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Telecommunication

1. Introduction

Computer and telephone networks inflict a gigantic impact on today’s

society. From letting you call John in Calgary to letting you make a withdraw

at your friendly ATM machine they control the flow of information. But today’s

complicated and expensive networks did not start out big and complicated but

rather as a wire and two terminals back in 1844. From these simple networks to

the communication giants of today we will look at the evolution of the network

and the basis on which it functions.

2. The Beginnings

2. 1. Dot Dot Dot Dash Dash Dash Dot Dot Dot

The network is defined as a system of lines or structures that cross.

In telecommunications this is a connection of peripherals together so that they

can exchange information. The first such exchange of information was on May 24,

1844 when Samuel Morse sent the famous message “ What hath God wrought” from the

US Capitol in Washington D. C. across a 37 mile wire to Baltimore using the

telegraph. The telegraph is basically an electromagnet connected to a battery

via a switch. When the switch is down the current flows from the battery

through the key, down the wire, and into the sounder at the other end of the

line. By itself the telegraph could express only two states, on or off. This

limitation was eliminated by the fact that it was the duration of the connection

that determined the dot and dash from each other being short and long

respectively. From these combinations of dots and dashes the Morse code was

formed. The code included all the letters of the English alphabet, all the

numbers and several punctuation marks. A variation to the telegraph was a

receiving module that Morse had invented. The module consisted of a

mechanically operated pencil and a roll of paper. When a message was received

the pencil would draw the corresponding dashes and dots on the paper to be

deciphered later. Many inventors including Alexander Bell and Thomas Edison

sought to revolutionize the telegraph. Edison devised a deciphering machine.

This machine when receiving Morse code would print letters corresponding to the

Morse code on a roll of paper hence eliminating the need for decoding the code.

2. 2. Mr. Watson, Come Here!

The first successful telephone was invented by Alexander Graham Bell.

He along with Elisha Gray fought against time to invent and patent the telephone.

They both patented their devices on the same day-February 14, 1876- but Bell

arrived a few hours ahead of gray thus getting the patent on the telephone. The

patent issued to Bell was number 174, 465, and is considered the most valuable

patent ever issued. Bell quickly tried to sell his invention to Western Union

but they declined and hired Elisha Gray and Thomas Edison to invent a better

telephone. A telephone battle began between Western Union and Bell. Soon after

Bell filed suit against Western Union and won since he had possessed the basic

rights and patents to the telephone. As a settlement Western Union handed over

it’s whole telephone network to Bell giving him a monopoly in the telephone

market. During his experiments to create a functional telephone Bell pursued

two separate designs for the telephone transmitter. The first used a membrane

attached to a metal rod. The metal rod was submerged in a cup of mild acid. As

the user spoke into the transmitter the membrane vibrated which in turn moved

the rod up and down in the acid. This motion of the rod in the acid caused

variations in the electrical resistance between the rod and the cup of acid.

One of the greatest drawbacks to this model was that the cup of acid would have

to be constantly refilled. The second of Bell’s prototypes was the induction

telephone transmitter. It used the principle of magnetic induction to change

sound into electricity. The membrane was attached to a metal rod which was

surrounded by a coil of wire. The movement of the rod in the coil produced a

weak electric current. An advantage was that theoretically it could also be

used both as a transmitter and a receiver. But since the current produced was

so weak, it was unsuccessful as a transmitter. Most modern day telephones still

use a variation of Bell’s design. The first practical transmitter was invented

by Thomas Edison while he was working for the Western Union. During his

experiments Edison noticed that certain carbon compounds change their electrical

resistance when subjected to varying pressure. So he sandwiched a carbon button

between a metal membrane and a metal support. The motion of the membrane

changed the pressure on the carbon button, varying the flow of electricity through the microphone. When the Bell Vs. Western Union lawsuit was settled the rights to this transmitter were also taken over by Bell.

2. 3. Please Wait, I'll Connect You.

The first network of telephones consisted of switchboards. When a customer wanted to place a call he would turn a crank on his telephone terminal at home. This would produce a current through the line. A light at the switchboard would light up. The caller would tell the operator where he wanted to call and she would connect him by means of inserting a plug into a jack corresponding to the desired phone. In earlier years he found that he could use the ground as the return part of the circuit, but this left the telephone very susceptible to interference from anything electrical. So in the mid 1880s Bell realized that he would have to change the telephone networks from one wire to two wire. In 1889 Almon Brown Strowger invented the telephone dial which

eliminated the use for telephone operators.

