GILDER TECHNOLOGY REPORT

May 1998 www.gildertech.com Volume III Number 5

Published Jointly by GILDER TECHNOLOGY GROUP and FORBES MAGAZINE

THE INTEL OF THE TELECOSM

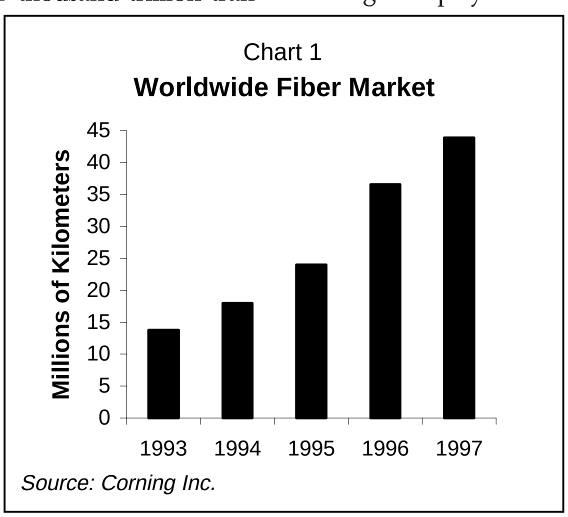
What is this party anyway? A new paradigm of integrated optics to rival the previous paradigm of integrated electronics. Launched on November 15, 1971, when **Intel** (INTC) simultaneously announced the microprocessor, the DRAM, and the EPROM, the next quarter century's three best selling chips–hey, it was a good day–the old party exploded into the PC era. It would prove to be in John Doerr's words, "History's greatest legal creation of new wealth." Now, admit it–what with Bill Gates cornering the cash, and lawyers and lobbyists crawling all over computerland–we are ready for a new party.

Lying at the foundation of fiber optics is an onrush of fortuitous innovation resembling the discoveries of the microcosm.

In preparation, we're off to a premonitory bash at the end of March, 1998, in Switzerland. Beginning on the alpine reaches of the 1998 Nasdaq, then effervescing in a three story Gothic restaurant on a Zurich plaza, then moving on to the iridescent slopes of Davos, capitalist carousers celebrate the possible emergence of a "new Intel of the telecosm."

Called **Uniphase** (UNPH) and headquartered on Baypointe Parkway in San Jose just minutes away on 101 from Intel, the company is still obscure in 1998. Without making a major mark, it had spent nearly two decades producing a motley assortment of lasers and other lightwave widgets. But a new Intel implies a new paradigm–a transformation of the calculus of critical abundances and scarcities that shapes economic growth and opportunity.

Since shortly after World War II, the global economy has feasted on cheap and abundant power, transistors, and silicon area. In 1998, wafer fabs will produce some 46 thousand trillion transistors, give or take a few trillion, each transistor a tiny switch. At the same time, silicon area has also expanded dramatically. Now at around 40 square kilometers of bare chips a year, the semiconductor industry could annually coat Silicon Valley itself, from San Jose to San Francisco and across to Santa Cruz, with scores of layers of crystalline silicon striated with microscopic aluminum and polysilicon wires and doped with enough exotic chemicals to get Al Gore on a superfund high.



Source: Corning Inc.

What has been scarce is bandwidth or communications power. Now, this regime of abundances and scarcities is about to crash. The ascendant fiber optic, wireless, and satellite technologies tend to use batteries or other severely constrained power sources, and, increasingly, are based on single chip systems with sharply limited silicon area.

As mobile devices proliferate at ever higher bit rates, the key constraint in digital cellular base stations are power amplifiers that maintain linearity–that can avoid smudging the bits while amplifying them to be sent out into the cell or transferred to the wireline network. Only two companies, **Spectrian** (SPCT) in Silicon Valley and **MPD** (MPDI) on Long Island can make power amplifiers sufficiently stable for the broadband smart radios of the next generation of digital cellular data. From Palm Pilots, **Nokia** (NOKa) 9000s and digital cellular phones, to fiber optic nets under the

As in the microcosm, so in the telecosm: *the smaller the space the more the room*.

sea and microwave communications on satellites, mobile or remote devices make power and silicon area scarce again.

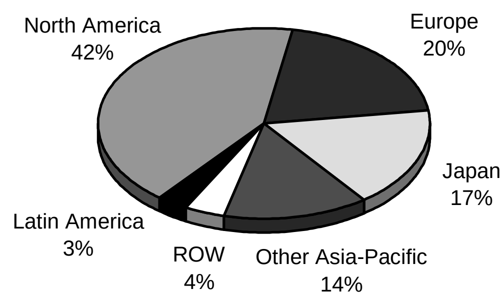
With this reversal of the calculus of abundances and scarcities, two principles will govern the new era. First, originating with Claude Shannon, bandwidth is a replacement for both switching and power. Second, optical and wireless bandwidth are growing at least twice as fast as Moore's Law, which doubles silicon efficiency every 18 months.

In both fiber and wireless, the implicit Shannon message is "wide and weak"–broadband signals transmitted at relatively low power. In wireless, wide and weak impelled the triumph of low power wide band code division multiple access (CDMA) systems from **Qualcomm** (QCOM) over time division multiple access systems (TDMA). Although the commercial war goes on, the European Telecommunications Standards Institute has settled the debate. The Europeans have ruled that the GSM (Global System Mobile) consortium–now the key champion of TDMA–will switch to wide band CDMA for the next generation.

In fiber, where distortion increases as the bit rate and power rises on a single frequency channel, wide and weak dictates wavelength division multiplexing (WDM). This means sending an infrared rainbow at low power down each fiber thread, using a separate color for each bitstream. Many low powered bitstreams will carry more information than a few high powered TDM channels.

Chart 2

1997 Fiber Market



Source: Corning Inc.

