Chapter 7

Information, Computers and Communications

Communication Intelligence Corporation #1 100
Computer Recognition of Natural Handwriting

Communication Intelligence Corporation #2 103
Chinese Character-Recognition Methods for Computer Data Entry

Engineering Animation, Inc. 105
Three-Dimensional Anatomy of Human Body, With Animation, for Medical Training

ETOM Technologies, Inc. 109
Packing More Data Into Optical Data-Storage Disks

Mathematical Technologies Inc. 111
Mathematical Technology to Restore or Enhance Movies

Torrent Systems, Inc. 114
A User-Friendly Programmer's Tool for Writing Parallel-Processing Software

Communication Intelligence Corporation (CIC)

Computer Recognition of Natural Handwriting

Since the beginning of the computer age during World War II, virtually all data have been entered into computers via the keyboard. Teletype machines were adapted so that typing created a punched paper tape, which was read by a second device attached to the computer. Later, the key-punch machine was developed; it created holes in cards that were read by a card reader connected to the computer. In time, keyboards were used to enter data directly into computers, first via terminals connected to main-frame computers, and then for desktop computers as well.

A computer user entering information into her PC with a pad and stylus. Company software in the PC converts the data from the pad into letters and words.

Handwriting: An Easier Way to Enter Computer Data

Each development advanced the science of data entry, but keyboards have continued to be problematic. Some people cannot use them because of physical limitations, such as arthritis or carpal tunnel syndrome, or because they do not know how to type. Others find them difficult to use in particular settings and circumstances, such as conducting inventory on the shop floor or a geology survey in the wilderness, where using a keyboard is cumbersome. Difficulty in using keyboards and their inappropriateness in certain situations were seen as two of the obstacles limiting computer use to only about 5 percent of the U.S. population when this project was proposed in ATP's first competition in 1990.

Software That Recognizes Cursive Writing

Communication Intelligence Corporation (CIC), a small California company spun off from SRI International (formerly Stanford Research Institute), has addressed these keyboard problems by using technology created in its ATP project for a reliable, cost-effective alternative: a stylus and pad that can be used by the computer to "read" handwriting. The hardware was simple to implement, since touch-sensitive pads already existed. The difficult part was perfecting techniques for software that would effectively recognize fully cursive handwriting.

CIC researchers accomplished this technical goal during the project by collecting a database with thousands of cursive handwriting samples and developing new recognition algorithms. After analyzing the handwriting-sample database and developing the recognition methods, they also developed procedures that permit fast computation with modest computer memory requirements.

. . . received, in early 1997, the "Ease-of-Use Seal of Commendation" from the Commendation Program of the Arthritis Foundation . . .

PROJECT:

To develop a natural handwriting data-entry system for computers for applications where pen-based entry works best and for use by people who do not or cannot use a keyboard.

Duration : 4/1/1991 — 9/30/1993
ATP number: 90-01-0210

FUNDING (IN THOUSANDS):

ATP	$1,264	58%
Company	912	42%
Total	$2,176	

ACCOMPLISHMENTS:

CIC developed new data-entry software technology that recognizes each user's natural handwriting without "training" the computer or the user. The company:

- incorporated some of the ATP-funded technology into an existing software product, Handwriter®, giving it the ability to recognize connected letters in cursive writing in limited circumstances (previously, it recognized only handprinting);
- licensed the Handwriter® software to more than a dozen computer manufacturers around the world, generating $360,000 in revenue from sales of 30,000 units in 1997;
- launched a new product in 1996 called Handwriter® Mx™, a stylus-and-tablet data-entry device using the upgraded Handwriter® software;
- sold 11,000 copies of Handwriter® Mx™ in 1997, with sales totaling more than $2.2 million; and
- received, in early 1997, the "Ease-of-Use Seal of Commendation" from the Commendation Program of the Arthritis Foundation, for the company's Handwriter products — indicating their value to disabled people who have trouble with keyboard entry.

COMMERCIALIZATION STATUS:

The ATP-funded software technology is widely licensed, and a new product fully incorporating the software is due on the market soon. Both are generating revenue.

OUTLOOK:

The outlook for this technology is strong, since it opens up possibilities for much wider use of computers and expanded market opportunities for U.S. producers of hardware and software. The potential is likely to increase further as languages other than English are incorporated into the approach. The company is actively seeking additional market opportunities for further distribution of its products.

COMPANY:

Communication Intelligence Corporation (CIC)
275 Shoreline Drive, Sixth Floor
Redwood Shores, CA 94065

Contact: Russ Davis
Phone: (650) 802-7757

Number of employees:
33 at project start, 93 at the end of 1997

New and Upgraded Products

Prior to its ATP project, CIC was marketing a software product called Handwriter®, which could recognize handwritten printing but not cursive writing. The company has now incorporated some components of the ATP-funded technology into Handwriter®. Even though the technology for recognizing fully cursive handwriting has been developed, the upgraded software currently available commercially cannot yet read fully cursive handwriting. It is able to recognize connected letters in cursive writing in limited circumstances, however. CIC has licensed Handwriter® to most of the PC manufacturers in the world, and the upgraded Handwriter® software is now incorporated in a number of pen-based, hand-held computer devices on the market.

. . . this technology . . . opens up possibilities for much wider use of computers and expanded market opportunities for U.S. producers of hardware and software.

The company also developed two new consumer products based on the ATP-funded technology. One product is Handwriter® Mx™, which includes a stylus and pad, as well as the upgraded Handwriter® software. In late 1996, CIC began marketing Handwriter® Mx™ in a large computer chain, with a retail price of about $200. The other product, Handwriter® fx™, also contains the upgraded software but has a larger writing pad and other features useful to graphics artists. In early 1997, CIC began marketing it in the same computer chain. During that year, the company sold more than 11,000 units of these two products, generating revenues in excess of $2.2 million.

Company officials say the Handwriter® software will be upgraded again in the near future to fully recognize cursive handwriting. One barrier to complete implementation of the ATP-funded technology has been the need for tuning the software system to operate with the standard amount of memory available in modern desktop computers and to run fast enough to keep up with a typical person's handwriting speed. That obstacle is now being addressed.

Broadening Access to Computers

CIC's handwriting-recognition system should prove extremely beneficial. Computer users are now able to enter data via the digitizer tablet, as well as by keyboard or other means. This advance makes computers more useful for more people, especially those whose keyboard use is limited by physical problems or other circumstances. Other computer users may find a note-taking stylus a useful adjunct to the keyboard. For some jobs, particularly those that involve field work, the pen-based computer is the only reasonable solution, and the benefits of having it may be quite high for the user.

As more languages besides English are added to the software, users who write in these languages will benefit from using a handwriting input device that readily accepts all manner of handwriting styles. Markets for hardware and software should expand in response to wider use of computers and related products.

. . . thousands of cursive handwriting samples . . . new recognition algorithims . . . fast computations . . .

CIC projected at the start of the project in 1991 that the overall research, development and marketing effort needed to get to market would take four to five years.

