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THE SECOND HALF OF THE CHESSBOARD

As FPGAs become faster and denser, the chameleon dream comes closer to reality by the day.

For close to 50 years, beginning 15 years before Gordon Moore identified the phenomenon, Moore's Law has doubled the cost effectiveness of microchips every 18 months and reshaped the global economy. But its reign is now past. Rapidly emerging is a new exponential law that is unlocking the secrets of a new era. Let us call it the law of the telecosm. Like Moore's Law, it beats a regular rhythm of doubling capability in the key technology of the era.

To grasp the power of cumulative doubling, consider–in modern dress–the venerable tale of the Emperor of China and the Inventor of Chess.

So enthralled was the emperor with his new game that he offered the inventor any prize he wanted in the kingdom.

"Just one grain of rice, in the first square of the chessboard," replied the inventor.

"Just one grain of rice?" asked the baffled emperor.

"Yes, just one grain of rice in the first square, two grains in the second square, four grains in the third square, and so on, through the sixty four squares of the chessboard."

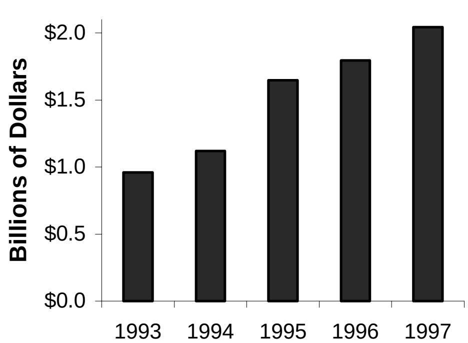
The emperor, who was not a mathematician, readily granted the inventor his apparently humble request.

Now there are two possible outcomes to this story. The first is that the emperor goes bankrupt. Two to the 64th power adds up to 18 million trillion grains of rice, which at a density of 10 grains per square inch would cover the entire surface of the earth with rice fields, two times over, oceans included. That's the power of repeated doubling.

So the emperor has a problem. Now emperors do not like having problems. So the second outcome, which somewhat alarmed Raymond Kurzweil, the brilliant American inventor who first told me the story, is that the inventor is decapitated.

One lesson of the story, therefore, is that if you command exponentially advancing technologies, *always keep an eye on the emperor.* Bill Gates is learning this lesson today, but next year, or the year after, it will be the turn of his indulgent rivals who are encouraging government lawyers in an ill considered foray of federal involvement in the computer industry. For a runaway prosecution of **Microsoft** (MSFT) for monopolistic practices, the emperor is donning fancy new clothes from Santa Fe, diaphanous "market failure" figments cultivated by leftist academics ever alert to new flaws of capitalism.

Chart 1
Programmable Logic Devices



Source: IC Insights

Key to the pursuit are overblown concepts of "lock-in effects" in the world's fastest changing technology, "bundling" chicanery in an age of ever more integrated circuits and suites, "dumping" claims in an industry always dependent on plummeting prices, and notions of perpetually "increasing returns" to inferior technologies in an industry whose superior technologies are the source of most of the new wealth in the world economy. All these principles would have prohibited the growth of the business in the past and could stifle progress in the future. Gates' serious abuse of Java is a different matter,

Along with SiGe and dynamically reconfigurable FPGAs, Atmel has expanded its efforts in several key telecosm technologies.

despite Microsoft's sophistry on the subject, but this problem is being corrected in the courts without the assistance of Janet Reno. The rule remains, Do not seek the emperor's help, or ask him to bail you out, because he is likely to take you over…

Meanwhile, back on the chessboard with the Emperor of China, it is worth noting that through the first half of the game–two to the 32^{nd} power–the inventor's deal required the transfer of only four billion grains of rice. This amount could be readily produced on only a few acres of the emperors plantation, easily visible to the naked eye. Although the inventor was becoming a significant commodities trader, the Emperor was not alarmed. It was not until they moved onto the second half of the chessboard that things began to pop.

Today, all of us in the new economy of Moore's Law, are approaching the second half of the chessboard. The year 2000 marks just 32 doublings of transistor density since the invention of the monolithic transistor by William Shockley and his colleagues at Bell Laboratories in 1952. Perhaps more significant, the year 2000 marks just 28 doublings since Gordon Moore first made an integrated circuit with Robert Noyce, his colleague at Fairchild Semiconductor, who invented the device in 1958.

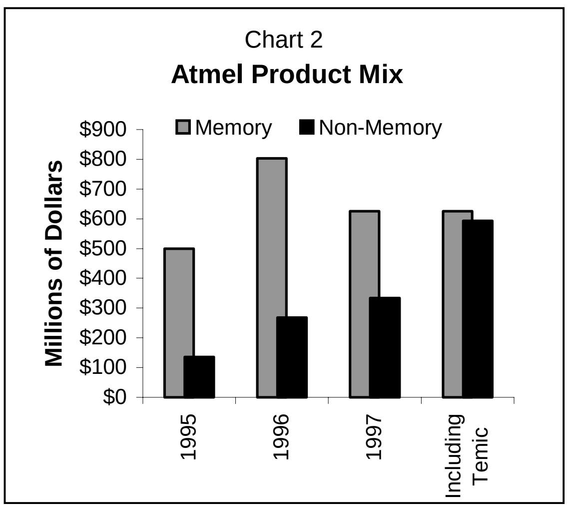


Chart 2
Atmel Product Mix

You double anything for long–whether deforestation in ecological nightmares or transistors on silicon in the continuing miracle of microchip progress–and you soon can ignite a sudden moment of metamorphosis: a denuded world, a silicon brain, a new world economy springing from the overthrow of television, telephony, and income taxation.

