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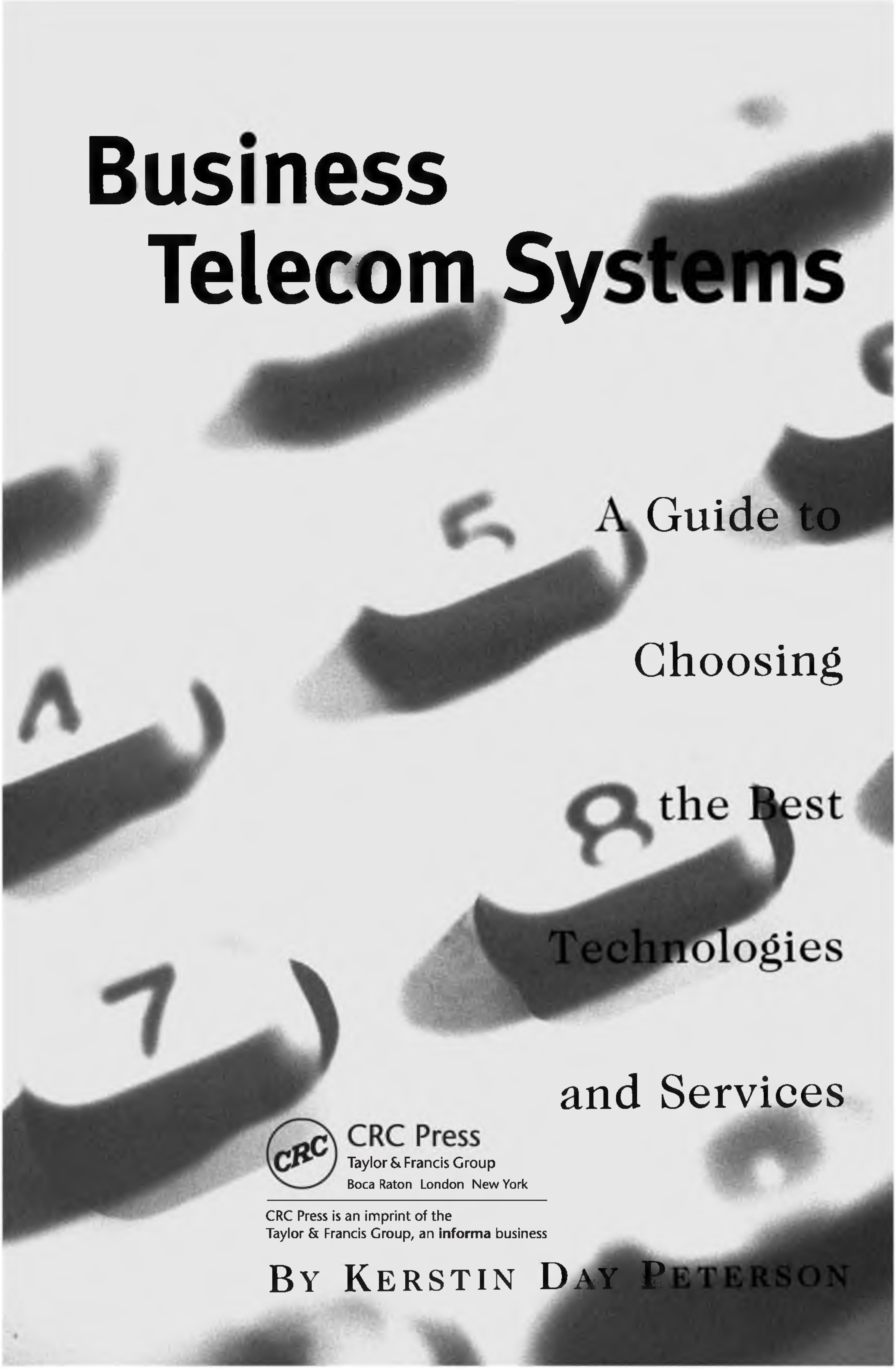
Business Telecom Systems

A Guide to Choosing the Best Technologies and Services

BY KERSTIN DAY PETERSON



Business Telecom Systems

A Guide to Choosing the Best Technologies and Services

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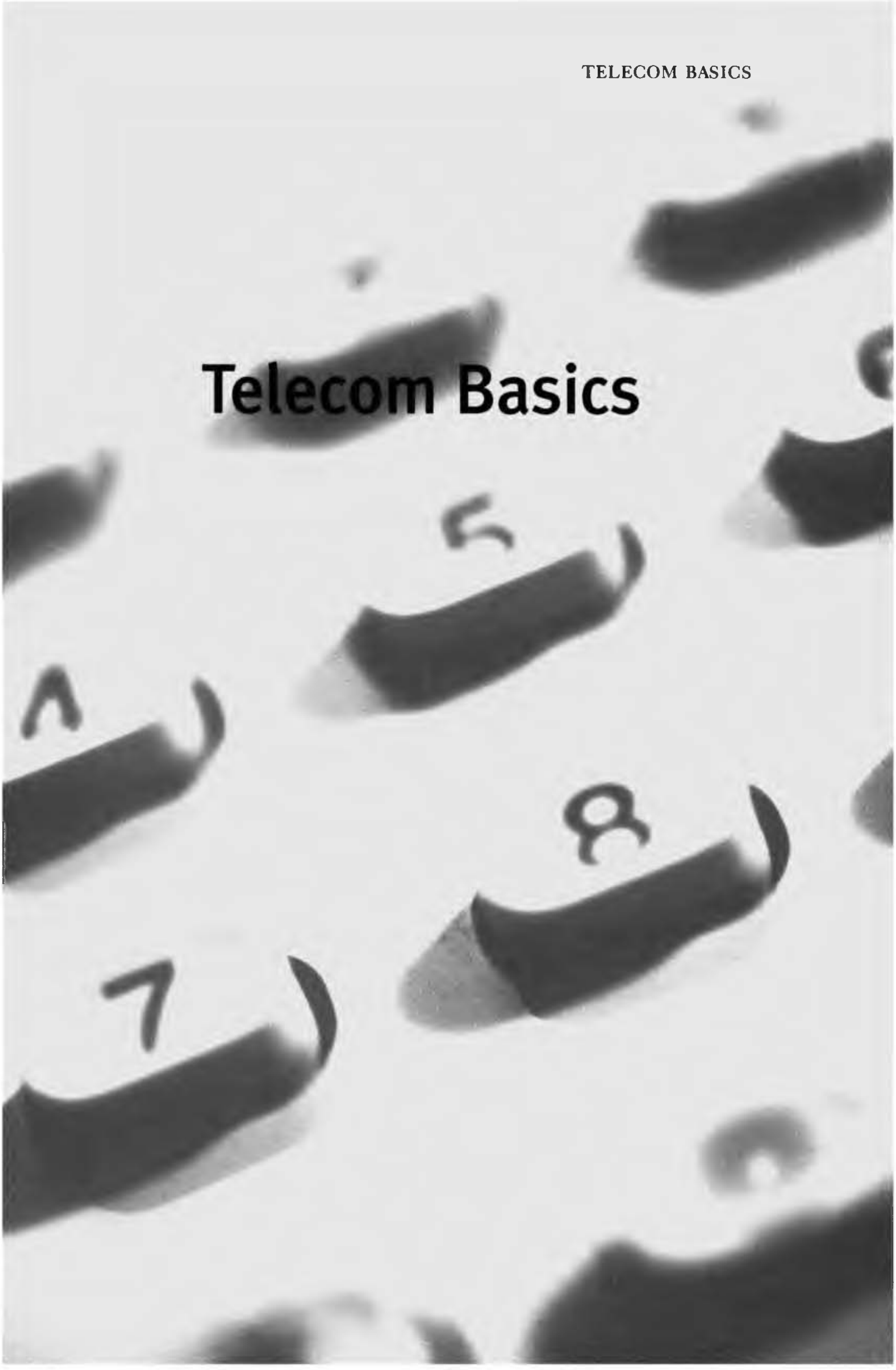
Telecom Basics



