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# THINKING OUTSIDE OF THE BOX

Sometimes I wonder whether my readers are ready for truly new paradigms. Paradigms so shocking they numb your neurons and curdle your cortical fluids. Paradigms that seem so outrageously off the wall and out of the question that they defy the credulity of all but a few bearded boffins raving in the wilderness–paradigms as patently absurd, as baldly in violation of the very laws of physics, as CDMA wireless phones, or multi-megabit cable modems, or terabit per second fiber optics, or billion-transistor chips seemed less than a decade ago.

But this is a time of market turbulence–a time to think outside the box.

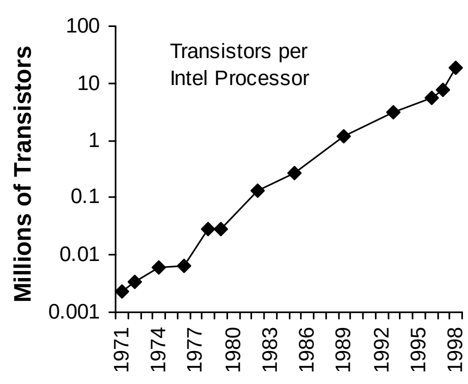
I have recently encountered a radical new paradigm, but I am not sure I am altogether ready for it myself. So don't worry, we have a piñata of conventional stock market bargains for you to savor in these parlous times. But first I would like you to contemplate the approach of a potentially earthshaking asteroid, a full millimeter in diameter, hurtling toward the heart of the microchip industry down several miles of tubes in a space age factory being built in Allen, Texas, by **Ball Semiconductor**.

**This is a time of market turbulence —a time to contemplate radically new paradigms.**

Like the previous blockbusters, this new paradigm will be said to violate physical laws and so forth. But science too has been known to advance by violating these laws. One hundred years ago, for example, the world of physics faced a similar millennial problem. Entering the new century, tantalizing clues of failure afflicted all of its systems and conceptual foundations. The speed of light was central to all these difficulties. If today the architectures of information technology face a similar predicament, the solution may turn out to be similar. Think out of the box of conventional architectures and contemplate four dimensional spheres.

Of course, Einstein's relativistic curves were not apparent in most terrestrial applications, any more than the curve of the earth's sphere is evident on your front lawn. Millennia passed before mankind even discovered the spherical shape of the globe. More millennia passed before Einstein conceived the spherically curvacious cosmos. Then it took fifty more years to produce Laetitia Casta.

Chart 1
**Processor Development**




Similarly, technologists did not have to face the reality of the speed of light as an ultimate limit until, like the young Einstein riding a beam in his mind, megahertz computers and terahertz fiber optic networks began to crash into the lightspeed wall.

Looking at the current state of the art in semiconductors, you sense a millennial foreboding, a photonic impasse. Today's leading edge microchips are the last generation that can be made with conventional optical lithography based on light wavelengths, which determine the size of the feature that can be resolved.

On a billion-transistor chip of the year 2004, the seven miles of wire will come in strands a tenth of a micron wide and two tenths of a micron high,

**Like all the other challenges in the history of Moore's Law, the lightwave limit in chip manufacture will be surmounted. Beyond, however, looms the lightspeed limit itself.**

an aspect ratio resembling a two-by-four laid on its side. These dimensions are smaller than the wavelength of visible light (.4 to .7 microns) and even than the wavelengths of the ultraviolet light (.18 microns) currently used to inscribe lines on a microchip. This gap between wire size and wavelengths implies yet another collision between the practice of engineering and the limits of light.

The wavelength of an x-ray is between one tenth and one fifty-thousandth that of blue light. Thus there are no practical limits to the infinitesimal geometries that x-rays could potentially project onto a chip. But x-rays are the lithographic technology of the future and maybe always will be. With photons commanding energies of hundreds to millions of electron volts (measured by Planck's *h* times their frequency), x-rays blast through all familiar photoresists (by which the design on a chip is "developed" like an infinitesimal photograph). Moreover, x-rays defy reduction through lenses and must be transferred to the chip through metalized quartz photomasks with a resolution the same as the chip. Such photomasks have yet to be perfected.

Meanwhile, **Lucent** (LU) in its "Scalpel" program and **IBM**'s Watson Labs have long pursued the dream of using electron beams (e-beams), resembling the ones in a cathode ray tube, to write the patterns directly on a chip, instead of photographing them. Only angstroms wide, direct-write electrons can achieve arbitrarily small geometries. But e-beam machines have always proved exorbitantly slow since they cannot scan or "step" across the die but must inscribe every micron of the seven miles of wire and the hundreds of yards of polysilicon and the millions of transistor-geometries. Now those giant laboratories are experimenting with e-beam arrays that may surmount the speed problem.

Like all the other challenges in the history of Moore's Law, the lightwave limit will be surmounted. Beyond the lightwave limit in chip manufacture, however, looms the lightspeed limit itself.

Synchronizing all microprocessor operations today is the pulse of a piezoelectric crystal clock. But this is the last generation of processors in which the clock pulse can actually reach across the entire chip within that timespan. In the .10 micron devices now emerging from laboratories, the clock pulse will be able to reach only 16 percent of the chip.

Hitting the lightspeed barrier, the chip's architecture will necessarily fragment into separate modules and asynchronous structures. We might term these processors now under development time/space "mollusks" (Einstein's word for entities in a relativistic world) with their size limited by the systole of a light pulse. Setting the size of the integrated circuit module will be a measure tantamount in the microcosm to lightyears in the cosmos.

