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The Great Divide

The Great Divide separates companies focused on big bandwidth (Nortel and Lucent) from companies focused on connectivity (Avanex and ONI)

At our recent Storewidth Conference 2001 in Laguna Niguel, a friendly venture capitalist approached our redoubtable Charlie Burger and floored him with a one punch question: "Does George really believe this thousand lambdas on a fiber stuff?"

Lambdas are the physicist's term for wavelengths or "colors" of light—the bearers of bitstreams down fiber optic lines. The most important industrial invention of the last decade is wavelength division multiplexing (WDM): putting many colors of light on a single fiber strand and a thousand strands in a single cable.

Having predicted thousands of lambdas on a fiber—and a million lambdas in a cable—in hundreds of speeches, articles, and newsletters for more than a decade, having launched a company and a monthly report on this premise five years ago, having held seven rousing conferences devoted to this vision, and having written *Telecosm* to make it all clear, I can say that thousands of wavelengths on a fiber is part of my DNA. If you are an investor in technology it had better be part of yours.

Today Wall Street is telling the world that all information technology companies are essentially the same. They may produce Internet infrastructure, terabit routers, Ethernet hubs, or SONET (telco-standard, optoelectronic) switches. They may manufacture cellphones or personal computers or net appliances. But whatever they do, they sell "technology," and they all face a recession, a collapse of orders, and a capital dearth.

This conventional wisdom is as wrong today as the similar view in the mid-1980s that all the companies in the semiconductor and computer industries were the same, that it didn't matter whether you invested in **Intel** (INTC) or Monolithic Memories, in **Applied Materials** (AMAT) or **Applied Microsystems** (APMC), in **Microsoft** (MFST) or Digital Equipment. A profound recession and a stock market crash were said to be pushing the entire industry massively to capital rich Japan and other Asian countries. To many observers, the most glamourous remaining U.S. projects were supercomputer ventures such as Cray Computer, Control Data, or Thinking Machines Corporation that were multiplying compute-power in a single box to 10 billion operations per second and above.

What in fact was going on in 1985 was the opening of a Great Divide in the computer industry. On one side were the companies achieving billions of operations per

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second in a single computer; on the other side were companies enabling production of hundreds of millions of computers. The companies such as Control Data, Cray, and even **IBM** (IBM) that focused on performing billions of operations per second in a single costly box lost to the companies that focused on enabling millions of people to use computers: Intel, Microsoft, and **Dell** (DELL).

Leading the supercomputer visionaries astray was their failure to identify the critical abundances and scarcities in their industry. They were on the wrong side of Moore's law: the epochal cliff of costs in the production of transistors and memory chips. They laboriously climbed the cliff by making small numbers of ever more costly and specialized devices that ran ever faster. By contrast, the winners plunged down the cliff of costs by making ever more billions, and eventually trillions, of cheap transistors that ran slower. In the end, the cheap, slow transistors rode a learning curve that enabled low cost portable boxes to reach higher performance than the supercomputers of the 1980s.

Pushing the optical industry over a cliff of costs three times as steep as Moore's law, WDM defines the sweet spot for technology investors

Today a similar Great Divide is opening up in networks. It also revolves around the key abundances and scarcities of an industry. Wave division multiplexing is pushing the optical industry over a cliff of costs at least three times as precipitous as Moore's law. Every six months or so the number of lambdas on a single fiber thread doubles. In 1996 the number was 16; in 1998, it was 40; in 2000, it was 160; in 2001, it may well reach 320—all with no increase in cost.

NT and LU puff toward gigabit precipice

Meanwhile, following the inspiration of the supercomputers of yore, many companies still prefer to climb the cliff of performance based on increasing the number of bits per second on a single lambda. Measured in SONET OC chunks, this number has risen from OC-48 or 2.4 gigabits per second in 1996 to OC-768 or 40 gigabits per second in some rare applications last year. **Nortel** (NT) plans to offer 80 gigabits per second early next year and **Lucent** (LU) proclaims the laboratory feat of putting 160 gigabits per second on a single lambda.

The difference between pushing the technology toward more lambdas and pushing it toward fewer, higher bitrate lambdas is the difference between multiplying connections and multiplying the capacity of a single connection. The new Great Divide pivots on the very issue raised by that venture capitalist in Laguna Niguel. How many lambdas can fit on a single fiber cable and thus how many customers can a single fiber or cable serve? Will it be a handful of gigantic expensive customers or millions of web citizens? Will bits be jammed together on a single lambda, making them practically inaccessible without costly electronic processing? Or will they be divided among multitudinous lambdas—one per customer or connection—allowing the bits to be cheaply and passively steered and selected by the laws of physics.

