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Out of the Copper Cage

Deftly evading copper and cable entanglements, Soma Networks transforms the economics of the last mile

As I sat down to write this report, I got a call from Andy Kessler, the former Bell Labs researcher and Morgan Stanley growth fund guru who not only manages the growth of my money through his Velocity Capital but also often renews my intellectual capital as well. I expressed anguish over the plight of subscribers lured into our companies at the top, who levered and levitated themselves on the hot air of a market spike and then tumbled down toward what seems to be an ever receding ground of hard value. I write about technology trends, which can actually be projected on the basis of current information, but all too many people want the impossible, which is to predict the timing of market shifts. As long as the Fed assumes that inflation is a threat while prices plummet everywhere, the economy will be in jeopardy and all asset values will have to adjust to real interest rates in the double digits. As long as Congress and the president think tax cuts cost money, there will be no significant tax cuts. The result is a slump and when it ends, no one really knows.

Some subscribers look to Warren Buffett for guidance. Buffett is giddy with vindication. Hey, if everyone spurned technology hype and bought **Coca-Cola** (KO) and **Gillette** (G) and the ***Washington Post*** (WPO), they would be as clean shaven, caffeinated, rich, and liberal as he is. A key to Warren Buffett's success, however, is insider trading, perfectly legal if like Warren you do your investing under a capacious corporate umbrella. **Berkshire Hathaway** (BRK), and **General Electric** (GE), for that matter, are essentially portfolios of unrelated investments without any real corporate identity or coherence. Their managers shift capital among their holdings and new acquisitions on the basis of intimate insider information. Most investors can't do that, and anyway if everyone did it, it wouldn't work. It takes technology and innovation to make an economy grow and to sustain the value of "value" investments.

Here is where Andy Kessler comes in. He believes, with me, that amid all the damage, the crash has served the interests of the Telecosm by shaking out flakier firms, technologies, and business models, leaving stronger survivors to lead a new phase of wealth creation that will leave the Buffetts in the dust. The collapse of 2000 and 2001 will seem a mere blip in a long run bonanza. But to grasp the opportunity, we need a lesson in history.

Both of us began our engagement in technology stocks during the mid-1980s. I had just given up my role writing the

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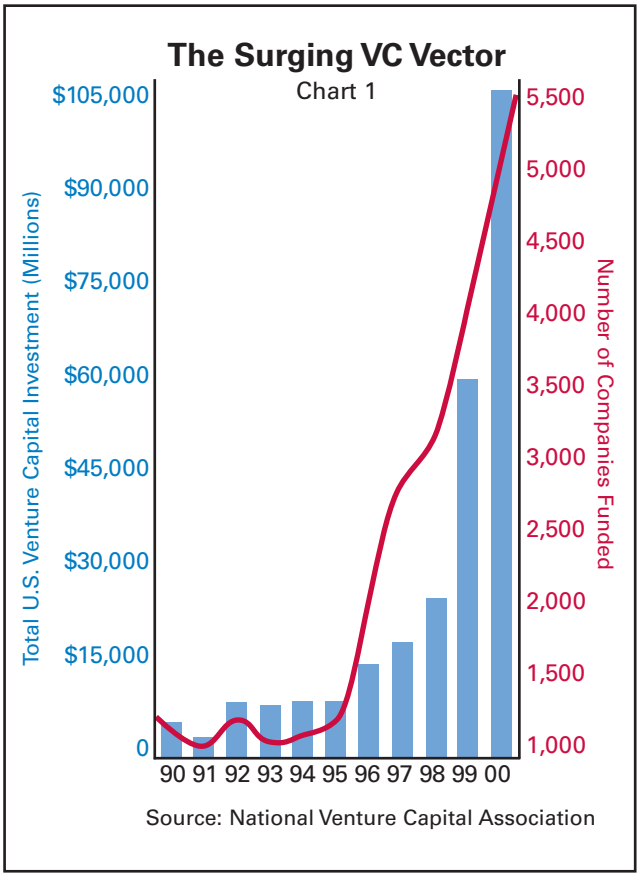
semiconductor sections of the *Rosen Electronics Letter* (formerly the *Morgan Stanley Electronics Letter*, later *Release 1.0* under Esther Dyson) and I was beginning my research for *Microcosm*. In 1985, Andy was starting a growth fund at Morgan Stanley. The mood of the time was grim. Industry keynoters bemoaned a glut of wafer fab capacity and memory chips and prophesied the end of the golden era of silicon, the move of the industry overseas, and its emergence as a mere cyclical part of the national economy. **Intel** (INTC) founder and Moore's law author Gordon Moore inquired morosely, "What could we ever do with millions of additional transistors on microchips?" Jerry Sanders of **Advanced Micro Devices** (AMD) reported a month of negative *sales* (more returns of chips than new billings). With a $100 million writeoff, Intel closed its Puerto Rican assembly plant, withdrew from the market for the dynamic random access memories (DRAM) on which the company was founded, and halted construction of its leading edge wafer fabrication plant in Corvallis, Oregon. **Motorola** (MOT) followed with writeoffs and cutbacks. **AT&T** (T) turned off its major DRAM facility in Kansas City and withdrew from the business. An innovative Silicon Valley pioneer of what Nick Tredennick terms "Dynamic Silicon," Monolithic Memories had invented programmable array logic (PAL) and key memory technology, but it teetered on the verge of bankruptcy. Semiconductor stock prices retreated below the levels last reached in the midst of the catastrophic recession year of 1982. Personal computer stars such as Osborne, Atari, Commodore, Coleco, Sinclair, and Fortune Systems were going broke. The U.S. storage industry was kaput, with "floppy" disk drives entirely dominated by Japan, and an obvious wretched excess of venture money pouring in multiple floppy hard disk companies, from **Seagate** (SGAT.SI) and Prairie to Conner Peripherals and **Quantum** (HDD). Spurred by somber complaints from Sanders and from Andrew Grove and Robert Noyce of Intel, the press sagged with articles predicting the death of the U.S. semiconductor industry at the hands of Japanese keiretsus. **Nikon**, **TEL**, **Canon** (CAJ), all of Japan, moved to the fore in semiconductor capital equipment.

