Telecommunications History

"Plus ça change, plus c'est la même chose."

For most of civilization, communication was largely borne by transportation. Messages were carried like parcels employing available means of conveyance. The modern term "telecommunications" was intended to describe a different type of communication system that operated over long distances. And while the term may be modern, some technologies fitting this definition can be traced back to antiquity. For example, the ancient Greeks employed beacons using fire or smoke signals. Beacon fires were erected on hilltops or tall structures. The signals could be seen from long distances. Aeschylus mentions their use the epic poem *Agamemnon* recounting the fall of Troy [1]. The Romans likewise developed similar systems [2].

Our interest here focuses on modern telecommunications technologies and especially those that have influenced the development of the Internet. For this reason, we can restrict the discussion mostly to the development of electrical telegraph and telephone technologies.

Modern Telegraph Communications

Although we tend to associate the invention of the telegraph with American Samuel F. B. Morse, its development was more international with many different inventors and devices [3].

The earliest inventions were mechanical telegraph or semaphore systems. They employed signals based on flags, shutters, or other objects that could be manipulated to represent letters or codes for messages. An observer at a distant station would view the signal through a telescope and relay it to the next station. Thus, telegraph technology is based on a **store-and-forward switching system**. Messages are transmitted and captured before being repeated to another location in the network. (This idea later returns as the basis for communications over the Internet.)

In France, Claude Chappe developed a widely-adopted system. In 1793, he established a telegraph system between Paris and Lille—covering 120 miles. Towers were stationed every five to ten miles. Each station had 96 T-shaped signals that could be configured in different orientations mechanically. Chappe called his invention "*telegraphe*" for long-distance writing. Competing optical systems were built in other countries, but his was the most popular.

While semaphore systems had the advantage of faster transmission compared to conventional message delivery, there were obvious disadvantages. Maintaining the numerous stations required considerable manpower. The systems were useless at night and in poor weather conditions. For several years, there were attempts to solve these and other problems by developing a telegraph system based on transmitting and receiving electrical signals. But, most of these early inventions proved impractical, because they were suitable for only short distances.

The first practical electrical telegraph systems were created almost simultaneously in Great Britain and the U.S. In the U.S., Samuel Morse began work on his system in 1832. With the help of Leonard Gale and Alfred Vail, he constructed a system that was patented in 1838. The earliest version consisted of a key, relay and register. The operator would depress the key to complete a circuit and send an electrical signal over the relay wire. At

the receiving end, the signal would generate a printed symbol. Later a sounder replaced the register; it made audible clicks that could be interpreted faster by the receiving operator. Alfred Vail (most likely) is responsible for what we now call *Morse code* [4]. The code consists of a sequence of short and longer signals signifying dots and dashes. These are used to represent letters, numbers, and other symbols. An interesting feature of the code is that the shortest sequences are assigned to the characters that occur most often in English messages. Characters that are used less often have longer coded sequences. This was determined by examining the frequency of symbols in a printer's typesetting kit. The idea of frequency coding is exploited for data compression in digital communications later.

Electrical telegraphs offered distinct advantages over semaphore systems. Messages could be transmitted day or night and were much faster. The technology was also economical enough to support systems that traversed very long distances. For example, the first transcontinental connection in the U.S. was completed in 1861—eight years before the completion of a transcontinental rail line. However, some of the same problems persisted. It was based on store-and-forward switching too. Thus, it required human operators to both send and receive messages. The operators must be capable of interpreting the code properly to prevent errors in retransmission. Likewise, the skill of the operator largely determined the speed and efficiency of the system. (Later mechanical devices were used to record and print messages.) Telegraph systems offered only one-way or **simplex** communications. In other words, the technology did not accommodate simultaneous two-way communication; connected stations could only alternate sending and receiving.

The first commercial (electrical) telegraph facilities were developed in Great Britain in the 1840s. A decade later, telegraph technology was well developed in the United States. Unlike Great Britain and Europe, however, the burgeoning telecommunications industry was privately owned and operated. In Europe, telecommunications were managed and controlled by national governments—much like the U.S. postal system. This historical singularity of private ownership of telecommunications technology ultimately led to its unique legal status among other industries—that of a federally regulated and often protected monopoly of a public utility. This precedent affected not only the telegraph industry, but also its successor the telephone industry and to a lesser extent, broadcast radio and television industries.

