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MEAD'S FABULOUS CAMERA

While we have been partying in our minds for the last half year with our frolicsome ascendant companies, last month we went realtime: carousing with **Wave Systems** (WAVX) founder and entrepreneurial swashbuckler Peter Sprague on his sixtieth birthday (the guy spent the previous two weeks helicopter skiing on top of some mountains in Calgary, so don't send flowers).

Blundering into a role of party pooper, however, I told Peter, who was the founder of **National Semiconductor** (NSM) in one of his multiple past lives, that his old firm was on the verge of great things under its new CEO Brian Halla. Peter said, "Humpf," or something else guttural or sibilant, and declared that National would never go anywhere until it gave up the dream of its Cyrix subsidiary going head to head with Intel in processors. In our January GTR on National, we had said much the same thing: "You can't disrupt a market by going head to head with the dominant producer, particularly if it's Intel. What makes National more than a processor pest is its new markets" for integrated single-chip systems, often containing analog functions and x86 instructions sets.

National brings still fiercer focus to its mission as a classic Clayton Christensen disruptor.

Just five days after Peter's grousing, National announced that it was sloughing off its processor pest. Exiting the race to fill standard PC processor sockets, National will accelerate its drive for an integrated PC on a chip. Thus it will bring still fiercer focus to its mission as a classic Clayton Christensen disruptor in an array of new markets for Internet web pads, thin clients, settops, point-of-sale terminals, cameras, scanners, and other networked appliances. Peter presumably feels better. So do we. But the real fireworks from National have only just begun.

In This Issue:

Before the Sprague bash, we were partying in a more virtual way, trying not to gloat while relishing the continued vindication of **Qualcomm** (QCOM), the complementary emergence of **Conexant** (CNXT), the cosmic splash of coinage at **Global Crossing** (GBLX), and the ascent of **Broadcomm** (BCRM), **@Home** (ATHM), and **Uniphase** (UNPH) up the alps of the Internet. Heck, we have hardly had to come to work. The companies just do their thing, and we hang on for dear life and pose for covers of technology mags.

Believe it or not, that's the downside of this party–the picture sittings. To get photographed for a high quality cover normally takes at least three hours of *rigor photis.* They have you crawling on the floor, ogling sprays of fiber and boards of microchips as if they were a callipygian hologram of Laetitia Casta. They pose you precariously standing on one leg and pretending to fly like the Internet, until your anterior cruciate ligament distends to the approximate width and length of a fiber optic thread. Or they make you sit ruminatively for hours like Rodin's thinker backwards on a metal chair spraining your rictus over bad jokes about Bill Gates and St. Peter until you look like a Gothic gargoyle, only to discover in the end that all the contortions were just for the Polaroid pretake….

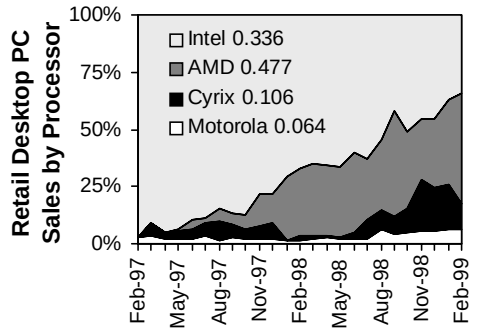
All that is over. Recent readers of the GTR may be excused for imagining that the paradigm is chiefly about optics or Code Division Multiple Access (CDMA) or Java. But the paradigms all stem from deeper sources, and the deepest of all–from my first work on the Law of the Microcosm–has been Carver Mead,

"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled." —Feynman

holder of the Gordon and Betty Moore chair in computer science at the California Institute of Technology. Providing the motif for the GTR, "Listen to the technology," Carver says, "Find out what it is telling you." Or as Mead's late colleague and collaborator at Caltech, Richard Feynman put it in his shattering report on the Challenger disaster: "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled." Whenever you encounter some business plan bent on fooling Nature–and there are many shysters out there who think they can win with marketing–think of Feynman. Think of the enemies of CDMA and WDM and dumb broadband networks.

Prominent among the technologies Carver has been listening to over the years is light processing. As a result, his new company, **Foveon**, has just permanently transformed the nature of photography. Rigor photis, hemorrhoids, rictal sprains, messy chemistry, all fall away. In the future, a cover portrait–or any other photograph–will take a couple minutes at most and always be as perfect as human flesh and art can allow. The camera industry will return to the US. And our mixed signal virtuoso, National Semiconductor, will find vivacious new life….

Chart 1
Cyrix Targets Single-Chip PC for Access Leaves PC Desktops to Intel and AMD



Source: ZD Market Intelligence

I work hard to discover new paradigms on the basis of already existing technology. Mead regularly invents radical new paradigms and, more important, implements them. Last month in San Francisco to receive the $500,000 MIT Lemelson Prize for innovation, Mead gave a clue to his technique. He averred that with technology moving so fast, colleges should eschew fragmenting themselves to keep up with the details and instead find the crucial truths underlying all the scientific disciplines: "The roots that radiate."