Moore's Law provides such a metamorphic promise. To calculate approximate timing, you had only to guess a product's optimal price of popularization and then match its need for MIPS (millions of instructions per second of computer power) with the cost of those MIPS as defined by Moore's Law. For example, a digital cellular phone requies about 40 MIPS and must sell for under $100. In 1996, a MIP on a microprocessor cost roughly one dollar and together with other components enabled the ascent of digital wireless telephone networks. A digital camera requires several hundred MIPS and related microchip capabilities and became feasible at the top of the consumer camera market in 1998. A network computer with digital video capabilities that permit it widely to displace TVs in home entertainment and information uses entails some 2000 MIPS and commensurate increases in storage and bandwidth. This millennial appliance will sink below a $1500 price point shortly after the turn of the century.

In appraising the constant claims of new laws of technology, you should understand that Moore's Law was not obvious at the time. But it changed everything.

Now a new law is emerging, doubling total world bandwidth about every four months. This too changes everything. Over the last thirty years, power, silicon area, and board level connections were all abundant; outside bandwidth was scarce. The new era reverses these conditions. In a time of light speed constraints, when you cannot readily move off chip, silicon area becomes precious real estate. In an era of increasingly mobile and remote devices–from hand held projection PCs to underwater fiber amplifiers, from satellite transceivers to digital cellular microwave base stations–both power and transistors grow scarce. The new mandate is systems on a chip.

Chiefly embodying such systems today are microprocessors, such as the Pentium in your PC, that offer an instruction set of standard functions which can be invoked for different purposes by multifarious software. But for many real time applications, systems of software, memories, and microprocessors become slow and cumbersome.

The alternative is to use an ASIC (application specific integrated circuit), usually a gate array, that is hardwired to perform a particular function. To gain efficiencies of mass production, chip firms batch process the initial layers of the device. They fix the specific application later during final metallization, when the gates are wired together in the factory at the cost of what are termed NREs (non-recurring engineering costs).

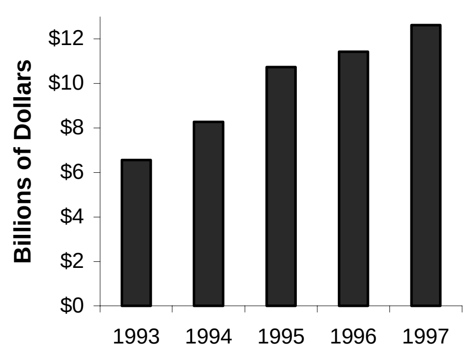
Such companies as **LSI Logic** (LSI) made their fortunes in gate arrays. In any particular design, however, as many as half the gates are not used. Thus gate arrays waste both silicon area and transistors. In response to the telecosm, these companies are now employing their design skills and technologies to create single chip systems–individual chips combining several core processing "cells" and designed from the bottom up to perform a specific function. LSI makes popular devices that perform the processing for a digital camera, a set top box, or a Sony Playstation. Its cell based sales advanced 42 percent in 1997, to some $700 million.

Left behind by the telecosm, it might appear, are the companies that make field programmable gate arrays (FPGAs), which are even more wasteful of silicon area and transistors than ordinary gate arrays are. FPGAs are wired in the field rather than only in the factory. Often consisting of patterned memory structures, such as EPROM (electrically programmable read only) or static random access memory (SRAM) cells, used for logic, FPGAs avoid NREs and inventory costs. They can be programmed just in time for use. But beyond their apparently wasteful use of silicon, they also tend to be slower and smaller than gate arrays.

None the less, FPGAs are becoming a key to the telecosm. In order to achieve true single chip systems, you must be able to program a single device to perform many different functions. The new telecosmic FPGAs achieve multi-functionality by changing their instruction sets or other capabilities on the fly–as fast as you can change the electrical charge on a memory cell (in a few nanoseconds, or microseconds, depending on the technology). Performing many purposes on the same silicon sliver, they end up saving silicon area and transistors as well.

The key current role of FPGAs is to enable the early modeling and prototyping of unfinished device designs. Many orders of magnitude faster than software simulations and incomparably more adaptable than hard-wired prototypes, emulators using FPGAs can test devices based on their specifications, before the circuits are finally laid out. Then for commercial manufacturing, the FPGA designs tend to give way to ordinary gate arrays with a similar structure of gates and connectors but without the costs and complications of programmability.

Chart 3
Microcontroller Units



Source: IC Insights

Inspired by such leaders in the field as Amr Mohsen of privately held **Aptix Corporation**, creator of **Actel**'s (ACTL) antifuse cell, FPGA designers have long cherished a secret dream. If FPGAs are so effective in testing a variety of designs, why couldn't they be used to create not a generic tester but a generic processor itself. Forget the gate array or the Pentium device. Create an all purpose computer that can be a Pentium for a moment to receive a Windows instruction, then a Java processor to invoke an applet, then a DSP (digital signal processor) or MPEG2 converter to prepare a full screen teleconferencing image.

As FPGAs become faster and denser–with million gate devices in view around the turn of the century–the chameleon dream comes closer to reality by the day. When users can reprogram the chips after they are installed in the circuit boards and systems, a single board could become the foundation for a range of products defined after manufacture by market demand or even by the end users themselves. Upgrades could be made in the instruction sets or other features of the chips themselves as readily as in software. Eventually new hardware instructions could be downloaded over the net. Such possibilities can fuel the emergence of a new paradigm in FPGAs and a new architecture for computers.

Such flexibility and adaptability have already powered the historic growth of the $2 billion FPGA market led by **Xilinx** (XLNX) and most recently **Altera** (ALTR). In 1997, according to data from IC Insights, Altera's market share for the first time passed Xilinx in FPGAs. Each company ended the year with about 29% of the FPGA market revenues, with Altera slightly ahead and with a faster growth rate focused on existing markets. But with FPGAs moving toward dynamic reconfiguration, Xilinx chips based on SRAM cells hold the edge over Altera's EPROM systems. Dynamic reconfiguration means reprogramming on the fly without shutting down the system.

