GILDER TECHNOLOGY REPORT

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The Bright Side of the Telechasm

The collapse of the price per bit of bandwidth is exactly the consummation that we have been seeking and predicting and explaining for the last ten years

Preparing for Telecosm 2001 this week in Tahoe, the excitement mounts. Nearly every day some industry panjandrum petitions us for a podium to tell the audience about a redemptive new broadband technology or business plan. But up here in bucolic Great Barrington, nearly free of broadband links to the world, we are still surrounded on all sides by verdant trees and their derivative paper.

Some of it is pretty in pink, from the *Financial Times*, to the Byronic *New York Observer*, and two estimable energy letters from our friends Art Robinson of *Access to Energy* and Howard Hayden of the *Energy Advocate* (pithy truth tellers on the environment). Most of the paper, though, is black and white and full of bleak misinformation, often signaled in headlines of Stygian gloom. Telechasms loom (I wrote that in the *Wall Street Journal* myself). Capex bubbles pop, leaving nothing but malodorous air. Fiber is a glut and optics is mostly an illusion.

The *Financial Times* compares the Internet buildout to the deployment of railroads leading nowhere. It concludes that after a trillion dollars of cash outlays, including two peak years of venture capital in 1999 and 2000 comprising 69 percent of the last 25-year total, and after two trillion of collapsed equity, "not much has changed.... As anyone knows who has tried to buy broadband links to their home or small business…the formerly dominant telecom operators are still largely in control of local access and still charge high prices for low speed capacity." Around here, that was a low but punishing blow.

As for the vaunted productivity miracle, economists have raced to declare it a mere cyclical blip dispelled by the latest government revisions of the data. On productivity, the *FT* declares, "Nobody has been able to measure the effect of broadband telecoms networks." Overall, the outcome is lugubrious, or even litigious. A front page story in the August 24 issue of the *New York Times* reports a portentous flight from the real economy into law school: the number of applicants taking the law school admissions test rose 18.6 percent over the level in June 2000. Gathering in the gloom are more lawyers. The *FT* series concludes that what has been happening in telecom is more "wealth destruction" than "creative destruction."

Good news, however, is breaking out in the offices of the *GTR*. For one thing, we are no longer beset by clammy and oppressive radiations from the "heat of the herd." A bracing chill has dispelled the earlier postmillennial jubilee of wealth and acclaim. I don a sweater and prepare to write this review of the companies on

In This Issue:

the list when Charlie Burger, our optics illuminatus, enters the room with the chart story for this issue. Bringing glad tidings to Tahoe, his findings will gratify all the remaining contrarians in the crowd.

Rohit Sharma, CTO of ONI, will introduce WDM gear offering a tenfold increase in cost effectiveness by the end of next year

To distill a complex argument, the telecosmic collapse, as painful as it has been, is mainly a monetary event. For reasons detailed in the September/October issue of the *American Spectator*, the financial world is undergoing an acute deflation. But as Charlie's numbers show, real world optical technology and Internet traffic are advancing at an accelerated pace. The data from Larry Roberts, the pioneer of the original Internet, show that bits on the Net have been increasing at roughly a fourfold annual rate since 1999, up from a 2.8 times annual rate between 1995 and 1998. Roughly confirming the direction of the data is Eric Schmidt, new chairman and CEO of **Google**, who tells us that Google searched web pages have increased nearly fiftyfold in the last 2.5 years, from 30 million to 1.61 billion, doubling every 150 days.

Two-bit bits

Combine Roberts' traffic data with SG Cowen Corp. data on carrier capital-equipment expenditures and you can calculate a drop in the cost of bandwidth of 58 percent per year, or roughly a hundredfold decline over the last 5 years. Fresh from deploying and lighting up some 42 OC-192 ready channels for **Sphera** corporation in a record 14 days last month, Rohit Sharma, chief technology officer of **ONI** (ONIS), believes that this rate of advance is sharply accelerating. ONI will introduce WDM gear offering a tenfold increase in cost effectiveness by the end of next year, a rate of advance equivalent to the 79 percent decline in bandwidth costs estimated to be occurring in 2001.

What has happened is a manifestation of the triple Moore's law pace of bandwidth advance. With a near doubling of capital outlays between 1998 and 2000 and a continuation of the trend expected, the capex drop of some 16 percent in 2001 is concussive to the industry. But adjusted for increasing cost effectiveness, actual bandwidth deployment or real capital spending continues to soar. At the carrier level, price elasticity of demand for bandwidth continues to register at a rate of around 4 (a 50 percent price drop yields a 200 percent increase of quantity demanded). But at a time of diminishing liquidity, as our friend Ashby Foote reminds us, the drop in prices may not yield the usual increment of monetary demand. Even high levels of elasticity may fail to bring adequate revenues to defray debt incurred in the previous period. But despite all the monetary static, Telecosm companies continue to create massive new capabilities that constitute the real foundation of new wealth.

