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The Telecosm Plot

With whole nations and governments mandating the switch to IPv6, the new protocol is now on its way and so is EZchip

Inside:

Andrew Odlyzko, the most savvy telecom pundit in academia and sower of turmoil at the Telecosm Lounge, gave me a wry look and affirmed that Corvis (CORV) is dead. Hey, it happens. Telcos go broke and die. There is enough fiber capacity, so he implied, to constipate the cosmos, but not enough traffic to exercise a single lambda-rich cable. Offering this eulogy at the seventh annual Telecosm conference in late August, Odlyzko did not even know about Corvis's alleged failure to win a major share of the Pentagon's Global Information Grid Bandwidth Expansion (GIG-BE) contracts. For all their talk about all-optical technology, the Feds apparently went for the legacy systems, as I feared after reading the DoD paper on their next generation networks. It demanded a router ark for their protocol zoo and guaranteed "quality-of-service" classes. If you have enough bandwidth and protocol neutrality, as David Huber of Corvis says, you don't have to worry about quality of service.

In Odlyzko's view, Corvis' problem goes far beyond a lack of spurious quality of service "guarantees." In one of four lugubrious slides (available at *http://www.gildertech.com/public/Tele2003speakerpresentations.htm*), Odlyzko showed that one transatlantic cable laid by 360networks for $850 million was recently sold for just $18 million. But there are scores of transatlantic cables and the 360 network line's lit capacity of 192 gigabits per second might hold three times the total average transatlantic Internet traffic (60 gigabits per second). In a world of wave division multiplexing (WDM), the potential lightable capacity of the cable is scores of times more. Corvis may have a nice long haul system, he said, but "long haul is not where the action is."

After sampling the scintillating Whitebox seminar on investment strategy with *WMO* authors Andy Redleaf and Richard Vigilante on Sunday, August 24, I had launched Telecosm 2003 on Monday morning with a short speech celebrating Korea, Corvis, and Qualcomm (QCOM). Korea boasts between twenty and thirty times more last mile bandwidth per capita than the U.S. The resulting hundredfold rise in Korean traffic in three years, so I said, portends a similar nonlinearity in the U.S. that will ignite the market for Corvis bandwidth and Broadwing services. Meanwhile, Wi-Fi wireless local area networks (LANs) captivate the microchip establishment and its personal computer clientele. But Qualcomm continues to disrupt from below, supplying a stream of chips that offer ubiquitous broadband services, all first launched and demonstrated by Korean companies such as Samsung (05930.KS) and SK Telecom (SKM).

Professor Odlyzko, however, had put three Korean grad students to work and they had debunked the story even before the conference began. Korea, he implied,

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is hugely overhyped. Its traffic might well have risen a hundredfold over three years but they started in 1998 with only a few thousand domain names. They endow apartment buildings with a lot of what Odlyzko calls "first mile" fiber lines bearing four to fifty megabits per second and back it up with 2.4 gigabit per second OC-48s. According to *Forbes*, they watch a lot of porn. But they have less actual broadband use per capita than the U.S., Odlyzko said. But forget broadband. It offers less upside promise for telecom than voice does, the professor maintains. Spearheaded by wireless voice, the U.S. telcos have been doing fine for the last seven years, with sales rising almost fifty percent. But only 40 percent of the traffic now starts out wireless. There's a lot more room to grow without video teleconferencing or other telecosmic developments.

What Korea means for Corvis

So Odlyzko set up a wall of worry for the conference to scale. Running up Squaw Peak every evening at dusk, I was not discouraged. Lake Tahoe glittered pink on the horizon. But still the hike through the two dense days of presentations was arduous. Let me sum up the view from the summit.

Viewing Odlyzko's slides after the conference—together with a 2003 White Paper from the National Computerization Agency in Korea that he sent along—I checked out his gut wrenching insights.

Korean capacity has undeniably soared since 1997, with a fifteenfold rise in users and a some hundredfold rise in bandwidth per user from its previous dialup days. That's a 1,500-fold non-linearity in capacity growth. The Koreans have laid broadband links averaging eight megabits per second to more than 11 million homes (73 percent of Korean households) and priced them at under $30 per month. Could this huge deployment of capacity at a price-per-bit 90 percent below ours have failed to foster any commensurate surge of use?

More than 80 percent of Korean traffic is now local and comprises a broad span of all the activities of the culture, with a focus on youth messaging, retail and banking services, government payments, and multi-player games. Contrary to a recent *Forbes* story, "adult content" seems to be a relatively small factor, representing, for example, only 1.4 percent of recent Korean wireless Internet transmissions. The Korean government is totally online for all forms, fees, licenses and taxes. Korean businesses increased e-commerce revenues 62 percent between 2001 and 2002, to a total of some $400 billion, as a third of the Korean economy moved to the Net.

