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SHOOTOUT AT CISCO CITY

Only connect…but faster! Optically. Punctually. Prophetically. That's what you all tell me. But from Networld plus Interop at the Peachpit in Atlanta to our Telecosm conference last month, where I was pilloried for lunch by a consultant as "the Dr. Kevorkian of Telecom," our world is turning at 38 miles per second and I am clinging to the hurtling debris.

SONET–the telco's Sisyphean Optical Network–sets new sales records in 1998 and is rolling the rock still higher and faster in 1999, notwithstanding all my many ministrations of Kevorkian compassion. The **Global Crossing** (GBLX) wave crashes on my head and I emerge with a bad hair day. **Cisco** (CSCO) consults Kleiner Perkins' Vinod Khosla and becomes an optical star. **Silk Road** opens its fluttering kimono and issues a new productoid that renders wavelength division multiplexing (WDM), so they say, history. Poof. Baffled, I peer ever more deeply into the clouded crystal ball and amid dark headlines and more fluttering kimonos reaching as far as my squinting brain can pry, nothing seems sure but the presence of one giant figure on the horizon, a sprucely bearded towering cowboy capitalist from a Mississippi motel.

The critics offered an image of WorldCom as a diplodocus, a vegetarian tyrannosaurus with a huge stomach and a brain the size of an English golf ball.

It's our favorite terrestrial fiber baron Bernie Ebbers, now in command of **Sprint**'s (FON) fiber galore, and with **Sprint PCS** (PCS), beginning to walk on serious air. Now all he needs is some **Terayon** (TERN) cables to hold him down to earth where we can contemplate the real value of his empire.

In This Issue:

At Telecosm, his critics were carping at all the ATM (asynchronous transfer mode) telco fat cells in UUNET and speculating on what hallucinogenic fiber Vice Chairman John Sidgmore was smoking when he claimed a doubling of his traffic every 100 days, and what second hand smoke had hit me when I quoted him reverently. The critics offered an image of **WorldCom** (WCOM) as a diplodocus (a vegetarian tyrannosaurus with a huge stomach and a brain the approximate size of an English golf ball) and said the company was having enough trouble gagging down MCI. Could it possibly swallow Sprint? (Knowing Ebbers, he will probably seek a watery chaser).

Don't they know about the magic of Bernie's elastic Eureka? Ebbers built his company from the outset on the crucial telecosmic and supply side premise of the price elasticity of communications–that lower prices yield higher profits. From the initial step by step consolidation of regional long distance companies, through the pivotal purchase of Wiltel's gas line fiber, the Mississippi Motel Man exploited the magic of elastic demand. A T-3 line costs half as much per bit as a T-1 line, so moving up, you can cut your prices in half and not lose any profit. But when you cut your prices in half your customers decide they want more than twice as much and you take over the market and all the benefits of scope and scale it affords.

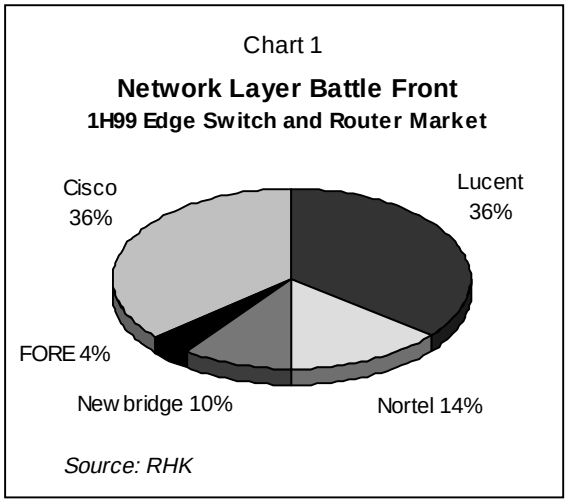
Some sixty companies later, in an age of plummeting communications costs and soaring Internet traffic, Bernie's principle applies more potently than ever. So long as he sticks to the script, I will stick with Bernie. Meanwhile, following the Bernie rule on a more manageable stage–and enhancing it with innovative technologies–is **Metromedia Fiber Network** (MFNX) (see GTR July 99, Sept. 99). Headquartered in White Plains, NY, it provides up to 32 wavelengths on demand using **Nortel**'s (NT) OPTera technology, or an

With revenues soaring more than fourfold during the first six months of 1999, Metromedia commands networks in some 20 metropolitan areas and is headed for a network of a million fiber miles.

array of Gigabit Ethernet offerings capable of spanning 1500 kilometers also over WDM. Like **NorthEast Optic Network** (NOPT), Metromedia is pioneering the use of **Lucent**'s (LU) revolutionary AllWave fiber (see GTR July 99), which potentially increases by 50 percent the number of wavelengths that can be put on a single fiber. With revenues soaring more than fourfold, to nearly $40 million, during the first six months of 1999 and reportedly still ascendant, Metromedia commands networks in some 20 metropolitan areas in the US and Europe and is headed for a network of 2000 route miles, a million fiber miles. And, October 7, Metromedia announced a $550 million dark fiber deal with **Bell Atlantic** (BEL) and an investment of $1.7 billion by Bell Atlantic for up to 19 percent of the company. Metromedia is a prime Telecosm company and joins our list this issue (and none too soon). Departing is P-COM, no longer the clear technology leader among up-spectrum radio makers, suffering, among other reversals, from its failure to make **Nextlink**'s (NXLK) vendor short list last month.

