Rise of Convergence Technology

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Wiring the world- Telecommunications and Data Networks for building a web of global communications

GROWTH OF TELECOMMUNICATIONS & DATA NETWORKS-AN OVERVIEW

- Personal computer of the 1980s replaced the typewriter, the accountant's ledger books, and the closely guarded secrets of the corporate mainframe.
- The real change came, however, a decade later (in 1990s), when the information contained in each isolated machine could be piped routinely into the wall (Internet) and transmitted anywhere.
- These networks represent many of the functions of the communication technologies, from telephone to mail services, that have begun to merge.
  - Users now have a single hand-held device that can relay phone calls, accept electronic mail, provide paging services, and - when s/he has lost the way - make a quick call to a satellite positioning service that will convey travel instructions.

Significance of Data Communications

- In its most basic form, a network is simply a set of connections that may be linked together by a variety of physical media, whether telephone lines, satellites, radio connections, optical fibers, or the coaxial cables used to transmit television programs.
- Data communications assume increasing importance given the possibilities offered by linking one computer to another. In a period of less than five years (since 1991), the Internet progressed from its academic and military uses to the global medium for connecting one computer to another.
- As the capacity of the Internet has expanded, this information conduit has begun to assume many of the functions formerly fulfilled by traditional media.
  - Today television networks, newspapers, and magazines supplement their standard offerings with World Wide Web pages.
  - In coming years, the Web may evolve into the main vehicle for their delivery of content.
  - For those interested, the Internet offers possibility of starting their own draws some of its attraction from interactivity: an ability to let people talk back immediately to a news paper or, if so inclined, to start their vanity newsletter or a Web page that shows their stamp collection to the world. And electronic mail holds the promise of reviving –in a somewhat supercharged fashion-the ancient art of letter writing. As much as they are a vehicle for entertainment, information, and communications, the Internet and online communications draw their allure from their potential as a direct sales outlet to consumers, hawking everything from stocks to socks.

- The transformation of the old-line media establishment progresses in lockstep with the emergence of compact and mobile computing technologies whose connection to the world may be a handheld telephone with a wireless radio link to a satellite that allows voice or data calls in either Los Angeles or Mogadishu. While achieving a global reach, the technology may literally begin to move closer to home. Over time, “smart homes” controlled by internal data networks, may automate a sprinkler system or be fitted with motion sensors that can turn on the lights and play a favorite CD when someone enters the room. The notion of exchanging data anywhere, at any time, may even extend to one’s person. Numerous schemes to fit one’s eyeglasses, clothing, or even undergarments, with networked computing devices have been put forward in both graduate student projects and even commercial products. Like the household robotic butler, some of these applications border on the fanciful. A BodyNet might sense sweat in an undergarment and then send a signal to turn up the air conditioner, though how big a market exists for wired underpants remains to be seen.

- That imagination sometimes outstrips pragmatism can also be seen in the push to build the “information superhighway,” a term that has become outdated as expectations for high-speed digital networks that transfer video and sophisticated graphics have arrived somewhat more slowly than expected. A wired world has also provoked international debate because of legal, social, and business dilemmas that may take years or perhaps decades to resolve. Academic and trade conferences abound in which social pundits ponder a host of questions: What does the notion of copyright and intellectual property mean when any digital object can be copied and relayed to millions who frequent the Internet? How does one charge for digital content that has been traditionally provided over the Net without charge? And what means exist to protect the privacy of an E-mail message or the security of a credit-card transaction, or to shield one’s children from a surfeit of Net-based pornography? What complicates these issues is that the prevailing ethos of the Internet culture borders the libertarian, and national laws are difficult to enforce on a truly global network.

- Still, the rise of computer networking has emerged as a watershed technological event as we crossed the millennial divide (the year 2000). From a technical perspective, the most momentous developments in communications center on the gradual transition from analog to digital communications-and the rise of broadband networks capable of relaying enormous numbers of thin bits. In this scenario, a stream of digital bits will intermingle transmissions of voice, video, and data, even to households and small business.

- For the moment (this is 1999 data), however, the vast majority of homes in the United States receive their phone calls as analog signals, in which the waveform of the electrical signal varies over time in the same way that a sound wave changes as it travels through the air. In an ordinary phone call, analog signals' variations in amplitude and frequency correspond to the loudness and tone of the human voice. When the signal reaches its destination, it makes the telephone's speaker vibrate, re-creating the spoken sounds. Most radio and television broadcasts also travel as continuous waves of analog information. To send or receive data from a computer over analog lines, the computer must be equipped with a modem-a modulator/demodulator-that converts a series of zeroes and ones to an analog signal or transforms it back into a stream of bits.

- This analog technology, with roots in the nineteenth century, is gradually being supplanted by digital communications systems in which the qualities of voice or picture image are represented as binary information-bits representing values of zero or one. Computers can manipulate those bits in order to move information from place to place or interpret the data to re-create an original sound or image. International communications are still a hybrid of digital and analog systems. Most traffic on the trunk lines between phone company switching offices travels as digital pulses. But the “last mile” connection to your home is still likely to be an analog transmission.

- Going digital has considerable benefits for the entire spectrum of communications. Analog signals suffer more easily from corruption that results from interference with other signals-and digital integrated circuits used to process the signals are cheaper their analog counterparts. Digital communications are also clearer than analog because of the error detection and correction capacities of the software and hardware. Another, important feature of a digital network is the ability to intersperse varying types of information, including text, pictures, sound, and numerical data on the same line. Network capacity also increases dramatically, since digital signals can be compressed, allowing them to carry more information. Converting satellite communications into digital form has increased capacity by an estimated factor of five.