After passing through the wires on the chip, the signals run out onto the expanse of the backplane buses and motherboards of a computer. Once you leave the chip surface and move to the pins, the speed of light is horrendously sluggish; it kills you. Resembling the legs of a silicon centipede, pins are the choke points in computer architecture. The so-called *Rents rule* states that pins multiply by the square root of the number of transistors. In other words, while the number of transistors rises from 7.5 million on a Pentium II (19 million in the new Celeron with integrated level 2 cache) to a hundred million on a new generation processor–a factor of 16–the number of pins ekes up by a factor of four. This makes it progressively harder to get data off the chip where you can use it. William Dally of MIT estimates that by 2010, the number of transistors will have risen one thousand fold but the number of pins only 10 fold since the mid-1990s. Ground and power pins–which are useless for communication–represent some 40 percent of the outside connectors on a Pentium microprocessor. With millions of times more transistors than links to the outside world, the chip faces a lightspeed crisis that requires a reconstitution of the time/space relations of processors and memories.

In sum, this problem is latency, the growing gap between processor speeds and memory access times. You can gun up clock rates and expand bus sizes and increase the bandwidth and capacity of memories by throwing money at the problem. A few billion dollars per year per fab will do it. Indeed Gordon Moore has issued a new Moore's Law: The cost of a microchip fab doubles for every generation of microprocessor. But latency–the delay between the issuing of an instruction and the retrieval of needed data from memory–is determined by the time it takes for that round trip from the processor down the pins to the needed memory address, and that delay is set by the speed of light. Money won't change it; you cannot bribe God.

Computer performance is now governed far more by memory speeds than by processing speeds. This crisis dictates single-chip systems that put the processor on the memory. This means that silicon area, once a key abundance fueling the industry, will become scarce. At the same time, the onchip clock crisis dictates new modular and asynchronous computer architectures.

Offering a solution to all these challenges at once is Akira Ishikawa, former president of **Texas Instruments** (TXN) in Japan and founder of Ball Semiconductor. At TI Japan, he built several of the world's most formidable microchip plants, including TI's flagship fabs at Miho and Hiji –now to be owned by **Micron Technology** (MU). For the last 30 years, Ishikawa has dreamed of producing integrated circuits in the form of tiny single crystal spheres in plants designed like chemical factories with continuous flows of product rather than a series of discrete equipment clusters. Such a factory, he believed, could be ten times cheaper than conventional fabs, thus addressing the challenge of the new Moore's Law.

Putting the circuitry on tiny spheres of silicon and connecting them in clusters would address both the crisis in silicon area (the spheres use silicon surfaces twenty times more efficiently than planar microchips do) and the crisis of the pins (Look, Ma, no pins!). Because the clusters would bring semiconductor modules closer together, communications could be faster, thus diminishing the latency problem. In addition, spheres a millimeter in diameter could function as antennas emitting and receiving microwave signals.

Indeed, Ball Semiconductor seems precisely targeted to resolve the current perplexities of the industry. But the company remains far from its goals. With investments of some $53 million from several Asian companies, it has proven its concept and inscribed small numbers of five micron devices on its millimeter balls. Using an ingenious array of mirrors, it has pioneered three dimensional lithography in league with **Canon** (CANNY).

Ishikawa and his team in Texas and Japan are working with such capital equipment producers as **Disco** to deliver product early in the next century. Crucial to success will be discovery of a niche where the balls perform functions impossible on ordinary chips. The RF (radio frequency) applications may prove most promising. Ultimately, however, Ishikawa's balls are designed as modules to be clustered in arbitrarily large arrays, suitable for most current microchip applications.

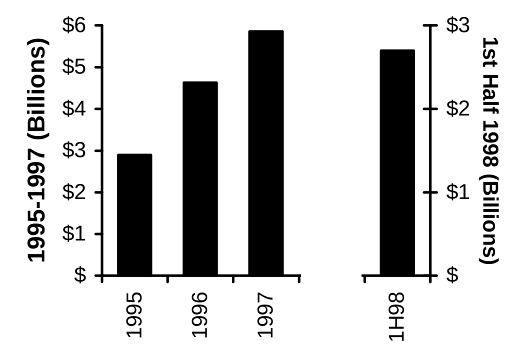
Ishikawa faces the classic entrepreneurial challenge of launching a radical invention, with many inevitable bugs and glitches, in the path of the juggernaut of existing methods and onrushing momentum of Moore's Law. Ball's team of 100 engineers must compete with rivals collectively commanding hundreds of thousands of en-gineers working with conventional planar silicon. Five micron geometries may give proof of concept but it took the planar chip industry 20 years to move from that point to the .3 micron geometries of today. Nonetheless, Ishikawa's concept commands the magic of "out of the box" boldness that his dismissive rivals must capture as they surmount the gathering storm of fin de siècle doldrums and meet the new conditions of scarce silicon area, constrained power, and bandwidth abundance.

The list of companies and technologies that outlived their usefulness because of a failure to think boldly reads like a "coming attractions" for "Where Are They Now?" The motto of the new era should be "Remember Tung Sol." It was a major producer of vacuum tubes that disappeared without a trace.

But if you want a rain check for the ball game, how about some silicon "dust." Under Brian Halla, **National Semiconductor** (NSM) has been thinking outside the box and has paid the price in an earnings slump. But it is pioneering in single chip systems and next year will introduce an entire Cyrix PC on a chip. Along the line of Ball, National is also selling operational amplifiers as small as a coarse grain of pepper. Used in cellular phones and pagers, these popular devices contain some 50 transistors on a silicon area about the size of one of Ishikawa's balls.

