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The Stupidity Paradox

The second great phase of the Telecosm would be the demise of local telephony and TV-only cable in favor of the broadband local loop, making Narad and Soma crucial companies for the next period

Inside:

Any rational observer would look at the upcoming Optical Fiber Communications conference later this month in Anaheim and wonder: What are all those people doing? Are they stupid or what?

Don't they know about fiber glut and optical illusion. Don't they realize that Gary Winnick achieved the ultimate Global Double Crossing (GXX), and that **Exodus** drowned in a red sea of debt? Don't they know that shareholder advocate Jim Crowe of **Level 3** (LVLT) will shortly learn that vying with his newly hypercompetitive, debt-free rivals will require dumping on *his* investors, too? (Just ask Michael Lewis. Chapter 11 is the new, new thing.)

Or maybe those 45,000 immigrant geeks can't read the English that *Barron's* uses to print its warnings. Otherwise they would know that of the 87 sectors ranked by Standard & Poor's, telecom is dead last. Carriers aren't spending, Wall Street isn't funding, and investors aren't buying. The all-optical story, that is.

Why then, as industry conferences from Supercomm to Interop shrink by 50 percent or more, does OFC promise more attendees, CEOs, engineers, exhibits, floor space, booth babes, and lambdas than ever? How do you explain that your friends from the *Gilder Technology Report* will even see you at our very own booth, #6513, Hall A?

Don't these people know about Isenberg's Paradox—better optics equals less revenue?

It all comes down to the question: Are optical engineers dumb or stupid? I have long upheld the case for dumb optical networks as the smartest investment in technology. It takes a smart engineer to build a dumb network. While marketers across the floor of every OFC blather and preen about the IQs and QoSes of their networks, their policy-wonk switches, and their Mensa-class multiplexers and management systems, our favored players in optics have had to prove to us that their systems actually are as dumb as a stone. Dumb means simple pipes passing multiple lambda colors of light that bear data regardless of protocol or bitrate and relegate all intelligence to **EZChip** (LNOP) network processors lurking near **IBM** (IBM) and **AMCC** (AMCC) switch fabrics on the edges of the network.

Some four years ago, however, our friend David Isenberg dissented. Then at **AT&T** (T) deep in the carrels of Bell Labs, he went on the Internet and declared to the world his case that "stupid" is better. In his iconic essay of June 1997, "Rise of the Stupid Network," he implied that "dumb" networks simply did not supply enough syllables. Their spare four-letter elegance was in itself a Shannonesque show of smarts. Instead, wrote Isenberg, networks should be "stupid."

Now dumbbell Dave has done it again. Under the title "The Paradox of the Best Network," he has penned, with David Weinberger this time, an incendiary essay on the future of telecom that has once again captured the imaginations of stupid people everywhere. His argument now is echoing from his own coterie of techno-left geeks to a credulous culture of fix-it Feds and on to a famished throng of investors hungry to the point of desperation for original thinking on the perplexing predicament of the Telecosm.

Citing the Internet as the prime example, Isenberg's earlier blockbuster opined that the best network is a simple network that unleashes an efflorescence of cre-

ativity from the users on its periphery. In his new essay Isenberg reprises the point—with another half decade of proof: "Of all the winning networked applications of the last decade—email, web browsing, instant messaging, chat, music sharing, streaming audio, e-commerce, etc.—every one appeared on the Internet. Not one was invented by a telephone company. And not one needed any special mechanism [or intelligence] within the network itself.…Because it is a stupid network…the value is added at the edge of the network, outside of telephone company purview…. This fact frightens the telephone companies. It should. The Internet's bits-are-bits simplicity even threatens to turn their cash cow—voice telephony—into something anyone can do just by installing simple software onto an everyday PC."

Confirming the thesis with more detail is Harvard's eminence Clayton Christensen and his associates. In an authoritative study of *Innovation in the Telecommunications Industry*, he finds IP (Internet Protocol) telephony, among all candidate technologies, as the only one with the "potential to be a powerful disruptive catalyst with seismic effects." The argument is cogent: IP telephony is now good enough to take root within the enterprise. From the enterprise it can march into the collaborative space among companies in a particular sector, where the flexibility of IP will enable Groovy peer-to-peer exchanges beyond the reach of conventional telephony that costs a hundred times more. Once out of the "walled garden" of the corporation, IP can invade the realm of full-scale business services and displace the SONET paradigm in the enterprise market. From there the next step is consumer voice and video, enabled by ubiquitous broadband.

A variety of radically simplified, extremely affordable technologies are storming the gates of the telephone companies' existing networks

With "the paradox of the best network," however, Isenberg dashes all these hopes. Although the best network is still a dumb optical network, a dumb network is *"the hardest one to make money running."* Optics will bankrupt you. The phone companies were right to resist. Not only can they not make money on an open network that does more to empower the users than the owners, no one can.

