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Metcalfe's Exaflood

There are really only two kinds of investment opportunities that yield outsized rewards–unforeseen or misunderstood technological breakthroughs and "risky" investments so contrarian as to look foolish at the time. By this standard this is a time of breathtaking opportunity across the Telecosm. But today, as on several occasions in the past three years, one opportunity reigns supreme…

The exaflood is coming. But Global Crossing is used to high water. There is no surer bet in the Telecosm.

In 1995, back in the antediluvian age of the 14.4 kilobit per second modem, the two megabit shared Ethernet local area network (LAN), and the 40 megabyte disk drive, Bob Metcalfe envisaged a catastrophe on the Internet. The Ethernet inventor and **3Com** (COMS) founder pointed out that the some 15 terabytes per month of Internet Protocol (IP) traffic on the public network at the time amounted to a mere bubble on the backplane of the 15 exabytes per month of Ethernet traffic then coursing through the LANs of the nation's businesses. As Metcalfe estimated, Internet traffic was then just one millionth of Ethernet traffic.

At the time I had no clear notion of what an exabyte was, so I looked it up. It is 10^{18} bytes, an inconceivable vastness, best measured in LOCs. At 20 terabytes or 20 million megabytes, the LOC has found favor as a unit of measurement designating roughly the contents of the Library of Congress translated into digital form. Since a megabyte sums up to around a 400 page book, a LOC comprises about 20 million big books. An exabyte is 50 thousand LOCs, which comes to a trillion big books. The 15 Ethernet exabytes would mean more than 15 trillion big books. Imagine a tower of tomes 200 million miles high, reaching twice as far as the sun.

I was a lowlander who eked out my living by puffing self-importantly into the sails of the Net's then meager vessels of Usenet news and email and bulletin board twaddle and declaring them an armada that would soon overthrow the empire of television. Metcalfe by contrast was an Olympian inventor and entrepreneur. Shocking was his image of these kiloLOCs looming over the frail defenses of the Internet, like the North Sea pressing against the dikes of Holland. Metcalfe wanted to know: What if all those Ethernets then only trickling onto the Internet through PC dialup modems began seriously to leak? What if they should burst through to mighty coaxial cables or T1 lines and pour their contents into the little T3 45 megabit backbones of the Net? It would drown. Glug, glug, gurgle, gurgle. We would see it no more.

Metcalfe was describing the *telechasm*. Lying between the Internet and the firewalled networks of the enterprise is a treacherous and turbulent area that remains the crucial obstacle to the fulfillment of the Telecosm. On the backbones of the Net is the

In This Issue:

immense potential bandwidth of wavelength division multiplexing; in the networks of the enterprise is the huge existing bandwidth of Ethernets moving from 100 megabits a second to gigabit speeds. But between the two is a world of pain, consisting of incompatible interfaces, internecine peering exchanges, proprietary protocols, egregiously costly access tools, arbitrary regulations, and bitterly conflicting network visions. Sometimes called the metro, sometimes the local loop, sometimes the last mile, sometimes the storage area network, sometimes the cable service area, its sclerosis today is the chief reason analysts speak of a bandwidth glut rather than an exaflood. In it, the existing mazes of routers and switches and SONET optoelectronics are too slow, costly, complex, and fragile to sustain the business plans of the Internet economy.

Yet SONET switches and add-drop facilities comprise more than half of the existing optical business for such companies as **Nortel** (NT), **Lucent** (LU), and even **Cisco** (CSCO). These companies represent perhaps 60 percent of the market for optical components from companies like **JDS Uniphase** (JDSU). Moving from the old topology of time division multiplexed (TDM) bandwidth to a new topology of networked storage and lambda connectivity, most of the industry must go over a cliff.

Nortel's investments eclipsed

Going over a cliff is no fun, even if you can buffer your descent with a hang glider, air bag, Gilder letter, or some other buoyant device, such as Geoffrey Moore's chasm theory. Between the existing hybrid network and the fibersphere to come is a region through which few companies will pass unscathed. The new all-optical network will be thousands of times more cost effective, but many of its crucial components have not yet been perfected. The first carriers that consummate the new regime will vastly outperform the carriers still saddled with the hybrid devices of the past. Until these systems are completed, though, with apparatus from **Corvis** (CORV), **Avanex** (AVNX), **ONI** (ONIS), **Sorrento** (FIBR), **LuxN**, and other wavelength multipliers, there will remain a nearly irresistible temptation to supply an array of makeshift comforts and prosthetics to the sinking ships and carriers of the old order.

Global Crossing, Williams, Level 3, and Metromedia Fiber suffer not from a bandwidth glut but from an accute dearth of connectivity

While the markets gag and gasp, Metcalfe's looming exaflood, meanwhile, ensures that eventually the slough will end in a bonanza for network suppliers and carriers—that the new lambda networks will be glutted with data. But as always there are no guarantees that any particular company will succeed. Contemplate the melancholy reflections of Carl Russo of Cisco/Cerent: "I think that the core backbone networks are coming along, but the rate of evolution is so fast…that you want to wait for a technological slowdown, so that you don't end up building a system with components that will be obsolete a few months after" you complete it.