The leader in dynamic reconfiguration technology, however, is probably **Atmel** (ATML), though their share was less than 2% of the 1997 FPGA market. Founded by the ingenious Perlegos brothers, the company spun out of **SEEQ Technology** (SEEQ), an early leader in electrically erasable programmable read only memories (EEPROMs), usually known as E squares. (In a turnaround, Atmel recently made a $6 million investment in the long moribund SEEQ, which is now making a gigabit ethernet chip used by **Intel**, INTC). Also producing EPROMs and flash, Atmel became a versatile memory star. That star has now dimmed. Atmel's memory revenues have crashed and so have the financials of the company. But Atmel is now moving to new and more ascendant technologies.

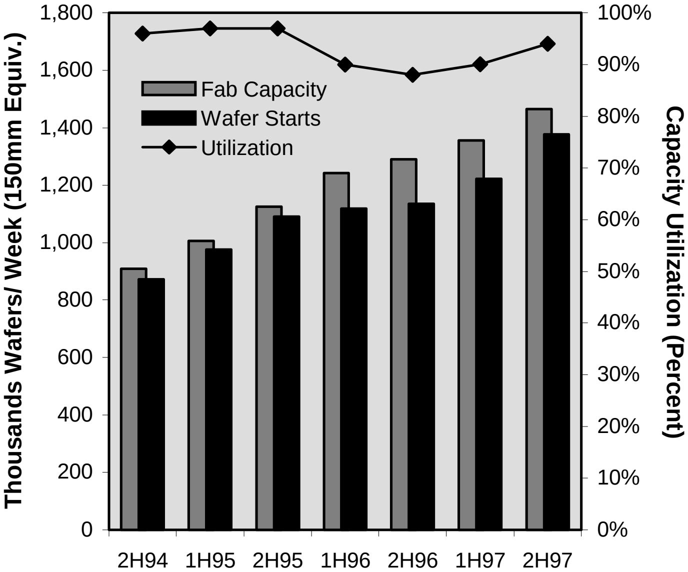
Atmel's FPGAs allow for the reprogramming of cells and connections while the chip is running. Originally developed and patented by Concurrent Logic, largely acquired by Atmel in 1993, this capability has been trademarked as Cache Logic by Atmel, in an analogy to cache memory. Cache memory (usually SRAM) is high speed memory used to store the most active data while the bulk of data resides in lower-cost DRAM. In Cache Logic, logic circuit designs are stored in low cost memory and configured and reconfigured as needed in the FPGA.

Atmel's design tools include more than 50 automatic component generators for creating reusable soft cores of virtually any logic or SRAM functions. The necessary functions can be loaded

Aptix has proceeded from field programmable chips to field programmable boards, and has been growing at an 80% annual rate since 1994.