The connectivity gold rush

In other words, this Great Divide separates the companies performing the mostly empty stunt of multiplying the number of inaccessible bits per second on a backbone fiber from the companies multiplying the number of customers who can access the network. It separates the companies focused on big, costly bandwidth such as Nortel and Lucent from the companies focused on cornucopian connectivity such as **Avanex** (AVNX) and **ONI** (ONIS).

An investor who shares that venturer's ignorance of impending lambda abundance faces an acute risk of finding himself on the wrong side of this decade's Great Divide. Even without thousands of lambdas, it may well be possible to provide limitless bandwidth with OC-3072 already promised from Lucent's labs. But limitless bandwidth packed on a single connection, though far from free, is nearly worthless. Requiring that every packet header be read at every node and mandating myriads of optoelectronic devices, lasers, collimators, and connectors, Lucent's 160 gigabits per second on a lambda will cost millions of dollars to add/drop or switch. Cheap bandwidth with expensive connectivity is just expensive bandwidth. When you hear tales of cutbacks in networking capital expenditures, you are hearing companies realize that their inaccessible bandwidth is also unaffordable.

The chief lesson from Storewidth 2001 is the emergence of a new industry that is going to make these millions of lambdas a mandatory part of the new economy. There may well be a glut of unusable bandwidth, but there will be no glut of connectivity. Just as a few gigantic computers could not meet the needs of hundreds of millions of people for personal computing, so a few gigantic switches and humongous point to point bitstreams cannot meet the needs of billions of people accessing their storage—the scattered output of their virtual lives—across the Internet.

Yale professor and entrepreneur David Gelernter prophesies a further step in the hollowing out of the computer that breaks through the concept of a computer desktop and disk drive altogether and collects and manages all your personal or business information regardless of source or location, organizing it intuitively without the need for the user to create a perfect file system ahead of time. "Software's ultimate goal," he writes in his elegant essay, *Machine Beauty*, "is to *break free of the computer*." When software breaks free of the computer, it moves onto the Net. Onto the Net with it will move the bulk of the contents of the billion disk drives attached to the billion personal computers around the globe. That means that the petabytes (10 to the 15th) of information currently sloshing around the Net every month will give way to exabytes (10 to the 18th) and more. Mike Ruettgers of **EMC** (EMC) estimated at

Storewidth 2001 that within the next five years each computer user will command five terabytes of information, most of it out on the Net. Indeed, to the traveler, even the information at "home" is out on the Net when the user is on the road. Included will be myriad kilobyte emails, hosts of megabyte photographs, swarms of gigabyte video cassettes, throngs of twenty gigabyte DVDs, movies, favorite TV programs, sports events, books, and video teleconference archives, all perhaps arrayed through time in Gelernter's ingenious "lifestreams," someday when we say the network is the computer we will believe it, so much perhaps that we will ask, What is a computer? But the triumph of such a network will be the triumph of abundant connectivity and the companies that are creating it.

Avanex and Chorum banish Bookham

Amid the orange afterglow of a sunset on Laguna Niguel, however, our timorous venturer reasoned that if networks were currently having trouble with 80 channels on a fiber, a thousand were out of the question. Then, simulating spontaneity, he asked Charlie Burger if he had heard of **Bookham** (BKHM), a company that his firm had aided and abetted in its pre-IPO days.

Bookham has mounted an intriguing effort to ride the learning curve of the silicon Microcosm into the Telecosm. But this approach, which leads the company to treat light more like electrons than photons, is pushing Bookham toward the wrong side of the Great Divide. Coming from Avanex, **Chorum** and other players are free-space interleavers that can separate and combine thousands of lambdas more scalably. These devices are banishing Bookham's 16- and 40-channel arrayed waveguide grating (AWG) silicon multiplexers to the coarse backend of WDM. Even in the back of the bus, Bookham may need to give up its seat to **Corning**'s (GLW) high-yield, thin-film filters and to Avanex's and **LightChip**'s gratings which elegantly multiplex dozens of colors in free-space, where photons thrive. Reality, however, evades our VC, serenely sipping wine as the WDM race accelerates past him.