Telephone Communications Systems

In 1875, the inventor Alexander Graham Bell had begun work on the "harmonic" telegraph. The objective was to improve the efficiency of the telegraph by sending multiple signals at the same time on the same transmission line (called ***multiplexing***). The harmonic telegraph attempted to do this by multiplexing signals at different frequencies. Inadvertently, he discovered that his device could send a voice signal over the electrical circuit [5]. In 1876, Bell patented his invention, the "talking telegraph." Like the electrical telegraph, the basic technology of the telephone is straightforward. A handset is composed of a speaker and microphone. The user speaks into the microphone and the sound waves are converted to electrical signals that are transmitted over a medium—for example, copper wiring. The incoming signal is converted back into sound waves through the small speaker in the handset.

What makes the telephone technology useful and much more complicated is how the signals are routed or switched [6]. A telephone user can connect and converse with any other subscriber in the network. But, subscribers are not joined directly by point-to-points

connections. (See Figure 1a.) This would be both impractical and extremely expensive. For example, a network of 100 subscribers having direct or point-to-point connections would require 4,950 two-way connections. Instead, switching makes this possible. This means that subscribers are connected to a network whose channels are shared.

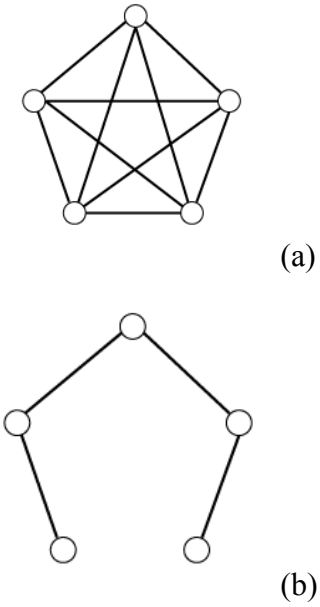

Figure 1: Point-to-Point connections vs. a shared or switched network. In a five-node network, (a) point-to-point connectivity would require 10 two-way or duplex channels. On the other hand, (b) a shared or switched network of five nodes could have full connectivity with as little as four duplex channels.

In a telephone network, the switches are employed to create a virtual circuit between two subscribers or endpoints. The circuit provides simultaneous, continuous two-way communication until the circuit is disconnected. During the time that the two endpoints are connected, the switch capacity is dedicated to that connection; no other calls can be handled by that switch. When the connection is terminated, the switch capacity is freed to handle other calls. This style of switching is dubbed **circuit-switching** because virtual circuits are established and disconnected throughout the network. (See Figure 2.)

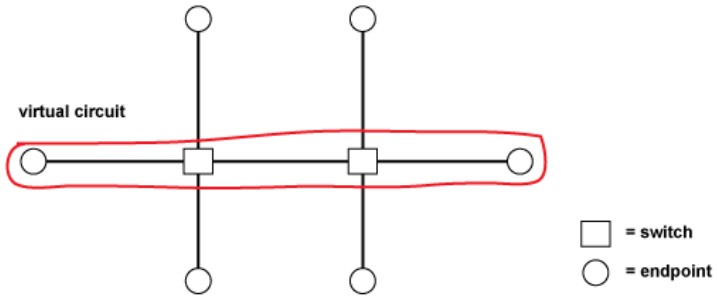

Figure 2: A simple circuit-switching network. In a four-node network with two switches, two nodes are connected by way of a virtual circuit.

Originally, switching was handled manually by telephone operators. In the 1890s, automatic switching devices were introduced. This meant faster switching and greater economy. Today, switching is handled by stored program or computerized switches that improve performance and offer additional services.

Telephone technology offers some distinct advantages over its rival telegraph technology. As mentioned, telegraph signals are simplex transmissions. On the other hand, telephone circuits afford two-way or duplex signals. Unlike telegraphs, telephone conversations afforded greater immediacy and privacy. Moreover, because labor costs were cheaper, telephone services became very competitive. Even though electrical telegraph technology ushered in the modern era of telecommunications, telephone technology eventually replaced it as the dominant form of communication.

