sgi™

Opening the Book of Human Life

the magazine of imagination, innovation, and insight

synergi

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U.S./Canada Edition

The Pepsi Center in Denver is a state-of-the-art arena that gives sports fans an unequaled combination of high-tech applications and amenities—pg. 14

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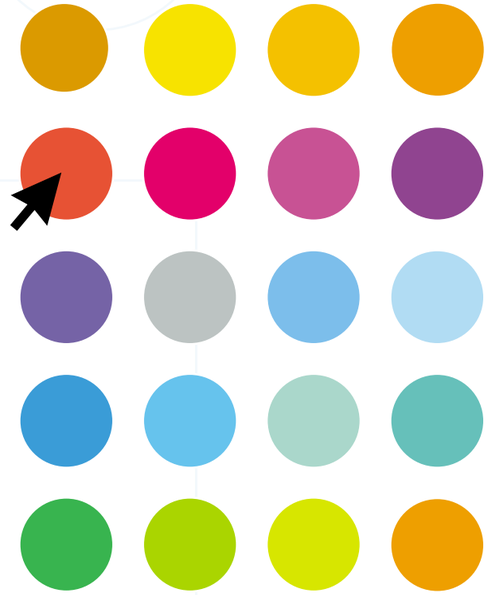

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Welcome to the latest edition of SYNERGI, the magazine of imagination, innovation, and insight from SGI.

Last July in New Orleans, SGI unveiled a new breakthrough in supercomputing technology and a renovated product line that will mark the return of the company to its time-honored leadership position in the realm of technical and creative computing. In the News section, we present the new SGI NUMAflex™ architecture, the revolutionary modular, brick-style technology that promises to lead high-performance computing into a new era of unprecedented performance and flexibility.

In its short history, information technology has gone from being a curiosity to the most important tool of the age. Never has this been more clearly demonstrated than in the Human Genome Project, a marriage of biology and computing that has enabled scientists to transcribe the human genome. Turn to page 18 to open the book of human life.

In this issue we examine the role of technology in shaping the world we live in and how it is set to develop over the first 20 years of the millennium. Bob Bishop, SGI's chairman and CEO, seeks answers to some of the most challenging questions. How soon will we be living in a global "infosphere"? Who are the winners and losers when you connect 6 billion people in "one planet, one network"? Will technology be the catalyst that unleashes the full potential of the human brain? Draw your own conclusions after reading the article on page 22.

Turn to page 14 to discover the new Pepsi Center. Denver's state-of-the-art arena boasts a complete Web-based video streaming solution that is without parallel at any sports/entertainment facility.

This issue also includes the magic of a virtual world created to experience Japan's cultural treasures, how 3D visual computing technology is helping to revolutionize the U.S. judicial system, and improving the hit-rate of oil exploration through reservoir simulation.

We hope you enjoy reading this latest edition of SYNERGI. Please let us know how we are doing by completing the feedback form on page 38. And if you would like to see particular topics covered in future issues, send your comments to *synergi_us@sgi.com*.

Mar Garcia
U.S./Canada Editor
SYNERGI

The Power of Core-Competency *Computing*

SGI is focusing its business around a compelling, focused mission.

For anyone who missed the last issue of SYNERGI, SGI's strategy is to focus on its core markets and consolidate and then expand its position within them. As a manufacturer of high-performance computing and visualization solutions, SGI's position is unusual in that its products are used by customers to support their "core competencies"—for example, by enabling them to design and build better products or find new solutions to their most difficult problems—rather than being used at the periphery of their activities, as with typical data-processing systems.

For example:

- Car manufacturers use SGI™ systems to build better, safer cars
- Oil companies use them to search for new reserves of oil and gas
- Chemical companies use them to design new materials
- Pharmaceutical companies use them to design better drugs
- Governments use them to give insight to their intelligence communities
- Media companies use them to create and deliver digital content over broadband Internet

SGI systems deliver unique insights and enable users to better collaborate and share information to solve their problems.

SGI estimates the total market for core-competency computing to be more than $20 billion in products and services, growing at more than 10% per year. SGI is targeting this through four main vertical markets—government, sciences, manufacturing, and telecommunications and media—and within these, SGI already dominates several sectors. The world's top 17 car makers, for example, all use SGI systems; 80% of the world's new oil and gas reserves are being explored using SGI equipment.

Meeting the needs of a sophisticated customer base.
By definition, SGI's target customers are sophisticated technical users (scientists, engineers, chemists, molecular biologists, analysts, etc.), creative users (artists, photographers, animators, architects, etc.), and the gurus of high-performance Web computing.

To support these customers, SGI's business, engineering, and design philosophy needs to be significantly different from that of most other vendors. SGI focuses on taking extremely large, complex computing problems and solving them through a combination of raw computing power and visualization—translating them into visual concepts that people can interpret. This ability is based on SGI's deep understanding of human collaboration and problem solving; its customers' businesses; and its expertise in research, development, and productization.

SGI is not targeting commercial data processing, enterprise resource planning (ERP), customer relationship management (CRM), or simple e-commerce applications. This is because these systems are normally built around enterprise-class data processing—the major design criteria for which are reliability, predictable performance, standardization, and low cost.

From an operating system perspective, this leads to monolithic, do-it-all operating systems suitable for general applications rather than high-performance, real-time, scalable operating systems. This is totally unlike SGI's approach, which focuses on real-time performance, I/O scalability, and visualization capabilities that precisely match system requirements to customers' core competencies.

Modular computing with IRIX® and Linux®.
Today, the IRIX operating system is leading the way for Linux. SGI is using its UNIX® expertise (through IRIX) to accelerate Linux suitability for mission-critical computing, while common software APIs across IRIX and Linux will allow customers to choose whether and when to migrate. This provides an easy transition from one platform to the other and also provides investment protection across platforms.

From a product architecture perspective, SGI is the vendor best positioned to take advantage of non uniform memory access (NUMA) in high-performance computing, as it has just released the highly modular third-generation SGI™ NUMA architecture. The premier high-performance computing and visualization platform from SGI will continue to be its MIPS®/IRIX OS–based offerings, due to their real-time performance, stability, and scalability. Using MIPS/IRIX as an innovation platform, however, SGI will eventually deploy such innovations within Linux, due to the ability of Linux on Intel® architecture-based systems to drive down costs. SGI's goal is to balance revenues between its MIPS/IRIX product lines and to deliver shareholder value by means of this balance.

Staying ahead of the competition.
SGI intends to grow its revenues 15% per year over the next five years, while sustaining a 40% gross margin. To achieve this, as well as growing its share in its four core markets, SGI will be entering new segments, including:

- Electronic design automation (EDA)
- Storage area networks
- Internet media streaming (where Linux is the operating system of choice)

SGI believes that this "single mission" strategy will enable it to retake market share from Sun, IBM, HP, Compaq, and Dell in its focus market areas. Even more importantly, it will allow SGI to continue to deliver core-competency computing solutions to its customers and help them stay ahead of the competition.

Intergraph Alliance

In July, SGI and Intergraph Corporation announced their intention to form a strategic alliance, allowing both companies to benefit from each other's products and expertise.

Under the alliance, Intergraph will purchase $100 million in SGI products and services over three years, and SGI acquired certain assets from Intergraph Corporation, including the award-winning Zx10 visual workstations and servers—known for their performance, features, and dependability in a Windows NT® environment. The Zx10 line will be exclusively marketed by SGI—complementing its own Intel architecture-based visual workstations.

"This is a tremendous opportunity for both our companies," said Greg Goelz, vice president, Workstations and IA Servers, SGI. "SGI's mission is to deliver industry-leading products and services to our leading-edge technical and creative customers. The Zx10 systems complement our current product offerings very well and enable us to expand our solution offerings for the digital content creation, print and publishing, visual simulation, and manufacturing markets. In addition, the alliance will create a new revenue stream for SGI as Intergraph adds the SGI product line to its portfolio."

"We've been actively seeking a strategic partner for our hardware business, and SGI is a natural fit for us," said Jim Taylor, Intergraph CEO. "This is a good move for Intergraph, strengthening our strategy of providing our customers with complete end-to-end solutions, including technical applications, systems integration, consulting, and services. By offering SGI and Intergraph technology to our customers, we provide a single source for software, services, and hardware with the performance levels that our applications require and our customers need."