2. 4. The Free Press Reported That President Carter…….

French inventor Emile Baudot created the first efficient printing

telegraph. The printing telegraph was the first to use a typewriter like

keyboard and allowed eight users to use the same line. More importantly, his

machines did not use Morse code. Baudot’s five level code sent five pulses for

each character transmitted. The machines did the encoding and decoding,

eliminating the need for operators. After some improvements by Donald Murray

the rights to the machine were sold to Western Union and Western Electric. The

machine was named the teletypewriter and was also known by it’s nickname TTY. A

service called telex was offered by Western Union. It allowed subscribers to

exchange typed messages with one another.

3. From The Carterfone to the 14, 400

3. 1. I’ll Patch Her Up On The Carterfone, Captain.

The first practical computers used the means of punched cards as a

method of storing data. These punched cards held 80 characters each. They dated back to the mechanical vote-counting machine invented by Hermen Hollerith in 1890. But this type of computer was very hard and expensive to operate. They were very slow in computing speed and the punch cards could be very easily lost or destroyed. One of the first VDTs (Video Display Terminal) was the Lear-Siegler ADM-3A. It could display 24 lines of 80 characters each (a remarkable feat of technology). One of the regulations that AT passed was that no other company's equipment could be physically connected to any of it's lines or equipment. This meant that unless AT invented a peripheral it would not be legal to connected to the telephone jack. In 1966 a small Texas company called Carterfone invented a simple device that could go around these regulations. The Carterfone allowed for a company's radio to be connected to the telephone system.

The top portion of the Carterfone consisted of molded plastic. When a radio

user needed to use the telephone, the radio operator at the base station placed

the receiver in the Carterfone and dialed the number. This allowed the user to

call through the radio. AT&T challenged the integrity of the Carterfone on the

phone lines and lost the battle in court. In 1975 the FCC passed Part 68 rules.

They were specifications that, if met would allow third party companies to sell

and hook up their equipment to the telephone network. This turned the telephone

industry upside down and challenged AT&T’s monopoly in the telephone business.

3. 2. So Gentelmen A’ Will Be 65

With more and more electronic communication and the invention of VDTs

the shortcomings of the Baudot code were realized. So in 1966, several

telecommunications companies devised a replacement for the Baudot code. The

result was the American Standard Code for Information Interchange, or ASCII.

ASCII uses 7 bits of code, allowing it to represent 128 characters without a shift code. The code defined 96 printable characters (A through Z in upper- and lowercase, numbers from 0 to 9, and various punctuation marks) and several control characters such as carriage return, line feed, backspace etc. ASCII also included an error checking mechanism. An extra bit, called the parity bit, is added to each character. When in even parity mode, the bit would have a value of one if there was an even number of ones and zero if there was an odd number of ones. IBM invented it’s own code which used 8 bits of code giving 256 character possibilities. The code was called EBCDIC, for Extended Binary Coded Decimal Interchange Code and was not sequential. The Extended ASCII was designed so that PCs could again attain compatibility with the IBM machines. The other upper 128 characters of the EASCII code include pictures such as lines, hearts and scientific notation. In 1969 guidelines were set for the

construction of serial ports. The RS-232C standard was established to define a

way to move data over a communications link. The RS-232C is commonly used to

transmit ASCII code but can also transmit Baudot and EBCDIC data. The connector

normally uses a 25 pin D shell connector with a male plug on the DTE (Data

Terminal Equipment) and a female plug on the DCE (Data Communications Equipment).

3. 3. Hello Joshua, Would You Like To Play A Game…

In the 1950s a need arose to connect computer terminals across ordinary

telephone lines. This need was fulfilled by AT’s Bell 103 modem. A modem

(modulator/demodulator) is used to convert the on-off digital pulses of computer

data into on-off analog tones that can be transmitted over a normal telephone

circuit. The Bell 103 operated at a speed of 300 bits per second, which at that

time was more than ample for the slow printing terminals of the day. The Bell

103 used two pairs of tones to represent the on-off states of the RS-232C data

line. One pair for the modem that is calling and the other pair for the modem

answering the call. The calling modem sends data by switching between 1070 and

1270 hertz, and the answering modem by switching between 2025 and 2225 hertz.