Carver Mead has built his career on "roots that radiate." After inventing the key gallium arsenide transistor in the 1950s, he proceeded to a profound study of the physics of semiconductors. This led him to the seminal insight of the entire microelectronics revolution. Enabling Moore's Law was Mead's discovery in 1968 that as transistors get smaller, they do not become more fragile, or hotter, or more expensive, or slower as everybody assumed at the time. Instead, Mead expounded the key principle of the Microcosm, which might be summed up "the less the space the more the room." All the way down to the .15 micron dimensions of today, Mead predicted in 1971, transistors would get faster, better, cooler, cheaper as they were miniaturized. The smallest computers would be the best computers. **IBM** would founder. The personal computer would rule.

This law of the Microcosm continues to underlie the GTR paradigm today. The inexorable movement of intelligence to the fringes of networks, to be embodied in ever smaller devices (e.g., Atmel smart cards)…the emergence of a worldwide fabric of communications linking these devices together (e.g., Global Crossing)…the rise of dumb passive webs of glass and light and air (e.g., Uniphase)…the relentless dissolution of smart systems in the center of the Internet and their migration into specialized servers on the edge (e.g., **Sun** [SUNW])…the eventual dominance of the most common PCs of the new era, based on digital cellphones, smart cards, and Java/Jini, with security and identity on board (e.g., Qualcomm pdQs)…all these developments mostly stem from the original microcosmic insights of Carver Mead.

Return To Analog

Mead saw, however, that putting as many as ten million transistors on a single silicon chip would require a new automated means of chip layout, a "silicon compiler." With colleague Lynn Conway, Mead went on to launch a revolution in hierarchical microchip design that enabled most of the digital miracles of the microprocessor era. For awhile, Mead was the toast of Silicon Valley, and when I covered the industry in the early 1980s for Ben Rosen's *Electronics Letter*, Mead and Conway's *Introduction to VLSI* was on nearly every executive's desk. But then in the mid 1980s, he left it all behind and predicted that the next frontier would be a return to *analog*, based on what he called neuromorphic models!

Nearly all his previous backers gagged. But Mead insisted. Like a human brain, a computer could be no more useful than its interface to the world, which is inexorably analog. Mead set out to develop new analog counterparts of human sight, hearing, and touch.

As Mead saw it, the problem is that the computer is still primarily a digital symbol shuffler. But the world consists of murky continuities all the way down to the quantum domain. Carver would say these continuities extend even inside the quantum, for he has a paradigm shift underway for physics too, waving it beyond the otiose idea of "particles." (For details, see our new book of the month, at www.gildertech.com.) The murky continuities of nature are interpretable only through the power of analogy.

A human being can descry the shape of a horse on a hill, whether in a line drawing, a color photograph, an impressionist painting, or a Cubist sculpture, or in a field, and he can link it to a neigh or a word or

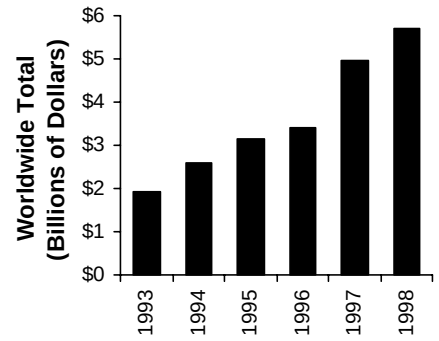
a clatter of hoofs or a pile of dung or a broomstick. But a digital computer would not even know where to begin. This information is knowable chiefly through analogies. Mead believes that the human brain functions by creating chemical and physical analogies of what it perceives. But computers immediately throw away all that analogical input by converting it abruptly to a digital symbolic form.

Analog electronics represent real world flows and forces by electrical currents and voltages. Dependent on the exact chemistry and physics of the device, analog can be incomparably more sensitive than digital ones and zeroes in capturing information—and also more sensitive to noise, heat and other outside influences. Thus your analog TV is degraded by bad weather, while your digital TV remains perfect until a catastrophic breakdown when even the ones and zeroes are unreadable.

For the capture of images, however, conventional analog chips cannot even begin to compete with the chemical analog system of film. Because of the acute sensitivity of the devices, most analog chips contain only a small number of transistors, resistors, capacitors, and other components. By digital standards, these components are large, measured in microns rather than in nanometers. Bloating the circuits are feedback loops and other compensatory devices that assure the stability of the functions in the face of temperature changes and other environmental impacts. Every analog device had to be different. Yet an image requires millions of pixels, which would mean millions of perfectly wrought analog circuits. Most analog engineers doubted it was possible. Like the digital engineers of the 1960s, they did not believe that the laws of the Microcosm—the smaller the space, the more the room, the better the performance—applied to their art.

Chart 2

Communications Analog IC Market



Source: IC Insights

Yet Mead was proposing analog VLSI (very large scale integration): analog chips with millions of devices on them. Most microchip sages concluded that now in his sixties, he had gone around the bend or over the hill, where he was contemplating the majesty of the redwoods near his home high on a bluff in the Woodside hills. Periodically, though, he and his students would announce some new neuromorphic analog device: silicon cochlea or retina chips and a "see-hear" device that simulated ears and eyes. Perhaps for old times' sake, *Scientific American* put an image from Mead's retina on its cover—the blurry but identifiable face of a cat created with his late student Misha Mahowald. However, Carver's VLSI analog usually turned out to have hundreds rather than millions of elements. It seemed doomed to lag forever behind the pace of advance in digital signal processing (DSP), where **Texas Instruments** (TXN) rules supreme.