In the encounter with the lambda-skeptic VC, the entire Gilder Storewidth 2001 conference came into focus. For two and a half days last month, as dozens of beach boys caught California waves outside, network storage gurus inside the Ritz Carlton rode lightwaves into the heart of an emerging paradigm.

Internet service providers (ISPs), application service providers (ASPs), collocation centers, e-commerce hubs, and storage nodes housing troves of information all need to be accessed by a variety of outside computers and appliances. At the interface between bandwidth and storage, "storewidth" is the accessibility challenge—the conversion of abundant bandwidth and storage into instant information anywhere on the Net.

Storage cannot move onto the Net without cheap, abundant, and reliable connections. Rightly wasteful of bandwidth, the best links tend to be circuits up for the duration of the call. In an all-optical network, lambda wavelengths can supply such circuits.

The law of the Telecosm tells us to waste abundant bandwidth and storage to achieve connectivity through lambda circuits. Yet some at Storewidth 2001 were furiously coping with a perceived bandwidth dearth, rather than preparing for the coming tide of lightwaves. The opening night exchange between **Akamai**'s (AKAM) feisty netwise Avi Freedman and **Mirror Image**'s (XLA) reflective Bob Hammond set the conference stage.

While Hammond founded his model on abundant wavelengths, Avi described a world of congested Internet pipes, incompatible parallel networks, contested peering centers, hot potato routing, lost packets, and paralytic politics. He denied that the all-optical network is anywhere near except in a few point to point applications on the backbone. Describing well the briarpatch of the current Internet, where he uniquely thrives, Freedman reflects a view pervasive in the industry.

Mirror Image's Bob Hammond founded his model on abundant wavelengths; Akamai's Avi Freedman denied the all-optical network

We recalled our meeting with SONET startup Cyras (since acquired by **Ciena** - CIEN) at the National Fiber Optic Engineers Conference in Denver last August. There, we were put in our place for merely suggesting SONET's rapid decline and fall. The Cyras man told us that the industry was years away from adding and dropping wavelengths all-optically and balancing power among channels in the fiber, two crucial functions of an all-optical network.

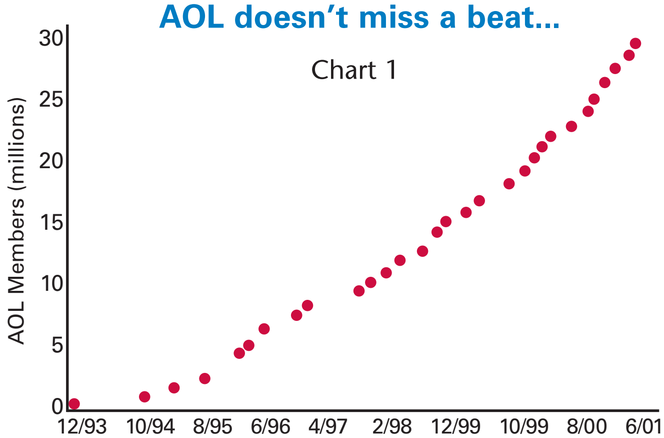
Yet three months *earlier,* cutting-edge **Corning** (GLW) had delivered all-optical add/drop multiplexers (OADMs) to **Alcatel** (ALA), which credited its **British Telecom** (BTY) contract win to the product. Today, OADMs and dynamic power balancing components are commercially available from Avanex, Chorum, Corning, **JDS Uniphase** (JDSU), and others along with critical WDM enablers from dozens of vendors (April GTR, on OFC 2001 in Anaheim).