ATP Partnership Speeds Technology Development

ATP's participation in this project advanced development of the technology by 18 to 24 months and improved the company's credibility with commercial partners. This credibility was important in establishing the licensing and manufacturing relationships needed for rapid commercial deployment of the technology.

The history of this ATP project offers a good example of the amount of time needed by a well-run program to both develop and commercialize a new technology. CIC estimated at the start of the project in 1991 that the overall research, development and marketing effort needed to get to market would take four to five years. In 1996, three years after completing the two-and-a-half year ATP research project, the company launched Handwriter® Mx™, and in 1998, seven years from the time the project began, the company was nearing release of a new software version that fully met the original goals.

Help for Victims of Arthritis

In early 1997 the Arthritis Foundation awarded CIC its "Ease-of-Use Seal of Commendation" for the company's Handwriter products. The Foundation's Commendation Program, founded in the late 1980's, recognizes products and packaging that are particularly accessible and easy to use. The award followed a favorable review by health professionals and arthritis patients.

Communication Intelligence Corporation (CIC)

Chinese Character-Recognition Methods for Computer Data Entry

China is the world's most populous country, and in the last decade its economy has begun to mushroom. Because modern economies rely heavily on computers, the potential market for computers in China has grown along with its economy.

Accessing China's Giant Computer Market Potential

A major technical problem, however, impedes the widespread use of computers in China: the Chinese language is ideographic, using symbols to form characters representing things or ideas rather than letters to form words. Written Chinese employs thousands of symbols, as opposed to the 26 letters used in written English. Some keyboard methods exist for entering Chinese characters into a computer, but they are laborious. This technical barrier means that the large potential Chinese market is not readily accessible to U.S. computer businesses.

This ATP project enabled Communication Intelligence Corporation (CIC), a small California company, to develop a stylus-and-tablet method for writing Chinese directly into a computer. CIC is a spin-off from SRI International (formerly Stanford Research Institute) and was founded in 1984 to commercialize English handwriting recognition technology. In its first ATP project, CIC developed technology for a digitized stylus-and-pad system that can be used to enter cursive handwriting in English into a computer. In this second ATP project, CIC applied several techniques from its earlier work: using a tablet and stylus to record pen strokes, getting tablet sensory data into the computer and using algorithms to convert graphics signals to digital form. In addition, the company created a way to recognize handwritten Chinese characters.

. . . the large potential Chinese market is not readily accessible to U.S. computer businesses.

A screenful of Chinese characters, with one in the process of being composed. They were entered into the computer after being written on a pad using a stylus.

A System That Recognizes Nonalphabetic Writing

For the foundation of its system, CIC developed a high-quality database of about 750,000 characters penned by 2,800 Chinese writers. It also developed an algorithm that recognizes 6,763 Guojia Biaozhun characters, the standard set of characters determined by the Chinese government to be used by schools, publishers and other institutions. The technology can be applied to personal computers in the People's Republic of China, the Republic of China, Taiwan and countries such as Japan and Korea, where Chinese characters are part of the written language.

The technology will also be useful in applications for other languages that use nonalphabetic writing. Most important is Japanese, which uses symbols to represent the syllables of words and employs two different syllable sets — hiragana (made with more-flowing strokes) and katakana (made with more-angular strokes). Application to handwritten Japanese is also complicated by the interspersion of Chinese characters and English words in Japanese writing.

. . . entered into discussions with several major U.S. computer companies about incorporating the CIC character recognition technology into their computers for sale in China.

Entering the Chinese Market

The company has entered into a joint venture, which is called CICC and has 50 employees, with the Ministry of Electronic Industries of Jiangsu (the coastal province that includes Shanghai). Under the agreement, CIC will perform system integration services and market its pen-based business computer systems (incorporating the ATP-funded technology) to Chinese business and government users. The goal of the venture is to develop and market a "Chinese computer" designed specifically to meet Chinese business requirements.

Part of the agreement specifies that the company will package U.S. hardware and office automation software as part of the Chinese computer. To implement this agreement, CIC is in discussions with several major U.S. computer companies about installing the CIC character-recognition software in their products before selling them in the Chinese market.

The sale of its products in the Chinese market will open a huge opportunity for CIC, as well as many other U.S. sellers of personal computer hardware and software in China. For a country with a population of about one billion (few of whom now use computers), the potential market is vast. But solving the technical barrier to entering data in Chinese was a necessary step in actualizing the market and making it accessible to U.S. producers of computers and computer products.

ATP Accelerates Technology Development

CIC officials say the company was able to accomplish this technology development 18 to 24 months sooner than it could have without the ATP funds. Moreover, the ATP award helped the company develop licensing agreements and secure a joint-venture partner.

. . . the ATP award helped the company develop licensing agreements and secure a joint-venture partner.

PROJECT:

To develop a Chinese character-recognition system to be used in place of a keyboard for computer entry of information in Chinese, opening Chinese markets to U.S. computer products.

Duration: 12/20/1993 — 3/19/1996
ATP number: 93-01-0211

FUNDING (IN THOUSANDS):

ATP	$1,480	62%
Company	911	38%
Total	$2,391	

ACCOMPLISHMENTS:

CIC fulfilled its goals by developing a recognition system for Chinese characters. The company's progress is indicated by the fact that it:

- collected a high-quality database of about 750,000 Chinese characters penned by 2,800 Chinese writers;
- developed a recognition algorithm that supports 6,763 Guojia Biaozhun characters, the standard set of characters determined by the Chinese government to be used by printers, schools and so forth;
- entered into a joint venture with the Ministry of Electronic Industries of Jiangsu Province, China, to perform system integration services and to market the company's pen-based business computer systems to Chinese businesses and government agencies;
- released the first major product version of its character-recognition software in September 1997; and
- entered into discussions with several major U.S. computer companies about incorporating the CIC character recognition technology into their computers for sale in China.

COMMERCIALIZATION STATUS:

Commercialization is in progress. CIC recently closed its first major deal with a Chinese company to incorporate the ATP-funded technology into its products. CIC is also in discussions with major U.S. computer companies to incorporate the technology into their products for China.

OUTLOOK:

Benefits from this project are expected to accrue to U.S. companies through U.S. leadership in China's computer market, the development of computer standards in China based on U.S. technology and large direct sales of U.S. computer components into China's markets.

COMPANY:

Communication Intelligence Corporation (CIC)
275 Shoreline Drive, Suite 520
Redwood Shores, CA 94065-1413

Contact: Russ Davis
Phone: (650) 802-7757

Number of employees:
66 at project start, 93 at the end of 1997

Engineering Animation, Inc. (EAI)

Three-Dimensional Anatomy of Human Body, With Animation, for Medical Training

Every day, surgeons operate on thousands of patients around the country. For each operation, the surgeon and support staff have trained in some way to perform the delicate surgical procedures, some of them training on cadavers in medical school and others learning by doing. For each operation, the patient has gone through a learning experience as well, via conversations with doctors and nurses, while first considering and then preparing for the surgery. Occasionally, patients get to see a video of another person undergoing the procedure to be performed on them.