Chart 2

**Worldwide Router Market**




*Source: Dell'Oro Group, Dataquest*

Now making a bold attack on the silicon area problem is the **ARM** (ARMHY) microprocessor. Approaching agreements that could bring the device into most GSM (Global Systems Mobile) cellular phones–and working on CDMA (Code Division Multiple Access)–ARM was originally established in 1990 in England as a joint venture between **Apple** (AAPL), **Acorn**, and **VLSI** (VLSI). ARM's focus is high performance, low cost, power efficient, small die size RISC (reduced instruction set computing) processors. These chips employ rapid and efficient processing of a relatively small set of simple instructions. Targeting embedded control, consumer multimedia and portable systems, the new ARM7 pumps out an impressive 100 million instructions per second (MIPS). Leveraging increasingly scarce silicon area, the ARM7 contains only 35 thousand transistors, one 200th the number in a leading edge Pentium with some six times the MIPS rating. ARM's agreement with **Intel** (INTC) for development and production is a further asset.

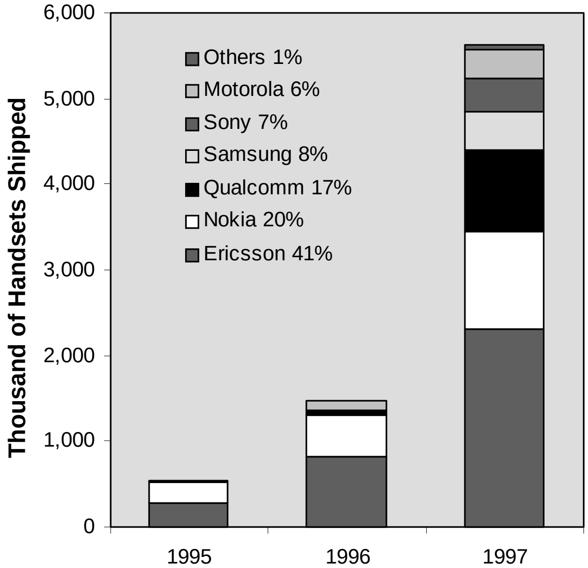
No less significant is Texas Instruments' leading edge .07 micron technology, and ability to place 400 million transistors on a single low-voltage chip using an e-beam direct write process. This will allow an unprecedented level of system integration and creation of new generations of wireless and multimedia applications. This technology will be used to advance **Sun Microsystems**' (SUNW) UltraSPARC chip which TI manufacturers for Sun.

Also venturing outside the usual CMOS (complementary metal oxide semiconductor) box is **Cree Research** (CREE), of Durham, NC, a developer and commercial producer of silicon carbide (SiC) wafers. This material functions at up to 600 degrees Celsius (five times higher than silicon and more than double gallium arsenide) and it operates at roughly double the power and frequency of other semiconductors. Thus it is suitable for microwave applications, particularly as power transistors. Target markets are wireless base station manufacturers, RF power amplifier manufacturers, millimeter wave radio manufacturers, and satellite transmission systems as well. Chips will be ready for beta testing by early 1999.

Another advantage of SiC is power density. SiC will provide at least five times the power density of pure silicon or gallium arsenide. This effectively reduces the number and size of chips that must be employed to produce a given power output. Systems

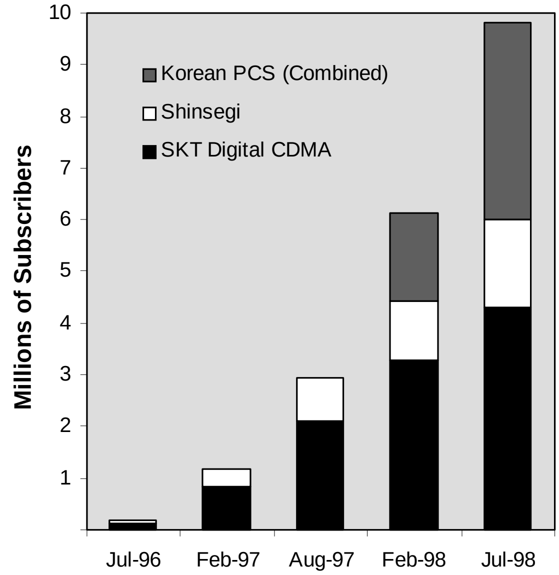
**With millions of times more transistors than links to the outside world, the chip faces a lightspeed crisis. Ball Semiconductor seems precisely targeted to resolve the current perplexities of the industry.**

Chart 3
**US Digital Wireless Handsets**




Source: Dataquest

Chart 4
**Korean CDMA Subscribers**




Source: Co. Reports, Maeil Bus. Newspaper, Korea

**Code Division Multiple Access (CDMA)** *wireless handset manufacturers, Qualcomm, Sony, and Samsung, burst into the US market in 1997, as total digital handset sales rose 283% from 1996 (***Chart 3***). With Nokia producing both GSM and CDMA phones, CDMA handsets reached some 2 million units or nearly 50% of the increase in shipments. Market share of GSM producer Ericsson slipped from 56% to 41%, even as its shipments increased by 180%. As CDMA expansion in Latin America accelerates, Qualcomm will begin phone shipments from its new Brazilian manufacturing facility in October. Motorola is expanding Peru's CDMA cellular network following the success of its trial overlay on Lima's analog network, where CDMA subscribers grew to 60,000 (15% of wireless subscribers) from 10,000 in December 1996. Over 20,000 subscribers signed up for DDI's new CDMA service in Japan during the first two weeks following its launch on July 14, 1998. With nearly 10 million CDMA subscribers by July, Korea leads the world's CDMA deployments (***Chart 4***).*