Interop Earthquake

Bernie and Metromedia dominated the month, but just as significant in appraising the future of the telecosm were the weird and wirespeed events at my favorite industry show, Interop. In 1999, they actually, no kidding, finally managed to run Gigabit Ethernet over barbed wire, thus portentously overcoming one of the last challenges on the Interop agenda.



Until the late 1970s, no one had to "interoperate" machines from different vendors using different protocols. You just used machinery provided by Ma Bell and her minions around the globe. Today, by contrast, some five thousand companies supply components for the Internet, and the communications scene has changed from a pyramid of Bell to a tower of Babel.

For many years Interop has been Cisco City, for Cisco routers could interoperate with more protocols and interfaces than anyone else. But a photonic earthquake has hit Cisco City and is on the way to shaking down all the seven tier towers of the Open Systems Interconnect model, the foundation of Interop and the key paradigm of networking. Since the OSI model offers a way to grasp and discuss the earthquake, you should learn it. To help, some time ago I contrived a misleading mnemonic: *phydlnets*, pronounced "fiddlenets."

Starting at the bottom with the physical layer (phy), the OSI layer cake moves upward through datalink (dl), network (ne), transport (t), and session (s). It concludes with the actual presentation (p) and application (a). These layers can be seen as a set of multiple envelopes inside envelopes that must be opened in sequence as the message passes through the network. For a deceptively familiar example from the Bell era, consider a phone call. Pick up the handset and listen for a dial tone (*physical layer*); dial up a number (every digit moves the call another *link* closer to the destination); listen for the ring (signifying a *network* connection and *transport* of signals). Getting someone on the line, you may be said to have completed the first four layers of the OSI stack. Then your hello begins a *session*, the choice of English defines the *presentation*, the conversation constitutes the *application* layer.

All six layers above the physical network form a wholly immaterial logical network. For instance, a signal cannot pass a single stretch of the physical network without observing codes and protocols suitable to that physical link in the chain. These hardware specific codes and protocols, bit rates and electronic or optical rules constitute the *data link layer*. In other words, the link is a homogeneous physical span of the network, and the link layer comprises the rules for transmitting information over it.

Although this layer is not as fragmented and various as the physical layer, it will only get you across one path of a specific kind. The link changes again at the central office or Internet hub, where it may be converted into digital form, usually SONET frames of 64 kilobits per second or Ethernet packets of up to 1550 bytes, or asynchronous transfer mode (ATM) cells of 53 bytes, all to be switched onto the path to the next link, which could be a phased array microwave antenna connecting to a satellite, or a messenger on a bicycle.

If there were just one link–as in an original telegraph system–the physical and data link layers would be essentially all there was for manufacturers to supply with equipment. One company, such as **Western Union** (or **AT&T** [T]) could do it all and Interop would be a boring place. But to get an end-to-end connection in a modern global system, you need some higher level of abstraction and end-to-end addressing that can ride on all the different links. You have to ascend to the *network layer*.

On the Internet the *network layer* begins in the TCP-IP protocol stack in your computer. TCP-IP stands for Transport Control Protocol-Internet Protocol. All the specifications of an end-to-end communication are contained in an IP packet header, which is the most crucial of the electronic envelopes. It contains an address, priority (air mail? special delivery?), data lifetime in total number of hops permitted (dead letter disposal), and other informa-

tion needed to send messages across the network (or throw them away if they are not received).

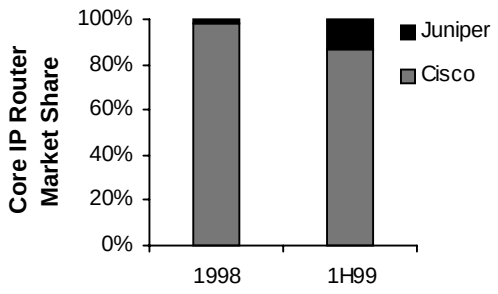
The *network layer* defines the entire network. However, you will probably want to send particular messages over it. That will require you to make a specific connection through the *transport layer*, which sets up the rules for a particular channel between the origin and the destination. TCP functions on the transport layer to control and balance the flows across an IP network, in part by slowing transmission if a lack of acknowledgments signifies that packets are being dropped.

Transport defines a particular connection. But it does not control the actual session–how it begins and ends and how the dialog is managed. That is the job of the *session layer*. Moreover, some communications may comprise several transport linkages. A video teleconference, for example, may combine an image with a voice message and documents. The *session layer* handles these multiplicities and such companies as **PictureTel** (PCTL), **RealNetworks** (RNWK), and **Microsoft** (MSFT) do it for you.

The most basic network function, switching, happens at layer two. Using layer two link addresses and fast microchips, switches merely forward the bits over the next hop. In a homogeneous network such as a campus LAN, switching might suffice. But switching cannot handle an Internet, with its chaos of subnets and connections. That requires a router that can dig down and read the addresses on IP layer three packets and transfer them, using a lookup table of best routes rather than switching's simple hops. But the advance of microchips such as **Xilinx**'s (XLNX) new 4 million-gate field programmables, that can do hardware IP routing at "wirespeed," is blurring the distinction.

Chart 2

Cisco Proves Vulnerable in High Speed Routers



Source: RHK

Layers Collapse

The most embattled issue in networking today is whether to try to route at layer two by jazzing up a switch with end-to-end ATM virtual circuits, as Nortel, Lucent via its Nexabit acquisition, **Newbridge** (NN), and **FORE Systems** (FORE) would prefer; or whether to switch at layer three, merging the two functions in a packet-forwarding engine or hardware "finite state machine," as Cisco, **Pluris**, and **Juniper** (JNPR) want.