Animated 3D Anatomy

This ATP project enabled Engineering Animation, Inc. (EAI) — a small company founded in 1988 in Ames, Iowa, and specializing in three-dimensional (3D) visualization — to develop a new set of computer-based technologies for making training tools to help surgeons and patients better understand important aspects of surgical procedures before they are performed. The technology was developed for use in health care, medical research, medical education, surgical planning, rehabilitation equipment design and patient education prior to surgery.

EAI was established to create software that can show animated 3D objects, and its initial products were used in court cases to present "re-enactments" of car crashes and other events. The company sought ATP funding to develop new methods that would enable it to extend its technical capabilities to depict the inner parts of the body, not just the exterior. In the process, the company hoped to extend understanding of human anatomy. Its attempts would be path-breaking, since there were then no other known efforts to gather digital anatomical data from different sources into one uniform database or to present that data in 3D motion.

The breathing patterns of asthma patients are demonstrated with a computer-generated dynamic model of the lungs. This is one of a sequence of images — the next one in the sequence has the ribs removed.

The 3D aspect is critical, because flat pictures do not provide enough information for a good understanding of anatomy and surgical procedures.

"Walk-Through" Surgery

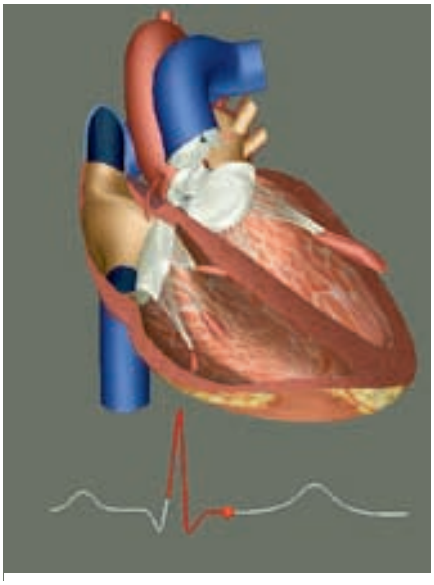
During the ATP project, EAI researchers developed algorithms for a system that can show realistic 3D images of human body parts and their motion. The pictures of tissues and organs can be manipulated to present a "walk-through" of surgery. The 3D aspect is critical, because flat pictures do not provide enough information for a good understanding of anatomy and surgical procedures. Dynamics, or animation, is also important because joints bend, the heart beats and the lungs contract and expand. Seeing these motions is extremely useful to surgeons planning an operation. Realism, too, is critical so that the images look like natural anatomy.

The realism of these images was achieved by using new databases with digitized, two-dimensional (2D) images showing cross-sections of human cadavers from head to toe. Several organizations provided these databases, including a highly detailed one from the National Library of Medicine. Using newly developed methods to combine 2D images, the researchers put together a complete 3D representation of the human body, including the exterior and all distinct interior parts.

With its ATP award, EAI developed large databases with detailed, digitized images of a generic human body and the associated technologies for storing and accessing the information. The project succeeded in depicting the whole body (male and female versions) as a 3D computer-generated image, as well as separately showing each interior part — bones, muscles, heart, lungs, brain and so forth.

Software Tools Commercialized

Substantial commercialization has been achieved and further effort is under way. After making sufficient progress on the research and development work of the ATP project, EAI used



A snapshot of the beating human heart shown with the output of an EKG, at one point in time. In use, both are dynamic — the heart beats in time with the EKG, so medical students can visualize the relation of the beating heart to electrical impulses captured by the EKG.

its own funds to combine the new technology and databases with its existing software in a new product — the Virtual Human — for use in medical training. The company began offering the Virtual Human at the end of the ATP funding period but was unable to sell a single copy of it because the hardware was so expensive. The costs for setting up the system using a Silicon Graphics workstation and the Unix operating system ran as high as $100,000. The company delayed commercialization of that product to modify the software and databases to operate on lower-cost personal computers running the Microsoft NT operating system. The company has recently successfully converted other products to run on the lower-cost systems, and is on track to do the same for products derived from the Virtual Human product.

In the meantime, much of the ATP-funded technology that went into the Virtual Human has been adapted to three CD-ROMs (The Dissectable Human™, The Dynamic Human™ and CardioViewer 3D™) and two medical books which use unique prints show-

. . . 20 employees at project start, 400 at the end of 1997 . . .

PROJECT:

To develop computer visualization and computational dynamics technology for presenting animated 3D images of the human body and its parts in order to improve medical education and surgical simulation.

Duration: 7/1/92 — 6/30/95
ATP number: 91-01-0184

FUNDING (IN THOUSANDS):

ATP	$1,947	76%
Company	625	24%
Total	$2,572	

ACCOMPLISHMENTS:

EAI developed core algorithms to enable the creation of 3D images from sets of 2D cross-sectional images of the human body. Researchers organized and integrated these digitized images in a large database and developed the technology to present them as animated visualizations of human anatomy. The company also:

- received the Smithsonian Award from *Computerworld* magazine in 1994, for the use of information technology in the field of medicine;
- received the Award of Excellence in Animation from the Association of Medical Illustrators in 1995;
- was a finalist, together with Walt Disney Studios, in the International ANNIE Awards category in 1995, for best animations in the film industry;
- produced and started offering the Virtual Human software, to run on a Silicon Graphics workstation, in June 1995;
- adapted the Virtual Human technology for three CD-ROMs using dynamic 3D visualization and for two publications, all of which are now on the market;
- incorporated the ATP-funded technology in the tools EAI uses to provide custom modeling in biomedicine, health education and custom animation;
- raised $30.5 million via an initial public stock offering in February 1996;
- opened international offices in 1997 and 1998, in England, France, Germany, Italy, and Malaysia;
- received one of the 25 Technology and Innovation Awards from *Industry Week* in 1996;
- entered into an agreement in January 1997 to develop software that supports Endovascular Technologies' Endovascular Grafting System — a less-invasive, less-costly alternative to open vascular surgery that should lead to lower mortality, fewer complications, shorter hospital stays and quicker recoveries;
- raised another $26.6 million via a second public stock offering in June 1997;
- was named one of "America's Fastest Growing Companies" by *Individual Investor* magazine, September, 1997;
- had its CEO, Matthew Rizai, recognized as one of the best entrepreneurs of 1997 by *Business Week* magazine, January 12, 1998; and
- was recognized as one of the 100 most dynamic technology companies in the US — with a rank of number eight — by *Forbes ASAP* magazine, Feb. 23, 1998.

COMMERCIALIZATION STATUS:

The new computer visualization and computational dynamics technology developed in this project has been successfully commercialized. Though an early product called the "Virtual Human" was not commercially successful because it could only be run on a very expensive work station, much of the technology was adapted for three CD-ROMs and two print publications and has also been used to create CD-ROMs that supplement medical books and are sold as a bundled package. Increased sales of medical books are attributed to the CD-ROMs. Software to support open vascular surgery is being tested and has shown promising results. This rapidly expanding company is now active in a multiplicity of applications featuring 3D animations which utilize computer visualization and computational dynamics.