Travelling back and forth across the country, I confronted such academic experts as Lester Thurow, Charles Ferguson, Kenneth Flamm, and Robert Reich who insisted that only socialism could save American high technology from the dominion of the awesome Japanese and dirigiste Europeans. The shares of U.S. microchip and computer companies went into free fall. Investment conferences thronged with grim reapers touting purchase of gold, coins, and canned goods, bomb shelters, and AK-47s to defend them from roving packs of vandals.



Collapsing prices fueled chip market

As Andy Kessler observed, it was these conditions that set the stage for his career. After initially succumbing to the gloom and urging the sale of microchip shares, he then in July 1986 began to accumulate them massively. The subsequent performance of his growth fund propelled him to the forefront of technology analysts and investors. Meanwhile in two books and many speeches and articles, I doggedly predicted the revival of the American semiconductor companies and their ultimate defeat of the Japanese and European models.

Believing that all real economic growth comes from the supply side and is animated by innovation, my confidence sprung from Moore's law and venture capital. By reducing component prices and enabling new goods and services, Moore's law constantly enriched the palettes of semiconductor designers. A resurgence of venture capital fueled hundreds of new companies and inventions. Although portents of excess afflicted DRAM markets, this commodity product seemed far less significant than the rapid advances in chip design tools from such companies as the then embryonic **Cadence** (CDN), application specific circuits from **LSI Logic** (LSI) and **VLSI Technology**, new memory architectures from **Xicor** (XICO), **Seeq**, and **Cypress** (CY), chipsets from Chips&Technologies, microprocessors from Intel and Motorola, **MIPS Technologies** (MIPS) and **Sun** (SUNW), programmable logic just initiated by **Altera** (ALTR) and **Xilinx** (XLNX), and computer software from **Microsoft** (MSFT) and **Oracle** (ORCL).

I saw the collapsing price of foreign produced DRAMs not as a dangerous dumping threat but as a huge opportunity for U.S. computer and software firms and thus ultimately for new U.S. chip designs. Cheaper memory chips meant cheaper computers and hence larger

markets for microprocessors and other profitable high-end devices in which the U.S. led the world.