Introduction

The telecommunications infrastructure that exists in a handful of high-income countries includes 71% of the world's phone lines and supports only 15% of the world's population. The least and lesser-developed countries of the world, with more than 77% of world population, have only 5% of the world's phone lines. More than half of the world's nearly six billion people have never even used a phone.

Telecommunications equipment giant Lucent Technologies Inc. predicts the global market for communications systems and services will grow 14.5% annually to $650 billion by 2001.

It's impossible to predict what the telecom market will look like in three to five years. The technological and regulatory changes underway are unprecedented. One thing you can count on is that the technology will continuously improve and that technology and services will spring up, and quickly.

Bringing phone service into a business is basically twofold. There's the provisioning, the outside part (how you connect to everyone else in the world you want to communicate with) and there's the equipment you use to make the connections.

There are exceptions to this, like Centrex service (for more see that chapter), but basically, you need a way to communicate inside your enterprise and from your enterprise to the outside world, equipment-wise, and a way to connect to the outside world, service-wise.

This book tries to make some sense of the industry to those not familiar to it, in a no-nonsense way so that it is easier for you to buy and equip your office telecommunications.

There is an additional section about a combination technology, Computer Telephony that impacts making and taking call in ways you should know about, even if your office is very small.

Computer telephony is an end-to-end digital technology that not only can let you make regular voice calls, it also lets you make and receive Internet, video, fax and e-mail calls, too. Computer telephony is also the technology behind phone-system related products like voice mail, auto attendant and ACD, or Automatic Call Distribution, a technology that's used when there are groups of people answering or making a lot of the same kind of calls.

The type and number of trunks or lines you use to bring in and take out your phone calls (or data) has something to do with the kind of equipment you need to handle the calls. More lines or digital lines mean bigger or fancier (or even just different), equipment and usually more money, on a per-station basis.

There are lots of ways you can answer and make basic voice phone calls. From technologically basic to complicated, they are:

POTS (Plain Old Telephone Service)

It's probably what you have at home; a one-line phone with a regular old number from the phone company. One-person offices can get away with a single line set and an answering machine or a voicemail box from the phone company. A fancier phone, with a hold button, perhaps, or more features from the phone company (see Centrex) would be top-of-the-line cheapest.

SOHO (Small Office, Home Office)

If you need more than one but not more than four regular outside lines, the next-cheapest way to get phone service is by using phones that can share lines. SOHO is a general term that refers to a one-person or very small business. If you work out of your home or have a tiny office that probably won't grow, you can get away very cheaply with SOHO, and still have a lot of the features that bigger systems offer.

Systems that are called SOHO can be KSUless phones or small key systems. The term doesn't usually differentiate between these types of systems, but the difference is pretty important in terms of how the equipment works and how it is wired together.

KSUless

KSUless systems are phones that are smart enough by themselves to form a system.T here's no central computer (KSU, Key Service Unit) or processing unit. KSUless systems can give your tiny enterprise some really useful features for $100 to $150 per phone. You can buy them at office supply stores. And they're easy to install, because the phones can usually be plugged right into your existing jacks.

The biggest disadvantage to SOHO KSUless systems is their lack of expandability. Understand that the money spent on fancy phones will be forfeit when your company grows to over three or so people. KSUless systems can normally handle only up to four numbers.

Phone-only systems are also usually lacking in more sophisticated telephony tricks like voice mail, paging and music on hold.

Key Systems

There's a big difference between SOHO Ksuless systems and small key systems, both in the way they work and in the way they're installed. Key systems have a dedicated computer-controlled system unit, or KSU (Key System Unit). They are connected differently than KSUless systems, in that a wire has to be installed from the KSU to each phone, directly. Key systems sold for the SOHO market usually range from two lines to six lines and four phones to eight or twelve phones.

Private Branch Exchange (PBX)

The difference between a key system and a PBX (Private Branch Exchange) is basically one of size. Although, until recently, key systems were called key systems because they had significantly lesser capabilities than PBXs, small systems are now sporting abilities that used to be reserved for bigger companies and bigger bank accounts.

The smallest two or three or four or six line key system is often feature-short compared to PBXs designed for corporate use, but size is not a hard and fast rule. If you're expecting to grow and expand madly, or want fancy lines from the telephone company, or want to get fax, email and voice messages on your computer screen, you can buy a bigger-capacity system and only a few expansion cards for lines and phones and you'll have a small, feature rich (abeit more expensive) system.

In addition to centralized processing (done by the KSU), key systems and PBXs let you use different types of phone lines that might make running your business easier. They have voicemail that's included, or there are voicemail systems that you can buy that will integrate easily with the key or PBX system. (See the voicemail chapter for more about voicemail-phone system integration.)

Key systems and all PBXs distribute calls over the incoming and outgoing lines so that you can have fewer lines than people and can hook up phones with as few as one pair of wires. They have a brain in the form of a central process unit. And the bigger the brain, the bigger the system and the more features it'll have. PBXs are the biggest and smartest of phone systems.

Communications Servers

Comms servers switch phone calls like key systems and PBXs, using Computer Telephony (CT) technologies to integrate computer and telephone functions. They're usually a PC with voice cards running on the Windows NT operating system.

At this writing, comms servers can handle up to about 400 phones. Comms servers are limited in the number of ports they support, although the upper limit is being pushed very hard.