Modular Computing:

Evolution and Revolution

"Brick" technology promises to lead high-performance computing into a new era of unprecedented performance and flexibility.

At its launch, SGI branded its new NUMAflex™ modular supercomputing technology "a revolution in the way digital infrastructure will be purchased, assembled, maintained, and upgraded."

Through the new technology, SGI is first to market with a revolutionary, modular approach to building digital infrastructure. Among the many benefits of NUMAflex are:

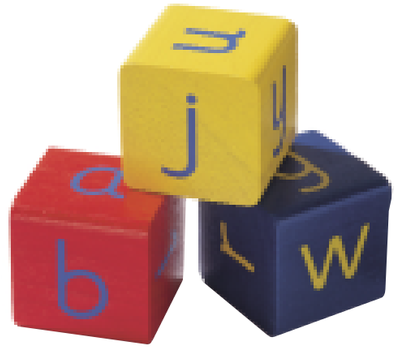
- Flexibility—customers can build the precise configuration they need when they purchase a system (build to suit) and keep the system perpetually sized and balanced to meet their evolving needs (build on demand)
- Resiliency—through nonstop operation and easy component servicing
- Investment protection—through the ability to add new technologies to existing configurations as they become available
- Performance—superior performance and scalability that are unique within the market

These benefits are the result of SGI's extensive experience in NUMA computer architectures. SGI believes that SMP is reaching the limit of its capabilities and that all vendors will have to turn to new architectures to keep up with ultrafast componentry.

SGI is now on its third-generation NUMA architecture, which combines the benefits of SMP (ease of use and scaling) with the unique benefits of modular computing that only SGI NUMA can deliver. NUMAflex also builds on the strengths of the previous-generation ccNUMA architecture from SGI (double the bandwidth and a more than 100% improvement in memory speed)—making it evolutionary as well as revolutionary.

What is modular computing?
With modular systems, you buy the precise configuration you want, spending money on the components you need and saving money on components you don't. This is why SGI predicts that modular computing will ultimately displace all-in-one boxes for high-performance computing.

The first modular computing products based on NUMAflex are the new SGI™ Origin™ 3000 series servers and SGI™ Onyx® 3000 series visualization systems. Because of the evolutionary nature of NUMAflex, these systems provide 100% binary compatibility for user-level applications, while the systems' architectural improvements result in application performance improvements of 30% to 85% or more over ccNUMA—with the same microprocessor technology.



Modular computing also allows selective component upgrades. In the future, when Intel Itanium™ (IA-64) processors come to market, the new systems will deliver the first open source supercomputing platform. And, by the time of McKinley (the second-generation IA-64 microprocessor from Intel), SGI will have introduced open source supercomputers scaling to 2,048 microprocessors in a single system.

NUMAflex modular computing uses a collection of system building blocks—or "bricks"—all complying with the industry-standard 19-inch rack form factor. The bricks include:

- C-bricks for compute and memory (initially MIPS and later IA-64 as well)
- R-bricks (system routers for high-speed module interconnect)
- I-, P-, and X-bricks—first I/O bricks, followed by PCI and XIO expansion bricks
- D-bricks for online disk storage
- G-bricks for InfiniteReality3™ graphics

The systems also feature a modular power system with easy-to-access redundant hot-plug supplies. And, in the future, new bricks will be introduced to cover future I/O interfaces, as well as new scalable graphics options.

Flexibility.
Different applications require different balances of resources. Computational fluid dynamics, for example, requires lots of compute power and less of other resources; broadband distribution requires a tremendous amount of I/O and less compute power. SGI modular computing enables you to buy a comparable solution for less—or, for the majority of customers who purchase on a budget, to buy even more of the components you want with the money you haven't had to spend on unused infrastructure.

Flexibility also means being able to expand the system over time, in precise balance with your changing needs. And it means being able to perform rapid upgrades when requirements increase, satisfy peak demands, or meet a project deadline. The standard form factor also allows SGI to integrate systems into existing rack infrastructures—for instance, into vehicles and trailers for mobile applications. And, with system-partitioned operation, new levels of system availability and serviceability are achieved. When a system component fails, most of the system continues to operate, reducing downtime, minimizing impact, and reducing the time and effort to restore the system to its original state—creating virtually nonstop computing.

Investment protection.
Computer technology is moving forward at ever-increasing speeds. For example among the new I/O technologies, that are currently on the way to market are PCI-X, which should be ramping up by next year, and Infiniband, which holds the promise of gigabyte-per-second I/O in two or three years. NUMAflex modular computing enables you to purchase a system today, knowing that you could add these new technologies in the future. And this applies not only to I/O and compute technologies, but also to future advances in system interconnect and graphics.

Performance.
Processor for processor, the new NUMAflex systems deliver more performance than systems with significantly higher (theoretical) peak performance, because the true power of a system is delivered by the architecture that binds the various components together.

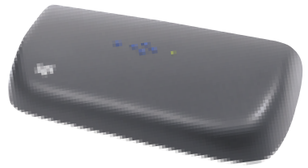
All these benefits come together in the SGI Origin 3000 series and SGI Onyx 3000 series systems. One set of modules makes up the building blocks from which the SGI™ 3000 family systems are built, so you can start with a couple of processors and scale to hundreds of CPUs. And ultimately, thousands of processors and terabytes of physical memory will be supported using this building-block approach.

NUMAflex modules can also be configured into clusters. These enable the achievement of the highest peak performance for the lowest hardware cost and are ideal for users who have throughput-oriented workloads or applications exhibiting high degrees of course parallelism. Should needs change over time, SGI Origin 3000 series systems can also be upgraded to full shared-memory operation by replacing the router interconnect with the SGI NUMA-3 system interconnect for even greater performance.

SGI customers have already enthusiastically embraced the new systems, purchasing more than $100 million in systems before they were even launched. Many of these customers chose to buy them because of the revolutionary benefits of modular computing, combined with the dramatic (and evolutionary) improvements in performance when running existing applications without recompilation.

For more information:
www.sgi.com/features/2000/july/3000/index.html

Bringing Award-Winning Display Technology *to Virtually Any Desktop*



The new Silicon Graphics MultiLink™ Adapter for digital display provides users with the freedom to connect to virtually any video card.

A convenient on-screen display enables precise picture controls, including back-light color temperature adjustment—a feature unique to the Silicon Graphics® 1600SW flat panel display. A multi-resolution scaling feature enables users to view lower-resolution images at full-screen size.

"With the Silicon Graphics MultiLink Adapter, Silicon Graphics 1600SW customers don't have to sacrifice digital quality for analog connectivity when they make their flat panel display purchasing decision," said Joel Ingulsrud, product manager, Flat Panel Display Group, SGI.

"As standards evolve, Silicon Graphics MultiLink provides our customers with the flexibility to migrate their flat panel investment to the interface of their choice. With LVDS, TMDS (DVI/DFP), and analog options, now the ultimate display has the ultimate connectivity."

SGI is working with leading video card manufacturers, including 3dfx, 3Dlabs, Appian, ATI, Matrox, and nvidia, to create SuperWide™ savvy drivers that support the display's native 1600x1024 resolution.

"One of the greatest benefits of the Silicon Graphics MultiLink Adapter is that the leading graphics cards in the world can now drive our SuperWide display," said Ingulsrud. "Once you have used a SuperWide display—whether for wide-aspect video playback, extra tool palettes, or another 10 columns of your spreadsheet—you can never go back."

Winner of more than 20 awards for quality and innovation, the Silicon Graphics 1600SW flat panel display is the top-selling LCD monitor in the 17-inch category. The 1600x1024 high-resolution display delivers stunning image quality and fast pixel response in a stylish, space-saving design. The unique SuperWide monitor format, high image quality, and ergonomic design make it an ideal LCD for business, technical, and creative professionals.

For more information:
www.sgi.com/flatpanel


Scientific Imaging

Superior Performance


Entertainment

Maintaining its position as the premier supplier of visual computing solutions, SGI boosts performance on its Silicon Graphics® O2® visual workstation line.