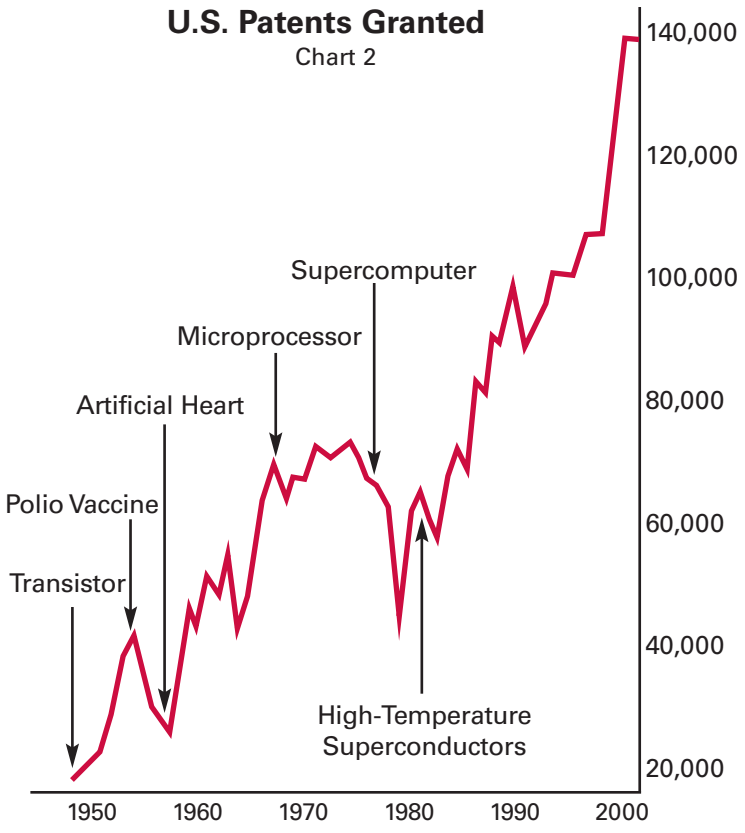
Fueling an inventive siege of U.S. startups was venture capital. During the first half of the decade of the 1980s, the number of venture capital firms rose from 25 to over 200 and venture money under management surged from $4.5 billion in 1981 to $19.6 billion in 1985. Money raised from limited partners rose from under a billion to $4.5 billion in 1986. Venture outlays and initial public offerings together rose tenfold or more since the late 1970s, and the number of new patents issued annually began to skyrocket after falling in the late 1970s. Meanwhile, the personal computer era had just begun. As the prime mover of the information infrastructure, it would ultimately prevail over the previous era's broadcast television. Together with supply side economic policy—tax cuts and deregulation—I believed that PCs would ignite a decade of economic boom.

Venture capital continues to surge

Less than a decade later, venture capitalist John Doerr of Kleiner Perkins vindicated our confidence of the mid-1980s. He observed that the PC industry had achieved "the largest legal creation of new wealth in the history of the world." Intel leapt dramatically ahead of all its Japanese competitors and U.S.-based companies dominated the lists of top microchip producers. **Applied Materials** (AMAT) became the world's leading semiconductor capital equipment firm, displacing Nikon. Microsoft, Oracle, **Peoplesoft** (PSFT), **Adobe** (ADBE), and **Computer Associates** (CA) pushed to the fore in software. Scores of new firms gave the U.S. the lead in services, design tools, and capital equipment, and even in high-end manufacturing. Experts pondered the emergence of a "new economy" and speculated on the possibility that stock prices had entered a plateau of higher valuations. Europe and Japan were studying American venture capital and stock markets closely for insights on how to prosper in the new age.

As Andy observed, history repeats itself today. Replacing the 1980's anguish over inventory excesses in memory chips as they moved from 16 kilobits through 64 kilobits toward 256 kilobits, today optical equipment stars bemoan inventory buildup as the industry moves from OC-48 through OC-192 toward OC-768, from 2.4 gigabits per second to 40 gigabits per second. Where Gordon Moore denied profitable uses for the millions of new transistors on microchips, Wall Street wiseguys now can see no markets for terabits per second of network capacity. Where *Barron's* previously deplored the fall of DRAM prices, today it laments a perpetual "bandwidth glut." The collapse of dot-coms repeats the earlier collapse of computer startups.

Venture capital is the catalytic force that drives U.S. economic growth and stock market value. According to in depth studies by Harvard Business School's Michael Jensen and his students, the return on venture capital outperforms internal Forbes 500 corporate investments



Source: *It's Getting Better All the Time,* Stephen Moore & Julian Simon

by a factor of 20 or more. *Forbes* publisher Rich Karlgaard, founder of the now solidly profitable net venture company Garage.com, estimates that as much as a hundred times more venture capital was raised in 2000 around the globe than in 1990 (chart 1). His partners at a *Forbes* roundtable in Burlingame, Tim Draper of Draper Fisher Jurvetson Gotham and Michael Moritz of Sequoia Capital projected that some $40 billion will be added in 2001.

Next decade more promising than last

Both in finance and technology, conditions today are incomparably more promising than in the mid-1980s. Then, I took confidence from a fourfold rise in venture funds to some $20 billion. Today, with over $100 billion raised from limited partners in 2000—and another $40 billion expected in 2001—venture funds under management exceed $200 billion. Then annual disbursements of 4 or 5 billion encouraged a belief in the viability and resilience of the innovative process. Today disbursements run at a level some twentyfold higher. Then investors concentrated on a few firms in computers, chips, and software. Today entire new industries are emerging in communications, storewidth, biotech, "digital power," and Internet devices. In the earlier period, I found encouragement in a fourfold rise in U.S. patents, from around 20 thousand in the late 1940s to 80 thousand in 1985. Since then, in an admittedly mixed blessing, patents have catapulted to nearly 150 thousand annually (chart 2). Then I was enthralled by the Moore's

law microchip learning curve, doubling cost-performance every 18 months. Today storewidth doubles every 12 months and the Metcalfe's law advances in Telecosmic technology double every 4 months or so. Then computers tended to be devices on local area networks with slow access to attached local storage of a few megabytes most of the time, a few gigabytes in big companies or campuses. Today all computers can roam the World Wide Web with access to storage facilities containing exabytes (10 to the 18th).

