LOOKING AHEAD: COMMUNICATION TECHNOLOGIES THAT WILL CHANGE OUR LIVES

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ABSTRACT
This article describes Communication Era undertakings currently that dominate post-industrial economies. Since the late-1970s, knowledge, information, education, and entertainment enterprises in the US have accounted for over 50 percent of all jobs. Today this group of activities generate about 66 percent of jobs and GDP. These calculations vary, depending upon what's counted. One thing about this era is clear: brains, not brawn, has become the key resource.

Digital communications, ranging from massive supercomputers to ubiquitous handheld "personal assistant" PCs, are the economic linchpin. The current information revolution ushered in a vast new range of services -- pay cable TV; interactive TV; teleconferencing; video recording; electronic funds transfer systems; electronic shopping; electronic mail; facsimile newspapers and specialized magazines on video; electronic plebiscites on vital public policy issues; automatic home security services (fire, police, flood, storm, etc.); special services for the handicapped; and home computers to handle a vast and growing range of activities.

Solid state devices, micro-electronics, computers, and communications equipment of all kinds are today's economic mainsprings. Computer household penetration rose from 27 percent in 1990 to 51 percent in 2001. Integrated circuit chips fashioned from flyspecks of rare earths and traces of silicon marshal knowledge and information that can change the fate of a business or an empire.

SCIENTIFIC BREAKTHROUGHS AND TECHNOLOGICAL SUBSTITUTIONS

Better communication means consistently have been introduced throughout history. Improved methods of communication displace the less effective and become the dominant mode. Spoken words preceded the handwritten word, which gave way to the mechanically printed word that was eclipsed by the telegraph and telephone. Four major communication modes, each one more efficient than the preceding one, dominated eras of US economic growth over the past century:

- Low cost "penny press" which made inexpensive mass-circulation newspapers and periodicals available to an increasingly literate populace.
- Regular radio broadcasting that began in the mid-1920s.
- Television, starting in the 1950s.
- Computers that flooded consumer markets by the late-1970s.

Computers of the 1960s-1970s were big, costly, few in number, and limited to top management use. During the 1980s, desktop PCs lopped off middle-management paper pushers, and decentralized decision-making. Take-off during the 1990s greatly enlarged computer networking and the Internet provided access to the fund of human knowledge.

Science constantly seeks faster, better, more efficient, less costly, and more streamlined technologies. Communication advances can be categorized into at least seven successive stages of development that follow this pattern:

1. Physical/mechanical stage. Edison's primitive phonograph utilizing a mechanically vibrating pickup and diaphragm to reproduce sound, commercially introduced in 1877, exemplifies this introductory stage. Forerunners of modern computers can be traced back thousands of years to the hand--manipulated

abacus. Later on, came Charles Babbage's calculating engine that was partially constructed between 1822-1871.

2. Electro-mechanical stage. Alexander Graham Bell's telephone, introduced in 1876, demonstrates this type of innovation using electric pulses to vibrate a diaphragm or open and close an audible circuit. Computer antecedents are characterized by Herman Hollerith's electrically operated tabulator using printed punched cards that was used to process 1890 census data.

3. Fully electronic stage. Marconi's first wireless telegraph signals (precursor to the radio), demonstrated in 1895, represents this principle. Continuing to track computer development, the earliest numeric analog computer, the Electronic Numerical Integrator and Computer (ENIAC), was developed by Eckert and Mauchly in 1946.

4. Electro-optical stage. Telephone analog switching systems converting signals to photonics characterize this development.

5. Optical/photonic stage. Light transmission is the latest communications frontier. Light changes polarity more than one quadrillion times per second. Scientists already succeeded in switching light 100 trillion times per second (100 terabits). Emerging evidence that the speed of light may be exceeded by a factor of 10-1,000-fold, perhaps even 10,000,000-fold, suggests future threshold potentials.

6. Bio-electronic stage. Some foresee organic semiconductor devices and bio-computers as the next (science-fiction-like) stage of potential development. Crude experiments already have demonstrated these possibilities.

7. Extra-sensory stage. Much more speculative are the possibilities inherent in development of extra-sensory perception (ESP) – clairvoyance, precognition, prodigals, "tongues," telepathy, telekinesis, faith healing, hypnotic states, out of body experiences, and so on, suggest the possible potentials. Dismissed as "quackery," ESP might become the preferred communication mode at some future date.