Visual Simulation


Defense

A new MIPS 400 MHz R12000A™ processor and expanded processor cache and system memory allow the O2 visual workstation to deliver up to a 45% increase in compute performance and a 27% increase in graphics performance over previous-generation systems.

Designed from the ground up to provide powerful 3D graphics, digital media, and image processing capabilities, the O2 line continues to deliver superior performance on a wide range of scientific simulation and digital content creation applications.

O2 leads the workstation industry in texture memory and image processing capacity with support for more than 900MB of resident texture memory from available system memory. Additionally, the integration of all memory resources and the integrated high-bandwidth connection between graphics and system memory allow unique support for real-time video editing and compositing.

The O2 workstation employs the efficient SGI unified memory architecture (UMA), which enables access to nearly unlimited texture capacity by taking maximum advantage of processor advancements. As a result, users see not only the typical compute performance improvements associated with faster processors on traditional systems, but also dramatic gains in graphics performance. This feature, combined with its affordability, makes O2 the ideal modeling station for real-time visual simulation applications.

In the entertainment industry, creative professionals can benefit from the O2 workstation's support for compressed or uncompressed video, excellent compositing performance, and the ability to create high-quality fully textured 3D models.

In the defense industry, as well as for scientific imaging applications, professionals can take advantage of the O2 workstation's high-performance texturing, volume visualization capabilities, and high bandwidth to handle large data sets, which allows users to easily manipulate images in real time while maintaining high-quality resolutions. Its form factor and modular design make O2 easy to deploy in the field. Ruggedized O2 systems are available through third-party vendors.

"We designed the O2 workstation not only to handle the graphics-intensive tasks and applications being used by technical and creative professionals, but also to allow for flexibility and expandability down the line," said Greg Goelz, vice president of marketing, Workstations and IA Servers, SGI. "This foresight translates into an incredible return on investment for customers and ensures that they will continue to see increasingly powerful image processing and data manipulation capabilities on their O2 systems."

O2 workstations can be combined with a comprehensive offering of SGI and third-party peripherals such as award-winning Silicon Graphics 1600SW flat panel displays, dual display options, digital video devices, and other I/O options for professional users.

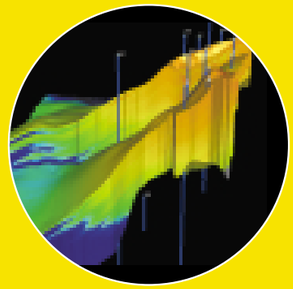
For more information:
www.sgi.com/o2/

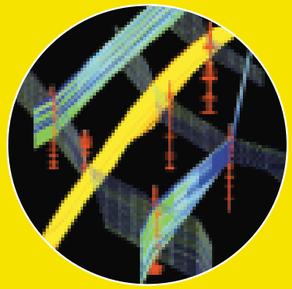
Images courtesy of University Hospital of Rotterdam and Duke University; IMP and Virtual Studio Hamberg; Gemini Technology; and VSM SA and MultiGen, Inc.

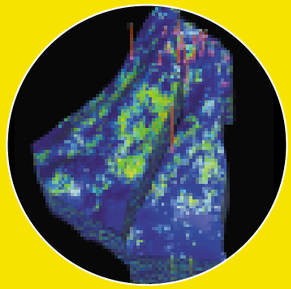
Reinventing

Reservoir Simulation

The world's largest petroleum reservoir simulation system ever installed is powered by SGI.







Images courtesy of Landmark Graphics.

The investment required to develop an oil and gas field is huge, so it is vital that a company has accurate information before it makes a significant financial commitment. The most important question to be answered is how much oil and gas can be optimally produced over time without damaging the asset of the petroleum reservoir. In order to help oil and gas companies in decision making, both before an oil field is active and then throughout its life, oil companies use complex computer simulations of the underground reservoirs where oil and gas are located.

Data from 3D geophysical surveys and exploratory drilling in the area are fed into a computer model to historically match and simulate the future movement of fluids within the reservoir over time. The output of the simulation allows engineers to evaluate hydrocarbon volumes at given pressures and temperatures. They are then in a position to implement the most effective way of recovering the oil. Simulations are used throughout the active life of the field to monitor operations and manage underground assets. These complex calculations may run for several weeks on supercomputer-class machines before the results are ready for analysis.

The Abu Dhabi National Oil Company (ADNOC) is the national oil company of the United Arab Emirates. In 1998, its engineers decided that they wanted to increase the size and resolution of the models they simulate to reduce economic risk. "ADNOC engineers needed a scalable solution that could adapt to the particularly complex simulation requirements for the reservoirs in the Middle East," said Gilbert Soufan, business development manager, for SGI based in Dubai.

ADNOC researched and evaluated several computer and software companies more than six months in search of a solution for its demanding and complex requirements. After benchmarking an SGI Origin™ 2000* server, the decision was made—it came out a clear winner in all categories of performance, ease of use, ease of system management, stability, and versatility.

As a result, and with the help of Emirates Computers, the SGI distributors for the U.A.E., ADNOC commissioned the world's largest production reservoir simulation computer system ever installed. The Origin 2000 solution, which comprises 64 processors, 32GB of memory, and 1TB of disk, now enables ADNOC to simulate production of large, high-definition, full-field reservoir models more accurately and in a period of hours rather than weeks. The resulting time and cost savings have enabled ADNOC to improve efficiency and reduce risk throughout its operations.

*Origin™ 2000 is now being marketed and sold as the SGI™ 2000 series.

The Pepsi Center

The Pepsi Center is a state-of-the-art arena that gives sports fans an unequaled combination of high-tech applications and amenities.

It's Friday night at the Pepsi Center, and the Avalanche have just tied the Sharks at 8:08 of the second period. In their luxury suite far above the ice, the group from the office cheers wildly. Using a Silicon Graphics 1600SW flat panel display with a MicroTouch touch screen, they order hot dogs, Pepsi, and beer, which arrive at the end of the period. Food and drinks in hand, they touch the screen to pull up second-period highlights. They cheer all over again as an SGI Origin 2000 server running MediaBase* streams video clips of outstanding plays to the monitor with spectacular color and sharpness.

Somebody remembers a great play from last week's home game and brings up the highlight for all to see. Two of the women use the touch screen to order Avalanche sweatshirts; their touches generate pull tickets in the retail store, and a runner delivers the sweatshirts to the suite at the end of the game. As they stream out of the arena, other fans are watching the replay of the game-winning goal on touch-screen kiosks around the arena. A great night has been made better by SGI video-on-demand technology.

The new Pepsi Center: An instant sellout.
Denver's dazzling $160 million Pepsi Center opened October 1, 1999 to become the new home of the NHL's Colorado Avalanche and the NBA's Denver Nuggets and to give Denver sports fans a venue that is unequaled for amenities and high-tech flourishes. The center, which seats between 17,000 and 20,000, has scheduled concerts by Celine Dion, the Backstreet Boys, Ricky Martin, and Neil Diamond. But don't bother trying to book one of the 1,854 club-level seats or the 95 luxury suites. They're all sold out on multiyear contracts.

"The people of Colorado have really embraced the building, its amenities, and its features," says Pepsi Center Premium Services and Sales Director Todd Goldstein.

A World-class first: video, refreshments, and souvenirs on demand.
The Pepsi Center boasts a complete Web-based video streaming solution (designed by the local SGI sales team and implemented by SGI Professional Services) that is without parallel at any sports/entertainment facility. Each of the 95 luxury suites includes a Silicon Graphics visual workstation for Windows NT and a Silicon Graphics 1600SW 17-inch 1600x1024 flat panel display—the world's first all-digital, high-performance display system. The system delivers spectacular color and eye-popping resolution unachievable on ordinary desktop systems.

Video of each game is captured by the center's regular production crew for team analysis and training. During the game, editors select highlight clips to build reels that are played on scoreboard screens during period breaks or time outs. The same reels are MPEG1-encoded by an Optivision encoder and routed to MediaBase utilizing two 6-CPU SGI Origin 2000 systems in IRIS FailSafe™ configuration. When a period ends, the server streams broadcast-quality, 3Mb-per-second MPEG1 video highlights to the luxury suites on demand. Silicon Graphics visual workstations easily handle this massive flow of data to deliver video to the flat panel displays.