- The capacity of a digital network is often described in terms of the number of bits that the network can transmit from place to place every second. A digital telephone network carries millions of channels of voice conversations, typically transmitted at 64,000 (i.e., 64 k) bits per second. This is enough capacity for a telephone conversation, but far too little for VCR-quality television, which needs about 1.5 million bits per second. The capacity of a digital network, measured as the number of bits it can transmit every second, is called *bandwidth*. Engineers refer to networks with the capacity to send relatively small number of bits as low-bandwidth or narrowband networks. High-capacity networks that can transmit a torrent of bits are called broadband or high-bandwidth networks.

- The components of networks continue to undergo dramatic evolution so that even the copper wires that have carried phone conversation since the era of Alexander Graham Bell may one day finds themselves obsolete, as fiberoptic lines or wireless links give rise to broadband networks. Until then, methods of taking advantage of digital communications using the existing base of copper wiring have been devised. An Integrated Services Digital Network (ISDN) allows voice, data, and some types of video to be transmitted over the same phone line at speeds of 128,000 (i.e., 128 k) bits per second, more than twice as fast as commonly used high-speed modems. Some telecommunications analysts even question whether it is necessary to go to the expense of creating expensive new infrastructure- putting in place high-speed fiber. The reason: another digital standard – under the rubric (a title – other meanings: a set of instructions written in a book, an exam paper, etc.) of Digital Subscriber Line (DSL)- offers enough speed, up to a million bits per second or more on a regular copper wire. A number of U.S. computer companies and international telecommunications carriers have embraced the technology. Besides DSL, a broadband network already extends into a majority of American homes. Specialized modems that can send Internet data over the television cable network at a speed of millions of bits per second have already been adopted in tens of thousands of homes- and the technology, in theory, might suffice for the delivery of high-speed interactive data and video.

COMMUNICATION PIPES

- The metaphor often used for building a web of global communications is “wiring the world.” And indeed most communications still takes place on a pair of copper wires. But, ironically, one of the key symbols for this new era is not a traditional wire but a thin fiber made of ultra-pure glass. This optical fiber, which carries information as a modulated beam of light, is a key technology in implementing broadband communications. A broadband network will help transfer digital audio, graphics, and video and computer data rapidly enough that the user will not notice any waiting after requesting information from another computer.

- Though most households make telephone calls and Internet connections over copper wiring, most telecommunications companies have already replaced many of the connections on the trunk lines between their central offices with optical fibers. Optical fibers can also be used in the high-speed local area networks that transfer information within a single office complex.
- The cost of laying fiber to individual homes –in the absence of critical new services that consumers are willing to pay for- has, for the moment, stalled plans to make fiber the medium of choice for ubiquitous broadband communications. In fact, some communications experts believe that broadband links to the home may be completed with a wireless connection. Alternatively, the cable television network could provide the needed high-speed connections.

- Whatever scenario comes to pass, fiberoptics will still play a role when high-capacity networking is required. Fiberoptics can transmit information at rates and volumes that far outstrip conventional copper wiring. Hair-thin glass fibers that transmit light from lasers or light-emitting diodes offer the possibility of virtually unlimited communication capacity at relatively lower cost. The amount of information that can be carried depends on the frequency of the signal: the higher the frequency, the more the bits fit in what are sometimes called “light pipes”(See Figure [13.1]). A single fiber has enough capacity to accommodate millions of telephone calls or thousands of television channels, although only a fraction of the bandwidth is utilized in today’s networks.

- By contrast, most copper wiring still sends data at rates that do not usually exceed 50,000 bits or so per second. Fiber’s capacity steadily increases as the technology improves. Following the same trajectory as microprocessor technology, the capacity of optical fiber to transmit information has often doubled every year since 1970s the Moore’s law), when the first major fiberoptic line was installed. This doubling is accomplished by improvements in the electronics, transmitters, and receivers.

RISE OF MOBILE COMMUNICATIONS

- Fiber systems have their limitations in providing mobile service or supplying broadcast services over a large region or to remote areas. Rewiring the world with fiber is a costly undertaking. Tens of thousands of miles of cable, complete with transmitters, multiplexers, amplifiers, and photo- detectors, will have to be physically installed underground and inside buildings.

- Another approach is to bypass physical wiring altogether and take to the airwaves. Wireless communications technologies- based on radio and microwave signals – cannot yet match fiberoptics for transmitting billions of bits of information at lightening speeds. But wireless has many advantages. Mobile communications afford convenience, permitting "soccer moms" and international executives to place and receive calls while on the move. For developing countries that do not already have a communications infrastructure in place, there are significant cost and time advantages to using radio and satellite communications. Already, satellite operators are beaming digital broadcasts of movies, sports, and other entertainment into homes around the world at a fraction of the cost of building new cable and wiring infrastructure. And, to provide telephone service to the billions of people around the world who have never made a telephone call, developing countries are increasingly opting for wireless service.

ADVANTAGE OF SATELLITE COMMUNICATIONS

- The place where calls are relayed between a caller and its recipient is often found from hundreds to thousands of miles above the Earth, in the form of communication satellites. The hundreds of orbiting satellites are a linchpin of international communications: On an international telephone call, that slight time lag at the other end of the line results from the travel time of the signal to a satellite 22,300 miles away and back to the Earth.

