In fact I was engaged to try to build up a system of information for the management of the company which would be superior, more sensible, than just depending upon the profit and loss account and such like [...] in this respect the company was already ahead". [CAM 98, Annex B, pp. 360–374]

Simmons had risen through the ranks and set up the Systems Research Office whose job was evaluating existing systems, traveling the world in search of better ways to support management activities and inventing, testing and implementing improvements. Numerous innovations have, moreover, been set up by the Systems Research Office, in particular the concept of "sales representatives", each one with responsibility for a small group of retailers with a duty of accounting, credit, payment, etc.

Over the years, Lyons developed a new management style where information went from operations, manufacturing, sales and distribution to bills and payments. Each subsidiary of the business had its managers who reported on its activity. These masses of information were summarized and compared in relation to standards, forecasts and budgets. It was thus possible for the management to inquire about the effect of a 10% reduction in the production of chocolate, for example, on overall profit.

In 1947, two of the company's top executives visited the United States to see the changes in office equipment since the end of Second World War. There was nothing new, except that they heard about an "electronic brain", the Engineering Numerical Integrator And Computer (ENIAC), used by the army and for engineering calculations. They very quickly grasped the possibilities of this type of equipment for economic and commercial calculations and they began to visit the pioneers who were using the installation. Significantly, at Harvard and Princeton they learned that Cambridge University in England was in the process of developing an Electronic Delay Storage Automatic Calculator (EDSAC). Returning to England, the two men visited Cambridge, where they noticed that the development of the machine was very slow. They made a report to Simmons, which included the following:

> "Here, for the first time, there is a possibility of a machine which will be able to cope, at almost incredible speed, with any variation of clerical procedures, provided the conditions which govern the variations is predetermined. What effect such machines could have on the semi repetitive work of the office needs only the slightest effort of imagination. The possible savings from such a machine should be at least £50,000 a year. The capital cost would be of the order of £100,000" [LAN 00, p. 19].

In this report, they also proposed building a machine in Lyons' workshops based on the university's advice. In 1949, Lyons agreed to financially support Cambridge University once it had shown the EDSAC's ability to solve complicated mathematical problems. In exchange, the university would help Lyons create its own computer, the Lyons Electronic Office (LEO). In 1951, the LEO team created the basis of the computer whose first applications would concern the bakeries of Lyons. In 1953, the LEO I (Figure 1.6) was formally declared operational [LAN 00, p. 20].

Figure 1.6. *Control console of the LEO I in 1953 (source: the LEO Computers Society). For the first time, a computer system supported an information system in a business*

The first mass-produced computer was the IBM 650, produced between 1954 and 1962. In 1957, the Railway Technical Research Institute imported the first stored program computer to Japan, a Bendix G-15, to conduct research on seat reservation systems [MUR 10]. During Japan's 1955–1973 period of high growth, the development and the use of information systems supported by computers made it possible to streamline business procedures and to reduce costs [MUR 10, p. 5]. By 1961 in Japan, the number of orders for computers had surpassed orders for punch card systems.

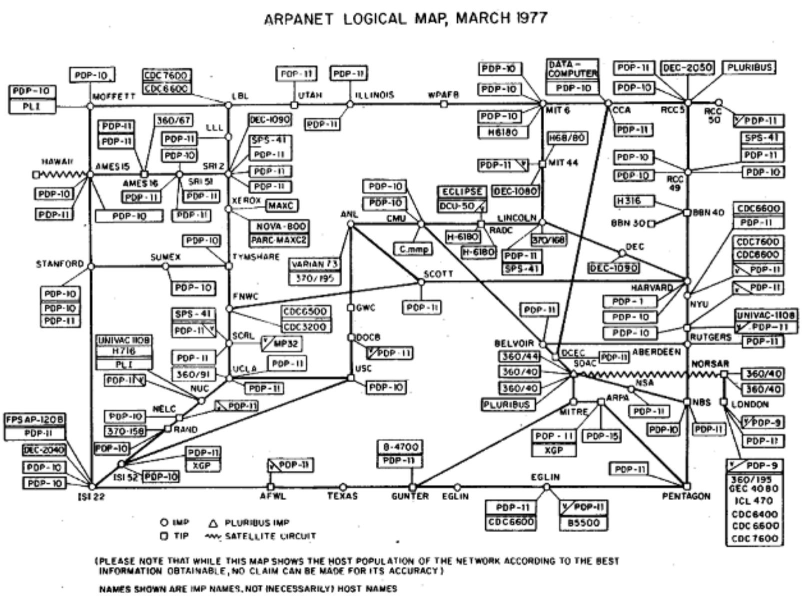
In 1968, in front of a crowd of around 1,000 professionals and researchers in computer science, Douglas Engelbart of the Augmentation Research Center of the Stanford Research Institute in California demonstrated a computer system, hardware and software, which he and his team had been working on since 1962. For the first time, two people located in different places could share a screen and work simultaneously on a file while communicating through a network with an audio and video interface. It also involved the first use of a mouse and hypertext links. Figure 1.7 shows this system's interface and corresponds to an extract of the recording of the 1968 demonstration. Computer systems then would gradually support the information systems within organizations. In fact, not only did they considerably increase the processing time of information, but they also made it possible to transmit different types of information (text, audio and video). Information transmission and processing times were reduced even more and confusion was created between "computer system" and "information system". However, although the first is confined to processing information automatically, the second integrates a human component that must not be forgotten. The increase in quantities of information to be processed brought about the use of computer systems to support the information system. Paradoxically, computer systems, although they have allowed the transmission and processing of information at a high speed, have at the same time considerably massified the quantities of information to be transmitted and processed.

