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The State Of The Paradigm: 2004

In the next year, we will see a decisive move of the telecosm into the microcosm

Inside:

"Why is spectrum scarce?"
"Why is fiber glutted?"
"Why is optics dead?"

As an economic analyst of abundances and scarcities and as the voice of a cornucopian "spectronics," I frequently ponder these questions. Lending them an enigmatic cast is the reality of fiber optics as merely another waveguide for the electromagnetic radiance that we call "spectrum."

Beginning from the zero Hertz (cycles per second) and infinite wavelength of direct current (DC) used in your computers, the spectrum runs through the 60 Hertz alternating (AC) flows of commercial electricity in wires and lightbulbs, into the near one megahertz (AM) and near 100 megahertz (FM) "radio" waves (also used for broadcast TV), and through the spans around 900 megahertz used for cellular phones. It rises up into the 2 gigahertz, 2.4 GHz, and 5 GHz (billions of cycles per second) of Pentium clock rates and microwaves for personal communications services and WiFi. It then weaves through a withered wasteland of military and radar millimeter waves before bursting through into the 193 terahertz blaze (trillions of cycles per second) of infrared light in fiber optic lines or Terabeams in the air. It reaches a rainbow of colors in a band of frequencies (350 terahertz to 750 terahertz) emitted by the sun and a climax of intensity in the infinite frequencies and asymtotically zero wavelengths of cosmic rays and beyond.

Variously diffracted in terms of frequency and wavelength, wires and wireless, radio and radar, free space and fiber, all are beams in Maxwell's rainbow of radiance, all unified and routinized by the velocity of light, all converging in a bandwidth buzz that fills the bonnets and fitfully the bank accounts of investors in the Telecosm.

The Telecosm brings together this infinite radiance of the electromagnetic spectrum with the communications rules of information theory. Developed by Claude Shannon in the late 1940s at MIT and Bell Laboratories, information theory, in simplest terms, is the science of surprise. Measured as "entropy" or news-value, information is defined as unexpected data or news. A message with no surprises possesses no entropy. It does not increase the knowledge of the recipient.

A message that consists entirely of surprises, however, bars successful communication. To communicate a message requires a carrier, a grammar, a vocabulary that lends it structure and significance. In Aristotelian terms, it needs an "unmoved mover" or an unvarying vehicle. A message without structure is termed noise.

The central law of communication ordains that it takes *a low entropy carrier to bear a high entropy message.* Restated in the vernacular, to carry surprising content

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takes a surprise-free channel. Constant changes in the grammar, vocabulary or template carrying the message will render the message unintelligible. That principle of information theory is the foundation of the entire paradigm and the source of all art and science.

There was no real bubble. The Internet just moved to Asia.

Creativity depends on a stable structure of law and expectations. If the laws—or the value of the money, or the rate of taxation—are capriciously changing, the creator has no stable foundation on which to build. His message mixes into chaos.

It is the absence of surprise that makes the electromagnetic spectrum the supreme carrier of information. The spectrum offers the lowest possible entropy. As *"an infinite span of regular radiance free of mass,"* that can pervade time and space, the spectrum is a blank sheet in four-dimensional space/time. It is embodied in perfect orthogonal sine waves (undulating perpendicularly in the electrical and magnetic domains) which can be modulated (altered) with a message in the time, space, phase, polarity and power domains.

Infinite, the spectrum is not scarce or limited and can accommodate a global system of broadband for everyone. *Regular*, it is a carrier that inflicts no surprises of its own—no entropy, no noise—and thus can carry identifiably modulated information, bearing content that is instantly separable from carrier. *Radiant*, it consists of patterns of energy that can be enhanced and harbored, amplified and resonated through wires and air, walls and microchips, cavities and carriers. *Free of mass,* it can converge into a bright blur and diverge through a prism into its original colors or carriers. Because the radiance is massless, thousands of carriers can join together for passage along a fiber thread or point-to-point through the atmosphere and then be divided back into their component frequencies at the other end like white sunlight into a rainbow.

