3M Company Health Information Systems

Capturing and Integrating Patient Healthcare Information to Improve Accessibility

The healthcare industry has faced challenges in adopting new computer technology to track patient data. Changes in the industry have made it more important than ever to adapt information infrastructures so that patient records and related data are accessible to a variety of healthcare professionals, regardless of their locations or the types of systems they use. In 1995, 3M Company Health Information Systems applied for co-funding from the Advanced Technology Program (ATP) to further develop the technology necessary to bring this information infrastructure to market. With ATP funding and its own capital, 3M developed revolutionary technologies that allow healthcare providers not only to maintain their investments in legacy systems, but also to migrate demographic and clinical information into a clinical data repository. The technology, marketed in several 3M products, is now used by more than 150 healthcare facilities nationwide.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
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Research and data for Status Report 94-04-0027 were collected during October - December 2001.

Healthcare Industry Faces Challenges

The U.S. healthcare industry faces the challenge to provide higher quality, lower cost service to an increasing number of customers. Information technology is seen as a valuable tool in reaching this goal. The medical field, however, is large, complex, and growing rapidly. Moreover, it is difficult to reduce operating costs and improve productivity levels because of factors such as institutional culture, interoperability issues, and business processes. Nevertheless, healthcare reform drives the need for interoperability within the industry, and healthcare institutions are recognizing the need to improve the exchange of data among their various operating entities and the wider healthcare community.

During the mid-1990s, information management within the industry was not integrated, and patient information was often not readily accessible at the point of care. Healthcare professionals spent a great deal of time looking for records or repeating tests simply because they could not find previous test results in a timely manner. Infrastructure throughout the industry was fragmented, with individual institutions using unique diagnostic systems, internal data formats, patient record systems, and communication and computer networks. The healthcare industry needed systems that would ensure reliability, maintainability, and data integrity, as well as a high level of confidence that patient data would be available for every authorized healthcare professional 24 hours a day, 7 days a week. The lack of a complete infrastructure, combined with the technical risk inherent in developing systems to complete these tasks, prevented many commercial entities from attempting to make advancements in this area.

During the mid-1990s, information management within the industry was not integrated, and patient information was often not readily accessible at the point of care.

The reengineering of medical information technology systems promised significant economic benefits and cost savings for healthcare organizations and patients. According to a 1992 study conducted by the

Department of Health and Human Services, a nationwide electronic healthcare information network had the potential to save $100 billion over eight years, with more than half of the savings attributed to a reduction in both the number of diagnostic tests ordered and the length of hospital stays.

The Clinical Data Repository Promises Infrastructure Integration

In 1995, when 3M submitted its proposal to ATP, many disparate systems were used to store and transmit patient records data and other information within the healthcare industry. Various healthcare system vendors were beginning to develop central data repositories (CDRs) (later renamed clinical data repositories), but most of these CDRs offered limited capabilities with varying degrees of reliability, usability, and accessibility. Moreover, the healthcare industry faced the challenge of integrating information systems and automating data exchange processes across organizational components.

The objective was to maintain computer-based patient records in CDRs, which would contain the patient's lifetime records.

Development of a CDR required a computer-based patient record. This record is the electronic format that holds data with standard components, such as the patient's demographic information, active problems, family history, test results, clinical observations, active medications, allergies, and any images and documents that accompany apatient's record. The objective was to maintain computer-based patient records in CDRs, which would contain the patient's lifetime records. 3M Health Information Systems conceptualized a system that would allow healthcare providers to maintain their investments in their legacy systems and migrate demographic and clinical information into a CDR.

3M Proposes to Accomplish Four Tasks

3M applied for funds under ATP's Information Infrastructure for Healthcare program to develop an infrastructure that would capture patient data, integrate it into a knowledge base, and make it accessible to the appropriate parties. The company believed that there

CDRs will help to increase the quality of patient care and provide continuity.

was a good fit between ATP's objectives outlined in this program and 3M's development goals. Therefore, 3M submitted a proposal to ATP that included developing and testing the following components:

- A common medical data dictionary to facilitate the reliable storage and retrieval of complex medical information, the contents of which would be integrated to form a CDR.
- Terminology that would ease the translation of different medical coding schemas.
- Database object development that would allow the data dictionary components to function across an organization's entire computer network.
- An alert writer that would route patient messages to caregivers on the basis of alerts written directly by clinicians.

Collectively, these components would achieve something that had not yet been accomplished in the healthcare industry: access to data by multiple individuals at various locations, regardless of the type of system each was using. This effort would rely on a terminology program that would be created to provide a universal dictionary for common medical terminology.

3M Achieves Technical Success

During this two-year ATP project, 3M completed the four tasks summarized above. The company achieved its project goals by developing a prototype and conducting beta testing at a number of hospitals. Based on the feedback that 3M gained through prototyping, the company developed "plug-and-play" interoperability

between applications, or components of applications between the database objects, and the healthcare data dictionary.

CDR Becomes Part of 3M's Care Innovation System

Since completion of the project in 1997, 3M has leveraged the technology to further develop its healthcare information system products. The company has incorporated the components developed through this ATP-funded project into other development activities within 3M. It markets the technology as part of its Care Innovation (CI) System (formerly called the Healthcare Enterprise Management System), along with the company's established applications such as the 3M Clinical Workstation. Through further development, 3M has commercialized new software packages that use this technology. According to the company, the software will become the foundation for the Department of Defense Military Health System's computer-based patient record program, which is aimed at improving healthcare delivery to military personnel. The CI System is currently being used in more than 150 healthcare facilities. Additional marketing efforts are under way to encourage other vendors to embed pieces of the CDR functionality into their systems.

CDR Benefits Extend to End Users

The end users of 3M's CDR have benefited from its use without having to make a substantial investment in new systems. Many healthcare providers were able to protect their investments in legacy systems and migrate demographic and clinical information by linking together previously installed systems rather than having to install new ones. Two institutions that have realized benefits from the CDR are Health Partners of Southern Arizona (HPSA) and Driscoll Children's Hospital.

HPSA successfully used CDR to unite all of its care facilities using a single source for information. HPSA needed one central patient index with common identifiers and a way to ensure accuracy, integrity, and encoding of the data. The central patient identifiers and translation of data into common nomenclature offered by the CDR enabled HPSA to reach this goal and achieve economies of scale.

Driscoll Children's Hospital, a regional pediatric referral medical center with offices throughout rural areas in southern Texas, used the CDR technology to solve the challenges of sharing data among geographically dispersed locations while preserving its original investment in its legacy systems. CDR seamlessly integrated data from Driscoll Children's Hospital and clinics into individual, longitudinal patient records. The system helps to provide Driscoll clinicians with expert decision support tools at the point of care, which can make a difference in both outcomes and cost.

Conclusion

The ability to demonstrate the components of this ATP project through prototypes and beta tests helped the Health Information Systems division of 3M garner support from within 3M to internally fund additional developments. Furthermore, based on the support it received from ATP, 3M was able to introduce this technology into the healthcare marketplace two years ahead of schedule. According to 3M, "The work that was accomplished with the help of ATP in the Information Infrastructure for Healthcare focused program, along with access to NIST technologists with standards experience, gives us the capability to respond to market needs."

PROJECT HIGHLIGHTS
3M Company Health Information Systems

Project Title: Capturing and Integrating Patient Healthcare Information to Improve Accessibility (Healthcare Lifetime Data Repository Infrastructure [later renamed the Clinical Data Repository])

Project: To establish key elements of a technology infrastructure that would make it possible to integrate incongruent systems throughout the healthcare industry. These elements include a common medical data dictionary that allows for the storage and retrieval of complex medical information; a code translator that facilitates ease of translation among different coding systems; an object-oriented database element that implements a data dictionary into individual healthcare enterprises; and an expert alert system that allows clinicians to write alerts that are sent when conflicts occur in the patient data.