Isenberg's apparent paradox rests on three factual claims, each one false, each one being made more false, right now. Successive breakthroughs in network technology are accelerating the delivery of broadband to the local loop, unleashing exabytes of traffic onto an ever more optical, capacious, and affordable network core, promising a fulfillment of the Telecosm just as it seems most elusive.

Isenberg's essay is so persuasive because each wrong conclusion is based on deep insight into the very strengths of the open network. His first proposition is that the established networks—essentially the "local" phone companies or RBOCs, and even the cable companies—resist broadband because their business models are based on a narrowband network. Broadband networks are inherently dumb and open, transparent pipes, blissfully unaware of the multiplying communications "services" embedded in their photonic bits. But reduce the bandwidth and the network must be optimized and centrally managed for a particular type of traffic or content. Thus before we had the Net, all networks carried modifiers. The phone network. The television networks. The U.S. mail network. The cable TV networks. All optimized in dramatically different ways for specified content.

Here, for Isenberg, is the crucial point: narrowband, closed networks make money precisely by charging for the optimization required by scarce bandwidth. They thrive by offering these networks the services uniquely enabled by that optimization. They make money, in short, by limiting their utility. Render bandwidth abundant and optimization obsolete and their margins disappear.

Disappearing margins

Isenberg is certainly right. Narrowband networks charge for specified services whereas broadband networks charge for the users' right to create any service that can be represented in bits. But it doesn't matter. The RBOCs cannot extend the life of the narrowband model no matter how much they might wish it. They have no choice but to try to become broadband companies.

They will do it ambivalently at first, and then desperately. No longer their greatest fear, broadband will soon appear as their only hope. But they will mostly fail, beaten by less regulated competitors wielding far more powerful technologies than RBOC copper upgraded to digital subscriber lines (DSL). Just when conventional wisdom is shouting that the only viable telecom model is the RBOC's, whose copper cash flow and customer relationships make them a paragon of Graham and Dodoism, local voice revenues are about to begin the same death march to zero that long distance voice has been trudging for more than a decade. Far from being in a position to dictate the future of broadband, the RBOCs will have to morph beyond recognition or die. From Verizon to Qwest, they will morph. Soon. Five years. But in three it will be a cliché.

Narad and Soma conquer local loop

Distracted from Isenberg's essay by a Verizon telemarketer calling to pitch DSL, available even here in the remote Berkshire hills, perhaps I misunderstood this part of David's argument. But why was the phone company's telemarketer explaining to us that we could have DSL for just about the same price as basic monthly phone service?

They meant "in addition to," but surely the nervous thought behind the call was "instead of."

Even if the RBOCs are forced to offer broadband, however, Isenberg will not be impressed. The second pillar of his argument is that neither the RBOCs nor the cable companies can do it. Isenberg nurses a nerd-snob disdain for both cable modems and DSL, which he calls "crippled compromises" that "milk already-depreciated assets without overturning established business models." But even humble DSL, though it cannot match cable, improves inexorably over time as the RBOC fiber stretches closer to the home, shortening the leaky copper links.

As for cable, it is "near broadband" no longer as **Narad Networks** uses Dev Gupta's analog ingenuity to quintuple the usable bandwidth of the coaxial cable TV infrastructure, which passes more than 90 percent of U.S. homes and more than 60 percent of U.S. small and medium businesses. With Narad, cable will bear cheap Gigabit and 10 Gigabit Ethernet backbones and 100 Mbps subscriber connections. That's more than 60 T-1 lines, broadband by any standard, enabling user-designed services from voice and video to VPNs to storewidth.

From **Soma** and **Terabeam** are coming wireless equipment that enables a separate full service local loop of gigabit dimensions. The Soma consumer service will offer not only a broadband Internet link, which at a peak rate of 12 Mbps will be more capacious than the Net connections most American *businesses* have today, but four "toll quality" Internet telephone lines as well. Run off a rapidly shrinking desk top antenna, soon to be reduced to a plug-in card for your PC, already the Soma service—based on **Qualcomm** (QCOM) CDMA—can be deployed for one third the cost of DSL.

Gig-E companies take on telcos

The first great phase of the Telecosm can be pictured as the displacement of long-distance voice networks by the long-haul data networks that form the core of the Internet. The second great phase will be the demise of local telephony—and TV-only cable—in favor of the broadband local loop. As such, Narad and Soma become indispensable and find places on our brand new Phase II Telecosm Table comprising the crucial companies for the next period. (See center spread.)