Corvis flies on Broad Wings

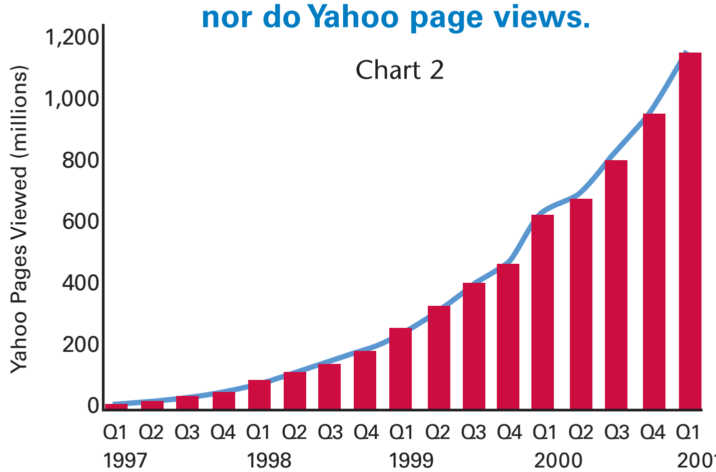
Four days before Avi Freedman's presentation at Storewidth 2001, **Broadwing** (BRW) had completed its **Corvis** (CORV)-built, nationwide all-optical backbone—18,500 WDM miles with no electrical conversion in sight. Hardened with Corvis's small 6 x 6 all-optical switches and enabled by ascendant Raman amplification, an area where Corvis likely leads, Broadwing can please four million Napster downloaders per minute or supply 50 thousand rabid readers with an eBook each during the same 60 seconds. Broadwing's 160 wavelengths on a fiber will expand to 240 channels. With the potential of thousands of lambdas per fiber, Broadwing and broadband could become synonymous. Not far behind Broadwing, **Williams** (WCG) is currently com-

INTERNET BUBBLE?

AOL doesn't miss a beat...

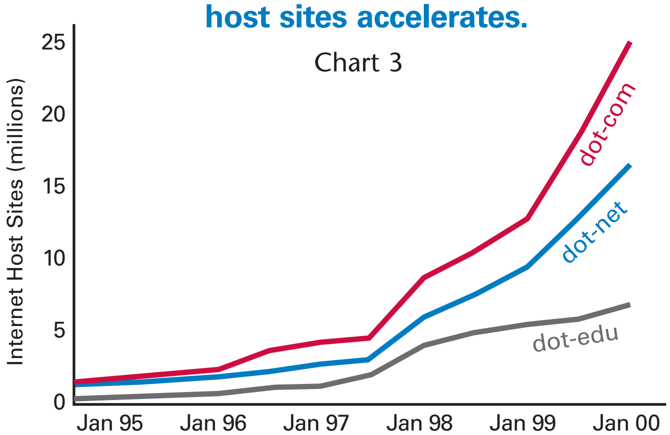


nor do Yahoo page views.



Internet traffic soars with no end in sight. AOL membership continues to increase at a rate close to half a million subscribers per month (chart 1). AOL users alone request 245 million stock quotes and send 656 million instant messages per day. The number of Yahoo daily page views has increased by 2,650% in the past four years (chart 2). The number if Internet host sites also continues to rise (chart 3). Online traffic will continue its ascent with the advancement of Net user penetration (chart 4) and as more applications move onto the Net. One such application, the online storage of the estimated 52 billion photographs snapped annually could potentially produce over 26 petabytes (10^{15}) of online traffic per year, or 26 times total monthly Internet traffic of 1999. - Mary Collins

Growth in Internet host sites accelerates.



Still huge room for global growth.

Chart 4

Country	Population	Internet Users	Net User Penetration
1. United States	276 Million	91.0 Million	**33.0%**
2. Japan	127 Million	29.0 Million	**22.8%**
3. Germany	83 Million	18.9 Million	**22.8%**
4. United Kingdom	60 Million	18.8 Million	**31.3%**
5. South Korea	46 Million	14.0 Million	**30.4%**
6. France	59 Million	10.7 Million	**18.1%**
7. China	1.3 Billion	10.0 Million	**0.8%**

All figures as of March 2001

Data Sources: AOL, Morgan Stanley, Navigators.com, Yahoo!

pleting 24,000 backbone miles with 160 Corvis all-optical channels per fiber which they plan to double to 320 channels within a year.

Most market forecasts extrapolate the details and ignore paradigms. During a paradigm shift, when progress is often exponential, even visionaries can be caught by surprise on the wrong side of the Great Divide. Catching Telecosm blazer Avanex off guard was the sudden collapse of its legacy products, mostly thin-film filter sales to MCI, which fell from a 50 percent customer to a less than 10 percent customer in one quarter. In these numbers, pundits saw a disaster. In fact Avanex's future shines brighter than ever as interest in its next-generation products flourishes. The PowerMux interleaver and PowerExchanger all-optical add/drop multiplexer (which guides lambdas passively on and off the network highway) saw sales increase 30 percent over last quarter, though the paradigm shift from SONET to WDM is just beginning.