"SGI is excited to provide the scalable hardware platform to support new broadband multimedia applications like the Pepsi Center," says Greg Estes, vice president and general manager, Telecommunications and Media Group, SGI. "Our broadband technology offers a vast array of innovative video and audio application services at the consumer level."

The monitors are fitted with MicroTouch systems that allow users to interact with Pepsi Center Web pages by touching the screen. They can view highlights, order refreshments or souvenirs, or access a wealth of information about the center and its attractions.

"It's amazing how many people use the system to see the great save at the end of the period or the basket at the buzzer," says Goldstein. "People tell us they look forward to using the replay as much as the event itself. The high-resolution screens are phenomenal. People say, 'I wish we had that at home.'"

Streaming to kiosks and video walls.
The luxury suites are not the only targets of MediaBase. It also streams video-on-demand to 13 public kiosks distributed throughout the arena.

Video walls made up of projection screens in 3x6 or 1x3 format display paid advertising messages above escalators or on concourse walls. The Origin 2000 system uses SGI Video Server Toolkit technology to stream the video in MPEG2 format to a Vela Research decoder, which breaks it down into the NTSC analog video streams required by the video walls.

No other facility in the world enjoys this combination of broadcast-quality video and e-commerce applications—a totally integrated SGI solution that includes image generation, video streaming, flat panel displays, and touch-screen access, designed by SGI. "We were looking for a company that could deliver a technology that is unparalleled at any sports and entertainment venue," says Goldstein. "SGI brought its hardware and software to the table to create a unique partnership with us." At least three arenas that plan to open in the near future have already expressed an interest in the Pepsi Center's breakthrough installation.

For more information:
www.pepsicenter.com

*MediaBase software was developed by SGI and is now marketed and sold by Kasenna, Inc.

Insight

Computing has become an essential and intrinsic component of modern human life. In its short history, information technology has gone from being a curiosity, the province of eccentrics, to the most important tool of the age. Never has this been more clearly demonstrated than in the Human Genome Project, a marriage of biology and computing that has enabled scientists to transcribe the human genome—the book of human life.

Opening the Book of

Human Life

Using awesome computing power, including technology supplied by SGI, teams in Europe, the U.S. and Japan have deciphered the three-billion letter DNA alphabet that shapes and determines human existence. Were it to be published as a single-spaced book, matching the dimensions of this magazine, the transcript of a single human would fill 750,000 pages. Instead, as befits this child of the IT revolution, the information is being made available over the Internet in daily installments, enabling researchers everywhere to carry on this revolution in understanding life itself.

A long and winding code.
The Human Genome Project began as a leap in the dark and has now introduced a new information age. It might never have happened: critics said it would be ridiculously costly and that it would take decades to produce an almost wholly meaningless stream of data encoded in an alphabet of four letters.

When scientists first proposed the idea nearly 20 years ago, it took hours of painstaking effort using phenomenally difficult chemistry to read even a few thousand bits of DNA. The cost was put at $5 to $10 for every letter in the three-billion-letter genome. This has now fallen to around 15 cents, and the first "rough draft" is complete, thanks to astonishing advances in computing and robotics and some subtle tricks with electrochemistry.

The challenge was to decipher the entire DNA of one representative human, selected from a group of anonymous donors. Even at a basic level this seemed almost impossible: before the scientists could read the DNA, they had to make it legible. The DNA of one human is an invisible double-stranded molecule arbitrarily chopped up by nature into 46 chromosomes—23 inherited from the mother and 23 from the father—and twisted into almost unfathomable tangles. It is impossible even to see DNA in this form, much less manipulate or read it.

What the scientists did was to take lengths of human DNA and insert them into bacteria. They then grew the bacteria, much in the way we grow yogurt, allowing each bacterial specimen to clone the same bit of DNA indefinitely, so that it could be preserved in dishes in a human DNA library. Very clever, but this was still the equivalent of tearing random paragraphs out of a book, in the hope of reading them later.

So the first step was to try to make a map of the human genome, that is, to establish recognizable genes, or telltale lengths of DNA, at points along all the chromosomes so that those given the challenge of reading the sequence would start with a rough idea of where, in a particular chapter, their paragraph might fall. That effort continued throughout the 1990s, as individual groups in the worldwide community of biologists began to identify and then locate genes associated with diseases such as muscular dystrophy and cystic fibrosis.

The Human Genome Project began as a leap in the dark and has now introduced a new information age.

But the process also needed to be fast. To read a base pair sequence of a human being out loud—at, say, five letters per second—would take 20 sleepless years. The original method could deliver thousands of letters a day, but the project demanded millions. So what began as a meticulous matter of test-tubes, syringes, and white-coated laboratory staff became rooms full of robots, demanding engineering skills and computing power far greater than were needed for the Apollo program.

The real work begins.
The complete sequence of the human genome may be the crowning achievement of the 20th century, but the real work of understanding how all these genes work together to create a living, breathing organism is only just starting. In a report in a recent issue of *Nature*, George von Dassow and colleagues from the University of Washington in Seattle presented a remarkable essay in simulating the activities of networks of genes as a logical system in a computer—genes in silicon.

The aim is to piece together decades of experimental work into a network representing how genes (and their protein products) interact to create biological structures. This would give an overall understanding of how genes work as a single, dynamic system, something greater than the sum of its individual genetic parts.

As pioneer complexity theorist Stuart Kauffman explained in the July 2000 issue of *Scientific American,* the future of biology will rest on thinking of organisms as "emergent properties" of genomes: the products not so much of genes as of their myriad interactions.

Some might say that the goal of modeling genomic interactions is impossible. Why? Because computer scientists appreciate what molecular biologists have yet to grasp: how hard it is to model the interaction of even a small number of elements in a network. Working out the interactions between each of the approximately 50,000 human genes is an extraordinarily large problem. Even if each gene could occupy just two states—"on" or "off"—the number of possible states would exceed by several orders of magnitude the number of particles in the universe.

The DNA of the future.
Despite the challenges, Henry Gee, a senior editor at *Nature*, has predicted that by 2100 "biology will have changed beyond recognition." It will have a precision close to that of physics, as we begin to understand how genes interact in complex networks. And as we understand how those networks operate, we will be able to interact with them, changing their functions and developing entirely new genomes on computer.

Princeton University Biologist Lee Silver finds the possibilities rather worrying. In his book *Remaking Eden*, he foresees a world 350 years from now where pressure from wealthy parents has leveraged gene and cloning technology to the point where society is divided into two classes: 90% "Naturals" and 10% "Gene-enriched," the latter forming a "modern-day hereditary class of genetic aristocrats" so different from their Natural counterparts that they are effectively another species.

It is this Brave New World aspect of genetic science that has captured—and terrified—the popular imagination. And there are certainly grounds for concern. The first signs of an emerging "genetic underclass" are already being seen, with genetic discrimination taking place in some workplaces. It is now reaching into the areas of adoption and military service. The fear is that people with genetic flaws may be denied insurance, access to schooling, or jobs. And while gene therapy offers the possibility of longer and better lives, will it be for everyone, or only for those who can pay?

It is also hard to see how a greater understanding of genetics can fail to impact on access to insurance. Being able to identify genes that make individuals fall ill will mean painful dilemmas for anyone making long-term financial plans, be they consumers or providers, and difficult decisions for the governments that must arbitrate between them.

According to Gee, one of the possibilities opened up by genetics and genomics will be literally out of this world. We will be able to digitize and store human genomes microscopically, on a chip. When we finally outgrow this planet (and how long can that take?), the genomes of millions of people and other organisms will be shrunk on a chip, placed into a spacecraft the size of a large walnut, and accelerated out of the solar system at 98% lightspeed. Gee predicts that this will happen by 2099.

Although biochemistry and computational biology have existed since the mid-1980s, bioinformatics is a fairly new scientific realm, made possible by the convergence of data-intensive life sciences research, laboratory-automation technologies, and the development of computer databases and algorithms that can rapidly organize, process, and distribute enormous quantities of data.

The complete sequence of the human genome may be the crowning achievement of the 20th century.