The principle on which the Bell 103 operated is still in use today. During the

sixties and seventies the concept of mainframe networks arose. A mainframe

consisted of a very powerful computer to which thousands of terminals were

connected. The mainframe worked on a timesharing process. Timesharing was when

many users on terminals could use limited amounts of the host computer’s

resources, thus letting many parties access the host at the same time. This

type of network, however, was very expensive, and since on time sharing you

could only use small amounts of the host’s total computing power (CPU), the use

of the terminal was slow and sluggish. In the late seventies the personal

computer was introduced to the public. A personal computer consisted of a monitor, a keyboard, a CPU (Central Processing Unit), and various other connectors and memory chips. The good things about PCs were that they did not have to share their CPU and that the operating costs of these systems were much less that that of their predecessors. The computers could, with a software package, emulate terminals, and be connected to the mainframe network. Bell laboratories came up with the 212a unit which operated at the speed of 1200 bits per second. This unit, however, was very susceptible to noise interference.

3. 4. Hey Bell! I Can Hang Myself Up!

After the breakup of the AT&T empire that controlled the modem industry, many other companies started to create new designs of modems. Hayes Microcomputer Products, took the lead in the PC modem business. Hayes pioneered the use of microprocessor chips inside the modem itself. The Hayes Smartmodem,

introduced in 1981, used a Zilog Z-8 CPU chip to control the modem circuitry and

to provide automatic dialing and answering. The Hayes unit could take the phone

off the hook, wait for the dialtone, and dial a telephone number all by itself.

The Hayes Smartmodems sometimes had more powerful CPUs than the computers that

they were connected to. The next advancement was the invention of the 2400 bits

per second modem. The specifications came from the CCITT, an industry standard

setting organization composed of hundreds of companies world wide. The new

standard was designated as V. 22bis and is still in use today. Other CCITT

standards that followed were the V. 32 (9600 bps), the V. 32bis (14400 bps), the

V42 (error control), and the V42bis (data compression). Virtually all modems

today conform to these standards. The next big computer invention was the fax

modem. It uses the on-off data transmission just as a modem but for the purpose

of creating a black and white image. Each on-off signal represents a black or white area on the image. The image is sent as a set of zeros and ones and is then reconstructed on the receiving end.

4. LANs

4. 1. I Donnwanna File-Share!

Network Operating Systems (OS) are actually a group of programs that

give computers and peripherals the ability to accept requests for service across

a network and give other computers the ability to correctly use those services.

Servers share their hard disks, attached peripherals such as printers and optical drives, and communication devices. They inspect requests for proper authorization, check for conflicts and errors and then perform the requested service. There is a multitude of different types of servers. File servers are equipped with large hard drives that are used to share files and information, as

well as whole applications. The file-server software allows shared access to

specific segments of the data files under controlled conditions. Print servers

accept print jobs sent by anyone on the network. These servers are equipped

with spooling software (saving data to disk until the printer is ready to accept

it) that is vital in the situations where many requests can pour in at the same

time. Network Operating Systems package requests from the keyboard and from

applications in a succession of data envelopes for transmission across the

network. For example, Novell’s NetWare will package a directory request in an

IPX (Internetwork Packet Exchange) packet, and the LAN adapter will then package

the IPX request into an Ethernet frame. In each step information about data and

error control data is added to the packet.

4. 2. Eight Go In One Comes Out

The Network Interface Card or LAN adapter, is an interface between the

computer and the network cabling. Within the computer it is responsible for the

movement of data between the RAM (Random Access Memory) and the card itself.

Externally it is responsible for the control of the flow of data in and out of

the network cabling system. Since typically computers are faster than the

network, the LAN adapter must also function as a buffer between the two. It is

also responsible for the change of the form of data from a wide parallel stream

coming in eight bits at a time to a narrow stream moving one bit at a time in

and out of the network port. To handle these tasks the LAN adapters are

equipped with a microprocessor and 8-64K of RAM. Some of the cards include

sockets for ROM chips called Boot ROM. These chips allow computers without hard

drives to boot operating systems from the file server.

4. 3. Take Your Turn!