- Until the mid-1950s, the possibility of communication by satellite was considered to be mostly in the realm of science fiction. The intellectual father of the concept was Arthur C. Clarke, who, in 1945, wrote an article proposing the use of satellites for communications. In the decades since, communications satellites have experienced dramatic increases in capacity: Telstar 1, a communications satellite launched in 1962, carried only a few voice circuits. A contemporary satellite can relay many tens of thousands of telephone conversations or over 200 digital TV channels. Today, some of the advanced international telecom satellites launched by Intelsat, a consortium of the United States and more than 100 other member nations, carry up to 100,000 phone channels.

- Using a satellite for a telecommunication link requires only one repeater-the satellite itself- to amplify the signal. Some types of satellites can provide worldwide coverage with as few as three “birds”, as satellites are sometimes called, parked 22,300 miles above the equator. By contrast, sub-marine or long-distance land cables need many repeaters. Putting a satellite to work inn orbit above the earth is a far less labor- and material- intensive task than laying tens of thousands miles of submarine or land cables.

- Most satellite systems communicate using microwaves that operate at frequencies ranging between 3 and 30 gigahertz (a gigahertz is a billion hertz). This band is not affected by electromagnetic interference in the ionosphere and does not get absorbed in the atmosphere. (Because microwaves do not bend to follow the curvature of the Earth, radio towers that transmit these signals for terrestrial communications must be spaced every 20-50 miles.) The projected expenditures for several current satellite projects for telephone and broadband data and video communications during the late 1990s will (would have) run into tens of billions of dollars. There are also considerable risks associated with getting a payload into space: rocket-borne satellites must be placed in orbits that range from 400 to 22,300 miles above the Earth. Aborted or failed rocket launches have resulted in the destruction of communication satellites worth millions of dollars. A failure of a satellite can have dire consequences. When a communication satellite went down in 1998, the majority of U.S. paging services were lost for several days. But satellites generally perform as expected. After a launch, they are typically more than 99.9 percent reliable.

- Once they have been placed in orbit, satellites use solar cells to power their functions and store the solar energy when the Earth eclipses the satellite’s view of the sun. They are not equipped with powerful engines; rather, they stay in orbit because of the interplay between the Earth’s gravity and their trajectory. A satellite in orbit is actually falling toward the Earth all the time because of gravity. But because the satellite is traveling very fast and at a high altitude, the Earth’s surface curves away form it as it falls. Thus, the satellite never actually gets closer. At times, onboard jets must be fired to ensure that the satellite’s antenna and the solar array remain in the right directions

- Communications are classified according to their height of orbit. Many of the earth’s communications satellites that relay television and telephone messages orbit above the equator at a height of 22,300 miles. When these satellites are launched, thy are accelerated to the right velocity and height so that their speed exactly matches the rotation of the Earth. Spacecraft that orbit the Earth at the same speed as the planet’s rotation are called geo-synchronous or geo-stationary satellites because they appear to be “parked” above a particular spot on the Earth’s surface.

- The advantage of such geo-stationary satellite is that a communication service provider can use a fixed signal to send signals to and receive them from the satellite, rather than having to follow a moving target across the sky. An equatorial orbit also has the advantage of covering an enormous amount of territory in both the Northern and Southern Hemispheres. High-altitude communications satellites can “see” a huge swath of Earth and so can send and receive signals to and from many Earth stations simultaneously. The portion of the Earth’s surface that is illuminated by a satellite is called its “footprint.” Except for the north and the far south, one equatorial satellite can cover about one-third of the Earth’s surface. Thus, theoretically, three geo-synchronous satellites can cover most of the Earth’s surface.

- The cost of high- orbit satellites and transmission delays has caused some telecommunications providers to seek an alternative in smaller and cheaper satellites in low Earth and medium Earth orbit. Low-Earth-orbit (LEO) satellites constantly circle the Earth usually at an altitude of between 400-1000 miles. Another orbit, called Medium Earth orbit (MEO), which is below geo-synchronous orbit but above low Earth orbit, can achieve global coverage with about 12-15 satellites. In addition to communications, MEO satellites are favored for global surveillance, environmental studies, and monitoring nuclear missile treaties. Commercial companies have now begun to launch constellations of LEO and MEO satellites, dozens or even hundreds of which will ultimately link together in a communications service web that surrounds the planet.

- LEOs are deployed so that there is always at least one on the horizon to receive transmission from an Earth station. A telephone call started with one overhead satellite is handed of to the next one that arrives overhead; conversations relayed by a LEO do not suffer from delays experienced when using communication satellites in geo-synchronous orbit. More of them are needed for full coverage of the Earth, but the failure of one satellite does not cause the failure of the entire communications system. The best-known LEO constellation is the sixty-six satellite Iridium system. This $6 billion effort has begun to provide handheld satellite telephone services from any location on Earth to any other. Around the year 2003, Teledesic, an ambitious project to deploy 288 LEOs for high-speed video and data, is scheduled to start service (update the information). The project, in which Bill Gates is an investor, has sometimes been dubbed an “Internet in the Sky.” The high cost of putting satellites into space has also spurred interest in unmanned High Altitude Long Endurance platforms that would hover above cities at about 65,000 to 100,000 feet, providing the capacity for two-way communications and distribution of video in circle 300-500 miles wide. Power requirements are a possible limitation for this technology, though one design proposes the use of helium-filled dirigibles, while another would use very high efficiency jet engines.