Chart 4

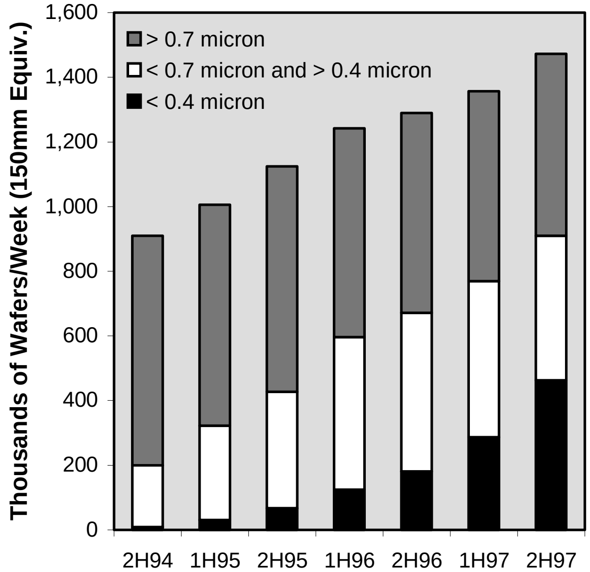
MOS IC Capacity and Utilization



Source: IC Insights

Chart 5

MOS IC Capacity by Feature Size



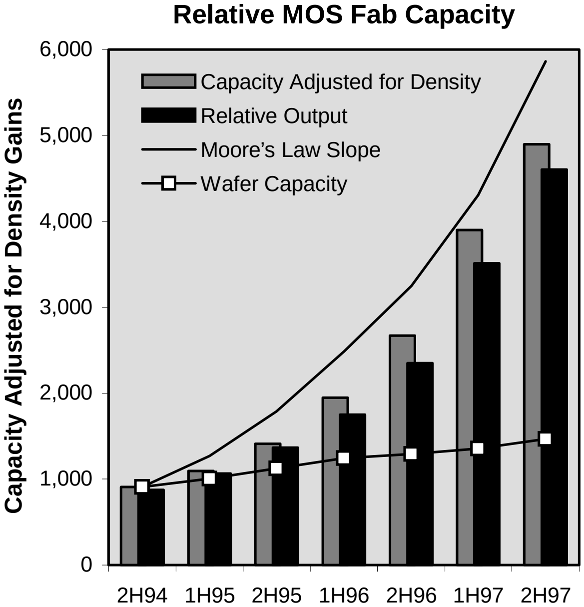
Source: IC Insights

The semiconductor industry's health *and vitality are constantly questioned because of a misperception following almost directly from Moore's Law. Doubling the number of transistors on a chip every 18 months effectively means that if demand were flat for the memory bits and processor MIPs, which are the true commodity delivered by transistors, then chip production would halve every 18 months. Conversely demand can double with unit shipments remaining flat. That is what occurred in 1996 when a misplaced gloom weighed in.* **Chart 4** *shows the worldwide capacity and utilization of MOS (metal oxide semiconductor) fabs. The capacity of fabs measured in thousands of silicon wafers per week (adjusted for wafer size to 150mm equivalents) clearly rose to overshoot utilization, or demand, which appeared to stagnate from 2H95 through 2H96. Absent from the picture is the impact of Moore's Law. The increasing density of ICs (integrated circuits) is what allows for the doubling of chip transistors.* **Chart 5** *shows the proportion of MOS fab capacity by feature size. Typically a 0.8 micron process might produce 4 megabit DRAM chips, 0.5 micron for 16 megabit chips, and 0.35 for 64 megabit chips. Each reduction in feature size produces a quadrupling of chip capacity. The same capacity chips could also be made much smaller and cheaper with more chips per wafer. In assessing demand for DRAM chips it is necessary to focus not on total unit counts but on the capacity of chips produced. A single 64 Mb chip can replace four 16 Mb chips. As per bit price parity approaches, total units shipped would plunge 75% without a rise in demand. Flat unit numbers can mask a 300% rise in bit demand. The wafer capacity numbers in Chart 4 can be adjusted, primarily relying on DRAM production data, to reflect the impact of feature density and unit size trends. The result is* **Chart 6**. *In addition to showing the actual change in MOS wafer fab capacity, it shows relative capacity and utilization adjusted for density improvements. It also shows Moore's Law's predicted improvement in transistor density relative to wafer capacity. Clearly demand was capped by limited capacity through 1995, and while wafer starts "stagnated" in 1996, true semiconductor demand–measured in bits and MIPs–began (and continues) to explode.* **Chart 7** *shows unused wafer capacity and its relative size over the same period as well as ASPs (average selling prices) for MOS ICs. The normal historical fall in ASPs expected as a result of density improvements was reversed prior to 1996. The shift from 4 Mb to 16 Mb DRAM in 1996 brought about a "correction" in ASPs. With efficient production, unused capacity rises even as demand soars. But here caution must be applied. Actual unused capacity, measured in wafers per week, may in this case be more accurate than adjusted relative capacity. It is likely that older, larger feature, less desirable and less efficient production processes would dominate the unused capacity negating relative improvements. Unused capacity is now declining and manufacturers have cancelled or put on hold some fab expansion plans. However, the announced plans to transition to 64 Mb and denser DRAMs reflects another four-fold increase in relative capacity. As ASPs continue their declines cries will arise over stagnant unit shipments and we will hear about the end of the industry even as GTR readers see true bit/MIP output and consumption rise even higher.*