Sloughing off all its conventional digital businesses, from microprocessors to dynamic random access memories (DRAMs), CEO Tom Engibous achieved one of the most powerful strategic transformations in the history of business. TI's strategy of combining spare analog front ends with DSPs was sweeping the world of realtime interfaces that Mead wants to transform.

TI's Tom Engibous achieved one of the most powerful strategic transformations in the history of business.

For all the feats of TI and DSP, however, I was captivated by Carver's analog paradigm. His retina chip was hugely ingenious. For example, the most common defect of the complementary metal oxide semiconductors (CMOS) that dominate the microchip industry is the parasitic bipolar transistor that can crop up spontaneously between the complementary negative and positive transistors. Endless ingenuity is lavished on suppressing this beast. Carver decided to enhance and harness the beast instead and put it to work detecting light as a photodetector. The CMOS devices he used in the analog mode below the 0.8 volt switching threshold for digital.

Thus on an ordinary CMOS chip operating at extremely low power, Mead could theoretically create an entire array of closely packed photodetectors and analog processors. It was a stunner. But years passed without any actual products or images more vivid than that penumbral cat.

Carver is nothing if not persistent. Beginning with the sense of touch, he joined with microprocessor inventor Federico Faggin to launch a new company, named **Synaptics**, to exploit his inventions. Heads turned at last when Synaptics took over 70 percent of the touchpad market. Carver wanted the touchpads to recognize fingerprints and signatures. But the market for ordinary touchpads exploded and these devices did not have to use analog VLSI after all. Then Carver applied his cochlear model to the problem of hearing aids, with **Sonic Innovations** in Salt Lake City. But once again ordinary digital DSPs with a conventional analog front end could do the job. It began to seem as if Carver had developed his analog VLSI technology for a future that would never come.

Nonetheless, his previous exploits sufficed to win him the most coveted innovation prize last week in San Francisco. Carver suggested that after the festivities I come out to the Valley to inspect one of his new inventions. Arriving at his Foveon Corporation, off Lawrence Expressway in Santa Clara, with GTR Publisher Richard Vigilante, I received somewhat

Chart 3

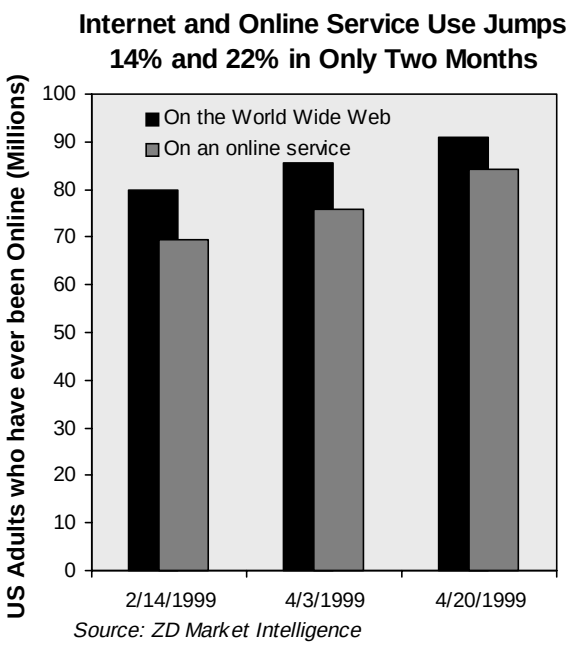
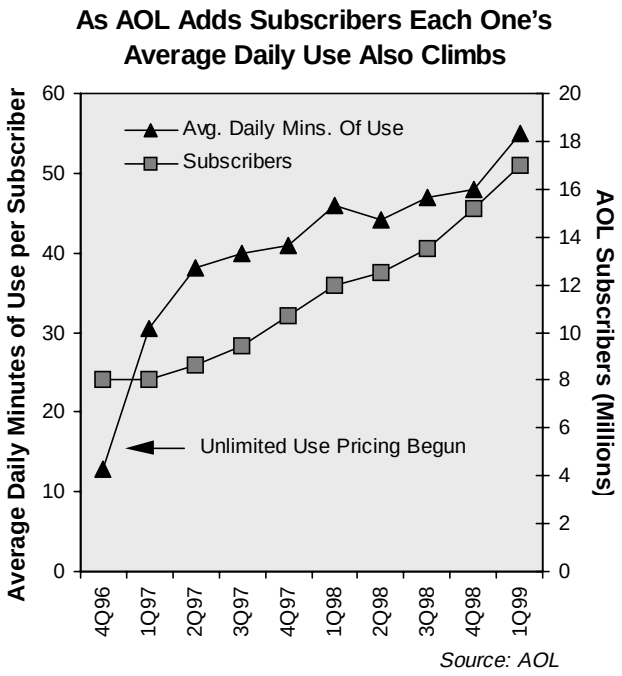


Chart 4



Internet Users Increase 11 Million in Two Months

In case you missed the message of explosive Internet growth in our last GTR, we thought you should know that the number of US adults who have ever been on the World Wide Web jumped by 11 million, or 14% in just two months, from February to March 1999. Those who have ever tried an online service climbed even faster, 15 million or 22%, with the tremendous success of AOL, MSN and other online services in marketing easy access (***Chart 3***).