The collapse of the price per bit of bandwidth is exactly the consummation that we have been seeking and predicting and explaining for the last ten years. Dramatizing its significance is Charlie's projection of the costs of the existing infrastructure without a bandwidth productivity miracle. If carrier capital expenditures had needed to grow as fast as the Internet grew, every dollar of GDP and then some—*nine trillion dollars*—would have been consumed. In other words, the Internet would have been impossible.

In the telecosmic scheme of abundances and scarcities, bandwidth is indeed the canonical abundance. Devoted to its expansion are the world's supreme intellectual resources, wielding the most potent technologies in the economy. We are watching the entire global system reorient itself around the exponentially expanding ability to communicate.

In crucial ways, this process differs from the analogous effect of Moore's law and the collapse of the price of computation. While the power of microelectronics seeped through the rest of the economy sector by sector with an increasing diffusion of machine intelligence, the collapse of the price of communications imparts a general tide of advance that lifts all buoyant vehicles at once. But what it does not lift it drowns.

With ONI, **Avanex** (AVNX), **Corvis** (CORV), **Corning** (GLW), **NP Photonics**, and hundreds of cohorts reducing the price of a marginal gigabit per second by a factor of ten in a year or so, companies that persist in producing the old optoelectronic tollgates will disappear under the tide. With two thirds of the cost coming from lasers, mux-demux, and transceivers, Sharma believes that costs can continue to come down from **JDS Uniphase** (JDSU) and others as components mature on the learning curve and more can be integrated in single modules. But the largest gains accrue to streamlined architectures. With "transparent" optical gear blind to bit rates and SONET protocols, Sharma asserts that over the next year the passage from one metro ring to another, which currently takes four transponders, will give way mostly to passive optics, cutting the optoelectronic tolls in half or more.

ONIS puts onus on Nortel

Using SONET gear from **Nortel** (NT), **Lucent** (LU), **Cisco** (CSCO), or **Ciena** (CIEN) the task of deploying Sphera's channels would have entailed a suspension of existing service, a forklift upgrade, and two months at a minimum. But ONI has optimized its entire system for flexible provisioning of new lambda circuits in the metro without disturbing the existing service.

Smart erbium doped fiber amplifiers (EDFAs) from Corning linked to each other adjust the power in real time as new wavelengths are added or dropped. JDSU thin-film filters perform adequately the mux-demux at 42 wavelengths, though Sharma says ONI is contemplating a variety of other designs for the future.

In the smaller metro and regional networks, where WDM (wavelength division multiplexing) has long been proclaimed too expensive, ONI continues to defy conventional wisdom. Building a captive customer-base (now an impressive 24, up from 7 a year ago) primed for future upgrades, ONI's Sharma continues to succeed against competitors Nortel and Ciena in this rapidly growing space. ONI's recent 31 percent quarter-to-quarter revenue increase trounced Wall Street estimates and proved that connectivity matters much more than mere bandwidth since connections are what customers are willing to pay for. Sharma's remotely reconfigurable WDM system currently scales to a connectivity-rich 160 channels per fiber, well beyond current metro-network deployments.

ONI technology makes lambdas at the edge more flexible, easier to deploy, and cheaper while reducing power consumption and conserving precious central-office space. Replete with dynamically reconfigurable optical add-drop multiplexers, lambda management software, automated power-level measurement and adjustment, and "smart" variable-gain EDFAs from Corning tunable within milliseconds, ONI can adapt to channel fluctuations on the fly, provisioning lambdas from network cores to enterprise campuses and high-rises.

The forever forward looking Sharma, whose San Jose–based company plows a quarter of its revenues back into research, sees next on the opportunity horizon a transformation of storage technology—what we term storewidth—combining the increasing capacity of disk drives with the multiplication of wavelengths. Storage needs to be networked as dynamically as lambdas are, affording access on demand across a metro region. Most storage networks are local in nature now. But in the future, storage facilities will be as transparent as fiber and bits will be deliverable anywhere in the world without any constraint of locality beyond the speed of light.