**Sub-$1,000 PCs** *have had the greatest impact on the retail market, capturing over 40% of sales. The business PC market is now beginning to see a similar shift, with sales of sub-$1,000 PCs through the corporate reseller channel rising from less than 3% in January 1998 to over 20% in April and June (***Chart 5***). The low end of the market has been driven by cheaper non-Intel processors. Back in the retail market, the new category of sub-$800 PCs captured 17.6% of June 1998 sales as prices move still lower. In August, Micro Center rolled out the PowerSpec 1810 system with a 180MHz Cyrix MediaGX MMX processor, 22 MB of RAM, a 1.6 GB hard drive, CD-ROM drive and modem for just $399. In the retail market, Intel has seen its processor market share drop from 97.3% in February 1997 to 60.1% in June 1998 (***Chart 6***). Intel is fighting back with an improved version of its low-end Celeron processor which incorporates L2 cache memory (the first model was panned for poor performance due in part to lack of cache). But rivals are moving forward, too. National Semiconductor, which pioneered the low cost market but has recently been upstaged by AMD, has announced new processor shipments from its South Portland, Maine fab. Using 0.25 micron process technology for the new chips, National is able to cut die size by 25% to 40%, resulting in significant cost savings. Other investments in National's Singapore test and assembly facility will cut total manufacturing cycle time by 50%.*

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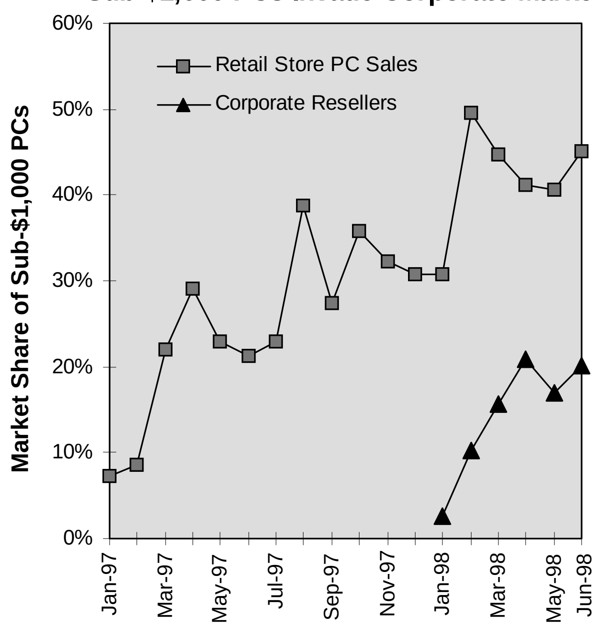
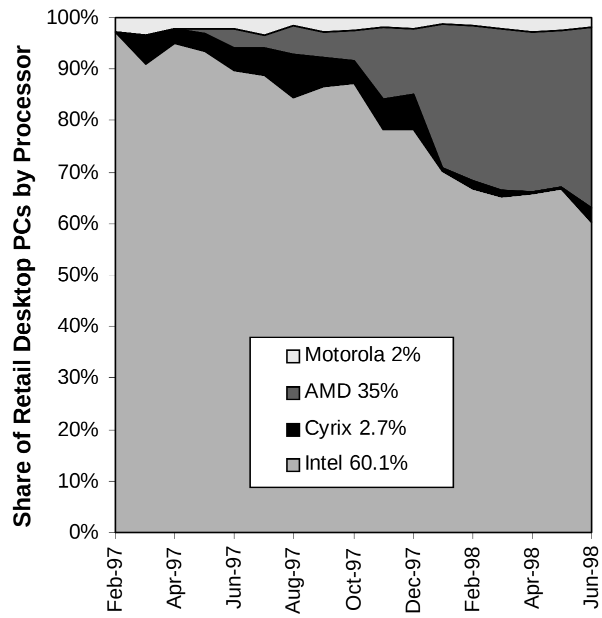
Chart 5
**Sub-$1,000 PCs Invade Corporate Market**