"Just look at Xros," he said, "now owned by Nortel. They built a system based on components available 22 months ago and those components are now obsolete." One is tempted to say, speak for yourself Carl. But Nortel's desire to cross the chasm to the all-optical future prompted them to invest some $12.5 billion in Xros, Qtera, and Alteon, all visionary companies that were eclipsed by more adroit rivals such as Corvis, Avanex, and **Foundry** (FDRY). Thus Nortel had to write off this $12 billion of obsolescent "goodwill" along with $7 billion of other mishaps, just as Cisco had to write off its investment in Monterey and may well have to write down Cerent and scores of other acquisitions as well.

Data glut

Now prevalent on Wall Street is a belief that the world has too much optics, giving carrier networks a glut of capacity—that the "next generation" networks such as **Global Crossing** (GX), **Williams** (WCG), **Level 3** (LVLT) and **Metromedia Fiber** (MFNX) with their millions of miles of fiber were canine companies burying glass bones in a wavelength wilderness. These networks, however, suffer not from a bandwidth glut but from an acute dearth of connectivity, especially in metropolitan areas and enterprises where lurk Metcalfe's exabytes. Bogged down in costly and costive SONET optoelectronics that make it impossible to exploit the promise of wavelength division multiplexing, the older telco networks of the metro cannot link up the world's millions of businesses to the broadband backbones of the network core.

In order to bring about the kind of exaflood that Metcalfe envisaged six years ago—and end forever all talk of a bandwidth overbuild—the channels between business networks and the public network must be opened through the kind of cheap, passive lambda-based connectivity that is at the core of the paradigm.

The potential traffic can be quantitatively gauged. Let us use storage capacity as a proxy for the potential overhang between public and private networks. In 1995, according to **EMC** (EMC) estimates, the total storage capacity of the world's computers was some 200 terabytes, including a total of 75 terabytes at 9,000 mainframe sites. Then most disk drives were not connected to the Net. Today most are, and total storage capacity has mounted to ten exabytes or more, half-a-millionfold growth in less than a decade. In 1995, 95 percent of storage was analog (such as films, tapes and microfiche) and unsuited for transmission on the Internet. Today 95 percent of storage is digital, and with the onset of digital video disks (DVDs) and the dominance of CDs, most movies, music, and photographs are digital and web-ready. A single high resolution movie comprises about a 100 gigabytes of pictorial information. If every GTR subscriber were to watch just one, it would create nearly 400 terabytes of backbone traffic. Online storage of the some 52 billion photos snapped annually would require 26 petabytes. Sharing one in fifty of these photos with a friend or proud grandparent every month would roughly double traffic on the Internet.

Sorting, searching, managing, streaming, buffering and delivering these heterogeneous petabytes to customers when and where they want them is the key challenge of what we call storewidth. The interplay between storage and bandwidth, it will entail a huge new infrastructure of **Exodus** (EXDS) hubs, **Volera** (NOVL) caches, **Mirror Image** (XLA) content access points, **Scale Eight** global storage, **StorageNetworks (STOR)** services, and ISPs and Application Services Providers. All these facilities will become more crucial with the rising tides of the exaflood.

The new peer-to-peer

Joining this storewidth infrastructure in unleashing the exaflood is a newly ascendant architecture called peer-to-peer, which enables the ebullition of spontaneous sharing across the Net. As storage moves to the Net, computers and storage facilities increasingly interact as equals, as peers. Network attached storage itself, the industry invented by **Network Appliance** (NTAP), was primarily an effort to circumvent the bottleneck of client server architectures and ape the efficiencies of peer-to-peer. Peer-to-peer is not a substitute for an Exodus center but a complementary source of data traffic, storage, and technical management challenges.

In the antediluvian past, in order to pump gigabytes of data onto the Net, you needed a $50 thousand server with multiple ports and processors, threads, queues, and buffers, and with costly specialized disk facilities and databases. For many crucial functions, including rapid simultaneous downloads from high traffic sites, such architectures remain indispensable and will proliferate with Metcalfe's flood. But a Bear Stearns study on Internet Infrastructure by analysts Chris Kwak and Robert Fagin calculates that in January Napster's 65 million registered customers unleashed a tsunami of nine petabytes of MP3 digital music onto the Net, between one quarter and one half of all Internet traffic that month, with no such centralized functions at all. If Napster were built on a centralized model, it would have had to purchase over 5,000 F840 six terabyte Enterprise Filers from Network Appliance, at a cost of some $666 million to store all the files, and then purchase bandwidth at a cost of $6.7 million per month. But Napster centrally commands only a small disk space for pointers, addresses, and song lists; it uses the disk drives of its millions of customers as its storage facilities and pays not $666 million, but nothing at all. Although Napster ran afoul of the copyright law, the German giant Bertelsmann bought Napster and is aggressively adapting it for micropayments. Napster and its like will be back.

Driving peer-to-peer architectures is **Sun Microsystems** (SUNW), with their new open source JXTA protocol and Infrasearch technology, **Intel** (INTC) with its P2P Working Group of top industry companies, and **Microsoft's** (MSFT) .NET initiative that can release hundreds of new terabytes in new computer readable XML formats across the Net from the hundreds of millions of Windows computers.