Scale Eight hits right note

Fulfilling Sharma's prediction and joining our list this month is Scale Eight. In the age of the Telecosm, optimal systems waste abundant storage and communications to save on scarce processing and software. Scale Eight Storage Centers employ no RAID (redundant arrays of independent disks), which achieve reliability by using processing and I/O intensive error correction and "striping" of data across several ordinary disks. Achieving high performance by a massively parallel architecture of cheap storage (JBODS—just a bunch of disks), Scale Eight Storage Centers have roughly 4,000 disks running in parallel. Surprisingly, Scale Eight's chief scientist is computer science titan Dave Patterson, the very inventor of RAID, which originated as redundant arrays of *inexpensive* disks but have contracted costly featuritis.

While working at **Inktomi** (INKT), Patterson's former student at Berkeley, Josh Coates, learned that even using "cheap" RAID, storage of a terabyte would cost roughly 1 million dollars. While at Berkeley Coates was part of a three man team that beat out teams from **IBM** (IBM) and **Compaq** (CPQ) and broke the world record in parallel sorting using a 16-node **Intel** (INTC) based cluster. Conceiving an analogous solution to the storage problem, Coates showed Patterson that a massively parallel architecture of commodity drives could obviate RAID while achieving far greater scalability and adaptability for the Internet. Wasting storage and bandwidth and saving on processing, any file written to one storage center is automatically mirrored to a second storage center thousands of miles away.

Scale Eight's competitive advantage comes from centralizing dumb storage while moving file systems (intelligence) to the edge

With centers in London, Tokyo, Santa Clara, and Sterling, VA, Scale Eight's scheme overcomes write latencies and closely approaches real-time mirroring by writing data simultaneously to disks in two globally disparate storage centers. Using commodity hardware rather than costly storage systems, the servers inside of the storage centers are what Scale Eight refers to as Intelligent Storage Nodes (ISNs). Virtualization software enables each ISN to appear as one large pool of storage able to be viewed as a single entity. The Global Storage Ports ("magic boxes" discussed by CEO Dick Watts at Storewidth 2001) are handed out for free and installed in customer data centers, obviating the need for a separate server infrastructure.

Using twice as many disks as more "efficient" rivals, Scale Eight's competitive advantage comes from centralizing dumb storage while moving file systems (intelligence) to the edge. Scale Eight Global Storage Ports provide industry standard Network File Service (NFS) and **Microsoft** (MSFT) CIFS-based access on local area networks (LANs) at the edge, but are not confined to the CIFS and NFS protocols, which have difficulty scaling beyond the LAN.

Exodus exits

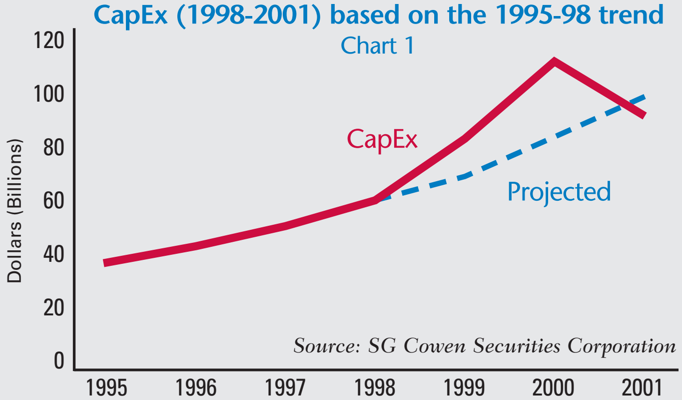
So, who killed **Exodus** (EXDS)?

Among the suspects, list Alan Greenspan's crash of the capital markets and the Clinton FCC's garotte on local broadband Internet. Like so many shaky carriers, the data center companies are suffering from the

Cap Expectations

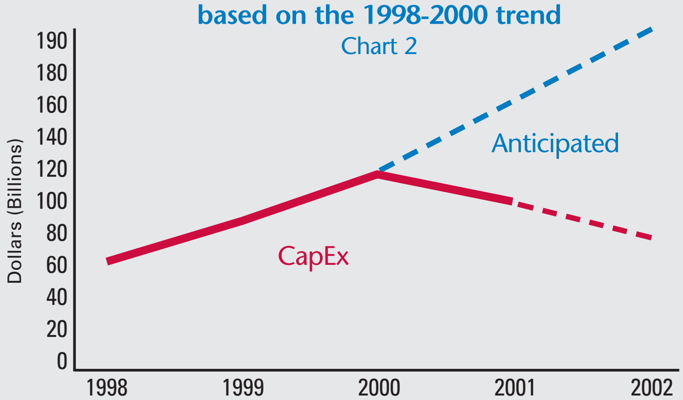
Carrier CapEx (1995-2001) and projected CapEx (1998-2001) based on the 1995-98 trend