Duration: 2/1/95-1/31/97
ATP Number: 94-04-0027

Funding (in thousands):**

ATP Final Cost	$1,196	15%
Participant Final Cost	7,890	85%
Total	$9,086	

Accomplishments: 3M accomplished all of the technical goals it defined in its ATP proposal. In addition, the company installed prototypes of the CDR in healthcare facilities throughout the United States and beta tested the functionality of its technology components at conferences and in real-life settings. More than 150 healthcare customers currently use this technology to track patient records.

Commercialization Status: 3M has incorporated the components of this project into other corporate development activities. The company is marketing the components as part of its CI System, along with the company's established applications such as the 3M Clinical Workstation. Through further development, 3M has commercialized new software packages that use the ATP-funded technology. According to 3M, the software will become the foundation for the Department of Defense Military Health System's computer-based patient record program, which is aimed at improving healthcare delivery to military personnel. The CI System is currently being used in more than 150 healthcare facilities, and additional marketing efforts are under way to encourage other vendors to embed pieces of the CDR functionality into their systems.

Outlook: The outlook for this technology is excellent. 3M is continuing to build upon the CDR and to pursue new and innovative high-risk technologies through a subsequent project with ATP. 3M hopes other vendors will continue to embed some of the functionality of these components into their systems to move the healthcare industry closer to true interoperability.

Composite Performance Score: * *

Number of Employees: 85 employees at project start, 85 as of December 2001.

Focused Program: Information Infrastructure for Healthcare, 1994

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** As of December 9, 1997, large single applicant firms are required to pay 60% of all ATP project costs. Prior to this date, single applicant firms, regardless of size, were required to pay indirect costs.

Research and data for Status Report 94-04-0027 were collected during October - December 2001.

Accenture (formerly Andersen Consulting)

Centralized Information System To Improve Nation's Healthcare Delivery

In the early 1990s, the nation's priorities shifted toward a universal healthcare system. This shift drew practitioners' attention to the need to control costs, reduce duplicative testing, transfer medical records easily, and provide quality patient care across a patient's entire life. Critical elements of a new information infrastructure would include an easily transferable medical record, standardized best-practice care paths, and methods of documenting utilization. Healthcare information systems that could provide this kind of information for the U.S. population simply did not exist in 1994. Andersen Consulting submitted a proposal to the Advanced Technology Program (ATP) and was awarded cost-shared funding for a joint venture through ATP's focused program, Information Infrastructure for Healthcare, to develop such an infrastructure. ATP assistance was required because private investors were not confident that this technology, when commercialized, would result in sufficient revenues. By 1997, when the ATP-funded project ended, Andersen Consulting's project had met all of its technical innovation goals. Changes in the healthcare industry, however, made a centralized information infrastructure irrelevant, and commercialization did not take place.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
No Stars

Research and data for Status Report 94-04-0025 were collected during January - March 2001.

Processes Limit Efficiency in the Healthcare Industry

Throughout its evolution, the U.S. healthcare industry has not developed information systems capable of handling a universal delivery system. Until 1994, information technology systems operated along enterprise and system boundaries in the healthcare delivery system and were further fragmented by the proprietary business interests of large entities that sought to control patient information.

The application boundaries and the processes assumed by existing applications blocked systems reengineering efforts. In the mid-1990s, as the U.S. healthcare marketplace began to explore methods of granting access to patient information, creating lifelong medical records, and enabling information sharing and systems interoperation, available systems proved incapable of expanding beyond the boundaries of individual practices.

Joint Venture Proposes High-Risk Research and Demonstration

Healthcare providers following the fee-for-service model in 1994 had no incentive to change to an information system that would limit the administration of duplicative medical care. Industry trends, however, suggested that a new type of information system would be needed in the future. Payers, such as the Federal Government's Health Care Financing Administration, which administered the Medicare program, and private insurance providers, were just beginning to scale back reimbursement for medical services to limit redundant care.

Beginning in the mid-1990s, while attempting to negotiate more favorable reimbursement terms from payers, the healthcare industry began to consolidate and control costs by eliminating excess staff and services and by providing comprehensive care under one organization. It was into this environment that

Andersen Consulting proposed to implement the healthcare information infrastructure (HII).

If successful, Andersen Consulting's joint-venture project would adapt as the industry contracted, generating tremendous cost savings to surviving providers; would reduce adverse healthcare outcomes through the use of best-practice care paths; and would increase productivity across the U.S. economy by decreasing time spent receiving medical care. Given the potential benefits to the U.S. healthcare system, and the impact that a successful project could have on the overall productivity of the U.S. workforce (which would spend less time in the doctor's office), Andersen Consulting turned to ATP for funding.

Throughout its evolution, the U.S. healthcare industry has not developed information systems capable of handling a universal delivery system.

Because of the healthcare industry's information infrastructure needs, the high technical risk of the proposed project, and the potential for broad-based economic benefits across the U.S. economy, ATP awarded the joint venture $3.8 million in cost-shared funds to conduct a two-year research and demonstration project of a new healthcare informatics system.

New System To Comprise Six Major Components

The goals of the proposed patient-focused information system were dramatic cost and quality improvements and seamless healthcare delivery.

To meet these goals, the proposed HII system would comprise the following six separate, but interrelated, systems:

- Master Member Locator Service (MMLS): A domain-centric service would maintain the "system address" of every customer medical record via a unique HII identifier and would allow search engines to pull up all necessary data on particular members at any time, anywhere, in much the same way that Internet search engines operate.
- Medical Record Object (MRO): The MMLS would access a "virtual" patient medical record which would approximate the pen-and-paper record. This MRO would operate across disparate computer information system applications throughout the domain.
- MRO Security Service (MSS): A domain-centric service would monitor and control access to consumer health practice data in the MRO form through the use of roles and privileges. This powerful firewall would keep the medical record and all the sensitive data kept therein safe from information thieves.
- Non-Native System (NNS) Adapter: NNS adapters would enable existing health practice systems to engage HII services and extend their market collaboration. The NNS adapter would be the "middleware" that would allow many different types of information systems to access and use the HII.
- Process Server: A healthcare-focused workflow engine would represent and enact local definitions of preventative, chronic, and episodic care protocols on a consumer-specific basis. This server would push care paths to the practitioner, as well as enable internal data mining to monitor treatments, outcomes, and other standards and measures.
- Notification Server: An event monitor and expression logic would deliver appropriate updates to inform practitioners and care-delivery organizations of changes in a patient's care delivery or health status. This server would replace the phone calls or memoranda that practitioners receive with an automated system. This system could, for example, keep a primary care or referring physician apprised of a patient's stay in the hospital.

Andersen Consulting Brings Together Industry Talent

Although Andersen Consulting (currently known as Accenture) was a management consulting firm with global systems integration experience, it needed assistance in accomplishing its ATP project goals due to the extraordinary complexity of developing an integrated healthcare informatics system. Therefore, the company formed a joint-venture team with requirements providers and reviewers, component providers, and end users. Andersen Consulting was responsible for overall project management and systems integration. Many other firms contributed to the joint venture's research, although Andersen Consulting performed much of this research in-house.

The companies in the joint venture included:

Expersoft Corporation This privately held company focused on the emerging market for distributed object management software. The company also offered integrated tools that addressed many of the problems encountered in building and managing distributed information systems in large-scale organizations. Expersoft would provide the software backbone of the system that would enable the MRO.

MedicaLogic, Inc. This company develops, markets, installs, and supports electronic medical record (EMR) software for use in ambulatory care practices. MedicaLogic's computerized clinical records technology was the leading supplier of EMR systems for office-based medical practices at the time that Andersen Consulting proposed this project to ATP. The company would work to ensure that coding of and access to medical records could occur smoothly within the proposed HII system.

Medical Records Corporation (MRC) MRC is a privately held company that is the oldest and largest medical transcription service in the United States. The company has developed proprietary database management and hospital mainframe information systems that have been used throughout the healthcare industry.

Enigma Logic Enigma Logic is a privately held company that pioneered the development of computer security products. Enigma Logic has provided hardware and software to a variety of users in highly complex computerized and networked environments across large organizations. The company would supply significant expertise to make sure that the proposed information infrastructure would be secure.