Regulating Telecommunications

As mentioned, unlike in other countries, telecommunications companies in the U.S. are privately held. Subsequently, throughout its history, the telecommunications industry has come under legislative scrutiny for anticompetitive practices. In general, state and federal agencies have employed a variety of regulations and remedies against anticompetitive business practices.

Regulations are laws that prescribe responsibilities or requirements for service carriers. Remedies are typically court-ordered actions that seek to prevent or reduce the means for unfair competition. Regulations generally fit one of several different categories: **common carriage** requirements, **interconnection** requirements, and **scarcity management** [7]. Remedies include **definitional distinctions**, **structural separation**, and the **regulation of rates** [8]. Definitional distinctions provide the basis for arbitrarily dividing the market into segments. The goal is to increase competition by assigning specific market segments exclusively to particular companies. In structural separation, a dominant company is divided into separate units. For example, an identifiable portion of the company's business might be assigned to a separate and newly independent subsidiary company. This would permit the parent company to divest these interests and compete in new markets. The history of telecommunications is marked by a number of instances when these regulations and remedies are applied. We will focus on some of the more significant actions by federal agencies.

In the beginning, the telegraph industry had many competing carriers that served common geographical areas. Ultimately, though, this intense competition resulted in low profit margins. As a result, Western Union could control the market by either buying or forcing competitors out of business. Congress passed the *Telegraph Act of 1866* to respond to Western Union's business strategy.

Although the legislation was intended to foster more effective commercial competition, its impact proved quite the opposite. For a short period, Western Union achieved a virtual monopoly control over the industry that extended even to newswire services through its ownership of the Associated Press. However, a newer technology—the invention of the telephone—would pose an even greater challenge to its market supremacy.

Shortly after acquiring a patent for his invention, Bell offered to sell the rights to Western Union. After Western Union refused, he formed the Bell Telephone Company in 1877. This marked the origin of an eventual monopoly that would last for nearly a century in the U.S.

Though primitive initially, telephone service improved and became very popular among consumers. As mentioned earlier, telephone service was less expensive than telegraph and offered additional advantages to the consumer. Eventually, Western Union was forced to admit its mistake in not purchasing the patent. To compete against the new

telecommunications service, Western Union created the American Speaking Telephone Company. They employed technology from other inventors, but Bell sued subsequently for patent infringement.

In a landmark decision, the Court upheld Bell's complaints, but applied the first definitional distinctions for the industry. Western Union was ordered to sell its telephone interests and pledge to stay out of the "voice" industry. But, the Court likewise ordered Bell to divest its telegraph facilities and refrain from competing in the "record carriage" services. This decision introduced the longstanding distinction in U.S. law between voice and data services. (This would ultimately be extended to voice, data, and video services.)

Through consolidation and competition, the American Bell Company grew to dominate the voice industry. In 1909, it acquired control of Western Union in a stock purchase. As a result, the new American Telephone & Telegraph became the dominant player in both telecommunications technologies.

After decades of monopoly pricing and discriminatory business practices, Congress sought to rein in telecommunications companies through the *Mann-Elkins Act of 1910*. The law classified both telegraph and telephone companies as "common carriers." The term was borrowed from the transportation industry. Taxis and freight trucks, for example, were common carriers in the sense that they were forbidden by law to discriminate against consumers seeking their services.

The Act established AT&T as a federally regulated and protected monopoly. As a common carrier, AT&T had to offer services to any customer willing to pay for their services. In addition, the Interstate Commerce Commission was assigned the authority to set prices for these services. In return for these restrictions, AT&T enjoyed a special protected status as a private company. Like common carriers in transportation, it would not be liable for the content carried over its network.

A few years later, the federal government was forced once again to deal with further anti-competitive business practices. Besides its long-distance monopoly, Bell was attempting to dominate the local phone service market as well. At the time, there were many different phone companies that provided local phone connections to their customers. AT&T prevented these carriers from using their long-distance lines. The Justice Department and AT&T entered into what is known as the "*Kingsbury Commitment*" in 1913. Named after its Vice President, Nathan C. Kingsbury, AT&T pledged in the agreement to permit local providers access to its long-distance service. The company also agreed to sell some of its interests in Western Union as a structural separation.