Chart 1



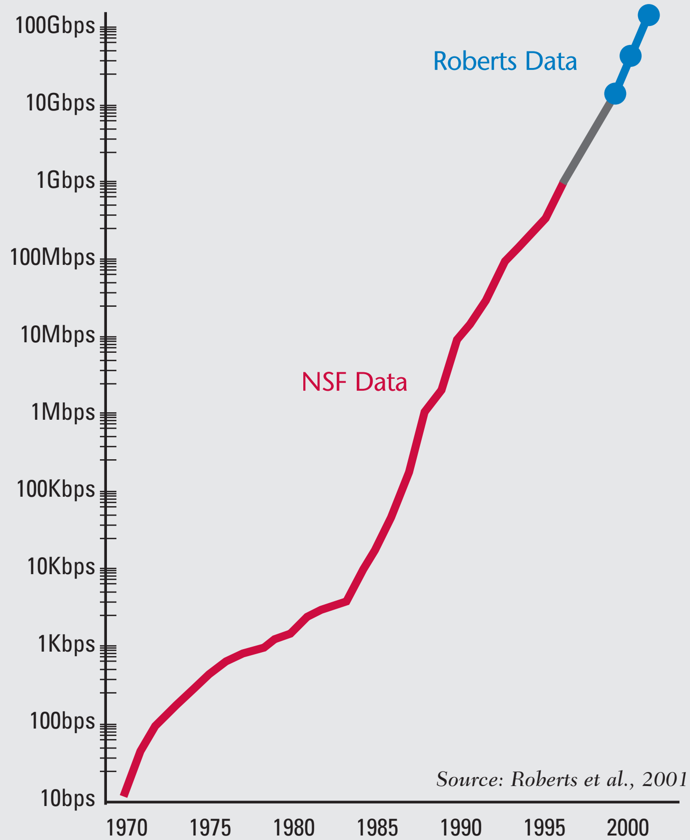
Carrier CapEx (1998-2001) and anticipated CapEx based on the 1998-2000 trend

Chart 2



U.S. Internet Traffic

Chart 3



Carrier CapEx (capital expenditures) increased steadily from 1995–2000 according to SG Cowen Securities Corporation (Chart 1). However, with almost two-thirds of 2001 behind us, Cowen anticipates that carriers will spend "only" $94 billion this year, down 16 percent from 2000. Chart 1 reveals that CapEx expansion accelerated in 1999 and 2000. A polynomial projection of the flatter 1995–98 growth curve (dashed line) predicts 2001 spending in line with current estimates. Viewed from this perspective, the past two years unleashed a $34.2 billion CapEx spike—a 13 percent "bonus" in carrier spending above earlier growth trends.

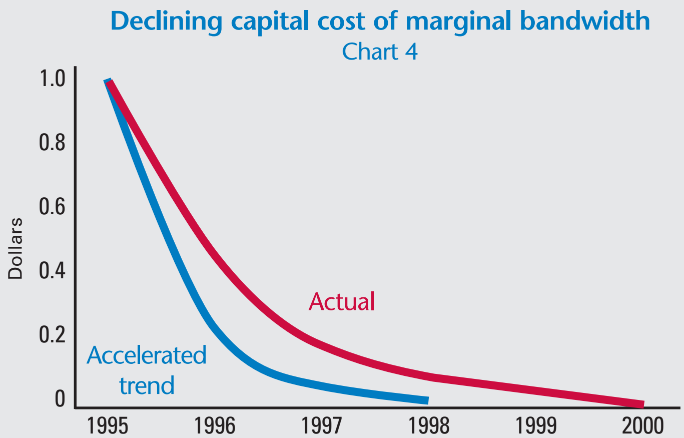
Amid the gurgles of gloom engulfing the Telecosm, Chart 1 appears less than catastrophic. Why the dysphoria? Because we compare this year's CapEx to our expectations based on the accelerated growth of recent years. Home in on 1998–2001 CapEx (Chart 2) and up pops a trend-line anticipating $148.8 billion of carrier spending in 2001 and proportionately more in future years. Thus, we confront a 37 percent *psychological* decrease in CapEx in 2001—three times the face value—ballooning to a 60 percent "expectation gap" in the second year ($193 v. $76 billion).