Stanford University's Section on Medical Informatics This division within Stanford coordinated the university's medical computing research. In its 20-year history, the Section has developed extensive national medical resources and a series of major medical decision-support and electronic records applications.

Infratechnology Could Generate Spillover

Infratechnologies are sets of technical tools for making an entire economic process more efficient. These tools generate broad-based economic benefits through the efficient processes they enable. Andersen Consulting's joint-venture proposal was designed to create an information technology process that could be shared across the entire healthcare industry, making the industry significantly more efficient. To facilitate this process, the company also pledged to distribute its MRO master member index directory service programs openly and free of charge; the company also said it would invite feedback. By using open distribution, even if the project failed, substantial knowledge spillover would occur throughout the healthcare industry. If the project was successful, the spillover could be significantly greater.

Although the administration costs of the information system itself would be $25 per year per patient, the system would eliminate enough duplicative care to save $50 to $200 per patient per year, as well as enable productivity increases across the economy from less time spent in doctors' offices. In addition to the financial benefits, a successful HII project that pushed care paths to practitioners and reduced time spent on other administrative tasks would generate significant nonmonetary benefits across the economy. These benefits would accrue to the healthcare industry as a whole in the form of additional time available to providers to care for other patients; better care for patients, who would have more time with care providers; and increased profitability for providers and insurers.

The components of the system were distributed freely among healthcare providers in an attempt to coalesce the industry around a single information system standard. The knowledge spillover was intentional, and there were no efforts to limit access to this knowledge through the patent process or secrecy.

Joint Venture Identifies Industry and Technical Goals

Andersen Consulting identified separate industry and technical goals for the information infrastructure system. Two defined industry goals were to demonstrate the utility of an information system that requires less effort to adapt to ever-changing methods of care delivery and to develop support within the industry for this type of cost-control-based information system when the current fee-for-service practices do not reward cost controls. The chief technical goals of the project were to develop the six separate elements of the information infrastructure and to enable these elements to work together in a secure, stable, easily adaptable information system that could be used throughout the healthcare system.

Andersen Consulting proposed that the technical goals would be reached through extensive research, systems design, and troubleshooting-leading to a system-wide product demonstration in 1997. The industry goals would be achieved through the joint venture's commercialization plan after the technical goals were met.

Overcoming Obstacles Leads to Technical Successes

During the project, Andersen Consulting overcame two challenges that threatened its goals of integrating system elements. At the end of the project, however, the integrated delivery system, with its "cradle-to-grave" care hallmark, was not accepted because it did not fit with healthcare practices as they had evolved over the project's life.

One major obstacle that the company encountered was that the backbone MRO software from Expersoft did not function properly. The MRO software was supposed to provide complete patient medical records that would be accessible to any provider at any location at any time.

After months of delay and attempts to debug Expersoft's MRO software, Andersen Consulting elected to use Iona's Orbix product instead. Orbix enabled the six diverse elements of the healthcare information system to work together.

The components of the system were distributed freely among healthcare providers in an attempt to coalesce the industry around a single information system standard.

A second obstacle to the project's success was that the joint venture faced barriers to accessing patient data. Much of the existing patient data in the mid-1990s were stored in different forms on proprietary servers, with server owners often unwilling to share access to the data (note that this problem continues even today). To overcome this resistance, Andersen Consulting had to write in substantial amounts of code to translate the existing data into the new information system. This code was added to the NNS architecture in order to make the healthcare information system useful and effective.

Andersen Consulting eventually succeeded in overcoming these technical barriers, and the joint venture conducted a demonstration of the healthcare information system. The demonstration profiled a patient who had just joined a new health system and had selected a new primary care physician. The patient answered questions programmed into an on-line entrance exam. The entrance exam flagged the patient as "at risk for heart disease" and set up appointments for diagnostic tests, steps that were completed before the patient visited the doctor. During the patient's first office visit, the doctor focused on treatment and follow-up care because the routine patient-intake work and diagnostic tests had already been performed. Without Andersen Consulting's healthcare information system, the same process would have required three appointments with the doctor.

Industry Evolution Stifles Commercialization Strategy

In order to generate broad-based economic benefits, the joint venture's proposed HII system would need to

be adopted by care providers. Andersen Consulting developed a commercialization plan to accomplish widespread adoption after completion of the ATP-funded research and product demonstration steps. This commercialization plan was designed to leverage the information system's utility for a fully integrated delivery system. Although the common gateway interface language-based medical record and retrieval program was a bit restricting, its use within an integrated system of somewhat standardized information technology platforms would achieve many of the project's goals.

At the end of the project the integrated delivery system, with its "cradle-to-grave" care hallmark, was not accepted because it did not fit with healthcare practices as they had evolved over the project's life.

By the time the ATP-funded portion of the project ended in 1997, the healthcare industry had undergone dramatic changes. Although consolidation and cost-control efforts had increased dramatically between 1994 and 1997, by early 1998, the trend slowed markedly. At that time, the attempt to forge a universal healthcare system through integrated delivery systems had failed, and the idea was no longer widely discussed. By late 1998, the healthcare industry settled on a hybrid system of partial integration. The move away from a fully integrated delivery system rendered the joint venture's healthcare information system largely irrelevant because it did not fit with healthcare practices as they had evolved over the project's life.

During an interview in early 2001, an Andersen Consulting partner indicated that the company does not expect to generate any revenue from the commercialization of this ATP-funded project's accomplishments.

Conclusion

In the early 1990s, the healthcare industry began to see trends toward consolidation and cost containment as payers such as the Federal Government and private insurers started limiting expenses. Providers who found it extremely difficult to cut costs began paring back services to Medicare and Medicaid recipients. Andersen Consulting formed a joint venture to create a healthcare information system that could reduce costs and inefficiencies associated with repetitive care and could save money for the healthcare industry and the Federal Government.

The move away from a fully integrated delivery system rendered the joint venture's healthcare information system largely irrelevant.

This ATP-funded joint-venture effort met all of its technical goals and held a successful system demonstration. Shortly after the ATP-funded project ended, however, healthcare industry dynamics changed in a way that prevented successful commercialization.

PROJECT HIGHLIGHTS
Accenture (formerly Andersen Consulting)

Project Title: Centralized Information System To Improve Nation's Healthcare Delivery (Healthcare Information Infrastructure (HII) for Interoperation of the Healthcare Delivery System)

Project: To develop an open-system architecture and information metastructure to serve as an interface between independent healthcare information systems on the basis of a high-level, patient-oriented data object.

Duration: 4/1/1995-3/31/1997
ATP Number: 94-04-0025

Funding (in thousands):

ATP Final Cost	$ 3,819	50%
Participant Final Cost	3,821	50%
Total	$ 7,640	

Accomplishments: This project successfully developed and demonstrated the functionality of a healthcare information system that could control costs, eliminate redundant care, and give health care providers more time with their patients. This healthcare information infrastructure (HII) relied on the following six separate components:

- Master Member Locator Service (MMLS) would allow search engines to pull up all necessary data on particular members at any time, anywhere, much as Internet search engines operate.
- Medical Record Object (MRO) would make up the medical record that the MMLS would access for each patient.
- MRO Security Service (MSS) would act as a powerful firewall to keep the medical record and all the sensitive data kept therein safe from information thieves.
- Non-Native System (NNS) Adapter would be the "middleware" that would allow many different types of information systems to access and use the HII.
- Process Server would push care paths to the practitioner as well as enable internal data mining to monitor treatments, outcomes, and other standards and measures.
- Notification Server would replace the phone calls or memoranda that practitioners receive with an automated system. This system could, for example, keep a primary care or referring physician apprised of a patient's stay in the hospital.

Commercialization Status: Within two years of the conclusion of this ATP-funded project, the healthcare marketplace had changed. Aggressive cost cutting had not proved successful for providers, and a universal approach to healthcare delivery was no longer widely discussed. These market changes minimized the potential impact of the healthcare information system developed by Andersen Consulting's joint venture. The company does not expect to generate any revenue from this project.

