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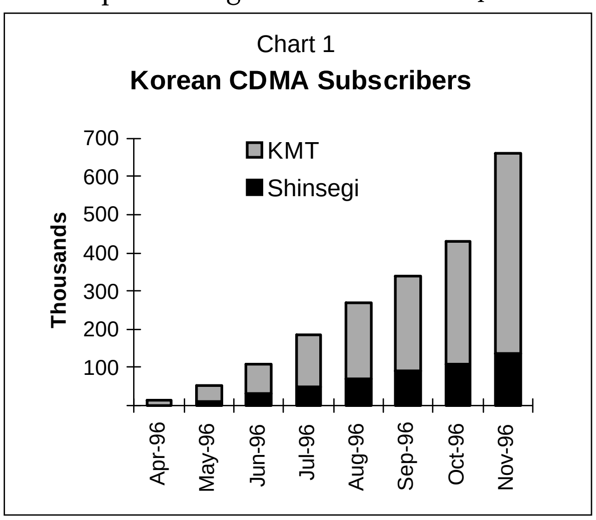
TELECOM COUP: OVER THE PARADIGM CLIFF

CDMA—long declared by its avid critics and shortsellers to be a technology scam—finally prevailed in wireless telephony.

As the "laws of physics" shattered, shortselling scientists gasped and rushed for cover. A dark cloud descended upon the telecoms of Europe. The chief technical officer of **AT&T Wireless** (T) reached glumly for his checkbook and contemplated the possibility that he had led his giant company into a disastrous deadend.

Just five years after going public in one of the great entrepreneurial success stories of the epoch, **Qualcomm** (QCOM) began posturing like a new **Motorola** (MOT). Motorola, **Lucent** (LU), and **Nortel** (NT) became as perky and passionate as new startups. Allen Salmasi, Qualcomm founder now running **NextWave**, a tiny new firm that bet $4 billion in the spectrum auctions, began declaiming like the next Theodore Vail.

Meanwhile, John Malone could entertain vast new prospects of Internet, teleconferencing, and multimedia trade for **TCI** (TCOMA) and other cable companies long in the doldrums. Lofted too were all the spearheads of the World Wide Web, from **Netscape** (NSCP) to **Silicon Graphics** (SGI), **Macromedia** (MACR) to **Oracle** (ORCL), **Sun** (SUNW) to **Corel** (COSFF) that had bet their futures on the early availability of broadband links to homes.



That's what happens when the world rolls over a paradigm cliff. It is a time when stock values, company strategies, and even national industrial policies meet their moments of truth and consequences.

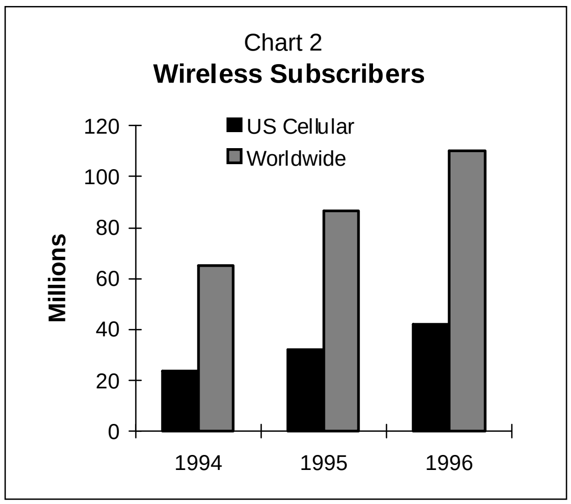
The seismic events occurred on opposite sides of the globe–in Seoul, Korea, and in Anaheim, California. In Seoul, the new digital cellular technology, CDMA (Code Division Multiple Access)–long declared by its avid critics and shortsellers to be a technology scam in "violation of the laws of physics"–finally prevailed over its rival TDMA (Time Division Multiple Access) in wireless telephony. Long the chief opponent of CDMA, **Ericsson** (ERICY) of Sweden gulped, launched a suit against Qualcomm, claimed to have invented code division in the first place, and ceded its superiority for data. Defying a nondisclosure agreement signed in 1989 that acknowledged Qualcomm's proprietary technologies in all the relevant areas, Ericsson unleashed its lawyers in a comic campaign to reinterpret as Qualcomm showstoppers an array of nine Ericsson TDMA patents that never mention CDMA or its generic name, spread spectrum. This did not surprise me. When I spoke to Ericsson executives at an exquisite sylvan retreat outside of Stockholm on May 13, 1991, they had never even heard of the CDMA technology that I was already touting.

By 1996, it was too late. The sphere had shifted, rendering Qualcomm central and Ericcson peripheral to the new era of wireless. Korean companies announced successful deployment of some 700 thousand Code Division Multiple Access phones based on Qualcomm licences. **Korea Mobile Telecom** (SKM) reported that the CDMA system

The CDMA system outperformed both analog and GSM phones in capacity, uptime, voice quality, and power usage.

outperformed both analog and GSM phones in capacity, uptime, voice quality, and power usage, and raced to raise their network capacity to over a million subscribers by the end of the year. Then came **PCS PrimeCo**, a partnership of **AirTouch** (ATI), **Bell Atlantic** (BEL), **NYNEX** (NYN), and **US West** (USW). One of the US PCS auction leaders, with 57 million mostly urban POPs, PrimeCo announced that it was up in 16 cities, beating AT&T's TDMA to the punch in PCS (the new cellular standard at 1.9 gigahertz). In Hong Kong, **Hutchison** executives declared that their 100 thousand CDMA phones, all crammed into one 1.2 megahertz channel, were also outperforming GSM or TACS (the European analog standard). Everywhere, CDMA was between three and six times more efficient in the use of spectrum and hundreds of times more efficient in the use of transmitted power.