No Fad, Net Use Grows Deeper, Not Just Wider

In the past two years, AOL's subscription rolls have more than doubled, but daily use per subscriber more than quadrupled. AOL's introduction of flat fee pricing was a factor, but also reflected is the growing significance of the Internet in the daily lives of users. Over the last quarter, daily usage per subscriber grew 14.58% versus an 11.84% increase in total subscriber numbers (***Chart 4***).

E-Commerce, One Night Stand or Meaningful Relationship?

E-commerce is exploding as novelty becomes habit. The percentage of online households who have made an online purchase has reached at least 47%. But the number of transactions per purchasing household more than doubled in a year from 1.57 to 3.73 (***Chart 5***).

The Rush of Consumers onto the Net is Met by a Stampede of Retailers and Manufacturers Selling Direct

Nearly 80% of the retailers surveyed by Ernst & Young currently have or plan online sales. Remarkably, 43% of manufacturers also have or plan to sell directly to consumers online (***Chart 6***).

-KE

Chart 5

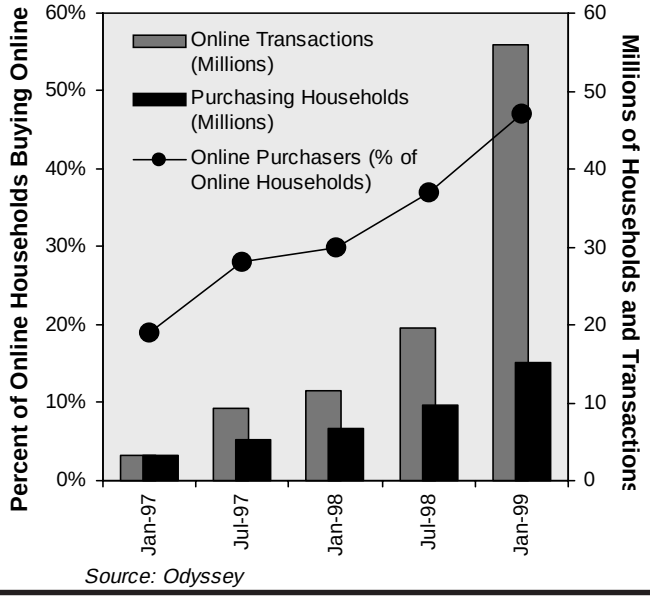


Chart 6

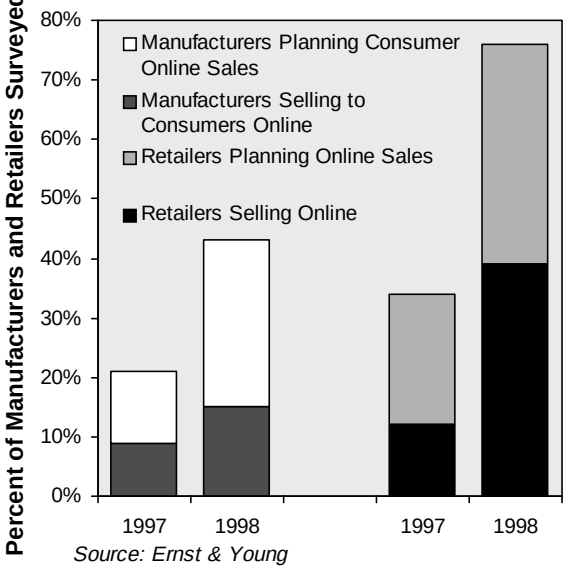
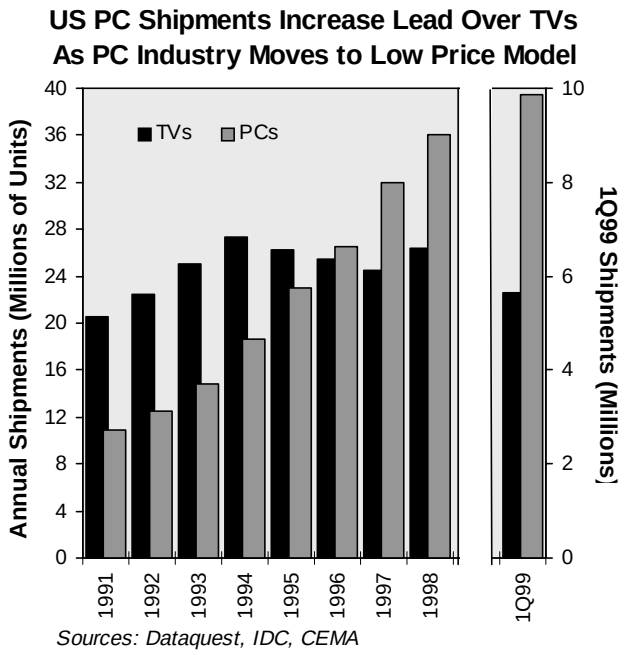
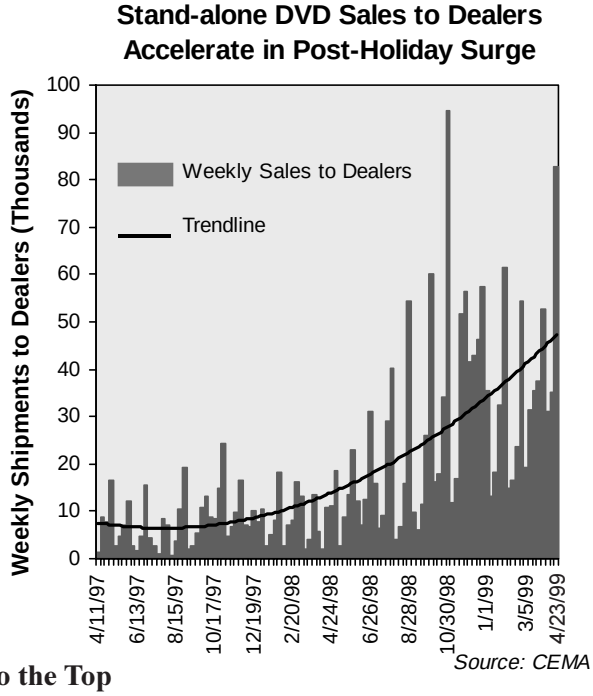