Spectrum power

These characteristics of spectrum make it the canonical carrier. As a bearer of information it is so absolutely superior that any other communications system will inevitably succumb to it. With millions of carriers occupying a single point in time and space, spectrum is intrinsically abundant, not scarce. It is uniquely adapted not to exclusive frequency assignments but to sharing and mutuality. In several fascinating papers, Kevin Werbach, formerly counsel at the Federal Communications Commission (FCC), now of the Supernova [consulting] Group, has been exploring the technical and legal implications of the boundlessness and mutuality of spectrum, which have found reinforcement in new spectrum policies launched by Michael Powell. Werbach sums up "a new dynamic paradigm":

"More than one service can occupy the 'same' spectrum, in the same place, at the same time. The frequencies that now carry one signal could someday carry thousands…or billions. There could be as many video broadcasters as today there are mobile phone subscribers. Government could cease the frustrating and inefficient task of parceling out spectrum, and instead allow users to share the airwaves without licensing. Broadband Internet connections could be far more ubiquitous and affordable. Innovation could proceed by leaps and bounds rather than a hesitant, drawn out shuffle." (*Radio Revolution: The Coming Age of Unlicensed Wireless,* Washington, DC: New America Foundation, 2003, www.newamerica.net).

Nonetheless, from **Verizon** (VZ) and **AT&T Wireless** (AWE) to **Nextel** (NXTL) and **NextWave** (NXLCO.PK), from **General Electric**/NBC (GE) and **Disney**/ABC (DIS) to **Qualcomm** (QCOM) and **Endwave** (ENWV), from **Netflix** (NFLX) to **Viacom** (VIA), hundreds of companies currently command market caps totaling nearly a trillion dollars to some extent on the assumption of a scarcity of spectrum. Other companies, from **Corvis** (CORV) to **Level 3** (LVLT), from **Avanex** (AVNX) to **Corning** (GLW), from **JDS Uniphase** (JDSU) and **Ciena** (CIEN), to **Lucent** (LU) and **Nortel** (NT), once collectively valued in the hundreds of billions, now languish with market caps orders of magnitude lower because of an assumed glut of fiber bandwidth.

Endeavoring to fathom this enigma a decade ago—how can bandwidth be at once both infinite and scarce? —I envisaged a thought experiment, which remains highly relevant. Let me remind you with an updated version.

Imagine it is 1971 and you are chairman of the new Federal *Computer* Commission. This commission has been established to regulate the natural monopoly of computer technology as summed up in the famous Grosch's law of **IBM** (IBM) engineer and theorist Herbert Grosch. In 1956, Grosch had demonstrated that computer power rises by the square of its cost and thus necessarily gravitates to the most costly machines.

According to a famous IBM projection, the entire world could afford just 55 of these giant "mainframes," timeshared from dumb terminals and keypunch machines. The owners of this mainframe infrastructure would rule the world of information in an ascendant information age. By the Orwellian dawn of 1984, Big Brer' IBM would establish a new digital tyranny, with a new elite of the data-rich lording over the data poor.

As head of the new Federal Computer Commission, you launch a bold program to forestall this grim outcome. Under a congressional mandate to promote competition for IBM and ensure the principle of universal computer service, you ordain the creation of some 2,500 mainframe licenses to be auctioned to the highest bidders (with special licenses reserved for minorities, women, farmers, and incumbent computer companies). To ensure widespread competition across all of America, you establish seven licenses in each Metropolitan Major Trading Area and seven in every rural Basic Trading Area in a computer topology defined by Rand McNally. To guarantee universal service, you mandate the free distribution of keypunch machines to all businesses and households so that they can access the local computer centers.

In establishing this regime in 1971, you had no reason at all

to notice that a tiny company in Mountain View, California, called **Intel** (INTC) was about to announce three new technologies, together with some hype about "a new era of integrated electronics," that exchanged the topology of Rand McNally for the topology of the microcosm. After all, these technologies—the microprocessor, the erasable programmable read only memory (EPROM), and a one-kilobit dynamic random access memory (DRAM)—were far too primitive even to compare with IBM's massive machines.

The likely results of such a Federal Computer Commission policy are not merely matters for conjecture. France pretty much did it when it distributed free Minitel terminals to its citizens to provide them access to government mainframes. While the U.S. let Intel Corporation and its followers supply nearly ubiquitous personal computing, the French chatted through central databases and ended up making computer power scarce in France. France soon fell far behind the U.S., with one-quarter as many PCs per capita as this country, and one-tenth the number of computer networks. More than thirty years later, France still has no significant computer company.