From an array of gigabit Ethernet companies such as **Yipes**, **Cogent** (COI), and **Telseon** are emerging fiber systems around cities that break wide open the pricing models of the incumbent telcos. Already offering 100 megabit links for $1,000 a month, Cogent promises to lower its cost still further through an agreement with **Cisco** (CSCO) to roll out an eight lambda WDM gigabit Ethernet system based on a hub and spoke topology. Redundant and "resilient," it can reach 80 kilometers across the metro on fiber and then 100 meters down Category 5 wire to your desktop gigaNIC (network-interface card).

Isenberg knows all this as well as anyone and concedes that "a variety of radically simplified, extremely affordable technologies are… storming the gates of the telephone companies' existing network. These promise every home more bandwidth than a medium-sized town uses for all of its conventional telephony—for about the price of a monthly bus pass." So what is the problem? A Bell lifer until he got tossed out for cramming too much intelligence

> The RBOCs cannot extend the life of the narrow band model no matter how hard they might wish

into his own neural network, Isenberg just cannot believe the Baby Bells can either move to broadband or allow competition. So, unless government intervenes, these technologies "will be developed and deployed" only where "established companies hold less sway." But with the very idea of local voice rendered incoherent by mobile telephony, and the network that delivers it rendered irrelevant by the Internet, the RBOCs do not "hold sway" anywhere but in their own copper cage. They're just swaying.

The Isenberg Uncertainty Principle

Grant all this, and still Isenberg will trot out his most apparently powerful argument: "As a network gets stupider"—that is better, faster, more optical and open—"connectivity becomes a commodity. Those who own and operate the network have less to charge for. After all, they're just moving bits. The high-value services, the ones that command premium prices, reside at the edge of the best network." All of a sudden getting a town's worth of telephony for the price of a bus pass sounds a little fishy: How is a company that commands only a bus-pass worth of revenue in exchange for the engineering marvel of the age going to pay its bills? Isn't that what happened to **Global Crossing** and **Williams** (WCG) and **360 Networks** and threatens the rest? Didn't their own prowess at driving down the cost of bandwidth put them out of business by leaving them nothing they could charge for?

The transparent transportation of bits is certainly a commodity business or soon will be. Lambda circuits have at least one characteristic of a commodity: the product is standardized and interchangeable. No one wants a lambda with "special" features; in a communications channel the name for special features is noise. But it is a mistake to equate commoditization with low profits. With price and quality standardized, companies dealing in commodities compete primarily on cost, reliability, and availability. Innovation is in the process not the product and can reap the rewards of innovation anywhere.

Reaping these rewards was what the next generation carriers were about when instead they reaped the whirl-

TELECOSM TECHNOLOGIES

ONI Systems (ONIS)

METRO WDM PLATFORMS

FEB '02 MONTH END: 7.97 | 52-WEEK RANGE: 6.92 - 59.92 | MARKET CAP: 25M

MAN-MASTERS—After winning the long-haul, broadband optics now face heavy lifting of MAN-hole covers: refitting city networks with optics. Short for "metropolitan area networks" MANs are the key test. Just to open the hole costs bribes to most of the city council. Second in MAN sales only to Nortel and still gaining share, Rohit Sharma's are radically increasing the number of channels per manhole and have even hooked the interest of Ciena. If the deal goes through, ONI gets economies of scale, new sales channels into ILECs and IXCs, and expertise from a proven product marketer. Ciena may get enough fresh Telecosmic ideas to put the one-time GTR star back in the paradigm.

Spousal Revelations: ONI was shocked by Ciena's 67 percent revenue plunge in two quarters, from its peak of $458M last July to $160M in January, and a projection of $100M for the current quarter. This shifts the acquisition in favor of ONI, whose revenue guidance is now 42 percent of Ciena's.

JDS Uniphase (JDSU)

ACTIVE AND PASSIVE OPTICAL COMPONENTS

FEB '02 MONTH END: 4.85 | 52-WEEK RANGE: 4.74 - 33.25 | MARKET CAP: 7.3B

TELECOSM MALL—A sprawling empire of some two dozen acquisitions and the Telecosm's only components supermarket, JDSU boasts tunable filters, fiber Bragg gratings, transponders, modulators, multiplexers, source lasers, tunable dispersion compensators, planar lightwave and thin-film technology, diffraction gratings, tunable optical add/drops, MEMS technology, interleavers, tunable lasers, optical switches—almost any component besides fiber. Leads the drive toward more efficient and less-costly standardized modules including EDFAs and un-cooled 980 nm pump lasers.

Crucial Going Forward: Can JSDU avoid an innovation-quashing corporate culture?