RISE OF CELLULAR PHONE

- The cellular phones (also called mobile or radio phones) are now a ubiquitous feature of techno-culture in U.S. and around the world. From the first radio transmitter built by Marconi in 1895 sending a burst of radio waves to a simple receiver about one and a half miles distant, the wireless communications, spurred by several waves of innovation, are widely considered the fastest-growing segment of this global industry. In Finland, more people communicate by mobile phone than by fixed landline. Analysts project that by 2001, nearly half a billion people worldwide will subscribe to wireless service of some kind (update the information).

- With so many millions of people communicating on the move, one may wonder how cellular communications providers can give everyone a device to call any other phone, fixed or mobile, without ever having someone intruding on their conversation. Indeed, until the 1980s, a mobile phone was an expensive and scarce commodity with long waiting lists because of frequency limitations; there was no way to share the limited range of frequencies available. Then came the concept of the cell, in which a geographic region is divided into sub-areas, each of which equipped with a low-power transmitter. When making a call, a mobile phone first communicates with a base station inn a cell that assigns it a given frequency and relays its call to the telephone network and then to the recipient. This method of appropriating the frequency spectrum among the users in the cell is called Frequency Division Multiple Access (or FDMA).

- If somebody dials a mobile phone, the telephone network finds the nearest base station and transmits the signal. If a mobile- phone user starts to move out of the range of one base station, another base station picks up the signal so the callers can keep talking, a process known as a hand-off. This system of dividing up service areas into cells, with each cell served by a base station, allows cellular service providers to reuse radio frequencies in the various cells of the network. The cell concept has been taken even further with PCS or Personal Communications Systems, a digital telephone network that relies on a multitude of low-powered antennas that are much cheaper than the large, expensive, high-powered antennas used in cellular service. (Some areas, of course, still lack any type of commercial cellular service.)

- One digital technique that permits multiple calls to take place within the same area is called Code Division Multiple Access, or CDMA. This system provides 10-20 times the capacity of previous analog systems and perhaps 2-3 times that of the more conventional digital technique known as time-division multiple access (TDMA). It had its genesis in military communications that had to be secure. CDMA assigns a unique code to every telephone call or data transmission. At the receiving end, this code distinguishes a given call from the multitude of calls transmitted simultaneously within the same band of frequencies. Only another CDMA phone that has been given the proper code can descramble an incoming call. CDMA is just one of several standards vying for customers as wireless networks go digital.

DISTRIBUTED WORLD OF COMPUTER NETWORKS

- The technologies of telecommunications and computers are remarkably intertwined: modern telephony is saturated with microprocessors- from the computers that switch and route millions of telephone calls every day to the photoreceptors that receive and decode the on-off light signals of a digital data message that has traveled thousands of miles along a fiberoptic cable. Similarly, with the growth of distributed data processing- in which tasks for a given endeavor may be apportioned among different computers- the telecommunications network has become an extension of the internal memory, storage, and communications that reside in each computer. Data that travel around computer networks can be routed along a company's private transmission lines or else sent on their way over the public communications lines.

- The roots of distributed information processing go back thirty years, to the infancy of computer networking. To use the very expensive processing power and memory of mainframe computers, time-share systems were developed in which dumb terminals (which lacked processing power) were linked to mainframes that could be hundreds of miles away. The nature of networked computing changed, first with the ascent of the minicomputer, and the trend accentuated greatly with the arrival of the personal computer. Computing functions are no longer centralized in a mainframe; instead they are distributed among a number of personal computers or workstations ina network. These combine the processing power and memory of multiple computers, making it possible to achieve a combined performance that is comparable to that of a super computer. In the 1980s, local area networks (LANs) were developed to connect devices usually in a single building or group of buildings. The most common LAN is called Ethernet and was developed by Xerox, Digital Equipment, and Intel. In an Ethernet LAN, a computer connected to the network uses a protocol that “listens” for gaps in transmission before transmitting data to another computer over a variety of media, form optical fibers to telephone wiring.

- Individual LANs operate in a limited are. But other networks may hook LANs together over grater distances using high-speed telephone lines and specialized hardware. A metropolitan area network (MAN), for instance, can tie together corporate campuses throughout a major urban area, while wide area network (WAN) might serve corporate offices to be connected throughout the country or worldwide.