-KE

Chart 6

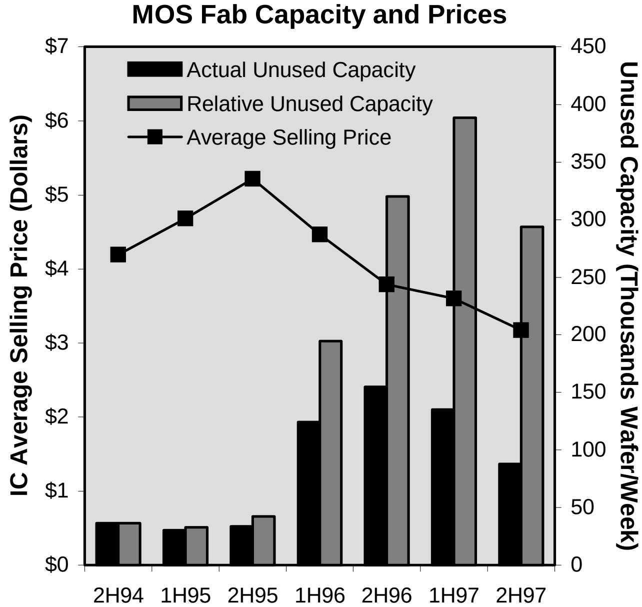
Relative MOS Fab Capacity



Source: IC Insights, GTG

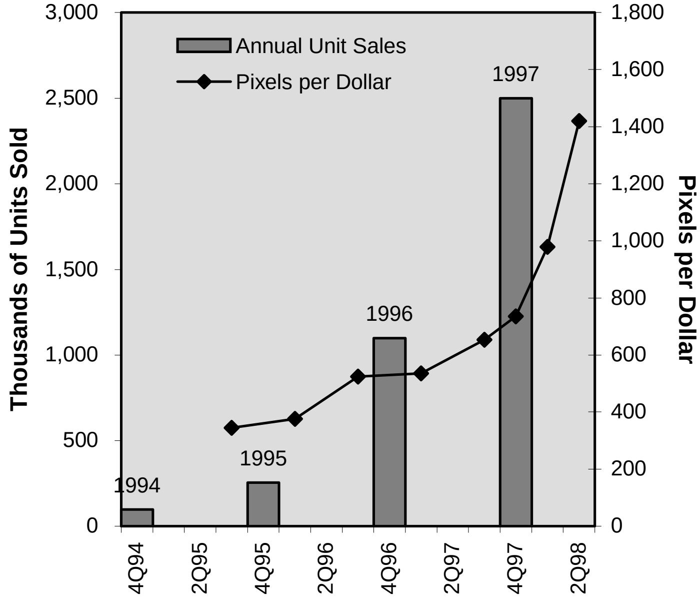
Chart 7

MOS Fab Capacity and Prices



Source: IC Insights, GTG

Chart 8
The Coming Digital Camera Boom

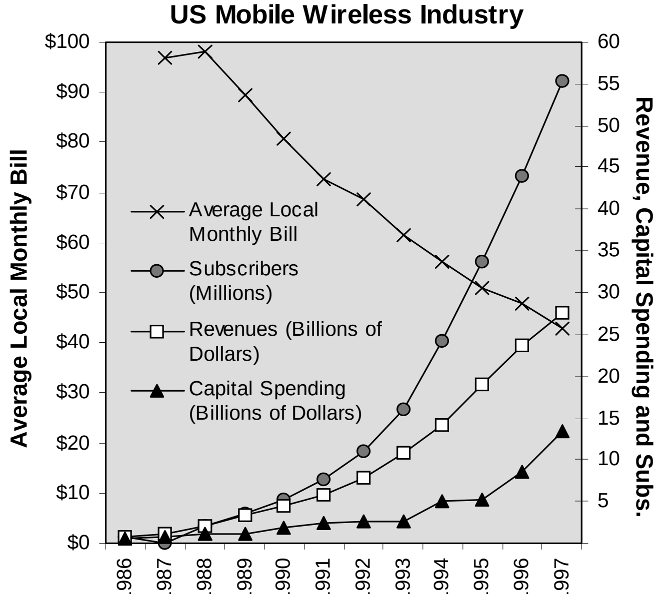


Source: GTG, German Photo Ind. Ass.,Dataquest

Digital camera *shipments reached 2.5 million units in 1997, according to the German Photographic Industry Association, a 127% increase over Dataquest's estimate for 1996. Worldwide digital camera shipments equaled 4% of the total of some 58 million analog cameras shipped. In Japan, digital cameras passed 1 million units or 20% of analog shipments. Sales have increased as resolutions improve and prices drop (***Chart 8***). Nikkei Market Access reports that in Japan the percent of cameras with greater than 800,000 pixels rose from 7% in 1Q97 to over 30% in 4Q97. The 1Q98 announcements of a dozen new models with over a million pixels for $600 to $1,000 sets the stage for an explosion of value and shipments in 1998. Taiwan's Industrial Technology Research Institute reports that more than 10 local companies are launching new products in 1998 to compete against Casio, Epson, HP, Kodak, Olympus, and some 25 other commonly available brands in an already fiercely competitive market pitting the traditional film and camera leaders against computer and electronics giants.*

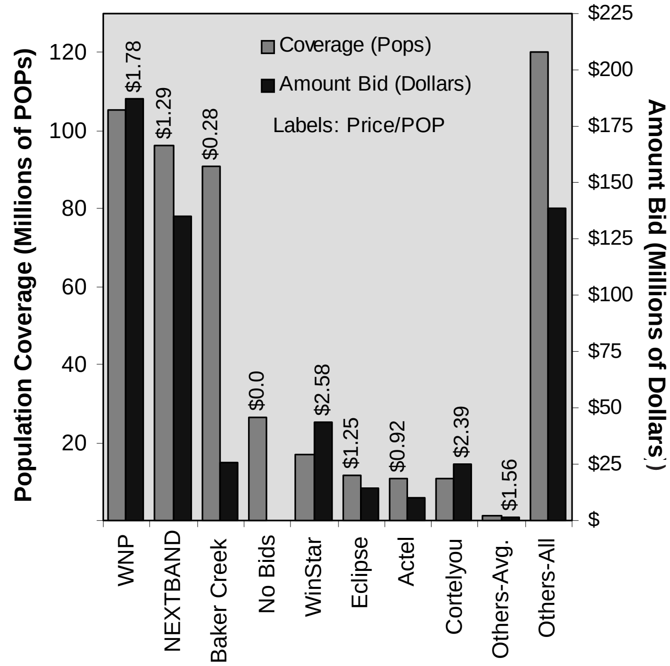
US wireless phone subscribers*–cellular, SMR and PCS–increased over 25% or 11,270,301 subscribers in 1997 according to the Cellular Telecommunications Industry Association (CTIA). Service expansion and upgrades, including rollout of PCS services and conversion to digital systems, resulted in 1997 spending of nearly $13.5 billion for capital investment in equipment and infrastructure, a 59% increase from 1996 representing a full 29% of the industry's total cumulative capital investment. Increased competition and cheaper PCS service plans continued the trend of lower average monthly bills as revenues increased 16.3% to $27.5 billion (***Chart10***).*

Chart 10
US Mobile Wireless Industry



Source: CTIA

Chart 9
LMDS Auction Winners



The LMDS auction *(local multi-point distribution services), in which the FCC raised some $579 million dollars for two blocks of frequencies in 493 BTAs (basic trading areas) across the nation, has completed with 122 markets representing some 26 million POPs (the number of POPs in each market is equivalent to its population) failing to receive any bids. The A block licenses (1,150 MHz each) sold for an average of less than $1.70 a POP. The smaller B block (150 MHz) earned just $0.64/POP. The LMDS winners (***Chart 9***) include WNP Communications, a new privately held company combining former telecommunications and cable industry executives with venture capital funds, which bid $187 million for 40 of the largest markets totaling 105 million POPs; Nextband Communications, backed by Craig McCaw's Nextlink and Nextel, which bid $135 million for 42 markets with 104.8 million POPs; and Baker Creek Communications which won 90.8 million POPs spread over 232 markets, but bid only $26 million or merely 28 cents a POP by focusing on the B block in smaller markets (Philadelphia being the largest). Mirroring the ISP (Internet Service Provider) market in which a small group of national providers are complemented by a few thousand local ISPs, these winners are complemented by 101 other licensees.*

Korean wireless phone subscribers *utilizing CDMA (code division multiple access) technology pioneered by Qualcomm and Samsung have continued rapid growth despite the country's economic troubles (***Chart11***). The growth has been attributed to discounts and special plans being offered by Korea's three PCS (personal communications services) carriers, Korea Telecom Freetel Co., Hansol PCS Co. and LG Telecom Co., which began service in October, 1997.*