Companies such as Nortel, which commands 34 percent of the SONET market, are competing against their own SONET/ATM offerings through acquisitions such as terarouter maker **Avici** and metro WDM vendor Cambrian. These boxes potentially obviate both ATM and SONET and most of Nortel's profits. Through Lucent's new Ascend subsidiary, Lucent commands some 33 percent of the ATM market, but it has now acquired Mukesh Chatter's Nexabit boxes, which make ATM irrelevant. Cisco, on the other hand, is lagging in ATM with 24 percent market share and was devoid of SONET until the recent purchase of Cerent. Thus, depending on your point of view, Cisco City is acquiring an historic preservation problem or a legacy liquidation challenge at layer two.

After memorizing the five bottom layers, you still need *p* and *a*, as in *chutzpa*, to really make it as a networking expert. The two final ones are for presentation and application layers, which actually originate or receive the message and constitute the actual functions being performed, such as email or streaming media. To network nerds, layers six and seven are frosting on the cake. To Internet users, they are the cake.

Let them eat cake. We have the OSI model and telecosm companies at nearly every lower level. Of course, if you lack the *chutzpa* for fiddlenets, you can just go directly to layers eight and nine–the corporeal and spiritual layers–at an Interop hotel bar or at one of the riotous GilderGroup conferences.

Sycamore's Early IPO

At the center of most arguments at Interop and across the industry is the issue of whether the seven layers are too many or too few. Adding a layer–of middleware, encryption, caches, or access, for example–often rings cash registers, or brings initial public offerings and new lucrative niches for the companies that do it (**RSA** [RSAS], **Akamai**, **Sandpiper**, **@Home** [ATHM]). Removing a layer or three, as by WDM (**Ciena** [CIEN], **Corvis**) can mean amputating dozens or even hundreds of companies that supply gear connecting at that level.

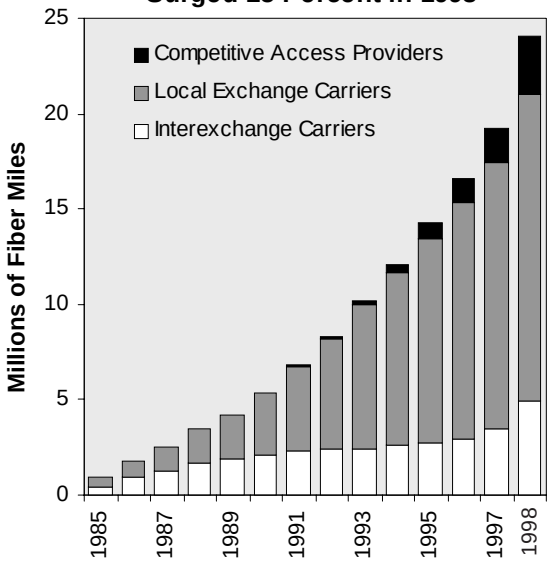
Removing a network layer or three can mean amputating dozens or even hundreds of companies that supply gear connecting at that level.

Thus all optical networks remain highly controversial at Interop, where most of the expertise revolves around complex protocols, often devoted to guaranteed "quality of service" at higher levels. With ten million times more reliability and more potential capacity than electronics, optical networks largely banish or trivialize all "quality of service" guarantees inherited from the electronic networking industry.

The big issue for investors in networking companies today is how many of the layers will survive and how many will be eliminated by the optical juggernaut. Cisco is central to most of these questions. It is currently attempting to subsume all the lower layers into the router, running IP directly over wavelength division multiplexing. With **Intel**'s (INTC) purchase of Softcom Microsystems, however, Cisco faces a challenge from below. Intel is trying to run IP directly from the computer backplane onto optical networks, leaving Cisco to figure out where to connect. Meanwhile, Ciena, Corvis, **Chorum**, **Sycamore**, Nortel,

Chart 3

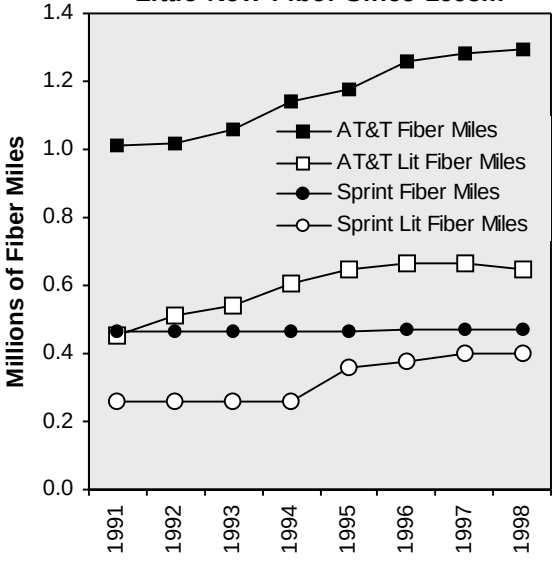
Fiber Deployment by Telcos Surged 25 Percent in 1998



Source: FCC

Chart 4

AT&T and Sprint have Lit Little New Fiber Since 1995...