So how could the U.S. show greater use per capita than Korea, as Odlyzko asserts? He points to backbone bandwidth at Internet Service nodes. The 2003 Internet Korea White Paper shows that Korean commercial Internet Service Providers (ISPs) at the end of 2002 handled "total peak traffic volume" of 104.5 gigabits per second, or about 34 petabytes per month. According to the general rule of thumb, peak traffic at U.S. network nodes is between six and eight times average traffic, the large usage spikes occurring during lunch breaks in America's broadband offices. Applying the same rule to Korea, Odlyzko calculates average traffic at just 4 petabytes per month.

In Korea, however, homes have as much per-user bandwidth as offices, and Korean mobile phones are also broadband, with two million Qualcomm EV-DO links now delivering consistent 650 kilobit streams, faster than most American DSLs (digital subscriber lines). Broadband usage is thus heavy around the clock, and the peak-to-average ratio is much smaller. Because Korea's population is densely concentrated in high-rise apartment buildings, moreover, lots of traffic remains on intra-building LANs. Topping it off, the "total peak traffic volume" that Odlyzko stresses is a nebulous concept—which is it, peak or total?

U.S. monthly Internet traffic is around 160 petabytes per month, a number boosted by our prominence as the world's content provider and pass-through point for much of the globe's real-time communication. But Korea possesses no such traffic-boosting factors. Its traffic volume thus more accurately describes the richness of the average Korean's Internet experience.

In any case, the statistics for domain names, commercial

The Corvis opportunity is still the most exciting in world communications

transactions, and deployed bandwidth, wired and wireless, first mile and backhaul, and furious attempts to upgrade its optical infrastructure to avert traffic slow-downs all confirm a huge Korean lead over the U.S. in broadband Internet. Recent data from Italy indicate a similar ascendancy in that country, with fiber to the premises deployments in six cities, led by e.Biscom.

All things considered, we assert that current total Korean Internet traffic of around 34 petabytes per month at the very least matches that of the U.S., a country five times as large, on a per capita basis. And because it is in the midst of a pronounced non-linearity, per capita Korean traffic could soon dwarf U.S. traffic by a factor of two or three. For all the useful cautions from Odlyzko, my view from the Telecosm summit is that the Korean story holds up. Thus the Corvis opportunity—up walls of worry and risk and against Pentagon rebuffs and analysts' gloom—still is the most exciting in world communications.

CDMA disrupts Wi-Fi

Meanwhile our CDMA (code division multiple access) wireless paradigm faced a challenge from Wi-Fi. Sky Dayton, of Boingo Wireless, the leading evangel of the Wi-Fi faith, converged with Paul Otellini of Intel (INTC), to imply that CDMA 3G is dead. They deny it, but that was the obvious conclusion of Otellini's detailed and confident observations. Despite a professed enthusiasm for it, Otellini confirmed that

Intel is not pursuing Qualcomm's CDMA in any of its wireless projects. In any case, Intel's advanced microprocessors—Pentium successors running at four gigahertz clock rates—would soon be able to execute all the wireless protocols at once in multiple threads (and perhaps cook a steak on the package.)

After the conference, Intel announced their EDGE (enhanced data GSM environment) chip for GSM (global system for mobile) data, blithely ignoring Qualcomm's more than tenfold better performance in CDMA 2000 EV-DO. As Andy Seybold, the sage and salty guru of *Forbes/Andrew Seybold Wireless Outlook* pointed out at Telecosm, EDGE promises to run at about 50 kilobits per second, compared to the demonstrated (and aforementioned) average rate of 650 kilobits for EV-DO's peak 2.4 megabit per second service being deployed massively in Korea.

Otellini also said Intel communications processors could run all the world's routers. Cisco (CSCO) will presumably have to plaster its chassis with *Intel Inside*. One regime soon to be needed, according to John Csapo of Samsung, is orthogonal frequency division multiplexing (OFDM), which is being tested in Korea in Flarion's FLASH (fast low-latency access with seamless handoff) version, targeted to usurp Qualcomm in next generation mobile wireless. In the U.S., as Otellini noted, OFDM is also moving ahead as part of a new all purpose standard of wish-list wireless functions, called WiMax. Meanwhile, also at Telecosm, Texas Instruments (TXN) promised to exploit its digital signal processing (DSP) and single-chip system prowess to take over whatever remains of the CDMA business in the wake of Wi-Fi and WiMax.

Without the data market perhaps Qualcomm will be gasping as well. As the Tahoe sun set on the first day it was looking bad for the paradigm.