CDMA thrives in the noisy environment of cellular and PCS wireless communications. But in a genuine upset, CDMA also is likely to prevail in the grossly noisy bottom span of spectrum between 5 and 42 megahertz in cable TV coax. Channel one of cable TV begins at 54 megahertz. Below it are some 40 megahertz of potentially usable spectrum afflicted with ingress noise from garage door openers, hair dryers, and hundreds of other vibrating devices. Today, therefore, this bottom twenty megahertz of frequencies in cable are not used at all, and the twenty megahertz above them serve for narrowband upstream telemetry links to cable headends. In the prevailing industry view, these 40 megahertz will be useable for upstream Internet data only after upgrades that are estimated to cost cable companies more than $20 billion.



At the Western Cable Show in Anaheim, however, **Terayon Corporation** of Santa Clara demonstrated a technology that can use these fraught frequencies to transmit as much as 60 megabits per second of data upstream in ordinary cable TV plant without any upgrades at all. Terayon's secret? It's CDMA. At Anaheim, a constant stream of visitors watched as for two days the Santa Clara firm demonstrated simultaneous video conferencing, video multicasting, and Internet access in the face of impulse spikes, narrowband interference, and other ingress noise that would cause unacceptable degradation with ordinary cable modems. Thus in one technological coup, Terayon increased the number of homes eligible for fast Internet cable service from some 10 million to over 60 million. **Cisco** (CSCO) has purchased 20 percent of the company, which currently claims a backlog of 100 thousand orders for its CDMA system.

In one month, this esoteric way of transmitting data, long dismissed as a broadband pipedream, derided as a Qualcomm scam, lambasted as snake oil, transformed the technical horizons of both the global cellular and cable industries. CDMA is not merely a clever way of sending bits through the air; it expresses a new spectronics paradigm. In it, the differences between wired, fibered, coax, and wireless technologies are dwarfed by their similarities. Wireline links turn out to be electromagnetic waves insulated by plastic or rubber. Wireless links are just electromagnetic waves insulated by air. As the industry moves to digital, paradigms turn, and worlds collide and converge.

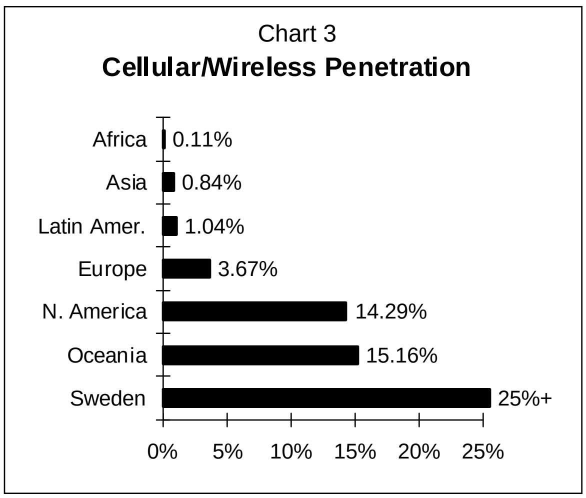
The key to paradigm shifts is the collapse of formerly pivotal scarcities, the rise of new forms of abundance, and the onset of new scarcities. Successful innovators use the new forms of abundance to redress the emergent shortages. For examples, explored in earlier newsletters, the industrial revolution saw an abundance of watts, plummeting in price, used to overcome shortages of labor and natural resources.The microprocessor revolution, marked by the plummeting price of transistors, saw the use of MIPS and watts, switches and power, to redress the scarcity of bandwidth. The new paradigm, foreshadowed by Claude Shannon in 1948, sees the use of abundant bandwidth, at ever higher frequencies, to compensate for newly scarce power and switching.

In a world of billion transistor microchips the idea of a switching shortage seems bizarre. It arises because the entire world is being connected to the Internet, almost at once, while the terminals double almost yearly in processing speed and memory, graphics capability and communications power. The complexity of a network rises by the square of the number and power of the terminals attached to it. This means that universal networks of billions of terminals will require more than 10 to the 18th connections and those links will be loaded with ever more variegated and demanding bitstreams.

But for one basic constraint, Moore's Law might surmount this challenge. That one constraint is: time. Time has many faces–time to market, turnaround time, network delay, memory latency, time to retirement, time to metastasis. But all reduce to two key constraints: the speed of light and the span of life. The speed of light is the basic scarcity in electronic engineering and computer science. Electronic charges move just nine inches a nanosecond and cross the continent in 30 milliseconds, while new microprocessors cycle in less than two nanoseconds and take as long as 50 nanoseconds to access working memory. Dictating that processors spend most of their time waiting on memories, local or remote, these limits shape and constrain the future architectures of computers and networks, routers, adapters, and telephone central switches.

The span of life–programmer years–determine the ability to execute complex switching schemes in software as these billions of terminals perform trillions of interrelated transactions. Exacerbating all these complexities is mobility: the terminals increasingly will move. They will not be tethered to the industrial power grid or the local area network. They will rove the reaches of the electromagnetic spectrum.

Remember, the most common PC of the new paradigm will be a digital cellular phone. It will be as mobile as your watch and as personal as your wallet; it will recognize speech, it will navigate streets, it will collect your mail and your paycheck, it will conduct transactions. It will command an Internet address and a Java runtime engine. It will link to a variety of displays, keyboards, and other input-output gear through radio frequencies and infra-red pulses. Every device will be able to link to every other one, like a telephone. But unlike a telephone it will have to manage not a homogeneous flow of 4 kilohertz voice signals, but a variety of synchronous, isochronous, and asynchronous bitstreams and bursts, requiring constant bit rate, variable bit rate, and available bit rate transmissions, broadcasts and point to point links, all with different protocols, error rates, and other constraints.