Almost overnight, the volume and complexity of biological information has grown exponentially, driving up technical computing infrastructure requirements to manage the data. Larger and increasing numbers of databases, geographically dispersed researchers, and increasingly complex sets of database queries are requiring scalable server and storage systems, higher throughput, sophisticated data mining, data visualization and digital asset management tools, and nimble integration to pull it all together.

Several SGI customers around the world have been working on the Human Genome Project, and SGI has been a leader in the life sciences community for more than 15 years. In the next issue of SYNERGI, we will cover in more detail some of the exciting projects being carried out by SGI customers around the world in the field of bioinformatics.

For more information:
www.sgi.com/chembio

Technology:

Where Is It Taking Us?

By Bob Bishop
Chairman and CEO, SGI

At the recent WIPO (World Intellectual Property Organization) conference on electronic commerce and intellectual property held in Geneva, Bob Bishop, chairman and CEO, SGI, outlined his vision for the future of technology.

Here's what he had to say:

First of all I'd like to talk a little about what we mean by "technology." Basically, technology includes everything that's been invented since you and I were born, so once upon a time even a simple nail was considered to be technology! And this makes an important point, which is that technology cannot be "disinvented." Once it's out there, it's out there—whether it's harnessed for good or for bad.

If good use is made of technology, it can underpin national and economic power. Technology changes the very fabric of society, its look and its feel.

And, especially in transportation and communication, technology gives us individual sovereignty, because it enables us to choose between countless different products and services.

The pace of technological development continues to accelerate. If business is evolving at three times the speed of government and law, and e-business at three times the speed of normal business, then e-business is accelerating at nine times the speed of government. There are also more technologists working today than ever lived before. One example of the impact of this is SGI shipped more compute power in 1999 than in all its previous 18 years combined.

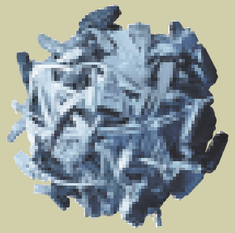
Furthermore (and hardly surprisingly!), technology has become the engine of globalization. Whereas the Concord and the TGV got us halfway there, satellite TV, GSM phones, and now the Internet have made the "global village" a reality. E-commerce and 24x7 markets are both enabled by technology, and we are rapidly heading toward a borderless, boundaryless world.

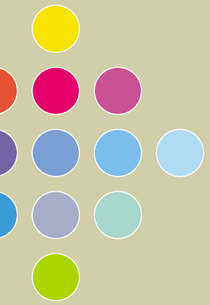
> "Technology changes the very fabric of society, its look and its feel."

But who is in charge? Who sets the rules? Who provides the governance? And who owns what? While many such questions still have yet to be answered, what certainly isn't in doubt is that technology will play an increasingly important role in our 21st century life—sustaining it on the one hand, complicating it on the other; disturbing all our social paradigms, and driving us inevitably forward.

So what does the technology roadmap for the first couple of decades of the 21st century actually look like?

One planet, one network: The "Infosphere". First, Moore's Law for semiconductors will last another 20 years, after which we'll be building devices at the atomic level. Moore's Law states that semiconductors deliver double the performance at half the price every two years. Put another way, this means a four-fold improvement in price/performance every two years; a thousand-fold improvement every 10 years; and a million-fold improvement every 20 years.





So what will this do for us 20 years out? Zero-cost computing and telecommunications will result in a world bathed in information. Second, and as a consequence of this, most services—including government, health, education, entertainment, and commerce—will go online and digital, as will most content such as books, films, music, and video. We can expect that most historical content will be converted into this new digital format. Radio, TV, phone, fax, and the PC will probably converge into a single digital device. Printing, publishing, cinema, and photography will converge into a single, integrated industry. And libraries, art galleries, and museums will converge into a single organization.

It's also likely that we will each have a single ID number that will allow us to roam the world and still receive a single itemized monthly statement listing all the charges for content and services that we have accessed along the way. And while many people may not like this newly emerging digital world—the world of teleworkers, teleconsumers, and televoters—the trends are there for all to see.

Third, intelligent software will do most of the work for us. Modular, componentized, and object-oriented; user-oriented, tolerant, and idiot-proof; voice-driven, visually intensive, personal, and friendly software will give technology a human face.

Finally, a vast array of consumer-oriented, Internet-based, digital products will emerge, incorporating digital cameras, local wireless links, GSM, and GPS. Countless digital chips will be in every house, automobile, and appliance, and in clothing too—flexible, washable, and even dryable. And it's this million-times improvement in price/performance that will take us there—precisely as it got us to where we are over the previous 20 years, from 1980 to 2000.

The new currency—intellectual property.
It would be wrong, however, to think of Moore's Law as the only driving force behind technology today. We also have deregulation, which is powering competition both locally and globally, and venture capital fueling young start-up technology companies.

On top of all this, technology is generally multiplicative, not simply additive—creating an exponential effect as each new technology spawns other new technologies and resulting in higher-level effects. Just some examples where this is becoming increasingly apparent are the new product design processes, the Internet business model, and new e-marketing methods.

The product design process, for example, is now both digital and paperless—a new virtual process encompassing digital prototyping, testing, and simulation; customized manufacturing; build to order; and a zero-inventory business model.

> "As bandwidth is being upgraded from narrow to broadband, so content will be upgraded from text through audio to video streaming."

The Internet business model, meanwhile, is all about chat rooms, bulletin boards, and Web sites; hit rates, eyeballs, and click-throughs; portals, ISPs, ASPs, auction sites, and banner ads; and the enormous market valuations of ".com" companies.

New e-marketing methods pitch transnational versus national marketing; one-on-one versus mass marketing; direct versus indirect marketing; and the removal of the need for traditional middlemen and their replacement by the new infomediaries.

In each of these, content is king, resulting in whole new generations of media and digital intellectual property entrepreneurs.

As bandwidth is being upgraded from narrow to broadband, so content will be upgraded from text through to audio to video streaming. In fact, content and bandwidth are developing at such a pace that the holy grail of live, interactive, full-motion, color videoconferencing around the world at very low cost will soon become an achievable reality.

As a natural consequence of these developments, digital IP will take center stage as the main currency of the 21st century. Already, intellectual property accounts for 20% of world trade (amounting to $740 billion)—a figure that's likely to increase to 50% by the middle of the 21st century.

According to leading copyright/new media lawyer and author Lesley Ellen Harris, the value of digital IP is that it can be perfectly replicated countless times, and so a single copy has much essential value in its own right. By comparison, analog IP invokes a high value for the original, but much lower value for the less-than-perfect duplicates—especially if they are fully distinguishable—whereas for the exact same reasons, stealing digital IP is very easy.

Brave new world?
What about the other major changes that we can expect as we navigate the early days of this new millennium? First, materials science will explode—leveraged by IT. "Smart" materials are on the way that can sense their own state and respond. These include materials that can sense fatigue and erosion; others that can sense temperature, pressure, and sunlight; and yet more that can mimic nature with self-healing and adaptive, biological-type responses.

Such materials will ultimately contain both structural and computing elements: rigid rectilinear designs will become fluid and dynamic when in motion; car tires will change shape as they round corners; and houses will change color with sunshine, flex with the wind, and perhaps even rotate like a sunflower. We will have created an intelligent landscape.

Second, smart materials and IT will ultimately be applied to the human body itself, with major implications for cosmetic surgery, cavity-free teeth, and computer-designed prostheses; the elimination of physical handicaps; organ replacements; and the entire aging process.

Third, genetic engineering may well become the most visible of technologies in the 21st century. Already, genetically modified foods are with us and are indeed causing a tremendous uproar around the world, as witnessed by recent antitrust actions in 30 countries. We also have significant cloning capabilities (as demonstrated by Dolly the sheep). We'll soon have a complete map of the human genome, including all three billion basepairs. And gene therapy is very likely to follow, curing thousands of known diseases, although the politics of who gets access to gene therapy will be hotly contested.

However, and as I touched on at the beginning, who owns all the intellectual property related to all this is a question that is yet to be settled. Does it belong to the individual researcher or jointly to the vast number of researchers who are working on these developments around the world and sharing their knowledge by means of the all-pervasive Internet? Does it belong to corporations, or should it all simply belong to the public domain, as part of nature itself?