We also know the results of such a policy in the United States. Instead of a Federal Computer Commission, the U.S. has a Federal Communications Commission. In an age of digital communications, where computers and telecom increasingly converge, a communications commission has now become virtually the same thing as a computer commission. Treating digital communications much the way the French treated digital computers, the FCC acted exactly the way my hypothetical Federal Computer Commission acted. Across the entire telecom industry, it imposed millions of words of rules in a geographic regulatory grid, full of price caps and competitive mandates, "level playing fields," Universal Service laws, and Rand McNally gerrymanders in fifty states.

As a result, U.S. spectrum power (broadly considered to embrace all electromagnetic communications, wired and wireless) became as scarce as computers did in France. When the Internet joined computers and communications in an inexorable mesh, the Fed mistake of choking off spectrum eventually choked off progress in the Internet as well. In the most vital measure of broadband connectivity, Asian countries boast scores of times the per-capita last mile bandwidth of the U.S. Korea has no less than 40 times more per-capita last mile bandwidth, wired and wireless, than the US does, and transacts a 30 times greater proportion of its GDP on the Internet. Even France, Italy, and other European countries are now excelling the US in providing broadband Internet connections. There was no real bubble. The Internet just moved to Asia.

Interference

In the early 1970s, though, the FCC did not seem irrational. Just as the French were responding to the presumed competitive dynamics of obsolescent mainframe computers, the FCC in the U.S. acted in recognition of the peculiar sensitivity of the signals used in obsolescent phone and television systems. These were *analog* transmissions that essentially simulate sounds or images rather than encode them in numbers. Analog carriers use every point in an electromagnetic wave to convey information. Thus every point on the wave must be preserved immaculately for delivery from transmitter to receiver.

Examples are voice signals that reproduce in exact electrical form the very vibrations of human speech, or video signals that transmit a precise map of a scene's colors and intensities. An analog transmission is hypersensitive. It is susceptible to any influences that impinge on it. There is no digital rubber between it and the electrode, no shock absorbers, no insulators, digital buffers or error correctors. Such a bare signal will merge with any intrusion into its frequency space. Any distortion of the wave will be manifest at the receiver as "static" or "snow." An analog television signal, for example, requires a signal-to-noise ratio of 50 decibels. That's 100,000-to-one. An analog cellular signal needs 30 decibels (1,000-to-one signal-to-noise).

This property of analog is often described in terms of "interference." In the same frequencies, an undesired signal adds seamlessly to the desired signal and will be seen as "noise" at what is termed the "physical layer" of the "communications stack."

Such systems, however, are obsolescent. What seems a seamless and homogeneous mix of noise—a blur of undifferentiated color of the same frequency—can be separated into individual messages by polarization, by phase, by directionality, by time slot, and most ingeniously by digital codes at higher layers in the communications stack. Between one thousand and 200 thousand times more resistant to noise, CDMA (code division multiple access) spread spectrum systems can use their code convolutions and adaptive power controls amazingly to exhume the signal even from a point far below the noise floor. Such CDMA receivers from Qualcomm require merely zero (one) or even sub-zero decibels to distinguish between the presence and absence of an energy bit. Thus the development of spread spectrum low power transmissions completely transforms the nature and impact of "interference" and makes Qualcomm the crucial wireless company of the epoch.

At the time when the FCC developed its policies, however, communications were dominantly analog. Thus the FCC determined that electromagnetic communications require exclusive command of particular bands of spectrum—the frequency *carriers* used to transmit the information *modulated* onto them. In an entirely negative focus, Federal policy sought not to promote sharing but to prevent what it called "interference." Defined as interference was any wisp of electromagnetic power that might wander into the path of a tower or antenna of broadcast television or government radio that together commanded most of the then usable spectrum below the domain of microwaves. Stopping all interference thus required the FCC to become the great interferer, intervening massively in the telecommunications industry. It established the detailed mazes of exclusive licenses, empty channels and protective spectrum moats called *guardbands*—and the specifications for

TELECOSM TECHNOLOGIES

Agilent	(A)
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)
McDATA	(MCDTA)
Microvision	(MVIS)
National Semiconductor	(NSM)
Proxim	(PROX)
Qualcomm	(QCOM)
Samsung	(05930.KS)
Sonic Innovations	(SNCI)
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.