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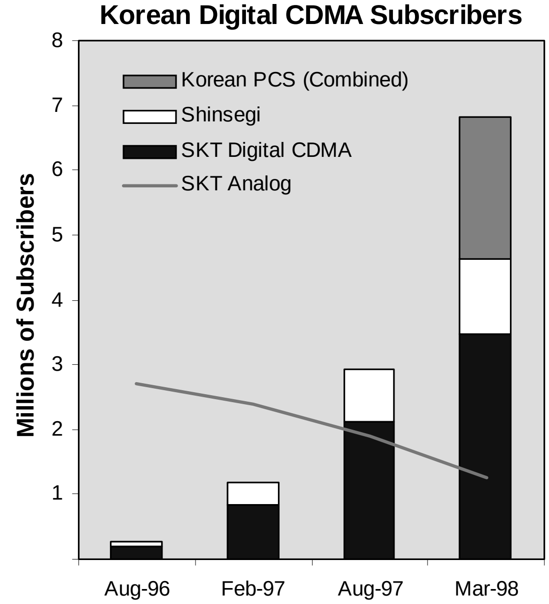
Chart 11
Korean Digital CDMA Subscribers



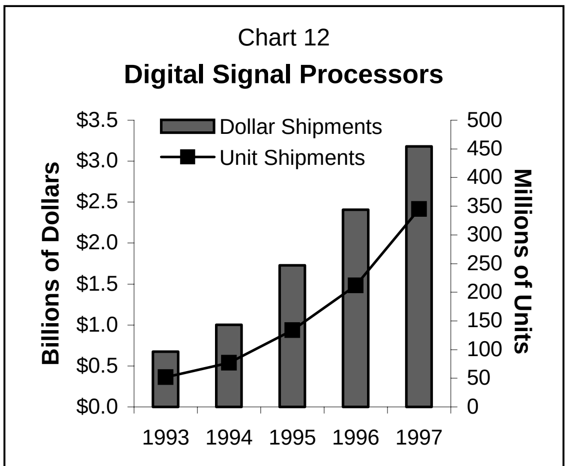
Source: Co. Reports, Maeil Bus. Newspaper, Korea

Level 3 intends to provide a full range of information and communications services.

into the Cache Logic without losing the data already there or disrupting the operation of the rest of the chip. As one set of operations are being completed, the next logic gates can be defined, or multiple functions can be implemented in parallel on different portions of the chip.

Another patented Atmel innovation is trademarked as FreeRAM. FPGAs from Xilinx and others use logic cells for SRAM data storage. FreeRAM avoids this inherent conflict by placing discrete SRAM blocks throughout the chip, allowing logic to be reconfigured without disturbing the active data and reprogramed without a delay penalty.

The significance of Atmel's achievement is easy to miss in a world dominated by Moore's Law. Thriving in the microcosm required the wasting of transistors and the conservation of bandwidth. Here is a new chip technology which instead conserves silicon by allowing portions of a chip to be repeatedly reconfigured as needed without waste. Here is a chip design which allows for enormous internal bandwidth through the ability to process bits in parallel on different portions of a single chip. Atmel's technology thus prepares for the telecosm.



Source: IC Insights

Atmel's numbers, though, still reflect the throes of a paradigm shift. Inherited from the days at SEEQ, the core of Atmel's business has been non-volatile memory in the form of EPROM, EEPROM and flash. EPROM is dying. Requiring removal from the system for reprogramming, the chips are giving way in nearly all designs to the more versatile and functional flash and E squares. Nonetheless Atmel succumbed to the temptation of a market from which the leading players were fleeing. Between 1994 and 1996, it doubled its share of the EPROM market to 20 percent and grew its EPROM revenues by 55 percent. When worldwide EPROM revenues plummeted by nearly 60 percent over the last two years, Atmel crashed. It wrote off over a hundred million dollars worth of inventories and fabs and disinvested from memory, which will drop from 80 percent of revenues in 1995 to 50 percent of revenues this year.

More important than the markets Atmel is getting out of, however, are the markets Atmel is pursuing. Readers of GTR have long been familiar with the huge potential of Silicon Germanium (SiGe) to expand the reach of traditional silicon fabrication processes into the range of applications only previously possible using Galium Arsinide (GaAs). In March 1997 we warned "to watch out for IBM's new silicon germanium." On February 17, 1998 IBM announced it would acquire CommQuest Technologies for $180 million, "with a goal of applying its silicon germanium process technology to CommQuest's high-frequency analog and DSP designs for cellular handsets and satellite receivers." Other major silicon germanium announcements have come from **Nortel** (NT), Temic, **Harris** (HRS), **NEC**, **Hitachi**, and **Texas Instruments** (TXN), among others.

On March 4, Atmel purchased Temic's $260 million SiGe technology and IC business for some $110 million. Atmel's President and CEO, George Perlegos, stressed the importance of Temic's RF and SiGe capabilities for applications in the telecommunications and automotive industries. In addition to accelerating diversification of Atmel revenue sources into non-memory categories, the Temic IC purchase diversifies Atmel's global exposure. Atmel's 1997 revenues were derived 40% from North America, 20% Europe, 19% Japan and 21% ROW (rest of world, including rest of Asia), whereas Temic sells approximately 60% of its products to Europe.

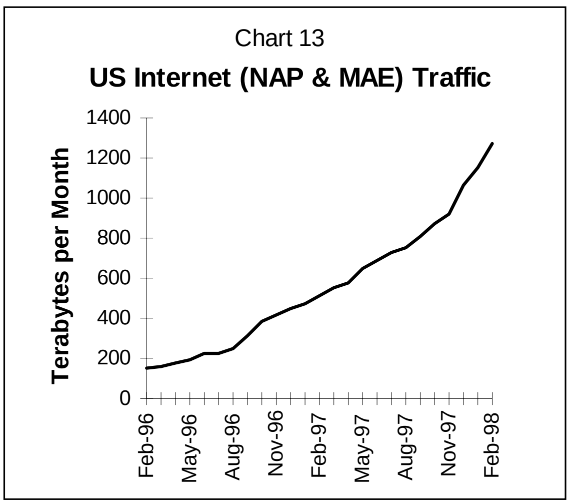
Along with SiGe and dynamically reconfigurable FPGAs, Atmel has expanded its efforts in system on a chip technology, DSP subsystems, CMOS digital imaging, and integrated internet access chips.