ONI defies pundits

In the smaller metro and regional networks, where WDM has long been proclaimed too expensive, ONI continues defy conventional wisdom. It claims 21 customers, representing a 31 percent increase over the past quarter and trouncing Wall Street estimates. To get a foot in the door, CEO Hugh Martin and CTO Rohit Sharma currently straddle the Great Divide, obliging telco customers with SONET ports until its demise. But their remotely reconfigurable WDM system currently scales to 160 channels, outer space compared to most metro networks today. Not for long, though. Watch as Avanex drops the marginal cost of lambdas to $100 from $500 and then down significantly from there.

As Digital Equipment, booking record revenues, toppled almost overnight in the face of the PC assault, so will the SONET regime crumble just as its revenues hit all time highs. With growth in communications power exceeding growth in computer processing power by at least three times every 18 months, optics accelerates almost an order of magnitude faster than electronics over three years and more than a thousand times faster in a decade—it pulls away exponentially. SONET imposes much of the astronomical optoelectronic cost of WDM today. Add just one more lambda channel and you must add another set of SONET gear, keeping the cost of marginal lambdas prohibitively high (in the hundreds of millions of dollars across an entire network).

In the face of Cao's law of the Telecosm, the SONET empires of Nortel, Lucent, and **Cisco** (CSCO), limited by Moore's law, will die even more rapidly than ONI expects. Most of North America's major carriers will run out of capacity in less than six months, forcing immediate outsourcing to the likes of all-optical Broadwing and Williams, who will be able to connect more and more new customers as their lambda counts continue to increase. Eventual follow-on upgrades by the major carriers will tend to follow suit, shunning SONET in favor of less expensive and more capacious optics.

Sphera sidesteps SONET

The SONET hurdle has halted most metropolitan rollouts in their tracks. Surmounting it with SONET-free WDM, **Sphera Optical Networks**—an eighteen month old toddler—opened five all-optical metropolitan area networks (MANs) last December alone. As of February their build-out totaled seven MANs with eight more under rapid-fire construction, using **Level3** (LVLT), **Fiber Net**, and **Metromedia Fiber** (MFNX) dark fiber. Sphera built its first two networks using **Sycamore** (SCMR) switches, but quickly migrated to ONI's WDM system including its OADMs, which necessarily power balance channels, and ONI's remote lambda provisioning capabilities. With 33 channels (three for protection) at a maximum 10 Gbps bandwidth, Sphera configures dedicated switchless lambdas between customers, Internet hubs, and storewidth centers.

Paradigm trailblazer Avanex showed us at OFC what is possible today in a 100 km metro ring, sans SONET and switches, using the PowerExpress amplifier, the PowerExchanger switchless add/drop multiplexer with power balancing among channels, and an **Agere** (AGR.A) tunable laser. PowerExpress not only boosts waning signal power, it also reshapes fiber distorted pulses, maintaining clean, sharp, readable signals. Controlled by Simon Cao's tunable transmitter board, the tunable laser assigns lambdas based on destination—data destined to exit at a particular node rides on a wavelength assigned to that node, where the PowerExchanger guides it off the metro ring and onto the access ramp toward its destination. Based on Avanex's PowerMux interleaver, which in its newest form can combine and separate any channel spacing and any bit rate, the PowerExchanger will help harden the WDM network. **Fujitsu** (FJTSY) recently reported a trial with **WorldCom** (WCOM), using 176 reconfigurable channels, with any combination added and dropped.

Sorrento's (FIBR) Xin Cheng, whose vision parallels his friend Simon Cao's, is also pioneering WDM in the metro. His 128 channel system will soon incorporate the first metro all-optical switch, scalable a lambda at a time. Why a switch rather than an optical add/drop mux (OADM) such as Power Exchanger? Much as ONI uses SONET to get into carrier networks, Sorrento will use photonic switching to make initial inroads since it fits the carrier mindset and since the tunable laser technology used in Avanex's OFC demonstration is in its infancy. But Sorrento will be ready to go switchless since their design can function as an optical add/drop mux (OADM).

WDM edges Ethernet

Most of the data that is piling up in offices and high-end homes awaiting release onto the Net currently runs on Ethernets. In its infancy, Ethernet was chiefly constrained by its software and lagged behind the pace of Moore's law. Therefore, once the software and protocols were in order, the system could advance in catch-up mode merely by adapting existing microchip technology to real time network applications. With digital signal processing power improving some tenfold every two years, electronic networking surged forward during the last decade, and some advocates of Ethernet imagine that it can keep pace with wavelength division multiplexed optics.