Outlook: Given the change in the healthcare marketplace, the impact of this project is now its potential for knowledge spillover to other industries that may undertake similar information system projects in the future.

Composite Performance Score: No stars

Focused Program: Information Infrastructure for Healthcare, 1994

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American Healthware Systems

Automated Care Plan System to Lower Healthcare Costs

In 1994, widespread attention throughout the U.S. economy was focused on the need to control healthcare costs. Many healthcare information systems were used to track a wide range of information, from billing to treatment outcomes. However, because the systems were not fully interoperable, the data could not be used to improve patient care. American Healthware Systems sought to help solve this problem. In 1995, the company, teamed with Columbia-Presbyterian Medical Center, was awarded Advanced Technology Program (ATP) cost-shared funding. American Healthware Systems' proposal to ATP outlined a research program to set up an automated system that would electronically provide care plans to practitioners and track their compliance with the plan.

Although the company failed to develop an interface that could prompt physicians to use the care plans in an effective manner, the company continued its research into hospital information systems after the project ended in 1997. Several years later, American Healthware Systems was purchased by a division of Siemens that was also conducting research in hospital information systems separate from the American Healthware Systems products. Commercialization of a Siemens product that incorporates some of the knowledge learned during the ATP-funded project is expected in 2003 or 2004.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
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Research and data for Status Report 94-04-0017 were collected during December 2002 - January 2003.

Care Plans that Could Cut Costs Were Not Being Used

The healthcare industry has a pivotal role in the economic health of the United States due to its sheer size and the cost of the services it provides. In 1994, medical spending exceeded $938 billion, and 20 percent of that amount was related to inefficiencies associated with the processing of information. One method used in the mid-1990s to speed the flow of best-practice guidelines to practitioners was paper-based care plans. Hospitals and health systems put care plans in the hands of practitioners and expected them to use the documented best-in-class care practices that similar institutions used to reduce lengths of stay and the cost of care. One study conducted in the mid-1990s at Columbia-Presbyterian Medical Center, a major university hospital in New York, showed that adherence to care plans for a high-volume procedure reduced the length of the hospital stay and the cost of care by 20 percent. Despite these significant, tangible benefits, the rate of best-practice use by physicians remained low because the paper-based plans could not be easily customized for individual patients. In part because of this lack of flexibility, and the inconvenience of referring to a care plan manual before every treatment decision, physicians in the Columbia-Presbyterian Medical Center study eventually stopped using care plans. Consequently, at that point, lengths of stay and the cost of care reverted to their pre-study levels.

Care Plan Automation Could Be Key to Practitioner Buy-In

Medical literature in the mid-1990s touted care plans as the most efficient way to bring best, cost-effective practices to hospitals and health systems. The major

problem was how to convince physicians to accept and adhere to the care plans. American Healthware Systems, a New York City company that was an outsourcing billing center for several New York City hospitals, along with the Columbia-Presbyterian Medical Center's Center of Medical Informatics, proposed to use recent advances in computer technology to develop an automated environment for implementing and monitoring care plans and practice guidelines. The automated environment would allow physicians to tailor the care plans to individual patient needs and would allow hospital administrators to monitor all failures to comply with the care plans.

In 1994, medical spending exceeded $938 billion, and 20 percent of that amount was related to inefficiencies associated with the processing of information.

To accomplish this, American Healthware Systems proposed to develop an automated Hospital Care Plan System (HCPS), which would encode patient test results and histories along with the care plan. The system could then issue treatment alerts, based on patient-specific data, directly to the physicians' computer screens where they entered the treatment orders. With such a system, physicians would be reminded of the care plans on a continuous and timely basis, and an administrator could question them on a decision to ignore the plan if that decision resulted in an adverse outcome or an increased length of stay. The hope for HCPS was that it would overcome the barriers to using care plans and would allow the healthcare system to realize significant savings from shorter lengths of stay.

ATP Funding Crucial to Company's Research

At the time of its proposal to ATP, American Healthware Systems provided outsourced actuary and billing services for hospitals. A company employee who had a programming background recognized the added costs of not using care plans and developed a broad outline for the HCPS. American Healthware Systems was able to complete a pilot project using HCPS-type architecture to record costs and savings associated with the use of care plans for coronary artery bypass grafts (CABGs). However, the company was not in the software development business, and internal funds could not be used to further develop the system. Furthermore, external funds were not available for full system development. HCPS's potential for cost savings, information sharing, and new avenues for treatment met the criteria for ATP's 1994 “Information Infrastructure for Healthcare” focused program. ATP awarded American Healthware Systems $2 million in cost-shared funds to design a more complete HCPS prototype with the Columbia-Presbyterian Medical Center's study/assessment.

Potential Cost Savings Could Be Significant

Data from the initial study at Columbia-Presbyterian Medical Center showed that an annual potential savings of $5.48 million was possible by using best-practice care plans on just the current load of 548 CABG patients. Much of these savings were anticipated to result from the average projected decrease of four days in the traditional length of stay. However, the study also found that if practitioners were not continually reminded of care plan requirements, after one year they lapsed into old habits that increased the cost of care and the lengths of stay.

Extrapolating this type of cost savings across the healthcare delivery system, it could be possible to reduce overall healthcare costs by nearly 20 percent, saving close to $180 billion annually. Best-practice care plans could also lead to increased productivity because, theoretically, sick employees would return to work faster when treated under care plans.

The Challenge Was To Develop a User-Friendly System

The overarching technical challenge for the American Healthware Systems' project was to develop a system that the doctors would use. Cost savings would only accrue when practitioners followed the plans. With traditional paper or CD-ROM-based plans, practitioners stopped using the plans after about a year because of the constant requirement to refer to a book during treatment.

American Healthware Systems believed that the key to physician adoption of the HCPS was a graphical user

interface (GUI) that would prompt doctors with the next care plan step as they entered their orders in the computer. This would be accomplished by using the Arden Syntax system, a commonly used software system for care plans, that would pipe next steps right onto a healthcare provider's ordering system to prompt a specific action at every step of entering patient orders. To prevent the physicians from merely declining an action every time the reminder came on-screen, American Healthware Systems proposed a back-end database that would record each time a practitioner disregarded the care plan. These data could then be cross-referenced with any adverse outcomes. Administrators would have the ability to monitor care plan compliance and could bring the outcomes to the physicians' attention on a regular basis.

The GUI would not function properly in order to prompt physicians in an effective manner.

Administrators would also have the option to integrate the HCPS into the hospital's total quality management system. That way, administrators could focus on gaining practitioner support for using care plans for the most expensive procedures where best practices were likely to result in the most dramatic outcomes. Once physician support for using care plans was gained, administrators could insert additional plans to cover lower cost procedures without encountering resistance.

Even with Solid Design Ideas, HCPS Could Not Be Developed

American Healthware Systems had lofty goals for the HCPS. Unfortunately, because the company was not able to design the system according to the specifications in its ATP proposal, the HCPS did not become a reality. The GUI would not function properly in order to prompt physicians in an effective manner. The database with care plans did not correlate well with patient information and the physician's choice of precise wording of the proposed treatment. Moreover, the back-end database could not record as much data as the company had planned, making a full utilization review impossible.

American Healthware Systems did, however, create an Internet-enabled GUI that could be used in more general applications. At the end of the ATP-funded project in 1997, the company devoted an additional $500,000 of its own money to further the research and development of a user interface. Two years later, Siemens Medical Solutions Health Services Corporation purchased American Healthware Systems (primarily for its outsourced hospital billing expertise). According to American Healthware Systems' President, Harold Fischman, development of the user interface continued at Siemens. Siemens' Eagle Gold Base System, the next generation of American Healthware Systems product offerings, incorporated some of the knowledge gained during the ATP-funded project. Although the software was set to launch in 2002, technical problems delayed commercialization. To date, no revenues have been earned from innovations flowing from the ATP-funded project.