Combining all these indices of the vitality of the innovative process, a reasonable guess is that the opportunities of the next decade are roughly ten times more promising than the opportunities opening in the mid 1980s multi-trillion dollar wealth explosion. The challenge is to find the right companies. The *GTR* believes the right companies are concentrated in the Telecosm.

A glut of bandwidth means a dearth of connectivity and that's the focus of Avanex, Broadcom, Conexant, AMCC, Terayon, and Qualcomm

The key insight of the telecosmic paradigm is the recognition that the communications power of the electromagnetic spectrum is essentially infinite. A near infinite resource implies a near zero price. That means that communications power can undergo the kind of plummeting price and surging cost effectiveness that impelled microchips to the central role in the global economy during the last two decades of the twentieth century. *Barron's* is worried once again that communications prices are dropping too fast. The *GTR* says the faster the better. The price of a transistor and support circuitry collapsed from some seven dollars 30 years ago to perhaps seven millionths of a cent today—that's a *hundred millionfold* drop—without notable damage to the electronics industry. Although thousands of companies participated, the players who benefited most from this plunging price were Intel in microchips, Microsoft in personal computers and software, Applied Materials in microchip production gear, and **IBM** (IBM) in computer systems and services. Retailers such as **Wal-Mart** (WMT) and **Home Depot** (HD) took advantage of the technology to dominate their field.

Fiber and wireless coexist

Weaving the fabric of all economic and social activity, communications is a force more far reaching and catalytic than computing is. Today the price of a bit per second per mile of communications power is well into a plunge that will soon prove far steeper than the Moore law descent of microchip prices. Indeed, bandwidth prices have recently dropped more slowly than we expected. Bandwidth will be nearly free. But a glut of bandwidth means a dearth of connectivity, and the Telecosm companies, from **Avanex** (AVNX) and **Broadcom** (BRCM) and **Conexant** (CNXT), to **Applied Micro Circuits** (AMCC), **Terayon** (TERN), and **Qualcomm** (QCOM), are nearly all focused on connectivity. The *GTR* is devoted to the fascinating and sometimes treacherous challenge of identifying the companies that are best aligned with the new century's governing vector of growth. Historical evidence tells us that these companies will end up creating many trillions of dollars of new wealth.

The Telecosm asserts the essential unity and complementariety of fiber and wireless technology. Both use the electromagnetic spectrum, the span of frequencies running from the zero oscillation of direct current (DC) through the petahertz frequencies (10 to the 15th) of cosmic rays and beyond. Although radio waves the size of soccer fields and infrared waves the size of molecules might seem to have little in common, they both travel at lightspeed and follow the regime of Maxwell's famous wave equations. The wireless transmissions are merely insulated by air rather than by leaky plastics and other materials.

The frequencies of infrared light used in optics together comprise less than one hundredth of one percent of the total span. Fiber may never be displaced as the ideal fixed communications medium. Its bandwidth and error rates are both ten orders of magnitude better than those of their copper and wireless rivals. But for mobility and transportability, for quick deployment and tetherless access, wireless is indispensable. The fibersphere needs the atmosphere as our lungs need air.

"Equal access" a deterrent

Today the crucial bottleneck in the global network is last mile access, last mile connections to homes and offices. Six interest rate hikes in the face of falling prices and a super strong dollar were the proximate cause of the crash of technology stocks. With the dollar rising in price or purchasing power against every technology function, against gold, against commodities, and against other currencies, how could there have been too many dollars?

In the long run, however, as we wrote in the *Wall Street Journal*, a more crucial source of the trouble is the viscous mire of last mile Internet access caused by the effective socialization of the local loop. Where the government does not play—in business networks—bandwidth and connectivity are soaring. **Cisco** (CSCO) has been selling some 200 thousand Gigabit Ethernet ports a month, or two and a half million a year, and 10 Gigabit technology is moving toward an even faster ascent. Fiber is being rolled out at a pace of 10 thousand miles per day. But at the local loop, progress screeches to a halt. Mandating that the Bell Operating Companies (BOC) give "open access" to rival vendors under a regime of controlled prices—and threatening to extend similar constraints on the cable TV industry—the federal and state governments have cast the industry under a damoclean cloud of doubt. They uphold an ideal of "level playing fields" and "competition" in which no one can win or make any money.