In recent months, *Dynamic Silicon's* Nick Tredennick alerted me several times to the far-reaching implications of a company called **OpenReach** that was permitting the launch of peer-to-peer virtual private networks (VPN) from any personal computer. I nodded and proceeded on with Storewidth preparations. Then last week, Global Crossing announced that it was combining its "state of the art" global network services with OpenReach's premises-based VPN technology to deliver secure and cost effective data solutions for enterprise customers in Asia. The first trials will begin in Japan with Asia Global Crossing in the second half of 2001. With Sun, Intel, Global Crossing, Bertelsmann and possibly even Microsoft on board, the new generation of peer-to-peer technology is set to emerge as a huge source of new bandwidth demand.

In lower bandwidth forms, peer-to-peer was a driving force of computer networking from an era when time-shared mainframes gave way to minicomputers and Ethernets. With the onrushing abundance of bandwidth and storage, the new version of peer-to-peer can enable your PC to access the entire Internet, and most of its resources, as readily and intimately as its LAN.

With Sun, Intel, GX, and possibly MSFT, the new generation of peer-to-peer technology is set to emerge as a huge source of new bandwidth demand

That is, assuming that you can get a connection. Metcalfe's floods do not yet flow because the link between enterprise exabytes and the Internet core is still constricted. Wherever the link is supplied—as in the college campuses with rich connections used by Napster—the flood surges. *"Supply creates its own demand." "If you build it they will come." "You cannot build a bridge by counting the swimmers."* Still as true as ever, those supposedly discredited maxims of the price elasticity of demand for new communications bandwidth will guide any successful company in the Internet era. Remember, in both storage and communications, every one percent drop in price brings a three to five percent increase in unit demand. But remember also: *"Only connect."*

Who then should arrive at our door last week but this very same Bob Metcalfe, now a venture capitalist at Polaris in Boston. In tow he had a new company, **Narad Networks**, which proposes to open the channels between enterprise and Internet, unleashing the exaflood through cable TV systems, previously regarded a broadband option exclusively for homes.

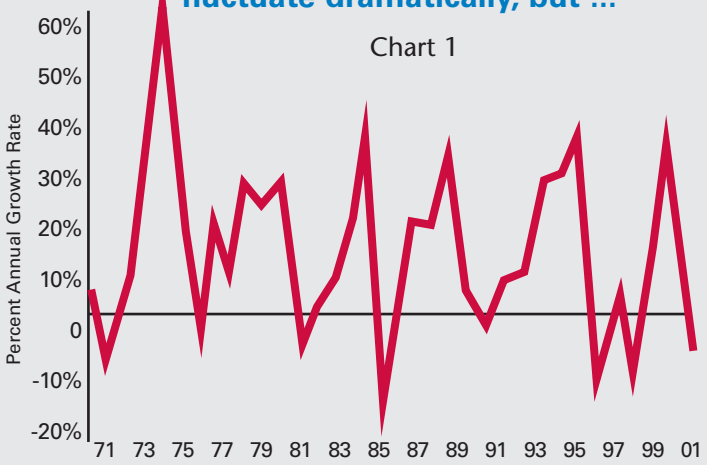
Narad doubles coax bandwidth

Direct fiber connections are still scarce and expensive. Afflicted by regulation and the meager capacity of the twisted pair copper medium, DSL struggles to provide sub T1 bandwidth at typical distances. Since the beginning ("Why Cable Will Win," *Forbes* 1990), our favorite residential access medium has been coaxial cable used for cable television. The reason was simple. Unlike the twisted-pair copper owned by your local telephone company, coax is inherently broadband. The potential of its currently usable spectrum is a gigahertz, which is a hundred-

MOORE'S LAW READIES SEMICONDUCTORS FOR

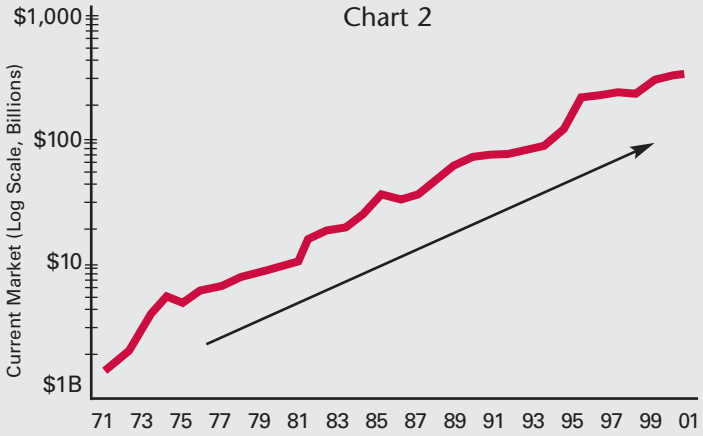
Annual semiconductor growth rates fluctuate dramatically, but ...