Many people balk at the idea of bandwidth as a replacement for switching. Everywhere I go in the telephone world, they tell me that data is rising some 25 to 35 percent a year and Internet data somewhat faster than that. Yet what is that great sucking sound? GTG data shows that over the last three years US NAP (network access point) and MAE (metropolitan area exchange) traffic has grown some 265% per year, even as it represents a diminishing portion of all Internet traffic due to the addition of new exchanges. Extrapolation from this limited subset of data to the global Internet suggests 500% to 650% annual growth. The Commerce Department on April 5 cited reports from UUNet that Internet traffic is rising tenfold a year despite all the limitations in access bandwidth. That means 1000 times every three years. Data is fleeing the dense fabric of telephone switches to the broadband backbones and routers of the Internet. Peter Cochrane of **British Telecom** (BTY) estimates that WDM will allow him to reduce the number of switches in his UK network from some 1500 to six.

To envisage the inversity between bandwidth and switching, imagine in the extreme case that communications power is limitless. It suffices to broadcast all the world's information to everyone all the time. Imagine that terminals are smart enough and broadband enough to find the desired bitstream from the mass of signals and respond to the message. At this extreme, no one would have to store or compress, multiplex or process, switch or buffer anything. You just tune into what you want as you do with an analog radio or TV. As Shannon pointed out, with enough bandwidth, you can simulate any topology of switched networks.

Of course, this ideal will never be fulfilled. But a world in which bandwidth increases twice as fast as switching power will move ever closer to it. Ethernet prevailed in the office by using bandwidth as a substitute for switching. All the signals are available at every terminal. Always on, bandwidth wasting, cable modems represent a further step. Using a "bus" topology that brings all the signals to every household in a cable neighborhood, cable modems also fulfill the mandate for wide and weak. That is why **Broadcom** (BRCM) can announce Q1 chip sales of $33 million, close to its 1997's annual total, and why cable modems are blowing away all other broadband access technologies to homes, including ADSL (asymmetrical digital subscriber line).

In the new era, rather than using transistor switches and power to compensate for inadequate bandwidth, successful companies will use bandwidth to make up for inadequate power and silicon area. The new Intels will race down the learning curve with ever more cost effective broadband optical components. If you are in the optical business and grasp this new reality, it is time for a party.

Here in the Alps, Uniphase gathered most of its key backers and technologists to celebrate the new era, epitomized by the opening of a new leading edge laser factory on March 27 on Binzstrasse on the edge of Zurich. With Silicon Valley bankers and venture capitalists and European photonic engineers, the cultures of money and optics mingled happily at the onset of the new era.

At the heart of Intel's leadership was a single felicitous technology of metal oxide silicon that prompted Intel's engineers to speak in an idiom of miracles. In the bounty of [Carver] Mead's Law and contrary to all expectations, ever tinier transistors ran exponentially faster, cooler, and cheaper. *The smaller the space the more the room.*

Lying at the foundation of fiber optics is a similar set of felicities. Early calculations at **Corning** (GLW) indicated that sand, cheap and inexhaustible, could become a millionfold better carrier of signals than copper. Still, an apparent showstopper was an array of different forms of dispersion. Modal and chromatic signal spreading could accumulate down the miles of fiber, smearing out the signals into an unreadable blur, as infinitesimally different colors ran at different speeds down the glass.

In a rush of fortuitous innovation resembling the discovery of Mead's Law of the microcosm, all these obstacles gave way. Reducing the size of the core of the fiber–the path of the light–by a factor of 20 (from 100 microns to ten microns and later to five microns) eliminated modal dispersion, allowing the signal to take only one path. A smaller core, so it turned out, could accommodate an exponentially larger message. As in the microcosm, so in the telecosm: *the smaller the space the more the room.*

Corning scientists then found that the chromatic dispersion diminished to nothing at a specific infrared wavelength (1310 nanometers). Not only was this wavelength easily created by existing infrared lasers but it also represented a low point of attenuation.

Nonetheless, fiber optics remained a servant of the microcosm. To increase the bitrate required increasing the power. Each bitstream used a different fiber and was amplified by a different set of some nine expensive bipolar transistors. Narrowband and power hungry, these repeaters wasted thousands of milliseconds, tens of watts, and scores of thousands of dollars.

Launching the wide and weak regime in fiber communications was the miracle of the erbium doped fiber amplifier (EDFA). First conceived at **American Optical** by Elias Snitzer in 1971, it was elaborated for British Telecom at Southhampton University in England by David Payne and Simon Poole in 1986 and prototyped successfully by Randy Giles and Emmanuel Desurvire at Bell Laboratories in 1991. By infusing a 10 centimeter stretch of the fiber signal path with rare earth erbium ions, and pumping it with an attached laser on the side, the doped glass functioned as a broadband amplifier of all the signals in the fiber.

The all optical network is a new form of integrated circuit. Just as the original IC of Noyce and Moore ultimately put an entire computing system on a single sliver of silicon, so the new integrated circuit promises to put an entire communications system on a seamless seine of silica.

In the late 1990s, this ideal is moving ever closer to fulfillment. A new breakthrough in silica, following the inspiration of the EDFA, promises a new era in optics. Unveiling the possibility of a trend of advance within silica as fruitful as Moore's Law in silicon, it became possible at last to conceive of an Intel of the telecosm.

Key to the emergence of most modern WDM was an amazing innovation in the humble field of gratings. Used for selecting, filtering and deflecting light, gratings have always been an external device, like a prism, on which the light must be focused. Thus they entail the fusing or splicing of the fiber to the grating. In 1983, Eli Snitzer, then in his fifties, and two others researchers at the **United Technologies** (UTX) Research Center in East Hartford, Connecticut discovered an efficient "Method for Impressing Gratings within Fiber Optics" patented in 1988. With two beams of angled ultraviolet light, focused at the side of the fiber, the researchers created a permanent holographic image in the silica core. They also found they could adjust the grating features by "shaping and tilting the writing pattern through control of the included angle and divergence of the beams." In other words, the chosen wavelengths could be diffracted, reflected, and refracted as desired.