Provisioning

For the first time ever, you have a reliable alternative for local telephone service. What's more, you can now (or soon will be able too) obtain local, long distance, and Internet service from a single phone company. Best of all, both of these are or will be available at lower prices, bundled with better customer service.

Provisioning is the other side of the telecommunications function. Your CPE (Customer Premise Equipment) hands off any traffic (calls) leaving your building to the phone company, or local exchange carrier (LEC).

The LECs carry traffic within the local area and hand calls (with competition, these calls could be either local, local/long distance or long distance) off to an inter-exchange carrier (IXC). At the other end of a local/long distance or long distance call the IXC hands the call to the LEC to deliver it to the distant customer's premises.

The Local Loop is generally what connects your system to the nearest Central Office. It includes the copper cable, fiber optics, pole lines, conduits, terminals, and other facilities that deliver signals from the central office to your premises and vice versa.

Local switching equipment is the switching matrix at the Central Office (CO) of your LEC that connects lines and trunks together to establish a communications session. This is the phone company's phone system.

Local trunking is the network of circuits running between local central offices and between local and long distance switching systems or carriers.

Long distance systems are a combination of switching systems and circuits that haul telephone traffic between local exchange areas.

Provisioning is probably the most difficult part of buying and installing a phone system. The Telecommunications Act of 1996 de-regulated local service so that there are new companies offering local service and long distance carriers are local vendors now, too. There are also a lot of new products, most of them digital. Eventually, the competition will be better for consumers, but there will be a lot of confusion in the meantime.

The History of Telephones and Telecommunications

Telephone comes from the Greek word tele, meaning from afar, and phone, meaning voice. A telephone is a device that conveys sound over a distance.

On March 10, 1876, in Boston, Massachusetts, Alexander Graham Bell invented the telephone. Thomas Watson fashioned the device itself; a crude thing made of a wooden stand, a funnel, a cup of acid, and some copper wire.

The courts awarded Bell one of the most valuable patents in American history, a patent that made him rich and enabled one of America's largest corporations.

Bell succeeded because he understood acoustics, the study of sound, and something about electricity. Other inventors knew electricity well but little of acoustics.

The Beginnings of Telephony

A real telephone could not be invented until the electrical age began, and even then it didn't seem desirable. The electrical principles needed to build a telephone were known in 1831 but it wasn't until 1854 that Bourseul proposed transmitting speech electrically. And it wasn't until 22 years later in 1876 that the idea became a reality.

In 1729 the English chemist Stephen Gray transmitted electricity over a wire, sending charges almost 300 feet over brass wire and moistened thread. An electrostatic generator powered his experiments, one charge at a time.

In 1746 Dutchman Pieter van Musschenbroek and German Ewald Georg von Kleist independently developed the Leyden jar, a battery or condenser for storing static electricity. Named for the city of its invention in Holland, the jar was a glass bottle lined inside and out with tin or lead. The glass between the metal sheets stored a strong electrical charge that could kept for a few days and transported.
In 1800 Alessandro Volta developed the first battery. Volta's battery provided sustained low power electrical current. Chemically based, the battery improved quickly and became an electrical source for other experimenting.

Batteries got more reliable, but they still couldn't produce the power needed to work machinery, light cities, or provide heat. And although batteries would work telegraph and telephone systems, and still do, transmitting speech required understanding two related concepts, electricity and magnetism.

In 1821 Michael Faraday got a weak current to flow over a wire revolving around a permanent magnet. In other words, a magnetic field caused or induced an electric current to flow in a nearby wire. This was the world's first electric generator. Mechanical energy could now be converted to electrical energy.

The simple act of moving a conductor caused current to move and turned mechanical energy into electrical energy. Move or rotate a wire fast enough and things could begin to happen. Faraday worked through different electrical problems in the next ten years, eventually publishing his results on induction in 1831.

In 1830 Professor Joseph Henry transmitted the first practical electrical signal, shortly after he'd invented the first efficient electromagnet. He also made unpublished conclusions about induction similar to Faraday's. Henry proved that electromagnetism could be used to communicate.

In his classroom, Henry demonstrated the forerunner of the telegraph. He wrapped an iron bar with several feet of wire and built an electromagnet. A pivot mounted steel bar sat next to the magnet, and a bell stood next to the bar.

From the electromagnet Henry strung a mile of wire around the inside of the classroom, completing the circuit by connecting the ends of the wires at a battery. The steel bar swung toward the magnet striking the bell at the same time. Breaking the connection released the bar, freeing it to strike the bell again.

Joseph Henry did not pursue electrical signaling research himself, but he helped someone who did: Samuel Finley Breese Morse. Joseph Henry and Morse built a telegraph relay or repeater that allowed long distance operation.

Samuel Morse invented the first practical telegraph in 1746, applied for its patent in 1838 and was granted the patent in 1848. Morse was captivated by electrical experiments although not an inventor by profession.

In 1832 he heard of Faraday's recently published work on inductance, and was given an electromagnet at the same time to ponder over.

Morse's system used a key to make or break the electrical circuit, a battery to produce power, a single line joining one telegraph station to another and an electromagnetic receiver or sounder that upon being turned on and off, produced a clicking noise. He completed the package by devising the Morse code system of dots and dashes.

The telegraph helped unite the country and eventually the world. Telegraphy replaced the Pony Express, clipper ships, private messengers and all communications any slower than instantaneous. Service was limited to Western Union offices or large firms but convenience was hardly a problem when communicating over long distances was now instant.

The success of telegraph made inventors' thoughts turn to transmitting speech over a wire.

In 1854 the Belgian-born French inventor and engineer Charles Bourseul wrote about transmitting speech electrically using a flexible disk that made and broke an electrical connection, reproducing sound.

The Inventors: Gray and Bell

In the early 1870s Elisha Gray, Alexander Graham Bell, and many others were working on a multiplexing telegraph that could send several messages over one wire simultaneously. Such an instrument would greatly increase traffic without the telegraph company having to install more lines. As it turned out, the desire to invent the multiplexing telegraph turned into the invention of something very different.

Elisha Gray was born in 1835 in Barnesville, Ohio. His first telegraph-related patent came in 1868. An expert electrician, he co-founded Gray and Barton, makers of telegraph equipment. The Western Union Telegraph Company (funded by the Vanderbilts and J.P. Morgan), bought a one-third interest in Gray and Barton in 1872. Gray and Barton was renamed the Western Electric

Manufacturing Company. Transmitting speech was an interesting goal but not a lifetime passion for Gray.

Alexander Graham Bell, conversely, became consumed with inventing the telephone. Born in 1847 in Edinburgh, Scotland, Graham was raised in a family involved with music and the spoken word. His mother painted and played music. His father originated a system called visible speech that helped the deaf to speak. His grandfather was a lecturer and speech teacher. His entire education and upbringing revolved around the mechanics of speech and sound.