Since local loop access poses difficult technical problems and financial risks, the result of this regulatory regime is painfully slow deployment of digital subscriber line (DSL) and other broadband access technologies. With business plans that depend on getting judges to command generally clueless Bell company bureaucrats to grant rivals access to local lines, the DSL companies such as **Covad** (COVD), **Northpoint** (NPNTQ), and **Rhythms** (RTHM) are all close to going broke. The Telecom law of 1996 essentially privatized the risks and socialized the profits of broadband. So just as we predicted at the time, no significant broadband happened. Meanwhile the cable companies are moving much faster, with some 4 million links deployed, but the continuing threat of expropriation and mandate for "equal access" deters investment.

With Michael Powell, son of the secretary of state, as the exemplary new head of the FCC, the new administration may break through this regulatory bottleneck. But it is not a sure thing, since Republican senators and congressmen have been little better than Democrats on this issue. Moreover, the politicians are only partly at fault, since Silicon Valley has offered brain dead leadership. Technologists in general love to bash the Bells and cable companies with "fairness," "open access," "level playing fields," contempt and other cudgels, and then wonder why broadband doesn't happen. Even Andy Kessler and Bob Metcalfe fantasize that this time the bureaucrats could get it right, if they just keep content and conduit apart, following some set of competitive principles that seem obvious and fair. But "fairness" is a snare and a delusion in life, and under pressure from politicians bureaucrats never get it right for long, and constant technological surprises assure that the right answer yesterday is wrong tomorrow. Deregulation of the last mile is the only solution that can work. Such listed companies as Broadcom, Conexant, Terayon, and even **Texas Instruments** (TXN) cannot prosper in the long run in a socialized local loop.

Terabeam transmitting

The prime bypass vessel is wireless. Our favorite wireless carrier is still Terabeam, the fiberless optics innovator (*GTR*, March 2000). Although half of its network was shaken loose during the recent Seattle quake, it offers an increasing array of broadband access options. Terabeam uses the same essential technologies that send infrared signals three thousand kilometers through fiber to send infrared signals one or two kilometers across a city. Launching in 3 cities this spring and 50 over the next year, Terabeam deploys holographic telescopes to capture light signals from base stations and 5 watt erbium-doped fiber amplifiers to transmit downstream. The links run at 1.25 gigabits per second.

But Terabeam remains an exotic technology now chiefly usable in urban commercial environments. To break open the local loop for most of the 750 thousand business buildings and 100 million homes will require another solution. We hope we have found it in a company named **Soma Networks**.

Plagued by unreliable service, line-of-sight limitations, expensive equipment, and dreaded truck rolls, wireless breakthroughs have been elusive. To date there are fewer than 450,000 Internet satellite subscribers and a few thousand LMDS (local multipoint distribution service) links at between 28 gigahertz and 38 gigahertz—microwave frequencies that behave enough like light to require tricky line of sight connections.

With provisioning, service creation, billing, signal processing, and a softswitch, Soma's NetOS is a Java central office on your desk

Undeterred, numerous companies comprising tens of thousands of RF engineers continue to pour energy and capital into the hunt for Shannon's limit and a better radio. Shannon's name for the information content of a message is entropy. Entropy is essentially news: unexpected information. A key rule is that to send a high entropy signal, you need a low entropy carrier. A blank piece of paper, a white board, or a perfect silicon crystal will work. The reason the electromagnetic spectrum is the prime vessel of information is that it is so totally regular and predictable that separating out the news and the noise is relatively easy. From the fibersphere of wavelength division multiplexing (WDM) to a variety of multi-carrier wireline and wireless technologies, the magic of spectronics endows complex waveforms with the ability to bear any arbitrary combination of regular frequency carriers, each "color" with its own "news."

Unlike the fibersphere, the airwaves are an arena of bandwidth scarcity. Residential wireless engineers work with bandwidths of 1 to 100 megahertz. Their lucky optical engineering counterparts have a potential 44 terahertz (44 million megahertz) to play with. They can, and should, waste bandwidth. Operating among the mazes of residential and small business America, fixed wireless developers must save bandwidth.

Soma's dual disruptions

The two prime requirements of copper-killing wireless are escape from the need for exacting line of sight calibrations and avoidance of the regulatory swamp of existing last mile links. The master of this dual escape route is Soma Networks. Secreted away in San Francisco and Toronto for the last three years, the Soma team of Yatish Pathak, Martin Snelgrove, and Michael Stumm has built a cellular multi-megabit wireless link with associated software that enables bypass of the briarpatch of Bell system local loops, lawyers, and lobbyists.