Agilent (A)

CDMA DUPLEXERS AND AMPLIFIERS, FIBER OPTIC TRANSCEIVERS

DECEMBER 16: 27.46, 52-WEEK RANGE: 11.33 – 29.30, MARKET CAP: 13.07B

Returning to our list this month, Agilent has returned to profitability after losing money during the tech downturn. Fiscal fourth quarter revenue was $1.68 billion, with earnings of $.03 a share. Analysts expect the company to achieve non-GAAP earnings of about $.70 a share in fiscal 2004. The company's sales in the most recent quarter broke down like this: test and measurement, $631 million (38%); automated test, $260 million (15%); semiconductor products, $463 (28%); life sciences and chemical analysis, $321 (19%). Life sciences and automated test are the most profitable, while test and measurement loses money.

Analog Devices (ADI)

RF ANALOG DEVICES, MEMS, DSPs

DECEMBER 16: 43.99, 52-WEEK RANGE: 22.58 – 50.35, MARKET CAP: 16.16B

September quarter revenues increased 7% sequentially to $558 million. Earnings were $.23 a share, and the company ended the fiscal year with $2.1 billion in cash and short-term investments. Gross margins increased from 55.1% to 55.8%. The board also declared a new dividend of $.04 a share. Analog remains a key telecosmic innovator in 3G basestations, modems, transceivers, and all manor of industrial and automotive applications. But its smaller rival National Semiconductor still offers investors a price-to-sales ratio just half that of Analog, along with rapidly increasing earnings.

Broadcom (BRCM)

BROADBAND INTEGRATED CIRCUITS

DECEMBER 16: 32.52, 52-WEEK RANGE: 11.86 – 37.65, MARKET CAP: 9.85B

In the news:

-DISH Network operator EchoStar selected Broadcom's new single-chip satellite receiver, the first to enable a single set-top box to support multiple televisions within a home.

- Sony-Ericsson selected Broadcom to power its EDGE wireless laptop cards, now operational in the AT&T Wireless data network.

-Broadcom announced it is tripling the size of its Taiwan system-on-a-chip design center to 125 engineers.

Corvis (CORV)

WDM SYSTEMS, RAMAN AMPLIFICATION, EDGE SWITCHES

DECEMBER 16: 1.57, 52-WEEK RANGE: 0.47 – 2.09, MARKET CAP: 745.59M

With the Broadwing network now fully incorporated and the equipment division going into temporary hibernation, September quarter revenues were $143.2 million. Adjusted EBITDA loss was $34.2 million, but profitability is coming soon. When it does, we expect Corvis's dramatic competitive advantages to translate to the stock price. Investment house Needham last week recognized this, making the obvious but oft ignored comparison between Corvis and competitor Level 3. Needham noted that although the companies' assets are similar, Level 3 trades for 4x communications revenues and commands an $8-billion enterprise value, while Corvis trades at just 1x revenues with a $500-million enterprise value. Corvis's undervaluation is greatly reinforced by its low-cost position going forward. It expects to end the year with $275-300 million in cash.

EZchip (LNOP)

10 GIGABIT NETWORK PROCESSORS

DECEMBER 16: 9.48, 52-WEEK RANGE: 3.88 – 11.20, MARKET CAP: 69.11M

EZchip now claims 30 customers, 15 of which are "tier one" companies. Most recently, ECI Telecom announced it was using EZchips in its new metro Ethernet switches. The company also announced its second-generation network processor, NP-1c, is now in volume production.

CEO Eli Fruchter reports that when customers base their decisions on technology, EZchip almost always wins. When companies are reluctant to deal with a start-up, EZchip loses. But as he says, with IBM, Vitesse, and

PMC Sierra out of the business, it no longer makes sense to go with established net processor vendors for its own sake. Top competitor Intel, meanwhile, has yet to deliver a 10-gigabit product.

In financial news, the company completed a $6-million private placement from an institutional investor at $8.00 a share. EZchip parent LanOptics plans to use the money to increase its 51% ownership of the EZchip subsidiary, and for other corporate purposes.

Intel (INTC)

MICROPROCESSORS, SINGLE-CHIP SYSTEMS

DECEMBER 16: 30.26, 52-WEEK RANGE: 14.88 – 34.51, MARKET CAP: 197.66B

The company raised its December quarter revenue estimate from a range of $8.1-8.7 billion to $8.5-8.7 billion and said gross margins could reach 62%, compared to a previous estimate of 60%. Wall Street was surprised, however, by a $600 million goodwill impairment charge for poor performance at Intel's Wireless and Communications divisions. The company has lost cellphone flash memory share to AMD, and several communications acquisitions have not panned out. The consequence is early retirement for Wireless chief Ron Smith and the combination of Wireless and Communications under Sean Maloney.