In January 1984, Snitzer left United Technologies and was replaced at UT by a young optical whiz from MIT Lincoln Labs named Fred Leonberger. At UT Leonberger went to work with inventors W.W. Morey and Gerry Meltz to perfect the fiber grating. At the same time, Bell Labs researchers had discovered that by "hydrogen loading of the fiber" through a simple diffusion process, they could enhance the photosensitivity of the glass by two orders of magnitude.

At UT, Leonberger ultimately assembled a set of 17 gratings patents. Developing sensors and fiber lasers, he also pursued his Lincoln Laboratory interest in optoelectronic modulators made of lithium niobate, which is three times as efficient in electro-optic emissions as gallium arsenide. Most important, in 1986, Leonberger and Paul Suchowski invented "annealed proton exchange," a powerful new way of manufacturing the lithium niobate waveguides essential to both modulators and gyros.

With the early 1990s cutbacks in defense spending, however, United Technologies announced in December 1994 that it was seeking a buyer for its optical group. Among the first companies to bid was **Ortel** (ORTL). Under CEO Wim Selders and with an impressive research team led by Israel Ury, Ortel was then a stock market initial public offering (IPO) and an important force in fiber optics. A later bidder was Uniphase, a gas laser company with no fiber optics or semiconductor laser capabilities. Most of the UT team understandably was inclined to go with Ortel. With the UT group, Ortel rather than Uniphase would have become a contender in the telecosm.

Meanwhile, the gating component in the EDFA, as Snitzer saw from the outset, was the laser to "pump" the loop of erbium doped fiber that amplifies the signal. In telecom, unlike in printers or CD players, the laser must operate constantly everywhere from the ocean floor to underground trenches, maintaining a mean time between failures (MTBF) of a million hours or a hundred years.

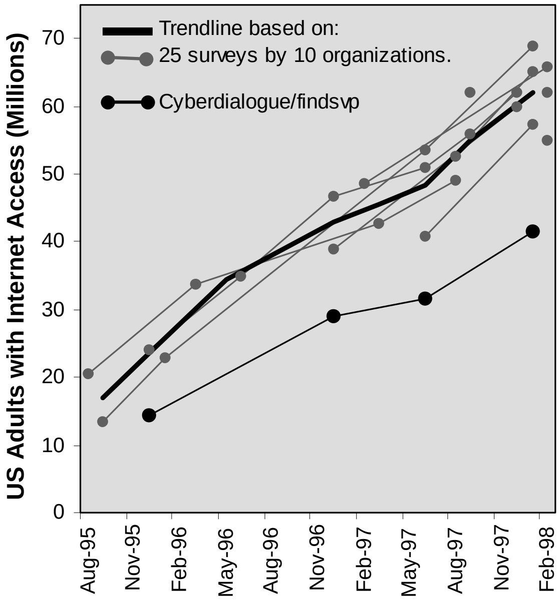
In the 1980s and early 1990s at the **IBM** laser laboratories in Rushlikon, near Zurich, Switzerland, the prospects for such a device seemed dim. Like United Technologies, IBM was "refocusing on its core assets." As at UT, this meant no fiber optics. Technically, the effort to create robust laser chips for telecommunications was foundering.

Just as the semiconductor industry in its early years faced a dire but mysterious showstopper that

The EDFA and the fiber grating show the way to inscribe entire networks in the luminous cores of fiber optic thread.

Chart 3

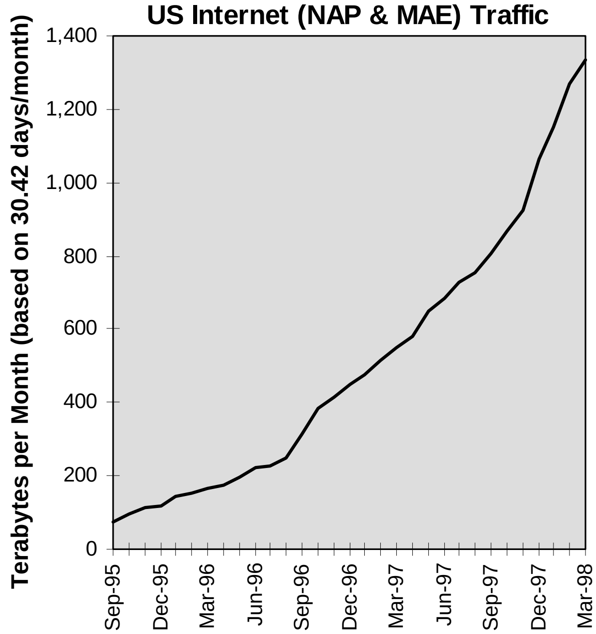
US Internet Users



Sources: Nielsen, Harris, Intelliquest, Cyberdialogue

Chart 4

US Internet (NAP & MAE) Traffic



Internet users *in the US numbered some 62 million adults by January 1998 (***Chart 3***). Surveys from AC Nielsen, Intelliquest, Harris Polls, Relevant Knowledge, Zogby International, Nasdaq, IDC, Media Matrix, Odyssey, and Forrester Research find that 20% to 23% of homes, 36% of adults, and anywhere from 55 to 69 million US adults have Internet access. Cyberdialogue/findsvp found that 57.4 million have accessed the Internet during the last 12 months, but that only 41.5 million were current users. The discrepancy between Cyberdialogue/findsvp's lower finding and the other studies could be the result of users with transitory access–MCI's Libray Link Study shows 29% of users have school access and 16% use alternative access points such as libraries (7%); work access (49%) which may be available whenever needed but not necessarily continuously; and home users (68%) who are frequently switching between services. A study by Strategis Group shows nearly 40% of users have switched ISPs at least once, and that, each month, 10% of subscribers cancel service with two-thirds then signing up with another provider.*