Chart 7



Sources: Dataquest, IDC, CEMA

Chart 8



Source: CEMA

The "Hollow PC" Floats to the Top

Even GTR readers already aware that PCs unit shipments have topped TVs in the US may be amazed by the widening of that lead in the 1st quarter of 1999. The "hollowing out" of the PC–as connecting to the Net becomes a prime motive of home PC buyers– is pushing the PC into the arms of the consumer electronics industry. The current crop of low-priced PCs are already price competitive with most TVs. Sony is willing to lose money in the PC market to safeguard its position in consumer electronics. Meanwhile emachines has adopted the consumer electronics models of streamlined production, low margins, paid support and product differentiation based on low prices. Traditional PC manufacturers, relying on fatter margins and differentiation based on the latest technology at the highest margins, are being disrupted from below (***Chart 7***).

DVD Market at Convergence of PCs and Consumer Electronics

Sales of stand-alone DVD players for high-quality playback of movies on TV sets have increased as the technology moves from the early adopter stage into the mainstream. Meanwhile sales of DVD-drive-equipped PCs suffered a false start as the vibrant low-end market for cheaper CD-equipped PCs took off. emachines' $599 DVD PC may change that. Sony's transition of its PlayStation video game player to DVD will also raise volumes (***Chart 8***).

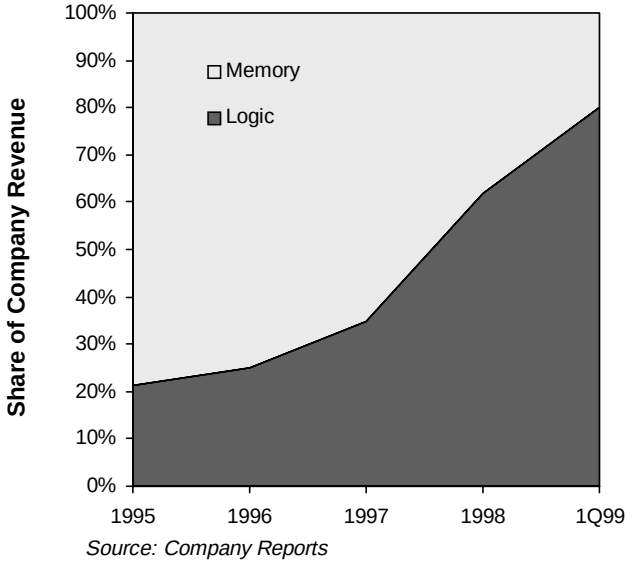
Atmel Prepared for Logic Growth as Memory Business Fades

Completing its transition away from memory and in to new businesses and markets, Atmel's1995 80/20 revenue mix between memory/logic was completely inverted by 1999's 1st quarter (***Chart 9***).