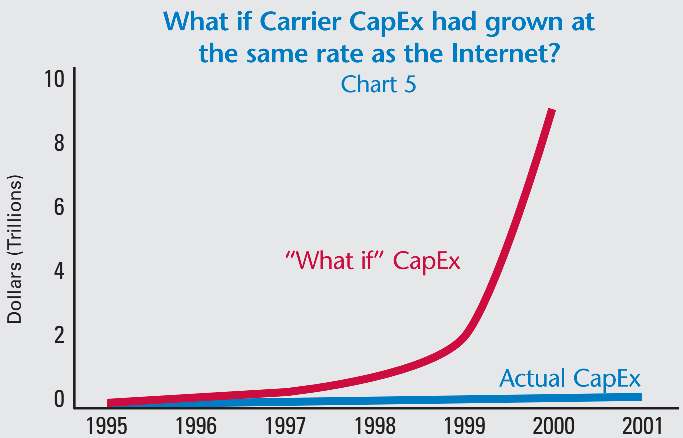
The emerging paradigm party pooped.

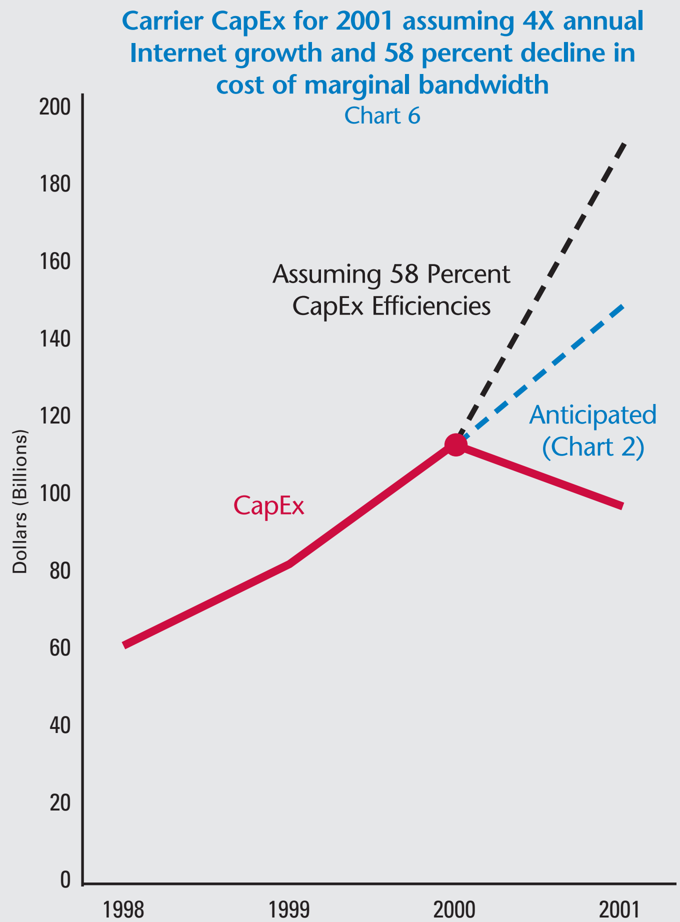
So what's wrong with Larry Roberts, Internet patriarch and founder of Caspian Networks? Still back at the party, he hands us a report on U.S. Internet Traffic Growth 1970–2001 (Chart 3) based on data collected annually by the National Science Foundation through 1996 and on his own figures compiled for the months of April and October 2000 and April 2001. With access to confidential statistics kept by top scientists at the leading carriers, Dr. Roberts consolidated hard numbers of trunk utilization in network cores rather than musing on carrier-capacity speculations or carrier revenue growth to "dream up" traffic figures. His finding: after doubling every 8 months during the middle and late 90s, growing 2.8X annually (the average yearly increase between the final NSF data point and the first Roberts point), the Internet has recently begun doubling every 6 months, a 4X annual growth-rate.

Progressing at the 2.8X rate, the Internet grew 22X from 1995 through 1998. During the same period carrier CapEx increased 1.6X (1.17X annually). Thus, the capital cost of marginal bandwidth decreased 58 percent per year. That is, a unit of bandwidth increase which cost $1.00 in capital expansion in 1995 cost 42 cents in 1996, 18 cents in 1997, and 7 cents in 1998 (Chart 4, top trend-line).

As Internet growth transitioned into Dr. Roberts's 6-month doubling cycle, traffic increased approximately 10.9X during 1999 and 2000, that is, 2.8X in 1999 and 3.9X in 2000 or 3.3X average annual growth. Meanwhile, carrier CapEx grew 1.9X, or 1.36X per year, continuing the slide in the capital cost of marginal bandwidth at the 58 percent per year pace estimated for 1995–98 and extending the cost-reduction curve of Chart 4 (top trend-line) to one cent in 2000, a two order of magnitude reduction in the cost of a unit of bandwidth increase in just five years.







