Inventing the Internet by Janet Abbate  
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The Internet is a multi-faceted system comprising of diverse features and components featuring a collection of world-wide networks communicating through Internet Protocol (IP). The system has advanced and popularized to the extent that it has become an essential element of the socio-economic fabric of modern society. Although still evolving as a system, investigating the development of the internet is highly relevant to the study of complex systems. It is a complicated system that exhibits itself in simple ways as opposed to being a system that is simple but exhibits itself in complex ways. In this regard, Janet Abbate in her book *Inventing the Internet* outlines key technologies, players, organizations and systems that have collaborated together to develop the internet such as computer scientists, academics, military and government agencies, standards organizations and telecommunications companies. In addition, she demonstrates how various cultural and social factors influenced these various systems and players when designing the internet, which contributed to the trend of user-driven, decentralized development that made the Internet a diverse and flexible environment. The paper will further explore the complex organizational cultures, styles, and technical designs involved in the invention of the Internet, in light of Abbate’s research, to illustrate how these various structures came together to create such a complex system.

# Summary of the Book

In her book, Abbate (2000) shares many stories and events that led to the creation of the Internet as we know it today. The internet began from being a simple network in the 1960s comprising of a few sites in the US to a worldwide network allowing millions of computers to connect. Janet starts her book by showing us the significance of the Cold War and the impact that it had on the invention of the early technologies that led to the later creation of the internet. Some of those very important technologies were the packet switching and the ARPANET. Janet covers in detail how each of those technologies came to life and of course all of the challenges and strategies that had to be overcome in order to complete those projects. The author highlights the important aspects of the collaboration and the conflicts between the key players in each project. The ARPA organization was formed with the idea to drive vision and to manage the mega projects that had to take place for a technological advancement which will allow various researchers and computers to connect and collaborate instantaneously. In the late 1960s, Lawrence Roberts was recruited to join the ARPA organization and to oversee one of the most important projects for humanity – the ARPANET. His idea was to connect all of the existing ARPA sites with one another to exchange information. Building upon the ideas of another scientist – Davies and his work on the Mark I system, Roberts was able to build upon his existing idea and combining Davies’s idea for packet switching which made the idea of a continental network possible.

The idea of packet switching was a critical advancement during the era as it allowed the flow of data by reducing it to smaller chunks, in order to quickly transmit them over various network lines, and to later reassemble them at the recipient’s end. The newer technique was efficient and faster compared to other methods such as circuit switching that was being utilized in telephony, and had the additional advantage of making it more difficult to intercept this data while it was being transmitted, thus serving another benefit during the Cold War days. Earlier, science conferences were the only events that made collaboration among scientists possible. A shared desire to collaborate and exchange ideas in real-time for mutual benefit drove the development of the ARPANET.

In subsequent chapters, however, Abbate (2000) also clarifies that the development of such networking technologies was not inevitable as many claim. Although, Cold War military spending and the then ideological conflict served as a factor, yet, researchers developing the internet struggled to sustain funding and saw little approval until the introduction of the email. The demand for email substantially helped them sustain funding for further research, which proves that the internet was not solely a creation of an industrial, military, and academia complex but rather its potential use in commercial and academic activities which drove its development. At times these objectives were cultural, social, or personal, and would conflict with the funding institution’s efforts. During development, the teams and their project managers had to look outside the conventional resource and time-sharing model of interactive computing and shift to a full networked environment, which enables computing research centers in far flung areas to effectively network together. The scientists working on these systems were able to design programs to enable resource sharing, and with the introduction of the email, had demonstrated the capabilities of the network beyond what had been originally planned by ARPANET. The idea of network itself changed to allow not just incompatible computers to connect but entire networks to connect with other networks (Malone, 2000).

Furthermore, the development of these networking technologies was not solely an American creation but rather prominent scientists working at CERN and Minitel projects were involved that played a critical role in developing standards that would be used in these networking technologies. The development of the internet had driven various standards, technologies, people, and views together which transcended geographical boundaries under a complex synergy before being ready for commercialization in the 1990s. The trend of a decentralized, user-driven, and informal development that marked the evolution of the internet followed the same pattern of development. The internet drew various technologies and people together as it continually shifted. Eventually it gained mass commercialization and appeal and became the World Wide Web as we know it today.