Expanding into the rapidly growing digital camera market, one of the final challenges in the triumph of Moore's law over analog systems, Atmel and **Polaroid** (PRD) announced July 23, 1997 that they would jointly develop single chip integrated cicuit solutions for a variety of imaging applications, with the circuits developed under the pact available for manufacture by Atmel for the general market.

In November 1997 Atmel partnered with **Osicom Technologies** (FIBR), of Waltham, Mass., to develop a line of embedded RISC processors for Web access. The *EETimes* reported that "the companies will work together on architectures that combine Fast Ethernet MACs (media access controllers) and physical layer cores, and on TCP/IP-based Internet access logic, including both serial controllers and IP processing." Atmel further expanded its non-memory efforts at the end of last year with their October acquisition of Fincitec Components Oy, a design group in Helsinki, Finland, with expertise in DSP and analog IC development.

Meanwhile, the pioneer of much inventive FPGA technology, Amr Mohsen has proceeded from field programmable chips to field programmable boards. Founded in 1989, his Aptix now produces reconfigurable prototyping systems for design and verification of complex electronics systems, taking Electronic Design Automation (EDA) from the level of chip design to the circuit board level. The company has installed more than 300 systems and its list of customers includes **HP** (HWP), NEC, **Nokia** (NOKa), Intel, **Lucent** (LU), **IBM**, and **Qualcomm** (QCOM), among others, and the company has been growing at an 80 percent annual rate since 1994.

This emulation, or prototyping, system can output data that cannot be adequately simulated such as audio, video, network traffic, and mechanical interfaces. Its open architecture offers the unique ability to incorporate system functionality in many forms–with off-the-shelf ICs and components, or if functions are not already on silicon, with custom logic configured in user selected FPGA technology (Verilog or VDHL code is synthesized into the FPGAs). The designer and client can see and hear how a system will actually perform and even test-drive the prototyped system in complex, real-world environments. This saves much of the cost and time to lay out, fabricate, and test circuit boards and system ASICs.



The key to this emulation is the Field Programmable Interconnect Component (FPIC). With one or more FPICs interconnecting all the FPGAs and off-the-shelf components in the prototype, designers can completely control the system's configuration via software. Debug facilities allow both hardware and software designers to observe and correct every aspect of system operation as the design process proceeds.

These hardware-based prototypes operate at speeds near real-time system performance levels. The direct connect bus structure enables speeds as high as 50 MHz (typically 20-35 MHz), comparable to PC buses. Components such as microprocessors, DSPs, memories, ASICs, and I/O control units can be incorporated and run in near real-time.

As Amr Mohsen sees it, these reprogrammable chips and boards will ultimately lead to the generic computer, adaptable on the fly to a variety of purposes. This is the new paradigm for the telecosmic appliance, which must be portable, silicon efficient, low powered, and versatile.

To begin to thrive on the second half of the chessboard, imagine that bandwidth will be free. If the law of thrift in the most recent paradigm was to "waste" transistors, the law of thrift in the new one will be "waste" bandwidth. After all, it will *cost* you too much *not* to do so. Bandwidth is now growing at least 10 times faster than computer power. Driven by the explosive rise of bandwidth, the laws of the telecosm are therefore eclipsing Moore's Law as the commanding force of industry.

For more than a decade, American companies have been laying fiber at an average pace of some 4000 miles a day, for a total of more than 10 million strand miles. Five years ago, the top 10 percent of US homes and businesses were, on average, a thousand households away from a fiber node; by 1998, they were some fifty households away.

Contributing significantly to this trend will be **Level 3 Communications**, Inc. (LVLT)**.** Formerly traded on the NASD OTC Board as **Peter Kiewit Sons'** Inc., Level 3 Communications, Inc. was listed on the NASDAQ National Market on April 1, 1998 with no new public offering. As mentioned in previous GTR's, Level 3 intends to provide a full range of information and communications services, primarily to businesses, over an advanced fiber optic network across the U.S. and eventually overseas based on Internet protocol technology and packet switching.

With an asset base of over $3 billion and a total market capitalization of $9.2 billion, the company plans to spend upwards of $1 billion a year on the buildout. Hitting the ground running, Level 3 announced on March 24, 1998 an agreement with **Frontier Corporation** (FRO) to lease capacity on Frontier's SONET fiber optic IP-capable network for a period up to five years. This will enable the company to provide service to business customers in fifteen major cities beginning in the third quarter 1998 while building its own IP-based network.

The newly independent Level 3 combines the derived asset base of Kiewit and the intellectual capital and experience of James Q. Crowe, president and CEO of Level 3 and president of MFS Communications Company, Inc. when it was purchased by **WorldCom**, Inc. (WCOM) for $14 billion. The new firm commands such valuable telecom assets as **RCN Corporation** (RCNC), building wireless local loop and Internet access facilities, and has good prospects for rights of way from railroad companies linked to Kiewit. Rejoining Crowe at Level 3 are key former MFS executives who plan to bring this $3 plus billion startup into competition with WorldCom and **Qwest** (QWST) for IP-based business in the continuing explosion of Internet traffic.

At the heart of this Internet's explosion was Marc Andreessen and **Netscape Communications** (NSCP). They provided the window to the web and the software to make it worth looking through. They led the popularization of Java. But

Intentia has been blowing away the competition in presentations to prospective clients.

