

The Development of the Internet

Understanding the History and Relevance of the World Wide Web

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Over the past 10 years, social networking has gradually assimilated into daily life. Yet, few question how the Internet, or digitization of our interactions came to be. By understanding this global network and its history, we can gain insight about how our society regards networking technology today and how its use may evolve in the near future.

History

The origins of the Internet can be traced to a series of memos written by J.C.R. Licklider, Professor of Electrical Engineering at MIT, in August of 1962. In these memos, Licklider discussed the concept of a globally interconnected set of computers that he termed the “Intergalactic Network” (4). His idea relied on a few crucial developments. One of the most important was the improvement of computational tasking. Prior to 1957, computers only worked on one task at a time. This limitation, called batch processing, was bypassed when the idea of time-sharing emerged. Time-sharing allows for a single computer to be operated by multiple users at once. This discovery established the groundwork for information communication. The origins of this method can be traced to the Defense Advanced Research Project Agency (DARPA) which was founded in 1958. One of DARPA’s first projects was to plan a large-scale computer network to increase the rate of information exchange. This project would eventually become the ARPANET, whose development began in 1966 with the founding of the Information Processing Techniques Office (IPTO) head by Licklider. While there, Licklider assisted in the development of the time-sharing method. He also convinced many others, including Ivan Sutherland, Bob Taylor, and Lawrence Roberts, of the importance of an interconnected system. The major obstacle at the time in achieving this vision was deciding how to share information between computers. Two strategies were proposed: circuit switching and packet switching.

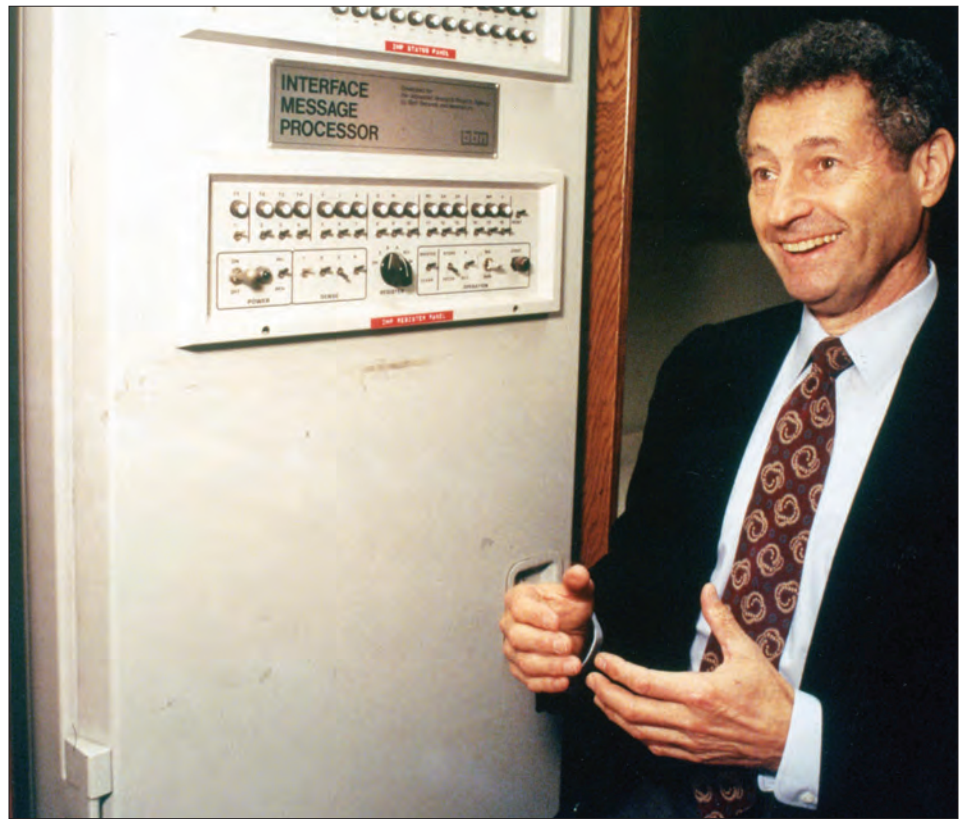


Figure 1: Leonard Kleinrock in front of the first IMP.
Image courtesy of Leonard Kleinrock. Retrieved from <http://en.wikipedia.org/wiki/File:Leonard-Kleinrock-and-IMP1.png> (accessed 3 October 2012)

Circuit Switching

Circuit switching is a method that establishes a connection between two computers via a continuous wire circuit. The system protocol provides for constant transfer of data that is protected from competing users (7). However, this technique is inefficient because it requires peak bandwidth at all times, meaning that high levels of computational power would be required to allow the information to flow at a continuously maximized rate. This issue was discovered in 1965 when Roberts connected two computers, the TX-2 at MIT and the Q-32 at Santa Monica, via a circuit switching system.