Chart 1



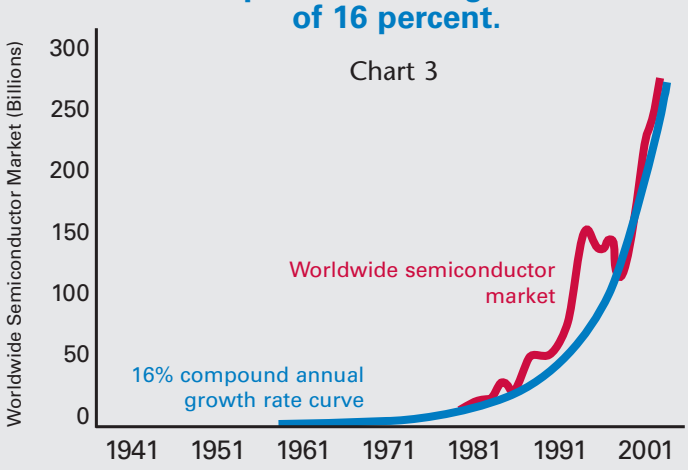
the semiconductor market continues its upward climb, with ...

Chart 2



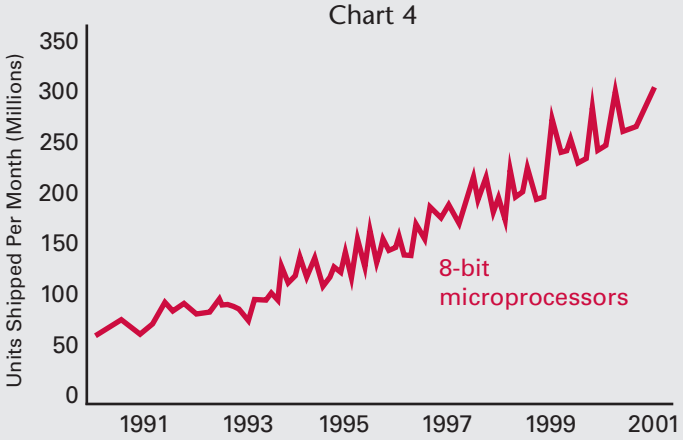
a compound annual growth rate of 16 percent.

Chart 3



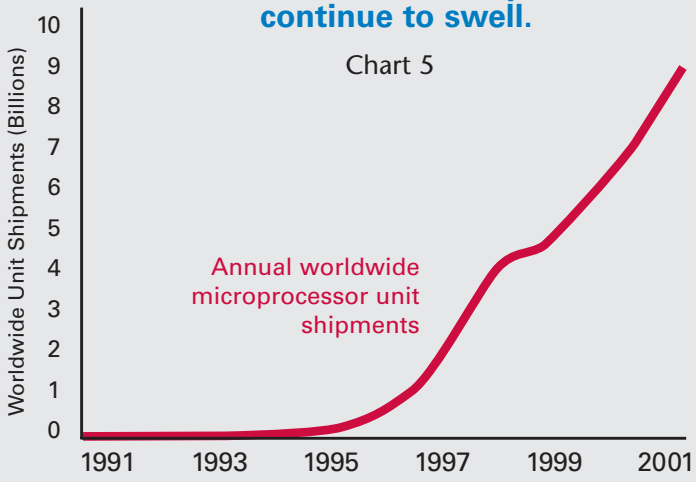
The number of microprocessor units shipped per month oscillates, but ...

Chart 4



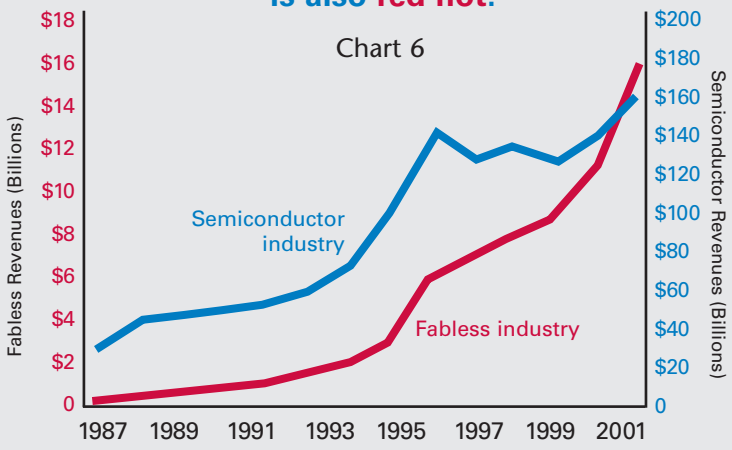
cumulative annual shipments continue to swell.

Chart 5



The fabless segment of the industry is also red hot.

Chart 6



Sources: Dynamic Silicon, Fabless Semiconductor Association, LSI Logic, ARC Cores

Chart story by Mary Collins

ANOTHER UPSIDE SURPRISE

For the semi-conductor industry the "tech-wreck" is just a familiar cycle, one that always ends in a dramatic upside, driven ultimately not by business cycles but by Moore's law, which relentlessly opens up new markets as chip capabilities expand and prices fall.

Industry annual growth rates have fluctuated dramatically since the invention of the integrated circuit, in 1958. Even since the invention of the microprocessor in 1971, annualized growth has dipped below zero over half-a-dozen times (chart 1).