Project Knowledge Is Shared Within the Healthcare Industry

Knowledge gained during the ATP-funded research was shared with Columbia-Presbyterian Medical Center through its relationship as the potential test bed for the American Healthware Systems' program. Knowledge was also shared with Siemens after its purchase of American Healthware Systems.

Conclusion

American Healthware Systems, working with Columbia-Presbyterian Medical Center, responded to ATP's Information Infrastructure for Healthcare focused program by proposing to create an extensive graphical user interface that could link physicians with best-practice care plans and could allow hospital administrators to monitor adherence to care plans and conduct full utilization reviews. Due to programming difficulties, the user interface could not be used to help physicians care for patients by using best-practice care paths. The interface did show promise for other more general applications. This led Columbia-Presbyterian Medical Center and American Healthware Systems to invest an additional $500,000 to further research the interface. Furthermore, Siemens has incorporated some of the knowledge learned from the ATP-funded research into their Eagle Gold Base System software package set for commercialization in 2003 or 2004.

PROJECT HIGHLIGHTS
American Healthware Systems

Project Title: Automated Care Plan System to Lower Healthcare Costs (Automated Care Plans and Practice Guidelines)

Project: To develop an automated Hospital Care Plan System (HCPS) that will issue treatment alerts based on patient-specific data (such as test results and histories) and optimal care rules encoded in the system.

Duration: 1/1/1995-12/31/1997
ATP Number: 94-04-0017

Funding (in thousands):

ATP Final Cost	$1,135	57%
Participant Final Cost	855	43%
Total	$1,990	

Accomplishments: Although American Healthware Systems did not meet all of the technical goals it defined for this ATP-funded project, the company did develop a graphical user interface that could potentially be used in hospital applications that are less complex than the HCPS. Research continued after the 1999 purchase of American Healthware Systems by a division of Siemens. Some knowledge learned from the ATP-funded research has been incorporated in Siemens' Eagle Gold Base System software package that is set for commercialization in 2003 or 2004. The system is an Internet-enabled method of allowing users to communicate with a back-end mainframe in a healthcare setting.

Commercialization Status: Siemens' commercialization of the Eagle Gold Base System, which incorporated information from the ATP project, is planned for 2003 or 2004. No other commercialization is anticipated.

Outlook: Because American Healthware Systems did not achieve all of its technical goals, the outlook for the HCPS is uncertain. Until the Eagle Gold Base System is actually commercialized, the outlook for technology that incorporates knowledge from this ATP-funded project is uncertain.

Composite Performance Score: *

Focused Program: Information Infrastructure for Healthcare, 1994

Company:
American Healthware Systems
Siemens Medical Solutions, Health Services
51 Valley Stream Parkway
Malvern, PA 19355-1406

Contact: Harold Fischman/ Ann Strong
Phone: (610) 219-1435 / (610) 219-6300

Research and data for Status Report 94-04-0017 were collected during December 2002 - January 2003.

Hynomics
(formerly HyBrithms Corporation, formerly Sagent Corporation)

Technology to Control Hybrid Computer Systems

Businesses and industries, both large and small, increasingly rely on complex, distributed networks of computers and information systems. Manufacturers, international banking firms, independent physicians in medical networks, utilities, food and commodity distributors, retailers, and communications companies are all examples of industries that could use complex computer networks to manage operations. However, efficient and effective control of distributed systems is difficult, particularly in the increasingly common situation where the system is a "hybrid" that includes discrete and continuous functions and digital and analog signals. A major obstacle has been the need for network and application synchronization-the task of assuring that events between different nodes on the network happen in the proper order and that data managed by different nodes remain consistent.

In late 1995, after years of conducting research, Dr. Wolf Kohn and Dr. Anil Nerode founded Sagent Corporation (currently named Hynomics) to turn a breakthrough in theoretical mathematics into technology for hybrid systems, automata (software), and control theory. They sought ATP funding to accelerate their research and development. With cost-sharing from ATP, Dr. Kohn and his team developed Multiple-Agent Hybrid Control Architecture (MAHCA) technology to reactively synchronize real-time distributed processes under uncertainty and continuously maintained system-operating constraints. This technology is being commercialized with SAP, the leading supplier of enterprise management software.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 95-09-0052 were collected during January - March 2002.

Existing Technology Left Processes Distributed

By the mid-1990s, many distributed processes were deployed in business, government, and industry to implement functionalities of varying complexity. Manufacturing firms were studying "virtual enterprises" that could connect their design and manufacturing operations with their suppliers via computer networks. International banking firms were relying on large-scale networks and resource planning software to coordinate activities among branch offices in the volatile world of international finance.

Complex enterprise resource planning systems are used to manage operations in many businesses and industries, such as medical networks, utilities, food and commodity distributors, retailers, and communications.

In many of these distributed processes, automation extends only to low-level tasks performed by pre-determined procedures. For more high-level coordination and synchronization of tasks, humans must still be a part of the process. These distributed systems relied on extensive manual intervention to achieve the desired enterprise functionality.

Commercial Need to Increase Optimization and Synchronization of Processes

Efficient and effective control of distributed systems is difficult, particularly in the increasingly common

situation where the system is a "hybrid" that includes discrete and continuous functions as well as digital and analog signals. A major obstacle to controlling these systems has been the need for network and application synchronization; that is, the task of assuring that events between different nodes on the network happen in the proper order and that data managed by different nodes remain consistent.

Industry practice for the integration of heterogeneous systems requires extensive and expensive integration hexperiments and the prototyping of integration alternatives. The addition of new components requires that the experiments be repeated since current approaches depend upon simulation or prototyping experiments to identify failure modes of the composed system. Commercial control, design, and implementation tools have code-generation capability based upon analysis of extensive experimentation of the interaction of logic and continuum constraints. These tools all depend on the assumption that a solution exists for a complex, nonlinear, composed system model.

Hynomics Seeks to Increase Efficiency of Large-Scale Distributed Systems

Hynomics proposed a new approach to address the problem of network and application synchronization. Their approach included two mechanisms to achieve the next significant increase in efficiency for large-scale, real-time, distributed systems. Hynomics' approach would lower the cost of building and maintaining these systems by providing a flexible framework for automatic compliance with declared constraints in accordance with specified relaxation criteria for achieving a "close-enough" solution.

First, individual agents react to satisfy (synchronize) explicit local and global constraints on system execution. This unified treatment of hybrid system requirements produces a formal methodology that permits effective synchronization of local goals and resulting control strategies with global goals. It also simplifies stating and maintaining distributed system requirements.

Second, a network of agents coordinate to achieve local and global control of distributed processes. This is done via a global cost criteria and by generating software (automata) at each local node and at each update interval (time scale) that comply with logical and continuum (hybrid) constraints on global system behavior. This supports treating either entire blocks of legacy software as components or new small segments of code as components, since agents can be used reactively to seamlessly integrate previously un-integrated, real-time systems.

A major obstacle to controlling these systems has been the need for network and application synchronization.

Before the ATP-funded project began, Hynomics' approach was a theoretical construct, and Hynomics had demonstrated the feasibility of this approach only for very small problems. Many barriers still remained to demonstrating that this approach could be turned into a viable technology suitable for industrial application.

Need for High-Risk Capital Leads Company to ATP

Early revenue from the Army Research Office to develop battlefield dynamic simulation using Hynomics' developing technology and modest angel investments maintained the cash flow and funded the company's small-scale R&D initiatives. Silicon Valley's largest and most influential players were also interested in Hynomics' budding technology. Because there was no demonstrable prototype, however, Hynomics was not able to secure any venture capital.

To launch the high-risk R&D initiative necessary to build the final product, Dr. Kohn turned to ATP. In 1995, Hynomics was granted a two-year, $1.9 million award to 1) decrease the amount of memory required to implement Hynomics' program-generation algorithm, which was initially an exponential function of the complexity of the system being controlled; and 2) build a semantic-based user interface that would lower the technical barrier to enabling users to enter the mixed-mode (i.e., logic and evolution) models accommodated by the technology. There was potential economic advantage to the nation through lower costs of producing and maintaining distributed, real-time systems. Furthermore, this economic advantage had

potential benefits for other industries served by real-time software and hardware.