Avanex (AVNX)

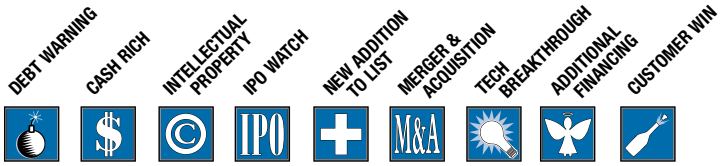
ADAPTIVE PHOTONIC PROCESSORS

FEB '02 MONTH END: 3.26 | 52-WEEK RANGE: 2.70 - 28.50 | MARKET CAP: 225.7M

RAINBOW FACTORY—With $161 million of cash still on hand, Avanex was the first of our optics companies to show an up-tick in quarterly revenues, from $7.2 to $8.3 million. Under the direction of Telecosm visionary Simon Cao, Avanex defined the photonic processor, launched the product, and leads the field. Its elegant core paradigm of free space optics, using etalons and holographic gratings, makes Avanex the top commercial WDM innovator. As flexible as its lambdas, Avanex has successfully adapted its powerful long-haul-network components and subsystems to more immediately promising metropolitan area networks.

Feng Shui Flop: Simon's PowerMux is still the best. But his karma consultant has got to go.

KEY



Essex (ESEX.OB)

OPTICAL PROCESSORS

FEB '02 MONTH END: 4.50 | 52-WEEK RANGE: 2.88 - 8.25 | MARKET CAP: 22.9M

GENIUS ALERT—In all technology, no more than five minds rival Terry Turpin. His 1280 lambda Hyperfine wavelength multiplier promises to proliferate thousands of lambdas per fiber across the Telecosm and into the metro where they will eventually displace switches and other electronic bottlenecks. Now in trials at MIT's Lincoln Lab, Hyperfine must play catch-up to Avanex, and Turpin has more incandescent inventions than any small company can pursue.

Major Breakthrough: With the University of Central Florida and Sarnoff Corporation, successfully generated 45 distinct transmission wavelengths using single laser source. This technique, which the GTR's own Charlie Burger first suggested 18 months ago, could radically simplify (and reduce prices for) active telecom components.

Corvis (CORV)

WDM SYSTEMS, RAMAN AMPLIFICATION, EDGE SWITCHES

FEB '02 MONTH END: 1.14 | 52-WEEK RANGE: 1.10 - 13.63 | MARKET CAP: 413.5M

PARADIGM EPITOME—The leading WDM systems innovator using Raman amplification, Corvis empowers cross country lambda transport without electronic regeneration, cutting capital costs by up to 75 percent over a Nortel Sonet network. Even bigger operational savings. Currently capable of supplying 320 2.5 gigabit lambdas per fiber, David Huber's crew will soon move to 640 channels and beyond.

Bad News, Good News: Major cutbacks at biggest customers Broadwing, Williams, and Qwest must be weighed against some $600 million in cash.

StorageNetworks (STOR)

DATA STORAGE MANAGEMENT, SOFTWARE

FEB '02 MONTH END: 3.26 | 52-WEEK RANGE: 3.10 - 23.54 | MARKET CAP: 317.1M

AND WE NOW MAKE HOUSE CALLS!—With a 156 percent year-over-year revenue increase, storage management service contacts with 39 of the Fortune 100, and 1.25 petabytes worth of data back-up deals, StorageNetworks is powering through the SSP depression. STOR's success is based on hardware agnosticism and a deep bench of storage networking professionals churning out the right combination of bandwidth and software to render storage accessible, robust, and secure.

Tough Question: Is the collapse of most SSP competitors good? Or is there something fundamentally wrong with the model?

Scale Eight

MASSIVELY PARALLEL GLOBAL STORAGE

PRIVATE

NEXT-GEN STOREWIDTH—29-year-old Josh Coates is the storewidth industry's top thinker and talker. Empowered by the optical Net and cheap storage, Scale Eight achieves high performance and superior scalability with a massively parallel architecture of commodity disk drives. Scale Eight breaks out of the local box and leverages the wide area network to store and mirror terabytes of unstructured data in just four global locations, yielding big economies of scale and data that is available anytime, anywhere.

Customer List: MSN Photo, MTV, Akamai.

MEAD'S ANALOG REVOLUTION (see Carver's Companies/page 8)

National Semiconductor (NSM)
Synaptics (SYNA)
Sonic Innovations (SNCI)
Foveon
Impinj
Applied Neurosciences
DigitalPersona

COMPANIES TO WATCH

Analog Devices (ADI)
Bandwidth 9
BlueArc
Genoa
Mirror Worlds Technologies
NP Photonics
Samsung
Xilinx (XLNX)

Mirror Image Internet

GLOBAL CACHING AND STOREWIDTH PLATFORM

PRIVATE

MYSTERY MIX—As we predicted, industry is adopting this company's centralized model. Even Akamai is moving toward the paradigm, but corporate leadership and structure is still murky. As competitors scurry to keep up with the explosion of data and edge devices, hiring like mad and placing tens of thousands of boxes next to nearly every enterprise, Mirror Image moves to consolidate its 22 strategically-placed Content Access Points. With 200-odd customers and another cash infusion from parent company, Xcelera, Mirror Image is looking at a potentially break-even year.