In 1870 Bell's father moved his family to Canada after loosing two sons to tuberculosis, hoping the Canadian climate would be safer. In 1873 Alexander Bell became a vocal physiology professor at Boston College and taught the deaf the visual speech system. In his spare time he worked on what was called a harmonic or musical telegraph.

Bell, familiar with acoustics, thought that he could send several telegraph messages at once by varying their musical pitch. The harmonic telegraph proved simple to visualize but almost impossible to build. Bell labored over the harmonic telegraph into the spring of 1874 when, at a friend's suggestion, he started working on a teaching aid for the deaf, a disgusting device called the phonoautograph. It was made out of a dead man's ear.

Speaking into the device caused the ear's membrane to vibrate and then move a lever. The lever wrote a wavy pattern representing the speech on smoked glass.

Bell fixated on how a thin membrane like the human ear's could make a much heavier lever work. He thought he could make a membrane work in telephony by using it to vary an electric current in intensity with speech. The current could then replicate the speech using another membrane. It took him another two years to figure out how to apply the principle.

Reaching for the Phone

Bell continued harmonic telegraph work through the fall of 1874. He wasn't showing a lot of progress but his tinkering got some attention. Gardiner Greene Hubbard, a prominent Boston lawyer and the president of the Clarke School for The Deaf, became interested in Bell's experiments. He and George Sanders, a wealthy Salem businessman, both gambled that Bell would get his harmonic telegraph to work. The three men signed a formal agreement in February, 1875 that gave Bell financial backing in return for equal shares from any patents Bell developed.

Bell's experimenting picked up quickly with the help of a talented machinist named Thomas A. Watson. Bell feverishly pursued the harmonic telegraph his backers wanted and at the same time, the telephone, now his real interest.

On March 1, 1875, Bell met with Joseph Henry, the great scientist and inventor, then Secretary of the Smithsonian Institution. (Henry, remember, pioneered electromagnetism and helped Morse with the telegraph.) Uninterested in Bell's telegraph work, Henry urged Bell to drop all other work and get on with developing the telephone. Bell took his advice.

On June 2, 1875, Bell and Watson were testing the harmonic telegraph when Bell heard a sound come through the receiver. Instead of transmitting a pulse, which he couldn't get it to do, anyway, the telegraph transmitted the sound of Watson plucking one of many differently-tuned springs.

Their telegraph, like all others, turned current on and off. But this time, a contact screw was set too tightly and allowed the current to run continuously, the essential element needed to transmit speech.

Bell figured out what happened and the next day had Watson build a telephone based on continuous current. The Gallows telephone, so called for its distinctive frame, substituted a diaphragm for the spring.

It didn't work. No speech could be transmitted, only a few sounds. Discouraged, tired, and running low on funds, Bell's experimenting slowed through 1875.

During the winter of 1875 and 1876 Bell continued experimenting while writing a telephone patent application. Although he hadn't developed a successful telephone, he felt he could describe how it could be done. With his ideas and methods protected he would focus on making a working model.

Fortunately for Bell, the Patent Office had dropped its requirement that a working model accompany a patent application in 1870. On February 14, 1876, Bell's attorney filed his patent application, only hours before Elisha Gray filed his Notice of Invention for a telephone.

Mystery still surrounds Bell's application and what happened that day. Most peculiar is that the key point to Bell's application, the principle of variable resistance, was scrawled in a margin, looking like an afterthought.

It's been contended, but never proven (despite some 600 lawsuits that would eventually challenge the patent), that Bell was told of Gray's Notice and allowed to change his application.

Telephonic Success

Finally, on March 10, 1876, one week after his patent was allowed, Bell succeeded in transmitting speech. Again, by coincidence or conspiracy, Bell used an idea he hadn't outlined in his patent or even tried before, the liquid transmitter. The liquid transmitter concept was outlined in Gray's Notice, however.

The Watson-built telephone looked odd and acted strangely. Bellowing into the funnel caused a small disk or diaphragm at the bottom to move. This disk was, in turn, attached to a wire floating in acid in a metal cup. Two wires attached to the cup connected it to the distant receiver. As the wire moved up and down in the acid it changed the resistance in the liquid. The varying current was then sent to the distant receiver.

The central claim of Bell's patent was that undulating current was the best method to transmit sound, as opposed to the on-off current commonly used in telegraphy. The undulatory current preserved the gradual changes in intensity produced by speech or musical tones. This is what is called analog signaling.

The Coming of Telephones to America

Early telephones were voice powered. No battery or line current charged the instrument. Later, a transmitter worked by itself, producing a weak current when spoken into. Good transmission only happened if the users were shouting and when distances measured in hundreds of yards. Bell and Watson managed a long distance call on October 9, 1876, a distance of only two miles.

Promoting and developing the telephone proved far harder than Hubbard, Sanders, or Bell expected. Despite Bell's patent, broadly covering the entire subject of transmitting speech electrically, many companies sprang up to sell telephones and telephone service.

Other people filed applications for telephones and transmitters after Bell's patent was issued. Most claimed Bell's patent couldn't produce a working telephone or that they had a prior claim. Litigation loomed. Fearing financial ruin, late in 1876 Hubbard and Sanders offered their telephone patent to Western Union for $100,000. Western Union refused.

On April 27, 1877 Thomas Edison filed a patent application for an improved transmitter, a device that made the telephone practical. A major accomplishment, Edison's patent claim was declared in interference to a Notice of Invention for a transmitter filed just two weeks before by Emile Berliner. This conflict was not resolved until 1886. Edison produced the transmitter while the matter was disputed, starting late in 1877.

Bell used an improved transmitter invented by Francis Blake. On July 9, 1877 Sanders, Hubbard, and Bell formed the first Bell telephone company. Each assigned their rights under four basic patents to Hubbard's trusteeship.

Against tough criticism, Hubbard decided to lease telephones and license franchises, instead of selling them. This had enormous consequences. Instead of making money quickly, dollars would flow in over months, years, and decades. It proved a wise enough decision to sustain the Bell System for over a hundred years.

The Earliest Local Competition

In September, 1877 Western Union changed its mind about telephony. They saw it would work and they wanted in, especially after a subsidiary of theirs, the Gold and Stock Telegraphy Company, ripped out their telegraphs and started using Bell telephones.

Rather than buying patent rights or licenses from the Bell, Western Union bought patents from others and started their own telephone company. They were not alone. At least 1,730 telephone companies organized and operated in the 17 years Bell was supposed to have a monopoly. These earliest local competitors either disagreed with Bell's right to the patent, ignored it altogether, or started their own phone company because Bell would not provide service to their area.