The implication of the Wi-Fi forces is that Wi-Fi is a disrupter on the Clayton Christensen model (his state-of-the-art new book, *The Innovator's Solution*, is out this month). Wi-Fi is supposed to be good enough and cheap enough to disrupt the telco 3G establishment supported by the global telecommunications carriers. At Telecosm though, I concluded that Wi-Fi, WiMax, OFDM and all the rest are sustaining technologies contrived by the personal computer establishment to hold onto their dominance in data networking. As Qualcomm's Paul Jacobs put it, "Wi-Fi is the new cordless phone," competing in data networks with ascendant cell technology. The disrupter is Qualcomm and its unending stream of CDMA data innovations. Qualcomm is providing good enough data services on CDMA handsets and is embarked on a learning curve that will always yield more ubiquity and functionality than the Wi-Fi establishment does. Now widely available in Korea and Japan and soon to be launched in D.C. and San Diego, Qualcomm's EV-DO will offer bandwidth comparable to Wi-Fi at cheaper prices. As a wireless local area network, Wi-Fi will be used in every home and office. But it is not a wide area network (WAN) and never will be.

Dissenting was Ethernet inventor and rabble rouser Bob Metcalfe, who gave an incandescent luncheon speech the next day that declared the death of cellphones at the hand of Ethernet. He pointed out that Wi-Fi is the name for wireless Ethernet. But as he wryly admitted, Metcalfe is now part of the established forces in networking. Qualcomm founder Klein Gilhousen rose in the audience and suggested that wireless Ethernet would prevail in wireless devices when Qualcomm begins to use that name for CDMA 2000. Since the physical layer of Wi-Fi is already basic CDMA spread spectrum, convergence will not be difficult for Qualcomm.

Altera inside everything?

With all its prowess in innovation and portfolios of patents and other intellectual property, Qualcomm is chiefly a communications chip and systems design company. The chips it designs are application-specific integrated circuits (ASICs) and application-specific standard products (ASSPs). The ultimate threat to the company's current mode of operations may come from the microchip industry. In authoritative data-rich offerings, two speakers from Altera (ALTR), Robert Blake and Jordan Plofsky, offered a detailed case for the eventual death of ASICs and ASSPs.

Central to the argument is the current $30 million upfront cost of developing a new logic chip. Assuming that these research and development costs run around 20 percent of revenues in a high end microchip company, this "non-recurring expense" prohibits profitable production of devices with an available market of less than between $500 million and $1.5 billion (depending on market share). The number of such markets is tiny—cellphones, PCs, TVs, games, network nodes. Moreover, Plofsky showed that for communications, consumer, and industrial products, these development costs were growing between two and four times as fast as revenues. Thus the logic is inexorable: every year more application specific designs will move onto the kind of programmable logic devices (PLDs) made by Altera.

Qualcomm continues to disrupt from below, supplying a stream of chips that offer ubiquitous broadband services

Following the inspiration of the software programmable microprocessor, still too slow for wirespeed applications, the goal is to rev up volumes by using the same device in many applications. This can be achieved by a general purpose device with *hardware* reprogrammability, such as a field programmable gate array (FPGA). Geoff Barrall of our ascendant Storewidth company BlueArc attested that Altera's hardware reprogrammability has made BlueArc the fastest growing storewidth player. Our Nick Tredennick pointed out that Xilinx's (XLNX) relentless pressure as an Altera competitor has pushed the industry into a spiral of PLD innovations even steeper than Intel's microprocessor ascent.

TELECOSM TECHNOLOGIES

Altera	(ALTR)
Analog Devices	(ADI)
ARM Limited	(ARMHY)
Avanex	(AVNX)
Broadcom	(BRCM)
Cepheid	(CPHD)
Chartered Semiconductor	(CHRT)
Ciena	(CIEN)
Corvis	(CORV)
Cypress	(CY)
Energy Conversion Devices	(ENER)
Equinix	(EQIX)
Essex	(EYW)
EZchip	(LNOP)
Flextronics	(FLEX)
Intel	(INTC)
JDS Uniphase	(JDSU)
Legend Group Limited	(LGHLY.PK)
Microvision	(MVIS)
National Semiconductor	(NSM)
Qualcomm	(QCOM)
Samsung	(05930.KS)
Sprint PCS	(PCS)
Synaptics	(SYNA)
Taiwan Semiconductor	(TSM)
Terayon	(TERN)
Transmeta	(TMTA)
United Microelectronics	(UMC)
VIA Technologies	(2388.TW)
Wind River Systems	(WIND)
Xilinx	(XLNX)

Note: The Telecosm Technologies list featured in the *Gilder Technology Report* is not a model portfolio. It is a list of technologies that lead in their respective application. Companies appear on this list based on technical leadership, without consideration of current share price or investment timing. The presence of a company on the list is not a recommendation to buy shares at the current price. George Gilder and *Gilder Technology Report* staff may hold positions in some or all of the stocks listed.