Conexant Shifts Product Mix to Face Challenge of New Era

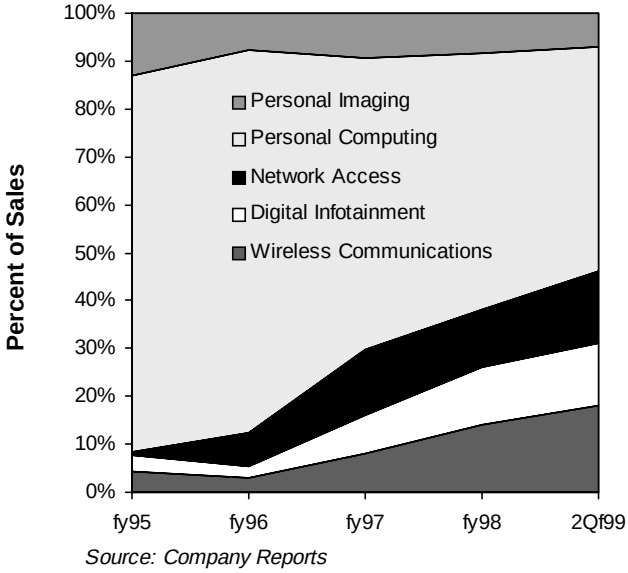
Conexant's traditional reliance on revenues from its Personal Computing division's analog modem sales is declining as the company shifts emphasis to higher growth Telecosm Technologies such as Network Access (xDSL), Digital Infotainment (satellite/set tops), and Wireless Communications (CDMA) (***Chart 10).*** -KE

Chart 9



Source: Company Reports

Chart 10



Source: Company Reports

As National's Halla puts it: "This is not *a* revolution in photography; it is *the* revolution in photography."

disturbing information at the door: We would begin with a session of portrait photography.

Foveon's Picture Perfect

Sitting down to pose in the usual uncomfortable backwards chair, I prepared myself to stay polite in the face of an expected ordeal of *rigor photis*. Instead, after the obligatory joke about Bill Gates and St. Peter, it was all over. With no Polaroids, no endlessly repeated takes, no sweat and powder, no messy chemical development process, a two minute sitting produced the best portrait I have ever had taken. Another two minutes and Richard was similarly dispatched. Flawlessly rendered was every tiny chink and check in the intricate grid of the pattern on my blue shirt. Every mole and blotch of my countenance was preserved with dermatological accuracy. No matter how much the image was enlarged, the fabric of threads and colors, the glint of light, the opalescence of the retina, the wisps of hair, the oily pustules all remained intact to charm the eye.

As National 's Halla, an avid amateur photographer himself, puts it: "This is not *a* revolution in photography; it is *the* revolution in photography." The pros agree. Paul Skipworth was official photographer both for the UN's 50th anniversary and for the last four Presidential Inaugurals. He observed: "I tried the Foveon camera and I was absolutely blown away. I could not see any 'moire' [defects] even when it was blown up…. I showed it to a bunch of top line professional photographers and they were also blown away with the quality and how easy it was to use…. There is nothing like it on the market."

A top executive at one of the world's supreme camera companies confirms: "I have not worked with any other camera which delivered that quality."

Carver at last had found an application hard enough to require his analog VLSI. As he explains, "silicon is not a substitute for film; it is a far superior image plane." The entire photographic process is performed in analog; there is no sacrifice of critical information until the image is converted to digital form for storage. In this operation, resolution can be arbitrarily high. Foveon oversamples its analog pixels in order to create a digital representation that can be manipulated without distortions.

National's Analog Ascendant

The first public beneficiary of Foveon will be National Semiconductor, which owns over 40 percent of the company (Synaptics, soon to go public, owns another 30 percent). Under chip manufacturing wizards Gobi Padmanavhan of National and Dick Merrill (now at Foveon but working at the National fab), National also uniquely commands the proprietary process necessary to fabricate analog VLSI devices containing millions of transistors. Unlike digital semiconductors (which merely have to function in a binary mode and thus can be made by specifiable and transferable processes), analog devices are mostly in the heads of their creators.

Under CEO Ray de Moulin, formerly head of **Kodak**'s (EK) Professional division, Foveon will begin by concentrating on the $4 billion market of professional photographers. They can immediately recognize the peremptory superiority of the Foveon device and they need to buy the camera that can attain the highest resolution, verisimilitude, and convenience. But in Mead's paradigm the best products soon become the cheapest products. Mead's technology is produceable on any leading edge wafer fab with access to Foveon/National's processing tricks and savvy. Thus it partakes of the silicon learning curves that ultimately reduce the cost of any chip to between 80 cents and $2 apiece. As volumes rise, prices will plummet. In the end, this technology will dominate the entire still camera market, from top of the line to throwaways. Although moving images impose complex mechanical and storage requirements, Mead's "silicon image plane" could make its way in due course to the video market as well.

Foveon brings analog into the Microcosm of VLSI. In the future, analog VLSI can transform most of the input-output technology in electronics, from

Qualcomm, TI Feel the Force

The special effects may be super and the screen multiplex, but a night at the movies still depends on a technology–celluloid film and mechanical projectors–a century old. Duplicating and distributing thousands of canisters of film can take weeks and be hugely expensive.

Now thanks to technology from two of our Telecosm stars, **Qualcomm** and **Texas Instruments**, both masters of the analog-digital interface, "digital film distribution" may make the film canister obsolete.

Startup **CineComm** will use Qualcomm's superior compression algorithms, along with satellite technology borrowed from cousin **Globalstar**. The technology will capture and compress a finished film, encrypt to prevent piracy, and then transmit it via satellite to theaters. The digital files are then decrypted, decompressed, and projected using cinema projectors provided by **Hughes-JVC**.