Initially, the Kingsbury agreement fostered a sharp increase in the number of independent telephone companies. But, in the final analysis, the agreement did little to prevent AT&T from achieving a virtual monopoly over local services. Bell achieved control of the industry through its campaign for "universal service" while continuing to isolate competitors by refusing them access to its local service.

The goal of universal service was the stratagem of AT&T President Theodore Vail. The company promoted the idea that nationwide telephone service at an affordable price was not only its goal but also in the best interests of the nation. Universal service, on the other hand, was not likely in a market place filled with numerous, unassociated and competing telephone companies. Naturally, only AT&T had the wherewithal to achieve this goal. Under the shadow of World War I, the argument was not lost on the federal government.

Thus, despite common carriage and interconnection requirements, AT&T achieved monopoly control over telecommunication services early in the 20th century. The U.S. government not only tolerated but also actively supported it. A common nationwide telecommunications system was officially publicized in our national interest. In exchange for its unique market position, AT&T agreed to federally regulated pricing and some public interest responsibilities.

It is one of those historical ironies that the unique position of AT&T as a protected monopoly helped to contribute inadvertently to the creation of digital communications and the Internet. As we will document shortly, in the 1960s the U.S. Air Force offered AT&T the contract to develop an experimental digital communications network that eventually became the model for Internet communications. AT&T flatly turned down the offer. Senior executive Jack Osterman summed up the company's views, "First, it can't possibly work, and if it did, damned if we are going to allow the creation of a competitor to ourselves" [9]. As a monopoly, AT&T had the luxury to maintain such a stand. But, as a protected monopoly, AT&T was subject to federal regulations. And, as part of its public interest responsibilities, later in the 1970s, AT&T was required to allow others to lease its lines as a common carrier without discrimination. Thus, its telephone network served as the original infrastructure for what would evolve into the Internet. If AT&T had agreed to develop the experimental network, digital communications would likely be very different today. Furthermore, if common carriage regulations had not been extended, the Internet would not be the same either. Consequently, the special circumstances of its status as a protected (and regulated) monopoly provided the impetus for the creation of the next great rival technology and its ultimate demise. This did not happen overnight however.

This favored status began to erode in the latter part of the century. The first successful challenge to its domination came from a company called "Hush-a-Phone."

Originally, the AT&T telephone monopoly was strong enough to control vertical markets. Specifically, it had exclusive control over the devices connected to its telephone lines. Handsets, for example, were owned by the company and leased to its customers. Purchasing and connecting third-party handsets was strictly prohibited.

The Hush-a-Phone company marketed a specially designed rubber cup device that fit the mouthpiece of the telephone. It was intended to make conversations more private. AT&T persuaded the Federal Communications Commission (FCC) to block the sale of these devices. But, the Court of Appeals for the District of Columbia reversed the decision in its landmark decision of 1956. The Court ruled that the Hush-a-Phone device did not violate the Communications Act of 1936 because it did not impede the operation of the telephone network nor obstruct consumer use.

A decade later, the Carterphone posed a stronger challenge to AT&T supremacy. The Carterphone employed an acoustic coupler attached to the telephone that connected to a 2-way radio. This made it possible to carry on remote conversations over the telephone network. Thus, someone employing a mobile CB radio could signal a base station operator to make a call to a telephone subscriber. Once connected, the base station operator would put the handset in Carterphone coupler cradle and the radio transmitter would be connected to telephone signal. When done, the base station operator would remove the handset and close the telephone connection. Again, AT&T sought to prevent the sale and use of this device. In 1968, the FCC ruled that it was permissible because it did not harm the network or its users.

Figure 3: The Carterphone

Eventually, this precedent led the way for the introduction of an assortment of telephone products such as answering machines, fax machines, modems, and consumer-owned handsets. Thus, the Hush-a-Phone and Carterphone decisions represented the first instances of weakening AT&T's dominance in telecommunications. A decade later, Microwave Communications Inc. (MCI) challenged its long-distance supremacy, which, in hindsight, marks the beginning of the end for the AT&T monopoly.

Besides subscriber services, AT&T also provided special leased private line services. These were separated lines forming a point-to-point network that typically connected the offices of a large corporation. After World War II, microwave technology was adapted for commercial uses. In 1959, the FCC opened microwave frequencies for the development of private networks [10]. Some large companies used the opportunity to construct their own private microwave networks rather than leasing lines from AT&T.