COAXING THE MOST OUT OF AVAILABLE RESOURCES: DOING MORE WITH LESS

Smaller, faster and cheaper are hallmarks of communication technologies. Technological advances wrest more and more from basic raw materials. Falling prices being such conveniences to mass markets.

Clocks, the forerunner of mechanical invention, initially occupied entire temples. Pocket watches, ponderous and thick at the outset, steadily diminished in size. By 1700 the average thickness slimmed down to 1.5 inches, trimmed to one-half that thickness (0.75 inch) by 1800, and shrank to 0.25 inches by 1850. Today, LED display timepieces measuring the thickness of a sheet of paper and molecule-thick versions have been developed. Once again, underscoring how science provides ever newer ways of doing the same thing better, utilizing even fewer resources.

The first programmable computer (ENIAC) filled an entire room. This huge computer included 17,468 vacuum tubes and semiconductor diodes, 70,000 resistors, 10,000 capacitors, 6,000 switches, and 1,500 relays. It weighed 30 tons. Standing 10 feet tall it occupied space measuring 80 X 30 feet. The dimensions were equivalent to an oversized 18-wheel tractor trailer. This is not exactly the sort of device you could carry around in a briefcase, a short pocket, or on a wrist. Electrical consumption was enormous -- 140,000-174,000 watts per second -- enough to provide power to an average home for over a week. This enormous machine performed a mere 5,999 basic mathematic operations per second. It cost a whopping $450,000.

By the 1950s, computers shrank to refrigerator-size. Recently, massive mainframe computers filling an entire room have been reduced to PCs with "footprints" the size of a telephone book or even smaller ones that slip into a shirt pocket. Now, computer devices occupy postage-stamp dimensions. Meanwhile, R&D focuses on quantum computers the size of a pin-head!

Virtually every facet of communications benefits from ephermalization -- doing much more, with much less.

- Birthday cards that tinkle the "happy birthday" tune when the card is opened incorporate more computing power than the first room-size computers.
- Wristwatches may contain more computing power than existed in the entire world before 1961!
- Palm-size computers and video games today posses more computational capability than the best supercomputers of the mid-1970s.
- Motor vehicles -- some with 30-100 onboard dedicated computers that constantly check and adjust oil pressure, fuel mixture, tire air pressure, seat adjustments, headlights, and navigation -- surpass the computational ability of the lunar-lander spacecraft, Apollo-11!
- Gigantic satellite receiving antennae 10-100 feet in diameter have been replaced by receptors as small as 12-16 inches in diameter.
- CD-ROM disks plummeted from 12-16 inch diameter to 5 inches, shrunk to 2-3 inch diameter, then to units the size of a quarter. Diminutive disks storing one trillion bits have been developed.
- Tape cassettes shrank from 12 inches, to 4 inches, to as little as 2-3 inches, and smaller.
- A few thousand pound communications satellite outperforms copper lines more than a trillion-fold.

Fiber optical cable, fashioned from silicon, replace (and/or complement) vast tonnages of copper wires. The first copper transmission lines, measuring about one-fourth inch in diameter, carried but a single message. Coaxial cable voice channel capacity rose from 48 in 1955 to 4,200 by 1976. Fiber optics boosted the number of voice channels which rose from 8,000 in 1988, to 16,000 during 1991, and >500,000 around 1998. Fiber optic cables with ten terabit capacity emerged by 1998, and others carrying 10 trillion bits per second have been demonstrated. Photonic transmission rates will reach 100 terabits per second rates by 2004, and transmissions at 200 trillions bits per second are projected.

Science typically starts out using cruder and larger dimensions. Inevitably, and step-by-step, as mastery is accomplished, artifacts become better, less resource intensive, and more efficient. Moore’s law that anticipates computer capabilities double every 18 months, is easily understood in terms of the basic parameters of packing density and speed. Smaller scales increase packing density, involve shorter travel distances, and enhance speed. Electrons have a certain speed and photonics posses still more diminutive dimensions. Knowing the range of those parameters reveals basic limitations that indicate the highest level potentials attainable.