OUTLOOK:

Further potential applications of the technical capabilities developed in the ATP project — and extended by subsequent research and product development — appear abundant. When a reduced-price hardware/software system to support the Virtual Human technology becomes available, potential economy-wide benefits should be large as a result of likely wide-spread use of the technology in health care.

COMPANY:

Engineering Animation, Inc. (EAI)
2625 N. Loop Drive
Ames, IA 50010

Contact: Mike Sellberg
Phone: (515) 296-9908

Number of employees:
20 at project start, 400 at the end of 1997

Informal collaborators: The Mayo Clinic, Biomechanics Laboratory; Johns Hopkins University

. . . much of the ATP-funded technology has been adapted to three CD-ROMs (The Dissectable Human™, The Dynamic Human™ and CardioViewer 3D™) and two medical books . . .

ing layers of body parts. All five products are now being marketed by Mosby-Year Book, a subsidiary of Times-Mirror. In addition, EAI has formed an alliance with Elsevier Science to create 3D multimedia titles in the neuroscience area. These products have achieved several of EAI's original marketing objectives and have been used successfully in training medical students. One professor who used The Dynamic Human™ as a teaching aid reported that her students "seem to retain more information after using this visual tool" and "are more excited about anatomy and physiology when the material is viewed with 3D animation and graphics on a computer screen."[1] The company has also incorporated its ATP-funded technology, both the anatomical database and the motion capability, in the tools it uses to provide custom modeling in biomedicine, health education, human body animation, and entertainment.

EAI is especially interested in offering its software as training tools for surgery via laparoscopy (for example, using a laparoscope to look into the abdomen) or other less-invasive surgical procedures. One candidate for this type of treatment is abdominal aortic aneurysm, which afflicts 1.5 million people in the United States each year. If left untreated, the aorta can rupture, usually causing death. This type of open-surgery repair has a morbidity rate of 15 percent to 40 percent.

In January 1997, EAI entered into an agreement to develop software that will support Endovascular Technologies's Endovascular Grafting System, a less-invasive, less-costly alternative to open vascular surgery that should lead to lower mortality, fewer complications, shorter hospital stays and quicker patient recoveries. The software will automatically calculate key aortic measurements, based on actual CT (computerized tomography) data, and enable doctors to "walk through" a patient's anatomy on the computer. The software allows doctors to identify structures, discern damaged and healthy tissue, and determine a patient's condition without performing invasive procedures. This application is directly dependent on the technology developed by the ATP project.

A person's body is more than just the "dry bones" of the skeleton; here the heart and major arteries and veins are shown in their proper places within or along-side the bones.

Better-Trained Doctors

The CD-ROMs and books developed or bundled with the new technology and databases have benefited anatomy and physiology students. The successful modification of the Virtual Human product for less-expensive computers, which will bring down the cost of the complete system, has the potential for creating large economy-wide benefits. In many areas of surgery, less-physically invasive procedures are replacing traditional techniques. Angioplasty, for example, can often be used instead of open surgery to repair blood vessels. If the Virtual Human proves valuable in training for these and other surgical techniques, then less-invasive procedures would likely be used more often in surgery. And by reducing the need for painful, highly invasive surgeries, the ATP-funded technology would lower the costs and improve the quality of health care. If this happens, the value of the resulting benefits will be counted in the hundreds, possibly thousands, of dollars for each patient treated by a doctor trained with the system — and could amount to life itself.

One professor who used The Dynamic Human™ as a teaching aid reported that her students "seem to retain more information after using this visual tool" . . .

Transition from Consulting to Software Products

At the beginning of the ATP award period, June 1992, the company had 20 employees. By the end of 1997 it had 400 employees, and near the end of 1998 it had more than 900. Total revenues in 1992 were $1 million. By 1994 they had grown to $5.5 million, and in 1996 they were $20.4 million. By 1997, after accounting for mergers, revenues had grown to $49.7 million.

EAI reports that the ATP project was a huge part of this commercial success. "This cost sharing enabled us to assemble technology," said Dr. Martin Vanderploeg, EAI executive vice-president, in 1994 during the ATP project. "The award was a major event that launched us into this growth phase," he added.[2] In 1994, EAI's total expenditures on research and development were $869,000, and in that year it received $564,000 from its ATP grant, about 65% of its total research and development budget.

When it applied for the ATP grant in 1991, EAI's only revenues were from consulting fees for providing support in court cases, and it had no software products on the market. By 1997, it was no longer reporting this line of business separately, and its computer animation software products had become its major activity.

The company has since its inception sought to exploit synergies among all its technological assets, continually seeking ways for

Awards for technical achievements roll in.

the company's product lines to benefit from and build upon each other. For instance, it utilizes its 3D visualization software products internally, to improve its ability to deliver high-quality, interactive animation software products, such as CD-ROM medical education products, in a timely manner. But the flow of technology works in the other direction as well, according to company publications, because it is continuously modifying and enhancing the 3D visualization software as it develops new interactive software products.

Awards for Technical Achievements Roll In

EAI began to receive awards for its technical achievements in 1994. In that year, it received the Smithsonian Award from *Computerworld* magazine for the use of information technology in the field of medicine. The next year, it received the Award of Excellence in Animation from the Association of Medical Illustrators, and was a finalist, together with Walt Disney Studios, in the International ANNIE Awards category for best animations in the film industry. And in 1996, EAI was one of 25 recipients of the Technology and Innovation Award from *Industry Week*, specifically for its interactive 3D visualization and dynamics products used in the manufacturing sector for product development.

ATP Funding Plays a Crucial Role

According to EAI officials, the company would not have been able do its research and development work without the ATP funds. The award enabled EAI to establish collaborations with the Mayo Clinic and Johns Hopkins University, and work performed during the ATP project facilitated collaboration with the National Library of Medicine on a later project. And it enabled the company to significantly extend its capabilities in computer visualization and computational dynamics, providing new technology that could be applied to other areas of the company's activities.

The award enabled EAI to establish collaborations with the Mayo Clinic and Johns Hopkins University, and work performed during the ATP project facilitated collaboration with the National Library of Medicine on a later project.

Having the award and doing the project also made EAI more attractive to potential investors. This was crucial in the early years of the company. In a 1995 interview with a reporter from *The Wall Street Journal*,[3] Matthew Rizai, CEO of the company, noted that winning the ATP award — which was for $1.9 million — gave him leverage with private investors, from whom he raised an additional $1.5 million. And the company says the ATP grant continued to be important to investors as it conducted its initial public stock offering in February 1996, a few months after the ATP project ended, raising $30.5 million.