ASCENDANT TECHNOLOGY	REPORT(S) Volume: No.	COMPANY (SYMBOL)	Reference Price	Price as of 4/3/98
Cable Modem Service	I: 2, 3; II: 7, 8, 9, 11, 12	*@Home* (ATHM)	19 1/2	33 3/8
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	II: 3, 7, 12; III: 2, 4	*Analog Devices* (ADI)	22 3/8	34 1/2
Java Thin Client Office Suite, Rapid Application Development (RAD)	II: 6, 7, 12	*Applix* (APLX)	4 1/2	6 1/4
Dynamically Programmable Logic, Silicon Germanium (SiGe), Single Chip Systems	III: 4	*Atmel* (ATML) +	17 11/16	17 11/16
Low-Cost Single-Chip Broadband Data Transmission Chips	II: 10; III: 3	*Broadcom Corporation* (private)	Anticipated IPO	
Digital Video Codecs	II: 5	*C-Cube* (CUBE)	23	19 3/4
Low Earth Orbit Satellites (LEOS)	I: 2; II: 1, 3, 4, 8, 10	*Globalstar* (GSTRF)	21 3/4	64 3/4
Business Management Software	III: 4	*Intentia* + (not traded on US market - traded in Sweden)		
Broadband Fiber Network	III: 2, 3, 4	*Level 3* (LVLT) +	62 1/2	62 1/2
Single Chip ASIC Systems, CDMA Chip Sets	II: 8	*LSI Logic* (LSI)	31 1/2	26 13/16
Telecommunications Equipment, Wave Division Multiplexing (WDM)	II: 1, 2, 7, 9, 10, 11, 12; III: 1, 2, 3, 4	*Lucent Technologies* (LU)	23 9/16	72 15/16
Single-Chip Systems	II: 8, 12 III: 4	*National Semiconductor* (NSM)	31 1/2	20 1/4
Telecommunications Equipment, Wave Division Multiplexing (WDM), Code Division Multiple Access (CDMA), Silicon Germanium (SiGe)	II: 1, 7, 9, 11, 12; III: 1, 2, 3, 4	*Northern Telecom* (NT)	46	64 3/4
Wave Division Multiplexing (WDM), Satellite and Wireless Systems, Code Division Multiple Access (CDMA)	II: 10	*Ortel* (ORTL)	20 3/4	13 3/4
Point to Multipoint System for 7-50 Ghz, Spread Spectrum Broadband Radios	II: 10, 11	*P-COM* (PCMS)	22 3/8	19 15/16
Code Division Multiple Access (CDMA)	I: 1, 2; II: 1, 3, 4, 7, 8, 9, 10, 11 III: 4	*Qualcomm* (QCOM)	38 3/4	55 3/4
Broadband Fiber Network	II: 9, 10, 11; III: 1, 2, 3	*Qwest Communications* (QWST)	20 3/8	38 1/8
Java Programming Language, Internet Servers	I: 1, 2, 3, 4; II: 1, 5, 6, 7, 8, 10, 12	*Sun Microsystems* (SUNW)	27 1/2	41 1/8
Optical Equipment, Smart Radios, Telecommunications Infrastructures	I: 1; II: 1, 2, 3, 9; III: 3	*Tellabs* (TLAB)	29 1/8	65 5/8
Broadband Wireless Services	II: 9, 10, 11, 12	*Teligent* (TGNT)	21 1/2 *	30 5/8
Digital Signal Processors (DSP), DRAM	I: 2, 3, 4; II: 5, 8, 11, 12; III: 3, 4	*Texas Instruments* (TXN)	23 3/4	55 11/16
Wave Division Multiplexing (WDM) Modulators	II: 7, 9, 10 III: 4	*Uniphase (UNPH)*	29 3/8	45
Telecommunications, Fiber, Internet Access	II: 9, 10, 11, 12; III: 1, 2, 3, 4	*WorldCom* (WCOM)	29 15/16	43 7/8
Field Programmable Logic Chips (FPGA)	I: 3 III: 4	*Xilinx* (XLNX)	32 7/8	37 1/2

\+ New Addition * Initial Public Offering

New Additions: Atmel, Level 3, Intentia. Removed from the Table: Netscape, Wireless Telecom Group.
Note: Intentia is NOT traded on US markets, to buy Intentia shares on the Swedish exchange contact a full service brokerage such as Merrill Lynch. The Broadcom (BRCM) IPO was anticipated in late March, the latest indication is mid-April. For further information on this IPO, contact Morgan Stanley or BT Alex. Brown Inc., the underwriters.

Note: This table lists technologies in the Gilder Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for these core competencies, without any judgement of market price or timing.

with browser products now free and Netscape's source code boldly released to the world, the revolution is over.

More promising as a Java enterprise software play is **Intentia**, a Swedish company which delivers software to internationally active mid-sized businesses. Although progressing to Windows NT and 95 systems as those clients increasingly dominate the corporate landscape, the company is now deep in the process of converting their system to Java. Intentia's business management software, Movex, combines and coordinates project design, ordering, manufacturing, distribution, sales, finances and human resources and links them to intranets and extranets. Built in a modular fashion, Movex glues together existing legacy software or–often appropriate in the face of the year 2000 threat–enables migration to new components.

Competing with **SAP** and **Oracle** (ORCL), among others, Intentia has been blowing away the competition in presentations to prospective clients, including **Berkshire Corporation**, where I serve as a board member. With its strongest base in Europe, Intentia has some 3,600 clients worldwide and is quickly moving into the US where in three months Movex garnered some 76 customers. A move to the US stock market, while rumored, has been denied by Intentia's President for North America, Ed Koepfler, who claims it is a minimum of 18 to 24 months down the road. But savvy investors can do what I did and contact a full service brokerage such as Merrill Lynch to buy Intentia shares on the Stockholm Exchange.

George Gilder (with Ken Ehrhart), April 6, 1998

After much consideration, we have decided to allow ForbesASAP exclusive rights to publish an occasional adapted text from the reports some six to eight weeks following receipt by GTR subscribers. In practice this will mean there is a possibility of a second wave of impact after initial publication.

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