Western Union began entering agreements with Gray, Edison, and Amos E. Dolbear for their telephone inventions. In December, 1877 Western Union created the American Speaking Telephone Company. A tremendous selling point for their telephones was Edison's improved transmitter.

Bell Telephone was worried about competing with Western Union, since there were only 3,000 Bell phones installed by the end of 1877. Western Union, on the other hand, had 250,000 miles of telegraph wire strung over 100,000 miles of route. If not stopped, Western Union would have an enormous head start on making telephone service available across the country.

Western Union was realistically the world's largest telecom company then, with an unchallenged monopoly on telegraph service, however, Bell's shrewd Boston lawyers filed suit against them.

Switchboards are Vogue

On January 28 1878 the first commercial switchboard began operating in New Haven, Connecticut. It served 21 telephones on eight lines; many people were on a few party lines. On February 17 Western Union opened the first large city exchange in San Francisco. Phones were no longer wired point-to-point; subscribers could talk to others on different lines. The public switched telephone network was born.

Also in 1878 the Butterstamp telephone came into use. This telephone combined the receiver and transmitter into one handheld unit. You talked into one end, turned the instrument around to listen to the other end. People got confused with this clumsy arrangement, and consequently, a telephone with a second transmitter and receiver unit was developed in the same year. You could use either one to talk or listen and you didn't have to turn the phone around. This wall set used a crank to signal the operator.

These early phones were still voice powered as was the original telephone, that is, no battery or external power helped speech get to the other party or a switchboard. On August 1, 1878 Thomas Watson filed for a ringer patent that was very like Henry's old classroom doorbell.

A hammer operated by an electromagnet struck two bells. Turning a crank on the calling telephone spun a magneto, producing a ringing current. Before this invention, subscribers used a crude thumper to signal the called party, hoping someone would be around to hear it. The ringer was immediately successful.

Subscribers grew steadily but slowly. Sanders had invested $110,000 by early 1878 without any return. He located a group of New Englanders willing to invest but unwilling to do business outside their area. Badly needing the funding, the Bell Telephone Company reorganized in June, 1878 (10,755 Bell phones were in service), and formed a new Bell Telephone Company, the forerunner of the strong regional Bell companies to come..

In early 1879 the company reorganized once again, under pressure from patent suits and from competition from other companies selling phones with Edison's superior transmitter. William H. Forbes was elected to head the board of directors and restructured it to embrace all Bell interests into a single company, the National Bell Company, which was incorporated on March 13, 1879.

On November 10, 1879 Bell won its patent infringement suit against Western Union in the United States Supreme Court. In the resulting settlement, Western Union gave up its telephone patents and the 56,000 phones it managed, in return for 20% of Bell rentals for the 17 year life of Bell's patents. It retained the telegraph business.

This decision allowed National Bell to enlarge. A new incarnation, the American Bell Company, was created on February 20, 1880, capitalized with over $7 million dollars. Bell now managed 133,000 telephones.

Chief Operating Officer Theodore Vail began building the Bell System, regional companies offering local service, plus a long distance company providing toll service and a manufacturing arm providing equipment.

The manufacturer was a previous company rival. In 1880 Vail started buying Western Electric stock and took controlling interest on November, 1881. The takeover was consummated on February 26, 1882, with Western Electric giving up its remaining patent rights as well as agreeing to produce products exclusively for American Bell.

On July 19, 1881 Bell was granted a patent for the metallic circuit, the concept of two wires connecting each telephone. Until that time a single iron wire connected telephone subscribers, just like a telegraph circuit. A conversation works over one wire since grounding each end provides a complete path for an electrical circuit.

Houses, factories and the telegraph system were all grounding their electrical circuits using the same earth the telephone company employed, introducing a huge amount of static. A metallic circuit, on the other hand, used two wires to complete the electrical circuit, avoiding the ground altogether and thus providing a better-sounding call.

It was not until 10 years later that Bell started converting grounded circuits to metallic ones. And it took another ten years to complete the project.

Long Distance is Born

In 1885 Vail formed his long distance telephone company, AT&T. Capitalized on only $100,000, American Telephone and

Telegraph provided long distance service for American Bell.

Only local telephone companies operating under Bell-granted licenses could connect to AT&T's long distance network. Vail thought this would continue the Bell System's virtual monopoly after its key patents expired in the 1890s, reasoning that the independents would not be able to compete since they would be isolated without long distance lines.

With only Bell-licensed companies providing local service, his Western Electric manufacturing equipment and AT&T long distance, Vail's structuring of the Bell System was now complete. His job done, in September 1887 Vail resigned from American Bell.

In 1889 the first public coin telephone came into use in Hartford, Connecticut. The first payphones were attended, with payment going to someone standing nearby.

In 1892 Bell controlled 240,000 telephones, but independents were coming on fast by using better technology. The first automatic dial system began operating that year in La Porte, Indiana. The central office switch worked in concert with a similar switch at the subscriber's home, operated by push buttons.

Central Office Switching

Patented in 1891 by Almon B. Strowger, the Step by Step or SXS system replaced the switchboard operator for placing local calls. People could dial the number themselves. This required different kinds of telephones and eventually models with dials. A.E. Keith, J. Erickson and C.J. Erickson later invented the rotating fingerwheel needed for a dial.

The first dial telephones began operating in Milwaukee's City Hall in 1896. Independents were quick to start using the new switch and phones. The Bell System however, did not embrace this switch or automation in general, indeed, a Bell franchise commonly removed step-by-step switches and dial telephones from territories it bought from independent telephone companies. Not until 1919 did the Bell System start using Strowger's automatic switching system.

The automatic dial system changed telephony forever. Almon Brown Strowger (pronounced STRO-jer) was born on 1839 in LaPorte, Indiana, the city in which he later installed the first commercial automatic exchange.

Strowger was an undertaker. His invention was developed because someone was stealing his business and he sought to do something about it. Telephone operators, perhaps in league with his competitors, were routing calls to other undertakers. These operators, supposedly, gave busy signals to customers calling Strowger or even disconnected their calls. Strowger thus invented a system to replace an operator from handling local calls.

Like Bell, Strowger filed his patent without having perfected a working invention, describing the switch in sufficient detail and with enough novel points for it to be granted Patent number 447,918, on March 10, 1891. Again like Bell, Almon Strowger lost interest in the device once he got it built. It fell upon his brother, Walter S. Strowger, and Joseph Harris, who helped promoted the switch and provided investment money.

Without Harris, soon to be the organizer and guiding force behind Automatic Electric, dial service might have taken decades longer for the Bell System to recognize and develop. Competition by A.E. forced the Bell System to play switching catchup, something they really only accomplished in the 1940s with the introduction of crossbar switching.