As exabytes of data rush out of LANs and into the metro and beyond for storage, however, Ethernet will have to bow to WDM at the edge of the network, just as SONET succumbs at its core. Both are stymied by the inefficiencies of optoelectronic packet switching. Even entering and exiting high-rises, Avanex envisions thousands of its inexpensive WDM lambdas per fiber for connectivity.

The SONET empires of Nortel, Lucent, and Cisco will die even more rapidly than ONI expects

Customers may not pay much for bandwidth, but they will pay for connectivity, and WDM enables the most with the least switching. GigE provider **Telseon** has recently added WDM services and Ethernet stalwart **Yipes** has been forced into contemplating WDM for its access networks as the cost plunges. Meanwhile **LuxN** continues its penetration of WDM into the access and LAN.

Now LuxN is rivalling Ethernet cost efficiencies with a coarse, or low channel-count WDM system for campus interconnections, metro access, and smaller metro rings. At the University of Texas, LuxN aggregated exploding Gigabit Ethernet traffic between two major campuses. For Widener University, it opened a WDM network to link campuses in Pennsylvania, Delaware, and New Jersey, with video on demand, voice, and remote storage while reducing its 12-strand fiber requirement to a single fiber pair.

Exodus likes Volera and Scale Eight

The hollowing out of the computer is pushing untold petabytes of heterogeneous data onto the network—petabytes of information that must be accessed from the edge in a homogeneous, controllable, and timely manner. Thus the hollowing out of the computer will hollow out the IT department as well. Just as storage and other applications naturally migrate to the Net, where the information and business are, IT professionals will migrate to where the IT equipment and functions are—for example, to **Exodus** (EXDS) Internet Data Centers (IDCs). Enterprises will be only one (Yipes, **Giant Loop**, Telseon) connection away. Distinguishing themselves among all other data centers, Exodus IDCs have become the service hubs of co-located service providers. Exodus customers want guaranteed power, security, and speed (22 gigabits of sustained egress) but also connectivity and access to services like those offered by Mirror Image, **Scale Eight**, and **Volera**. Exodus provides the playing field for the outsourcing game.

Betting hard on multiple lambdas, Scale Eight pursues a strategy perfectly aligned with the storewidth paradigm

Scale Eight's service comprises centers in London, Tokyo, Virginia, and California, each containing between 500 terabytes and one petabyte and housed in Exodus Internet Data Centers (IDCs). A storage service provider (SSP) betting hard on bountiful bandwidth and multiple lambdas, Scale Eight pursues a strategy perfectly aligned with the storewidth paradigm. Similar in vision and architecture to Mirror Image content delivery infrastructure, Scale Eight wastes bandwidth by dumping petabytes of storage onto the Net and storing data cheaply in large storage centers built with low-priced off-the-shelf storage. Spurning the increasingly complicated RAID (redundant array of inexpensive disks) configurations common in the industry, it offers a local cache and a tunnel to an infinitely scalable storage trove.

Volera Excelerates access

Akamai now uses Scale Eight to access large pools of centralized data. MTVi, the company responsible for MTV.com and VH1.com uses Scale Eight to manage the global storage of its large audio and video files. Backed up through instant geographic mirroring to multiple storage centers, Scale Eight can throw out multiple copies of the same object. Exodus has committed to reseller agreements with both Scale Eight and **StorageNetworks** (STOR), and with Eric Schmidt's new venture, Volera.

Spun off from **Novell** (NOVL) with funding from Nortel and **Accenture**, Volera provides an Excelerator that stands in front of the origin web server, acting as a proxy server. Caching recently requested information, Volera alleviates the processing burden on the web server, freeing it to handle other applications such as indexing, sorting, and transactions. The first point of contact for future requests, the Volera boxes allow two to five times more requests to be handled in the same period of time and replace some 10 web servers. The box is also the location for caching and building applications on top of storage such as dynamically preparing content for delivery over a CDN (where data is Akamized). Volera has established partnerships with both Mirror Image and Akamai.

Enabling the movement of data to the Net and requiring a proliferation of connectivity, storewidth companies both feed on the lambda based network and spur its expansion in an exponential spiral. Although humans have a hard time conceptualizing exponentials, human progress has been one big exponential, as Ray Kurzweil demonstrates in his new book, *The Singularity*.