Source: FCC

Fiber Deployed by Telcos Surged 25 Percent in 1998

*Led by new fiber networks like Qwest and expanding networks like Frontier, long distance companies or IXCs (interexchange carriers) laid 1.5 million miles of new fiber in 1998, increasing the total deployed by IXCs 45%. Route miles increased 27% to 159,779. Local exchange carriers (LECs) including the regional Bell operating companies laid over 2 million miles of new fiber, a 15% increase in deployed fiber miles, and Competitive Access Providers laid 1.2 million fiber miles, a 66% increase in installed fiber. (***Chart 3***)*

AT&T and Sprint Light Little New Fiber Since 1995, but Boost Capacity with WDM

*The impact of WDM since its commercial introduction in 1996 can be seen in the network statistics for long haul carriers. From '95-'98 AT&T's fiber miles increased by only 9.9%, and the company actually reported a slight decrease in lit fiber (***Chart 4***). Yet, through the magic of WDM, AT&T system capacity nearly doubled, up 95.3% (***Chart 5***). With fully 85% of Sprint's network already lit and essentially zero new fiber (***Chart 4***), Sprint used WDM to boost capacity 200% (***Chart 5***). Fast growing Frontier, now part of Global Crossing, reported a dramatic fiber buildout with fiber miles exploding 8,530% to 285,000 fiber miles, lit fiber up 1,400% to 22,800 fiber miles, and WDM enhanced capacity rising 15,670% to 631,000 DS-3 miles.*

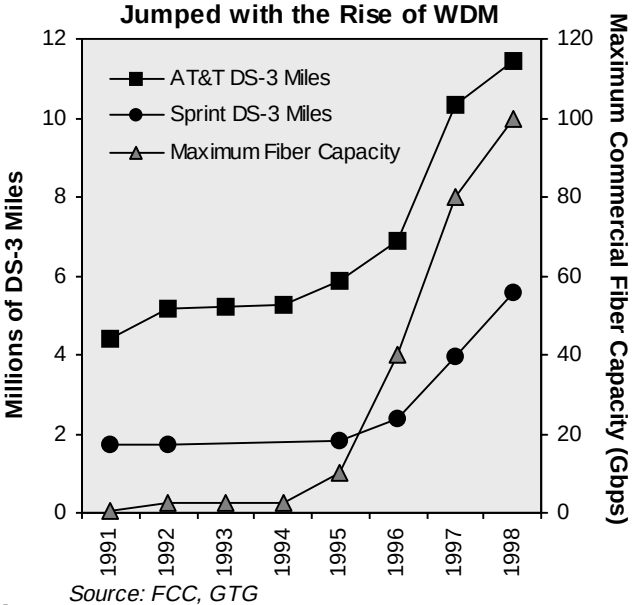
Local Carriers Lighting New Fiber While Interexchange Carriers' Dark Fiber Grows

*With new network builds, IXC (interexchange carrier) fiber miles increased 45% from '97-'98. Yet IXCs grew capacity by adding more WDM lightpaths rather than lighting fiber; lit fiber rose only 0.9%. Thus, the percentage of IXC fiber which is lit has plunged from 60% in '96 to less than 38% at the end of '98. The situation is very different among the LECs (local exchange carriers), which since 1993 have lit fiber about as fast as they laid it with total percentage lit flat at about 33% (***Chart 6***). In 1998, LECs met demand by lighting 38% of their fiber. But since they barely used WDM, LEC capacity rose just 30% from '97-'98, equivalent to the 29% rise in lit fiber.*

-Ken Ehrhart

Chart 5

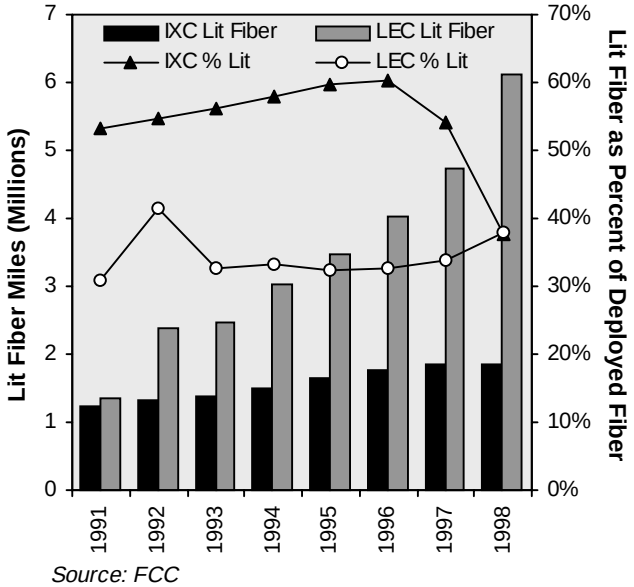
...but their Systems' Capacity Has Jumped with the Rise of WDM



Source: FCC, GTG

Chart 6

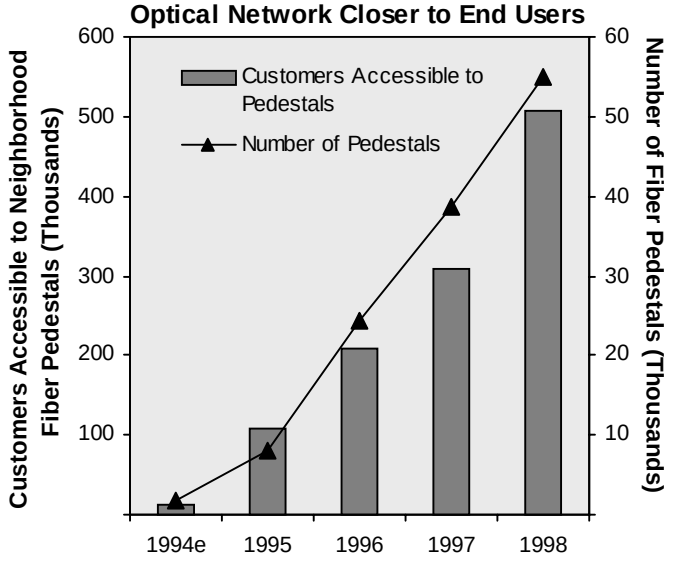
Local Carriers Lighting New Fiber While IXC Dark Fiber Grows