Packet Switching

Packet switching was proposed by Leonard Kleinrock in 1961, at the time a graduate student at MIT. This method serves as an alternative data transfer method to circuit switching. It groups all

transmitted data, regardless of type, into blocks of information called packets (6). Each packet includes an address that is used to route itself to the correct location within a computer network. The main problem with packet switching is that packets are sent individually. As a result, they are sometimes delivered out of order. The major benefit of this technique, as opposed to circuit switching, is that it makes maximal use of available bandwidth for all communication and is thus highly efficient. Multiple users can simultaneously send information over the same network, keeping the rate of exchange high at all times.

ARPANET

By 1969, host-to-host communication was established via ARPANET with the connection of computers at Stanford and UCLA (2). Rather than communicating directly, mainframe computers used smaller computers called Interface Message

Processors (IMPs) to handle all the network activities. Thus, the mainframe computers were only in charge of the initialization of programs and retrieval of data files. For the first connection, the Network Work Group (NWG) developed the Network Control Protocol (NCP), which described the procedure for sending and interpreting messages between computers. Later, the more efficient Transmission Control Protocol (TCP) replaced the NCP. The advantage of the TCP was that it featured the additional requirement of a verification of file transfer, which decreased errors associated with packet loss and failure to reach the intended destination.

Internet

As Cold War tensions grew, fear of a nuclear attack led to concerns about the breakdown of communication networks. The original design of domestic communication networks relied on a central node that was potentially vulnerable to attack. As such, the development of decentralized network architecture became a primary objective of the U.S. government. While radio waves had been used to send messages in the past, scientists realized that these waves would not survive disruptions in the air space caused by a nuclear explosion. At first, radio frequency waves of longer wavelength, known as long waves, were seen as the solution to this problem. They are not as easily distorted by environmental inconsistencies. However, their short range rendered them ineffective. Rather, the solution was a distributed network utilizing several computers called nodes. When information was sent over the network, it passed through a series of nodes before arriving at its final destination. Thus, this system provided multiple paths of communication that could withstand the destruction of some of the nodes. It was



Image courtesy of Coolcaesar. Retrieved from http://en.wikipedia.org/wiki/File:First_Web_Server.jpg (accessed 3 October 2012)

Figure 2: The first web server of the World Wide Web.

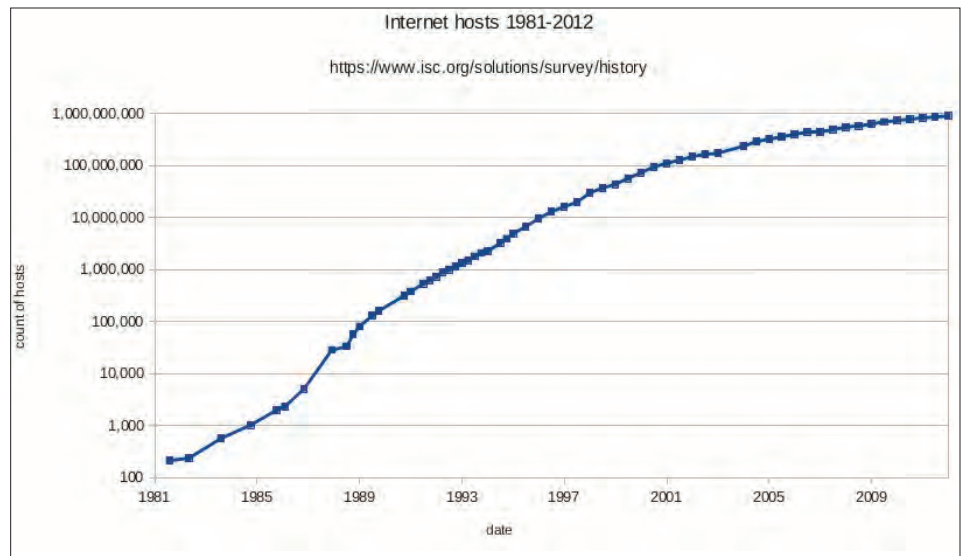


Image courtesy of Ke4roh. Retrieved from http://en.wikipedia.org/wiki/File:Internet_host_count_1988-2012_log_scale.png (accessed 3 October 2012)

Figure 3: Graph of Internet hosts from 8/1/1981 to 1/1/2012.

during this time that the term “Internet” came into use, as communication occurred between multiple networks rather than from just one machine to another.