Had CapEx grown at the same pace as the Internet during that period, by 2000 carriers would have been coughing up $8.7 *trillion* yearly to facilitate traffic, trivializing actual spending growth ($112 billion in 2000) as Chart 5 illustrates. (Can you find the immortalized carrier-spending "bubble"?) The disparity illustrates the power of technology to exponentially decrease cost while increasing functionality.

Assuming Internet traffic continues doubling at a 6-month pace through the end of the year, Cowens's 2001 CapEx figure would mark a 79 percent decrease in the capital cost of marginal bandwidth over 2000, a pronounced acceleration in capital efficiencies, as Chart 4 reveals (bottom trend-line). That is, had the 79 percent trend begun in 1995, a unit of bandwidth increase which cost $1.00 in capital expansion that year would have cost two orders of magnitude less, one cent, by 1998, *two years earlier* what actually occurred. Have capital-cost efficiencies temporarily improved or have they begun a trend to even greater efficiencies as WDM optics overtakes electronics in the network, making it increasingly easier to provision marginal lambdas for marginal bandwidth rather than lighting new fibers or installing new systems? The question is crucial: had the cost of marginal bandwidth continued to decline at the slower but still feverish 58-percent pace during 2001, to maintain 4X yearly Internet growth real CapEx would have had to *increase* substantially to $188 billion this year, two times SG Cowen's estimate and 26 percent more than the anticipated trend of Chart 2 (see Chart 6).

Fears that Napster's meteoric rise alone might have instigated the Roberts Internet inflection are not groundless, with estimates of up to 9 petabytes per month spurred by Napster at its peak, around January 2001. But many of Napsters old users have apparently not given up their habits, gravitating to slower, more decentralized peer-to-peer sites such as Music City and Aimster. In addition, Roberts's April 2001 data, equivalent to 46 petabytes per month, comes after Napster's peak; downloads through Napster were cut in half in March alone.

However, even if Internet growth were to slow to the historic 8-month doubling tempo for the rest of 2001 yielding a 3.14X annual expansion, CapEx would still reflect an impressive 73 percent decline in the cost of marginal bandwidth. What at first looked like bubbling "irrational exuberance" may turn out to have been a rational response to a more rapidly growing Internet prodded by technological advance, increased broadband connections, and price elasticity. The elasticity dictates that bandwidth multiplies its own demand, with a greater than one-unit rise in demand for every one unit decline in bandwidth price. Advances in optics in turn continue to decrease the cost of bandwidth. The cycle feeds itself. Meanwhile, broadband access also increases Internet usage according to Nielson/NetRatings, with Web pages viewed ballooning 130 percent when users switch to high-speed connections.

- Charles Burger

mood swings of a market no longer willing to wait for their revenues to outgrow their debt.

Driving the conception and expansion of Exodus is the storewidth paradigm: as bandwidth outside the computer outstrips bandwidth inside, stored data becomes increasingly insensitive to location. Ultimately, nonlocality would even seem to doom most data centers, which are tied to costly real estate in particular places. Along the way toward the ideal of a net instantaneous, infinite in capacity, and nonlocal, large benefits still accrue to data pooling in large centers astride the network's main arteries and interchanges. With the core network location eliminating local hops on narrowband capillaries, farther can be closer. Even more crucial is the opportunity to outsource both the facilities—servers and their costly, secure, climate controlled, act of God resistant real estate—and the facilitators, the IT staff that tends the machines or even manages the data.

An obvious takeover candidate, Exodus' 59 penny stock could easily be the best investment on our list over the next few months

No one built data centers bigger, better, faster than Exodus. To this day gold plated clients like **Merrill Lynch** (MER) endorse the proposition that Exodus—as long as it survives—is the best in the field and often preferable to complete in-house storage solutions. Over time, true, two of the three key reasons for using a data center will decline in significance. As the Net becomes broadband everywhere, and end to end WDM circuits eliminate router hops, the arterial junctions becomes less strategic. But as Scale Eight shows, multiple global locations for high-demand material will remain crucial to coping with the ultimate scarcity—the speed of light.

StorageNetworks stays in the game

More important, outsourcing data storage management no longer means putting the data in the same place as the managers. Led by **StorageNetworks** (STOR), storage service providers (SSPs) will now happily manage your data across the Net from their own central management facilities. So you can outsource your storage management while leaving your data on your servers in your basement.