In 1893 the first central office exchange with a common battery for talking and signaling began operating in Lexington, Massachusetts.

This common battery arrangement provided electricity to all telephones controlled by the central office, where before a customer's telephone needed its own battery to provide power.

The common battery had many consequences, including changing the basic design of the telephone instrument. Big and bulky wall sets with their wet batteries providing power and cranks for signaling the operator could be replaced with sleek sets that fit on desks.

In 1899 American Bell Telephone Company reorganized yet once again. In a major change, American Bell Telephone Company conveyed all assets, with the exception of AT&T stock, to the New York state charted American Telephone and Telegraph Company. The rationale was that New York had less restrictive corporate laws than Massachusetts did.

In 1900 loading coils came into use. Patented by Professor Michael I. Pupin, loading coils helped improve long distance transmission. Spaced every three to six thousand feet, cable circuits were extended to three to four times their previous length.

Essentially a small electro-magnet, a loading coil or inductance coil strengthens the transmission line by decreasing attenuation, the normal loss of signal strength over distance. Wired into the transmission line, these electromagnetic loading coils keep signal strength up as easily as an electromagnet pulls a weight off the ground. But coils must be the right size and carefully spaced to avoid distortion and other transmission problems.

In 1901 the Automatic Electric Company was formed from Almon Strowger's original company. The only maker of dial telephone equipment at the time, Automatic Electric grew quickly.

The Bell System's Western Electric refused sell equipment to independents, so Automatic Electric makers like Kellog and Stromberg-Carlson found rapid acceptance. By 1903 independent telephones numbered 2,000,000, of which Bell managed 1,278,000.

Big, Bad Bell

Bell's reputation for high prices and poor service worsened with increased competition. When bankers got hold of the Bell System, it faltered.

In 1907 Theodore Vail returned to the AT&T as president, pressured by J.P. Morgan himself, who had financial control of the Bell System. Morgan was a true robber baron and thought he could turn the Bell System into America's only telephone company. He bought independents by the dozen, adding them to Bell's existing regional telephone companies. AT&T management finally organized the regional holding companies in 1911, a structure that held up over the next seventy years.

Morgan also worked on buying all of Western Union, acquiring 30% of its stock in 1909 then installing Vail as its president. Vail thought telephone service was a natural monopoly, much as gas or electric service, but he also knew times were changing and that the present system couldn't continue.

In January 1913 the Justice Department informed the Bell System that the company was close to violating the Sherman Antitrust Act. Things were going badly with the government, especially since the Interstate Commerce Commission had been looking into AT&T acquisitions since 1910.

J.P. Morgan died in March 1913; Vail lost a good ally and the strongest Bell system monopoly advocate. In a radical but visionary move, Vail cut his losses with a bold plan. On December 19, 1913, AT&T agreed to rid itself of Western Union stock, buy no more independent telephone companies without government approval and to connect to the independents with AT&T long distance lines.

Rather than let the government remake the Bell System, Vail did the job himself. Since the independents paid a fee for each long distance call placed on the Bell network, and because the threat of governmental control had eased, the Bell System grew to be a de facto monopoly within the areas it controlled, accomplishing by craft what force could not do.

To this day, 1,435 independent telephone companies still exist, often serving rural areas the Bell System ignored (and still ignores).

Long Distance, Thanks to the Electron Tube

In 1906 Lee de Forest invented the electron tube. Its amplifying properties led the way to national phone service. Long distance service was still limited. Loading coils helped to a point but no further. Transcontinental phone traffic wasn't possible, consequently, a national network was beyond reach.

In 1907 Theodore Vail instructed AT&T's research staff to build an electronic amplifier based on their own findings and De Forest's pioneering work. They made some progress but not as much as de Forest did on his own. AT&T eventually bought his patent rights to use the tube as a telephone amplifier. Only after this and a year of inspecting De Forest's equipment did the Bell Telephone Laboratory make the triode, an amplifying electron tube, work for telephony.

The triode in particular and vacuum tubes in general would make possible radiotelephony, microwave transmission, radar, television, and hundreds of other technologies. Telephone repeaters could now span the country, enabling a nationwide telephone system, fulfilling Alexander Graham Bell's 1878 vision.

The vacuum tube repeater ushered in the electronics age. The device was a true amplifier, powered by an external source, capable of boosting strength as high as was needed.

As evidence of the triode's success, on January 25, 1915 the first transcontinental telephone line opened between New York City and San Francisco. The previous long distance limit was New York to Denver, and only then with some serious shouting.

Two metallic circuits made up the line; it used 2,500 tons of hard-drawn copper wire, 130,000 poles and countless loading coils. Three vacuum tube repeaters along the way boosted the signal. It was the world's longest telephone line. In a grand ceremony, 68 year old Alexander Graham Bell in New York City made the ceremonial first call to his old friend Thomas Watson in San Francisco.

In 1921 the Bell System introduced the first commercial panel switch. Developed over eight years, it was AT&T's response to the step by step switch. It offered many innovations and many problems. Although customers could dial out themselves, the number of parts and its operating method made it noisy for callers. The switch used selectors to connect calls, these mechanical arms moving up and down in large banks of contacts.

In 1934 a New Deal measure enacted the Federal Communications Commission. The FCC began investigating AT&T and every other telephone company, issuing a 'Proposed Report' after four years

The commissioner denounced AT&T for unjustifiable prices on basic phone service and urged the government to regulate prices the Bell System paid Western Electric for equipment, even suggesting that AT&T should let other companies bid for Western Electric work.

At that time AT&T controlled 83% of United States telephones, 91% of telephone plant and 98% of long distance lines. The outbreak of World War II, two and a half months after the final report was issued in 1939, staved off closer government scrutiny.

In 1936 coaxial cable was installed between New York City and Philadelphia. In 1937 the first commercial messages were sent through it. Multiplexing developed, letting toll circuits carry several calls over one cable simultaneously.

By the mid 1950s, 79% of Bell's inter-city trunks were multiplexed. Multiplexed signals eventually moved into the local network, improving to the point where one circuit could carry 13,000 channels at once.

One major accomplishment was directly related to WWII. Fearing its radio and submarine cable communications to Alaska might be intercepted by the Japanese, the United States built the longest open wire communication line in the world began operating between Edmonton, Alberta and Fairbanks, Alaska. Built alongside the newly constructed Alcan Highway, the line was 1500 miles long, used 95,000 poles and featured 23 manned repeater stations.

In 1938 the Bell System introduced crossbar switching to the central office, an improvement on work done by a Swedish engineer, Gotthilf Ansgarius Betulander.

Installed by the hundreds in medium to large cities, crossbar technology advanced in development and popularity until 1978, when over 28 million Bell system lines were connected to them. (Panel switching lines peaked in 1958 at 3,838,000 and step by step lines peaked in 1973 at 24,440,000.)