Altera (ALTR)

PROGRAMMABLE LOGIC DEVICES

SEPTEMBER 17: 21.73,52-WEEK RANGE: 8.32 – 23.36,MARKET CAP: 8.31B

The company announced it has over 1,400 customers for its new Cyclone family of field programmable gate arrays (FPGAs). Since its introduction nine months ago, it is Altera's fastest selling product ever. Cyclone represents Altera's first significant move into low-cost consumer, communications, and industrial applications. Where FPGAs used to cost many hundreds or even more than a thousand dollars a piece, Cyclone family devices range from $5 to $25 and are thus suited to markets previously untouched by FPGAs.

Altera delivered a comprehensive case for the coming dominance of programmable logic over ASICs (application-specific integrated circuits) and ASSPs (application-specific standard products) at Telecosm 2003, in late August.

Analog Devices (ADI)

RF ANALOG DEVICES, MEMS, DSPS

SEPTEMBER 17: 40.67,52-WEEK RANGE: 17.88 – 43.00,MARKET CAP: 14.94B

Revenue for the second calendar quarter was $520.4 million, and net income was $79 million. Gross margins increased sequentially from 54.5% to 55.1% of sales. The company also announced the industry's fastest 16-bit digital-to-analog converter (DAC) with a conversion rate exceeding 600 MSPS.

Avanex (AVNX)

ADAPTIVE PHOTONIC PROCESSORS

SEPTEMBER 17: 6.39,52-WEEK RANGE: 0.63 – 7.00,MARKET CAP: 442.22M

Avanex purchased the Optical Systems Division of communications chip maker Vitesse for $6 million.

Broadcom (BRCM)

BROADBAND INTEGRATED CIRCUITS

SEPTEMBER 17: 26.32,52-WEEK RANGE: 9.52 – 29.96,MARKET CAP: 7.81B

Broadcom introduced the world's first single-chip Wi-Fi solution, placing a 2.4 GHz radio, power amplifier, IEEE 802.11b baseband processor, media access controller (MAC), Tx/Rx and diversity switches and all other radio components onto a single silicon die. The all-CMOS (complementary metal oxide semiconductor) integration eliminates more than 100 discrete components and means a chip some 87% smaller than current solutions, consuming up to 97% less power. The small, low-power "Air Force" chip makes practical for the first time the insertion of Wi-Fi into small portable devices like PDAs and mobile phones.

Ciena (CIEN)

METRO WDM PLATFORMS

SEPTEMBER 17: 7.08,52-WEEK RANGE: 2.41 – 7.74,MARKET CAP: 3.32B

Second calendar quarter revenues were $68.5 million, a 37% increase year-over-year. But the net loss was still $88.9 million. The company added seven customers in the quarter, bringing the total to 72. It also announced the acquisition of Akara Networks, a provider of Sonet/SDH-based storage area networks (SANs).

In bigger news, Ciena won a large contract from the U.S. government. Ciena beat out rival Corvis for the optical transport portion of the Defense Information Systems Agency's (DISA) GIG-BE contract. The Global Information Grid Bandwidth Expansion, which will connect 90 strategic U.S. Defense nodes around the world, is said to be worth some $300 – 400 million to Ciena over several years.

Corvis (CORV)

WDM SYSTEMS,RAMAN AMPLIFICATION,EDGE SWITCHES

SEPTEMBER 17: 1.52,52-WEEK RANGE: 0.47 – 2.09,MARKET CAP: 616.42M

The company privately placed 67,278,280 shares of its common stock at a purchase price of $1.15 per share, for gross proceeds of $77.4 million. The stock initially dropped to $1.15 on the news but has since reversed course and achieved a 19-month high at $2.00. DISA's GIG-BE award to rival Ciena sent the stock back down 25% to $1.50. The failure to secure the contract could determine the fate of Corvis's equipment business for the next few years.

Equinix (EQIX)

SECURE INTERNET BUSINESS EXCHANGES

SEPTEMBER 17: 19.15,52-WEEK RANGE: 2.00 – 20.29,MARKET CAP: 174.0M

China Telecom established its U.S. hub at the Washington, D.C., Equinix data center.

EZchip (LNOP)

10 GIGABIT NETWORK PROCESSORS

SEPTEMBER 17: 9.36,52-WEEK RANGE: 3.79 – 9.49,MARKET CAP: 68.24M

EZchip now reports 25 design wins, up from 20, at least 10 from large customers.

Intel (INTC)

MICROPROCESSORS, SINGLE-CHIP SYSTEMS

SEPTEMBER 17: 28.88,52-WEEK RANGE: 12.95 – 29.20,MARKET CAP:188.01B

The company upped its financial guidance for the second time in the quarter, saying revenue will be in the $7.6 – 7.8 billion range.