US Internet Traffic, *shown in* **Chart 4**, *surged in 1996 and in late 1997 to early 1998 in an exploding-slowing-accelerating pattern reflective of the growth of Internet users, shown in Chart 3. The GTR Internet traffic statistics are derived from performance measurements taken every 5 to 15 minutes at the Sprint, Ameritech and PacBell NAPs (national access point) and at the metropolitan access exchanges MAE East, MAE West, MAE Houston and MAE LA. These are the major commercial exchange points which supplanted the NSFnet (National Science Foundation Network) to become the core of the privatized Internet. The monthly traffic totals we calculate and report do not represent total Internet traffic. The total does not account for traffic transiting only within one network (AOL, WorldCom, etc.), traffic passing directly between two cooperating networks (Sprint-MCI, etc.), traffic through hundreds of small exchanges points or overseas traffic. However, the data measures a consistent subset of Internet data reflecting the Internet's minimum growth rate. And unlike subscriber numbers this traffic is directly monitored, and factors in the increasing usage of the Net by each subscriber.*

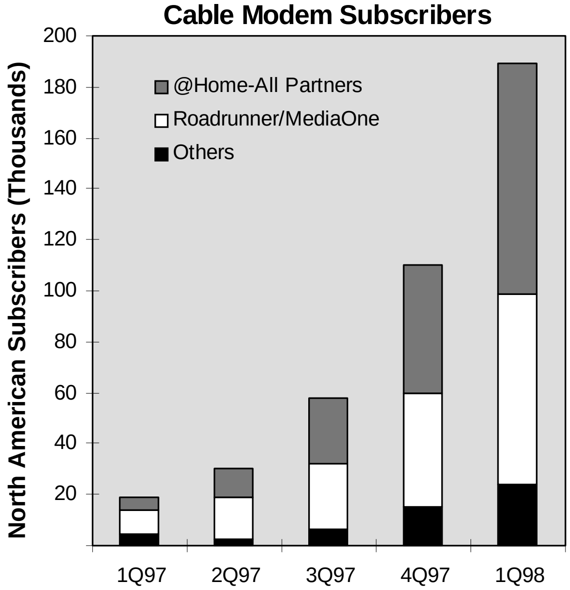
Cable Modem *high bandwidth Internet access subscribers in North America rose some 75% during 1Q98 and totaled some 207,000 at the end of April (***Chart 5***). In Portland, Maine, after 9 months of active marketing, the Roadrunner service now rivals AOL as the largest Internet provider with some 7% penetration of the entire market. Terayon's S-CDMA cable modems scored their biggest North American wins with the concurrent announcements that @Home approved them for use in the network and Canadian @Home partner Shaw placed a 40,000 unit order. Reflecting their chips' dominant usage by cable modem manufacturers, Broadcom experienced stellar first quarter growth. As cable modem and digital set-top box technologies converge, Broadcom's success in modem chips will spread to boxes.*

The Web Development Tool *market has expanded with the Internet. While Microsoft has established a share of over 60% of the market, the share of Sun's JavaSoft division has stabilized at 30%. JavaSoft's Oct/Nov 97 weakness (noted in GTR Feb-98) was reversed in Dec-97 and their market share remained solid into 1998 (***Chart 6***).*