Wirelessly linking these machines to the increasingly unlimited bandwidth of fiber optics is the basic challenge of communications for the new epoch. Cleaving the world of wireless is a seething debate between advocates of TDMA, led by Bill Frezza, and of CDMA, led by Ira Brodsky, that can be sampled in all its fine fury and narrative heat at http://www.cmp.com/cgi-bin/techtalk/cdma.html.

As the plot thickens and races toward its denouement, the issue reduces to the question of what is scarce and what is abundant. In systems linked to the industrial power grid, the answer is that power is abundant everywhere but in satellites and at the bottom of the ocean. Using abundant watts as a replacement for scarce bandwidth, you get broadcasters blasting complex images across single spans of long wave spectrum. You get cellular systems with one base station every thirty miles and with each radio tied to one exclusive span of frequencies. You get computers and other appliances all constantly wired and plugged in. Using transistors as a replacement for bandwidth, you get the Public Switched Telephone Network, with millions of four kilohertz wires linked to massive switches and fiber used at about a millionth of its potential capacity. You get the 28.8 modem, the celebration of narrowband ISDN. You get 8 kilobit vocoders for cellular that give voice quality inferior to wireline. You get 384 kilobit video teleconferencing inferior to NTSC television.

In a world where several companies have demonstrated terabit per second transmissions in a single fiber thread, you get an entire worldwide communications net that carries a rough total of just one terabit per second. Everywhere you look you find capacity expanded through TDM (Time Division Multiplexing), by compressing messages into ever smaller time slots and spans of spectrum in both wired and wireless telephone networks.

With the rise of data, bursty and elastic, however, TDM breaks down. The pattern of data transmissions will rarely correlate with the pattern of narrowband time slots, while broadband time slots mean long access delays. A burst might well overflow a particular slot, while allowing a long series of slots to pass by unused, like so many empty freight cars on a railroad track. The recent history of networking represents a steady flight from the TDM systems of the phone companies toward ethernets, frame relay, asynchronous transfer mode, and the Internet. Using forms of shared bandwidth resembling CDMA, all represent ways to avoid the inefficiencies of TDM systems optimized for voice.

None the less, when the phone companies around the world contemplated the problem of digital cellular, they naturally inclined toward time division multiplexing. It was deterministic, it was familiar and it worked wonderfully on wires. These same companies gravitated toward the lowest possible spectrum bands, which could penetrate and circumvent obstacles, and used high levels of power to economize on base stations. Assuming bandwidth scarcity, they designed systems with vocoders that yield voice quality inferior to wireline, and thus prevent wireless from escaping the gilded ghetto of mobile-phone niches. The result is that US wireless systems, though claiming "penetration" of 14 percent, actually command a market share of total telephone minutes of under one percent.

Urgently needed for a decade has been a wireless telecom strategy and technology adapted to the pattern of abundance and scarcity of the new era. Ultimately it should offer service as cheap and clear as wireline, far more convenient, and readily us-

Terayon demonstrated a technology that can transmit as much as 60 megabits per second of data upstream in ordinary cable TV plant without any upgrades at all.

CHIPS FOR SALES AND CHIP SALES

Chart 4

Credit, Debit and Smart Cards

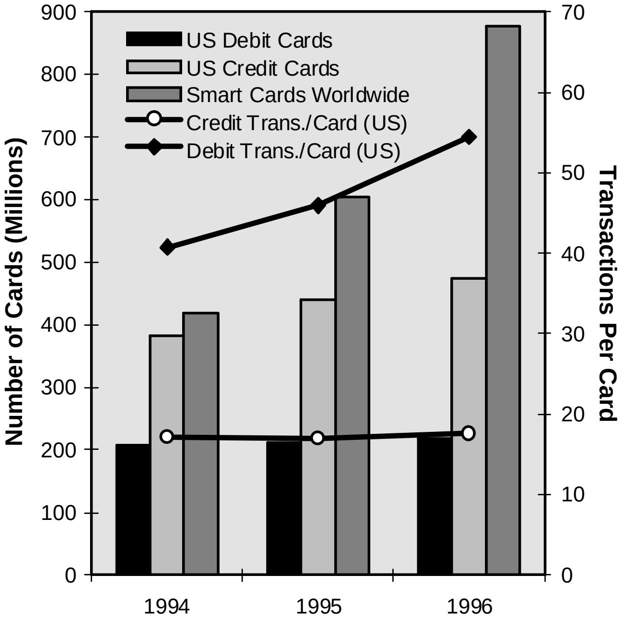
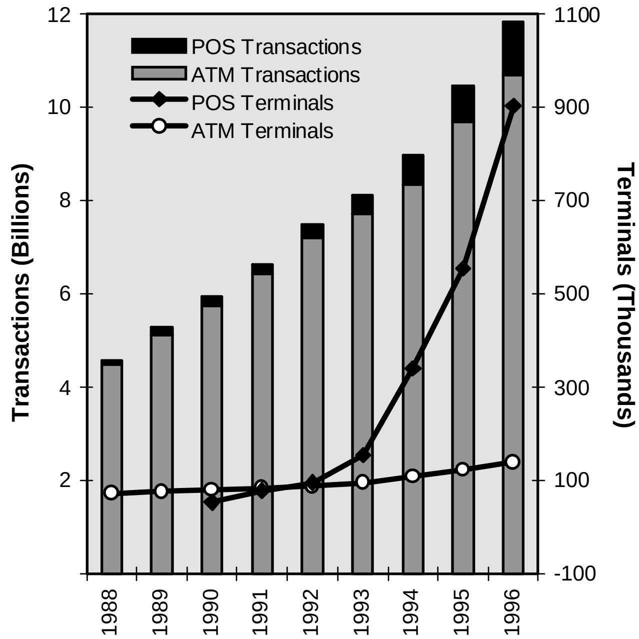