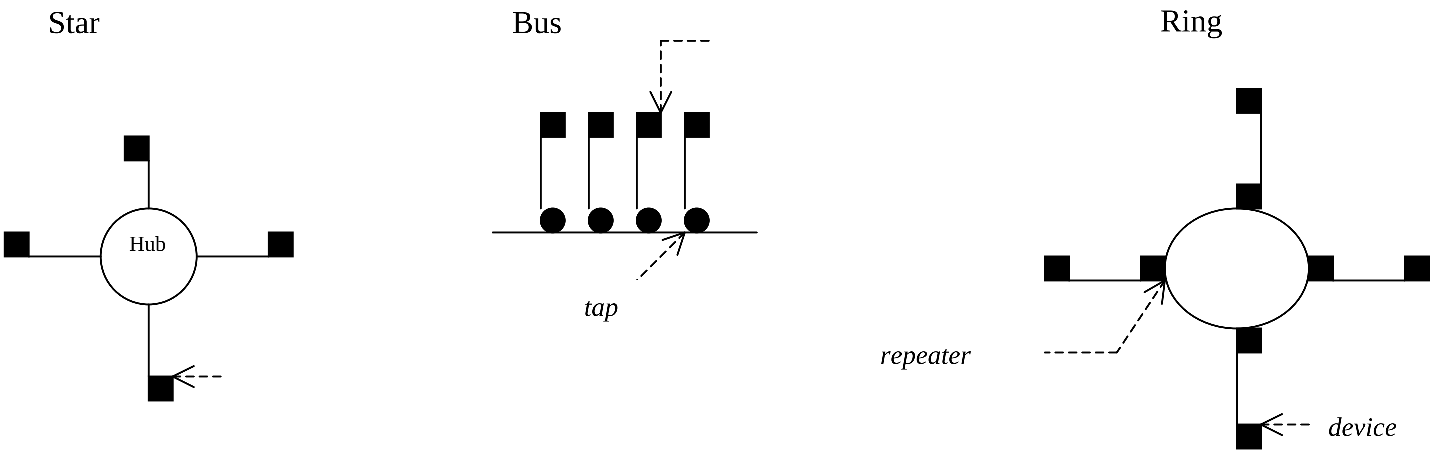

Figure: Local area networks, or LANs, link together numbers of computers and other peripheral devices that need to communicate with each other. The topology of a LAN describes how the devices are linked. Three common topologies are star, bus, and ring. In a star configuration, a device called a hub relays messages to other computers. A bus lets computers tap into a central connection. The ring circulates a message to a destination computer.

- Computer networks are designed to allow data to travel among many users with little delay. The design of the network – the way one computer is connected another – is called the *network topology*. One network topology may is described as a star in which a corporate mainframe, the centerpoint of the star, maintains links with, communicates with, and controls other devices on the network. Computers that store the information accessed over the network are called *servers*. And the user’s computer and hardware that interact with a remote server are called a *client*. A web browser, a type of client program, might request information about rheumatoid arthritis from a server at the National Institutes of Health, for instance.

HIGH SPEED DELIVERY: THE TECHNOLOGY OF SWITCHING CALLS

- A physical transmission medium-whether cellular or fiberoptic –cannot simply transmit from one point to another. Switching equipment must route a phone call or data to its destination. Switching is analogous to routing trains along an intricate web of railroad tracks. With the number of telephones in the world exceeding 800 million, however, connecting a telephone (or modem) call with another in the world is an enormously complex activity.

- In a telephone call, when the handset is lifted, an electric current is established, its power supplied by the nearest post office or switching station. This circuit signals a station to send a dial tone, indicating that the telephone or modem is now wired into the local, regional, national, and global network. The local station relays the connection to another telephone if the call is local, or to an outside trunk line that will send the call to the next station for a long-distance connection.
- From the advent of telephony in the late 1800s (when switchboard operators manually connected calls by literally plugging the two callers into a circuit) until the 1970s, the automatic exchange switching systems of the world were electromechanical. Those exchanges used motors and electrically powered relays to establish a connection between an incoming voice channel and a desired outgoing circuit. The connections were slow-moving and the switches required considerable maintenance.

- With the invention of the transistor, fast and reliable digital switches usurped electromechanical switching. State-of-the-art switching is done by powerful computers and mammoth software programs. For example, one of the 5ESS switches, developed by AT&T (now Lucent Technologies), handles more than 190 million calls on a normal weekday and is controlled by a program comprising about 2 million lines of code and costing about a billion dollars to develop. Like other digital technologies, the increasing speed and miniaturization of microelectronic circuits have led to the development of faster switches with enormous capacity. A switch recently developed by the giant Siemens corporation can handle more than a trillion bits per second of digital information, which the company claims is the equivalent of all the telephone calls of the world, in one control board.

- Certain types of switches can also transmit computer data efficiently, avoiding the need to hold a line or signal path open during a phone call or transmission, thus tying up network capacity whether or not data is being transmitted. A technique called "*packet switching*" splits up a stream of data into short segments or packets, which might be thought of as tiny data-carrying boxcars. Each packet has a header containing information about the identity of the message, the sender and receiver, the sequence of packets in a given message, and the message priority. Packets are then split up and sent over whichever lines are most available; a message is then assembled at the receiving computer.

- Though switches today already represent enormous advances over their electromechanical forebears, their limitations constitute the main obstacle to multimedia networks that integrate all kinds of information, including voice and video. Because older switching technologies are not capable of handling different types of traffic, especially the torrent of bits needed to transmit high-resolution video, networks have been unable to transmit the kind of live video that would make teleconferencing an everyday way of doing business. To increase the capacity of switches, networks have adopted what is called “fast packet switching,” which allows the flood of packets form high-bandwidth networks to be switched rapidly. The most notable of the fast packet switching concepts is called Asynchronous Transfer Mode, or ATM. It is a protocol for transferring multimedia - voice, video, audio, or data – by placing digital information in short packets that are reassembled at their destination into a cohesive message. Switches that use the ATM protocol have begun to be used in recent years by telecommunication providers and by some businesses on their internal private networks.

IMPACT OF INTERNET

- Perhaps the most prominent symbol of the interconnection of global computing and communications systems is the Internet – the collection of networks that links millions of computers around the world. Though it was decades in development, the “Net” has experienced its most explosive growth in the past few years; in the fall of 1990 there were just a few hundred thousand computers on the Internet; as of 1998, the number was in the tens of millions and still growing.

- The Internet has become such a presence that it seems that virtually every major organization and home has a Web address and a “home page” to visit. This impression is somewhat misleading. In fact, as of 1998, less than one-third of U.S. households were connected online, having grown just from just 7% just a few years ago. But these figures must still be compared with a medium like television, with its virtually total penetration of American homes. And the numbers drop substantially for the rest of the world. But the Internet’s impact on society is so great that it is sometimes difficult to understand the network’s physical structure – or to conceive of how it came about.