Like Broadcom, Intel is making chips for the dead-end EDGE (enhanced data GSM environments) wireless standard, announcing on September 9 the "first single-chip processor for phones running advanced wireless data networks." But by ignoring CDMA even as CDMA2000 and WCDMA become increasingly dominant across the globe, Intel ensures its first EDGE chip will be awfully lonely.

National Semiconductor (NSM)

SINGLE-CHIP SYSTEMS, ANALOG EXPERTISE,FOVEON IMAGERS

SEPTEMBER 17: 35.12,52-WEEK RANGE: 9.95 – 34.85,MARKET CAP: 6.46B

Profits for the first fiscal quarter increased from $1 million to $30 million year-over-year. Margins were up from 44.6% to 47.2% sequentially. The order backlog is the highest in 10 quarters. And the company expects revenue growth of 4 – 7% this quarter. The stock is up 54% in the last month and 182% since March.

The key product driver is National's broad and growing portfolio of analog power-management chips, which grew 36% year-over-year and 13% sequentially. Within power-management, portable applications grew more than 70% year-over-year and 30% sequentially. National now has chips in one-quarter of all LCDs (liquid crystal displays) and has successfully broken into the LCD television market. Another power-management driver has been DDR (double data rate) DRAM. Wireless RF sales were up 40% both year-over-year and sequentially.

With the Geode (Information Appliance) division now in the hands of AMD and the GSM/GPRS mobile baseband business gone, too, expenses should drop markedly in coming quarters, adding to the profit outlook. Although total R&D spending is going down, analog R&D is going up. With most of the good news coming from National's high-end analog businesses, its early-stage imaging solutions, including Foveon, still point to a mostly unnoticed upside. Early Intel pioneer and Synaptics chairman Federico Faggin has taken the job of CEO at Carver Mead's single-chip imaging company.

On Monday, September 15, National was granted a license from Impinj to design and manufacture Impinj's AEON memory into embedded memory applications across all of its product lines. AEON memory will allow National to cost effectively integrate low density nonvolatile memory (NVM) into its CMOS chips, enhancing functionality and, without incurring the high cost of specialized mask or wafer manufacturing.

Qualcomm (QCOM)

CDMA INTEGRATED CIRCUITS, IP, SOFTWARE

SEPTEMBER 17: 44.24,52-WEEK RANGE: 25.10 – 44.98,MARKET CAP: 35.11B

The company announced successful field trials in Asia, Europe, and North America of its MSM (mobile station modem) 6200 chipset, handing off both voice and data calls between 3G WCDMA (UMTS) and 2G and 2.5G GSM/GPRS networks. This event is another milestone for CDMA because it provides current GSM carriers with a clear upgrade path to WCDMA. Korea's LG Electronics chose the similar 6250 chipset for a new generation of phones. Qualcomm and SanDisk, the leading maker of flash memory cards, also announced all Qualcomm chipsets starting with the 6100 will support SD and miniSD removable card storage for 3G mobile applications.

Sprint PCS (PCS)

NATIONWIDE CDMA WIRELESS NETWORK

SEPTEMBER 17: 6.24,52-WEEK RANGE: 1.75 – 6.79,MARKET CAP: 6.46B

Sprint gave an update on its network improvement plans. In 2003, the company will make $2.1 billion in capital expenditures, yielding some 1,700 new cell sites. Sprint claims its customers use more minutes each month—some 13.5 hours worth—than any other U.S. carrier. Although Sprint plans to start offering Wi-Fi data services in several thousand select locations, the value of its wide-area CDMA data network is more apparent than ever. For a comparative analysis of the capabilities of WWANs (wireless wide area networks) versus Wi-Fi LANs (local area networks), see the Telecosm presentation of Qualcomm's Jeff Belk, available at *http://www.gildertech.com/public/Tele2003speaker - presentations.htm*, and his original globe-trotting memo, at *http://www.gildertech.com/public/Belk_WiFi_memo.pdf*

Synaptics (SYNA)

TOUCH-SENSORS, FOVEON IMAGERS

SEPTEMBER 17: 12.00,52-WEEK RANGE: 3.13 – 14.90,MARKET CAP: 286.03M

Synaptics chairman Federico Faggin became full-time CEO of Foveon, the revolutionary single-chip imaging company 15% owned by Synaptics.

Terayon (TERN)

BROADBAND CABLE MODEMS, HEAD-ENDS

SEPTEMBER 17: 6.38,52-WEEK RANGE: 1.39 – 8.25,MARKET CAP: 475.02M

Terayon stock rocketed in late summer and until a few days ago was up 321% since we put it back on the list of Telecosm Technologies on June 18, 2002 at $1.90. The most recent move up was fueled by an announcement that the company shipped its 1 millionth DOCSIS 2.0 advanced broadband cable modem. DOCSIS 2.0 modems triple upstream bandwidth, enabling voice-over-IP and other interactive and peer-to-peer Internet applications. Analysts say by the end of the year 8 million DOCSIS 2.0 modems will be in the field, fueling new cable operator demand for DOCSIS 2.0 cable modem termination systems (CMTS), or "head-ends"—the central network nodes that communicate with modems. Terayon, now with a 50%-plus share in cable modems, also happens to be the leader in the much higher margin DOCSIS 2.0 head-end business. An analyst downgrade last week moved the stock down 20% from its highs.