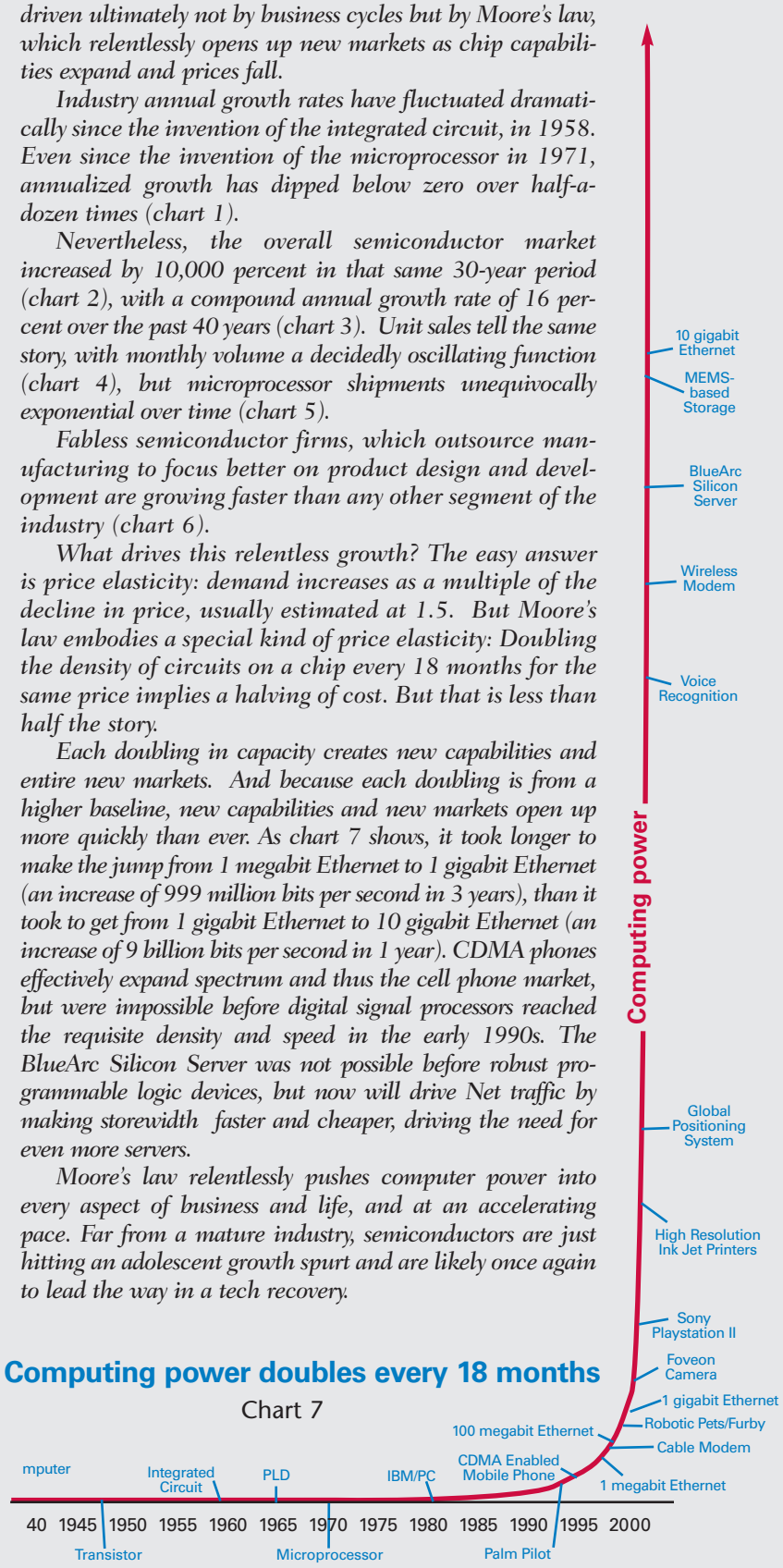
Nevertheless, the overall semiconductor market increased by 10,000 percent in that same 30-year period (chart 2), with a compound annual growth rate of 16 percent over the past 40 years (chart 3). Unit sales tell the same story, with monthly volume a decidedly oscillating function (chart 4), but microprocessor shipments unequivocally exponential over time (chart 5).

Fabless semiconductor firms, which outsource manufacturing to focus better on product design and development are growing faster than any other segment of the industry (chart 6).

What drives this relentless growth? The easy answer is price elasticity: demand increases as a multiple of the decline in price, usually estimated at 1.5. But Moore's law embodies a special kind of price elasticity: Doubling the density of circuits on a chip every 18 months for the same price implies a halving of cost. But that is less than half the story.

Each doubling in capacity creates new capabilities and entire new markets. And because each doubling is from a higher baseline, new capabilities and new markets open up more quickly than ever. As chart 7 shows, it took longer to make the jump from 1 megabit Ethernet to 1 gigabit Ethernet (an increase of 999 million bits per second in 3 years), than it took to get from 1 gigabit Ethernet to 10 gigabit Ethernet (an increase of 9 billion bits per second in 1 year). CDMA phones effectively expand spectrum and thus the cell phone market, but were impossible before digital signal processors reached the requisite density and speed in the early 1990s. The BlueArc Silicon Server was not possible before robust programmable logic devices, but now will drive Net traffic by making storewidth faster and cheaper, driving the need for even more servers.