Chart 5

Electronic Funds Transfer



Insert a plastic card, enter a password and a generic network computer reconfigures to your personal desktop settings with access to your own files and applications; or a borrowed wireless phone instantly awakens to accept incoming calls to your personal phone number and bill calls to your account; or you pay for the subway, lunch, downloaded news, entertainment or software–these are some of the coming applications available with smart cards (credit card sized plastic cards which incorporate a silicon chip providing for memory and/or processing capability). More common in Europe than the United States, smart cards are already being used to pay for phone calls, pay television services, provide health care information and identification, and as more secure bank cards. The most far reaching benefit lies in reducing the cost of transactions. Electronic cash moving from smart card to smart card indefinitely without a need for credit or debit balance verification speeds transactions and drastically reduces transaction costs. Low transaction costs–some say potentially even lower than the cost of cash handling–in turn allow for smaller transaction amounts in person or across the net. ***Chart 4*** *shows the number of smart cards worldwide compared to credit cards (Visa, MasterCard, American Express and Discover) and debit cards in the United States. Although the number of credit cards is increasing at a faster rate than debit cards the number of credit transactions per card has remained flat while debit card use has climbed. While the number of US ATM terminals continues to slowly rise, there has been an explosion of Point of Sale (POS) terminals and increases in POS transactions (****Chart 5****).*

*The 1H96 drop in DRAM chip sales, despite growing demand for bits, that resulted from the transition from 4Mbit to higher density 16Mbit chips was reversed in 3Q96 as DRAM bit demand soared even higher and chip sales climbed back above 4Q95 highs (****Chart 6****).*

*In the 3Q96, the DSP market continued its uninterrupted growth with dollar sales for the first three quarters of 1996 surpassing the total for 1995 (****Chart 7****).*

–KE

Chart 6

DRAM Chips and Bits

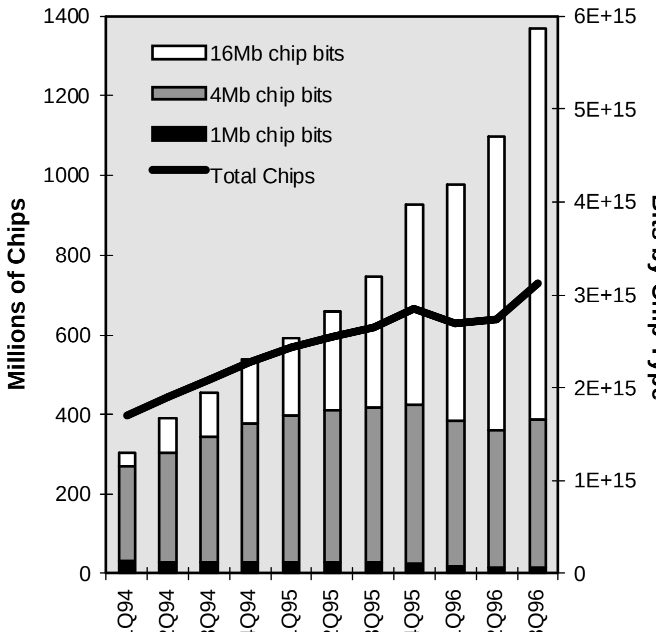


Chart 7

Worldwide DSP Market

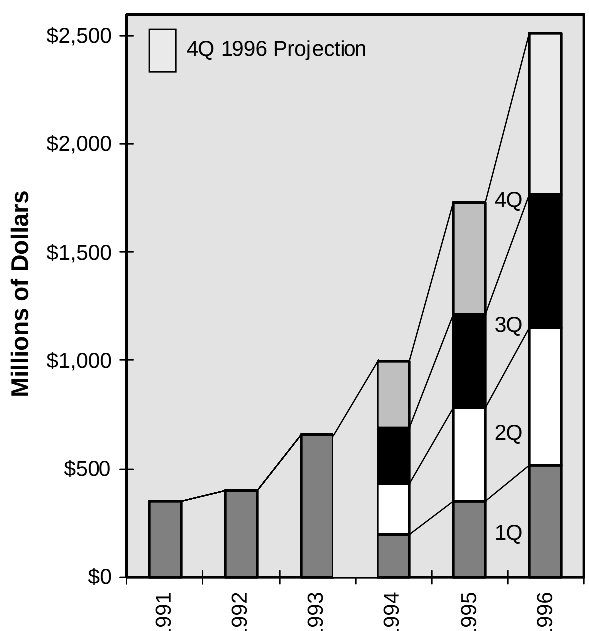
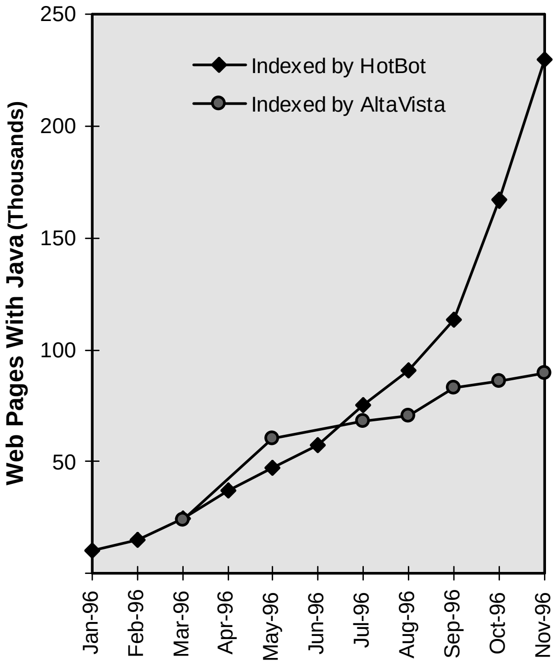