-KE

Chart 5

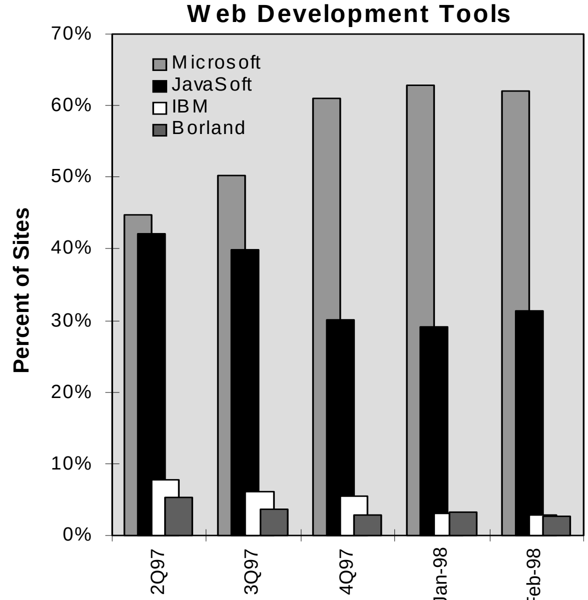
Cable Modem Subscribers



Source: Company Reports

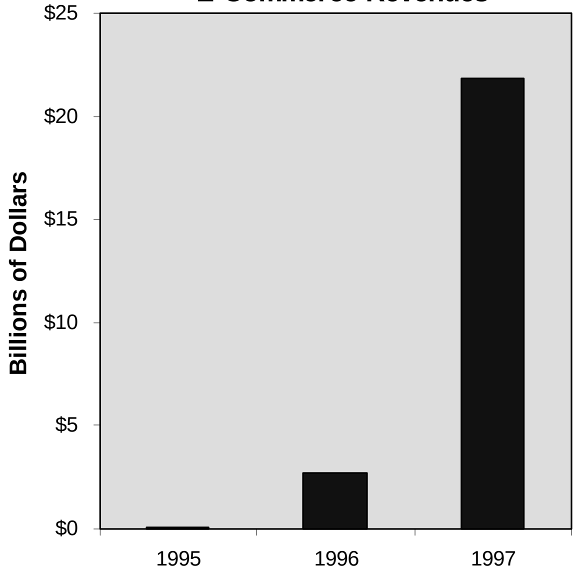
Chart 6

Web Development Tools



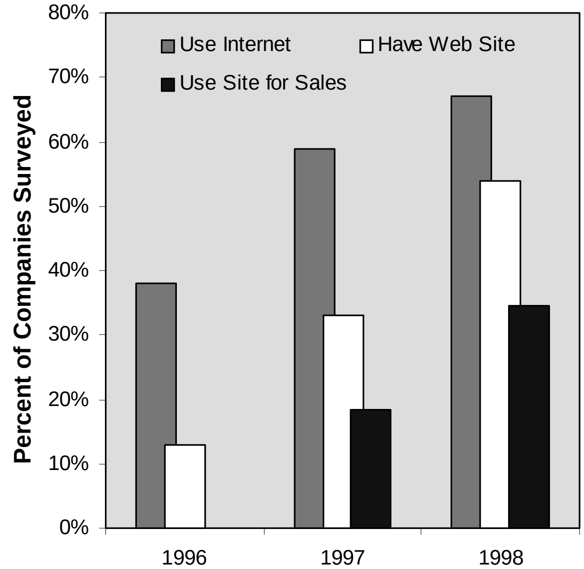
Source: Computer Intelligence

Chart 7
E-Commerce Revenues



Source: ActivMedia

Chart 8
Business Use of the Internet



Source: AccuStaff Inc.

E-Commerce Revenues *totaled $21.8 billion in 1997 according to ActivMedia (***Chart 7***). ActivMedia's data was collected in early 1998 from website executives and business managers worldwide. While Dell, Cisco and Boeing are at the pinnacle of online sales (with billions of dollars of 1997 web revenue), the ActivMedia data shows $1 million per month was not uncommon among other leading sites, and that website annual business revenues regularly exceed $100 thousand and in many cases $1 million. The percentage of Internet users making online purchases exploded during 1997 (see Chart 8 Jan-98 GTR). An Ernst & Young study for the National Retail Federation found 32% of consumers with Internet access have acquired goods online. The percent of Internet users making purchases more than doubled in a year that user numbers climbed 44% leading to a 208% annual increase in online shoppers. Cyberdialogue found that 95% of online buyers were satisfied (48%) or very satisfied (48%) with the experience, and consequently 19% said they were shopping less in stores and 14% were using catalogues less often. Still more dramatic is the rise in Internet purchases by businesses. A survey by Thomas Register and VISA U.S.A. of 2,000 corporate purchasing decision-makers reveals that 40% of respondents use the Internet on a daily basis to make purchases. Of the companies surveyed, 10% already utilize the Internet for more than half their purchases and 21% plan to by the end of the year.*

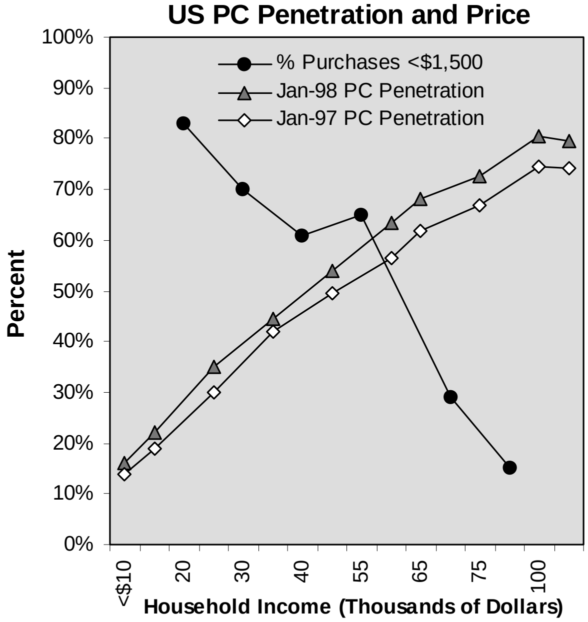
Business Use of the Internet *has exploded at a phenomenal rate (***Chart 8***). The huge growth in online purchasing by businesses (see above) has been made possible by the doubling in two years of the number of companies using online services, which was reported in March by AccuStaff Inc. The AccuStaff survey found that while 54% of companies surveyed now have a homepage, an additional 40% report they plan to have a homepage in the next twelve months, a 3 year rise from 13% to 94%. Of the corporations with web sites, 65% report already using the sites for sales.*

PC Penetration and PC Prices *are critical to the adoption rate of the Internet and e-commerce. Nearly all Internet access is currently via PCs, and accessing the Internet has become the killer app for most PC users. According to Intelliquest Information Group, 4Q97 marked the first time that Internet/online service users accounted for more than half of computer users (up from 40% one year ago). The Harris Poll conducted in Dec-97/Jan-98 reveals some 64% of all adults report using a computer at home, work, or some other location such as a library or college, and that 36% now go online. The key to continued growth in both PC and Internet penetration is price.* **Chart 9** *shows the link between PC penetration and household income and household income and PC purchase price. There is no magical limit to PC penetration in the 40% to 50% range, among those who can easily afford PCs (households with over $100 thousand in annual income) the current penetration is 80%. February and March 1998 retail PC sales figures from Computer Intelligence boded well for increased adoption, showing sub-$1,000 units at 45%-50% of sales and sub-$1,500 units at 74%-79% of sales, while units over $2,000 were only 4%-5%.*

US PC Shipments *surpassed the number of TV unit shipments by 42% in 1Q98 (***Chart 10***). Buoyed by low prices, rising PC shipments, and Internet growth have increasingly influenced the debate over digital TV transmission standards in favor of the PC camp.*