Moore's law relentlessly pushes computer power into every aspect of business and life, and at an accelerating pace. Far from a mature industry, semiconductors are just hitting an adolescent growth spurt and are likely once again to lead the way in a tech recovery.



Computing power doubles every 18 months

Chart 7

fold greater than the possible 50 MHz of twisted pair and where available is more convenient than microwave wireless with its line-of-sight limitations.

Today's most capacious cable systems do not use this gigahertz resource, limiting themselves to a frequency span between 5 MHz and 42 MHz for upstream signaling and frequencies between 42 MHz and 860 MHz for downstream broadcast and other broadband. Traditional analog cable systems can therefore deliver 140 downstream channels. Digital cable can convert each 6 MHz cable TV channel into an MPEG2 bitstream. With a variable band around 2.4 megabits per second, digital expands the effective capacity between three and tenfold depending on the number of bits per hertz that a particular system can handle. Nonetheless, even with coax's inherently broadband capacity, cable's shared neighborhood lines and its upstream bandwidth cap restrict most cable modem subscribers to a DSL-like 1 Mbps, not good enough for robust business service, certainly not enough to carry Metcalfe's floods.

Limiting cable's theoretical bandwidth advantage has thus been the inability of conventional silicon devices to convert analog frequencies above 860 MHz to digital and process them into a usable signal. Metcalfe comes to the rescue with a new technology to transform the huge feasible bandwidth of cable into a switched Ethernet resource, potentially bringing the huge video traffic of television onto the Internet together with petabytes of business traffic and even making **AT&T** (T) a likely star of the last mile. Narad Networks doubles the bandwidth of cable coax at the head end and supplies new access amplifier boxes for connection to the network.

Atmel supplies Narad

From Bell Labs to two DSL equipment startups bought by Cisco, Narad CEO Dev Gupta has devoted most of his professional life to squeezing more bandwidth out of narrowband media. As early as 1994, he developed a VDSL transceiver that boosted twisted pair to some 50 megabits per second over short distances. These experiences taught him that twisted pair copper would never be a truly broadband medium. He had squeezed out all the bandwidth he could. Now he and his new company have moved up spectrum.

In mid-June Gupta received working samples of his three new up-spectrum chips, manufactured in silicon germanium (SiGe) at an **Atmel** (ATML) foundry. Running at 2 GHz (compared to the less than one gigahertz of current leading edge cable spectrum), the chips promise to transform the world's coaxial cable television networks. Without affecting existing analog TV services, Narad adds to current CATV's shared, tree-and-branch, broadcast networks a superstructure of Internet-friendly switched Ethernet

webs. Using SiGe's smaller band-gap to process analog frequencies, Narad expands the usable spectrum of coax from the current 860 MHz limit up to 2 GHz and soon to 5GHz. This up spectrum leap will allow cable companies to provision 1 gigabit Ethernet on main trunks and deliver 100 megabit Ethernet to homes.

As Metcalfe predicted, existing Internet topology cannot survive exafloods of data as more users enter the broadband world on peer-to-peer Ethernets. SONET-based private lines will buckle.

Narad believes small and medium sized businesses should be the cable company's first targets. Four million of the 8 million such businesses in the U.S. are passed by coax, and each can consume the bandwidth of 40 consumers, on average. That's 320 million "consumer equivalents," as Narad says. And it is primarily these companies that are left behind by the current state of technology: DSL or cable modems are too slow, and SONET-based circuits normally sold to large enterprise customers are too expensive, if you can even obtain one. Narad executive VP Andy Chapman says the first business provisioned would cost $10,000, the third $5,000, the fifth $2,000, and on an on. In a hypothetical network segment passing 120 homes, adding just three business customers could double a cable company's EBITDA.

Narad is partnering with Phillips to deploy optical transceivers and WDM where needed on the optical fiber portion of the hybrid-fiber-coax (HFC) infrastructure. Ethernet expertise is found in partnership with Foundry Networks. Signals on both the fiber and coax are sent in parallel with current cable TV services, with no disruption of service. Once the right equipment is installed at the head of the network, customers can be provisioned one at a time by simply replacing the existing cable "tap" on the line running by their house with a $200 Narad access switch (which includes a conventional tap as well) and a Narad modem/set-top box. In other words, you don't lose the first 860 MHz when you order the new service, and your neighbor doesn't have to upgrade if he doesn't want to.

Terayon needs new markets

With Narad, coaxial cable running by 65 million American homes will soon be able to provide 1,000 times the capacity of copper telephone lines and 100 times that of DSL. Narad also brings us to a difficult decision on **Terayon** (TERN) and our friends, the Rakib brothers. Terayon developed the superior cable technology of its time. Unfortunately, it was not standardized or adopted in time to be deployed before the next wave of technological advance. Terayon used the superior processing power of S-CDMA to send more bits through a narrow window than the TDMA competition at **Broadcom** (BRCM) and **Texas Instruments** (TXN). Narad not only processes with the best of the Microcosm but opens new spectral windows on the World Wide Web by more than doubling the capacity of coaxial cable. That is why Narad is the new paradigm in cable and Terayon is still searching for new markets. Still robust is Broadcom, who knew its cable market was nearly maxed out anyway and began diversifying into gigabit Ethernet, wireless, and wide area networking, though Henry Nicholas will have to deal with the reality of no longer being the "90 percent market share" cable chip company.