Hynomics Uses Middleware Technology to Coordinate Distributed Processes

Hynomics' proposed technology included a distributed agent-based platform for the implementation of management, decision, and control systems (a technology that provides a common interface and translation between two applications, between an application and an operating system, or between other system services). This middleware system is a crucial architecture foundation for second-generation client/server configurations. Second-generation client/server architectures tend to use a distributed function model versus the remote data model common in first-generation client/server applications, wherein a client with a large amount of application logic interacts with a database server.

Advances made in the technology during the ATP-funded project have enabled Hynomics to commercialize its technology through the world's largest enterprise software companies.

With the distributed function model, application logic is distributed between client and server on either side of the middleware. The control-services layer in the middle comprises transaction monitors/servers, database gateways, and distributed function servers. Hynomics' technology would enable developers of client/server systems to build intelligent middleware into their applications.

Hynomics successfully completed the development of this technology by incorporating agent technology into the implementation of the middleware.

Multiple-Agent Hybrid Control Architecture

The key technology breakthrough on this project was Hynomics' development of MAHCA (Multiple-Agent Hybrid Control Architecture), which implemented and extended the theoretical work done on hybrid control prior to the project. MAHCA incorporated earlier theories on agent-based hybrid control and extended the implementation to include agents to analyze, design, and implement intelligent control of large-scale distributed processes. A single agent can be configured to control more complex distributed processes, while multiple agents interact through messages and can be either permanent or temporary.

MAHCA is useful for reactive synchronization of real-time distributed processes that require decision-making under uncertainty, where constraints on system operation must be continuously maintained, and where human operators must be kept informed of current system operation. The architecture also provides support for reuse of existing, trusted components and expanded functionality in components through formal construction of correct real-time software. Finally, MAHCA agents can be used in conventional digital procedures to speed up those procedures and compose more complex procedures.

The key technology breakthrough on this project was Hynomics' development of Multiple-Agent Hybrid Control Architecture.

After successful implementation, MAHCA demonstrated the potential to handle large-scale hybrid control problems.

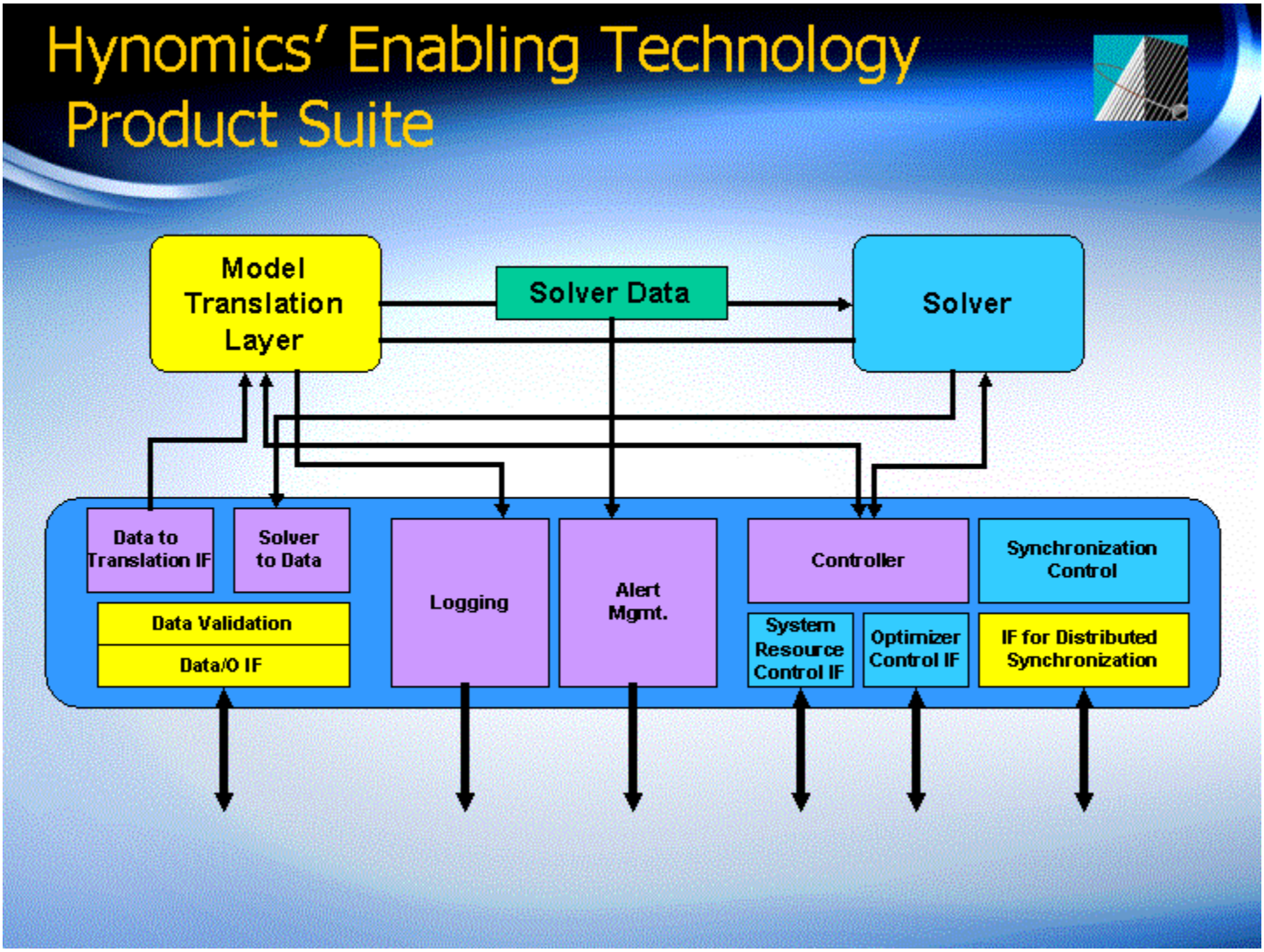
Partnerships Will Increase Market Access

After the ATP project, Hynomics positioned itself to license to original equipment manufacturers (OEM) for larger systems integration companies. Several years after the project was completed, Hynomics met with various private and venture capital investors and held discussions with several large system integration companies. In 1999, Hynomics formed a partnership with SAP, a global enterprise resource planning software developer, to build a workforce optimizer and a people scheduler. Hynomics continues to build partnerships with enterprise software companies in order to gain access to wider markets without high sales and marketing expenses. Hynomics will continue this model of partnering with large systems integration companies to secure revenue streams, to enter

markets, and to co-invest on future R&D projects. These partnerships will also become the foundation for direct investments into Hynomics. Currently, the company is working on a second significant partnership with one of the world's largest software companies to incorporate its technology into their current and future products. Hynomics has also published more than 15 articles in various professional journals and has participated in over 10 conferences and presentations.

Conclusion

ATP provided funding to Hynomics to help advance high-risk research in hybrid systems, automata, and control theory through the implementation of its theoretical work in the middleware and MAHCA (Multiple-Agent Hybrid Control Architecture) technologies. This risk was beyond what the private sector was willing to bear. The advances made in the technology during the ATP-funded project have enabled Hynomics to commercialize its technology through the world's largest enterprise software companies. This technology continues to be the apex of Hynomics' solution offerings today. The application of Hynomics' technology with enterprise software players could positively impact optimization and synchronization of companies worldwide.



A flow chart illustrating Hynomic's enabling technology systems.