Up Next?: Web services for .NET, SOAP, and JXTA.

Equinix (EQIX)

SECURE INTERNET BUSINESS EXCHANGES

FEB '02 MONTH END: 1.25 | 52-WEEK RANGE: 0.33 - 4.25 | MARKET CAP: 100M

STOREWIDTH STAR—With 39 customer wins in Q4, including Sprint, Cox Communications, and France Telecom, Equinix has retired $45 million in debt and is looking at free cash flow by the end of the year. Designed as a neutral peering and exchange within super-secure facilities, Equinix has no networks at all, but invites leading providers to compete for connectivity at its facilities. With 75-plus diverse networks in its IBX centers Equinix customers have access to 90 percent of the world's Internet routes.

Operation Save-the-Net: U.S. Government declares Equinix a national security asset.

Sprint PCS (PCS)

NATIONWIDE CDMA WIRELESS NETWORK

FEB '02 MONTH END: 9.25 | 52-WEEK RANGE: 7.22 - 29.05 | MARKET CAP: 9.1B

CDMA SPEARHEAD—The nation's fastest growing wireless carrier has lately been answering questions about its $17 billion of debt. After initial worries, Wall Street seems satisfied. A $1 billion loan facility, secured by the assets of Sprint's directory publishing business, $400 million in reduced 2002 cap-ex the FON side, and the delay of a $300 million payment related to NextWave should solidify the PCS's credit standing and its access to the commercial paper market after a recent Moody's downgrade.

Just Released: A solid first quarter outlook for both EBITDA and net subscriber additions, and guidance that it's on track to meet 2002 financial targets.

Qualcomm (QCOM)

CDMA MICROCHIPS, IP, SOFTWARE

FEB '02 MONTH END: 33.25 | 52-WEEK RANGE: 31.03 - 71.04 | MARKET CAP: 25.5B

CDMA PARAGON—Qualcomm reaffirmed its previous earnings target for Q2 and reported IC shipments at the upper end of guidance, adding that the June quarter will top March and that real growth should hit in September. Emerging-market invasions of China, India, and Latin America are going well.

New Product: GSM1x solution, enables the convergence of a GSM/GPRS core service network with CDMA2000 radio access. Launched at GSM World Congress

Altera (ALTR)

PROGRAMMABLE LOGIC DEVICES

FEB '02 MONTH END: 19.07 | 52-WEEK RANGE: 14.66 - 33.60 | MARKET CAP: 7.3B

TREDENNICK CHOICE—Altera has cranked up its investor, media, and analyst operations to compete with the better-publicized Xilinx (XLNX), its chief rival, but with a market-cap-to-revenue ratio of 10.1 still trades at a slight discount to Xilinx (12.1). The two fables chip companies are the real Intels (INTC) of the Telecosm, says Dynamic Silicon author Nick Tredennick, and form a devastating duopoly in the market for programmable logic devices, silicon "white boards" that can morph to perform increasingly diverse and high-speed applications, potentially replacing DSPs and microprocessors throughout the optical, wireless, and storewidth worlds.

Truce: After years of litigation, a five-year royalty-free IP cross-licensing agreement with Xilinx implies neither is likely to wipe the other clean on the technology front.

EZchip (LNOP)

10 GIGABIT NETWORK PROCESSORS

FEB '02 MONTH END: 10.08 | 52-WEEK RANGE: 2.70 - 13.02 | MARKET CAP: 73.4M

After we wrote about EZchip in January, its share price more than doubled. But with a $90 million valuation, it targets $20 B potential market for network processors. Samples of first chip are due this month from manufacturer IBM. EZchip's 10-gigabit, 7-layer NP-1 is two generations ahead of top rivals AMCC (AMCC) and Intel. Using *embedded* DRAM, EZchip achieves the 500 Gbps of memory bandwidth necessary to route and modify packets at 10-gigabit wire-speed. *Breakthrough:* operating "low and slow," the 10 gigabit speed comes from 64 parallel custom processors operating at only 200 megahertz speed. Designed in Israel by Intel defectors, EZchip runs at one tenth the Pentium clock rate on a single, 15-Watt chip, about one tenth of the power usage and heat dissipation of rival solutions. *Result:* order of magnitude increases of capability per cubic meter of rack space.