Xilinx (XLNX)

PROGRAMMABLE LOGIC DEVICES

SEPTEMBER 17: 31.07,52-WEEK RANGE: 13.50 – 38.80,MARKET CAP: 10.59B

Xilinx announced its plans, this week, for its next-generation Vertex field programmable gate array product line and touted its standing as the first vendor to ship 90 nanometer FPGAs. The move down the technology curve to 90 nanometers with its high-end chips could yield significant first-to-market advantages for Xilinx in the programmable logic device (PLD) space. But the move into the 90-nm process has its challenges. With a roadmap running ahead of that of its foundry, United Microelectronics (UMC), Xilinx had to turn to IBM for the 90-nm semiconductor fabrication process, which raises some caution flags concerning cost and the foundry's ability to deliver high-volume production. In the 90-nm process Xilinx and its competitors will also soon face a problem new to all PLD vendors—the billion-transistor challenge. Big chips in the 90-nm process will contain one billion transistors, and as the transistors get smaller, leakage current rises. It remains to be seen whether these billion-transistor chips will be leaking so much that they'll be unsuitable for some applications.

What is certain however is that with over 11,000 Xilinx Spartan FPGA series customers and over 10,000 worldwide Vertex-II Pro (Xilinx's 430 million transistor, high-capacity FPGA used in storage, communications and consumer applications) customer engagements, Xilinx is a PLD powerhouse that's keeping the competition on its toes.

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None the less, for the next decade, Qualcomm seems safe from the PLD juggernaut. With its ever growing share of one of the few markets that is growing at a pace comparable to the rise in development costs—cellphone handsets—the San Diego colossus may well benefit from the Plofsky trends, which may drive its lower market share rivals out of the business. Plofsky showed that the semiconductor content of cellphones now stands at some $16 billion (about twenty times the digital cordless market), with the mobile infrastructure market comprising another $2.5 billion of semiconductor slots.

Nick Tredennick also again declared the "Death of the DSP"; I countered with a renewed prophecy of the coming death of television. We failed to bet on which funeral would come first. Perhaps it will be the router's. Paul Otellini of Intel predicted that its four gigahertz Pentium successors and derivatives could usurp all communications processor slots, wireline and wireless.

EZ's new abundance

Where does this leave our network processor pick, EZchip (LNOP)? Up Squaw Creek paddling with PowerPoints. But with planned dinner speaker Ivan Seidenberg of Verizon held hostage in his copper cage by his union, we asked Bob Metcalfe to run a panel on a development that gives the edge to EZchip in several of the markets listed by Plofsky. That development is a new Internet Protocol, IPv6, that opens up a vast new abundance of potential connectivity.

Technologies advance through an interplay of abundances and scarcities. Entrepreneurs exploit the abundant resources to relieve the scarcities. They use oil and gas to save human muscle; they tap the compacted fossil fuels and uranium of the earth's core to preserve the arable and aesthetic spaces on the surface from visual pollution and agricultural exhaustion. On this point, Howard Hayden of the *Energy Advocate* offered the best trope of the conference. Commending the increasing practice of putting unsightly power lines under ground, he proposed a similar solution for windmills.

Both entrepreneurs and economists live in a world of scarcity. Only the entrepreneurs see the abundance beyond.

At Telecosm, Bill Manning of Kent Displays reported adoption by Kodak and Panasonic of displays that use no on board power at all. Called cholesteric displays, they have been adopted first for electronic books. Manning calls them "Kosher displays"—sun readable, with the contrast of ink on paper—because they were bought first in bulk by orthodox Jews in Israel to avoid use of energy in Synagogue signs on the Sabbath. Manning is opening the world to a new abundance of cheap high resolution low power displays.

Opening the world to a new abundance of potential connectivity is IPv6. After surmounting the Y2K problem, the digital infrastructure once again faces a challenge of too few bits. A few years after the intrepid mainframe geeks inaugurated their famous two-digit shortcut for dates, they gave birth to ARPANET, the early Internet, using packets that were routed via the network control protocol (NCP). By 1981, the Vint Cerfs and Bob Kahns of the world had worked out the lower-layer protocols of what that came to be called TCP/IPv4 (transmission control protocol/Internet protocol version four). With each IP address 32 bits long, the total "address space" of the Internet totaled an apparently inexhaustible 4.3 billion potential nodes.