The company also announced that it has produced fully functional SRAM chips using the next-generation 65-nanometer geometry/300 millimeter wafer technologies, including the use of strained silicon, copper interconnects, and low-k dielectrics, all going into production in 2005.

National Semiconductor (NSM)

SINGLE-CHIP SYSTEMS, ANALOG EXPERTISE,FOVEON IMAGERS

DECEMBER 16: 37.73, 52-WEEK RANGE: 12.54 - 45.25, MARKET CAP: 7.0B

Fiscal second quarter sales were $473.5 million, an 11% sequential increase. Earnings jumped more than 100% sequentially to $65.8 million, or $.34 a share. With fab utilization at more than 90%, gross margins topped 50%. The company also completed a $400 million stock repurchase program and ended the quarter with $698.3 million in cash and short-term investments. Normally, National's third fiscal quarter sales are seasonally flat, but the company sees sequential revenue gains of 3-5% and a slight uptick in margins. "Buy the rumor, sell the news," was the order of the day, however, as all this good news was greeted with a 15% drop in the share price. More "good news" for those waiting for an attractive buying opportunity. Not surprisingly, on December 15, SG Cowen upped National from "outperform" to "strong buy."

Proxim (PROX)

BROADBAND WIRELESS NETWORKS, WIFI

DECEMBER 16: 1.71, 52-WEEK RANGE: 0.45 - 2.49 , MARKET CAP: 209.8M

Added to the list this month.

Qualcomm (QCOM)

CDMA INTEGRATED CIRCUITS, IP, SOFTWARE

DECEMBER 16: 49.79, 52-WEEK RANGE: 28.58 – 52.00, MARKET CAP: 39.84B

The company issued an unexpected mid-quarter update, boosting its mobile chipset sales estimate by some 5 million units. The surprise volumes should turn a 1-6% expected decline in year-over-year revenues into a 10-12% increase. Pro forma earnings, previously expected in the $.37-.40 range, are now anticipated to be $.47-.48. Unit sales in 2003 are now expected to reach 110-112 million.

-AOL announced it is partnering with Qualcomm to deliver its premium content and applications, such as AOL Instant Messenger and AOL Mail, over the BREW mobile platform.

-Kyocera announced it would build new phones incorporating Qualcomm's BREWchat "push-to-chat" technology.

-PT Mobile-8 Telecom (Mobile-8) launched its CDMA2000 1X network in Indonesia and announced it would begin offering high-speed 1x EV-DO services in Jakarta in early 2004.

Synaptics (SYNA)

TOUCH-SENSORS, FOVEON IMAGERS

DECEMBER 16: 15.42, 52-WEEK RANGE: 5.75 – 15.00, MARKET CAP: 371.08M

Synaptics introduced a new "SpeakerPad," a combination laptop touchpad/audio speaker system that eliminates the need for separate speaker modules and saves space crucial in shrinking notebook computers. The company also announced a new capacitive "LightTouch" interface for MP3 players, which made its debut in the Samsung yepp YP-780 device.

Xilinx (XLNX)

PROGRAMMABLE LOGIC DEVICES

DECEMBER 16: 35.42, 52-WEEK RANGE: 18.50 – 38.00, MARKET CAP: 12.13B

The company announced a "revolutionary" new FPGA (field programmable gate array) architecture, based on "more than 100" technical advances. The application specific modular block (ASMBL) chips, set for a first-half 2004 launch, will contain more than 1 billion transistors and will aim for the heart of the "$33 billion" ASIC, standard logic, and microcontroller markets.

The company announced it shipped more than 6 million of its low-cost, high-volume Spartan FPGAs in the September quarter. Spartan was the first FPGA to be produced using 300 mm wafers and 90 nm process technology, which yields more than 5 times the number of chips per wafer as the 200 mm wafer/130 nm process combination. The resulting lower costs allow FPGAs to move into markets previously served by application specific integrated circuits (ASICs). More than 70 million Spartan chips have been sold since their introduction in 1998.

Like Altera, Xilinx is pushing its serial connectivity solutions. The company shipped more than 200,000 RocketIO multi-gigabit transceivers in the September quarter, more than 10 times that of its "nearest competitor." With Xilinx marketing its own lightweight, link-layer serial protocol named Aurora, and Altera announcing SerialLite, the two companies are engaged in an intense competition for high-speed serial applications.

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public use and universal service—that to this day dominate most policy and analysis.