Early on, exponential curves appear trendless—linear and nearly flat. The legendary washerwoman who agreed to clean Grand Central Station every day for a month, starting with a wage of a penny a day and doubling each day thereafter, understood this far better than her city employer. At the close of the first week, on day seven, her wage has crawled up to 64 cents per day. The washerwoman remains in poverty. At the end of week two, her daily wage has crept up to \$81.92, and her employer continues to feel safe. During week three, though barely out of poverty, her life begins to change—on day 21 she draws \$10,486. The city treasurer notices, but can easily hide the payment. Just one week later, our queen of exponentials pockets a check for \$1.34 million, and on day 31 she reaps \$10.7 million. The city convulses.

Broadband nears critical mass

Most of us have internalized an intuitively linear, or 63-cent view of technological progress. But the future will leave laggards on the wrong side of the Great Divide. As Kurzweil argues, the *rate* of progress is itself often accelerating. When the human genome project was launched in the mid-80s, critics complained it would take thousands of years to complete. Yet the project was finished in 14 years.

Peter Huber describes cycles of growth in digital markets—relative calm sandwiched between "sudden, convulsive spasms" of progress. "Each successive stage of eye-popping growth requires years of incubation, during which hardware and software accumulate and networks form. Then some critical mass is finally reached, a chain reaction begins, and the product or service makes an abrupt transition from techno-curiosity to mass-market necessity. Wall Street overreacts to the quiet interludes just as much as it overreacts to the crescendos." Huber points out that broadband Internet connections are currently following a trend that will reach a critical mass of some 20 million users by 2003.

When looking for paradigm shifts, don't get lost in the details. Those such as Avi Freedman who must deal with the daily details of the Net may do better in the short run since most of us underestimate day-to-day intricacies, but in the long run they'll founder in a linear, almost trendless pseudo-world amid an exponential reality.

The telecosmic "Gelerning" curve

The largest profits in business accrue to the company that supplies the key missing element that completes a commercial system and ignites a new spiral of advance. So writes Peter Drucker, the great American sage of business management and strategy.

Drucker's insight brings to the forefront of the next software era that quiet genius from Yale David Gelernter. We had heard that he is devoting most of his time and energy to his role as chief technical officer at a company named for his prophetic 1992 book, *Mirror Worlds*. But it was not until we interviewed him on tape for Storewidth 2001 on a snowy March day at the Yale television studio that we realized the tremendous storewidth implications of his company, **Mirror World Technologies**. Gelernter has supplied the single element that can complete the storewidth paradigm and spur the continued ascent of the Telecosm.

The computer and its current software all reflect an era when storage and bandwidth were scarce and MIPS (millions of instructions per second of computer power) were relatively abundant. It was an era when the bandwidth on the Net was hundreds of times less than the bandwidth on the motherboard. The result was the Mother Hub-board architecture, with everything running through the CPU and all the storage under the skirts of the computer or tightly tethered to it. Today, however, storage and bandwidth are both growing far faster than Moore's law of 18 month doublings of computer power. The boxed life no longer makes sense.

Gelernter's alternative is to shun the "desktop metaphor" altogether, with its finicky file names and its directory mazes and its murky menus and its enigmatic icons and dive into "lifestreams," which was the original name of his software. A "lifestream" is a network accessible archive of time ordered information that may begin in a terabyte disk drive under your desk, but typically reaches far beyond your computer or your company. Lifestream is an organizational mode designed for a world in which the user does not care about—or care to be limited by the "real" location of the information he accesses, a world in which the distinction between browser and desktop is pointless and in which neither "browser" nor "desktop" satisfactorily sums up the way we actually use information.

An artist at heart, Gelernter modeled his scheme after nature's own method of foreshortening. Regardless of "real" location, files are presented chronologically with the most recent documents in the forefront and previous documents trailing off towards the horizon—viewable in essence through an opening as small as a keyhole. The edge of each file is visible, presenting a visual cue and attributes of each document as the cursor is skimmed over it. Such a solution will be essential when looking at the size of the screen on a mobile phone or Palmtop. The onrush of handheld devices will drive demand for the Mirror Worlds desktop alternative.

You can tune in any stream, any time. It can be targeted or general, personal or public. Your personal stream, for example, would contain all of the documents that define you: e-mail, faxes, memos, personal files, web pages, a heterogeneous time-ordered electronic narrative of your life. A TV station would present a stream of programs. The stream is dynamic. It moves because life moves. As it advances in time, memos from the future will arrive to remind the user of appointments and other obligations.