Nevertheless, you may not want to. The physical maintenance of the machines, and of their demanding environment, remains a daunting and expensive task that most small and mid-size companies will not regard as a core competence. Even as some large companies decide to keep their servers in house, total demand for data center rack space will continue to grow. Many of the data center's direct customers will be storage service providers who use Exodus's and others' facilities to serve their own clients.

All this has been happening at Exodus and the results suggest that the IDC business will remain attractive while steadily losing sex appeal: it will become essentially a high margin real estate play in the highest growth sector of the economy. Though at the peak some 60 percent of Exodus's clients were dot-coms, the company has more customers today than before the crash. Even last quarter when the company's very survival was thrown into question, it won some 264 new customers. But the net increase was only 14 as dot-coms continued to die. Revenues declined sequentially last quarter and revenues per customer have dropped about 2 percent to $317,000 annually, but revenue from enterprise customers is actually up by 1 percent and now accounts for 63 percent of total revenues.

StorageNetworks CTO Bill Miller sees an ongoing need for the Exodus style Internet data center, and StorageNetworks remains one of Exodus' best customers (though an increasing proportion of SNI clients use SNI's remote management capabilities and leave their data in their own in-house data centers).

Exodus, however, faces catastrophic morale problems, and droves of its top managers—including the CFO and CEO—are abandoning ship in part because they have lost faith in the company's ability to manage the debt it acquired when straightened capacity seemed the only barrier to growth.

Yet even now removing Exodus from the Telecosm list is not an easy decision. The list is meant not as a model portfolio but a model of what the Telecosm will become and the companies that exemplify its creation. Removing a company that is well-positioned to dominate a crucial telecosmic niche sticks in the craw. Exodus is a growing company with highly valuable assets and to-die-for customers. Allowed to run the course Exodus would turn cash positive in a few months more or a few months less depending on the state of the telecosmic economy over the next year or two.

The sustainability of such a company's debt, the security of its cash position, are a function of the mood of the capital markets and Wall Street's willingness to roll the debt. With the company an obvious takeover candidate, its 59 penny stock could easily be the best investment on our list over the next few weeks or months.

Nevertheless it goes. The disarray at the top is too profound to allow for coherent analysis of the company's direction, and there is no point to having on the list a company whose actions we cannot meaningfully interpret. The most likely outcome: 12 months from now Exodus's currently functioning data centers will be operating at capacity, profitably, but under a different corporate logo.

Novell no more

When we added **Novell** (NOVL) to the Telecosm list in December of 1999, we saw three reasons to believe they might successfully remake themselves into a leading storewidth company. Their Network Directory Services (NDS) was the market-leading directory, with 90 percent of Novell's revenue coming from directory related products, services, and caching systems that would be crucial in the management of vast stores of data across the enterprise or the Net.

But with Microsoft's Active Directory Services bundled with the server, directories are no longer a direct revenue source. Thus even more important than directories was leadership from Eric Schmidt, the former **Sun Microsystems** (SUNW) guru who had first declared the "network is the computer" and predicted the "hollowing out of the computer" that is central to the storewidth paradigm, freeing storage facilities from a master-slave relationship with the processor and placing them directly on the Net.

In the event, Schmidt's new Net-based ideas for Novell became a new company, Volera, which will be spun out when the market recovers. Volera will focus on web accelerators, like Novell's Internet Caching System (ICS) now packaged as Volera's Excelerator product line, which conserve computes, power, real estate, and the speed of light, to keep pace with the demands of a broadband Net. **Fujitsu** is a key customer. Volera may flourish, but at only one percent of Novell's revenues, Volera's future promise does not justify keeping Novell on the Telecosm list.

Terayon terrific

Big news has erupted at **Terayon** (TERN). The formerly hostile industry standards board, CableLabs, has included Terayon's proprietary S-CDMA in the forthcoming DOCSIS 2.0 specification, to be published in 2002. The new Advanced PHY (physical layer) technology promises more upstream bandwidth and new revenue enhancing applications.

Coaxial cable TV infrastructure is a broadcast network and uses most of its 860 MHz of bandwidth transmitting cable channels downstream toward residential customers. Less than 5 percent of the bandwidth—a span between 5 MHz and 42 MHz—is reserved for upstream communications needed for broadband Internet. The downstream bias limits advanced two-way services like packet voice, peer-to-peer networking, and interactive video.

Terayon expands the usable upstream spectrum and also increases the data rate. "S-CDMA basically takes a two lane upstream highway and turns it into a six lane highway," Terayon's chief scientist Rich Prodan says. "And then it triples the speed limit."