Outstanding Commercial Performance

The company's recent rapid growth, accomplishments, and recognition received are impressive. Over the past 10 years it has emerged from the ranks of start-up to a company employing nearly 1,000 people. It has made the transition from a company heavily dependent on consulting revenues to one which relies on high-value software products. Its success has depended substantially on the internal integration of all its technical assets to develop new products in a variety of fields that draw on its technologies for very large database manipulation and visualization of motion, and on its belief that the company can succeed only if it brings those new products into the market.

In the September, 1997 issue of *Individual Investor* magazine, EAI was named one of "America's Fastest Growing Companies." And, early in 1998, two additional magazines recognized the company's achievements. *Business Week* magazine, in its January 12, 1998 issue, recognized Matthew Rizai, the company CEO, as one of the best entrepreneurs of 1997, and *Forbes ASAP* magazine, in its Feb. 23, 1998 issue, recognized the company as one of the 100 most dynamic technology companies in the US — with a rank of number eight.

ETOM Technologies, Inc.
(formerly Optex Communications, Inc.)

Packing More Data Into Optical Data-Storage Disks

Optical data-storage devices, typically CD-ROMs (compact disk, read-only memory), have taken the desktop computer market by storm, becoming a standard part of almost every computer sold. Just five years ago they were included in such equipment only by special order. Now, millions of these devices are manufactured and installed every year.

A Rewritable, Higher-Capacity Compact Disk

Optical disks hold much more data than conventional magnetic hard or floppy disks, the alternative data-storage technology. The optical devices employ the same technology used with music CDs: a laser stores the data by pitting the disk surface in a pattern that can be read by another laser. When it was introduced, a conventional plastic CD-ROM could hold 650 megabytes of data, whereas typical hard disks then held fewer than 50 megabytes. Optical disks, however, could be written only once, and the drive mechanism was much slower than magnetic hard disk drives.

New technology is addressing both deficiencies. Optical-disk-drive speeds have increased substantially, and several techniques for enabling the device to write new data are now commercially available. This project with ETOM Technologies, a small start-up company, developed technology that greatly increases the amount of data that can be stored on optical disks.

Large Jump in Storage Capacity

The ETOM technology uses a glass, rather than plastic, disk onto which is laid a light-sensitive substrate that can be written and read by the lasers in conventional CD-ROM drives. The core technology is called electron-trapping optical memory (ETOM). Data are "written" to the substrate by a low-power laser tuned to a specific frequency. The laser light raises individual electrons in the substrate to an elevated energy level, where they are trapped indefinitely. The data are "read" by a second laser, which releases the trapped electrons to return to their lower energy state, emitting a light signal in the process.

In addition to being a write-and-read device, the ETOM disk is able to store data at multiple energy levels, giving it the ability to use "multiple-ary" digits, as opposed to the binary digits (having two energy levels) used in conventional magnetic data storage. This capability greatly increases the amount of data that can be placed on the disk. For example, a byte (group of eight digits) using binary digits can store 256 different numbers. A byte using a multiple-ary digit with three energy levels, however, can store 6,561 numbers. Thus, the use of just three different energy levels instead of two increases the disk's storage capacity more than 25 times.

. . . barriers arose that made it impossible to offer a cost-effective video CD-ROM.

. . . ceased operations in January 1998 and filed for bankruptcy two months later.

Unforeseen Obstacles Block Commercialization

The company planned to manufacture and sell ETOM-based digital video recording products if the technology could be successfully developed. The technology was developed. But barriers arose that made it impossible to offer a cost-effective video CD-ROM. The company needed a green laser, but a commercial supply of them did not materialize as expected. Nor did the market materialize for a video-on-demand device, which would have used the video CD-ROM to temporarily store movies and other videos downloaded by viewer request from a cable-TV company.

After attempting to develop additional technologies to enable it to survive, ETOM ran into severe financial problems in late 1997. Private investors in ETOM decided it could not continue to operate without the business from a partnership to commercialize one of these technologies — a deal that ultimately fell through — so they decided to close ETOM. It ceased operations in January 1998 and filed for bankruptcy two months later.

. . . received 12 patents for technologies related to the ATP project . . . applied for 14 additional patents . . .

ATP Critical to Developing New Technology

ETOM reports that if it had not received the $1.4 million ATP award, it could not have performed the research and probably would not have survived as a company long enough to conduct the research. It encountered difficulties in bringing to market an optical disk device incorporating its new technology. Even though the company is no longer in business, the new approaches developed in this ATP project may eventually be picked up and used by some other company.

. . . the new approaches developed in this ATP project may eventually be picked up and used by some other company.

PROJECT:

To develop new optical disk data-storage technology capable of recording digital video information on an ETOM (electron trapping optical memory) optical disk, a development that could substantially reduce the cost of storing digital information.

Duration: 2/15/1993 — 12/31/1994
ATP number: 92-01-0122

FUNDING (IN THOUSANDS):

ATP	$1,433	56%
Company	$1,118	44%
Total	$2,551	

ACCOMPLISHMENTS:

ETOM demonstrated the ability to store data in a radically new optical data-storage mode. The company completed header pattern definition, mask fabrication and software for reading and writing M-ary (multiple-ary, as opposed to binary) data and developed specialized test equipment. It also:

- received 12 patents for technologies related to the ATP project:
  - "Partial Response Coding for a Multilevel Optical Recording Channel"
  - (No. 5,537,382: filed 11/22/1994, granted 7/16/1996),
  - "M=7 (3,7) Runlength Limited Code for Multilevel Data"
  - (No. 5,657,014: filed 5/12/1995, granted 8/12/1997),
  - "M=5 (0,2) Runlength Limited Code for Multilevel Data"
  - (No. 5,659,310: filed 5/12/1995, granted 8/19/1997),
  - "M=6 (2,4) Runlength Limited Code for Multilevel Data"
  - (No. 5,659,311: filed 5/12/1995, granted 8/19/1997),
  - "M=10 (3,6) Runlength Limited Code for Multilevel Data"
  - (No. 5,663,722: filed 5/12/1995, granted 9/2/1997),
  - "M=7 (1,3) Runlength Limited Code for Multilevel Data"
  - (No. 5,663,723: filed 5/12/1995, granted 9/2/1997),
  - "M=6 (3,6) Runlength Limited Code for Multilevel Data"
  - (No. 5,668,546: filed 5/12/1995, granted 9/16/1997),
  - "M=5 (3,7) Runlength Limited Code for Multilevel Data"
  - (No. 5,670,956: filed 5/12/1995, granted 9/23/1997),
  - "M=5 (4,11) Runlength Limited Code for Multilevel Data"
  - (No. 5,675,330: filed 5/12/1995, granted 10/7/1997),
  - "M=6 (3,8) Runlength Limited Code for Multilevel Data"
  - (No. 5,680,128: filed 5/12/1995, granted 10/21/1997),
  - "M=4 (1,2) Runlength Limited Code for Multilevel Data"
  - (No. 5,682,154: filed 5/12/1995, granted 10/28/1997), and
  - "M=6 (4,11) Runlength Limited Code for Multilevel Data"
  - (No. 5,682,155: filed 5/12/1995, granted 10/28/1997);
- applied for 14 additional patents for technologies related to the ATP project;
- prepared several technical papers for publication or presentation at professional conferences; and
- entered into preliminary negotiations with potential users of its patented M-ary coding algorithms.