Chart 8

Javatized Web Pages



*The number of web pages containing Java continues to grow. **Chart 8** updates our previously published data on the number of documents containing Java applets indexed by the Alta Vista search engine and shows the seemingly more dramatic rise in Java pages indexed by the rival search HotBot. The difference may be attributed to HotBot's much larger index size of more than 54 million documents (0.43% Java) compared with Alta Vista's 26 million (0.35% Java).*

*With Cox Communications' Cox@Home service roll-out in Mission Viejo, CA, Comcast@Home in part of Baltimore, MD, TCI@Home in Sunnyvale, CA, US West TeleChoice in Omaha, Neb, Cablevision Systems' Optimum Online in Oyster Bay NY, Adelphia in Toms River, NJ, and the Wave roll-out across Canada the number of homes within the service area of cable systems offering broadband Internet access continues the dramatic rise begun with the announcements of the first commercial services in September (**Chart 10**).*

Chart 10

Cable Modem Availability

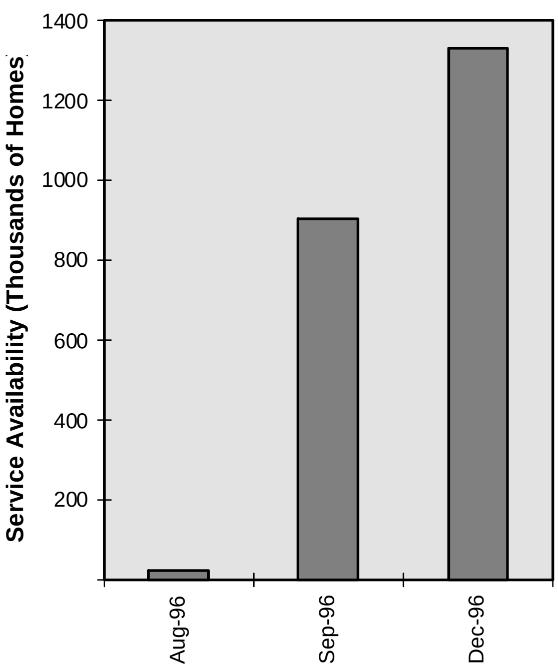
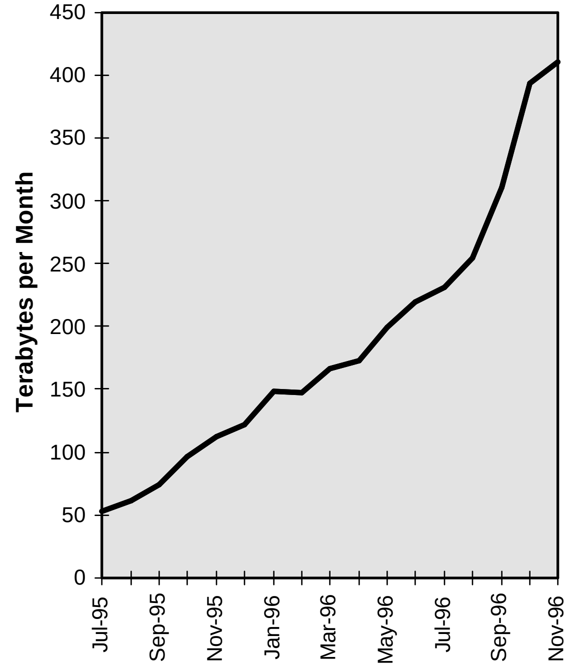


Chart 9

Internet Traffic



*Internet Traffic flowing through major exchange points (NAPs and MAEs) followed previous years' patterns with a slowed growth from October to November of 4.32% (**Chart 9**). Data for December, prior to the variable of a traditional holiday dip, shows a potential December increase of 10% to 15%. Thus, in the year since Bob Metcalfe's prediction that the Internet would "catastrophically collapse" in 1996 it has instead grown by approximately 380% (more than 200% in the last six months).*

One year after Microsoft's belated announcement of its intention to pursue Internet business opportunities, it has indeed made progress. Free distribution of browser and web server software has increased Microsoft's browser share from about 6% to nearly 20%–all but eliminating non-Netscape competitors but only chipping at Netscape's share–and web server share (on the public Internet as measured by the monthly Netcraft survey) from 0% to nearly 10%. With 500 thousand downloads of beta version of the FrontPage web authoring tool and another 230,000 downloads (in the first three weeks) of the FrontPage 97 beta, demand has also been strong for free versions of Microsoft's commercial Internet products.