Source: FCC

Chart 7

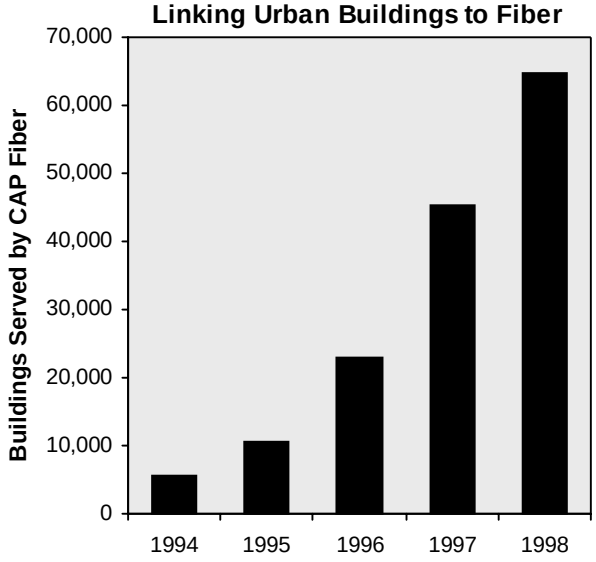
Local Carrier Fiber to the Curb Brings Optical Network Closer to End Users



Source: FCC

Chart 8

Competitive Access Providers Linking Urban Buildings to Fiber



Source: FCC

Local Carrier Fiber to the Curb Brings Optical Network Closer to End Users

*LECs are bringing fiber closer to end users, through buildouts of fiber to the curb where fiber is strung through neighborhoods and past homes. The LECs have brought fiber to 55 thousand pedestals accessible to a half million customers, a one year rise of 42% in pedestals and 64% in accessible customers (***Chart 7***).*

Competitive Access Providers Linking Urban Buildings to Fiber

*Competitive access providers have focused on businesses rather than residential homes, and in 1998 increased their deployed fiber by 66% and connected buildings by 43% to some 65,000 (***Chart 8***). But their fiber to the building growth rate is slow compared to the progress of the broadband wireless providers such as Teligent and WinStar, which during 2Q99 increased subscribers 88% and 30%, respectively–in just 3 months. In only 3 quarters of service, Teligent already has roof rights to 4,252 buildings, or over 6.5% of the number of buildings served with fiber by all CAPs at the end of 1998.*

Utility Company Fiber Deployment and Telecommunications Activity Growing

*The wildcard is utility fiber, which increased some 30% last year and 130% since the Telecommunications Act of 1996, to over 1.25 million fiber miles. The Telecom Act of 1996 authorized the FCC to grant Public Utility Holding companies special "exempt telecommunications status" allowing them to enter the telecommunications business, and as of June 1999, 46 companies have received such status. (***Chart 9***)*

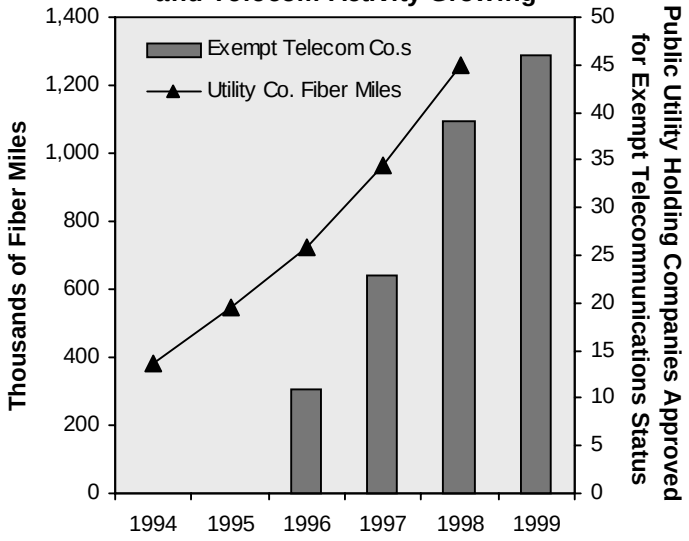
Plunging Long Distance Calling Rates Continue Seven Decade Trend

*The explosion of bandwidth continues to drive down long distance rates. Adjusted for inflation, the per minute revenue for intra and interstate toll calls has been declining since the 1930's (***Chart 10***). The latest offers by AT&T of 7 cent calls and MCI Worldcom and Sprint for 5 cent calls more than halve 1998's 14 cents per minute revenues. The trend will continue as new carriers position voice calls as a cheap or free loss-leader for other high bandwidth data services.*