COMMERCIALIZATION STATUS:

Commercialization of the original data storage device employing the ATP-funded technology faltered because not all necessary technical components were available for the system, and the expected market did not materialize. The company encountered severe financial problems in late 1997 and declared bankruptcy in March 1998.

OUTLOOK:

Although ETOM's recent bankruptcy precludes its commercialization of this technology, substantial knowledge was gained, as reflected in the patent applications and grants. The possibility exists that other companies will license and commercialize the technology.

COMPANY:

ETOM Technologies, Inc.
(formerly Optex Communications, Inc.)
2 Research Court
Rockville, MD 20850

Number of employees:
30 at project start, 3 at the end of 1997

Mathematical Technologies Inc. (MTI)

Mathematical Technology to Restore or Enhance Movies

Many old movies are extremely valuable. If they were made for entertainment, reviving them for current showing can earn sizable profits in addition to providing viewing pleasure to consumers. The film archives of some movie studios, in fact, are worth hundreds of millions of dollars. Documentary movies with footage of important people, industrial processes, and current or historical events have great value, too, for educational and archival purposes.

A frame from the movie Amacord, shown first with several areas that are damaged, and then shown after digital restoration automatically removed the damaged spots and replaced them with the original images.

Old Movies: a Resource Too Valuable to Waste

Movies mean reels of film. Commercial movie-making uses a master film from which others are copied. Film is a physical thing that can be damaged, soiled or broken like any other object. But unlike a scratch on a single car, a scratch or other artifact on an old movie master can affect the film's usefulness to viewing audiences and the fortunes of the company that owns it. If the master film is marred, each copy will also be marred. Even if the master film is converted to digital form for making video copies, the artifacts will persist. Everything on the old film, trash and all, is converted to electronic data that go onto the video copy.

Another difficulty with movies and other videos is the existence of several formats. It would be useful for film companies to be able to change films from one format to another so that current films could be easily converted to video, and older films could be made to fit today's video and film equipment. Format has to do with the technicalities of converting movies to digitized videos that can be shown on TV. One format problem involves resolution. The U.S. standard for TV is 525 scan lines and 60 hertz (Hz) — the frame rate. The European standard is 625 scan lines and 50 Hz. High-definition TV will have a different pair of numbers.

A second format problem concerns how to preserve the natural speed of motion depicted in a film when translating, for example, from a format that requires a speed of 24 frames per second to one that calls for 30. Because of the need to compensate for these differences in

Viewers of many films, both current and archival, are benefiting from what they do not see: defects removed by the technology.

Researchers developed mathematical algorithms to create data for filling in damaged areas . . .

. . . the 1958 film "A Night to Remember" . . . Fellini's "Amarcord" . . . DeMille's "Ten Commandments" . . .

PROJECT:

To develop generic software technology that can repair, enhance or reformat movie and video sequences, enabling the restoration of damaged movies, enhancement of military images and conversion between digital image formats.

Duration: 5/1/1993 — 8/31/1995

ATP number: 92-01-0053

FUNDING (IN THOUSANDS):

ATP	$989	88%
Company	136	12%
Total	$1,125	

ACCOMPLISHMENTS:

MTI developed technology to remove artifacts (unwanted defects) from movies, whether archived or newly created. It made progress in developing the reformatting technology, but this work is still experimental. The company also:

- formed MTI Digital Restoration Services early in 1996, a division now actively marketing software and restoration services in video post-production;
- received jacket-cover credit for restoration work on the laser disc version of the 1958 film "A Night to Remember," about the sinking of the Titanic;
- participated, via MTI Digital Restoration Services, in acclaimed restorations of recent re-releases of Federico Fellini's "Amarcord" and Cecil B. DeMille's "Ten Commandments;" and
- had its software used in the perfection or restoration of hundreds of new and old films for new video releases since 1995.

COMMERCIALIZATION STATUS:

Commercialization is in progress. Film-restoration software and services are being sold by MTI Digital Restoration Services, and MTI has other products under development. Viewers of many films, both current and archival, are benefiting from what they do not see: defects removed by the technology.

OUTLOOK:

In the restoration of old movies and the polishing of new releases, there are excellent expectations for the mathematical algorithm technology. It also has potential applications in forward-looking infrared imagery and in medical imaging areas like ultrasound and fluoroscopy. Completion of the technology for conversion between formats will widen applications further, particularly in high-definition TV.

COMPANY:

Mathematical Technologies Inc. (MTI)
1 Richmond Square
Providence, RI 02906-5139

Contact: Donald E. McClure
Phone: (401) 831-1315

Number of employees:
4 at project start, 6 at the end of 1997

resolution and film speed, translation from one format to another is not a trivial process.

A Mathematical Approach to Repairing and Converting Films

This ATP project with Mathematical Technologies Inc. (MTI), a small company formed in 1981, has solved many of the problems of reformatting and removing defects from films. MTI specializes in bringing mathematical theory to commercial applications via new programming technologies, and its defect-removal research during the ATP project was particularly successful. Researchers developed mathematical algorithms to create data for filling in damaged areas of the digitized versions of movie-frame images, a process that essentially restores the images to their original quality. Texture matching is an important problem that had not been anticipated but had to be solved in order to repair severe, wide scratches and other defects involving substantial amounts of missing data.

The MTI technology can remove tears, splotches, scratches, dust motes, liquid-spill marks and other unwanted visual defects from movies. Methods for using the new technology, as well as a specialized user-friendly screen display from MTI, have been integrated into post-production processing at a number of facilities in Hollywood and elsewhere.

MTI researchers succeeded in developing some components needed for format conversion. Work on other components is still experimental. The researchers thoroughly investigated motion compensation (which concerns the way moving objects are detected in a movie) and determined how to make adjustments for motion so that the new technology does not create new artifacts. Specifically, they estimated the frame-to-frame motion of objects and developed technology for the rapid calculation of the most significant motions. This technology is critical both for restoration of damaged images and for translating between film and video recording standards.

New Products and Services for Film and Video Industries

Commercialization is under way. Near the end of the ATP project, MTI established a division called Digital Restoration Services that sells movie-restoration software and services, and the company is developing other products that would use the ATP-funded technology, too. MTI has invested heavily in the development of new software for film and video post-production since the ATP project was completed. A new state-of-the-art algorithm for converting from ordinary video resolution to high-definition-TV resolution was demonstrated at the National Association of Broadcasters trade show in April 1998.

The new MTI offerings face competition from several other products — virtually all of them from abroad. Competitor products, however, tend to focus on the "artistic" end of the of the movie restoration business rather than on the "technical" end. MTI's products focus on the technical end, and the company reports it is currently the only one to provide such software technology for automated restoration.