The setup of this web was such that, during communications, the computers between the sender and the receiver would not interfere with the message, but simply serve as transfer nodes. The procedure, on a basic level, would allow a message to pass through all machines by making use of a layered channel. Nevertheless, as different networks arose, so too did discrepancies in protocol. As such, the International Organization for Standardization (ISO) designed the Open System Interconnection (OSI) model, which attempted to standardize networks and divide channels into separate layers. As more computers became connected, the TCP assimilated the preferences of the OSI model to produce the superior TCP-IP model, a standard that guaranteed compatibility between networks. In 1990, the last of the ARPANET hardware was removed, and the Internet was up and running.

How It All Works

As a simplified model, the Internet can be said to behave like a electrical wire with various conducting attachments. Connected to this main wire are more than a million special computers (servers) that communicate directly with each other (collectively called a network). Every server has a unique Internet Protocol (IP) address. Like a postal address, an IP address provides a means for packets of data to arrive at the correct destination. Because actual IP addresses are difficult

to remember, they are instead given user-friendly names like www.amazon.com, www.facebook.com, or www.wikipedia.org, called Uniform Resource Locators (URLs). The computers that ordinary users connect with are called clients because they are connected indirectly to the Internet through an Internet Service Provider (ISP). A client accesses webpages by communicating through its ISP to a server, which, after receiving a request, sends the file information back to the computer; webpages are simply files on a server’s hard drive.

In reality, everything connected to the Internet has an IP address: computers, servers, and all the equipment in between, such as routers. Routers are devices that direct packets around the Internet, helping them to reach their final destination. Each packet is wrapped in several layers, the first of which consists of the IP address of the computer. As a router passes a packet from client to server, it adds its own IP address to the packet. When the server sends information back, the layers of IP addresses are unwrapped until the information returns to your computer.

While the Internet has existed for a couple decades, many of its most influential applications have only recently been discovered. Online commerce, social media, and education have shown that the Internet has uses for businesses, individuals, and government.

Amazon

Founded in 1994, Amazon began as an online bookstore based out of the garage of founder Jeff Bezos (1). With the venture



Retrieved from <http://en.wikipedia.org/wiki/File:Original-facebook.jpg> (accessed 3 October 2012)

Figure 3: The original Facebook website. Facebook was launched less than a decade ago, in 2004.

capital of investors Nick Hanauer and Tom Alburg, Amazon entered the mainstream Internet. Amazon survived the burst of the dot-com-bubble of the 1990s, but it was not until Bezos added the option to write book reviews on the website that Amazon became the Internet titan it is today. By 1997, Amazon had generated more than \$15 million in revenue and was open for public consumption. The website then commenced the movement toward its current business model when it expanded its merchandize to include the sale of CDs and movies. By 1998, electronics, video games, toys, and many other products had been added to the online store. This trend has continued to date, with millions of items ranging from clothes and beauty products to house supplies and electronics now available for purchase on Amazon. In 1999, Time Magazine named Bezos "Person of the Year," recognizing the company's extraordinary success. Today, Amazon stands as the largest online store in the world and is credited with popularizing online shopping as we know it (1).

Facebook

Facebook established a new medium for online social interactions. The company was founded in 2004 by Mark Zuckerberg and a few of his friends as undergraduates at Harvard (5). Originating as a means for cataloguing Harvard students through

their pictures, Facebook's popularity and potential for expansion to other colleges were made quickly apparent. Later that year, the website was opened to the rest of the Ivy League and gradually to all universities across North America. Over the next eight years, Facebook would become a sensation, revolutionizing online social activity with more than 800 million active users (5).

Wikipedia

Wikipedia was originally created in 2001 to complement NuPedia, an earlier project by Jimmy Wales to produce an online, free-content encyclopedia that was edited only by experts (3). Wales's goal was that Wikipedia could supplement academic articles without the rigorous quality requirements known to delay academic publications. While this idea was initially met with some resistance, its popularity was quickly recognized. By 2003, the number of English Wikipedia articles surpassed 100,000. Today, as the world's sixth most popular website, Wikipedia features over 23 million articles in 284 languages and is estimated to receive more than 10 billion page views every month (3).

Conclusion

While the technical details surrounding the implementation of the Internet are complex, the overarching concepts are

simple and elegant. Knowledge of these ideas grants us the ability to understand not only how the Internet came to be, but also the possibilities it holds for our future. As computing power improves, there is no doubt that the Internet will continue to play a fundamental role in business, daily life, and society.

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