-Ken Ehrhart

Chart 9

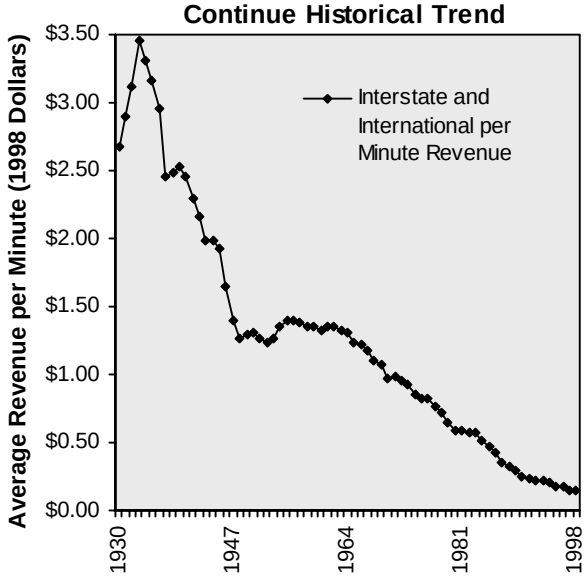
Utility Company Fiber Deployment and Telecom Activity Growing



Sources: UTC, Corning, FCC

Chart 10

Plunging Long Distance Rates Continue Historical Trend



Sources: FCC, AT&T

Others developing true optical cross connects include Xros, new home of the redoubtable Rajiv Ramaswami, and Astarte, working with micro-mirror leader Texas Instruments.

and Lucent, are trying to eliminate everything but the optical layer from the center of the network, thus marginalizing Interop itself, together with all the pastel boxes and seven tiered towers of Cisco City. In the Telecosmic pursuit, Sycamore is rushing to market with an actual product for a real customer-investor, **Williams Communications** (WCG) and an early bird IPO planned for October 22.

SONET Last Rush

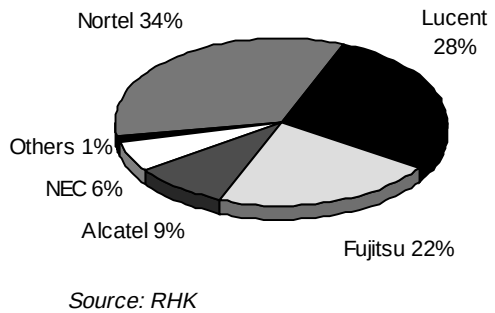
With the arrival of WDM, self-healing SONET rings have become Nortel nooses (or Lucent loadstones). For example, to protect against the some 50 fiber cuts a year experienced by, say, Sprint or AT&T, the rings are redundant and reversible (clockwise traffic zaps around the other way if the ring is cut). But the fiber used by WorldCom, **Qwest** (QWST), **Level 3** (LVLT), Williams and other newer players is encased in hard conduits or gas pipelines that cannot be cut without well-targeted military explosives.

Moreover, as Desh Deshpande, CEO of Sycamore, explains, a SONET ring is like a railroad line with no express trains. But SONET is even more wasteful because not only does every train stop at every station, but every passenger gets off at every station and trundles over to the station master where he has to show his ticket to get approval either to leave the station or get back on the train–until the next stop where it is all repeated again, perhaps 20 or more times coast to coast. A SONET digital switch operates by pulling every message stream off the fiber, converting an optical signal to an electronic one, and reading every layer two address before sending the bits on their way.

Chart 11

WDM Threatens SONET Vendors

1998 SONET Equipment Market Share



Source: RHK

The cost of the SONET boxes that do this work has been as high as $200,000, with each one filling a bay seven feet high. Though the Cienas and Cerents of the world are shrinking this price and size, the calculus is drastically worsening with the onset of WDM. Each ring typically has 8-10 of those boxes for each pathway. Before WDM that meant for each *fiber*. But every wavelength light path entails a new ring, so every time the carrier lights another wavelength in a fiber on a SONET ring, it must buy and install another 8-10 SONET boxes on that ring. With state of the art Nortel gear, this means 160 ring elements on each fiber costing hundreds of millions. So maybe you won't light another lambda, maybe you'll just gin up the bit rate from OC 48 (2.5 Gbps) to OC 192 (10 Gbps), or even, as Lucent now proposes, to OC 768, for a quick 4X boost in capacity at a critical point in the network. Sorry, you have to upgrade every box in the ring (and possibly in connected rings), because the equipment is bit-rate sensitive. Remember those passengers on the train? They're the bits, so if you pack more in at one station all the other stations have to acquire the capacity to check their tickets. That's enough to make sane men long for a Silk Road.

Because SONET has placed a choke-hold on the potential of WDM, even the most conservative voices at InterOp's Optical Day were ready to choke SONET and collapse all the telco protocols into the all-optical network. Sealed hermetically within their lambdas, whisked incognito and undisturbed along lightpaths, optical signals seek to avoid the sophisticated processing and protocol shuffling that represent the pride and potentiality of electronic networks. With wavelength routing, the perhaps 80 percent of wavelengths which at any given node bear only pass-through traffic can proceed on their way unread, leaving the electronics to manage only the 20 percent of lambdas that must be processed. These drop off bitstreams will be small enough (mostly OC 48 or 2.5 Gbps) to be handled by realistically scaled electronics, such as a Cisco Router or Nortel Edge Switch, serving a single campus, town, or skyscraper, **AOL** (AOL) server farm, **Exodus** (EXDS), or Global Center data warehouse. Presenting an Interop swan song before being consumed by WorldCom, even Sprint, previously a fervent advocate of ATM and SONET, agreed with the anti-ATM and anti-SONET all-optical consensus.