PROJECT HIGHLIGHTS
Hynomics
(formerly HyBrithms Corporation, formerly Sagent Corporation)

Project Title: Technology To Control Hybrid Computer Systems (Cost-Based Generation of Scalable, Reliable, Real-Time Software Components)

Project: The primary technical objectives of the project were to 1) decrease the amount of memory required to implement the Hynomics program-generation algorithm that was initially an exponential requirement on the complexity of the system being controlled, and 2) build a semantic-based user interface that will lower the technical barrier to users entering the mixed-mode (i.e., logic and evolution) models accommodated by the technology.

Duration: 9/1/1995-12/31/1997
ATP Number: 95-09-0052

Funding (in thousands):

ATP Final Cost	$ 1,934	92%
Participant Final Cost	168	8%
Total	$ 2,102	

Accomplishments: This project successfully developed new technologies in hybrid systems, automata, and control theory that are in the process of being commercialized. Since the project's completion, Hynomics has formed a multi-layered partnership with SAP and is currently forming another significant partnership with an international software company.

Hynomics has received two patents as a result of the ATP-funded project:

- "Multiple-agent hybrid control architecture for intelligent real-time control of distributed nonlinear processes"
  (No. 6,088,689: filed November 29, 1995, granted July 11, 2000)

- "Multiple-agent hybrid control architecture for intelligent real-time control of distributed nonlinear processes"
  (No. 5,963,447; filed August 22, 1997, granted October 5, 1999)

Hynomics has also published more than 15 articles in various professional journals and has participated in more than 10 conferences and presentations.

Commercialization Status: Hynomics is in the process of commercializing a workforce optimizer and a people scheduler with SAP. In 2001, Hynomics raised $280,000 for further R&D. Hynomics continues to partner with large systems integration companies to secure revenue streams, to enter markets, and to co-invest on future R&D projects. These partnerships may also become the foundation for direct investments into Hynomics. Currently, Hynomics is working on a second significant partnership with one of the world's largest software companies to incorporate its technology. Additionally, global software companies and financial services institutions are enthusiastic about the potential for Hynomics' technology to revolutionize supply chain management, transportation and logistics, and portfolio management.

Outlook: Hynomics has initiated a promising business plan centered on partnering with OEMs for international enterprise software companies. Initial results of the partnership with SAP are promising, and the budding partnership with a large software vendor could propel this technology and the company forward.

Composite Performance Score: * * *

Number of Employees: Three employees at project start, 14 as of January 2002.

Focused Program: Component-Based Software, 1995

Company:
Hynomics
10632 N.E. 37th Circle
Building 23
Kirkland, WA 98033-7921

Contact: Dr. Wolf Kohn, CEO
Phone: (206) 637-1180

Research and data for Status Report 95-09-0052 were collected during January - March 2002.

Koop Foundation, Inc.

Sharing Information and Controlling Costs in the Healthcare Industry

In the early 1990s, the United States attempted to institute a universal healthcare system, an initiative that drew attention to the need to control costs, reduce duplicative testing, and provide high-quality patient care throughout a patient's lifetime. As physician practice models began to evolve to meet the nation's challenge, the need to migrate to a better information infrastructure that encouraged information sharing and cost control became apparent. A joint venture of companies and nonprofit institutions, led by the Koop Foundation, Inc., attempted to develop the best information and process management models to share healthcare information and control costs. By building a set of healthcare domain analysis tools, the joint venture hoped to design information systems for industry-wide use that would overcome the existing problems of fragmented information and lack of cost awareness.

The Koop Foundation joint venture proposed the $30 million project to the Advanced Technology Program's (ATP) Information Infrastructure for Healthcare focused program. They received an award of cost-shared funds in 1995 to pursue research in metamodel development and an open and extensible system architecture that independent vendors could then use to develop a wide range of modern information tools for the healthcare industry. By the time the project ended in 1998, the joint venture had met all of its technical objectives, had developed an open-source Web-based collaborative toolkit for business process reengineering, had launched a healthcare reengineering Center of Excellence to support adoption of the technology throughout the industry, and had presented project knowledge at numerous conferences. However, when the healthcare industry moved away from universal integration in the late 1990s, the reengineering tools developed by the joint venture no longer had a role in the marketplace.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
*

Research and data for Status Report 94-04-0037 were collected during April 2002 - June 2002 and March 2003.

Existing Practices Limit Efficiency of the U.S. Healthcare Industry

Until 1994, information technology (IT) systems evolved to support the provider-driven, fee-for-service healthcare industry. As medical practices began to consolidate across municipality and state boundaries, and as business model changes ushered in an era of integration to provide a birth-to-death continuum of care, healthcare professionals found it extremely difficult to manage patient data and to eliminate duplicative costs. Information systems could not communicate with one another, medical records could not be accessed quickly, and dynamic best practice care paths were not available to providers across individual information systems, much less across the industry as a whole. This technological hindrance slowed migration to a fully integrated delivery system.

Joint Venture Proposes Health Informatics Initiative

The Koop Foundation joint venture formed to analyze the healthcare industry, to develop necessary information models to support reengineering, and to enable communication across software programs and hardware. Conceptually, the project envisioned the reengineering tools as the base of the healthcare information pyramid. The tools would provide the

infrastructure for enterprise integration, data banks/knowledge repositories, process reengineering strategies, and integration services for a national infrastructure. This foundation would then enable a Web-based middleware that would facilitate communications and incorporate point-of-care medical records, cost-control software, security and confidentiality systems, and critical care paths. Patients, physicians, and other care providers would interact at the top level. This interface would relate the middleware with the foundational elements to provide health education, prevention, cost management, telemedicine, and digital medical records across the entire information system. To create the foundational tools for healthcare industry reengineering, the joint venture proposed the following three-stage schedule:

Stage One: Lay out the requirements for an enhanced enterprise engineering life cycle methodology to ensure that reengineering tools are useful and manageable. This stage would be completed when the entire business process reengineering (BPR) toolset was generated.

Stage Two: Integrate the BPR toolset into a scalable, supportable, real-time software system capable of operating on any hardware platform.

Stage Three: Test, adjust, and achieve final demonstration of the process reengineering system.

Koop Foundation Assembles Top Industry Talent

In order to succeed, the joint venture needed participants with expertise in three diverse environments: healthcare, BPR, and information systems engineering. While overall project management was Koop Foundation's responsibility, the following health care organizations and IT companies participated in the joint venture:

Beth Israel Deaconess Medical Center. Located in Boston, Massachusetts, this medical center is a Harvard University teaching and research hospital and has its own system of community outpatient facilities throughout Massachusetts. As a large academic medical center, Beth Israel Deaconess assisted the joint venture by developing processes and systems that could be incorporated into physician practice, remote facility management, and critical care management.

Booz Allen Hamilton. Located in Arlington, Virginia, Booz Allen Hamilton is a large international consulting firm experienced in assisting commercial and public sector clients with information system integration. The firm participated in the venture to ensure software component compatibility and to provide insight into the types of systems that private medical centers and not-for-profit hospitals would need in the coming years.

D. Appleton Company, Inc. Located in Reston, Virginia, D. Appleton Company, Inc., is a consulting firm specializing in developing information engineering models and system architecture for public sector clients. The company maintained the joint venture's focus on the national healthcare infrastructure and the systems needed to administer healthcare across the United States.

GTE Government Systems. Located in Chantilly, Virginia, GTE maintains a staff of programmers who handle systems integration for a variety of highly sensitive networks, such as those for the Department of Defense. GTE provided systems integration experience, as well as a focus on information security.

International Cancer Alliance. Located in Bethesda, Maryland, the International Cancer Alliance is a nonprofit organization that provides high-quality, focused, user-friendly cancer information to patients and their physicians on an ongoing and person-to-person basis. The Alliance participated to provide a voice for patient education software and online health information as part of the systems reengineering process.

Meta Software Corporation. Located in Cambridge, Massachusetts, Meta Software Corporation provided modeling and simulation solutions to assist the BPR.

Oracle Corporation. Located in Bethesda, Maryland, Oracle Corporation produces large database products for commercial use. Oracle participated to ensure that the database backbone was strong enough to handle all information about patients, procedures, care paths, and billing processes across the healthcare system.