On June 30, 1948 the Bell System unveiled the transistor, revolutionizing every aspect of the telephone industry and all of communications.

Capitalizing on a flowing stream of electrons, along with the special characteristics of silicon and germanium, the transistor dependably amplified signals with little power with little heat. Equipment size was reduced and reliability increased.

In August, 1951 the first transcontinental microwave system began operating. One hundred and seven relay stations spaced about 30 miles apart formed a link from New York to San Francisco. It cost the Bell System $40,000,000.

In 1954 over 400 microwave stations were scattered across the country. By 1958 microwave carrier made up 13,000,000 miles of telephone circuits or one quarter of the United States' long distance lines.

Microwave wasn't possible over the ocean and radiotelephony was limited. Years of development lead up to 1956 when the first transatlantic telephone cable system started carrying calls. It cost $42 million. Two coaxial cables about 20 miles apart carried 36 two-way circuits. Nearly 50 sophisticated repeaters were spaced from 10 to forty miles along the way. Each vacuum tube repeater contained 5,000 parts and cost almost $100,000. The first day this system took 588 calls, 75% more than the previous 10 days average with AT&T's transatlantic radio-telephone service.

In the mid-50s Bell Labs launched the Essex research project. It concentrated on developing computer controlled switching, based upon using the transistor. It bore first fruit in November, 1963 with the 101 ESS, a PBX or office telephone switch that was partly digital.

In 1956 AT&T agreed under government pressure not to expand their business beyond telephones and transmitting information. Bell Laboratories and Western Electric would not enter the computer and business machines industries. In return, the Bell System was left intact with a reprieve from anti-monopoly scrutiny for a few years.

Recent History

The 1960s began a dizzying age of projects, improvements and introductions. In 1961 the Bell System started work on a classic cold war project, finally completed in 1965. It was the first coast to coast atomic bomb blast resistant cable. Intended to survive where the national microwave system might fail, the project buried 2500 reels of coaxial cable in a 4,000 mile long trench. 9300 circuits were helped along by 950 buried concrete repeater stations. Stretched along the 19-state route were 11 manned test centers, buried 50 feet below ground, complete with air filtration, living quarters and food and water.

In 1963, digital carrier techniques were introduced. Previous multiplexing schemes used analog transmission, carrying different channels separated by frequency. T-1 or Transmission One, by comparison, reduced analog voice traffic to a series of electrical plots, binary coordinates to represent sound. T-1 quickly became the backbone of long distance toll service and then the primary handler of local transmission between central offices.

In 1965 the first commercial communications satellite was launched, providing 240 two-way telephone circuits, and the 1A1 pay phone was introduced by Bell Labs and Western Electric after seven years of development. Replacing the standard three-slot pay phone design, the 1A1 single slot model was the first major change in coin phones since the 1920s.

1965 also marked the debut of the No. 1ESS, the Bell Systems first central office computerized switch. The product of at least 10 years of planning, 4,000 person-years of research and development, and $500 million, the first Electronic Switching System was installed in Succasunna, N.J.

Built by Western Electric, the 1ESS used 160,000 diodes, 55,000 transistors and 226,000 resistors, capacitor and other components. These were mounted on thousands of circuit boards. Not a true digital switch, the 1ESS did feature Stored Program Control, a fancy Bell System name for memory, enabling all sorts of new features like speed dialing and call forwarding. Without memory a switch could not perform these functions; previous switches such as crossbar and step by step worked in real time, with each step executed as it signaled.

In 1968 Carter Electronics Co. of Dallas, Texas challenged the telephone equipment monopoly in court. Carter provided a simple device called the Carterfone to connect mobile radio users to the telephone network. The device was nothing technically difficult; amateur radio operators had used home-made phone patches for years.

Southwestern Bell took Carterfone to court and lost. The Carterfone case was the first chink in the telephone companies' armor. The FCC established rules permitting connection to the local network. The Bell System argued that devices had to be manufactured to tight specifications to prevent harms to the network and its maintenance personnel. The damage possible was purportedly high voltage levels that could crosstalk into other circuits, and harmful voltages and currents that could damage equipment or shock technicians.

The solution that the FCC accepted was interconnection through a protective coupling arrangement (PCA). PCAs were provided by the phone company at a cost, and provided an interface to which customers could connect their equipment. Customers were inconvenienced, but were not restricted to Bell System-owned devices.

This was the birth of the interconnect industry.

Later, the PCA requirement was eliminated and in its place a registration process supervised by the FCC was instituted. Only registered devices were (and still are) permitted to be connected to the network. This provision includes devices manufactured and owned by the ILECs.

At the end of the 1960s AT&T began experiencing severe customer service problems, especially in New York City having to do with unforeseen demand coupled with reduced maintenance. The Bell System fixed the problems, but not without an attitude that embittered people by the millions.

Bell was not alone in dealing with dissatisfied customers. GTE also had problems. GTE and Automatic Electric went through tremendous growth in the 1960s. Automatic Electric expanded to four different facilities and cut over their first computerized switch in Saint Petersburg, Florida in September 1972. It was called the No. 1 EAX (Electronic Automatic Exchange).

In 1969 Microwave Communications International (MCI) began transmitting business calls over their own private network between Saint Louis and Chicago. By bypassing Bell System lines MCI offered cheaper prices.

AT&T strenuously opposed this specialized common carrier service, protesting that Bell System's long distance rates were higher since they subsidized local phone service around the country. Still, MCI was a minor threat, economically. The real problem started a few years later when MCI tried to connect to the Bell System network.

MCI's customers, like Carter's, began asking to connect to the local networks in both cities. MCI accommodated them with a service they called Execunet. The MCI switch was connected between its microwave network and local telephone company trunks. Users could dial into the MCI switch, identify themselves with a PIN number, dial the destination telephone number, and MCI completed the call through the telephone company's networks.

Again, AT&T objected, arguing that MCI's service was in direct competition with its monopoly. Again, the courts ruled in favor of.

In 1975 the Department of Justice (DOJ) filed an anti-trust suit against the Bell System.

The 1975 anti-trust case was occasioned by numerous complaints from other companies about the AT&T monopoly. MCI and other carriers were vocal in claiming (accurately) that their connections were technically inferior to those AT&T provided to its long distance customers. The telephone companies' customers could dial 1 for long distance and be automatically identified, but other common carriers' customers had to dial a PIN number. Transmission was inherently better on the AT&T network, and callers automatically received AT&T long distance unless they dialed a local telephone number to bypass AT&T.

Competing manufacturers complained that the Bell markets were closed to all but the AT&T captive supplier, Western Electric. The Bell operating companies (BOCs), suppliers argued, automatically selected Western Electric equipment even though competitors' equipment might be technically superior.