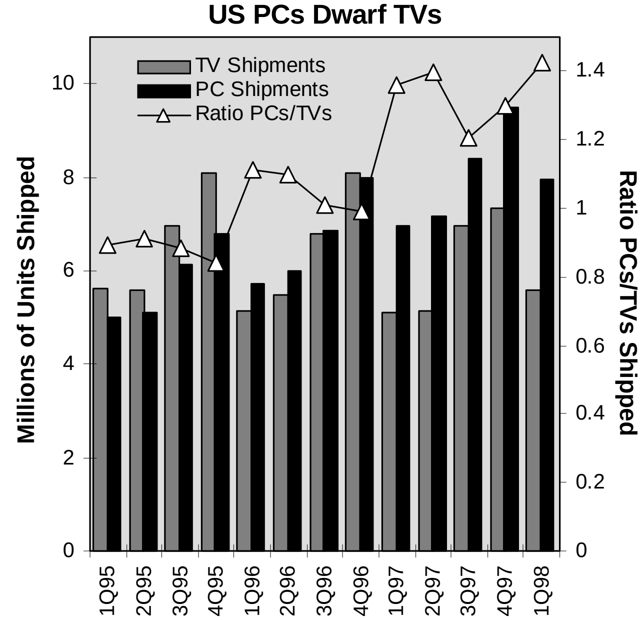
-KE

Chart 9
US PC Penetration and Price



Source: Computer Intelligence

Chart 10
US PCs Dwarf TVs



Sources: Dataquest, IDC, CEMA

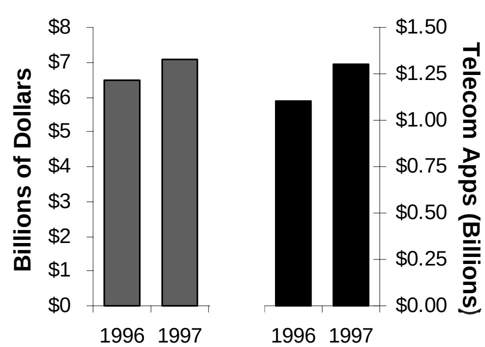
Uniphase's Kalkhoven saw the rise of an entirely new paradigm advancing at a pace too fast for faint hearts or haggling.

destroyed reliability in the basic MOS circuit, the semiconductor laser industry encountered a fatal defect that cropped up without warning and limited the dependable lifetime of the devices. Andrew Grove (ne Anders Grof) was the then unknown Intel engineer who spearheaded the solution of the mystery in semiconductors (sodium in the diffusion furnaces). The then unknown IBM engineer in Zurich who led the team that solved the problem in lasers was Volker Graf (oxygen in the mirrors). By the mid 1990s, Graf had built a profitable $15 million business producing reliable lasers for telecom, gaining some 70 percent market share in pump lasers for erbium doped fiber amplifiers.

The other key to WDM was a continuous wave infrared laser of similar durability and precision for transmitters. The leading merchant producer of such infrared lasers was **Philips** (PHG) Optoelectronics in Einhoven, Holland. A profitable operation with some $30 million in revenues and some 70 patents, Philips too was facing a management determined to refocus on its core assets. A world leader in digital television chip sets, CDs, and DVDs, Philips wanted to concentrate on consumer electronics, not fiber optics.

Chart 11

Optoelectronic Component Market



Source: Strategies Unlimited

By the mid 1990s, therefore, three of the world's technology giants, United Technology, IBM, and Philips, had succeeded, by dint of heavy investments over decades, in developing key components for WDM. Yet at the very moment when the market was about to explode into a rapidly growing two billion dollar business, these companies were giving up fiber optics. Separately the assets of the three leviathans would have propelled fast growing divisions. But together they could fuel a new high technology powerhouse for the a new optical paradigm, even a new Intel.

New paradigms do not come easily. As the 1990s opened, Uniphase was generating some $30 million in sales of helium neon lasers for portable bar code readers. The very opposite of wide and weak, helium neon lasers emit a straight and strong infrared beam in a very narrow frequency band, making them capable of reading dense bar codes swiftly swiped across the lens. You don't have to be a Republican president to be amazed at this feat. But with the market saturated by the early 1990s, the Uniphase board of directors decided to hire a new CEO in 1992 to upgrade and refurbish the company for an IPO. Kevin Kalkhoven was their man.

A fun loving Australian, Kalkhoven is readier to tell inquirers about his exploits in airplanes and on scuba expeditions than to describe his previous career as a Cobol programmer at IBM or as a turnaround artist for low ranking Silicon Valley software firms. As Kalkhoven remembers, a psychological test he took at the time put him far on the "intuitive" side of the scale, which in Silicon Valley is a polite way of saying, "This guy can't do math," but is too imaginative to go to law school. But he pulled off a modest IPO by 1994, raising $11 million and valuing the firm at $30 million. At nearly $2 billion, some 65 times higher, the current valuation accounts for much of the enthusiasm of the party in Switzerland.

The turning point for Uniphase came in January 1994, when **MCI** (MCIC) installed a 2,000 mile fiber optic line between Sacramento and Chicago with no optoelectronic repeaters. "Lights turned on" and sirens wailed in Kalkhoven's mind. To him, the MCI feat "showed that WDM was feasible, even inevitable." Key to the MCI breakthrough were EDFAs powered by pump lasers from Volker Graf's subsidiary of IBM's famed research lab.

Consulting with Uniphase Board Member William Bridges, an optical physicist from Caltech, Kalkhoven set his first target. It was Fred Leonberger's United Technologies Photonics research division in Bloomfield, Connecticut. Called UTP, it then chiefly sold lithium niobate optical gyroscopes for cruise missiles. Leonberger was preparing this gyro technology for use in fiber optic communications. Electrically pulsed, a lithium niobate device similar to a gyro could modulate a laser beam with the exquisite accuracy needed for WDM, shaping it to bear digital or analog information.

Until that time, most fiber systems used internal modulation, turning the laser off and on at the needed rate. But as that rate went up–from OC-12 (622 megabits a second) on into the gigahertz ranges–and the number of wavelengths increased from one to four and on up, Leonberger believed that direct modulation would break down. Turning a laser on and off billions of times a second, like turning a lightbulb on and off many times, would cause it to wear out. Transmitters would maintain a more stable frequency for longer lifetimes if the laser was a continuous wave, always on. The modulator would be better able to maintain exquisitely accurate frequencies if it was external to the laser.