- The Internet consists of tens of thousands of computers interconnected with each other over the international telecommunications system. A computer based in Johannesburg, South Africa, for example, is connected by modem to a local *node* or connection point that is itself connected to networks around the country and overseas. An E-mail message can be sent for only the charge of a local phone call. Internet providers whose nodes provide links to the worldwide network do charge a fee, which is relatively low in the United States but can still be a hefty amount elsewhere in the world.

- No single person, group, or organization runs the Internet (Here one can bring into play the recent discussion on UN for information sharing and on FreeNet). This seems wholly appropriate for a multitude of networks that interact with other networks to pass message. The Internet Society and the Internet Engineering Task Force (IETF) oversee the daunting task maintaining the well-being and growth of the network. The IETF is made up of volunteer technical professionals who establish standards and protocols, monitor the running of the network, and plan for the future. In mid-1998, moreover, an effort was under way to establish a new nonprofit corporation to coordinate how Internet addresses are assigned and to handle other network-related administration functions. Yet another organization, the World Wide Web Consortium (W3C), develops standards for the evolution of the fastest-growing part of the Internet, the World Wide Web. The Web consists of servers connected over the Internet that store documents that may contain text, graphics, audio, and video that are accessed with software called *browser*. Run by the Laboratory of Computer Science at the Massachusetts Institute of Technology (MIT), W3C serves as a storehouse of information about the Web for developers and users.

- Considering that the Internet has become a repository of information that ranges from DNA sequences of the human genome to advertising for catalog shoppers, one might be surprised to learn that this global network was fashioned by the United States military. In fact, the Advanced Research Projects Agency, a research arm of the Department of Defense, coordinated the building of the early Internet. ARPA,s network engineers faced the task of designing a robust network that could share the resources of scarce, expensive, and incompatible mainframe and minicomputers among groups of different scientists.

- Thus, in 1969, ARPANET, the first ARPA-sponsored computer network, went into operation. The developers of the Internet soon created protocols that allowed different types of computers or even distinct networks to “talk” with one another. They devised what became known as the Transmission Control Protocol/ Internet Protocol or TCP/IP, which remains the de-facto set of protocols used by computer networks around the world. The creation of ARPANET required network engineers to solve a daunting series of technical problems: connecting computers without requiring every computer to be linked directly to the other and hooking together computer systems from different manufactures that had many varieties of operating software.

- The solution was what is known as store and forward packet switching (see Item [h] above): Instead of having every computer linked to every other, store and forward technology routes messages through the network. Backbone communications lines, high-speed links that carry most of the traffic, connect networks or computers together in the same way that the spinal column serves as the conduit for the myriad nerve impulses that travel though the human body. These backbone used to be run by the National Science Foundation, but are now paid for by government agencies and by private corporations, which provide Internet access to customers. The computers, or nodes, that act as the switching centers receive packets and pass them along to the next node. A computer at the message's destination reassembles the original message from the myriad packets. (This can be meaningfully used to define I*I Technology System. Think how?).

- Information sent across the Internet is first broken up into packets by the Transmission Control Protocol, which runs in software on a local computer. The packets move from a computer to a local network, Internet service provider, or online service. From there they are sent through many levels of networks, computers, and communications lines before they reach their final destination. On their journey they are processed and relayed on their way by a variety of hardware, such as devices called routers (see Item [h]). If the destination of the packets lies outside a set of intermediate networks, they are sent to a NAP (network access point) to be dispatched across the country or the world on a backbone.

E-mail: HOW ISIT DELIVERED?

- One of the most helpful ways to understand the structure of the Net is to analyze the syntax ([i] meaning of syntax (noun): (1) the way that words and phrases are put together to form sentences in a language; the rules of grammar for this (2) (computing) the rules that state how words and phrases must be used in a computer language: The instructions were not carried out because of a syntax error; [ii] meaning of syntactic (noun): connected with syntax: syntactic rules/structures; [3] meaning of syntactically (adjective): to be syntactically correct/ incorrect. Think how these perceptions can be used in describing the design of I*I Technology System; for example, how information requirements at different decision stags are put together).

- Like an ordinary letter, electronic mail requires an address. Every address on the Internet is actually a series of numbers separated by periods, which are called dots. Because these numbers can change and are difficult to remember, a so-called Domain Name System (DNS) is responsible for tracking these addresses using letters and words that are easier to remember. Domains are groups of computers that are identified by names such as ".com" (pronounced "dot-com").

- Take a hypothetical journey of an electronic mail sent to John Smith at Acme Computing Company. The sender deploys a client, or a software program, to compose a message, and affixes the electronic mail address, john.smith@acme.com. Operating system software, called Transmission Control Protocol (TCP), divides the message into packets and attaches information about how each packet should be handled by the network. The message is usually passed from the sender's computer to a server, a computer connected to the Internet. After consulting computers on the Internet that supply information about network addresses, the server converts the domain names in the recipient's electronic mail into a numeric Internet Protocol (IP) address. It reads the domain name from right to left: ".com" for "commercial site" and "acme" for the destination computer server at the Acme Company. The IP address enables the packets to move through ten or so "router" computers dispersed throughout the network before arriving at Acme's mail server computer. The mail server stores the message in the "john.smith" mailbox. Then Smith's compute can retrieve the message.