The Department of Justice was asking to dismantle the Bell System.

AT&T argued that the structure of the Bell System operated in consumers' interests, and that regulation was an OK substitute for competition. They argued that the BOCs were required by law to subsidize local service rates through a complicated division of revenue procedure, and that competitive carriers were not saddled with this burden.

Experts argued that Bell Laboratories was a source of research and development that the nation could not possibly afford to lose. Others said out the nation's telephone network was the best in the world, and that dismantling it would not be in the public's interest. Other experts argued the other side: that technical progress was being impeded by the lack of competition, and that prices were kept artificially high since the Bell System had no incentive to economize.

In the midst of the arguments in the DOJ case, the surprise announcement came that AT&T had agreed to dismantle itself. The parent company would keep its long distance business and its manufacturing arm, Western Electric, and would be free to sell customer premises equipment.

The BOCs would be spun off into seven independent regions. They would be required to provide equal access to the local exchange to all long distance providers. They were prohibited from manufacturing equipment, and they were prohibited from offering service across artificial local boundaries known as LATAs. Finally, their procurement practices would be subject to open competition.

Bell Laboratories was divided into two segments. One was fundamental research and operations-oriented research on behalf of the BOCs. The other was product-oriented development for Western Electric. Accordingly, BOCs and Western Electric shared funding. The manufacturing-related portion of Bell Labs stayed with AT&T under divestiture, and the remainder was formed into Bell Communications Research (BellCore). The seven RBOCs jointly owned BellCore.

The Modified Final Judgement (MFJ) remained in force until the Telecommunications Act of 1996. The Act of 1996 modifies certain of the restrictions on the incumbent local exchange companies (ILECs) and imposes others. Over the next several years the nation's telecommunications network will be fractured and restructured. Instead of being driven by regulation, it will be driven by competition.

The Telecommunications Act of 1996, The Local Loop, and Competitive Local Exchange Carriers

The Telecom Act of 1996 was enacted by Congress in February, 1996 "to provide for a pro-competitive, de-regulatory national policy framework designed to accelerate rapidly private sector deployment of advanced tele-communications and information technologies and services to all Americans by opening all telecommunications markets to competition."

The Telecommunications Act of 1996 requires that ILECs (Incumbent Local Exchange Carriers), also called RBOCs (Regional Bell Operating Companies), open up their local telephone markets to competition.

The RBOCs are federally mandated to allow their competitors to interconnect with their local connections and wires by unbundling their networks and/or by reselling their network elements.

Any company can now offer services that require access to businesses and homes over local telephone connections. These new local service competitors are referred to as CLEC, Competitive Local Exchange Carriers. A CLEC offers its services to its customers by connecting the ILECs' "unbundled" network elements to its own switches and other systems.

Title I of the Act forces ILECs to open up their Central Office (CO) facilities to competitive service providers in exchange for entry into the lucrative long-distance and equipment manufacturing markets. As long as an ILEC is not offering CLECs access to existing facilities and networks, they aren't allowed to enter the long distance market.

Mutual Compensation, UNE (Unbundled Network Elements), Colocation and Resale

Broadly speaking, the Act gives CLECs three ways to compete with the ILECs: (1) network-to-network interconnection; (2) unbundled elements; and (3) resale.

<B>Mutual Compensation</B>
Network-to-network connections require payment from the company using the facilities to the company that owns the facilities. Most of the time the carriers pay each other because they're accessing each others' facilities or equipment every time a call is handed off.

The FCC calls these fees that interconnecting carriers pay to terminate traffic on each other's networks "mutual compensation."

The payments for mutual compensation are typically between two and four cents per minute as established by FCC rules. When the traffic is intra-state or local, the state commissions are charged with implementing and establishing mutual compensation payments. Long distance mutual compensation is handled by the FCC.

Unbundled Network Elements (UNE) and Colocation
The Telecom Act of 1996 makes sure that CLECs have access to rented floor space in the ILEC Central Offices (COs) and to any of the circuits terminated in that CO. Access to the floor space is known as colocation, and the access circuits are known as local loops. Local loops connect each residential or business subscriber in a given area to its CO.

A Section 251(c)(3) of the Act says that ILECs (Incumbent Local Exchange Carriers) must make "unbundled network elements" available to any competing telecommunications carrier for any communications service.

The Act defines an unbundled network element (UNE, pronounced "you-knee") as any "facility or equipment used in the provision of a telecommunications service," as well as "features, functions, and capabilities that are provided by means of such facility or equipment."

The FCC has identified a minimum list of seven UNEs that ILECs must offer, including such items as switches and inter-switch transport of telecommunications traffic. Practically, most CLECs want as little to do with ILECs as possible, so CLECs are most concerned about obtaining access to the portion of the ILEC network that it is most difficult and expensive to duplicate, the local loop.

The "local loop" (also known as the "last mile") connects the ILEC Central Office switches to their customers. The loop is one of the minimum UNEs identified by the FCC.

The Local Loop

The "local loop" or "last mile" refers to the last piece of (what's usually copper) wire that connects your building to the nearest Central Office (CO).

The Telecommunications Act of 1996, in part, deregulated the local loop. Now CLECs (Competitive Local Exchange Carriers) can use these wires with their equipment and sell new services like high-speed digital data.

The advantage the ILECs have over the new competition, at least for now, is that they own the copper cable loops to virtually every business and residence in the country. If CLECs want to reach residences and small businesses, they usually have to use, and pay for, ILEC loop facilities.

Copper local loops will probably not be replaced with fiber optic service any time soon. Converting to fiber optics at the residential and small business level is not yet worth the investment that is required: carriers estimate that that bringing fiber optic to the home will cost about $1,000 per residence.

Recently, the local loop has been used as is to push digital services. ISDN, xDSL, and Frame Relay services are being marketed by CLECs and ILECs both. These high-speed digital transmission schemes use the existing copper and can deliver video, telephone, Internet access, plus lower bandwidth services like alarm reporting and meter reading on the same old copper local loop.

See the Provisioning and Transport Services section of this book for more information about digital services.

Local subscriber loops are connected to the central office switching equipment using hardware called DLCs (Digital Loop Carriers). A DLC is T-1 carrier interface designed specifically for subscriber loops. DLCs connect to the subscriber lines in the central office, route the signals over a T-1 channel, and convert them back to a subscriber line signal at the remote end.

Colocation

Section 251(c)(6) of the Act says that the ILECs have to allow their competitors to "collocate" their equipment on Central Office premises, so that they can connect their facilities to the central offices' UNEs.

Using a colocation strategy, a CLEC will buy one or more switches and install fiber optic facilities connecting its switch(s) to one