Integrated circuits etched using extreme ultraviolet (EUV) lithography can create features smaller than 0.1 micron (about one five-hundredth a hair's width). This development can increase microchip capacity by 1000-fold, and boost speed of the fastest chips currently available by at least 100-fold. Lithographic chip etching will reach a limiting threshold -- 70 nanometers -- around 2100. "Short-channel effects" involving uncontrollable leakage across channels compromise functionality at this scale by disrupting and compromising semiconductor effectiveness. Quantum effect phenomena in the 50 nanometer range, and below, pose other limits to miniaturization. Double-gate technology may help reduce channel width to as little as 20-25 nanometers. But, other obstacles emerge at this scale. Nanotechnologies -- artifacts constructed at scales measuring one-billionth of a meter (about the length of ten atoms), or lower -- open up a new frontiers for development.

Experimental silicon germanium chips -- 50-times faster than standard chips -- outperform currently top-performing gallium arsenide. All told, nanotech products hold promise for using fewer materials, consuming less energy, minimizing wastage, and stretches out finite resource.

Technological resources that once dominated economies, often find new uses and much higher value-added uses over the millennia. Sand (silicon dioxide), for example has been a linchpin resource, in varying applications, over thousands of years. Back in 3400 BC, beads became a significant factor in commercial exchange, and acquired greater importance when intricate beakers were fabricated around 1500 BC. Later on, use in cement, beginning around 300 BC in Pompeii, followed by concrete in Rome, 240-190 BC, gave rise to a new epoch of building construction. Sand, in its purified forms (and doped with traces of rare earth elements) provides the basic building block of current Information Era technologies.

COMMUNICATION INVENTIONS – INCREASED RATES OF COMMERCIALIZATION

Time lapse between discovery and large-scale commercial penetration of new scientific technologies steadily decrease. Thousands of years lapsed between development of spoken words to written forms, and hundreds of years more between hand writing to printing. Radio took 30 years to amass 50 million users. Television required 13 years to match that feat. World Wide Web introduction attracted 100 million users within a mere six years. The Pony Express was displaced by airmail, which in turn has been supplanted by overnight mail, facsimile transmissions, and instant E-mail messaging.

Information/computer guru Ray Kurzweil delineates the following pattern for computer successive development: mechanical computing devices, 1900-1928; electromechanical (relay based) computers, 1939-41; vacuum-tube computers, 1968-1998. Kurzweil points out that "The speed of computation has been doubling every three years (at the end of the twentieth century), regardless of the type of hardware used." He expects this pace to continue.

Less material intensive technologies cut communications equipment costs and lead to reduced pricing. Material cost of copper wire, for example, amounts to 80 percent. Material in fiber optic cable amounts to less than 10 percent. And during the early-1980s, material and energy cost in semiconductor chips amounted to as little as 2 percent of product total cost.

Kurzweil suggests that PCs costing around $1000 will be able to process 20 quadrillion calculations/second by 2025. Nor does he stop there. He speculates that the brain's 100 trillion synapses represents one quadrillion bits. Specifying that one billion bits (128 megabytes) of computer RAM cost $200 in 1998, and that capacity doubles every 18 months, he estimates by 2023 quadrillion-bit memories will cost $1,000. Staggering the imagination, he contends that computer chips will operate one billion times faster than human brains!

All of this sounds a bit far-fetched. For perspective, bear in mind that even the best of the best don't get it right all the time. IBM founder Tom Watson erred, for example, when he contended "…there is a world market for about five computers" (1943). Ken Olson, President of Digital Equipment Corporation asserted, "There is no reason for any individual to have a computer in his home." (1977). Bill Gates contended that "640K ought to be sufficient enough for anybody" (1981). Settings within which projections are made change. Great thinkers continually adjust their ideas as new potentials emerge.

Ideas discussed in this article provide a framework for sizing up the future of communications.

"BIG SEVEN" TRANSFORMING COMMUNICATIONS TECHNOLOGIES

Telecommunications technology will experience more change in the next five years than occurred over the past 95 years. Seven vital technologies contribute to this outcome:

1. Transmission rates
2. Supercomputer speed
3. Artificial Intelligence
4. Satellite communications
5. Wireless communications devices
6. Broadcast digital technologies
7. Internet resources.