TI offers an alternative display based on its digital light processing (DLP) technology, with a projector composed of rectangular arrays of digitally controlled micromirrors, each only 2.5 millionths of an inch wide.

Enabling consistent copying with no degradation over time both digital systems provide excellent presentation at low cost. But the CineComm-Qualcomm entry is ahead in the PR wars. The new Star Wars pic will be the first digitally distributed film ever, employing the CineComm system at a handful of beta sites, for what promises to be the largest opening weekend in film history.

cinema displays to optical switches, from scanners to color faxes, from face recognizers in crowd scenes to eyeball readers for security. Analog VLSI could enable speech recognizers and microphone echo cancellers for automobile no-hands cellphones that actually work. It can even enable an image processor and searcher that can shave off the terrorist's beard and wig at Dulles and notify the CIA at Langley. But Microcosmic analog will not fully prosper without major advances in the Telecosm.

Converted to digital form for transport, storage, and display, each Foveon image requires between 20 megabytes and 40 megabytes. If it takes 200 milliseconds to expose a picture, it would be possible to click off five exposures in a second. That's up to 200 megabytes a second (or around 1.6 gigabits per second). This pace is no problem for fiber optics. But the PC is incapable of accepting bits at anywhere near that firehose pace. The state of the art I-O links, such as TI's Firewire 1394 or even ultra SCSI (small computer system interface) from **LSI Logic** (LSI) and **Adaptec** (ADPT), function at between 200 and 400 megabits per second. Attach a Foveon firehose to a Firewire and you drown it.

With optical technology advancing three times as fast as electronics technology, the coming proliferation of super high resolution analog imagers exalts the Telecosmic imperative: Use photonics bandwidth to compensate for the electronic bottleneck. The process that **Novell**'s (NOVL) Eric Schmidt calls the "hollowing out of the computer" is on its way. With images, films, and three dimensional simulations flashing around the net in search of optimal storage, processing, or display, the PC becomes a minor peripheral–a communications controller on the edge of the loop, in danger of slipping out of the loop altogether.

The PC will be unbundled and disaggregated into specialized appliances: a Foveon camera, a TI micromirror display, a petabyte jukebox, a high resolution scanner, an echo cancelling speech recognizer. This month a search party is combing the upper reaches of Mount Everest, looking for George Mallory's camera and its film to ascertain whether he reached the peak; in the future Mallory at the top of Everest takes pictures with a Foveon and zaps them to a **GlobalStar** (GSTRF) satellite and dies happily in the snow. Most of the "MIPs" and bandwidth migrate into servers on the net, along with most of the profits.

At the same time, transactions, authentication, encryption, and metering –all the functions of a "trusted client"–may move away from servers (whether at AOL or Amazon or your local ISP) and into PC or peripheral hardware.

As a member of the Wave board, I learned from Lark Allen of Wave at the Sprague party that our microchip leader **Atmel** (ATML) had agreed to combine the Wave "Embassy" e-commerce system with Atmel's high-end 32 bit programmable smart card technology. This transforms Wave-enabled Atmel devices from smart card chips to all purpose "safes" for transactions and metering of any digital content, from maps to music. Atmel gains potential access to a huge market of PCs and peripherals and Wave gains customers for its transactions systems and services. Nothing is sure in this game, but it was good for Atmel, and good for Wave.

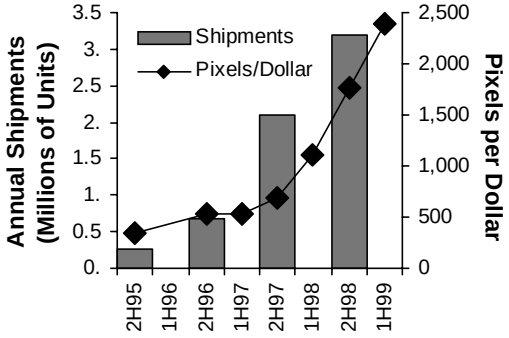
The PC will be unbundled and disaggregated into specialized appliances.

GBLX, Faster

Bandwidth is king and the king of bandwidth in the new era is Global Crossing. Global Crossing just took several further leaps beyond the competition by announcing on April 26 its purchase of Global Marine from **Cable and Wireless** (CWP) and the acceleration of its deployment of Pacific Crossing from March 2000 to December of this year.

The world's largest undersea cable installation and maintenance company, deploying the world's largest fleet of cable trawlers, Global Marine will free GBLX from the queues and trammels of the fiber laying companies. As Clayton Christensen explains, in a condition of technology overshoot, it pays to modularize and outsource. But in a condition of undershoot, such as the current plight of submarine bandwidth, the integrators will prevail. Global Crossing now controls all the key levers for winning the global race down the learning curve toward free long distance minutes and ubiquitous broadband internet.