–KE

Chart 11

Microsoft One Year Later

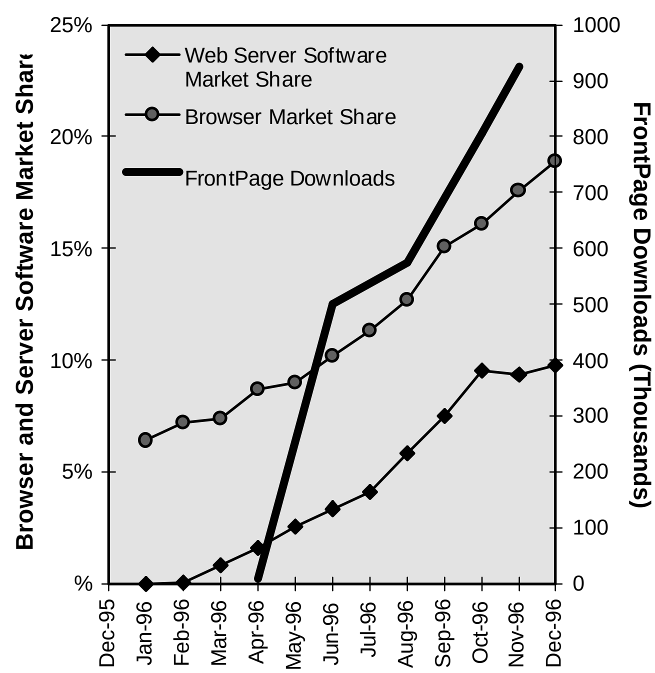


Chart 12
Fortune 500 on the Web

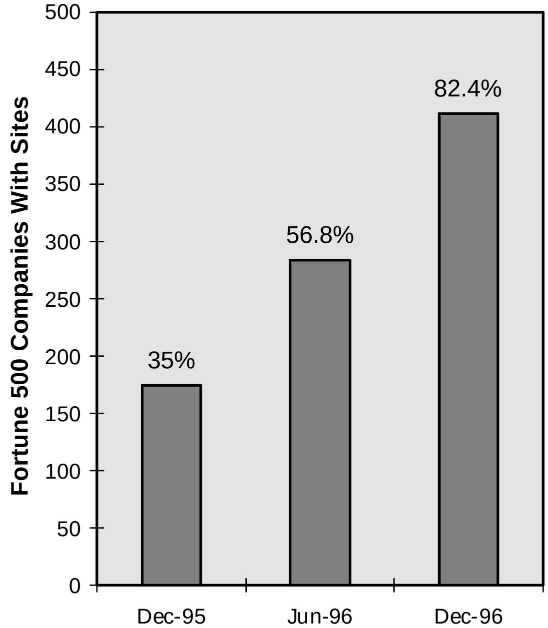
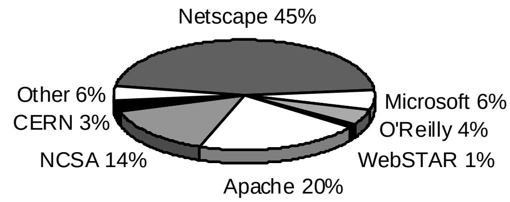


Chart 13
Fortune 500 Web Server Software



*According to GTG research completed on December 16, 1996, the number of Fortune 500 companies with web sites has risen to 412 (82.4%), up significantly from the findings of Zona Research just 6 months (284) and one year ago (175) (**Chart 12**). While the purpose of each site varies, from providing basic investment and press information to highly detailed product marketing information and sales, the result signifies the increasing adoption of the Internet as a basic component of business media strategy. Among the 412 sites, Netscape is the most popular web server software with 186 sites (**Chart 13**) and 13% contain Java.*

–KE

CDMA is not merely a clever way of sending bits. It expresses a new paradigm, anticipated nearly fifty years ago by Claude Shannon, the inventor of information theory.

able for data. It should join bandwidth abundance, gained through moves up spectrum, with a recognition of power scarcity as the prime problem of wireless, and it should focus on Internet data as the ultimate market.

Incorporating the TCP-IP Internet protocols in every handset, Qualcomm's CDMA is the first such system. Because it threatened the old order, it evoked more furious and bitter resistance than any new technology since the VCR. As the author of books against feminism, I have met many hostile audiences in my time. But none raged as hotly as European telecom executives against CDMA.

The new CDMA paradigm originates with Shannon's demonstration that in sending information down a noisy channel, engineers face a tradeoff between power and bandwidth. Just as you can get your message through in a crowded room by talking louder, you can overcome a noisy channel with more powerful signals. This is the usual technique in TDMA, where narrow time slots are vulnerable to narrowband interference spikes and impulse noise. This paradigm I have termed "long and strong," exploiting long wavelengths and powerful transmissions using the scarce radio frequencies at the bottom of the spectrum. The long and strong approach seemed far more efficient than digital systems requiring complex manipulation of long strings of on-off bits. Many opponents of CDMA, such as Bruce Lusignan of Stanford, long questioned the desirability of going digital at all.

Ironically, however, the long and strong policy of economizing on spectrum led to using it all up. When everyone talks loud, no one can hear very well. Today, the favored regions at the bottom of the spectrum are so full of spectrum-hogging radios, pagers, phones, television, long-distance, point to point, aerospace, and other uses that heavy breathing experts talk of running out of "air."

As in wireline, engineers responded to bandwidth scarcity by TDM, chopping up the existing bandwidth into ever smaller time slots. Because the Europeans faced a babel of incompatible analog systems, the EEC moved first, mandating a digital TDM system called GSM. Because US wireless was thriving with a single analog standard, AMPS, the CTIA approved a similar TDM standard–IS-54–but required it to be compatible with AMPS. Thus on both sides of the Atlantic, the old wireline paradigm of TDM prevailed as a remedy for scarce bandwidth.

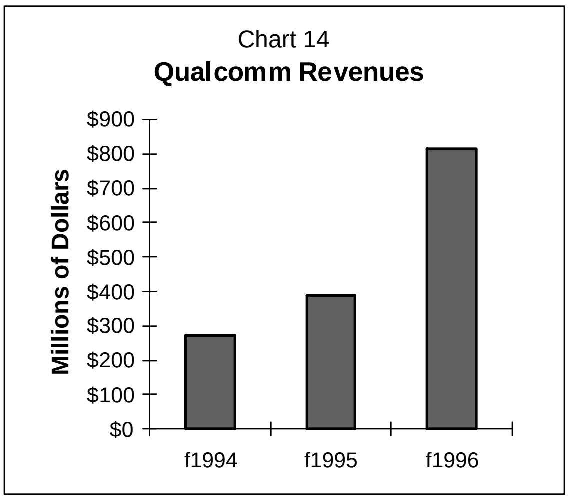
Bandwidth, however, has seemed scarce chiefly because governments regulate it as a national treasure. In fact, from DC to daylight, the electromagnetic spectrum is essentially infinite. Using smart radios soon to come from **Steinbrecher-Tellabs** (TLAB), basestations can be compressed to briefcase size and cells can be created everywhere. New smart antennas introduced by **ARRAYCOM** and other firms allow you to devote dedicated spectrum to each call, rendering moot the difference between wireline and wireless. If spectrum is not inherently scarce, it makes no sense to chop it up into time slots optimized for voice.