EZchips Everywhere?: Applications range from small firewall boxes to core routers and 3G wireless base stations. Critical Issues: Can IBM build? Will Cisco buy?

Broadcom (BRCM)

BROADBAND INTEGRATED CIRCUITS

FEB '02 MONTH END: 30.65 | 52-WEEK RANGE: 18.40 - 68.56 | MARKET CAP: 8.0B

CABLE KING—Cable is winning the last mile and Broadcom is the cable-chip King. But the company that raced to claim a 90+ percent share of the U.S. cable modem and set-top box market, is now well on its way in Fast and Gigabit Ethernet chips, I/O devices built into Compaq, Dell, and IBM servers, and potentially residential satellite, home gateways, and Wi-Fi wireless LANs. With 2,800 CMOS designers and most of the smart CEOs gained through some 20 acquisitions still on Broadcom's team, CEO Henry Nicholas III has built a high-volume, mid-market fabless powerhouse. The purchase of Newport and its 10 Gigabit Ethernet CMOS transceiver (see GTR, September 2000) proved a highly successful launch into up-market optical networks.

Baggage Handler?: A handful of other network- and communications-processor acquisitions are still searching for big design wins.

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Texas Instruments (TXN)

DIGITAL, ANALOG, MIXED-SIGNAL PROCESSORS

FEB '02 MONTH END: 29.35 | 52-WEEK RANGE: 20.10 - 42.91 | MARKET CA

DANCING DSP GIANT—The undisputed king of DSPs, TI is also the leading supplier of analog communications devices, and thus fits neatly into our single chip system paradigm. With mobile and military apps consuming more analog parts than any others, TI is well-positioned in two very hot markets. 1Q book-to-bill ratio will be close to one. Falling sales in 2001 drove the stock to a three-year low in September, rebounding up 75 percent since, TI still trades at its 52-week average. If a $62-billion company can have upside, this one does.

National Semiconductor (NSM)

SINGLE-CHIP SYSTEMS, FOVEON IMAGERS

FEB '02 MONTH END: 25.15 | 52-WEEK RANGE: 19.70 - 35.10 | MARKET CAP: 4.5B

GENIUS ALERT—With expertise in the "black arts" of analog design and process, National benefits from Carver Mead's vision. With a 49 percent stake in Mead's Foveon revolutionary X3 CMOS imagers, National is supremely exposed to the fast growing $20-30 billion market in still and full-motion photography. National also is a rare and proud owner of an x86 microprocessor architecture, the Geode, which it uses in a variety of web-friendly consumer devices that have yet to take off. Just reported a 22 percent quarterly increase in new orders.

Recently Overheard: Rival digital camera designer lamely claiming, "Foveon's got cross-talk between its pixels." Damn, Mead's chip is even better than we thought.

Narad Networks

GIGABIT ETHERNET COAXIAL CABLE NETWORKS

PRIVATE

TELCO KILLER—The breakthrough last mile company implementing IBM standard JAVA beans and databases over cable. Led by analog master Dev Gupta, designer of the first vDSL chip at Bell Labs in the early 1990s, Narad quintuples the usable bandwidth of the coaxial cable TV infrastructure, which passes 90+ percent of U.S. homes and 60+ percent of U.S. small and medium businesses. Enables symmetrical Gigabit/10 Gigabit Ethernet backbones, 100 Mbps subscriber connections, and user-designed services, from voice to VPNs to storewidth.

Look Out Baby Bells: All six major U.S. cable MSOs on Narad's radar…three in trials. Copper cage in jeopardy. Europeans interested, too.

Soma Networks

BROADBAND WIRELESS ACCESS, NETWORK SOFTWARE

PRIVATE

LAST MILE PIONEER—With the first desk-top non-line-of-sight MMDS wireless antenna, Soma is aiming for the broad market of residential and SOHO broadband users below Narad. Combines "toll-quality" IP voice with broadband Internet access peaking at 12 Mbps. One-third the cost of a DSL or cable-modem deployment, but more functionality. Three successful field trials, two by PCS spectrum holders in the U.S. and one by a foreign telco, point to wide-spread roll-outs. Second-generation antenna from Sharp is a 3"x3" cube that plugs into your lap-top.

Under Development: Third-generation antenna being designed directly into a PC-card.

The Telecosm Technologies list 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. Mr. Gilder and other GTR staff may hold positions in some or all of the stocks listed.

wind of a perfect storm that included a deflation effectively raising the cost of money to these deeply indebted firms by some 30 percent, and a Greenspan credit crunch that made refinancing practically impossible. But there was a "race to the bottom" factor as well.