1. TRANSMISSION RATES

This is an age of near-instantaneous communications. During the Stone Age early ancestors communicated at the rate of about one visual or audible message per second, the time required for simple gestures, grunts, body language, fire or smoke signals or reflected light to be conveyed. Today, mind boggling terabit per second communications usher in rates of speed that divorce time from human capabilities.

Advanced rates of communications took off during the mid-1800s. Invention of the telegraph in 1884 enabled transmitting 5 bits per second. The telephone, developed in 1876, boosted the rate to the equivalent of 2,000 bits per second. Rates escalated rapidly from that point, rising from the equivalent of 30,000 bits with transcontinental transmission of three voice channels per wire pair. By 1940, the rate over coaxial cable rose to 480 voice calls over a single cable, the equivalent of 7,680,000 bits per second. The first programmable computer, ENIAC operational in 1946, was capable of 5,999 instructions per second. In 1994 a DEC computer was capable of processing 1 billion instructions per second.

To help maintain perspective, bear in mind that one billionth of a second (one gigabit) is to a second what a second is to 31.7 years! By one estimate, the amount of information an individual uses in a lifetime is equivalent to a mere 20 billion bits of data. That amount of data, taking full advantage of current communication technologies, can be transmitted in the fleeting fraction of a second. In other words, the entire knowledge base individuals amass over an entire lifetime can be shunted from place to place, literally in the blink of an eye.

Wavelength division multi-plexing (WDM) of photonic signals tilted the entire field. Transmission rates skyrocketed from 20 billion bits per second using 8 channels in 1995; 40 billion using 8 channels in 1996; 400 billion utilizing 40 channels in 1997; to 800 billion using 80 channels in 1998; to a capacity of 1 trillion using the highest rated commercial cable available mid-2000. Bell labs achieved speeds of 3.28 trillion bits per second utilizing 82 different wavelengths in early-2000.

Transmission rates at trillion bits per second also require some perspective. Laboratory demonstrations achieved transmission rates of 10 trillion bits per second in 1998. At 10 trillion bits per second, the 24 million books in the Library of Congress could be transmitted in about 18-24 seconds time! Transmission speeds will not end at this point. Alastair Glass (Bell Labs) speculated in 1998, that rates of 200 trillion bits per second would soon become possible. More astounding yet, are the breakthrough potentials of on-going research into quantum computers theoretically capable of transmitting at quadrillions of bits per second.

2. SUPERCOMPUTER SPEED

America's speediest computer, dubbed ACSI White, will cost $110 million to build. Like ENIAC, it will fill a large room, about twice the size of a basketball court! This supercomputer, situated at the Lawrence Livermore Laboratory, engages 8,192 IBM PowerPC microprocessors. It consumes enough energy to power 10,000 homes, considerably more than the huge power requirements of ENIAC. All of this sounds familiar. Scientific change, as noted, typically occurs at an increasing tempo and, over time, it scales inputs down to Lilliputian levels. When this ACSI White becomes operational in 2004, it will be capable of churning out 100 trillion bits per second (100 teraflops), or performing 16 trillion calculations per second! At 100 trillion bits, transmitting the Library of Congress book collection would take the merest fraction of one second!

Accolades to IBM's impressive acheivement, have been outdone elsewhere. No nation, after all, has a monopoly on invention. As of 2002, the world's fastest supercomputer kudos go to Japan. The NEC-built Earth Simulator, situated at the Institute for Earth Sciences in Yokohama, operates at a blistering 35.86 trillion (floating point) operations per second.

IBM's biggest and fastest computer now under development -- Blue Gene – will operate at one quadrillion operations per second – when it becomes operational in 2005. IBM's website shows two versions under development Blue gene/C/CU-11 and BG/P/CU08. IBM's website also lists two other supercomputers: QCDOC – CMOS7SF operating at 20 teraflops, and ASCI-Q operating at 30 teraflops.

The truly extraordinary thing about Blue Gene is the fact that the machine will be dedicated to biomolecular simulation, protein folding and protein reactions. One report asserts that this single-purpose machine will be devoted, over the course of an entire year, to explicating exactly how a single protein (composed of 150 amino acids) folds into its peculiar shape in a millisecond.