Open air

On an early December trip to Washington, I discovered that this entire regime is now of the verge of being overthrown. As the result of a quiet campaign by Michael Powell at the FCC, a vast reform in that policy of geographic spectrum licenses is now underway. Barely noticed by the press, this change is likely to end by eroding irretrievably the very idea of spectrum scarcity and exclusivity that has long been the foundation of American communications policy.

Today the FCC is expanding and deregulating licensed bands such as MMDS (multichannel multipoint distribution service) which commands some 130 megahertz above the 2.5 gigahertz band. It is launching a 500 MHz span for transmission of something called multichannel video distribution and data service (more TV) at the "Ku" band (12.2 to 12.7 GHz). It is extending the bandwidth of satellite at the Ka Band between 17.5 and 20 gigahertz and awarding 40 megahertz in the 2-gigahertz band for mobile satellite. It is laboriously prying loose some 108 megahertz of the relatively low frequency television band above 700 MHz, anachronistically still known as UHF (Ultra-High Frequency). It is enlarging the unlicensed bands and creating new ones. It is exploring the sensible concept of "interference temperature" standards, opening television spectrum below 900 MHz to new "underlay" networks which function at such low power that they do not conflict with TV signals. If set in accord with the needs of digital rather than analog TV, this measure would allow extensive low power transmissions to "underlay" even licensed bands. Beyond the new allocations and prospective auctions, Powell is promoting a major increase in the freedom of spectrum holders to lease, resell, trade or traffic their frequencies in secondary markets.

Buying cheap Special Mobile Radio licenses for police and ambulance services and then converting them into full cellular capabilities, the Nextel example suggests that the FCC's long effort to specify the uses of particular spectrum will collapse under any concerted political pressure. At the same time, the most concerted political pressure comes from the TV broadcasters who hold and wantonly waste the most valuable spectrum of all-the long reach waves at the lower range of microwaves.

Already manifesting Powell's emancipation is the rise from a total of 195 MHz allocated for all mobile uses before 2000 to a total of 300 MHz allocated in the three years of the new millennium. Balked by the Federal paralysis on last mile policy—apparently designed to perpetuate the old regulatory regime until most of the U.S. economy is switched and transacted through Tokyo, Seoul, Shanghai, and Singapore—Powell has turned on to wireless. Breaking through massively already, he plans to release 1.5 gigahertz more spectrum for video and data services by 2006.

Powell's demarche has important implications for investors. It is safe to say that spectrum is no longer scarce. In the Ku band (12.2 to 12.7 GHZ), where direct broadcast satellite now sprays 500 channels, there is another 500 MHz available for terrestrial complements or competitors (that's another 250 digital channels). But investors in this realm will have to fear the swath of long reach TV UHF scheduled to become available in 2006 and perfect for rural Internet. This 500 MHz terrestrial Ku provision thus may remain mostly fallow for decades.

More useful is the 190 MHz of MMDS in the 2.5 to 2.7 GHz bands, which yields reach and span reasonably close to that achieved in the 2 gigahertz realms of PCS cellular from **SprintPCS** (PCS) and Verizon et al. Although this spectrum is partly owned by Sprint and MCI, the leading technical player in this area is still **SOMA Networks**, which can bring a point-multipoint panoply of IP telephony and Internet access without calibrated line of sight. Also active in this space and joining our Telecosm Technologies list this month, is **Proxim** (PROX), which offers an array of point multi-point radio technologies in these spectrum bands. With Guangdong Unicom's purchase of 180 Proxim network nodes and the recent announcement of the build-out of China's largest point-to-multipoint 5.8GHz wireless network, Proxim is a small tech company moving in the right direction.

In the costly and treacherous realms above 60 GHz, Powell has opened vast spans of spectrum for point-to-point backhaul operations. Here Endwave is the key player, and the most inviting possibility is a collaboration with Terabeam to provide a microwave default link to back up the multi gigabits-per-second of airborne infrared to urban offices through the fog.

Broadband bait-and-switch

In the face of this bold and ambitious agenda of liberation in the air, it would seem ungracious to quibble or demur. I support nearly all these moves. Yet the overall pattern of policy is less benign. The Fed is promulgating an entirely desirable "anything goes" regime for all new entrants. But it continues to saddle the incumbents with ever more Draconian regulations and restrictions. It is blasting open the air, while binding in ever more pervasive constraints the wire and fiber backhaul infrastructure on which wireless access ultimately depends.