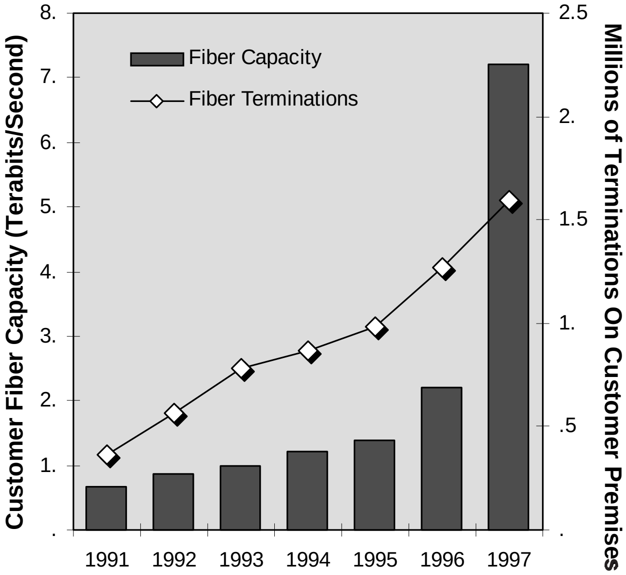

Source: ZD Market Intelligence

Chart 6
**Intel Loses Share in Retail PCs**



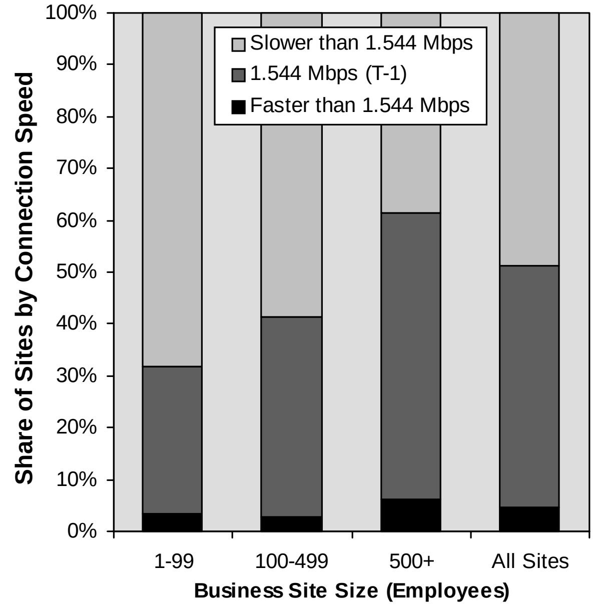

Source: ZD Market Intelligence

Chart 7
**RBOC Fiber Reaches Customers**




*Source: RBOC Reports to FCC*

Chart 8
**F1000 Internet Connections**




*Source: ZD Market Intelligence*

**Fiber optic lines** *terminating on RBOC (regional bell operating companies) customers' premises increased 25%, from 1996 to 1.59 million at the end of 1997, according to annual reports filed by the RBOCs with the FCC (***Chart 7***). Fiber connections operating at DS-1 rate (1.544 Mbps, T-1 equivalent) increased 25%, but the greatest increase came from DS-3 rate (44.736 Mbps) and faster connections, which rose 294% from 37,216 to 146,709 terminations. While these fast links account for just 9.2% of RBOC fiber terminations, they represent 91% of the data capacity of customer fiber, raising overall capacity 227% in a year to 7.2 terabits in 1997 (***Chart 7***). The Internet is increasing the demand for broadband connections. Of 4,600 Fortune 1000 business sites surveyed by ZD Market Intelligence, a majority (51.3%) are now connecting to the Internet at T-1 rates (1.544 Mbps) or faster (***Chart 8***). Among sites with intranet or electronic commerce implementations, broadband connections (T-1 or faster) rose to 70%.*

**Internet usage in North America** *continues to surge with 79 million US and Canadian adults (age 16+) now surfing the Net according to the June 1998 survey by Nielsen Media Research and CommerceNet. Significantly, a majority of people aged 16 to 34 are now Internet users. Netscape web browser share–among some 90,000+ unique weekly visitors to the Engineering Workstations WWW Server (EWS) at the University of Illinois, which has consistently reflected and predicted overall browser market share–dropped below 50% during August 1998 (***Chart 9***). Netscape and Microsoft now hold approximately equal browser share among all visitors (48%), while Microsoft leads among Windows users (53% to 46% for Netscape) and Netscape still dominates among non-Windows users (72%). The Netcraft survey of public Internet web servers, which polled 2,807,588 sites in August, continues to show a decline in Netscape share of web server software (***Chart 10***). The public domain (free) server software from the all-volunteer Apache Group, with 50.3% market share, got another boost this summer when IBM announced it would ship the Apache web server software and provide commercial support for the product within a package of other server components. Netscape revenues during the third quarter of its new fiscal 1998 (ending July 31, 1998), rose 18% from the previous disappointing quarter to surpass its old third quarter of 1997 (ending September 30, 1997) by one tenth of one percent, yet net income (3Qfiscal98) was just 1% of the 3Q97 figure.*

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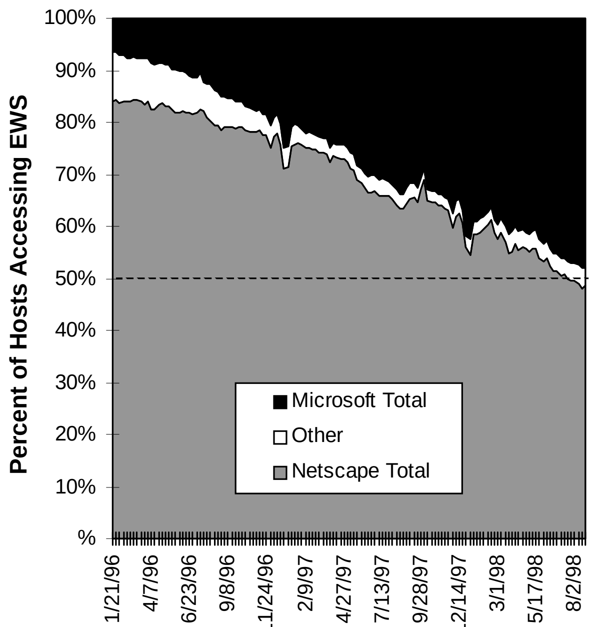
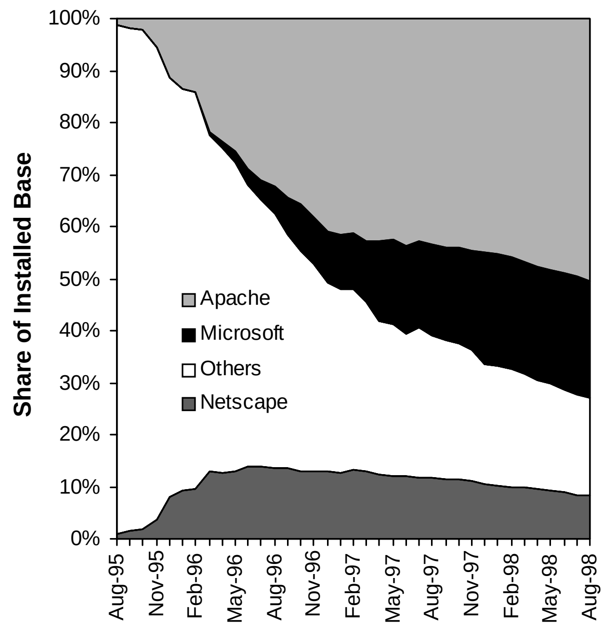
Chart 9
**Browser Market Share**




*Source: University of Illinois*

Chart 10
**Public Web Server Software**




*Source: Netcraft*

**Nexabit may be ready to supply one of the important pieces. . . how to move the exploding flow of data on to the telecom backbone.**

are thus simplified and reduced in size and weight.