Ethernet and Token Ring network adapters use similar systems of

electrical signaling over the network cable. These signals are very similar to

the Baudot and Morse codes. A technique called Manchester encoding uses voltage

pulses ranging from -15v to +15v in order to transmit the zeros and ones. The

network cable has only one drawback, it can only carry signals from one network

card at a time. So each LAN architecture needs a media-access control (MAC)

scheme in order to make the network cards take turns transmitting into the cable.

Ethernet cards listen to the traffic on the cable and transmit only if there is

a break in the traffic when the channel is quiet. This technique is called

Carrier-Sense Multiple Access With Collision detection (CSMA/CD). With

collision detection, if two cards start transmitting at the same time, they see

the collision, stop, and resume some time later. Token Ring networks use a much

more complex process called token passing. Token Ring cards wait for permission

in order to transmit into the cable that forms an electrical loop. The cards

use their serial numbers in order to find the master interface card. This card

starts a message called a token. When a card with information to send receives

the token, it sends the data across the network. After the addressed interface

card receives the information and returns it to the originating card, the token

is given back to the master to be passed onto the next card. The ARCnet network

uses a very similar system to that of the Token Ring. Instead of using a token,

the master card keeps a table of all active cards and polls each one in turn,

giving permission to transmit.

4. 4. Tied In A Knot

Various types of cabling are used to connect the LAN adapters to the

servers. Unshielded twisted pair wires offer rather slow speed, are very

inexpensive, are small, and can only span very short distances. These cables

use the RJ-45 connector. Coaxial cable offers fast speed, is rather expensive,

has a medium sized diameter, and can span medium distances. Coaxial cable uses

BNC connectors. The shielded twisted pair cable offers fast speed, is more

expensive than the coaxial cable, has a large diameter, and can only span short

distances. These cables use the IBM data connector. The fiber optic cable is

the fastest possible type of data transfer, costs astronomical amounts of money,

has a tiny diameter, and can span very long distances. This cable uses the ST

fiber optic connector. Wiring hubs are used as central points for the cables

from the network interface cards.

5. 5. Loves Me, Loves Me Not, Server Based, Peer To Peer…

There are two general types of LANs. The Server-based networks rely on

one major server to store data, offer access to perhiperals, handle the printing

and accomplish all the work associated with network management. The Server-

based networks have a high start up cost, but offer high security as well as

ease of operation. These networks become more economical as more computers are

added to the network. In Peer to peer networks the network responsibilities are

divided among many computers. Some act as file servers, others as print servers,

some as CD-ROM servers, tape drive servers, etc. The Startup cost of these

networks is much cheaper, but when more computers are added to the network, some

of the servers may not be able to handle the extra activity.

5. Links Between LANs

5. 1. She Just Won’t Send Sysop!

Most networks have very short information transfer ranges. But, in an

ever shrinking world the need for links between LANs has never been higher.

This section will explain the components and information needed to link LANs.

When an electric current travels over a long length, it’s charge decreases, and

it is susceptible to electromagnetic interference. To combat the length problem

a component has been devised. A repeater is a little box that is inserted

between a cable. It’s primary function is to amplify the weakening pulse and

send it on it’s way. Bridges are used to analyze the station address of each

Ethernet packet and determine the destination of the message. The Routers strip

the outer Ethernet packets of a data packet in order to get the data. This data

is sent to other routers in other places of the world and then repackaged by

those routers. The removal of the excess data packets by the routers decreases

the time required to transfer that data. If networks use the same addressing

protocol, bridges can be used to link them, however, if they use different

addressing protocols, only routers may be used. During these times MANs

(Metropolitan Area Networks) are in use and development today. These use

routers that are connected preferably via a fiber optic cable, to create one

large network.

5. 2. Pluto Calling Earth!

Any networks larger than 1000m typically rely on telephone digital lines

for data transfer. These networks are called Circuit Switched Digital Networks .

Circuit Switched Digital Networks utilize a switching matrix at the central

office of a telephone company that connects local calls to long distance

services. The Telephone companies now offer dial up circuits with signaling

rates of 56, 64, and 384 kilobits per second as well as 1. 544 megabits per

second. Another type of LAN to LAN connections are packet switching networks.

These are services that a network router calls up on a digital line. They

consist of a group of packet switches that are connected via intraswitch trunks

(usually fiber optic) that relay addressed packets of information between them.

Once the packet reaches the destination packet switch, it sends it via another

digital connection to the receiving router.