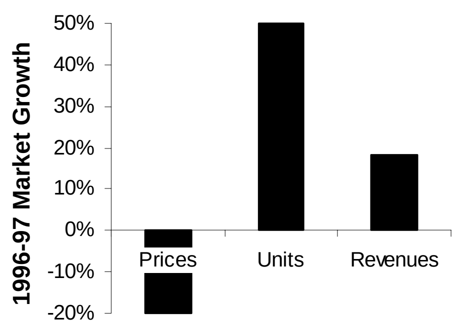
All these capabilities–and Leonberger himself–seemed destined for Ortel. But Uniphase invoked the magic of bold action. Under Kalkhoven and his finance chief Dan Pettit, it moved more aggressively to complete the deal. Kalkhoven saw the onrush of an entirely new paradigm advancing at a pace too fast for faint hearts or haggling. Ever since that fateful day in 1994, Uniphase stock has been ascendant and Ortel in the doldrums.

Uniphase now had command of its first crucial component for WDM–a rock solid external modulator that could operate at multigigahertz frequencies. Kalkhoven eventually invested the entire $11 million from the IPO in the project. Beginning with the modulators, Kalkhoven would assemble technologies to supply every crucial component for these revolutionary new optical networks, from erbium doped amplifiers based on Uniphase 980 nanometer laser pumps to fiber gratings to reliably resolve the signal to transmitter lasers at 1550 and 1310 nanometers, to industry leading packaging and assembly. Most importantly, he gathered in Uniphase many of the industry's leading scientists, including 100 PhDs in physics.

The pivotal acquisitions came in 1997 and 1998 when Kalkhoven, Leonberger, and Pettit bought the IBM Zurich laser operation for $45 million. In April of this year, Uniphase added the Philips Optoelectronics group in a complex stock deal rumored to be worth close to $150 million. Combining Uniphase's laser expertise and leadership with the IBM team, the Philips group in Einhoven, and Leonberger's UTP in Connecticut, Uniphase became the major force in the industry of optical components for the explosive WDM equipment market.

Chart 12

Telecom Optoelectrical Components



Source: Strategies Unlimited

Still, in order to capture the all optical standard and the telecosmic paradigm, it was necessary to gain a commanding position in fiber gratings. Unfortunately, although many of the key discoveries relating to the technology came from United Technologies, the company had closed down its gratings plant before Uniphase bought UTP. With **Lucent** (LU) using waveguide arrays to filter WDM frequencies, no other widespread use for the gratings had emerged.

In order to gain an edge, **Ciena** (CIEN) had been forced to master the technology itself. "It was the only area where we decided to integrate vertically," said CEO Pat Nettles, the Caltech PhD who leads Ciena. Under the guidance of former Bell Labs engineer Victor Mizrahi, Ciena's fiber gratings have served as the key enabler for the company's industry leading move to 16 and then 40 and eventually 100 wavelengths of light down a single fiber thread.

Ciena's rivals in WDM equipment production, however, will not want to depend on a competitor for such a critical product. Kalkhoven resolved to go for gratings. As it happened he knew just where to go. Using American Advantage miles, Kalkhoven left in early 1997 for Sydney, Australia.

Next to the airport lurked one of the leading figures in the evolution of the industry, the tall bearded co-inventor of the second generation of erbium doped amplifiers, Simon Poole. In 1993, he had left Southhampton and British Telecom to return to his home in Sydney to launch a new company, called Indx, to manufacture holographic fiber gratings and other in-fiber devices. Poole's central achievement was a method for overwriting a number of fiber gratings, with different refraction indices, in the same spot in the fiber core.

Freely bandying the names of Leonberger and Graf and resonating with Poole's Australian origins, Kalkhoven met with his countryman over a beer at the Sydney Opera House. By the end of the evening, Poole had agreed to make Indx part of Uniphase for $9 million. With expertise in add drop multiplexers and dispersion compensation modules as well as gratings, Indx will spearhead Uniphase's drive to bring the all optical dream into metropolitan and enterprise networks. In San Jose, on April 29, Uniphase announced initial shipments of wavelength locking modules. Based on gratings, lamda locks will be necessary for all generations of equipment with more than 16 wavelength channels.

Intel began with the goal of manufacturing memory chips for mainframe computers. But it did not achieve incandescence until it began manufacturing the key components of the personal computer. Similarly, networks cannot become truly all-optical until wavelength division multiplexing descends from the summits of continental trunks and undersea conduits down into the ramifying realms of smaller networks. The true target of Uniphase must be to become not only the dominant supplier of optical components for companies such as **Nortel** (NT) and Ciena, but the leading vendor of components for **Cisco** (CSCO) and **3-Com** (COMS), and perhaps, as time passes, even for Intel itself in its new networking mode.

The erbium doped amplifier and the fiber grating show the way to inscribe entire networks in the luminous five micron cores of fiber optic thread. To consummate the Uniphase dream, Kalkhoven will finally have to become a vendor of the key devices for linking the network computers of the future to the crystal cathedrals of an all optical web.

Combining with the IBM team, the Philips group and UTP, Uniphase became the major force in WDM optical components.