Pure SiC will be used in chips for wireless base station amplifiers at frequencies of 1.8GHz and 2.4GHz. Linearity, often a problem in demanding RF applications such as CDMA, is not a problem with this material. Operating at frequencies higher than silicon or silicon germanium (SiGe), these chips will reach 10GHz or higher with compound devices.

Purchasers of new technologies always want a second source. A private company entering the market is **Sterling Semiconductor** of Sterling, Virginia, which will produce high quality SiC wafers. Founded by former Soviet scientists with 30 years of experience with the material, Sterling is sponsored by **Novecon**, a company launched by economist Richard Rahn to develop technologies from the Eastern bloc. While supplying wafers to the microwave and cellular industries, Sterling will introduce devices using silicon carbide for the harsh environment sensor business. Government estimates suggest that silicon carbide sensors might allow elimination of 800 pounds from the weight of an F-16 fighter aircraft and enable more efficient and pollution free automobile engines.

From our founding in 1996, favorite paradigms of the GTR have been CDMA wireless, which rose in that time from a business of a few hundred million dollars to over $6 billion, and optical networking, which grew from $50 million in 1995 to approximately $1.5 billion in 1997. Combining these two paradigms is privately held CTC (**Commercial Technologies Corporation**), based in Culver City, California, and Richardson, Texas. It has created the industry's first commercially viable Optical Code Division Multiple Access (O-CDMA) system, and owns the intellectual property rights to O-CDMA. CTC is a spin off from **Research & Development Laboratories**, also of Culver City.

Because CDMA is most efficient for overcoming noise, which is nearly absent in modern fiber, engineers have long disparaged CDMA for optical applications. But CDMA also offers the further virtue of allowing many transmitters to share spectrum. It is this feature that is central to the CTC's product. Called CodeStream, it enables multiple network users to transmit and receive information over shared optical fibers. An all-optical network, CodeStream offers high bandwidth transmission, add/drop, cross-connect, and restoration capabilities all at the optical layer with one common optical-CDMA engine. Removing electronics from the signal paths of the network, CodeStream can create hundreds of simultaneous independent signals on a single fiber pair.

Instead of sending numbers of independent laser lightwave channels down an optical fiber (currently up to 40) as in wavelength division multiplexing (WDM), CodeStream uses complex coding and a unique photon phasing approach to transport up to 128 signals at 622Mbps (80 gigabits per second total) on a single fiber pair. CTC claims the system is protocol-independent, and is compatible with virtually all equipment used in the telecom industry.

The system employs a single broadband light source which is sent through a grating mirror and widened to a few tenths of an inch, filtered to take on the configuration of a bar code, and finally modulated to carry the information to be transmitted. All digital optical signals are sent onto a single fiber pair through an optical combiner.

Similar to wireless CDMA, which encodes each signal as a unique, wide, noise-like carrier wave only recognizable by the intended receiver, O-CDMA signals are labeled with the optical bar-code that spreads information across the optical spectrum. This technique also creates a unique signal with a high level of security, and information can be safely broadcast from any originating point on a network to every other location on the network, and recovered by setting the intended receiver's bar-code to match that of the originating transmitter. Only the receiver with the matching bar code will receive the transmission.

Like ordinary wireless CDMA, O-CDMA can be compared to a roomful of people all talking at the same time, but each in a different language. The listener will be able to hear the speech of the person who speaks his own language, and be able to "tune out" the other speakers.

A major benefit enabled by O-CDMA is a true optical cross connect. Optical cross-connect functionality is accomplished without the need for external equipment at the network edge. Given that every signal is securely broadcast everywhere on the network, any point can be connected to any other point by matching a receiver bar code with the desired transmitter. Similarly, passive optical add/drop, which allows signals to be added to or dropped from the network at various places between the endpoints, is accomplished by a simple unbalanced coupler, which can extract the entire spectrum, or add signals as required.

CodeStream does not currently have the capacity for the long haul market and other WDM fortes. But its fast optical switching and add-drop capabilities seem just the answer for the local loop. Beta testing of the product will occur later this summer, and commercial availability is planned for the first quarter of 1999. CTC plans an IPO for the second half of next year.

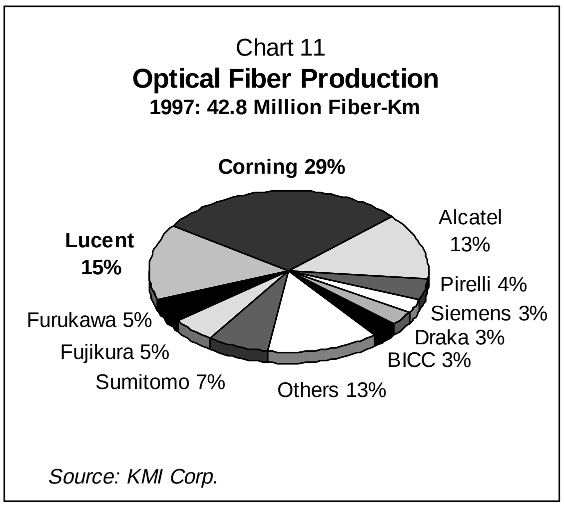
The telecom backbone, the long haul networks comprising fiber optic cables using WDM systems, can now carry terabits of information per second. A bottleneck in these networks is the router, the gear that determines the best path to send information over the network, which to this point can only handle gigabits per second. To provide a solution, the new router/switching platforms must deliver terabits per second of capacity now, and be expandable in the future.