- Today the Internet is widely used for electronic mail. But it also includes many other services. Usenet is the equivalent of a global soap box. It consists of tens of thousands of special-interest area called *newsgroups*. A Usenet newsgroup allows messages to be posted where they can be seen and commented upon by others. Usenet groups range in topic from art history to religion, politics, sex, cooking, sports, and warfare. The system emerged in 1979, the brainchild of students at Duke University and the University of North Carolina who developed a system known as Unix-to-Unix Copy (UUCP), which allowed users to automatically download text or software from Usenet groups. New versions are now widely used fro managing files by other Internet services.

EXPLORING THE NET: THE WORLD WIDE WEB

- Many people's notion of the Internet is synonymous with the World Wide Web (WWW). The Web, a hypertext system, was developed by the CERN High energy Physics laboratory in Geneva in 1989. it has been noted that Switzerland, where four languages are spoken, including German, French, and Italian, was an appropriate place to develop what has become, in essence, a common language for a worldwide communications system. Tim Berners-Lee, the inventor of the Web, reportedly envisioned it as a growing superhuman "brain" formed by linking together people's knowledge around the world.

- The Web became possible because of a series of software innovations that made feasible the concept of networked hypertext, allowing users to jump from one site to another. Berners-Lee came up with an addressing scheme called the Universal Resource Locator, or URL (pronounced “earl”), for locating files, pictures, audio, and video anywhere on the Internet. An example of an URL on the World Wide Web is *http://www.wiley.com*, which is the URL for John Wiley & Sons, Inc., the publisher of books.

- Berners-Lee also devised a simple programming language called hypertext markup language (HTML) for creating “pages” of information that may contain, say, a video animation clip with accompanying text displayed beside the image, similar to a newspaper layout. Browser software that runs on a user’s computer accesses the remote computers where text, objects, and pictures are stored using the hypertext transport protocol (http). The protocol defines how Web browsers request and obtain Web pages. To refer readers of a Web page to text, images, or other media on the Web, a reference is underlined and programmed with the URL (or hyperlink) of the site to be accessed. Likewise, other sites can include hyperlinks to the same page. This virtually infinite capacity for cross-linking using simple rules of association is a key reason the World Wide Web is such a powerful, innovative publishing medium.

- Because there is no way of stopping anyone from publishing anything and placing it on the Net, the Internet has started to represent a vast, disorganized library that contains millions of poorly cataloged documents. *No one ensures that information is accurate or up to date*. Also, despite vast stores of medical, financial, and other useful technical information, the Internet is also a repository of schlock (things that are cheap and of poor quality), including pornography and thousands of personal Web pages that shower the visitor with the site owner's pet possessions. Brief Course description

- *Bringing order and stability to this universe of information has now become a major research issue*. Software that helps track down information on the Web is called a search engine. With names like HotBot and Alta Vista, search engines crawl day and night on the Web. They are programmed to store every significant word they find in a gigantic index. Once the index is compiled, a computer user need only type in a key word or phrase, and the software will rapidly list pages that have been indexed with matching words. This kind of service can often present researchers with the daunting task of sorting their way through thousands of “hits” that list any documents with even passing reference to a topic.

- Moreover, despite their assiduous journey throughout the Web, most of the Web still remains un-cataloged. Besides searching the Web, browsers sometimes contain filtering software that can be used to cull the good from the bad. It can prevent minors from gaining access to pornography or other offensive sites. But it may also flag desirable sites- those that provide quality information on health, for instance. Standards groups have labored to create a rating system that can be used in conjunction with software filters, allowing a browser to pull up sites that have attained a certain ranking.
- But domesticating cyberspace remains problematic. Many other issues that are normally handled through government regulation -e. g., whether Web sites have the right to collect information about their visitors and whether Internet usage can be taxed- still remain hotly contested.

INTERNET CALL

- Because of the structure of the Internet, corresponding with an overseas friend by E-mail is considerably cheaper-and faster-than mailing a letter. The efficiencies of the Internet’s packet communications have not gone unnoticed by entrepreneurial companies who have started to specialize in voice calls over the Internet. Internet telephony is an evolving technology. In the 1990s it required a fast personal computer equipped with a speaker, a sound card, and a headset as well as a high- speed modem with a direct connection to the Internet. The user would speak into the computer microphone, and a special software would turn the voice conversation into digital “packets.” The message could then be relayed to someone else who had purchased similar equipment. But the data packets that make up a phone call – voice packet - could get backed up behind those (data packets) from someone downloading a pornographic picture (i.e., a picture packet). So the conversations were often fuzzy-sounding.

- Internet telephony has begun to target a wider audience. Improvements in communications software have resulted in protocols that let voice packets be delivered before data packets, which has meant better quality phone conversations. And some Internet phone companies compete with the likes of AT&T and MCI by offering service using regular phone sets. Many of the larger carriers have themselves begun to make plans to deliver phone service using packet networks. Internet calls are cheaper, in part, because they use bandwidth more efficiently. The calls are diced into packets, compressed, and then made to fill a communications pipe from end to end. In ordinary telephone connections, bandwidth is wasted by the pauses and silences during a conversation.