Rudimentary quantum-based computers already have been developed. Eventually, these devices are expected to operate at blistering quadrillion per second speeds. Grasping some concept of what quadrillion rates means helps to comprehend what's involved. The Library of Congress 24 million volumes, assuming a megabyte per book (and 8 bits per byte), equals 193 terabits. This means that the total contents of the world's largest book accumulation could be transmitted in the merest parsing of a second!

3. ARTIFICIAL INTELLIGENCE

Computers and artificial intelligence (AI) will be taking over more and more split-second human response. IBM's supercomputer that beat grand master chess player Kaspanov in 1995 led to speculation concerning reasoning powers and self-learning potentials. Problems that once required armies of people working their entire lifetimes to solve now can be solved in seconds. Ray Kurzweil, author of The Age of Spiritual Machines, foresees increased computer speed and transmission rates leading to voice entry and automatic language translation. These developments, he contends, pave the way for machines overtaking and surpassing capabilities of the human brain.

Computer Speech Recognition. Computers capable of speech recognition and direct data input were in use by 1998, and more primitive models considerably earlier. Voice recognition achieved a 10,000 word capacity with 95-98 percent accuracy by 2000. The English language utilizes 450,000 words, more than almost any other language. Those big numbers don't pose that big a barrier. The Merriam-Webster Third International Dictionary listed 70,000 words in the late 1990s. Usage is quite another matter. A learned person uses an average of 20,000 different words. Regularly used words total only 10,000. Average persons use about 5,000, and casual conversation involves a modest 2,000 words. Dealing with so few words, relatively speaking, amounts to kid's stuff.

Multiple language capabilities. The huge number of languages worldwide poses additional challenges. In 1995 there were 9,500 different languages and 96 official state languages worldwide. Although the number of languages is expected to decrease to 8,000 by 2025, the number of official state languages may increase to 150, thereby posing (at bare minimum) a 50 percent increase in translation needs. Word recognition software covering so many translations is not insurmountable.

Automatic language translation. While rudimentary voice translation software systems have been available for years, Kurzweil foresees sophisticated ones taking over chores like telephonic automatic language translation by 2007. Language translators capable of converting foreign languages into real-time audible signals or hard copy, once perfected, necessitates massive computer capabilities. Automated translation of telephone conversations -- US-Japanese -- was developed in 1998. Simultaneous language translation tears down one more barrier between peoples. International travel, tourism and diplomatic interchanges will benefit enormously.

By 2010, computers are expected to match computational capabilities of the human brain, an estimated 3.2 million instructions per second. A decade later, Kurzweil foresees personal computers capable of 20 billion instructions per second, equivalent (he claims) to the human brain. By 2029 Kurzweil predicts computers will be executing 200 trillion instructions per second. At this point, he speculates supercomputers could become so advanced that conferring "human rights," of a sort, will be widely discussed.

Kurzweil begins his straight-away path to AI by specifying the baseline of 100 billion neurons in the human brain. Assuming 1000 interconnections between neurons, he arrives at a grand total of 100 trillion connections. Sounds impressive. It is. Unraveling and deciphering how and why the human brain works is not likely (in my opinion) to be understood for well over another 100 years. Back to Kurzweil's projections. Next, he assumes that neural circuits operate at a mere 200 calculations per second. Mathematic calculations, based on these numbers (100 trillion X 200), yields 20 quadrillion operations/second.

Dispensing with calculating potentials of human brains, Kurzweil proceeds to spell out where computers have been and where they are headed. Supercomputer speed increases as development time shrinks, suggesting on-going trend potentials (within the physical limits of physical constants, as we know them). Kurzweil starts with a baseline of 2 billion computer calculations per second in 1997, assumes that speed doubles every year, and calculates that 23 interim doublings indicate speeds of 20 quadrillion by 2020. That's how Kurzweil arrives at supercomputer capabilities similar (if not equivalent) to human brains within 20 years. Considerable controversy rages around Kurzweil's technological optimism.

4. SATELLITE COMMUNICATIONS

The 1990s have been characterized as the era of optical fiber. The next several decades may be touted as the era of wireless communications. By 2005-2007 satellite service improvements, coverage and cost will encourage widespread use of this mode. Early use is largely taken up by commercial users. Consumer use will follow as costs drop. Some indicators of this trend:

-- Commercial satellite operations in 1998 included 1,700 payload launches. Commercial satellite launches over the next 10 years were valued at $140 billion worth (May 1999). Additional cost for launch systems and ground services were tagged at $70 billion.