Carrier survival

Over the last five years, Internet traffic increased some 3,000-fold as bandwidth prices dropped 500-fold. Driving this discontinuity was the widespread deployment of optics. As our legendary Charlie Burger has calculated, using the telco technologies of 1995, it would have cost as much as $39 trillion to accommodate the 40 petabytes (40,000,000,000,000,000 bytes) of traffic that passed through the Net every month in 2001, reaching an estimated 52 petabytes in December.

The huge price elasticity implied in these numbers, with demand for bandwidth rising 6 times as fast as prices fell, might have enabled a bonanza. But cascading down a Class V rapid with a 500-fold price reduction in five years raises navigation problems for even the most adept whitewater CEO. The only comparable descent in our time is the materially slower slide of transistor prices dropping 50 percent every 18 months under Moore's law. But last year's higher priced network equipment must still compete with a whole new generation of two-times cheaper, faster, and better gear every nine months.

In a field crowded with hundreds of telcos, the perfect storm makes the survival of any given carrier problematic. And with no carrier able to lay claim to a decisive technology advantage for long—and with companies such as **Worldcom** (WCOM) that take a lead pummeled by antitrusters—picking winners is a job we belatedly concede to be an exercise in hubris. We thus include no long-haul carriers in our Phase II Telecosm Table, not even those favored few who have taken the most decisive action against deflation by seizing the high ground of bankruptcy.

Value creation

Nonetheless, a price elasticity of six suggests that the successful carriers will indeed make it up in volume. Good thing, since volume that will dwarf even the fantastical increases of the past five years is heading their way.

Charlie Burger's analysis of Internet traffic for the last several years shows that it grows not by a smooth linear progression but by a cyclical process. A relentless doubling in the number of host computers on the Net leads to nonlinear surges of traffic, as a broader based and more capacious Net fosters new applications. Napster and its followers were a nonlinear supply-side phenomenon, triggered by universities' decision to provide near-broadband links to students in their rooms.

Measuring Internet value as a combination of host multiplication and traffic growth, Charlie demonstrates

in his paper on the subject that between January 1992 and July 1994 value rose 21 times. Then, between July 1994 and January 1997, as the Web and email exploded, value surged by a factor of 707. Between 1997 and 2002, botched deregulation and feckless broadband returned value creation to the earlier path. Now a new discontinuity impends.

Crucial Phase II companies

That is the suggestion put forward by Russ McGuire of the industry consultancy Telechoice. Instead of showing a bandwidth glut, a paradox, or any other such fatalistic vanity, the Telechoice network model, dubbed MADCAP, demonstrates that even small advances in last-mile business connectivity courtesy of, say, Narad, would overwhelm the current network. New traffic will mandate a metro and long-haul optical build-out dwarfing that of the last five years. Such a build out can be made affordable only by the crucial WDM and network architecture advances offered by such crucial Phase II companies as **Avanex** (AVNX), **Corvis** (CORV), **ONI Systems** (ONIS), and the sublimely hyperfine **Essex** (ESEX.OB), supported by the breadth and capacity of the **JDS Uniphase** (JDSU) one stop component shop.

Contrary to the *New York Times*' and *Wall Street Journal's* famous assertion that just 2.6 percent of the nation's fiber is in use, McGuire's statistics compiled from 29 U.S. carriers show that on the 22 most popular intercity, long-haul routes, 3,400 out of 15,177 total fibers are "lit." That's 22 percent of the installed base of silica strands. Fourteen of the 22 routes are running at 70 percent of capacity or more. More striking than the current figures, however, are McGuire's projections.

If by 2005 just 5 percent of U.S. businesses adopt Gigabit Ethernet connections to the Internet, the MADCAP model shows that all the capacity on every fiber on each of the 22 most popular routes will be used up. Gigabit Ethernet penetration of a mere 2 percent would still require the new lighting of thousands of fibers and would exhaust about half the major routes.

The total bandwidth for all 22 most popular routes today is 38.236 Tbps, for an average of 1.738 Tbps per link. Telechoice calculated average demand on those routes of 1,254 Tbps. Because networks are planned to accommodate *peak* traffic, not average or total traffic, it is likely that just 10,000 gigabit Ethernet connections to the Net would consume all the bandwidth that has ever been created in the U.S.

Collapse of the switched networks

We need more, a lot more. So much more, so much sooner, that the ultimate, futuristic, most far out of all, all-optical paradigm, the enigmatic switchless network, becomes a reality…now.

The two key resources of a network, wires and switches, always trade off against each other according to their relative cost. When wires, or bandwidth, are scarce, the rule is to economize on them by switching, to reuse each wire as often as possible and to statistically multiplex as much data as possible per unit of bandwidth. When bandwidth is abundant and wires as cheap as the virtual wires of wavelength division multiplexed lambdas, we waste both to maximize direct connectivity and economize on switches. If wires were free and without mass the best network would have no switches at all, and every node would connect to every other node directly.