Unlike most vendors who use roof-mounted transceivers that must be pointed at the signal source, Soma has engineered a non-directional indoor antenna. Wrapped in a blue plastic shell, the NetPort is the size of a large book and contains a passively steered antenna, a

Capital Costs: Wireline DSL vs. Fixed Wireless				
	DSL	**Soma**	**DSL**	**Soma**
	per Subscriber	per Subscriber	Per 64-kbps*	per 64-kbps*
Local Loop/Network Interface Units	**$568**	**$382**	**$41**	**$27**
Cable & Wire	$318	–	$23	–
DSL Modem	$250	–	$18	–
RF Base Station	–	$183	–	$13
RF End Customer	–	$199	–	$14
Switching	**$557**	**$13**	**$40**	**$1**
Class 5 Switch	$144	–	$10	–
DSLAM/Co-Location	$400	–	$29	–
POP Router & Gateway	$13	$13	$1	$1
Total	**$1,125**	**$395**	**$81**	**$28**

* Per 64 kbps equivalent (assume configuration of 2 phone lines plus 768 kbps burst data)

Source: Bart Stuck & Michael Weingarten, Signal Lake Venture Fund

WCDMA modem, power amplifiers, a microprocessor, and an innovative operating system. It fits easily on your desktop, or under it. No technicians on ladders and no visit from the cable guy. A wall outlet and a PC will do. Plug the NetPort into each, and if you are within five miles of a Soma-equipped cell tower, the NetPort acquires the signal. You are now surfing the Web at up to 5 megabits per second. You are also enjoying up to 4 Internet protocol (IP) phone lines.

On a recent trip to Toronto we received the first demonstration of the new system. From the fifth floor of a downtown building one and a half kilometers from an out-of-sight base station, we simultaneously made IP telephone calls, streamed *Toy Story 2*, and quickly clicked through the day's technology news on the Web. Restricted by an experimental license to just 5 downstream watts, Soma's demo pumped bits at just one-eighth its normal 40-watt transmission power.

Soma propels Sprint and WorldCom

Under the leadership of CTO and University of Toronto professor Michael Stumm, Soma has also invented software to take network management entirely beyond the reach of the regulated carriers. With provisioning, service creation, billing, signal processing, and softswitch functions all within the tiny NetPort shell, Soma's NetOS is more aptly termed a Java central office on your desk. From unified messaging to five-way conference calling, from automatic call transcripts to voice disguise features, and from encryption and echo cancellation to voice over IP, Soma moves central office intelligence to the network's furthest edge. An open system, it is designed to accommodate thousands of third party software vendors writing new applications and features directly downloadable by the end user. In 300,000 lines of code it can obsolesce the 60,000,000 lines of code in **Nortel** (NT) and **Lucent** (LU) central office switches.

Composed of customer NetPorts, cellular base stations, and Sun servers anywhere on the Net, Soma's distributed system transforms the economics of the last mile. A capital cost analysis performed by industry experts Bart Stuck and Michael Weingarten shows that DSL carriers spend, on average, $1,125 per subscriber. Because they rely on Bell assets, CLEC DSL carriers spend even more. Strategis reports that broadband cable costs average over $1,000. Soma, on the other hand, can roll out service for just $395 per subscriber and save on technicians, call center operators, and switches as well. With customers buying a NetPort at Radio Shack and reaching the Net in minutes, Soma allows spectrum owners at last to make some money.

This new residential wireless paradigm offered by Soma immediately propels **Sprint** (FON) and **WorldCom** (WCOM) into the last mile connectivity lead. Each owns spectrum for MMDS (Is it multichannel multipoint distribution system, microwave multipoint data service, or what? Even Harry Newton's Telecom Dictionary can't say: "Nobody seems to know what MMDS means.") covering some 30 percent of America's homes. **Nucentrix** (NCNX) of Dallas owns another 10 percent, mostly in the Midwest. At frequencies around 2.5 gigahertz, MMDS began as a "wireless cable" television technology offering 31 six-megahertz channels or 186 megahertz of spectrum over spans of up to 30 miles radius.

Five hundred PCS license holders, from **Sprint PCS** (PCS) and **Verizon** (VZ) to numerous small, rural owners of mostly unused spectrum, also find themselves with a new business opportunity. Contrary to widespread belief, most of the large PCS operators are using less than half of their 20 or 30 MHz licenses. Sprint PCS, in fact, is at just 15 percent capacity, providing plenty of room for mobile voice and data upgrades, and for new fixed data and voice as well. This company also has the clearest and quickest 3G roadmap. Look for it to continue its climb up the mobile market-share ladder. Recognizing DSL's technical and political hardships and the cost-saving potential of the new fixed wireless opportunity, the Bells are said to be pursuing 700 MHz UHF television spectrum. At 6 MHz each, channels 60-62 and 65-67 are scheduled for auction this September with many more dormant broadcast channels likely to follow.