-- Mobile and cellular phone subscribers, growing by leaps and bounds, could reach 32 million by 2007, generating $31.6 billion annually in revenues.

-- Annual revenues from telephone services, high-speed internet access, and imaging expected to be generated by satellites during 2008 were expected to reach $150 billion. [International

Space Business Council estimate.]

-- US commercial satellites, 200 of the 500 in orbit during 1997, were estimated to be worth at least $100 billion.

Satellite receivers initially were prohibitively costly and beyond consumer reach. Receiving antennas were so large and unsightly that zoning laws and nuisance restrictions barred them from use in residential neighborhoods. Smaller and less unsightly parabolic dish receivers, measuring a foot or so in diameter, pose little objection.

The first Earth stations established in the 1960s cost upwards of $10 million. By 1963 versions measuring 100 feet in diameter cost between $3-5 million. Second generation stations available in 1975 brought dish costs down to $100,000. Upscale retailer, Neiman-Marcus' famed Christmas catalogue several years ago offered to install home satellite receiver dishes for $36,500. A short while later prices dropped to $10,000-$12,000. Currently, dishes measuring less than 3 feet in diameter can be purchased for about one hundred dollars.

5. WIRELESS AND MOBILE TELE-COMMUNICATIONS

Cell telephone technology was developed by Bell Laboratories during the 1960s. Commercial US cell phone operations commenced in 1983. Units were cumbersome, costly and subject to restrictive regulations. Cell phones costing as much as $5,000 in 1986 -- a rich person's toy, or conspicuous consumption novelty -- plunged to less than $100 today.

Economics play a key role in burgeoning wireless telecommunications growth. Installation costs are considerably lower than land-based lines. Tele-communication costs have dropped from stratospheric levels. A 3-minute phone call between New York City-London costing $245 in 1920, and $19 in 1950, was only 78 cents in 1999. Soon, a telephone call to anyone from anywhere will cost the same as local calls. Distance will not matter. Wireless communication cost-per minute dropped from 35 cents in 1998, to 27 cents in 1999, and 23 cents in 2000. The cost is projected to continue dropping from 21 cents in 2001, to 19 cents in 2002, and 18 cents in 2003 [The Strategis Group estimates].

Wireless and mobile communications devices of all kinds have come into their own. Unwieldy telephones of yesteryear have been replaced by featherweight versions with billions of times the capability of their predecessors. Cell phones weighing 4-5 ounces, pack the punch of a 1960s mainframe computer. Broadband system costs will come down, use will soar, and revenues will grow. Consumers will enjoy the added convenience of Internet and multi-media communications on the go.

Tele-communication handsets initially were designed and constructed to last 50 years. Today, handsets have relatively short life spans that no longer require "battleship specifications." User friendly operation, diminutive size, blinding and capacious sending and receiving rates, web browsing capability, rapidly changing designs, and new styles encourage rapid turnover of mobile handsets. Obsolescence is measured in months, not years. The turnover and replacement rate for 1999 stood at 40 percent. Industry analysts expect nearly 50 percent of handset sales to be replacement purchases.

Overall, the trend is toward a universal communicator, a single unit used for digital transmission capabilities ranging from voice to video. Coalesced units will operate as a video-telephone, fax machine, computer, and smart card module data base with all the data handling capability needed. Melding of multiple communications capabilities into mobile communications attracts mass consumer interest. As practical capabilities to access multi-media and web retrieval develop, growth will explode. Older single-purpose devices and systems will become obsolete.

Added convenience of being able to pull up bits and pieces "on the fly" makes a valuable addition to overall computer/digital capabilities. That capability should not be confused with an "open ticket" to becoming the platform of choice. Acceptance of web-surfing platforms depend, in large part, upon ease of use. Screen size and display capabilities pose a major roadblock to runaway use of hand-held diminutive screen devices for heavy-duty full-size screen tasks. Users may not like using one inch or other diminutive screen size to access Internet capabilities.