> "Releasing the full potential of the human brain is indeed the greatest challenge of the next 100 years."

The political and economic ramifications of IP ownership are enormous, because IP seeks to restrict the use of products and content to those who are willing and able to pay for it. This exclusivity may unfortunately exacerbate the gap between the rich and the poor, creating, for example, agricultural control by a few global chemical companies; unaffordable AIDS treatment in Africa; and a digital divide between the haves and have-nots.

Ostensibly, today's IP protection system is meant to be an economic incentive for the author, the creator, and the developer. But the system may also have unintended negative consequences and, in addition, encroach too much upon the scientific, intellectual, and artistic commons.

The millennium of the mind.
Clearly, intellectual property and technology go hand in hand. One begets the other. Copyright grew up with the printing press, then was adapted to music and theater, and then subsequently to film, radio, TV, VCR, and cable. It survived beautifully. But now copyright must deal with very powerful forces on the Internet, plus an avalanche of emerging technologies.

Will it survive? Yes. In fact, it will become stronger and more important in the 21st century. Nevertheless, adjustments will be necessary; otherwise the industrialized countries will be accused of overcontrolling IP at the expense of the lesser-developed nations. So is it a question of horses nearest the trough drink all the water? Or did we climb the ladder and then kick it off the wall so that no one else could follow?

Finally, by the close of the 21st century, science and technology will be heavily focused on the brain. Today, all six billion of us on the planet Earth are walking around with a brain of similar capacity. So releasing the full potential of the human brain is indeed the greatest challenge of the next 100 years.

We will eventually understand how the brain works at the individual neuron level and be able to treat the brain as a complex electrical circuit, instead of a soup into which we pour more chemicals. We all know that the human species is more intelligent than any individual member. We are all climbing the same path from information through knowledge to wisdom. And we all have the responsibility of increasing the world's mental literacy and creative skills.

Fortunately, we're beginning the new century with brand new, very powerful tools: the Internet, for networking people with complementary knowledge; machine intelligence, to assist and even challenge human thinking; and virtual reality, a new branch of knowledge, a bridge between theory and practice, between analytical and empirical, and a form of being there but without the danger.

These three tools are power tools for the mind. Together they will soon deliver 3D, fully immersive, accelerated learning to anyone, anywhere on the planet, and at any time. And one thing that we can definitely say is that there will be an infinite amount of intellectual property generated in the process.

The past decade has seen rapid progress in our understanding of the human brain, due largely to the availability of greater funding and the development of more powerful neurological research tools.

Linux behind

Brain Imaging Project

Most notably, there have been significant advances in imaging and computer technologies, and SGI has had a key role in developing the computing capabilities at a prestigious new organization that has been set up to capitalize on and to further these advances—the National Foundation for Functional Brain Imaging (NFFBI).

The goal of NFFBI is to improve understanding of mental illness through the application of advanced functional brain imaging techniques. The foundation invests in basic research, clinical research, and technology development in the areas of mental illness, cognitive neuroscience, and cognitive disorders, as well as instrumentation, analysis, and modeling for functional brain imaging.

Much of the foundation's work has been possible because of new imaging modalities such as functional magnetic resonance imaging (fMRI) and improvements in older techniques such as magnetoencephalography and positron emission tomography (PET), all of which can track brain activity noninvasively.

These technological advances promise to reduce patients' exposure to cumbersome and potentially harmful procedures currently required in surgery. For example, noninvasive neuroimaging, used prior to neurosurgery, may eventually reduce or eliminate the need to do invasive intraoperative brain mapping. Intraoperative mapping, which is commonly done in epilepsy and tumor resections, requires the surgeon to stop the surgery in order to wake the patient and conduct stimulation tests for 15 to 20 minutes. The surgeon makes sure that the procedure is not harming a critical area of the brain, then puts the patient back to sleep and resumes the operation. The procedure is painless, but obviously inconvenient and increases the patient's susceptibility to infection.

Making these possibilities a reality requires an enormous research drive. NFFBI, which opened in Albuquerque last year, is an excellent resource for mental health and brain imaging research for New Mexico's universities, national laboratories, and other research organizations. Partners in the organization include Harvard Medical School/Massachusetts General Hospital, the University of Minnesota School of Medicine, and an array of science and technical institutions in New Mexico such as the University of New Mexico, Albuquerque VA Medical Center, Sandia National Laboratories, and Los Alamos National Laboratory.

The foundation and its partners have considerable and exacting IT requirements. Not only do functional brain imaging techniques generate vast quantities of data, but these data call for advanced analysis, modeling, and simulation capacity to derive the needed results. One of the important technical goals of foundation researchers is to combine data from functional magnetic resonance imaging and magnetoencephalography into a four-dimensional (three spatial dimensions plus time) representation of activity in the brain. The resulting spatial-temporal patterns of activity will help to provide a more detailed understanding of both normal brain function and functional abnormalities associated with mental disorders.

As a consequence of this need for high-end computing power, NFFBI has invested in a 32-processor compute cluster based on the SGI™ 1400L server running the Linux operating system. The system installed at NFFBI consists of eight SGI 1400L servers, each equipped with four Intel Pentium® III Xeon™ processors. Software includes Linux, SGI ProPack for Linux™, and SGI Advanced Cluster Environment for Linux to ease cluster management and enhance cluster performance.

The foundation was particularly impressed by the performance that the SGI system offered within its price bracket. As well as raw computing power, the NFFBI was attracted to the SGI solution because SGI compute clusters based on the Linux operating system and the Intel 32-bit architecture lend themselves well to research applications. They have found that as they start asking more and more complex questions, Linux clusters provide the ability not only to find the answers, but also to ask even more complex questions.

The foundation also welcomed the benefits offered by SGI's world-class support organization. They did not have the personnel and technical resources to build their own system from scratch and relied heavily on SGI's experience. In particular, the foundation was impressed by the technical support teams that SGI attached to the project, which NFFBI described as excellent.

A Virtual Tour of a Cultural Treasure:

The Tokyo National Museum

Toshodai-ji Temple, a UNESCO World Heritage Site, has been closed to visitors for the next 10 years during its restoration. But Toppan Printing Co., Ltd., one of the world's largest printing companies, has partnered with SGI to re-create the temple as a large-scale, high-resolution virtual environment.

This remarkable exhibit lets users enjoy Japanese heritage by strolling through the temple's grounds and viewing its interiors as if they were physically there.

Toppan has installed a Silicon Graphics® Onyx2® InfiniteReality2™ system at the Tokyo National Museum to project a real-time, interactive re-creation of the temple onto a 16-foot screen. SGI visualization technology and graphics content developed by Toppan have created a virtual world in which visitors can experience Japan's cultural treasures. SGI and Toppan are working together to bring this state-of-the-art exhibit technology to the museum community.

Experiencing a national treasure.
To preserve Japan's cultural treasures and make them available to the public, the Japanese Ministry of International Trade and Industry provided two billion yen for the creation of digital archives as part of the Content Market Environment Creation Project. Toppan's "Toshodai-ji Temple: Ganjin and the Art of Kaii Higashiyama" was one of 20 successful proposals.

Toshodai-ji Temple is a huge complex of buildings in Nara, Japan's ancient capital, that was founded by the Chinese priest Ganjin Wajo in 759. Ganjin lost his sight on an epic journey to bring Buddhism from China to Japan. His teaching changed the face of Japanese culture and religion in ways that can be seen everywhere in the country today.

The temple, one of Japan's most prominent cultural treasures, includes such architectural treasures as the Kondo, or main temple hall, which houses the seated image of the Rushana Buddha, as well as the Kodo (auditorium) and Koro (drum tower). In the rear of the temple grounds is the Mieido, which contains a seated image of Ganjin. Also in the Mieido are 68 paintings on partitions and walls, completed over 10 years by master painter of Japanese art Kaii Higashiyama, including "The Sound of Waves," "Mountain Clouds," "Yangzhou Shofu (Basho-Style Haiku of Yangzhou)," "Burnt Clouds of Huang Shan," and "Moon Evening in Guilin." Toppan has created high-resolution images around the themes of the temple's main hall, the seated image of the Rushana Buddha, the seated image of Ganji Wajo, and Higashiyama's paintings.