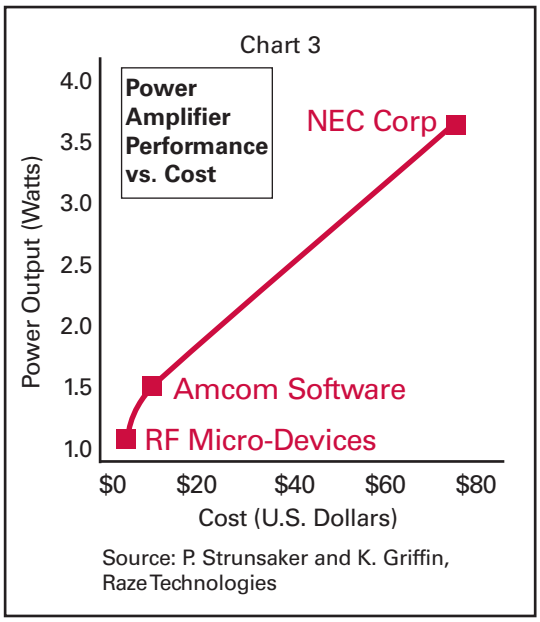
Fourier's fast mile

Currently agitating residential and even 3G cellular wireless vendors are the sometimes spectacular claims of OFDM (orthogonal frequency division multiplexing) start-ups. Numerous companies pursuing the technology claim that CDMA is history and that they're moving right past 3G to 4G wireless. Qualcomm's eminent Andrew Viterbi even retired and joined the board of

Flarion, a Lucent-Bell Labs spin off developing mobile OFDM products.

First patented by Bell Labs in 1970, OFDM is a multi-carrier technique in which the signal is divided into many narrow, parallel channels that can run at slower speeds. OFDM may, for example, chop a 5 MHz band into 100 50-KHz sub-carriers which can be monitored for performance. In adaptive OFDM, more data is pumped through the unobstructed channels. When used through wires, the system is called discrete multitone DSL. But because of its complexity, the adaptive version is not often used in radio. Most iterations use non-adaptive OFDM where each channel, whether "free" or "blocked," carries the same symbol rate. The key to OFDM is its special use of fast Fourier transform (FFT) transceivers to simplify complex signal processing.

Any regular wave pattern—sound, electromagnetic, stock market cycle, or fruit fly propagation—can be reproduced exactly through the summation of an infinite series of sine waves. (If you don't need exact, you can stop well short of infinite). Even entropic bitstreams of unknown digital data transmitted as a sequence of "on" or "off" square waves can be represented by the combination of a large number of known analog waveforms. Fourier analysis is the process of figuring out the coefficients that give us the characteristics of each of the curvaceous and continuous sine waves. Compiling and decompiling the coefficients allows a digital chip to accurately represent the original, irregular, information-bearing wave.



Carleton University's David Falconer, however, shows that single carrier systems can match or exceed the performance of OFDM by using decision feedback equalization (DFE) chips and FFT in the receivers alone. The total number of FFTs and complex calculations are the same. Moreover, Falconer shows, the OFDM vendor must use a more complex and expensive power amplifier. Triple the power of an amplifier and you increase the cost twentyfold. Ralph Muse, the now former CEO of **NextNet**, Soma's only competitor with an indoor antenna, recently admitted as much to *Interactive Week*: "Power amps are my problem."

While OFDM may be useful to wireless technologists for years to come, OFDM poses no near term threat to single carrier or CDMA based systems. Pursued by AT&T's Project Angel and projects at Cisco, NextNet, **WiLAN**, **BeamReach**, and **Iospan**, OFDM seems to attract widespread support not because of any superior agility in delivering bits but because of its nimble evasion of Qualcomm patents.

QCOM's CDMA learning curve

Qualcomm's Irwin Jacobs should take heed lest his company's overly aggressive stance on rights and royalties drives innovation into competitive technologies like OFDM and **LinkAir**'s LAS-CDMA. By charging less, Qualcomm would gain more, by eliminating the incentive to spend years on things that have marginal performance benefits but which confuse and tempt potential Qualcomm customers.

Luckily, Soma has a Qualcomm cross-license. Soma smartly relies on the CDMA learning curve and this license to reduce complexity and cost. Soma's air interface is based on wideband CDMA (WCDMA) and is deployable in any number of spectrum bands, from 1800 MHz PCS to 2600 MHz MMDS and even 700 MHz UHF. CEO Yatish Pathak says a new radio for a new frequency band takes 3 to 4 months to build. Soma's PCS radio is ready, and its MMDS radio will be by early fall. Occupying a band four times as "wide" as Qualcomm's original CDMA, 5 MHz versus 1.25 MHz, Soma achieves a committed data rate of 5 Mbps per sector and a peak data rate of 12 Mbps per sector.