As Metcalfe predicted, the existing Internet topology cannot survive the exafloods of data released by more and more users entering the broadband world on peer-to-peer Ethernets. SONET-based private lines to the backbones of AT&T, **Sprint** (FON), and **Genuity** (GENU) will buckle. Even the Net's basic routing scheme, the border gateway protocol (BGP), is breaking down under the strain (see, May's *Business Communications Review*, "The Internet Can't Scale"). Good news, one would think, for the vendors of the fibersphere—the next generation of carriers who have made bold bets on increasingly all-optical networks, on lambda connectivity, and extranets. One look at the market, however, can strike fear in the hearts of even the most committed touts of the Telecosm.

Corvis lights Williams

The long-term debt of the five major next generation fiber optic carriers, Global Crossing, Level 3, **360networks** (TSIX), Williams Communications, and Metromedia Fiber is $26.5 billion. Together, they have deployed some $60 billion in new fiber optic assets. Yet, the total market capitalization of these companies is $14.3 billion. Global Crossing's stock closed June 19 at $6.85, its lowest price since the days when it was scarcely more than a map of sub sea cables and an idea in Gary Winnick's head. Translation: Wall Street expects these companies to go under, with several facing bankruptcy within 18 months or less.

All the next generation carriers are making one bet, with a few variations. Focusing on technology that allows them to rapidly provision circuits orders of magnitude cheaper and more capacious than Telcos bound to the SONET model, their goal is provide circuits to AT&T or **SBC** (SBC), or CNBC or the Swift financial network, faster and cheaper than those companies can provide them for themselves.

The vertical monopoly telco business has been bursting apart horizontally for three decades, since **MCI** (MCIT) started picking off long distance customers from AT&T. The brightest future is to the companies that learn to love their horizontal niche. SBC recognized that, like most retail service providers, it is primarily a marketing and customer service operation, and would do better outsourcing its network to Williams. With its relentless technology focus Williams set about to cut SBC's trunk circuit provisioning time from 18 months to less than three months and soon to weeks and days as optics from Corvis and ONI come online.

Williams excels in its focus on wholesale and has more recurring network revenue with just 250 customers than Level 3 has with 3,000, many of them small ISPs. Global Crossing has proved the model internationally, most recently with its $300 million deal to link Swift's

7,000 banking and financial customers in 190 countries. With $5 trillion riding on 5 million emails each day, Swift's antiquated X.25 data network was running out of capacity and was far too expensive to upgrade. Global Crossing had the security, capacity, and breadth to take over the network and let Swift concentrate on its customers, not dark fiber, routers, and optronics.

While GX is thrilled with the Swift deal, emailing money uses less bandwidth than Gary Winnick's next target: digital Hollywood. The foreign appetite for American content makes GX's unique single global network supremely relevant. GX's first announced entertainment customer, CNBC Europe will now transmit its 11.5 hours of daily live content from New Jersey to London and Asia via Global Crossing's fiber, rather than satellite.

360 benched

WorldCom's (WCOM) international division is its fastest growing. So what will CEO Bernie Ebbers do with the $12 billion ($4 billion for refinancing) he recently raised? (The capital markets don't close for Bernie). Alas, they did close for 360 networks, which hemorrhaged a hemisphere, renouncing its Pacific and Asian plans even before renouncing its latest interest payment. 180 networks anyone? Perhaps Bernie will gobble them up and complete the planetary circumnavigation. But until then 360 is not the global network company (and possible rival to Global Crossing) we listed and therefore must take a seat on the bench.

Crippling 360 and many of the next generation carriers, is the capital market's belief in a "fiber glut." Wall Street's grasp of the matter is as confused as always. Citing a portentous Smith Barney proclamation that 90 percent or more of the fiber in the ground may never be used because lighting a fiber can allegedly cost $500 million and take 18 months, the *New York Times* as usual confuses the opportunity with the problem. SONET rings are premised on pre-WDM technology and voice as the primary source of revenue. They place hundred million dollar tolls on incremental expansions of the network, especially in the metro (where the customers are). That is why SONET has been a dead technology walking for the last two years, even as SONET companies (Nortel and Lucent) racked up their biggest years ever.

When Corvis and Williams *almost three years ago* presented their plans to replace the old SONET networks with a WDM mesh they were declaring the end of the era of $200 million pricetag for lighting a fiber. It is precisely because the legacy network can never accommodate an exaflood that the post-SONET carriers will triumph. As they deploy their systems, there will emerge a great sucking sound, with floods of terabytes pulled inexorably to the fibersphere, while the old-line SONET carriers complain to Wall Street of a strange bandwidth glut.

Global Crossing opportunity

Victory is assured for the new carriers who can find the time and money to deploy new wavelength rich networks with, for pivotal examples, Avanex PowerMuxes at both ends, Corvis transparent 700 lambda backbones, and Narad cable systems. Looking for a sure thing, Wall Street favors Qwest and Broadwing, bolstered by their phone company cash flow. With aggressively deployed Corvis systems already filling up ahead of schedule, Broadwing is indeed beginning to apply serious suction on older networks. But our first choice is Global Crossing.