Since the lifestreams name was already taken, Gelernter's visionary system is now dubbed Scopeware. You cannot have everything, as Gelernter discovered in 1993, when he was crippled and nearly killed by the Unabomber for predicting the World Wide Web in his 1992 book *Mirror Worlds*. Although he never recovered his full hearing or full use of his right hand, he may well inherit the world of computer software. To try the Gelernter system is to fall in love with it. It is elegant, easy, natural, and beautiful. It will prevail. Springing from the abundance of storage and bandwidth and the comparative lag of computer MIPS, Gelernter's Scopeware offers the software for the hollowing out of the computer long predicted by Erich Schmidt.

Gelernter has supplied the single element that can complete the storewidth paradigm and spur the continued ascent of the Telecosm

The slower advance of MIPS means that computer power, for all its prodigal abundance strewn around the planet, will tend to congeal in clusters on the Net, where storage can be coupled to it, and be linked to users by the fibersphere of wavelength division multiplexing (WDM). Millions of lifestreams will flow in light streams, down fiber optic threads each containing thousands of different wavelengths.

The resulting flood from the world's private networks and storage devices implies the yottabytes (10^{21}) network, a network that can only be completed all-optically, and that will become an indispensable channel for the business of the globe.

So are you ready for Lifestreams on Lightwaves? That is the Gelernter solution to the ills of the Internet economy. Step out naked into cyberspace, with a topless desk and a bottomless disk. Hollow out your computer, think out of the box and beyond the backplane. Move the vast bulk of your activity, your storage, your compute power out into the storewidth warp. Leaving your precious PC as hollow as a CRT, you will march forth through cybernautical time like the serial stream of your own chronological life. As the world follows your example, you will find yourself on the right side of the Great Divide for a telecosmic future.

By George Gilder and Charles Burger
with Mary Collins
May 10, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE	/ PRICE	APR '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	21.97	18.19 - 113.33	20.4B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	21.39	13.06 - 140.50	27.9B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	14.39	8.11 - 174.50	944.4M
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	39.01	25.00 - 104.13	17.8B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	12.85	9.25 - 165.13	974.9M
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	–	–	–	–
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	35.95	15.75 - 142.00	4.9B
WDM Systems, Raman	Corvis (CORV)	3/30/01	7.03	6.85	4.69 - 114.75	2.5B
Metro Semiconductor Optical Amplifiers	Genoa (private)	3/30/01	–	–	–	–
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6*	41.56	20.88 - 274.75	10.8B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	4.78	2.36 - 81.94	322.7M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	10.75	6.90 - 62.44	2.6B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	–	–	–	–
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	2.37	1.03 - 10.50	708.8M
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.45	0.25 - 15.75	48.9M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	57.36	42.75 - 120.00	43.4B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	25.63	15.72 - 65.88	24.0B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	15.55	10.50 - 41.21	34.1B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	6.75	3.31 - 84.81	295.9M
Internet Backbone and Broadband Wireless Access	WorldCom (WCOM)	8/29/97	19.95	18.25	13.50 - 49.97	52.7B
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	5.09	3.36 - 44.00	3.1B
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	12.53	8.77 - 37.75	11.1B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	7.63	3.50 - 71.00	162.8M
Global Submarine Fiber Optic Network	360networks (TSIX)	10/31/00	18.13	1.72	1.25 - 24.19	1.4B
STOREWIDTH						
Directory, Network Storage	Novell (NOVL)	11/30/99	19.50	4.78	3.44 - 20.00	1.5B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	17.12	12.85 - 64.69	55.8B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29	6.15	2.81 - 49.94	652.4M
Disruptive Storewidth Appliances	Procom (PRCM)	5/31/00	25	9.50	4.25 - 74.00	115.3M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27*	10.40	7.00 - 154.25	1.0B
Complex Hosting and Storewidth Solutions	Exodus (EXDS)	9/29/00	49.38	9.59	5.56 - 69.00	5.3B
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	–	–	–	–
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	1.02	0.75 - 18.38	27.5M
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	47.31	30.50 - 103.00	17.0B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	26.02	11.25 - 109.75	7.8B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	13.89	7.63 - 25.69	6.4B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	20.47	13.65 - 71.31	6.6B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	28.83	17.13 - 73.88	5.0B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	38.71	26.26 - 90.00	67.2B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	47.46	29.79 - 98.31	15.7B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	8.16	3.69 - 38.44	52.6M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	22.60	13.72 - 58.00	2.9B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	25.30	18.81 - 67.13	9.8B

* 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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