PERILS OF DISTRIBUTED COMPUTING

- Encryption
- Data Security
- Loss of Information Integrity

NETS OF THE FUTURE: THE COMING OF INFORMATION AVALANCHE

- Within a decade, the Internet has developed into a stunning cornucopia of international communications and data resources. But in its present state, the ease of use of the network of networks is limited in part by the capacities and sped of its links and switches. This is clear to anyone who explores the Internet using a modem that sends and downloads information at speeds of 28,000 bits per second. It can take twenty minutes for the transfer of a short video clip or a sample of music. Additionally, using hypertext links to explore the World Wide Web is often an exercise in tedium as the user is forced to call up one short link after then other. Nevertheless, given the growth of the Internet, and its penetration of everyday commerce and culture, there is no doubt that its present incarnation is but a harbinger of its future potential.

- Even more advanced communications are on their way as broadband networks and switches are implemented and manufacturers and governments worldwide agree to standards for linking the diverse components of global networks into a seamless web. The U.S. government has sponsored a project, dubbed Internet 2, that will link one hundred universities, allowing transfer of data at speeds of more than a billion bits per second.

- Within the next decade (i.e., by 2010), techno-pundits predict a halcyon (peaceful and happy) future in which the World Wide Web will reach into virtually every home, school, and business with high-speed links that feature high-resolution sound and video. Schools of the future will have ready access online to the same resources as scholars and scientists, and the whole record of human history will be deposited and accessed from virtual World Wide libraries. Increasingly sophisticated search engines will make it easy to find relevant information. And personal Internet secretaries (known as intelligent agents) will observe someone's interests and then seek out and deliver this information. Virtual corporations will consist of widely dispersed individuals and groups who work together for a time before moving onto next project with a wholly new set of collaborators. Their only common bond: the ability to communicate over electronic networks (well this visualization can be developed to bring in the postponement of heat death as the system's objective).

- In such case, those who provide quality information and entertainment will need some form of remuneration. Encrypted cash and identification will provide the technological means to carry out such transactions. Bank note may gradually be replaced by digital cash in systems that maintain account balances and credit information online. Digital cash will be transferred from an online account to pay for a garment ordered from an electronic retailer. Digital certificates will verify the identity of a consumer to an online merchant and also confirm who the merchant is to the consumer.

- Like a wallet or a key-chain, networked computing may become coupled to one’s personal possessions. Digital personal communications systems the size of a wristwatch are already available for making phone calls. A plethora of other systems, including wearable computers, active badges, and personal navigation devices, will become increasingly prevalent during coming the coming decade(s). These devices consist of small computing units and transmitter-receivers that process a signal to allow the user to interact with his or her surroundings (environments). An active badge, for instance, may transmit a communication signal to indicate the whereabouts of an employee. In fact, prototypes of badges let people exchange information about each other – name, title, telephone, and electronic mail- by an infrared link across a room.

- The personalization of the computer may be taken to its extreme with the BodyNet, also called the “personal area network,” which is intended to function as an extension of the person’s body. Such computing devices may e strapped to oneself to exchange information or to monitor changing bodily conditions. They may prove especially useful on the factory floor or in other settings where the user needs both hands free.

- “Smart” eyeglasses consist of a wearable computer with a head-mounted display, cameras, and wireless communications. One MIT researcher used a BodyNet to relay to his wife at home an image of supermarket produce. She then sent back an electronic mail message about her choices, which was displayed on the eyepiece of her husband’s BodyNet. The ultimate in computer-corporeal interaction may be smart underwear. A sensor in an undergarment can relay the level of perspiration and then adjust a heating unit accordingly. But any benefits from adjusting a thermostat by a touch of perspiration may be overcome by the discomfort of loading underwear with electronic sensors. Even the inventors of these devices recognize some of the drawbacks. One researcher raised the issue of what would happen if one person begins to sweat before another (this is an pointer to the complexity that characterizes the real world and to the need for defining a common operable goal).

- This future may be farther away than some visionaries predict because of limitations in the key technologies. Few purchasers may step forward if the control system for home heating and air-conditioning system prove as troublesome as a personal computer operating system. The wired home and BodyNet may be cumbersome or costly and, for the time being, may be embraced only by the very rich or by those enamored of technology for its own sake. Microsoft founder Bill Gate’s $30 million Seattle home can display pictures and music to suit the tastes of the occupant of a room after being cued by an active badge. But after the novelty of such a device wears off, few homeowners are likely to pull themselves from meal preparation to program badges for their dinner guests.

- Given the enormous infrastructure investments required by communications technologies, there are concerns, as with other technologies such as genetic engineering, that wiring the world will benefit rich nations more than poor ones, and widen the gap between the haves and the have-nots. Social critics worry about threats to personal privacy- as a networked world allows the government more easily to compile information on its citizens. Indeed, users of a recently implemented system to automate road-use tolls are concerned that information generated by payments at various locations may be used by law-enforcement agencies to track a person’s comings and goings.

- The costs must be weighed against the knowledge that networks can potentially deliver enormous advantages for social development. A phone line is needed for any Internet connection. Sand in poorer countries, the average density of the phone lines is about 5 per 100 people. In some cases, however, mobile telephone technology let some of these countries “leapfrog” the old copper network by delivering telephone service to remote areas without installing costly and time-consuming wiring infrastructure. The growth of the Internet, moreover, has begun to link remote corners of the world. For example, with higher-speed data links, the emerging field of telemedicine would make it possible for doctors in sophisticated Western hospitals to make diagnoses on patients in less-developed countries oceans away; a Boston-based physician might view a satellite-relayed video image of a heart patient in Thailand while manipulating a surgical instrument to cut or seal blood vessels from his or her office. The challenge, as in other rapidly developing technologies, is to make wise use of these capabilities.

THANK YOU