Impelling the microprocessor era was the recognition that as more transistors were crammed together on a chip, they did not become hotter and more fragile, as previously believed; instead they ran faster, cooler, cheaper, and better. Similarly, the spectronics era feeds on the recent recognition that as systems move up spectrum to higher frequencies they do not necessarily become more expensive, power-hungry, and immobile. They use less power and smaller antennas, with lighter handsets, and offer less interference to neighboring cells. CDMA feeds on all these trends.

Shannon laid the foundations with a

counterintuitive and initially baffling redefinition of the nature of noise in a digital world. He showed that a flow of signals conveys information only to the extent that it provides unexpected data–only to the extent that it adds to what you already know. Another name for a stream of unexpected bits is noise. Termed Gaussian, or white noise, such a transmission resembles random "white" light, which cloaks the entire rainbow of colors in a bright blur. Shannon showed that the more a transmission resembles this form of noise, the more information it can hold.

Shannon's alternative to long and strong is wide and weak: larger spans of bandwidth at lower power. In this paradigm, almost everything you learned in analog cellular is wrong. That's why the analog experts throw up their hands and mumble imprecations to the laws of physics. For example, digital requires signal to noise ratios some ten thousand times (40 decibels) lower. Digital improves by the square of the bandwidth, while analog improves only by the logarithm of the bandwidth. Analog benefits from improvements in signal to noise ratios that make no difference at all in digital, where a bit is a bit no matter how loud. But digital can benefit far more from increases in the span of frequencies (more bits). Indeed, even for point to point links, Shannon showed that sending a T-1 signal (1.544 Mbps) over a 200 kilohertz channel (the size of a GSM slot) requires more than 100 times (21 decibels) the signal to noise ratio of a channel six times as large: i.e. a Qualcomm CDMA channel. In other words, because of greater vulnerability to noise, breaking up the message into six slots requires 100 times as much power as spreading it across 1.2 megahertz.



This is the secret of CDMA or spread spectrum communications. You create a pseudo noise code consisting of a stream of bits that resembles "white noise" and use it to spread out the signal across a broad band of spectrum. At the receiver, you use the same noise code–inverted so every one is a zero and zero a one–to multiply across the spread signal. This despreads the signal. As a result, the message, now monopolizing the transmitted energy, pops out of the noise, like a color popping out of white light in a prism.

The magic of it is that in *despreading* the desired message and popping it up above the noise level, the inverted pseudonoise code at the receiver also *spreads* the actual noise, spikes and ingress, and sinks them below the noise level. Other spread messages in the band merely represent a small increment of white noise. Thus, all callers can use a single frequency band at once. The addition of new callers merely raises slightly the overall noise level.

As data increasingly eclipses voice as the dominant use of networks, TDM has given way on wireline networks to more flexible systems, such as frame relay, which average out the flows of information on the network. The supreme averaging system is CDMA which uses all the bandwidth all the time. Rather than isolating the signal in time and in frequency space as TDMA does–thus rendering the message vulnerable to narrowband spikes of noise–CDMA takes the opposite tact. It transmits the signal all the time and uses all the frequency space, isolating narrowband noise in time and space.

Irwin Jacobs of Qualcomm uses a cocktail party analogy. In TDMA, each person gets to speak for a brief time. In CDMA, everyone speaks at once, using different languages. But there is a crucial caveat. This tactic succeeds only if everyone speaks at about the same volume. A stentorian guest will overwhelm everyone else. Thus the heart of the Qualcomm system is power control. Because all the signals use the same frequency, they must all reach the base station at the same power level.

CDMA is based on the assumption that it is easier to control power than to shuffle frequencies and time slots. Old paradigm experts, such as Stanford's Lusignan and Bill Frezza regard power control in a wireless environment as nearly impossible, while they see timeslot and frequency shuffling as a natural process. Frezza, for example, writes, "Coordinating the real-time transmit power of hundreds of roving users...reminds me of the guy on Ed Sullivan who used to spin dozens of plates on bamboo poles: Turn your back for a moment and you're screwed."

Yet power is a homogeneous force fully understood by engineers. Controlling it in fact is much simpler than moving among frequencies and managing time slots for many varieties of data. Qualcomm samples the power every 1.24 milliseconds and makes realtime adjustments. In CDMA, messages hide amid white noise, and only emerge when multiplied by the inverse of their code. Using bandwidth as a replacement for power and switching, CDMA is a wide and weak system that accords with the new paradigm of bandwidth abundance and power scarcity.

CDMA ends up using hundreds of times less transmit power than TDMA. Transmit power comprises some 25 percent of the power usage in a handset. Voice activity is another 30 percent. CDMA inherently captures for other uses every pause or silence in a conversation. Thus CDMA

In the new spectronics paradigm, wired, fibered, coax, and wireless technologies converge, with the differences between them dwarfed by their similarities.