Powerful wireless phones and handheld or portable communication devices have been made possible by advances in materials sciences, especially solid state physics. Vacuum tubes the size of a potato shrank to peanut-size, only to be replaced by transistors. Next, transistors were miniaturized to the size of a fly-speck and densely packed into integrated circuits smaller than the size of a fly's wing. Miniaturization, lighter weight materials, and long-life batteries make the devices enticingly convenient and attractive. This trend of doing more with less is characteristic of most technological advance.

Digital optical broadband telecommunications offer advantages that totally overshadow copper lines. Signals don't fade (as they do with analog); are immune to static and noise interference; operate with lower energy demand; and transmit at rates far surpassing the capabilities of wire. Perhaps most important, broadband allows multiple users to utilize channels simultaneously.

Mobile full-time communication access is being nurtured from birth these days. Parents rely on continuous monitoring of babies left in their cribs by two-way radio transmitters. Teens and fast-trackers everywhere, wouldn't leave home these days without packing their mobile telecommunications device, whether it be telephone handset, personal communicator device, or other gadget. The modern world increasingly is bent on staying in touch.

Standard setting -- surmounting incompatibilities. Obstacles involve surmounting system incompatibilities, and moving beyond slow and prohibitively costly transmission rates. Competing operating standards are diverse and incompatible, in many instances. All of that is about to change.

Europe utilizes the most widespread digital protocol, the Global System for Mobile Communications (GSM). Harmonization of operating protocols enabled the leading mobile systems companies in Europe to plow straight ahead forthright. The result was that Vodaphone, Ericsson and Nokia acquired market domination. Mobile-phones achieved highest penetration levels early-on in Europe (63 percent). Scandinavian nations achieved the highest market penetration anywhere, reaching 100 percent among teenagers. Some major metropolitan areas in the US have reached penetration levels approaching those in Scandinavian nations.

American cellular and personal communications services (PCS) squabble among themselves and jockey for position. Basically, three different digital wireless telephone technologies vie for market share: CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access), and GSM. CDMA involves three additional protocols. CDMA One (widely used for cellular phones), CDMA 2000 (eight channel capacity), and WCDMA (Wideband CDMA for speediest data handling). CDMA uses two air interface standards: cellular (824-894 Mhz) and PCS (1850-1990 MHz). Further complicating matters, other standards apply to network interfacing, service options and performance standards. Special interfacing adaptations enabling telecommunications to operate on all three technologies have been developed – at a cost.

Underscoring the importance of operating standards, other protocols dealing with optical transmission systems also jockey for position and dominance. Competing standards -- not interoperable -- for the new G3 broadband systems pose problems including: wavelength division multi-plexing (WDM), and dense WDM (DWDM), and synchronous optical network/synchronous digital hierarchy (SONET/SDH). Setting compatible operating systems is crucial to growth of these new modes.

Bringing the Internet to wireless communications devices represents another problem involving competing standards. Wireless Application Protocol (WAP), and Bluetooth have been put forward. WAP is an open system but it requires that web pages be written in wireless markup language (WML), not hypertext markup language (HTML) typically used on the Internet

A single uniform standard would greatly advance commercial development. As major players vie for position, such squabbles are not uncommon -- in any industry. Incompatible systems and interfaces have plagued many emerging technologies, ranging from railroad track sizes to fire hydrant couplings, nut and bolt thread-sizing, or VHS versus Beta videofilm. The begrudging path to settling uniform standards hallmarks most competitive new technologies.

6. BROADBAND DIGITAL TECHNOLOGIES

Melding of information and communication technologies creates a new force -- tele-power -- that is the driving force of global change. All-purpose personal communicator systems geared to societies "on the go" involve multi-functions: cell phone, e-mail capability, PC, web surfer, fax, video-television, picturephone, AM-FM radio, global positioning system, and so on. "Teleinformatics," "telematics," and other new words have been coined to convey the coalescing of television, telephone and telecommunications of all kinds, with computers, data processing terminals, facsimiles and other elements of the micro-electronics explosion.

Bottleneck to the newest generation of digital communications needs is the lack of bandwidth in existing systems. Broadband involves communications channels handle frequencies above the narrow bandrage of voice frequencies, thereby enabling many simultaneous voice or data transmissions at high speeds. In an age of multi-media signal handling, such a communication "pipeline" becomes imperative.