Figure 1.7. *Audio and video interface with screen sharing in 1968 (source: web.stanford.edu); confusion developed between "computer system" and "information system"*

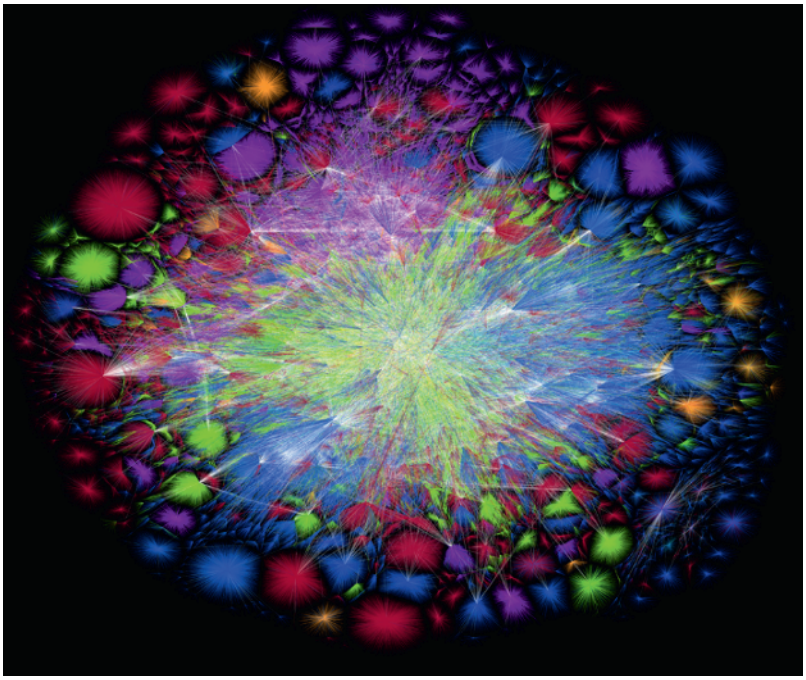
1.3. From the end of the 20th Century: facing massification

The reader might be surprised to discover the contents of the previous section: if people were already sharing screens remotely and exchanging audio and video information through a computer system within an information system in 1968, what happened after that? Close to half a century after Engelbart's demonstration, the information system seems to be supported by the same type of artifacts (computer systems) with the same goals (decreasing information transmission and processing times). This is the case. Nevertheless, the change is not any less tangible than that of the massification of the information to be transmitted and processed.

By way of illustration, Figure 1.8(a) shows the ARPANET (Advanced Research Projects Agency Network) in 1977; this network would serve as the basis of the Internet and connected major universities in the United States as well as the Pentagon. Figure 1.8(b) presents the Internet network in 2015, where each line corresponds to an exchange of information between two IP addresses. These figures show the massive change in the amount of information exchanged through the network between 1977 and 2015.



a)



b)

Figure 1.8. *a) The ARPANET in 1977 and b) the Internet in 2015*

This evolution goes hand in hand with the uses that are made of the digital artifacts supporting the information systems within organizations. For authors such as Bryant [BRY 08]: “IS [...] is inevitably caught up in an ambivalent relationship with modernity”. Where an executive could use a telephone in 1930, today all of the employees have access to the outside world from their work stations, whether through the business’ information system or through their own means. They also represent a threat to the information system’s security from within the organization itself: they represent an *insider threat*.