"The use of virtual reality technology at a national museum is a first for Japan and is outstanding even on the international level," says Teiichi Nishioka, head of Toppan's Multimedia Production Division and leader of the exhibit's production team. "Other computer-generated exhibits have been unable to create realistic motion. But the Onyx2 system gives us beautiful, realistic movement." The exhibit projects graphic images at 30 frames per second onto its 16-foot screen. Image resolution exceeds 3,600x1,000 pixels, more than twice the resolution of high-definition television. Visitors use a control pad to move freely about the virtual space, enjoying the illusion that they are in the real temple.

The Onyx2 system creates sophisticated space.
"As a printing company, we like to call this virtual environment software the book of the 21st century," says Nishioka. "We have considerable experience producing comprehensive art collections and printed material relating to museums, and we have assisted with museum exhibitions. Through this experience, we have come to believe that museums will be seen in people's homes using television. When digital terrestrial broadcasting is initiated in 2003, people will be able to use unused bandwidth to download the 500MB 'Toshodai-ji Temple' file in a matter of seconds and view the images from their homes."

Toppan chose SGI for the temple project because of its high-quality, real-time computer graphics. "When we began working on virtual reality systems, SGI was the only firm with the concept of a Reality Center facility. That's why there was no question of choosing anything other than Onyx2," says Nishioka. In April 1998, Toppan opened a virtual reality laboratory in its Tokyo headquarters. The laboratory's first work was "The Sistine Chapel." The laboratory then collaborated with the International Research Center for Japanese Studies to produce the folding screen painting "Rakuchurakugai (Views Inside and Around Kyoto)." Toppan is moving its reality laboratory to a site with four times its current working space, and is working with SGI on technological issues such as video projection. The company is currently developing SGI™ Reality Center™ solutions for customers in the education market.

A world of heritage preservation opportunities.
"Toppan is a premier creator of interactive content for cultural, art, and science museums," says Afshad Mistri, director of Scientific Education & Arts market, SGI. "They have brilliant real-time graphics programmers who know how to exploit the technological advantages of Onyx2. We're proud to be working with them."

"The virtual environment now on display at the Tokyo National Museum shows the limitless opportunities now available to museums to recreate cultural sites and artifacts with very high-quality, high-resolution, interactive experiences using SGI Reality Center technology and the skills of Toppan programmers," said Mistri.

Images courtesy of IPA (Information Technology Promotion Agency) Japan, Toppan Printing Co., Ltd. and Interactive Media Laboratory.

Dossier

The Sky Is *No Longer the Limit*

An exclusive alliance emerges to create spectacular projection breakthrough for planetariums.

SGI, Carl Zeiss Jena GmbH, and SCHNEIDER Laser Technologies AG have announced an alliance that will create a totally new breed of planetarium experiences. The three companies will jointly market solutions that enable the projection of very high-resolution real-time 3D graphics in planetariums.

A specially designed Zeiss All-Dome Projection System based on SCHNEIDER laser technology will project images generated by SGI Onyx 3000 series visualization systems onto immersive domes. The alliance was announced at the International Planetarium Society (IPS) 2000 Conference in Montreal.

The Zeiss All-Dome Projection System is a turnkey display system that creates an immersive, realistic, interactive environment for viewing the universe. SGI Onyx family visualization systems generate each presentation instantly, in real time, from high-resolution digital data stored on high-speed disk systems. Planetariums can use this new projection system to fly visitors through a science-based three-dimensional model of the entire Milky Way. No other graphics system can display this model at such high resolution and quality. The Zeiss All-Dome Projection System can be scaled to domed facilities 10 to 60 feet in diameter.

"Silicon Graphics Onyx2 InfiniteReality3 systems currently provide real-time digital images for public attractions worldwide," said Bob Bishop, chairman and CEO, SGI. "We are delighted to take our products to a new level by working with companies whose names are synonymous with quality imaging and optics. The digital images projected by this new combined system are truly spectacular and ideally suited to planetarium presentations. We have here a dramatic breakthrough in presentation quality and an appropriate environment to showcase SGI's graphics expertise."

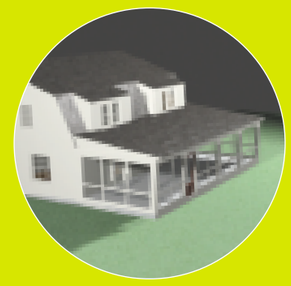
"The next decade will bring massive amounts of data from space explorations. This new medium for planetariums will incorporate real science data and bring them to life, capturing the imagination of audiences by adding insight and inspiration to an educational experience" said Afshad Mistri, director of Marketing, Scientific Education & Arts, SGI.

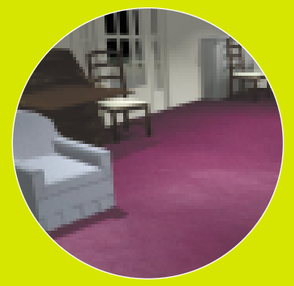
Howard Cook, chief technologist at the Denver Museum of Nature and Science, announced at IPS that they will purchase the SGI/Zeiss/SCHNEIDER system powered an SGI Onyx 3000 series visualization system in its new planetarium facility. "We will replicate the quality of a traditional opto mechnical projector system with the introduction of these new technologies."

"The sky is no longer the limit," said Thomas W. Kraupe, former director of the Munich Planetarium, who was attending IPS 2000 in Montreal. "The digital laser planetarium marks the beginning of a new era: the era of the 'boundless planetarium,' with full creative freedom to stage the dramas and wonders of nature at all scales in space and time, from molecular biology to cosmology, from the beginning to the end of time. With this quantum leap in quality and bandwidth, planetariums will become immersive hands-on windows on the universe. Visitors will become explorers in all branches of science, interacting with the environment in real time. This technology will reinvent the planetarium as a theater that enables whole groups of people to share sensations and compare their experiences. We can expect that this will have a dramatic effect on the public understanding of science for generations to come."

Zeiss and SCHNEIDER will provide the best solution in the industry for projection in domes. SGI will provide its expertise in complete systems integration through Professional Services, thus providing the next generation of planetarium customers with a totally new breed of planetarium experiences. For more information, please contact your local SGI or Zeiss representative.

Image courtesy of SCHNEIDER Laser Technologies AG.





The latest chapter of the Sam Sheppard "fugitive" case.

Seeing Is Believing:

Maya® Software from SGI Has Its Day in Court

First it was DNA analysis. Now 3D visual computing technology from SGI is helping to revolutionize the U.S. judicial system. In courtrooms and criminal investigation offices across the country, SGI technology is being used to solve crimes faster and with more certainty than ever before by allowing prosecutors, police officers, medical examiners, and forensic experts to accurately re-create crime scenes and explain complex evidence to juries in a visual manner.

The outcomes of an increasing number of legal cases nationwide are being influenced by advanced visualization technology from SGI. Using lifelike 3D imagery, this technology literally brings the crime into the courtroom by combining evidence with the laws of physics to portray people, objects, buildings, and entire crime scenes from every conceivable angle—even in motion or rotated in space.

Recently, the FBI used SGI computers and Maya software from Alias|Wavefront, an SGI subsidiary, to assist the State of Ohio in its defense of the civil action brought by Sam Sheppard's estate that he had been wrongfully imprisoned in the legendary case that inspired *The Fugitive* television series and movie.

Using SGI technology, the FBI and prosecuting attorneys built a 3D model of the Sheppard house, which no longer exists, in order to allow the jury members to "walk through" the 1954 crime scene as if the crime happened yesterday. In the latest chapter of the Sheppard case, a Cleveland jury deliberated for less than three hours before ruling in favor of the state.

"There is no better tool for taking a jury into a crime scene so they can observe the physical facts and evaluate them as to what is possible or not possible," said Dean Boland, assistant prosecuting attorney, Cuyahoga County Prosecutor's office. "What is presented to the jury are science-based physical and forensic facts, not conjecture."