CEO and co-founder of **Nexabit Networks**, Mukesh Chatter, speaks in excited tones about his company's new router. And this excitement is with good reason. Nexabit may be ready to supply one of the important pieces to complete the puzzle of how to move the exploding flow of data on to the telecom backbone. The new router uses patented switching technology to deliver 6.4 terabits per second (Tbps). This looks like a discontinuity.

Nexabit claims to be the only vendor able to deliver multi-terabit capability (per chassis), with carrier class availability, reliability, and short, predictable delay. The platform allows migration for those who have ATM networks but would like to move to an IP-based network core. The initial release of the NX64000 will support 128 OC-3s or 16 OC-192s. While these numbers do not add up to terabits, Chatter explains that terabit capacity is available by using higher optical interfaces as they become available.

Getting the router to beta is of some urgency, since other companies such as **Juniper Networks**, **Netcore**, **Pluris**, and **Avici Systems** are also developing next generation routers with terabit speeds. Nexabit plans to have pilot models for beta testing by November of this year.

Nexabit announced in August, over $20 million of new capital from Paul Allen's **Vulcan Ventures**, **The Thomson Corporation**, and **Hambrecht and Quist**'s (HQ) venture capital arm. A public offering is planned for next year.




In a different kind of fiber optic venture, Lucent Technologies, one of our Telecosm technology companies with its Bell Labs resource, will be a major provider of optical networking equipment and services for **CTR Group**'s Project Oxygen, a global undersea extravaganza, with a contract worth a billion over 4 years. Another of our Telecosm companies, **Corning Incorporated** (GLW), will supply the optical fiber for this gargantuan venture.

Project Oxygen is a gigantic submarine fiber optics network connecting all continents (except Antarctica). Oxygen's first phase will consist of 158,000 kilometers (km) of optical fiber cable with 101 cable landing points touching up to 74 countries. Cable landing points will have access to 90 percent of international traffic. The marine route survey and submarine cable installation will begin next year, with the first segments to be completed by the end of the year 2000, with completion of the first phase in early 2002. Using WDM, Oxygen will have a minimum throughput of 640Gbps over long-haul routes and carry at least 16 wavelengths per fiber. On land-based and shorter undersea segments, the Oxygen network will transport up to 1.92Tbps.

Project Oxygen, albeit the most ambitious, is only one of a number of undersea WDM fiber optic cable projects. Another is being built by **Global Crossings** (GBLX), the Bermuda-based company which is building a 14,000 km digital fiber optic cable system that will link the US and Europe, as well as a 21,000 km digital cable system that will link the US and Japan. The company went public in August with an initial valuation of nearly $6 billion. Others include **Gemini**, a joint venture of **WorldCom**'s (WCOM) MFS Communications and **Cable & Wireless** (CWP), an advanced transatlantic fiber optic cable system, and US/China Fiber Cable: a trans-Pacific network backed by **MCI** (MCIC), **AT&T** (T), **SBC** (SBC), and **Sprint** (FON) among others. Completion is scheduled for December 1999.

These enterprises will provide expanded opportunities for WDM optical networking equipment such as **Uniphase**'s (UNPH) new submarine lasers. Uniphase is the market leader in 980nm pump lasers for optical fiber amplifiers, and currently is the only approved supplier of pump lasers for submarine optical networks. The company has announced a new line of products, including new electro-absorption (EA) based external modulators from its **Philips** (PHG) Optoelectronics acquisition, which will bolster its market leading position in WDM external modulators. Uniphase has expanded its customer base to include a major European customer, and hopes to take advantage of the growing cable TV market for WDM systems. New fiber Bragg gratings and Wavelocker (used to maintain wavelength stability within the fiber) products will also enhance the company's offerings.

In our August 1996 issue of the GTR we talked about **Tut Systems**' advantage in copper technology. The company has the lead in ADSL (asymmetric digital subscriber line) technology with systems carrying high data rates running over 4 miles from the central phone office. The company has also developed a wireless Ethernet LAN (local area network) bridge for extending local area networks.

A new twist on copper pairs is Tuts' HomeRun, an in-home LAN, which utilizes existing twisted copper phone wiring to connect PCs in various rooms of the home. For the *wired* family with multiple PCs, HomeRun will create a home network, with as many as 25 different devices (these must have a 10Base-T Ethernet interface), including peripherals, simultaneously running over a LAN, and all without disturbing existing phone service. This

**Project Oxygen's gigantic submarine network will consist of 158,000 km of optical fiber cable with 101 cable landing points touching up to 74 countries.**