Although prodigious teraflop transmission rates are coming, how soon will those capabilities be available to consumers? The answer depends, to a large extent, upon bigger "pipes." Telephone services, designed to carry short voice transmissions, fall woefully short of being able to handle prodigious amounts of multi-media digital data. Fortunes beyond belief are being invested by telecoms, wired and wireless providers, cable servers, television broadcasters, satellite systems, even radio, microwave and a host of other carrier/transmission technologies. Titanic dimensioned struggles are underway. Vast fortunes have been waged on these technologies. Many have been lost. Timing is everything, as the saying goes.

A new generation of wireless service (third generation - 3G) is being modified to handle transmission rates of up to 384 kilobits per second in wide area coverage, and 2 million bits per second in local areas. European and Asian nations enjoy a leg up with their greater use of wireless technologies. Experts place the US as much as 10 years behind other post-industrial nations in adopting these technologies. US conversion to 3G broadband technologies is not expected until 2005.

Coalescing of information technologies. Universal "digital language(s)" encourage melding of communications functions and purposes. Communications of all kinds -- computers, consumer electronics, information, education and entertainment sectors -- are all evolving, albeit slowly, into one seamless communications web. Boundaries disappear between: voice and data, wireline and wireless, voice to text, and text back to voice. A single interactive information industry, based on standardized interfaces, was expected to generate >$3.5 trillion in revenues by 2001.

Television's commanding 99 percent US household penetration make it a strong candidate for morphing into the unified household information appliance of the future. Federal Communication Commission rules requiring the change-over from analog to digital signals by 2006 lend encouragement to that end. It isn't the only mode in the running. Indicative of these rivalries, television set sales were surpassed by computer sales during 1993.

7. INTERNET AND WORLD WIDE WEB

Interconnecting computers began in 1969 with a hookup of four computers. Developed by the Defense Department's Advanced Research Project Agency (ARPA), the system existed until 1990. By 1971 things hadn't changed much, a mere 15 sites with 24 connected computers were operational. The milestone event in 1972 was the first electronic mail exchange between two computers by Ray Tomlinson who also established the @ signage icon. By 1974, 62 computer were hooked up. Seven years later (1981), there were 200, and 500 computers in 1983, then 28,000 in 1987.

During 1989, the World Wide Web (WWW) was created at the European Center for Nuclear Research (CERN), a Geneva-based Particle Physics Lab, by Tim Berners-Lee. This breakthrough made multi-media available on the Internet in August 1991. During the early-1990s, WWW opened to commercial uses. Less than 1 million users were online in 1991. The turning point for opening up the web was laid in 1991 when the first web browser or software was released. During 1993, the National Center for Supercomputing Applications released versions of Mosaic, the first graphical web browser for Microsoft Windows (developed by Marc Andreesson at the University of Illinois). Now marketed as the Netscape browser, this system facilitated navigating among the multi-media offerings. The Netscape Navigator browser was released by Netscape Communications in 1984, and host computers or servers swelled to 3 million. Users jumped to 28 million in 1996, 57 million in 1997, and 97.2 million in 1998. High tech enthusiasts insist that one billion users is big enough to dub the virtual world of the Internet as the eighth continent!

Not only has the volume of Internet users grown by leaps and bounds, but the kinds of digitally-dense transmissions (graphic material, streaming video, and so on) impose huge demands in carrying capacity. Telephone lines, that still carry most of the Internet traffic, are reaching limits of their carrying capacity. The infrastructure is rapidly being converted to broadband information-carrying pipelines of vastly increased capacity. As the quality, speed, clarity and low cost of the new mode take hold, consumers will switch over in droves.

CONCLUSION

Propagation and dissemination of digital communication of all types is becoming accessible to anyone and everyone, anywhere and anytime – for a price. Faster transmission rates and increasingly powerful computers propel development. Rapidly improving satellite communications, wireless and mobile communication devices, broadband, digital technologies, and internet resources constitute the communication backbone. Territorial constraints and time of day no longer limit communications. "The Death of Distance: How the Communications Revolution Will change our Lives," written by Frances Cairncross, captures the nature of wrenching changes underway. Mind-bending potentials of artificial intelligence loom as communication changes reach toward surpassing human brain power. Perhaps one day far off, ESP will virtually moot the entire panoply of “traditional communications technologies.” Time will tell.

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Word Count: 5,963 en toto