MTI initially intended to develop applications for motion-compensated reformatting and standards conversion, as well as restoration. After the ATP project began, the company decided to focus almost exclusively on restoration, based on a reassessment of the market for conversion software and services. It planned to offer film-restoration software running at commercially viable speeds (perhaps three to four times slower than real-time) on graphics workstations or high-performance personal computers costing well under $100,000. MTI succeeded, and it is offering the software for use with contemporary and archived movies. In addition, the company says it is about two years ahead of where it would have been without the ATP funds.

Restored "Ten Commandments"

Viewers of the many films, both contemporary and archival, restored with MTI's technology have benefited. When Cecil B. DeMille's "Ten Commandments" was restored with the ATP-funded technology and re-released, a commentator on the television program "Entertainment Tonight" reported that "the difference between the original and this new vibrant version is a revelation. . . . Digital technology is the modern miracle that's made it possible."

As MTI's mathematical algorithm technology is applied to more films, more viewers will benefit. Further benefits will emerge if the technology is used in other areas. It has potential applications, for example, in forward-looking infrared imagery, which is used by the military to detect objects at night, and may also be useful in medical imaging procedures such as ultrasound and fluoroscopy. Additional benefits will materialize if the technology for standards conversion is completed.

The film-restoration technology already commercialized promises spillover economic benefits to the viewing public and to owners of films with defects. Many films of historical interest, once they are restored with the new technology, will be available to viewers. The number of viewers will grow over the years as the restored or enhanced films are shown again and again, so spillover benefits will grow, as well. If the reformatting technology is completed and commercialized, additional benefits will accrue.

A new algorithm for converting from ordinary video resolution to high-definition-TV resolution was demonstrated . . . in April 1998.

Torrent Systems, Inc. (formerly Applied Parallel Technologies, Inc.)

A User-Friendly Programmer's Tool for Writing Parallel-Processing Software

Parallel computers — especially so-called "massively parallel" machines with hundreds or thousands of individual processors — hold great promise for solving many formerly intractable computing problems in government and industry. Estimates suggest that parallel processing would save the U.S. airline industry alone more than $1 billion annually through more efficient scheduling of flight crews. It could enable U.S. oil companies to reduce exploration costs and increase oil reserves. Analysis of massive transaction databases using parallel processing could recover much of the tens of billions of dollars lost annually to health care and credit card fraud.

Easy-to-Do Programming for Parallel Processing

A difficulty with parallel processing, though, is that writing its software is more art than science, an art practiced well by a relatively small number of programmers. Torrent Systems, founded as a two-person company in 1993, had an idea for solving this problem but was unable to find venture capital to finance the research to develop the technology. The company then sought and won ATP funding that enabled it to proceed. Torrent ultimately developed a component software system that allows programmers to build parallel-processing software systems without needing to explicitly understand how the system exploits the underlying parallel-processing hardware. To accomplish this project, researchers studied the actual application needs of typical users — to assure that the results would be widely applicable and useful.

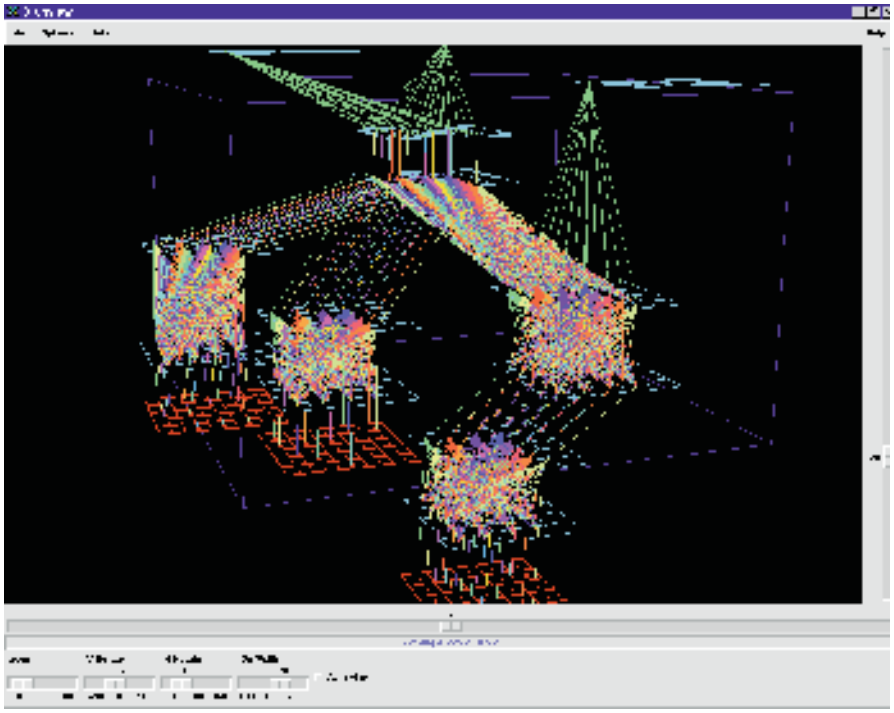
Quick to Market

Torrent produced a research prototype of a parallel-software component framework, created its basic components and performed limited testing on them. It also planned to develop a library of reusable code — containing components for a parallel-processing system. If such a library were available for other developers, then even more applications could come on line sooner. However, the company did not complete this research task. Torrent closed the project before its anticipated completion date in order to commercialize early technical results and generate needed revenue.

Torrent incorporated the ATP-funded component-based technology in a product called Orchestrate™, which the company describes as a "parallel application environment that insulates you from the complexities of parallel programming while delivering scalable applications." United Airlines and Citicorp were two of the first corporations to license it.

Strategic Marketing Alliances

The company has been quick to form strategic marketing alliances. It formed a partnership with IBM in July 1997, under which IBM will promote Orchestrate™ as a standard compu-



A graphic illustration of a 16 processor system under the control of Orchestrate — three sources of input data (shown at the top of the screen in green) are split into many parallel data streams, each to be manipulated by a sequence of software components (the grids at the bottom in red) which apply the same logic to each stream.

PROJECT:

To develop component-based tools for writers of parallel-processing software, as well as a library of reusable parallel-processing software components.