Although the FCC had expected only private development, MCI requested a license to construct a shared private network from Chicago to St. Louis. Their goal was to create an alternative for businesses to AT&T's service in the region. After several years of pleading their case, the FCC granted the license in 1969. Immediately other companies followed suit by requesting similar licenses. In 1971, the FCC determined that these companies—called **specialized common carriers** or **SCCs**—posed no serious harm to AT&T because they offered new data services that were not in competition with it.

Shortly after this decision, the FCC established the "*Open Skies*" policy, which allowed other companies to compete as SCCs using new satellite technology [11].

An emboldened MCI attempted to push the envelope further by offering a "metered" private line service that was a thinly disguised version of consumer long-distance service. The FCC rejected their application, but the decision was reversed in the appellate court in 1977. During the same period, MCI sued AT&T in the antitrust courts. In 1980, the jury concurred with MCI's complaint and levied substantial fines on AT&T.

The *coup de grace*, however, came from the Justice Department. Based on MCI's complaint, the Justice Department initiated its own investigation of AT&T anticompetitive behavior. A federal antitrust suit was also filed in 1974. After years of battling with the courts, AT&T agreed to settle out of court in 1981.

The agreement was called the *Modification of the Final Judgment* (*MFJ*) [12]. It prescribed the ultimate breakup of AT&T. It could retain control of Western Electric, Bell Labs, and its long-distance network. Local services were divested and seven independent

regional companies (the "Baby Bells") were formed to take over the local service networks. Long-distance service was open to competition from MCI and other companies.

While the MFJ dissolved AT&T's monopoly, it had the effect of establishing seven new regional monopolies. Local customers had access to local services only through their regional provider. Furthermore, although the local customer was free to choose a long-distance provider, the connection to this service required the use of a local line and switch. Thus, the regional providers could charge long-distance carriers for this connection.

This monopoly for local services was a brief one. Several states regulating local services decided to permit competition. The *Telecommunications Act of 1996* ended the monopoly nationwide. It mandated open competition in all areas of the telephone industry: consumer equipment, local and long-distance services, data services, etc. It seemed that the era of the dominance of the Bell System had ended once and for all. But, as we shall see later, the aftermath of the Telecommunication Act has had other results as well.

The history of telecommunications in the U.S. offers a marked contrast with that in other countries. Because telecommunications technologies have been privately held yet always tending towards natural monopoly, the industry has experienced an assortment of attempts to regulate this volatile combination. The result has been a persistent ebb and flow that is punctuated only by challenges from new technologies that it absorbs.

Next, we will turn our attention to the main act: the evolution of the Internet.

Notes

[1] R. W. Burns, *Communications: An International History of the Formative Years*. London: IEE, 2004. p.9

[2] Ibid.

[3] Christopher H. Sterling, "Telegraph," *Encyclopedia of International Media Communications*. Volume 4. NY: Elsevier Science, 2003, p. 355.

[4] Ibid., p. 357.

[5] Tom Standage, *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-line Pioneers*. NY: Walker and Company, 1998, p. 197.

[6] Phyllis Brent, "Telephone," *Encyclopedia of International Media Communications*. Volume 4. NY: Elsevier Science, 2003, p. 367.

[7] Timothy Wu, "A Brief History of American Telecommunications Regulation," *Oxford International Encyclopedia of Legal History*. NY: Oxford University Press, 2009.

[8] Sharon K. Black. "Competition and Regulation—A Continuing Telecommunications Cycle" in *Telecommunications: Law in the Internet Age*. San Francisco, CA: Morgan Kaufmann, 2002, p. 13.

[9] Judy O'Neill, "An Interview with Paul Baran," *Charles Babbage Institute Center for the History of Information Processing*. Minneapolis, MN: University of Minnesota, 1990, p. 20.

[10] Kevin G. Wilson. *Deregulating Telecommunications in the U.S. and Canadian Telecommunications, 1840-1997*. Rowman & Littlefield Publishers (2000), pp. 122-24.

[11] Ibid., pp. 130-37.

[12] Warren G. Lavey and Dennis W. Carlton. "Economic Goals and Remedies of the AT&T Modified Final Judgment," *The Georgetown Law Journal*, Vol. 71, (1982), 1497–1518