ASCENDANT TECHNOLOGY	REPORT(S) Volume: No.	COMPANY (SYMBOL)	Reference Price	Price as of 5/1/98
Cable Modem Service	I: 2, 3; II: 7, 8, 9, 11, 12	*@Home* (ATHM)	19 1/2	33 15/16
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	II: 3, 7, 12; III: 2, 4	*Analog Devices* (ADI)	22 3/8	39
Java Thin Client Office Suite, Rapid Application Development (RAD)	II: 6, 7, 12	*Applix* (APLX)	4 1/2	5 1/2
Dynamically Programmable Logic, Silicon Germanium (SiGe), Single Chip Systems	III: 4	*Atmel* (ATML)	17 11/16	20 1/4
Single-Chip Broadband Data Transmission	II: 10; III: 3, 5	*Broadcom Corporation* (BRCM)	24 *	52 3/4
Digital Video Codecs	II: 5	*C-Cube* (CUBE)	23	24 1/16
Fiber Optic Cable, Components, Wave Division Multiplexing (WDM)	II: 9; III: 5	*Corning* + (GLW)	40 15/16	40 15/16
Low Earth Orbit Satellites (LEOS)	I: 2; II: 1, 3, 4, 8, 10	*Globalstar* (GSTRF)	21 3/4	71
Business Management Software	III: 4	*Intentia* (Stockholm Exchange)	29	34
Wave Division Multiplexing (WDM), Fiber Optic Equipment	III: 5	*JDS Fitel* + (Toronto Exchange)	19 1/4	19 1/4
Broadband Fiber Network	III: 2, 3, 4	*Level 3* (LVLT)	62 1/2	61 3/4
Single Chip ASIC Systems, CDMA Chip Sets	II: 8	*LSI Logic* (LSI)	31 1/2	26 7/8
Telecommunications Equipment, Wave Division Multiplexing (WDM)	II: 1, 2, 7, 9, 10, 11, 12; III: 1, 2, 3, 4, 5	*Lucent Technologies* (LU)	23 9/16	75 1/16
Single-Chip Systems	II: 8, 12 III: 4	*National Semiconductor* (NSM)	31 1/2	21 7/8
Telecommunications Equipment, Wave Division Multiplexing (WDM), Code Division Multiple Access (CDMA), Silicon Germanium (SiGe)	II: 1, 7, 9, 11, 12; III: 1, 2, 3, 4, 5	*Northern Telecom* (NT)	46	61 7/16
Point to Multipoint System for 3hz, Spread Spectrum Broadband Radios	II: 10, 11	*P-COM* (PCMS)	22 3/8	20 1/2
Code Division Multiple Access (CDMA)	I: 1, 2; II: 1, 3, 4, 7, 8, 9, 10, 11 III: 4, 5	*Qualcomm* (QCOM)	38 3/4	55 5/8
Broadband Fiber Network	II: 9, 10, 11; III: 1, 2, 3	*Qwest Communications* (QWST)	20 3/8	38 3/16
Java Programming Language, Internet Servers	I: 1, 2, 3, 4; II: 1, 5, 6, 7, 8, 10, 12	*Sun Microsystems* (SUNW)	27 1/2	41 1/2
Optical Equipment, Smart Radios, Telecommunications Infrastructures	I: 1; II: 1, 2, 3, 9; III: 3	*Tellabs* (TLAB)	29 1/8	71 11/16
Broadband Wireless Services	II: 9, 10, 11, 12	*Teligent* (TGNT)	21 1/2 *	29 7/16
Digital Signal Processors (DSP), DRAM	I: 2, 3, 4; II: 5, 8, 11, 12; III: 3, 4	*Texas Instruments* (TXN)	23 3/4	64 3/16
Wave Division Multiplexing (WDM) Modulators	II: 7, 9, 10 III: 4, 5	*Uniphase (UNPH)*	29 3/8	55 3/4
Telecommunications, Fiber, Internet Access	II: 9, 10, 11, 12; III: 1, 2, 3, 4	*WorldCom* (WCOM)	29 15/16	42 3/4
Field Programmable Logic Chips (FPGA)	I: 3 III: 4	*Xilinx* (XLNX)	32 7/8	45 3/8

+ New Addition * Initial Public Offering

Added to the Table: Corning, JDS Fitel. Removed from the Table: Ortel.

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.

A TELECOSMIC BESTIARY

AMD of the Telecosm: **SDL** (SDLI)–competes with Uniphase in 980 nanometer pump lasers and is moving into modulators and other devices, but it still clings to the old stuff. With revenues 60% of Uniphase, SDL has one fifth the market cap.

Dell of the Telecosm: **Ciena**. Recent deal with Cisco brings them down from the backbone into the router. Ciena also is leader in fiber gratings and is regaining momentum across the board.

Gateway of the Telecosm: **Tellium**. Look for their new MetroLite all optical metropolitan network made with liquid crystal switches. To be introduced in October.

Analog Devices of the Telecosm: **JDS Fitel**, which makes a panoply of passive devices crucial to all optical networks. With some $140 million in revenues ($US) and 130% earnings growth for 12 months ended Feb. 98, JDS Fitel might be courted by Uniphase. Now though, the Canadian company plans to compete across the board in optical components.

Applied Materials of the Telecosm: None today (there was none in semicon either in the early years, but Applied stock has risen faster than Intel's). Corning makes fiber, liquid crystals, EDFAs, polarizers, band splitters, add-drop channel filters, and Lucent makes practically everything. Both command a huge array of proprietary capital equipment which could be entered into the merchant market by subsidiaries or spinoffs.

George Gilder, May 4, 1998

After much consideration, we have decided to allow ForbesASAP exclusive rights to publish an occasional adapted text from the reports some six to eight weeks following receipt by GTR subscribers. In practice this will mean there is a possibility of a second wave of impact after initial publication.

Gilder Technology Report *is published by*
Gilder Technology Group, Inc. *and* ***Forbes Inc.***
Editor: George Gilder; Associate Editors: Charles Frank and David Minor;
Director of Research: Kenneth Ehrhart.
Monument Mills P.O. Box 660 Housatonic, MA 01236 USA
Tel: (413) 274-0211 Toll Free: (888) 484-2727 Fax: (413) 274-0213
Email: gtg@gildertech.com