Now that S-CDMA is part of DOCSIS, others may build chips using the previously proprietary specs, but Terayon believes it has a substantial time-to-market advantage given its seven-year CDMA head-start. Broadcom, which has claimed up to a 95 percent market share in cable modem and set-top box chipsets, will likely be affected.

The entire asymmetrical, tree-and-branch DOCSIS regime, however, is itself vulnerable to competition from **Narad Networks** which later this year begins transforming cable TV plants into switched Fast Ethernet webs. Armed with Narad, cable MSOs may first target small and medium sized business while continuing to run DOCSIS cable TV and residential broadband underneath. A passive analog overlay, Narad's system is interoperable with any of the DOCSIS technologies including Terayon's. But over time Narad will likely encroach on the residential DOCSIS stronghold as an asymmetrical 1-megabit-per-second fails to meet a new 100-megabit-per-second definition of broadband.

Terayon expands a two-lane highway to six lanes—and then it triples the speed limit

Second quarter revenues at Terayon, behind Cisco the number two supplier of cable TV head-ends, were $65.7 million, up from $54 million in the first quarter. The third quarter revenue projection is $70–72 million. Net losses persist, however, from the bad inventory of chips that had to be written off last winter.

While the financial markets punish all Telecosm players indiscriminately, the real economy is opening a great divide between companies that foster and feed upon the collapsing price of bandwidth and those who resist and are thus imperiled by it. All this we have said before. What surprises even us is the speed with which the spread between the enablers and extorters has grown. With order of magnitude price shifts happening on the order of a year, robust and venerable enterprises that slip from the sphere can be eviscerated by the Avanexes, ONIs, and Scale Eights in the time it takes to say bandwidth glut.

The entire purpose of independent investment is summed up in such moments, when the market moving en masse obscures the crucial distinctions on which great fortunes will be built.

George Gilder with Mary Collins
September 10, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE	REFERENCE PRICE	AUG '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	12.01	11.660 - 113.33	11.2B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	7.05	6.30 - 126.00	9.3B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	5.30	5.24 - 161.38	344.7M
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	26.50	24.30 - 68.00	12.2B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	3.80	3.45 - 142.50	286.9M
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	–	–	–	–
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	13.90	13.00 - 111.13	1.9B
WDM Systems, Raman	Corvis (CORV)	3/30/01	7.03	1.97	1.88 - 108.00	709.4M
Metro Semiconductor Optical Amplifiers	Genoa (private)	3/30/01	–	–	–	–
Optical Processors	Essex (ESEX.OB)	7/31/01	5.90	6.13	1.50 - 6.70	30.4M
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6.00*	32.15	20.88 - 269.25	8.4B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	4.17	2.36 - 57.00	285.2M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	11.91	6.90 - 54.94	3.0B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	–	–	–	–
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	1.88	1.03 - 8.38	626.6M
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.27	0.24 - 14.19	29.5M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	58.85	42.75 - 107.81	44.8B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	24.98	15.72 - 51.25	23.4B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	17.40	10.50 - 37.00	38.3B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	8.30	3.31 - 82.69	375.1M
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	0.75	0.49 - 40.13	459.7M
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	4.23	3.65 - 37.75	3.8B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	3.85	3.40 - 50.13	82.1M
National Lambda Circuit Sales	Broadwing (BRW)	6/29/01	24.45	17.96	15.40 - 30.00	3.9B
Internet Backbone and Broadband Wireless Access	WorldCom (WCOM)	8/29/97	19.95	12.86	12.20 - 37.63	38.0B
STOREWIDTH						
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	11.45	10.40 - 64.69	37.3B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29 .00	1.79	1.51 - 29.00	203.1M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27.00*	5.55	4.25 - 115.88	537.8M
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	–	–	–	–
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	0.77	0.53 - 9.75	20.8M
Massively Parallel Global Storewidth Solutions	Scale Eight (private)	8/31/01	–	–	–	–
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	47.87	30.50 - 109.75	17.3B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	14.27	11.25 - 109.75	4.3B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	9.59	7.63 - 21.94	4.5B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	20.25	13.65 - 38.50	7.4B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	33.05	17.13 - 47.94	5.8B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	33.10	26.26 - 69.38	57.4B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	39.04	29.79 - 92.27	13.0B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	5.53	3.69 - 38.44	35.7M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	21.61	13.72 - 49.94	2.7B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	28.40	18.81 - 67.13	11.0B

ADDED TO LIST: SCALE EIGHT **DELETED FROM LIST: NOVELL AND EXODUS** * 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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