As in Qualcomm's HDR (High Data Rate), Soma serves the "easy" users first. It sends highly modulated signals to users with good connections to get them out of the queue; then it concentrates spreading on the tougher cases. Subscribers at the edge of the cell have the option of self-installing a non-directional outdoor antenna the size of a Coke can. Snelgrove says software enhancements could bring peak rates of almost 25 Mbps and average rates of 10 Mbps per sector in 2002. The system uses standard sectorized PCS antennas where one cell comprises six 60-degree sectors.

Unlike cellphones, which are too small and cheap to bear complex smart antennas, the new broadband fixed wireless brings smart antennas to the fore. Companies such as **ArrayComm**, which seeks to create virtual wires between tower and customer, **Metawave** (MTWV), which "load balances" traffic between PCS sectors, and **Antenova**, a new British firm with a solid-state 360-degree steerable antenna, have been working on these technologies for a decade or more and now may have their day in liberating the local loop.

With venture capital swelling beneath, phase two of the Telecosm begins.

George Gilder and Bret Swanson
March 14, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE / PRICE		FEB '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Wireless, Fiber Optic Telecom Chips, Equipment, Systems	Lucent (LU)	11/7/96	11.78	11.59	11.50 - 75.38	39.4B
Wireless, Fiber Optic, Cable Equipment, Systems	Nortel (NT)	11/3/97	11.50	18.49	18.20 - 89.00	56.5B
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	27.10	28.50 - 113.33	24.7B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	26.75	27.44 - 153.44	34.9B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	19.38	22.63 - 273.5	1.3B
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	36.00	35.55 - 162.00	16.4B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	21.69	16.00 - 165.06	1.4B
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	–	–	–	–
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	33.63	32.25 - 142	4.4B
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6*	49.25	53.00 - 274.75	11.6B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	5.53	3.50 - 142.63	364.5M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	12.25	12.63 - 106.50	3.0B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	–	–	–	–
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	3.71	2.69 - 16.00	1.1B
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.66	0.47 - 31.75	69.7M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	54.81	50.13 - 162.56	41.3B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	25.18	17.63 - 66.94	23.5B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	15.17	15.28 - 61.54	33.1B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	13.50	12.75 - 163.50	580.5M
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	9.50	9.13 - 51.88	5.2B
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	16.23	11.25 - 61.00	14.4B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	5.28	3.50 - 136.44	99.0M
Telecommunications Networks, Internet Backbone	WorldCom (WCOM)	8/29/97	19.95	16.63	13.50 - 49.94	47.9B
Global Submarine Fiber Optic Network	360networks (TSIX)	10/31/00	18.13	7.94	8.25 - 24.06	6.5B
STOREWIDTH						
Directory, Network Storage	Novell (NOVL)	11/30/99	19.50	5.94	4.75 - 34.56	1.9B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	19.88	19.06 - 64.69	64.8B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29	5.49	2.81 - 112.50	582.4M
Disruptive Storewidth Appliances	Procom (PRCM)	5/31/00	25	13.38	10.25 - 89.75	155.4M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27*	14.75	14.56 - 154.25	1.4B
Complex Hosting and Storewidth Solutions	Exodus (EXDS)	9/29/00	49.38	14.63	13.94 - 89.81	8.1B
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	–	–	–	–
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	2.50	0.75 - 28.00	67.3M
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	37.30	39.80 - 103.00	13.4B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	26.75	30.13 - 109.75	8.0B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	10.50	9.38 - 30.69	4.9B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	16.11	16.30 - 90.37	5.1B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	20.42	17.13 - 85.94	3.6B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	29.55	28.25 - 99.78	51.1B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	38.88	35.25 - 98.31	12.8B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	10.50	5.63 - 43.75	67.7M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	19.58	18.25 - 58.00	2.6B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	23.13	19.63 - 67.13	9.2B

ADDED TO THE TABLE: SOMA NETWORKS

* INITIAL PUBLIC OFFERING

NOTE: The Telecosm Table is not a model portfolio. It is a list of technologies in the Gilder Paradigm and of companies that lead in their application. Companies appear on this list only for their technology leadership, without consideration of their current share price or the appropriate timing of an investment decision. The presence of a company on the list is not a recommendation to buy shares at the current price. Reference Price is the company's closing share price on the Reference Date, the day the company was added to the table, typically the last trading day of the month prior to publication. Mr. Gilder and other GTR staff may hold positions in some or all of the stocks listed.

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