ISPs TRIUMPH

Chart 15
AOL Subscribers

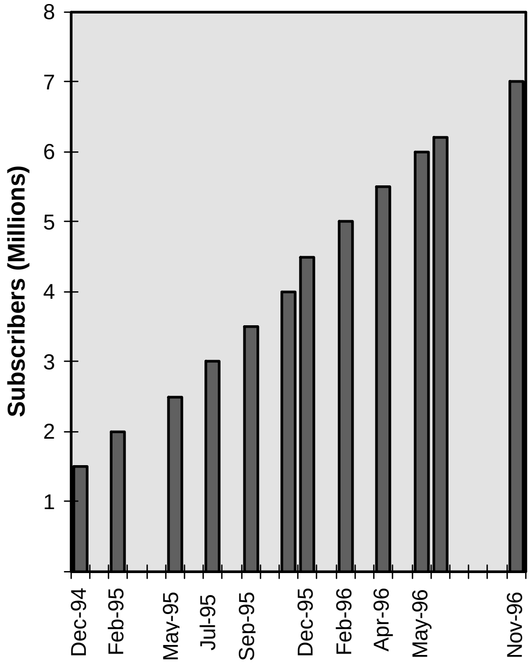
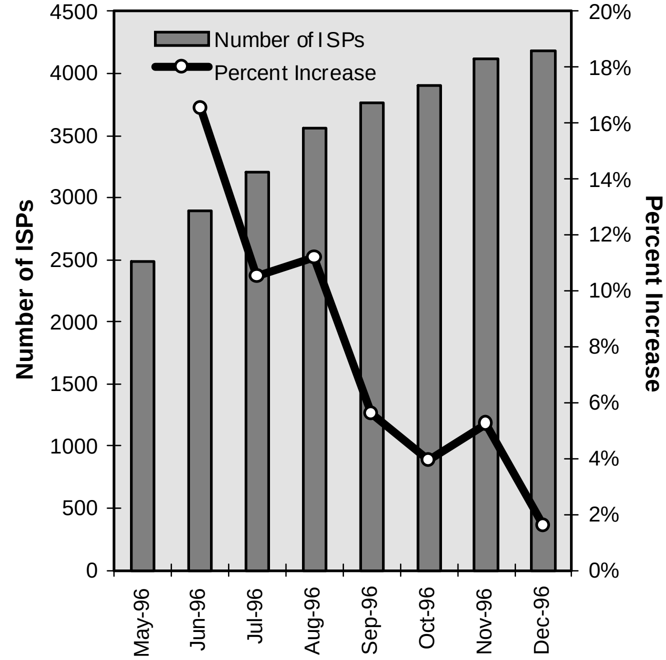


Chart 16
ISPs Worldwide



*The question was, "How can large expensive online services which charge the user per minute of connection time compete with hundreds and then thousands of Internet Service Providers (ISPs) which charge a cheap flat rate for unlimited Internet access?" Obviously they could not. One by one they fell or converted themselves into Internet based services, until only AOL remained aloof, managing to climb above 7 million members worldwide in November (**Chart 15**). Thus, it came as no surprise when AOL announced unlimited monthly access for $19.99, matching the rate charged by MSN and many ISPs and removing the last outward sign of the difference between AOL and the other access providers. Overnight AOL became the world's largest ISP. Meanwhile, the rapid growth in the number of ISPs registered on The List continues to slow (**Chart 16**) and we enter a new phase in which the ISP model is dominant over online services and ISPs begin their own fratricidal battle for dominance. In the new competition the players which offer reliability and–most importantly–high bandwidth will be the winners.*

–KE

batteries last at least 25 percent longer. Universal low-powered wireless communications become possible.

The increasing dominance of data clinches the case. Data bits already exceed voice bits on the wireline network in the US. With the spread of notebook computers and PDAs with radio modems, data will soon prevail in wireless as well. When that happens, CDMA will inevitably dominate because using all the spectrum all the time, it can offer bandwidth on demand.

The CDMA era will favor a new array of companies. The obvious wireless spearheads will be Qualcomm, Primeco, Nortel, Lucent, Motorola, and **Sprint** (FON), with NextWave emerging as the boldest pure play. Presuming that NextWave can get its auction licences approved by the FCC–it is falsely charged with being foreign owned–NextWave will command 110 million POPs in urban areas which it will service for marketing companies such as **MCI** (MCIC) that lack a wireless infrastructure. "AT&T will end up our biggest customer," says Salmasi, predicting the failure of their TDMA system. In the meantime, MCI has ordered 10 billion minutes of service.

On the wireline side, winners will include Terayon, TCI, **Comcast** (CMCSA), and US West and all the Internet and WWW companies that depend on a rapid opening of broadband connections. The cable companies who joined with Sprint in its PCS venture–TCI, **Cox Communications** (COX) and Comcast–can benefit both from wireless CDMA and Terayon's cable breakthrough. Overseas champions include chipmaker **Oki**, **DDI** (Japan's version of MCI), **Samsung**, **LG**, **Hyundai**, and Korea Mobile Telecom. Smaller companies include **Centennial Cellular** (CYCL) spreading CDMA through Puerto Rico and the Virgin Islands, **VLSI Technology** (VLSI) making CDMA chipsets, and **Wireless Telecom Group** (WTT) of beautiful Paramus, NJ, that provides CDMA testing gear. On the satellite front, **Globalstar**–a joint venture of **Loral** (LOR) and Qualcomm–promises to make the CDMA standard universal in the world, eclipsing GSM's one remaining claim of uniqueness, its coverage in 89 countries.

Although some of these firms are already highly valued, the market has yet to recognize that a fundamental shift has occurred. Many analysts think the TDMA/CDMA fight is a meaningless "religious war" and that GSM with its 25 million subscribers can still dominate. But with real wireless market share still well under five percent in telephony and under one percent in Internet access, the race has just begun. Listening to the technology, as Carver Mead advises, we hear a clear and resonant signal, amidst a shroud of artificial noise and litigious jamming; and that signal fortells the victory of CDMA.

George Gilder, December 21, 1996

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Editor: George Gilder; Associate Editors: Charles Frank and David Minor;
Director of Research: Kenneth Ehrhart.
Monument Mills P.O. Box 660 Housatonic, MA 01236 USA
Tel: (413) 274-0211 Toll Free: (888) 484-2727 Fax: (413) 274-0213
Email: gtg@gilder.com