Duration: 12/1/1994 to 7/31/1996
ATP number: 94-06-0024

FUNDING (IN THOUSANDS):

ATP	$1,117	77%
Company	325	23%
Total	$1,442	

ACCOMPLISHMENTS:

Torrent accomplished most of the project goals, including development of a software environment for building parallel data-processing applications. The company did not develop as extensive a library of reusable components as originally anticipated. It halted the project sooner than originally planned to exploit the excellent commercial opportunities for technology developed early in the project. Torrent's outstanding progress toward commercialization is indicated by the following:

- The company applied for a patent on parallel training of neural networks, as well as patents on several other innovations.
- Torrent incorporated the ATP-funded technology in a product called Orchestrate™, introduced to the market in 1996. The company describes it as "a parallel development environment that insulates you from the complexities of parallel programming while delivering scalable applications."
- Orchestrate™ was described in a December 1996 *Datamation* article, "Build Your Warehouse on MPP," as one of a number of approaches to use in data warehousing.
- Orchestrate™ was selected in 1997 for use by KO1, IBM, Citicorp, Autozone, Sears Roebuck and United Airlines.
- Torrent entered into a strategic partnership in July 1997 with IBM, which will promote Orchestrate™ as a standard computer application. IBM is focusing on rapid development and deployment of a parallel-processing software system that can be enlarged without needing to be replaced by a new version, because expansion of the system is built into its architecture. Orchestrate™ plays a key role in the expansion capability of the IBM system. Torrent extended the partnership in September 1997, with IBM agreeing to resell Orchestrate™.
- Torrent entered into partnerships in September 1997 with three new vendors: The MEDSTAT Group, i.d.Centric and Knowledge Discovery One.
- The company also negotiated bundling arrangements (selling two or more separately produced products as a unit) with independent software vendors and manufacturers including Emergent, Knowledge Discovery One, Lockheed Martin IS&T and MRJ Technology Solutions.
- During 1997, several commercial software vendors chose Orchestrate™ for building their software products. The first such product, produced by the SAS Institute, reached the market in late 1997.
- At the end of 1997, *Computerworld* magazine recognized Torrent as one of the "100 Hot Emerging Companies."
- Torrent had attracted investments of $3.8 million by the end of the ATP project in July 1996, and it increased the total to $10 million over the next 18 months.
- United Airlines, an early customer, is using Orchestrate™ and an IBM parallel-processing computer to design a system for managing airplane seat assignments. United expects the new system to generate between $50 million and $100 million per year in increased revenue. The company is spending only about $17 million on the system, which would not work without Orchestrate™.

COMMERCIALIZATION STATUS:

The ATP-funded programmer's tool for writing parallel processing software has been commercialized. It is embodied in Orchestrate™, as well as in derivative products.

OUTLOOK:

The outlook for further commercialization and economic benefits is excellent. The strong market interest in Orchestrate™ indicates its usefulness in processing immense amounts of data. Since government and many industries — retail, health care, energy and transportation — use massive databases, new tools that can dramatically increase processing efficiency stand to yield billions of dollars in savings across the economy. The benefits from this project will accrue mostly to users of the technology, rather than to Torrent.

COMPANY:

Torrent Systems, Inc.
(formerly Applied Parallel Technologies, Inc.)
5 Cambridge Center, Seventh Floor
Cambridge, MA 02142

Contact: Robert Utzschneider
Phone: (617) 354-8684 ext. 1162

Number of employees:
2 at project start, 32 at the end of 1997

. . . halted the project sooner than originally planned to exploit the excellent commercial opportunities for technology developed early in the project.

ter application. IBM's focus is rapid development and deployment of a parallel-processing hardware/software system that can be enlarged without needing to be replaced by a new version, because expansion is built into its architecture. Orchestrate™ plays a key role in that expansion capability. The IBM system is specifically designed to make full use of customer sales and other data across an entire company, regardless of the type of business. Torrent extended that partnership a few months later, with IBM agreeing to resell Orchestrate™.

United Airlines, an early customer, reported in a November 1997 *Chicago Tribune* article that it had installed a new IBM RS6000/SP2 parallel-processing computer. The software supplied by IBM included Orchestrate™ under a licensing agreement between Torrent and IBM. United paid $3.5 million for the hardware and planned to spend another $13.5 million to get the computer running. The system is expected to generate between $50 million and $100 million per year in increased revenue by doing a better job of matching potential fliers with available airplane seats. Orchestrate™ is a critical component that enables United personnel to program the computer, which United would not otherwise have bought. This advance is important, since the RS6000/SP2 has been on the market for several years.

. . . new tools that can dramatically increase processing efficiency stand to yield billions of dollars in savings across the economy.

. . . a component software system that allows programmers to build parallel-processing systems without needing to explicitly understand how the system exploits the hardware.

. . . this technology . . . is embodied in "industrial strength" computer programs used in diverse industries and by government agencies.

Torrent also formed a marketing partnership with Sun Microsystems in 1997. An early outgrowth of this alliance was a joint demonstration showing the advantages of using Orchestrate™ in a typical data warehousing application. Orchestrate™ was used to integrate the basic Torrent components and specialized components from three other vendors into a single test application. The test involved data cleaning of a name-and-address file of about 13 million records, which was then merged with a demographics file of about 16 million records. When the test was run without using parallel processing, the application took 32.5 hours on a machine using four processors. With Orchestrate™, the application took only 9 hours. When the number of processors was increased to 12, the Orchestrate™-based application finished in just 3 hours.

Torrent also entered partnerships in September 1997 with three new software vendors: The MEDSTAT Group, i.d.Centric and Knowledge Discovery One. And it negotiated bundling arrangements (selling two or more separately produced products as a unit) with independent software vendors and manufacturers including Emergent, Knowledge Discovery One, Lockheed Martin IS&T and MRJ Technology Solutions.

Potential for Huge Benefits

Torrent has succeeded in marketing its technology, and substantial broad-based benefits can be expected to flow from the use of the new technology incorporated in its software. Users of Orchestrate™ have benefited from the removal of the need to pay attention to programming details for C/C++ (the most common language used to write programs for parallel processing), because Orchestrate™ handles them. As more applications of the new technology are implemented through the use of Orchestrate™ and other Torrent products, more analyses of large databases will be done. Another product that uses the ATP-funded technology is Orchestrator for the SAS System™, recently released by the SAS Institute.

Economic benefits are likely to be large and widespread for this technology. It is embodied in "industrial strength" computer programs used in diverse industries and by government agencies. Users in these areas say they anticipate dramatic savings. Consumers will also benefit from these savings, as lower operating costs are passed on to them. Torrent, a small company, will be able to collect only a small percentage of the total additional value created by its technology, while the rest will spill over to others in the economy.

The benefits from the ATP project would likely be even greater if Torrent had been able to fully develop and make available the library of reusable components as originally planned. However, as is often the case with small, near-startup companies, cash-flow concerns related to ensuring company survival dictated a fast move to generate revenue. In this case, given its limited resources, Torrent felt it had to stop the research project early and commercialize the technology. As customers suggest needs for other components, they will be developed and integrated into the company's products.

ATP Project Speeds Exploitation of Parallel Processing

ATP funding for this project allowed Torrent to research and develop a prototype of a component software system that allows programmers to create parallel-processing software in a user-friendly way. Without the ATP funds, Torrent officials say, it is doubtful that the technology could have been successfully developed at all. Venture capital funding had been sought but was unavailable. ATP funded the project to enable U.S. industry to broadly and rapidly exploit parallel processing, expecting that it would generate significant benefits throughout the economy. The speedy adoption of Torrent's first commercial products confirms that expectation.

Venture capital funding had been sought but was unavailable. ATP funded the project to enable U.S. industry to broadly and rapidly exploit parallel processing.