Corvis Coast to Coast

More optical than thou or nearly anyone is David Huber, a founder of Ciena, our pioneering WDM company. Huber now heads Corvis, which we previously celebrated (see GTR July 99) for its dispersion management tools and modulation schemes which allow optical signals to travel some 3200 kilometers without being electronically regenerated. The previous need for regeneration every 600 kilometers or so was one of the bulwarks of SONET and electronics at layer two. Since the signal had to be converted to electronics anyway every 600 kilometers–roughly the distance between major American or European cities–it made sense to switch electronically as well. But if Corvis can enable signals to go coast to coast without regeneration, the major excuse for going electronic goes away. On a coast-to-coast trip, says Huber, eliminating regenerator stops can reduce 5600 line cards to 800.

Eliminating regenerations, however, won't enable large scale optical switching unless we have a large scale optical switch, or cross connect. Corvis, says Huber, has one, a 2.4 terabit "router" (actually an optical cross connect) ready for commercial use. Our follow up call produced a "clarification." The box will be ready by New Year's. No customers yet.

Monterey too is offering a wavelength router, i.e. an optical cross connect, but Huber accuses Monterey of ideological deviations because Monterey's device has…an "electronic core!" For shame! Not *very* electronic, responds Monterey's Michael Zadikian; the signals are not unpacked or read, the express passengers don't have to get off the train. The electronics "emulates optical processing."

Others developing optical cross connects include **Xros**, new home of the redoubtable Rajiv Ramaswami, former student and protege of Paul Green, the father of optical networking and, along with his student, our instructor in many of these matters; and **Astarte**, working with micro-mirror manufacturing leader **Texas Instruments** (TXN).

The promise of WDM is to throw off the SONET noose and multiply cheap wavelengths using optics from Nortel, Lucent, Ciena, and **Optical Networks**, among others. Then it can provide the backup once provided by SONET by creating new end-to-end light paths in milliseconds from unused lambdas.

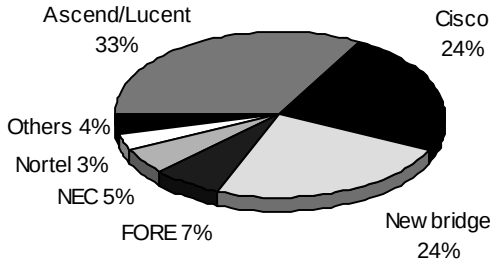
With new lightpaths set up in milliseconds, there is no reason for customers to wait half a year to buy or lease a new T-1 (1.544 Mbps) or T-3 (45 Mbps). By 2001 it will be common to buy fractional lambdas, certainly OC 3s (155 Mbps) in real time for contracts measured in hours or even minutes.

With this technology, energy giant **Enron** (ENE) thinks it can create commodity markets for bandwidth as flexible, deep, and realtime as its current markets for natural gas and electric power. Enron VP Stanley Hanks says the bandwidth market is the company's real future, dwarfing the opportunities in energy.

Chart 12

IP Threatens ATM Vendors

1998 ATM Share-Service Provider Core



Source: RHK

Cisco vs. Moore's Law

So if even energy companies can aspire to the Telecosm, why can't Cisco qualify for the list? With its massively electronic routers, Cisco and all its Interop rivals ultimately face a showdown between Moore's Law, which doubles the capacity or halves the cost of electronic processing "only" every 18 months, and the forces of the Telecosm which boost optical communications power at least four times as fast. As fiber data rates move from gigabits to terabits and beyond, electronic packet sorting becomes orders of magnitude more complex, while wavelength routing becomes ever more practical and elegant.

This trend, as CEO John Chambers has noticed, pushes the action toward optical networks. He has moved with astonishing speed and determination to reposition the company, through Monterey and more famously Cerent, with its $7 billion, $26 million *per employee* price tag. However, the Cerent 454, the company's sole product, is a SONET box. Admittedly it is the most stupendously efficient, versatile, diminutive, and altogether wonderful SONET box ever, at a fourth of the size and half the price of last year's boxes. Bit rates can also be swiftly and cheaply upgraded. And it incorporates post-SONET capabilities.

Not surprisingly, the 454 attracted customers like a blonde in Chinatown, more than a 100 signing up in less than 9 months, for a projected annualized run rate of $100 million before its first birthday. Among the eager buyers were Williams Communications, Frontier, Qwest, and Nextlink.

In 1999, however, almost anyone could sell SONET. It has been the biggest year in SONET history, 2000 will be better, and the market may eventually grow to $10 billion–right before it collapses. In fact nothing presages the decline of SONET more than the current boom in sales, or the desperation to find a SONET bargain in Cerent. The money flowing into SONET out of telco profits has made carriers desperate to kill it off. SONET is like a blackmailer, huskily whispering over the phone, "pay up or you'll never see your lambdas again." But while blackmailers work on high margins as long as they last they also suffer from one of the highest violent death rates of all the criminal professions. As one optical guru quipped at Interop, it's a good thing for Cerent that Cisco was there because as an independent company they were looking at a lifecycle of about two years.

Nothing presages the decline of SONET more than the current boom in sales, or the desperation to find a SONET bargain in Cerent.