Chart 11
Digital Cameras Rise with Quality



Sources: GTG, Nikkei Market Access, Dataquest

Nortel Bulks Up WDM

Meanwhile, back on the shore, our terrestrial market share leader, **Nortel** (NT), announced with **Corning** (GLW) a new Wavelength Division Multiplexing (WDM) system that can accommodate 160 different wavelength "lambdas" at 10 gigabits per lambda. Designed for IP over WDM networks, eschewing telco legacy SONET if desired, this breakthrough maintains Nortel's lead over **Lucent** (LU) and the world in bringing backbone bandwidth to market. With as many as 96 fibers in a cable sheath and scores of cables in a conduit, the capacity of a single route can explode into the petabits (10 to the 15) per second.

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	Reference Date	Reference Price	4/99: Month End
Cable Modem Service	@Home (ATHM)	7/31/97	19 1/2	143 15/16
Silicon Germanium (SiGe)	Applied Micro Circuits (AMCC)	7/31/98	22 11/16	53 5/16
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	Analog Devices (ADI)	7/31/97	22 3/8	35 1/8
Dynamically Programmable Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	17 11/16	18 1/4
Single-Chip Broadband Data Transmission	Broadcom Corporation (BRCM)	4/17/98	12 *	77 1/8
Digital Video Codecs	C-Cube (CUBE)	4/25/97	23	22 5/8
Erbium Doped Fiber Amplifiers, Wave Division Multiplexing (WDM)	Ciena (CIEN)	10/9/98	8 9/16	23 1/2
Linear Power Amplifiers, Cable Modems	Conexant (CNXT)	3/31/99	27 11/16	40 3/4
Fiber Optic Cable, Components, Wave Division Multiplexing (WDM)	Corning (GLW)	5/1/98	40 15/16	57 1/4
Submarine Fiber Optic Networks	Global Crossing (GBLX)	10/30/98	14 13/16	54
Low Earth Orbit Satellites (LEOS)	Globalstar (GSTRF)	8/29/96	11 7/8	20 1/8
Business Management Software	Intentia (Stockholm Exchange)	4/3/98	29	20
Wave Division Multiplexing (WDM), Fiber Optic Equipment	JDS Fitel (Toronto Exchange)	5/1/98	19 1/4	60 7/16
Broadband Fiber Network	Level 3 (LVLT)	4/3/98	31 1/4	90 1/16
Single Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	31 1/2	34
Telecommunications Equipment, WDM, CDMA, SiGe	Lucent Technologies (LU)	11/7/96	23 9/16	60 1/8
Telecommunications, Fiber, Internet Access	MCI WorldCom (WCOM)	8/29/97	29 15/16	82 3/16
Single-Chip Systems, Silicon Germanium (SiGe)	National Semiconductor (NSM)	7/31/97	31 1/2	12 1/2
Nationwide Fiber and Broadband Wireless Networks	Nextlink (NXLK)	2/11/99	40 7/8	73 1/4
Telecommunications Equipment, WDM, CDMA, SiGe, Cable Modems	Nortel Networks (NT)	11/3/97	46	68 3/16
Point to Multipoint (7-50 Ghz), Spread Spectrum Broadband Radios	P-COM (PCMS)	11/3/97	22 3/8	5 27/32
Code Division Multiple Access (CDMA)	Qualcomm (QCOM)	9/24/96	38 3/4	200
Nationwide CDMA (Code Division Multiple Access) Wireless Network	Sprint PCS (PCS)	12/3/98	15 3/8	42 1/4
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	13 3/4	59 13/16
Broadband Wireless Services	Teligent (TGNT)	11/21/97	21 1/2 *	54 3/8
CDMA Cable Modems	Terayon (TERN)	12/3/98	31 5/8	40 3/8
Digital Signal Processors (DSPs)	Texas Instruments (TXN)	11/7/96	23 3/4	102 1/8
High-Speed Copper Networking	Tut Systems (TUTS)	1/29/99	18 *	41 1/8
Wave Division Multiplexing (WDM) Modulators	Uniphase (UNPH)	6/27/97	29 3/8	121 3/8
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	16 7/16	45 5/8

*** 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.

Conexant Zips Home

Feeding this maw of new capacity will be new access links from Conexant. A paragon of CDMA power amps used in nearly all Qualcomm based systems, Conexant has announced its Zip Wire2 chipset for HDSL. We have long believed that HDSL, the original "DSL" product that was designed as a two way T-1 link, is the most promising of these digital subscriber line techniques. Conexant has now taken the technology a key step ahead. Supplying 4.6 megabits per second, the Zip Wire blows in at 83 times the speed of an analog modem. And unlike ASDL it goes as fast upstream as down, supporting the continued migration of creativity and content creation to the "consumers" whose transformation into producers has been driving the growth of net traffic. Released from the coils of its big company origins at **Rockwell** (ROK), Conexant continues to surprise us with its polyglot creativity in blasting open the bottlenecks to residential access.

With bandwidth galore in the offing, Carver Mead's inventions come at just the right time. They entail forgoing all the benefits of digital compression of analog information and relying instead on bandwidth, in the camera and out, to bring perfect images to the world. Trading off digital MIPs and bits for bandwidth is the heart of the Telecosm. Carver Mead is already the titan of the Microcosm. He is on the way to becoming an entrepreneurial titan of the Telecosm as well.

George Gilder, May 7, 1999

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