Every year more application specific designs will move onto the kind of programmable logic devices made by Altera

Within the next decade, however, an onrush of net-connected machines—including cars, phones, cameras, wireless mesh relay stations, and all manner of remote sensors—will bolt past the 4.3 billion IPv4 address limit (in reality, the effective limit is about 3.3 billion). The numbers point to an eventual address shortage as Asia comes online and more and more devices are digitized and connected to the net.

The successor to IPv4 is of course named IPv6. Version six is vastly larger than version four: the difference between 128-bit addresses and 32-bit addresses. This is the point in the speech where v6 futurists start babbling about IP addresses for all the leaves on the trees or the insulin molecules in your pancreas. Suffice it to say such talk distracts from the real and imminent importance of the expanded address space and functionality.

Although the American builders of the Internet have been slow to adopt IPv6, Japan, China, and India have moved to mandate its use. Then came a U.S. breakthrough when in August the U.S. Department of Defense announced that starting October 1 all equipment deployed into its Global Information Grid (GIG) must accommodate the 128-bit space. Because most companies want to bid for the government's vast GIG-BE (Bandwidth Expansion) projects, this announcement likely will push wide adoption among Western telecom equipment companies.

Unlike Y2K, however, this Internet transformation is not about a one-time labor-intensive patch for a problem but about real technological capability. It is the same challenge we have been writing about for at least seven years. Logic MIPS (million instructions per second) and storage bytes are abundant when it comes to *computation* but not necessarily when it comes to "wire speed" digital *communication* among billions of potential nodes at 10 gigabits per second.

When pushing packets across the network, digital telecom devices perform two key tasks. The first is a routing table look-up, which analyzes variable-length data known as longest prefix match (LPM) and then provides the destination address of the packet. The second is flow-classification, which governs the treatment the packet receives, be it type of service (ToS), time to live (TTL), or other provisioning instructions for special applications, users, security, and accounting.

Most current routing architectures from Cisco and its cohorts employ a central computer, usually a network processor or ASIC, and large numbers of content addressable memories (CAMs) and static random access memories (SRAMs). CAMs include comparison logic with each bit of storage and SRAMs provide more than ten times quicker access times than their cousin, dynamic random access memory (DRAM).

Although costing 35 times more per chip, CAMs and SRAM are just one-thirtieth as dense as DRAM and one-tenth as power-efficient. On a per-bit basis, power dissipation is 280 times lower for a cost 1,000 times lower. EZchip's fundamental insight was to shun high performance CAMs and SRAM in favor of slow, cheap DRAM. The new abundance was on-chip bandwidth, made possible by new semiconductor process techniques pioneered by IBM (IBM). Embedding very dense DRAM into a logic device, EZchip could eliminate most off-chip communications, using on-chip bus widths of 1,024 bits rather than off-chip busses of 64 bits, and drastically decreasing the round trip path-length between logic processors and memory cells.

EZchip's solution of one highly integrated network processor, the NP-1, plus four commodity DRAMs handles every proposed IPv6 implementation, from the low-end device with 125K look-up entries to the 2 million-entry core router. Where memory costs using CAMs and SRAM range from $1,500 to $23,000, memory costs for EZchip never exceed $28, the total of four DRAMs at $7 apiece. The four DRAMs, meanwhile, dissipate just 2 Watts versus a minimum of 23 Watts and a maximum of 532 Watts for conventional CAM and SRAM solutions.

> Brian Halla of National Semiconductor, heralded yet another electronic abundance: high resolution imager pixels enabled by the Foveon process

Where the CAM and SRAM-based solutions struggle to perform tasks, moreover, EZchip's NP-1-DRAM combination handles IPv6 with 88 percent of the DRAM memory to spare for future updates of software and look-up tables. Thus time *in* market is extended years beyond normal solutions.

EZchip's unique IPv6 capabilities have already been decisive in several of its 25 design wins, especially in Asia. In August, EZchip pushed its advantage further by providing IPv6 software for its chips.

Many vendors and service providers have gotten around IP address shortages by using network address translation (NAT) boxes that create artificial IP space behind and around the official realm. An IP-addressable NAT router might sit in front of an office LAN, for instance, eliminating the need for each Ethernet switch, PC, and server behind the NAT router to have its own IP address. But the NAT patch will only take us so far. Beyond a certain point, as Alex Lightman warned the conference, the Internet becomes an interNAT, with cascades of new complexity, rigidity, and cumbersome hierarchical structures. With whole nations and governments mandating the switch to IPv6, the new protocol is now on its way and so is EZchip.

A camera on a country

Meanwhile, Carver Mead and Dick Merrill at Telecosm, along with Brian Halla of National Semiconductor (NSM), heralded yet another electronic abundance: high resolution imager pixels enabled by the Foveon process.