# Primary themes of the book

The primary ideas that Janet Abbate expresses in her book the Invention of the internet are the historical events and cultural environment of the society that influenced the creation of the internet as we know it today. In the first part of the book, Janet paints a vivid picture of the 1960s and the US technology situation during the Cold War. The USSR had the technological advantage. they already had a program to support and develop technology that will give military advantage over the US. If the US government wanted to stay relevant, they had to act quickly and with full. That led to the creation of the ARPA organization. The ARPA organization had a different and more modern approach on technological projects. ARPA had its mission to keep the US ahead of military rivals by managing research projects that promise significant advances in defense related fields. ARPA was a small agency that specialized on managing projects and outsourcing the research and the development to contractors. The ideas that were initially developed as military defense projects led to the creation of multiple civilian technologies that helped to propel the US as a leader in technology and science. One of the most important projects was the ARPANET. The author gives us a detailed overview of the progress of the ARPANET. In the very beginning the ARPANET started as an idea to connect researchers throughout the US sites and to help them to collaborate and exchange ideas. Roberts knew that such a network will help the science society to collaborate and to advance faster. However, the cultural and political interests at the time influenced the development of the ARPANET. In 1972 Roberts left the ARPANET project to join BBN and its project called Telenet. Telenet was a commercial spin off of the ARPANET. And another scientist named Khan took over ARPANET. Khan was faced with the challenge to popularize the internet. The challenge was to create a protocol which will allow computers from different networks to connect to each other. TCP turned out to be the open protocol that everyone working on a networking project had come across at some point of their research. There were multiple tests and projects that were focused on breaching that gap. There was a successful three-way test between SATNET, ARPANET, and PRNET that represented the beginning of the Internet. The design made it possible for the three networks to operate independently but still to communicate.

As lower cost computers began to be introduced, it increased individual’s capability to access the ARPAET without the need to go through the host server, something which raised concerns about network security especially among the military. These concerns were a result of the open-architecture networking that had allowed networks to expand beyond a limited circle of connected computers. The initial protocol, called the NCP (Network Control Protocol) could only manage host to host communications among computers that lied within the same network. Thus, a new protocol was needed which had to be dynamic, reliable, and open. Eventually in 1978, Vint Cerf and Robert Kahn were able to develop such a protocol and termed it Internetwork Protocol/Transfer Control Protocol or TCP/IP. The new protocol opened up possibilities of collaboration between all similar global networks with that of ARPANET. Thus, the foundations of a network that could expand and connect on a global scale were laid where anyone could join in (Navarria, 2016). The internetwork protocol (IP) could be used for transmitting packets of data to packet switches while the transmission control protocol (TCP) helped manage communication among various hosts.

Eventually, the development split in two and a separate MILNET system was created for projects related to military operations while ARPANET became used by academic researchers for various projects. Moreover, with the success of TCP/IP, ARPA started to encourage its commercialization to support the development of a user or civilian-driven Internet. However, commercialization required the development and selection of International standards which had to involve all industry and government stakeholders. Thus, two international standard bodies, along with the telecommunications industry, computer manufacturers, and other standards-setting entities collaborated to develop the Open Systems Interconnection standard (OSI) which supported the development of public and universal standards. As personal computers began to popularize, the network began to expand dramatically, against which the ARPANET’s system could not keep up. Host connections had to be transferred to a newly developed NSFNET that many universities had started to rely upon. This process further shifted the network away from its military origins which became even further distant when NSFNET decided to allow commercial internet service providers to develop and strengthen the Internet’s infrastructure.

At the same time, the rapid development of the networks spiked interest in the rest of the military organization and more specifically in the Defense Communication Agency, which at the moment was still depending on extremely slow network called WWMCCS. It some cases, it was faster to copy the information on tape and transport it with an airplane instead of using WWMCCS. On July 1st, 1975, the defense Communications Agency officially assumed control over the ARPANET, which resulted into all military organizations made increase use of the network. And the first personal computer was introduced in the US, it was made by a small company called Micro Instrumentation Telemetry Systems. The Altair 8800 was an instant hit with amateur computer enthusiasts and thousands of them were sold in the first few months. The increased interest from civilian parties started to form the fear of hackers breaking into the military system of the ARPANET.