Ciena's Core Competence

Better positioned for the transition to an optical future is the pioneer of WDM, Ciena. Cerent features one box, one buy, one time as a major advantage, while Ciena supplies two boxes, one optimized for the core and one for the edge. Developed by Ciena's Omnia acquisition, EdgeDirector performs most of the functions of the Cerent 454, and is roughly the same size. CoreDirector, out of Lightera, acquired in March, electronically functions as an optical cross connect and add/drop multiplexer, supporting a wide range of transmission speeds. An important step toward the all-optical network, it shifts protection from SONET to the optical layer, in efficient meshes as well as rings, and will facilitate real-time provisioning of bandwidth. CoreDirector is an aggressive product from a strengthening company that has never turned from the light. Unfortunately, Ciena is already a Telecosm company so we can't put it on the list again, but we would.

God made photons for communication and barbed wire for electronics guys to show off with. Gigabit over barbed wire is a wow. But like all wire its place is on the fringes of the network. The message of the millennium is that Cisco and Interop are becoming edge cities.

George Gilder, October 11, 1999

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE	REFERENCE PRICE	SEP-99: MONTH END	52 WEEK RANGE	MARKET CAP.
CABLE TECHNOLOGIES/SERVICES						
Cable Modem Chipsets	Broadcom Corporation (BRCM)	4/17/98	12 *	112 1/2	29 - 149 1/2	11.19B
CDMA Cable Modems	Terayon (TERN)	12/3/98	31 5/8	47 1/4	9 1/4 - 60 1/2	0.987B
MICROCHIP TECHNOLOGIES						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	22 3/8	53 15/16	12 - 67 7/16	9.41B
Silicon Germanium (SiGe) based photonic devices	Applied Micro Circuits (AMCC)	7/31/98	11 11/32	60 7/8	6 1/8 - 67	3.27B
Programmable Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	17 11/16	34 1/2	6 1/2 - 42 7/16	3.46B
Digital Video Codecs	C-Cube (CUBE)	4/25/97	23	42 19/32	13 1/4 - 45 1/8	1.70B
Linear CDMA Power Amplifiers, Cable Modems	Conexant (CNXT)	3/31/99	27 11/16	73 3/16	13 - 83 7/8	7.14B
Single Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	31 1/2	53 1/16	10 1/2 - 62 1/2	7.82B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31 1/2	31 3/16	7 7/16 - 36 1/4	5.27B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	11 7/8	86 1/32	22 11/16 - 93 7/16	67.60B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	16 7/16	67 9/16	15 7/16 - 77 1/4	10.68B
OPTICAL NETWORKING						
Wave Division Multiplexing (WDM) Systems, Components	Ciena (CIEN)	10/9/98	8 9/16	35 3/8	8 1/8 - 42 13/16	4.87B
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	40 15/16	68 1/2	26 15/16 - 75	16.76B
Submarine Fiber Optic Networks	Global Crossing (GBLX)	10/30/98	14 13/16	25 15/16	8 - 64 1/4	11.28B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	14 1/2	115 1/4	15 5/8 - 121 1/2	19.97B
Broadband Fiber Network	Level 3 (LVLT)	4/3/98	31 1/4	51 3/16	22 3/8 - 100 1/8	17.40B
Broadband Fiber Network	Metromedia FIber Network (MFNX)	9/30/99	24 1/2	24 1/2	6 1/8 - 47 1/2	5.63B
Broadband Fiber Network	NorthEast Optic Network (NOPT)	6/30/99	15 1/16	35 7/16	4 3/4 - 45 1/8	0.571B
WIRELESS TECHNOLOGIES/SERVICES						
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11 7/8	25 1/4	8 5/16 - 33	2.07B
Satellite Technology	Loral (LOR)	7/30/99	18 7/8	17 7/16	10 3/4 - 22 7/8	4.26B
Nationwide Fiber and Broadband Wireless Networks	Nextlink (NXLK)	2/11/99	20 7/16	50 1/4	5 1/4 - 58 1/8	3.68B
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	9/24/96	19 3/8	186 13/16	18 7/8 - 199	29.98B
Nationwide CDMA Wireless Network	Sprint PCS (PCS)	12/3/98	15 3/8	75 1/2	12 3/4 - 78 1/4	35.88B
Broadband Wireless Services	Teligent (TGNT)	11/21/97	21 1/2 *	48 1/8	19 1/4 - 75 5/8	2.591B
INTERNET TECHNOLOGIES/SERVICES						
Internet Enabled Business Management Software, Java	Intentia (Stockholm Exchange)	4/3/98	29	22 1/2	17 1/2 - 35 1/4	0.540B
Telecommunication Networks, Internet Access	MCI WorldCom (WCOM)	8/29/97	29 15/16	70 1/2	39 - 96 3/4	131.8B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	13 3/4	92	19 1/2 - 95 3/4	71.81B
BROADBAND TELECOM TECHNOLOGIES/SERVICES						
Wireless, Fiber Optic Telecom Chips, Equipment, Systems	Lucent Technologies (LU)	11/7/96	11 25/32	62 5/8	26 11/16 - 79 3/4	191.4B
Wireless, Fiber Optic, Cable Equipment, Systems	Nortel Networks (NT)	11/3/97	23	50 1/16	13 3/8 - 51 7/8	67.08B

ADDED TO THE TABLE: METROMEDIA

REMOVED FROM THE TABLE: P-COM

NOTE: This table lists technologies in the Gilder Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for these core competencies, without any judgement of market price or timing. Reference Price is a company's closing stock price on the Reference Date, the date on which the company was added to the Table. Since March 1999, all "current" stock prices and new Reference Prices/Dates are closing prices for the last trading day of the month prior to publication. Mr. Gilder and other GTR staff may hold positions in some or all stocks listed.

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