In other words, the FCC is blundering toward a new policy skew as seriously off-kilter as its previous policy skew in broadband. Its previous bait-and-switch lured scores of companies, from Worldcom and **Qwest** (Q) to Global Crossing and Level 3, to bet a total of close to a trillion dollars building optical backbones, while bureaucrats in 50 states and the Fed embroiled access networks of the local loop in Laocoon

coils of serpentine re-regulation. That policy skew ended with the bankruptcy of nearly one thousand telecom carriers and suppliers and shifted the promise and the commerce of the Internet rapidly to Asia.

Yet the U.S. was the source of nearly all the major network breakthroughs of recent decades, from **Cisco** (CSCO) routers to Qualcomm CDMA systems, from **Terayon** (TERN) advanced cable modems and **Narad Networks** overlays to Amati (now **Texas Instruments -TXN**) discrete multitone digital subscriber line and Bell Labs (now **Telcordia**) VDSL (very high speed) last furlong technologies, from Ciena and Corvis wavelength division multiplexing (WDM) of fiber to seven layers of elaborate Internet innovations, all of which are now chiefly thriving in Asia and even Europe. In the entire hundred years history of the electromagnetic communications and computing industries, this U.S. surrender of technological leadership in just three years is unprecedented.

Beginning with the Democrats under President Clinton, the catastrophe has now engulfed the Republicans and stultified them. They are crippling the existing American telecom companies with a deadly reregulation and balkanization, while struggling to deregulate exotic spectrum technologies that will not become important for half a decade or more.

Visiting the loyal opposition on my trip to Washington, I addressed a significant player in all these changes, the New America Foundation, a liberal think tank that is spearheading the new paradigm of unlicensed spectrum. Led by Werbach, who served as counsel for New Technology in Reed Hundt's FCC (after following me by a decade or so at Esther Dyson's *Release 1.0*), the New America folks are venting a stream of trenchant and compelling white papers, brochures and broadsides, mostly in line with Powell's demarche.

The most sophisticated Democrats thus are opening a bold new front against the domestic policies of the Bush Administration at their most vulnerable point—their paralysis on technology. In the lobbying grasp of AT&T, the Administration beyond Powell is as clueless on technology as the U.S. Senate. The GOP is allowing its policy to be shaped by a dying old guard "long distance" phone carrier with an obsolescent wireless arm. Abandoning its previous broadband cable commitment, AT&T has adopted a last-mile strategy of wheedling their way into the copper cages of the Regional Bell phone companies using the legal clout of the Federal government. This approach ensures that neither side will invest in broadband.

The reality: CDMA and MMDS

For all its innovative vigor and flair, Powell's demarche will not suffice. Nor will the ingenious maneuvers of the New America program. All these forces echo the same euphoria over sexy but safely confined innovations such as WiFi that camouflaged the re-regulatory itch of the FCC under Al Gore and Reed Hundt. Politicians of both parties exhibit an amazing credulity toward confectionery technologies that fit current fashions and political tactics but that are ultimately peripheral to the major challenges facing the nation. From quixotic projects that don't really matter, such as George Bush's hydrogen cars to feasible projects that only matter to special interests, such as polluting gasoline with ethanol, to fashionable renaming and re-hyping of ongoing projects such as "nanotech," the political class is endlessly gullible about technology.

In Washington, I heard a lot about WiFi and spectrum

Agilent is perhaps the prime mediator between telecosm and microcosm

sharing, with no notice that Qualcomm's CDMA systems already share spectrum more intensively than any other technology. I heard a lot of talk about "ubiquity" and incantation of mantric numbers such as 802.16 WiMax. But I sensed no grasp of the reality that the closest thing to ubiquitous data is Qualcomm's 114 Kbps CDMA 2000 1x, which has already been joined in Asia by the up to 2.4 Mbps of EV-DO (also being slowly eeked out in America). Noone seemed aware that this CDMA cellular network provides cells that are at least 17 thousand times larger than WiFi access points.

Don't get me wrong. WiFi is a splendid local area network that provides a useful sustaining technology for the personal computer industry as it faces disruption from all-purpose CDMA *teleputers*, as I have long called the new multipurpose cellphones. WiMax and other wireless technology will prove valuable as a backup or fill-in where fiber does not reach. When the mostly unused 700 MHz band assigned to UHF television (dubbed the "vast wasteland" of spectrum by New America's Jim Snider) is opened to the public, powerful two-way broadband services will come to rural America. Smart radios, increasingly programmable in software, will become frequency agile and power adaptive, like existing Qualcomm handsets that move seamlessly between GSM, CDMAXX, AMPS, and soon even WiFi, in an ever expanding free range of frequency bands.