# How the book relates to complex systems

The book “Inventing the Internet” by Janet Abbate is full of examples of managing complex systems as we cover in our class. From the very beginning, the author covers the political aspect and situation that led to the major projects like the ARPANET. If it wasn’t for the political competition between the US and the USSR during the Cold War, we probably wouldn’t witness so many great projects that helped to shape the humanity. US was afraid that they were losing the technological competition with the USSR and they were not going to remain the dominant power in the world. They had to take drastic actions to stay relevant and to allocate enormous budget to support research and development. The ARPA organization is a great example of a government agency that is focused on managing complex projects and at the same time innovating by bringing a new approach and viewpoint. ARPA didn’t get involved with the actual execution rather they outsourced the development and the research to academic and industrial contractors. Their full focus was on managing the project, driving vision, making sure US is ahead in the technology competition. This new approach gave them the ability to be focused on the vision and the next thing that had to be developed instead of getting caught up in the weeds. Once, the ARPANET project became of significance to the entire country we see the political and economic aspect of the situation to take priority and to lead the project in different directions. Janet covers the split focus of the military involvement and the popularization of the Internet with the civilian and commercial society. The benefits of such a network were important not only to the military organizations. It was becoming important benefit for the entire society and that led to the popularization of the internet.

The Internet is essentially a highly complicated system but which exhibits simple behavior owing to a range of inherently characteristic architectural features involving a wide range of scientific fields and disciplines. This includes the key features of network traffic which operate in open-loop and closed-loop control that governs the flow of data, under control theory. It also relies upon graph theory to create the connectivity structure of the various information networks, while relying on information exchange theories to enable the development of protocols, conventions and rules. Similarly, it relies on game theory to create competitive and resource-bound environments, while also relying on various theories of organizational behavior that affect the development of its infrastructure and the relationships among various competing ISPs (Park & Willinger, 2005). One of the unique features of a complex system like the internet is that it became a melting point of various ingredients, each of which came from different fields and disciplines and converge together at some point. Secondly, the Internet is a multi-body man-made system which led to various synergistic opportunities, modeling challenges, and novel phenomena, which were grounded in science; hence, the internet’s two features can be said to form a corner stone of modern complex systems (Park, 2005).

The initial motivation for the development was resource sharing where the time-sharing systems connected to the ARPANET could be accessed by individuals on packet radio networks. This had allowed remote login and file transfer, however, it was email that had the most significant impact out of all networking innovations. It not only help people communicate in real time but also led to the development of the internet itself. Another key concept was that it was not just built for use by a single application but a general system that many applications could access and be purposely-built to utilize. The TCP/IP protocols enabled this general purpose use which made global collaboration possible (Leiner, et al., 1997). Another principle at play was network management, where many commercial and research entities interplayed together. Initially, this was restricted to implementing and defining protocols which allowed interoperation but later as the network expanded, simple ad-hoc protocols were found to be inadequate. Automated algorithms were developed which helped configure arrays and tables. Moreover, the need to remotely manage different components of the network led to the development of various protocols and standards such as the HEMS, the SNMP, and the CMIP (Park, 2005).

The web didn’t get invented from the ARPA research community. New organization called CERN had scientists work on a new idea that the internet could be more than just text. They wanted to incorporate multimedia messages, video, voice, and text. Personal computers were becoming more visual oriented and CERN saw an opportunity to create a new system that allows scientist to collaborate in a different way. Berners-Lee envisioned a system that can be built on top of the same protocols used so far. However, his system was going to be very different than the military idea of network. The idea was to create “a pool of human knowledge” accessible by anyone. In December 1990 the first version of the Web software began operating and it was an immediate hit the users in CERN. The Web transformed the internet from a research tool to a popular medium by simple relaying to the masses. Now, each individual had the ability to be a producer of content and a consumer of information.

To conclude, the internet today is not just a collection of various technologies and theories, but a collection of communities. Its success can be attributed to utilizing this network of communities in a way that helped achieve both the communities’ needs and for them to collaborate together to push its infrastructure further forward. The spirit of community could initially be seen with the development and work of the ARPANET wherein a close-knit community worked together to develop packet switching technology. Other research programs, initiatives and contractors collaborated together to create mechanisms that helped further coordinate these development efforts which added the capability for remote access, file, sharing, and email, which eventually paved the way for the World Wide Web. The way the ARPANET Network Working Group evolved into a global working group, is an example of how various organizational and management styles in various little sub-projects integrated and collaborated together to create complex projects and systems, which eventually led to the creation of the internet as we know it.

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