SGI technology has also been used to help prosecutors in Idaho win a murder conviction in a case involving the death of an 11-month-old baby. The technology not only helped simplify complicated scientific evidence for the jury, but it also played a role in refuting the defendant's alibi that the baby had fallen down a flight of steps.

"SGI technology made it obvious to the jury that the injuries cited in the medical examiner's report were not consistent with those that would have occurred had the baby really fallen down the steps," said Julian Meehan, deputy prosecutor, Ada County, Idaho. "In the past, prosecutors have been unable to show juries what really happened in cases like this. SGI has helped change that."

"Investigators, police officers, prosecutors, defense lawyers, judges, medical examiners, and forensic experts are just beginning to learn what an effective tool visual computing is and how it can be used in a wide array of cases," added Meehan.

SGI technology isn't confined to just the courtroom. The company's 3D visualization technology is being used across the criminal justice system to re-create explosive devices so that the type and structure of the components can be determined and the perpetrators identified; scan, analyze, and re-create fingerprints, footprints, and tire tracks in burglaries and other crimes; and show the locations and exact dimensions of every door, window, closet, and vent in every room of a building during a bank robbery or hostage situation.

In law enforcement, SGI visualization technology has been used to:

- Help investigators track criminal pollution both on land (from its source through its seepage into the soil and its entry into the water table) and at sea (working backward to identify the offending shipboard pipe, as well as tracing the flow all the way through ocean currents to shore)
- Analyze bullet trajectory after a shooting, to show the full range of possibilities—such as which directions the bullet could and could not have come from, where it entered the victim's body, what path it took within the body, and the angle at which it exited and entered a wall
- Graphically display the flow of drug money from person to person, from bank to bank, and from place to place in a complicated money-laundering case

Images courtesy of Cuyahoga County Prosecutor's Office.

We were promised the Information Superhighway, yet for many users the Internet has been more like an urban street with a restrictive speed limit. As the World Wide Web became known as the world wide wait, anticipation turned to frustration. The widespread introduction of broadband is changing all this. It is also ushering in a new era of Internet applications.

Switching to Broadband

The name broadband refers to its capacity to transmit data up to 25 times faster than current modems. While many corporations already enjoy the benefits of broadband through leased lines and private networks, these require a substantial investment. Companies in the media industry, for example, regard the regular exchange of high-resolution pictures as a basic part of their operations and are willing to pay the necessary price. Generally, smaller companies have not been able to justify the expense, although ISDN connections, which operate at between two to four times normal modem speed, have been one alternative.

The broadband services currently being introduced are targeted at consumer and home office use. The aim is to open up this new market without losing the lucrative corporate market for private networks. Current contracts often contain usage exclusions, such as linking to a Web server, to dissuade companies from switching to the cheaper public service. Competitive pressure will, however, overcome such obvious marketing ploys and bring down the costs of broadband transmission for large business and consumers alike.

Most home users and small businesses have been reliant on the telephone system for connection to the Internet. The maximum speed at which information is received from the Internet via telephone lines is typically 56Kb per second. This is adequate for sending e-mail and browsing static Web pages, but it does not support the viewing of high-quality video and the transfer of large files.

Apart from speed, the other advantage of broadband is that the user is always connected, while a PC is switched on. There is no need to dial up and wait to be connected, e-mails will arrive as they are sent, and there will be no bills based on per-minute usage. There are four main options: cable, digital subscriber lines (DSL), wireless, and satellite.

Images courtesy of Nokia.

Cable lines are being rolled out where cable television services already exist. Cable can be faster then DSL, but as the number of users on the line increases, each user gets a smaller share of bandwidth and performance goes down. Cable may also be cheaper than DSL depending on whether there is already a cable television service in the area. Download times are from 1 to 10Mb per second; upload times are from 128Kb to 10Mb per second. Because of the widespread availability of cable television in the U.S., cable has led the way in broadband service there. In the early days, there was some concern about security arising from the fact that lines are shared. In certain situations, users could see someone else's PC files; however, these issues have now been addressed.

DSL technology utilizes the untapped capacity of traditional copper telephone lines. In contrast to cable, a DSL connection is a dedicated service that goes straight from the user's PC to a phone company switch. It may therefore offer more reliability for business users. It provides about 2Mb per second download and about 500Kb per second upload. As yet, there is limited availability and higher cost in some areas because users have to be close to a telephone transmitter or exchange. The telephone company sets up the service by sending a technician to the user's location to install a splitter and test the telephone lines.

The ADSL (asymmetric digital subscriber line) service is now rolling out across Europe. Asymmetric refers to the uneven flow of data. Client-to-server speeds are generally slower because there is less demand for sending data to the Internet than for retrieving material from it. IDSL, which is ADSL-type technology over an ISDN line, is now on trial in the U.S. This will allow users to be a greater distance from the telephone transmitter.

There are alternative DSL technologies being developed, such as the G-Lite standard, approved in the U.S. in 1999. This will be easier for service providers to roll out as it does not require a splitter and it works in places where conventional DSL modems will not work. Users will be able to buy and install the modem themselves or obtain it already installed on a new PC.

Various new wireless technologies are making an appearance. These transmit data using next-generation mobile phone technology to a central base station that connects to a high-speed wired network. The major benefit of these is that they allow users to be mobile. GPRS (general package radio service), expected by the end of 2000, will sustain data transfer rates of 128Kb per second. Universal mobile telecommunications system (UMTS), due to arrive in 2002, will reach speeds of more than 3Mb per second.

Data can also be beamed to your PC from a satellite like the ones used for satellite television. Download speeds of up to 2Mb per second can be achieved. One advantage is that this method will work in rural areas where wire-based high-speed lines are not available. It is, however, for downloading only; uploading must be done through normal phone lines. Installation is more difficult and costly, but various companies have big plans in this area, and as new satellites are launched, this option will become more feasible.

The most talked-about applications for broadband are related to the entertainment business, and interest in this area has been a key driver in the development of mass broadband services. For many people, video-on-demand, CD-quality audio, and more sophisticated games are the biggest attractions.

At the same time, some people do not want to be tied to a PC and would like Internet access via a digital television. Multitasking also has its appeal—today's consumers want to be able to watch television, send and receive faxes, surf the Web and talk on the telephone using existing lines. They also want to consolidate their fees into one bill from one supplier. Potential demand is so big that experts predict that by 2002, half of all Internet users will be on broadband.

Meetings and conferences conducted over the Internet in real time will become much easier. In theory, people will need to travel less on a regular basis and home working will become even more viable. Interactive e-shopping will increase, distance learning will be more like the face-to-face experience, and medical diagnosis could take place without doctor and patient meeting. Yet, the most far-reaching effects are in the longer term.

With a broadband connection that is always on, there is no need for a user's individual machine to have actual computing power or to store software. It will make far more sense for users to license the use of hardware and software when they need it through the ASP (application service provision) model. Users will not need to purchase, maintain, and upgrade software or hardware. They will have access to a server much more powerful than a PC and to applications that they might not consider owning.

This is the point at which the PC becomes irrelevant. Voice recognition on mobile phones will also help to make keyboards redundant. A slim Web terminal with a simple interface, known as an edge of network (EON) device, will be all that is required. This opens the way for all sorts of smart appliances that will intelligently run a home, office, or factory based on remote messaging.

The year 2000 will go down as the year in which the Internet really asserted itself, when media-rich content previously restricted to networked users became available to the masses. SGI has traditionally met the needs of corporate users; now it is working with Web businesses to meet consumer demand for high-resolution graphics, media streaming, and digital asset management.

www.shareaphoto.com is just one example of a business that utilizes SGI servers to take advantage of broadband capability. The company enables individuals to create an online photo album to which they can direct family and friends. SGI has a strategic alliance with WAM!NET Inc., a fast-growing digital network company that specializes in high-speed transportation and storage of digital media.

For more information:
www.sgi.com/solutions/broadband

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We hope you have enjoyed reading this issue of SYNERGI, the SGI magazine of innovation, inspiration, and insight for the U.S. and Canada. As part of our commitment to continuous improvement, we would appreciate it if you would take the time to fill out the attached questionnaire and give us feedback for future issues of SYNERGI. Please complete the form and fax it back to the number shown. Many thanks for your help.

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