> Instead of showing a bandwidth glut, even small advances in last mile business productivity would overwhelm the current network

Deflationary horrors aside, the real cause of the "sudden stoppage of infrastructure innovation and growth in 2001" invoked by Isenberg was the sudden collapse of the switched network paradigm in an industry dominated by switching companies, including **Lucent** (LU) and **Nortel** (NT).

As our Charlie explains, the switching companies were doomed by the mathematics of WDM: The physics says we can proliferate analog lambdas faster, cheaper, better than we can add digital switches. If you are a switch company you see this as a problem—every one of those damn lambdas has to be switched—that your customer should pay for. Committed to a model in which every additional lambda was an excuse to charge for more switch capacity, the switch companies turned the cost savings of WDM into an unbearable toll on network growth. Suddenly unable to match the dramatic 500 times pace of cost reduction of the previous five years, the network build out hit a wall of CFOs, bankers, and investors no longer willing to bear the cost of the switched network paradigm.

Now comes dramatic confirmation that the switch companies cannot dictate the future of the Net anymore than the RBOCs. The switchless paradigm has been confirmed, and more clearly articulated than ever before, by Nortel itself.

Corvis and Broadwing first in switchless

As I sat down to address Isenberg's propositions, Charlie cruised into my office waving an article from January's *Journal of Optical Networking*. Bristling with calculus, matrices, tables, and schematics and titled prosaically "Comparison of Two Optical-Core Networks," the article made Charlie's day. "These guys from Nortel," he blurted out breathlessly, "show that where A sub jk is an element of matrix A, B sub jk is an element of matrix B, j is the index of a source node and k is the index of sink node, a simple PetaWeb outperforms a complex switched

multi-hop system by a factor of nearly five!!!" Wow, I said, hurling Isenberg's paper aside. (The output of Charlie's own optimized network can overflow your buffers.

It is likely that just 10,000 gigabit Ethernet connections to the Net would consume all the bandwidth that has ever been created in the U.S.

The Nortel paper fit perfectly with Charlie's and MacGuire's assessment of another looming discontinuity in network traffic. "Smart networks cannot keep up. Dedicated switches cannot keep up. We will have to deploy PetaWebs." Emerging like Isenberg's original cri-de-coeur from the bowels of an establishment company, the Nortel paper by Francois Blouin and his team in Ottawa shows that this dumbest network would fulfill most, if not all of Isenberg's telecosmic dreams.

The PetaWeb is the model for the first large-scale, switchless network. But Nortel did not invent it, if invention means a working model. Corvis and **Broadwing** (BRW) did that. The Corvis/Broadwing, "national express network" (see Oct 2001 GTR) links 13 regional networks together with semi-permanent lambda circuits, which require so little switching that it can be handled by Corvis's cheap, six port, no-moving-parts, prismatic, all-optical switch built with off the shelf components.

Similarly, the Nortel PetaWeb is a global star network that runs fiber to a series of pass through hubs from all the edge nodes such as routers, **Ciena** (CIEN) Core Director switches, and other proliferating edge access devices. With a single lambda path for each destination chosen either at the edge nodes, or ultimately at your own computer, the PetaWeb is a paradigmatic, fixed-lambda, circuit-based network that takes advantage of ultra-long haul fiber and thousand lambda WDM. By using some 25 percent more fiber, it achieves five times the effective throughput of the best competing switched mesh design, while demanding less than a third as many channel ports and less than half the number of hops. With this architecture Nortel simulates a system that can accommodate the hundredfold rise in Internet traffic by 2005 implied by a continuation of even high end estimates of threefold annual traffic expansion, to some 120 exabytes a month.

Switches will be useful at peering points between two networks and in linking together a hierarchy of switchless cores at their successive "edges." But in the cores themselves switches will just get in the way.

For a decade, I have been urging the adoption of a simple circuit-based all-optical network that wastes bandwidth and economizes on switches. As a manufacturer of SONET switches and add-drop multiplexers, Nortel has long led the opposition to the paradigm. But the Blouin team makes up for lost time with a cogent and portentous exposition of the immediate practical need for a circuit-based, switch-minimized network.

Resuming the precipitous collapse of costs that created a $39 trillion network for a few hundred billion dollars in five years, the next phase of the network buildout will accommodate the exabytes released from Narad local loops onto ONI metro optical networks out to the Corvis and, who knows, perhaps Nortel PetaWeb. The outcome will be the same collapse of prices and same creation of value.

Phase II. Broadband comes home. The build-out resumes. The switchless network gets real. Analog rules the digital world. Everybody thinks we're crazy, again. Jes' like old times.

George Gilder,
with Charles Burger and Bret Swanson
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