# TELECOSM TECHNOLOGIES

| ASCENDANT TECHNOLOGY | REPORT(S) Volume: No. | COMPANY (SYMBOL) | Reference Price | Price as of 9/1/98 |
|---|---|---|---|---|
| Cable Modem Service | I: 2, 3; II: 7, 8, 9, 11, 12; III: 6, 8 | *@Home* (ATHM) | 19 1/2 | 33 1/2 |
| Silicon Germanium (SiGe) | III: 8 | *Applied Micro Circuits* (AMCC) | 22 11/16 | 22 1/4 |
| Analog to Digital Converters (ADC), Digital Signal Processors (DSP) | II: 3, 7, 12; III: 2, 4, 8 | *Analog Devices* (ADI) | 22 3/8 | 14 15/16 |
| Dynamically Programmable Logic, Silicon Germanium (SiGe), Single Chip Systems | III: 4, 8 | *Atmel* (ATML) | 17 11/16 | 6 25/32 |
| Single-Chip Broadband Data Transmission | II: 10; III: 3, 5, 8 | *Broadcom Corporation* (BRCM) | 24 * | 59 13/16 |
| Digital Video Codecs | II: 5, 8 | *C-Cube* (CUBE) | 23 | 15 3/8 |
| Fiber Optic Cable, Components, Wave Division Multiplexing (WDM) | II: 9; III: 5, 9 | *Corning* (GLW) | 40 15/16 | 24 |
| Low Earth Orbit Satellites (LEOS) | I: 2; II: 1, 3, 4, 8, 10; III: 6 | *Globalstar* (GSTRF) | 11 7/8 | 14 3/16 |
| Business Management Software | III: 4 | *Intentia* (Stockholm Exchange) | 29 | 26 1/2 |
| Wave Division Multiplexing (WDM), Fiber Optic Equipment | III: 5 | *JDS Fitel* (Toronto Exchange) | 19 1/4 | 13 3/4 |
| Broadband Fiber Network | III: 2, 3, 4, 8 | *Level 3* (LVLT) | 31 1/4 | 32 3/8 |
| Single Chip ASIC Systems, CDMA Chip Sets | II: 8; III: 8 | *LSI Logic* (LSI) | 31 1/2 | 12 1/4 |
| Telecommunications Equipment, Wave Division Multiplexing (WDM) | II: 1, 2, 7, 9, 10, 11, 12; III: 1, 2, 3, 4, 5, 7, 9 | *Lucent Technologies* (LU) | 23 9/16 | 78 1/8 |
| Single-Chip Systems, Silicon Germanium (SiGe) | II: 8, 12; III: 4, 8, 9 | *National Semiconductor* (NSM) | 31 1/2 | 9 7/16 |
| Telecommunications Equipme[illegible]ave 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 | 50 15/16 |
| Point to Multipoint System for 7-50 Ghz, Spread Spectrum Broadband Radios | II: 10, 11; III: 7, 8 | *P-COM* (PCMS) | 22 3/8 | 4 3/8 |
| Code Division Multiple Access (CDMA) | I: 1, 2; II: 1, 3, 4, 7, 8, 9, 10, 11 III: 4, 5, 6 | *Qualcomm* (QCOM) | 38 3/4 | 47 9/16 |
| Broadband Fiber Network | II: 9, 10, 11; III: 1, 2, 3 | *Qwest Communications* (QWST) | 20 3/8 | 25 11/16 |
| Linear Power Amplifiers | III: 5, 6, 8 | *Spectrian* (SPCT) | 14 | 12 7/8 |
| Java Programming Language, Internet Servers | I: 1, 2, 3, 4; II: 1, 5, 6, 7, 8, 10, 12; III: 9 | *Sun Microsystems* (SUNW) | 27 1/2 | 40 5/8 |
| Broadband Wireless Services | II: 9, 10, 11, 12; III: 7 | *Teligent* (TGNT) | 21 1/2 * | 23 7/16 |
| Optical Equipment, Smart Radios, Telecommunications Infrastructures, Wave Division Multiplexing (WDM) | I: 1; II: 1, 2, 3, 9; III: 3 | *Tellabs* (TLAB) | 29 1/8 | 46 1/2 |
| Digital Signal Processors (DSPs) | I: 2, 3, 4; II: 5, 8, 11, 12; III: 3, 4, 6, 8, 9 | *Texas Instruments* (TXN) | 23 3/4 | 50 5/8 |
| Wave Division Multiplexing (WDM) Modulators | II: 7, 9, 10 III: 4, 5, 9 | *Uniphase (UNPH)* | 29 3/8 | 43 1/2 |
| Telecommunications, Fiber, Internet Access | II: 9, 10, 11, 12; III: 1, 2, 3, 4, 7, 8, 9 | *WorldCom* (WCOM) | 29 15/16 | 44 1/4 |
| Field Programmable Logic Chips (FPGA) | I: 3 III: 4, 8 | *Xilinx* (XLNX) | 32 7/8 | 31 9/16 |

* Initial Public Offering

*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.*

is also an ideal network solution for many small businesses and home offices.

Every telephone jack throughout a home or office will be Internet ready with HomeRun. Simple network interface cards or small external adapters connect PCs and Internet appliances to an access line. Multiple users will have concurrent Internet access. A network hub is unnecessary with this system and it requires no special terminations, filters or splitters. The network can be run over distances of up to 500 feet.

Tut is also developing products that will bring bandwidth and networking possibilities to multiple dwelling units and hotel rooms in a similar fashion.

In order to make these systems truly "plug and play," Tut has entered into a cooperative marketing agreement with **Microsoft** (MSFT), to work together with third-party vendors to release consumer products for these Ethernet-compatible platforms.

Tut Systems is funded by a number of leading venture capital firms and industry partners, including AT&T Ventures, **Vanguard Venture Partners**, Microsoft, and **Spectrum Equity**. Tut filed for an IPO in late July with no date set for the new issue.

So in a time of market turbulence, remember Tung Sol, get out of the box and have a ball.

*George Gilder with Jeff Dahlberg, September 2, 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.*

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