With all due respect to Powell's untethered heroics and Werbach's ingenious advocacy, what will bring broadband to America over the next decade is investment in the local loop, bringing fiber optics ever nearer to the nation's homes. What will bring wireless ubiquity is not only more unlicensed spectrum but also less licentious regulation of wireless and wireline carriers in fifty states. The idea that every nook and niche in telecom needs six or more competitors as current policy upholds merely assures that the U.S. will fall ever farther behind, as regulators force a dynamically innovating technology in the world's most competitive industry into a barren commodity regime. Smart radios, unlicenced bands,

interference temperatures, mesh networks, WiFi and WiMax galore are all a sideshow compared to the vast optical potentialities of what was once celebrated as an information superhighway or simply the fibersphere.

Into the microcosm

The paramount reality of the debate over communications remains unchanged. Robust full screen video and robust interactive broadband from the Internet will simultaneously doom the current business models of broadcast TV, cable TV, and telephony. No distinction between local and long distance can survive. Yet the local TV broadcasters remain the most powerful single influence in most Congressional districts. And AT&T retains its grip on the Bush Administration and the Senate. It will be a long slog before the spectronic paradigm, fibersphere and atmosphere, burst forth in its full radiance of infinite bandwidth. Against the spectronic cornucopia of physics and technology, the politicians still stonewall.

The Telecosm, however, finally depends far less on politics than on physics. The physics of spectrum begins with the difference between spectronic bosons (chiefly photons but also mesons) and fermions (such as electrons, protons, and neutrons). Fermions (electrons and protons) have mass and charge, can move slowly through a medium, and deflect and displace one another when they collide. They can be stopped and stored, and cannot occupy the same energy state together (in accord with Wolfgang Pauli's "exclusion principle").

Bosons (photons), on the other hand, lack mass and charge, move only at the speed of light in the medium, and do not deflect or displace one another in collisions. They can occupy the same energy and space together. Photons do not durably interact, but merge, temporarily adding or subtracting their amplitudes according to the phase relationships between their crests and troughs.

This affectless merging is precisely the reason photons are optimal for communications and bad for computations (which require inputs to affect one another in an enduring way for mathematical logic or memory). Photons can be stored only as charges on electrons.

Recent events make the Telecosmic division of functions more sure to prevail than ever before. Rooted in the physics of the electromagnetic spectrum and the laws of information theory, the heart of the paradigm is the inexorable supremacy of photonics in communications and the inexorable superiority of electronics in computing and storage. Today antiparadigm forces are growing in confidence. On one side, the mazes of electronic communications ramify daily in new buses, I/O systems, switches, routers, and board architectures. On the other side, venture capitalists still support the creation of optical computing and storage systems. All this infrastructure, however, is otiose in the paradigmatic system of electronic computing and optical communications.

As a result, back on the list comes **Agilent** (A), the erstwhile test and measurement arm of **Hewlett-Packard** (HPQ). Perhaps the prime mediator between telecosm and microcosm, Agilent focuses on the fertile crescents of opportunity between the two domains. Not only is it the leading supplier of CDMA duplexers and amplifiers but it is also the leader in fiber optic test and measurement and in fiber optic transceivers which convert electronic signals to photonic inputs and outputs. Based on integrated arrays of vertical cavity surface emitting lasers (VCSELS), Agilent's transceivers and connectors can now bring hundreds of gigabits per second of optical communications power onto the backplanes and mother boards of computers. Agilent was recently awarded a DARPA contract with IBM to extend this technology to terabit speeds. When optics brings terabits to the backplanes of computers, optoelectronics become an alien obstruction on networks everywhere. The all-optical regime of Corvis and **Essex** (EYW) moves ever closer.

In the next year, the most important news will come from this fertile crescent where optics for communications increasingly penetrates to the boards and backplanes, connectors and metalization layers of computers and microchips. We will see a decisive move of the telecosm into the microcosm and the microcosm into the telecosm. Bringing terabits of communications power onto the fringes of the network, it will ultimately require the extension of all-optical networks from the microcosm to the planet. Forget the politicians. Stay tuned to the technology.

—George Gilder
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Got Questions?

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