Using this new resource, they now are attacking the market from above, using Foveon's high resolution and accuracy to invade the markets for professional single lens reflex (SLR) cameras, starting with the Sigma S-9 in Japan. Foveon is also attacking from below, using its one chip cheapness and dual function, still and full-motion versatility, to enter the mass markets for cellphone imagers, throw-away cameras, and camcorders. That is the target of the new Foveon F-19 chip oriented toward point-and-shoot cameras.

Ultimately, with the help of its 40 percent owners at National Semiconductor, Foveon must do for the camera what Intel did for the computer: reduce it to a chip and make it ubiquitous. Dismantle it and disperse it across the network. Render it wireless, wanton, and waste-able. Then, as Moore's law allows the imager to be combined with an ever more robust array of logic devices, the Foveon device will assume ever more functions. No longer merely a sensor, it will aim toward intelligence. It will evolve into a vision system. It will become something of an eye, something of a brain.

To save the databases of the world from diluvian exabytes of image data, pouring in everywhere from billions of high-resolution chips gushing pixels 24 hours a day, graphic intelligence must be distributed and localized just as computer intelligence was distributed and localized by the PC. Rather than remitting endless raw files, Foveon's chip will necessarily move toward recognition and pattern matching, selectivity and signaling.

Revived will be the challenges of intelligent imaging embodied in the neuromorphic devices and neural network recognizers that the company pursued under Federico Faggin in its original incarnation as Synaptics (SYNA). In one of his freshman physics lectures, Richard Feynman explains how the retina develops in the embryo as an extrusion of brain tissue. During gestation, long fibers later grow back to link the eyes to the visual cortex. Through the retina, as Feynman quotes an unknown observer, "the brain has found a way to look out into the world." Thus the retina is a window not only outward into the realms of light but also inward into the life of the brain and "the whole problem of physiology."

It is the prime example of the "transducer physiology" that Mead studied with Nobel laureate Max Delbruck. And it offers a new way to understand the analogies between retina and camera—the way that the computer can extrude photosensitive silicon and find a way to look out into the world.

Like the retina, the Foveon camera must also find "long fibers" to link it back to its users and give the optical network a way to look out onto the world. To be stored or transported, Foveon pictures must be converted to digital form. If Foveon imagers are to make their way into the hands of every hobbyist and onto every computer videoconferencing terminal and into every surveillance application, from convenience stores to airports, the pictures will require and endow an abundance of storewidth: voluminous storage linked to immense bandwidth.

The first great optical technology exploiting the parallel advantage of light and image is wavelength division multiplexing. Toward the end of the second day of Telecosm, David Huber of Corvis explained the logic of uniquely advanced use of WDM. It is a wave network rather than a bit network. Exploiting the natural parallelism of light, the wave network combines many different "colors" of infrared radiation, each bearing the equivalent of billions of bits per second, on a single fiber thread the width of human hair.

But why "billions of bits" if it is an analog system? The source of the superiority of the wave net is its indifference to content. An all optical network can transmit any kind of information without distortion; it does not have to convert its waves into any readable form until their destination. In all-optical wave networks, the different colored streams pass down passive analog optical paths that perform in parallel all the functions of active switching and multiplexing done in serial digital form in mixed optical and electronic networks. Bit networks have to read the digital addresses on every packet at every point where traffic must be added or dropped.

Wave networks are self-addressed in the very colors of the light, the frequencies of the waves. Each frequency designates a different path to a particular terminal. Like a Foveon camera, WDM is an inherently analog system optimized for the defining and transmission of colors. It is a camera on a country. The fiber optic wave network is not merely a communications medium. It is also an analog processing path at the heart of a still massively digital Internet.

Despite the optical depression of the early two thousands, the superiority of the wave network grows steadily. New systems in preparation bear as many as one thousand wavelengths. Current Corvis equipment represents an 11,000-fold advance in six years, a rate of well over four doublings every year. Parallelism pays. With more than 1,000 fibers now sheathed in a single cable and 1,000 wavelengths per fiber and 10 gigabits equivalent per wavelength, a single fiber installation will soon be able to carry over a petabit, more than a full day's worth of 2003 Internet traffic, in one second. Emerging will be a global foveal economy, engaged in dense image traffic, teleconferencing in high resolution, with full exploitation of the parallel advantage of light and image.

By the inexorable evolution of the industry, Foveon's color imaging will become the analog first step in a long process of cerebration that will end in simulating ever larger reaches of the human brain and extending back over fibers into a new global consciousness suffused with color and light.

That was the original dream, and it is the continuing quest of the Telecosm.

—George Gilder
September 17, 2003

Got Questions?

Visit our subscriber-only discussion forum,the Telecosm Lounge, with George Gilder and Nick Tredennick,on www.gildertech.com

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