Gary Winnick's financial jump on the competition and his team's furious build-out of the world's largest advanced network mean GX is actually a beneficiary of the crash. Cash reserves of more than a billion dollars and the scheduled sale of Frontier for $3.5 billion reduce its $8.3 billion of gross debt to a Net of $4.5 billion, and annual obligations of around $600 million. With adjusted cash flow of more than $ 1 billion and growing, GX is its bankers' best friend.

Where the horizontal wholesale model will prevail domestically, Global Crossing will prosper as a vertically integrated, high-margin service provider internationally. There, most of the customers are large companies with specialized and rigorous demands. Networking between boundaries and across oceans is also a much more complicated task. Embroiling the magpie mazes of cross-border patch networks are new tariffs, laws, protocol mixes, and margin gouges at each link. Global Crossing transcends these problems with its planetary scope and global MPLS (multiprotocol label, soon to be lambda, switched) IP services. With the demise of 360 it continues to have the only fully integrated global network.

Broadwing is indeed beginning to apply serious suction on older networks. But our first choice is Global Crossing.

The GX opportunity is better than in 1998 when we first announced it, and bigger than in 1999 when another apparent fiber glut and share price collapse made it available once again. If you bought Global Crossing in 1998, you bought one 5,000-mile cable. Today you are buying a 102,000-mile network. If you bought Global Crossing in 1998, you bought $400 million in revenue. Today you are buying over $5 billion in sales and more than a billion dollars in adjusted cash flow, growing at 40 percent a year. If you bought Global Crossing in 1998, you bought into static trans-Atlantic STM-1 sales. Today you are buying an IP backbone with traffic growing at 450 percent a year and 20 percent ownership in Exodus, the web's key hub for exafloods of content, storage, and services which almost doubled year-to-year revenues in the March quarter. If you bought Global Crossing in 1998, you bought the dream of a global web of glass and light. Today you are buying that web.

The exaflood is coming. But Global Crossing is used to high water. There is no surer bet in the Telecosm.

George Gilder and Bret Swanson
June 21, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE / PRICE		MAY '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	18.92	18.19 - 113.33	18.6B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	16.71	13.06 - 140.50	24.9B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	13.02	8.11 - 174.50	846.8M
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	33.54	25.00 - 83.75	15.3B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	9.99	9.25 - 165.13	757.9M
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	–	–	–	–
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	31.04	15.75 - 142.00	4.1B
WDM Systems, Raman	Corvis (CORV)	3/30/01	7.03	6.02	4.69 - 114.75	2.2B
Metro Semiconductor Optical Amplifiers	Genoa (private)	3/30/01	–	–	–	–
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6*	33.26	20.88 - 274.75	8.65B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	5.88	2.36 - 81.94	398.4M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	8.48	6.90 - 60.81	2.1B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	–	–	–	–
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	3.02	1.03 - 8.50	1.0B
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.43	0.25 - 14.19	47.1M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	60.74	42.75 - 107.81	46.0B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	22.00	15.72 - 65.88	20.6B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	14.70	10.50 - 39.75	32.3B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	6.07	3.31 - 84.81	271.8M
Internet Backbone and Broadband Wireless Access	WorldCom (WCOM)	8/29/97	19.95	17.84	13.50 - 49.97	51.5B
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	4.02	3.36 - 44.00	2.4B
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	12.70	8.77 - 37.75	11.25B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	7.60	3.50 - 71.00	162.1M
STOREWIDTH						
Directory, Network Storage	Novell (NOVL)	11/30/99	19.50	4.53	3.44 - 12.75	1.4B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	16.47	12.85 - 64.69	53.6B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29	4.98	2.81 - 43.38	528.3M
Disruptive Storewidth Appliances	Procom (PRCM)	5/31/00	25	10.53	4.25 - 74.00	127.8M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27*	17.15	7.00 - 154.25	1.7B
Complex Hosting and Storewidth Solutions	Exodus (EXDS)	9/29/00	49.38	7.93	5.56 - 69.00	4.4B
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	–	–	–	–
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	1.08	0.53 - 18.37	29.1M
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	44.55	30.50 - 103.00	16.0B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	18.07	11.25 - 109.75	5.4B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	11.10	7.63 - 24.41	5.1B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	18.31	13.65 - 71.31	5.9B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	26.52	17.13 - 73.88	4.6B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	34.12	26.26 - 90.00	59.2B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	41.25	29.79 - 98.31	13.6B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	9.66	3.69 - 38.44	62.3M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	21.15	13.72 - 55.75	2.7B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	24.00	18.81 - 67.13	9.3B

DELETED FROM LIST: 360NETWORKS

* INITIAL PUBLIC OFFERING

NOTE: The Telecosm Table is not a model portfolio. It is a list of technologies in the Gilder Paradigm and of companies that lead in their application. Companies appear on this list only for their technology leadership, without consideration of their current share price or the appropriate timing of an investment decision. The presence of a company on the list is not a recommendation to buy shares at the current price. Reference Price is the company's closing share price on the Reference Date, the day the company was added to the table, typically the last trading day of the month prior to publication. Mr. Gilder and other GTR staff may hold positions in some or all of the stocks listed.

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