Wizdom Systems, Inc. Located in Alexandria, Virginia, Wizdom Systems provides training services for BPR,

change management, and activity-based costing to achieve employee and executive "buy-in." Wizdom Systems worked to make sure that the joint venture's final product was manageable, teachable, and useable within the healthcare industry.

Other firms participated in the joint venture, but became inactive or withdrew across its lifetime. These firms included AT&T, Corporation for Studies and Analysis, Logicon, Systems Research and Applications Corporation, Science Applications International Corporation, and the Western Consortium for Public Health.

By funding projects that would reduce the astronomical IT costs within the healthcare system, ATP hoped to reduce healthcare costs overall.

This diverse joint venture was formed in response to the ATP focused program "Information Infrastructure for Healthcare." ATP requested research plans in this area because wide-ranging partnerships were needed to advance the state-of-the-art; there were significant technical issues associated with the development of medicine-related tools; and the results would be broad, bringing new technologies with significant economic benefit to the U.S.-based healthcare market. As of 1994, medical spending for the entire United States exceeded $938 billion; however, 20 percent of those costs were related to the processing of information. By funding projects that would reduce the astronomical IT costs within the healthcare system, ATP hoped to reduce healthcare costs overall.

New Information System Promises Tremendous Cost Savings

Healthcare providers using the fee-for-service model in 1994 had little incentive to change to an information system that would maximize communication, minimize duplicative testing, and increase the efficiency of costly medical care. Industry trends, however, suggested that a new type of information system would be needed in coming years. Payers, such as the Federal Government's Health Care Financing Administration (the agency that administers the Medicare program, now known as the Center for Medicare and Medicaid Services) and private insurers, were just beginning to scale back reimbursement for medical services to limit redundant care. In an attempt to negotiate more favorable reimbursement terms from payers, the healthcare industry was beginning to consolidate, to control costs by eliminating excess staff and services, and to provide comprehensive services through health maintenance organizations. If successful, the Koop Foundation project could provide the base knowledge and tools to adapt information systems to fit the emerging paradigm, enabling tremendous cost savings to providers, payers, employers, and the U.S. Government. Given this potential for significant social benefits, the Koop Foundation submitted a proposal to ATP.

Potential for Infratechnology Yields ATP Research Funds

The Koop Foundation joint venture's proposal was designed to create an IT process that could be shared across the entire healthcare industry as business processes and information systems were reengineered around emerging IT capabilities. Facilitating this process, the Koop Foundation proposed to build open-source software systems and to distribute information on BPR via the Internet. By using open distribution, even if the project failed, substantial knowledge spillover would occur throughout the healthcare industry. If commercially successful, the spillover effects could be significantly greater.

The Koop Foundation proposed to build open-source software systems and to distribute information on BPR via the Internet.

For example, there would be a direct benefit of cost reductions of 50 to 75 percent resulting from both a reduction in administration costs and the elimination of redundant tests. Moreover, spillover benefits would accrue to the healthcare industry as a whole in the form of additional time available to providers to care for other patients, improved patient care from these providers, and increased profitability for providers and insurers. Concomitant with better medical care would be decreased sick days and increased productivity

throughout the U.S. workforce. Benefits for the Federal Government would also be significant, to include cost savings to the Medicare and Medicaid programs.

Given the fit with the healthcare industry's information infrastructure needs, and the potential for broad-based economic benefits across the U.S. economy, ATP awarded the Koop Foundation joint venture $14.4 million in cost-shared funds to conduct research and to establish a demonstration project of a new healthcare informatics BPR information system.

Joint Venture Defines Goals for the Initiative

Three major technology challenges had previously limited the healthcare industry:

- Lack of interoperability across the healthcare system
- Lack of tools to identify appropriate IT elements to meet high-level business needs
- Lack of software to enable communication among the diverse software and IT systems used in the healthcare market

The joint venture identified four main "thrust areas" for its research and development activities: domain, methodology, metamodel/knowledge base, and pilot application. Not surprisingly, the first three thrust areas aligned with the three major technology challenges. Each thrust would develop knowledge within the healthcare industry that would spill over to other market players even if the entire project failed. If successful, the BPR software package could become the infratechnology described above.

The domain thrust would involve constructing tools to analyze the healthcare industry, to identify needs across the healthcare domain, and to analyze existing systems. The methodology thrust would entail identifying business goals of players within the healthcare system and selecting appropriate IT elements that could address those goals. The metamodel/knowledge base thrust would consider the potential for interoperability of the previously identified IT elements. Finally, the pilot application thrust would bring all of the areas together into a working model for healthcare BPR using open and extensible system architecture tools.

Upon completion of the research project, participating institutions hoped to use the BPR toolkit to restructure their own IT departments. Participants would then work to convince other healthcare market participants to use the toolkit, visit the Center of Excellence for hands-on lessons in BPR, and acquire information from a variety of web sites regarding this project.

Koop Foundation Overcomes Technical Obstacles

The Koop Foundation had to overcome three technical objectives in order to develop and demonstrate a BPR IT application. First, the fragmented nature of the healthcare system and the lack of system interoperability had hindered previous attempts to understand the full healthcare domain. This required a top-to-bottom analysis of available healthcare information systems, their prevalence, and their use. To obtain this kind of analysis and understanding, a diverse group of joint venture participants would need to use all available resources to understand and map the healthcare domain. After intensive effort early in the project, this was accomplished.

Second, the project required that joint venture participants establish a set of comprehensive methodological processes that could reliably and predictably transform high-level business objectives into executable specifications for information infrastructure services. In order to accomplish this, an extraordinarily complex program was needed that could understand the existing systems, could be tailored by administrators to make it compatible with current systems as well as be adaptable and compatible with future systems, and could recommend a menu of IT applications that could enable the strategic plans in the most effective manner. The joint venture developed a tool to accomplish this task.

Third, the joint venture needed to address the industry's lack of software that could enable communication among programs and across systems. This task was particularly difficult because the BPR toolset could potentially recommend a different set of information systems for each user. Joint venture participants

needed to develop additional software that could facilitate the communication between software packages, as well as allow each software package to run on any IT system that the healthcare market participant used. This was the most challenging of the technical tasks and required a tremendous amount of time, energy, programming, and expertise from each joint venture participant. Before the end of the ATP-funded project, a team from Booz Allen Hamilton and Oracle held a successful demonstration where they achieved communication of basic data between the same types of basic software applications used by Beth Israel Deaconess Medical Center. Substantial additional work would be needed to make the demonstration commercially viable.

The healthcare industry's goals had undergone a drastic change by the time the ATP-funded project ended.

Upon completion of the ATP-funded research and development project in 1998, the Koop Foundation joint venture had met all of its technical goals and had conducted a successful demonstration of its model for healthcare BPR.

The joint venture had also developed several BPR web sites that gave the public access to much of the knowledge developed as part of this ATP-funded effort. Joint venture participants employed up to 12 new full-time employees for the ATP-funded project, many of whom continued employment into 1999 and beyond. Moreover, the joint venture constructed a Business Process Reengineering Center of Excellence where they provided access to their tools in order to assist healthcare market participants in their reengineering efforts. Staff members from several of the joint venture participants, such as Wizdom Systems, GTE Government Systems, and Beth Israel Deaconess Medical Center, delivered 16 presentations on the IT system at various conferences and symposia.

Outside the joint venture, Wizdom Systems successfully expanded its healthcare BPR software for customization and use in industries other than healthcare, and the company commercialized six BPR products.

Full Commercialization Never Realized

The information generated by the joint venture was available to healthcare market participants, but the healthcare industry's goals had undergone a drastic change by the time the ATP-funded project ended in late 1998. Universal integration was no longer an industry focus, so this type of healthcare informatics initiative was no longer necessary. Although consolidation and cost control efforts increased dramatically between 1994 and 1997, by early 1998 the trend had slowed markedly. By that time, the attempt to forge a universal healthcare system had failed, the idea had faded from national discourse, and the largest and most aggressive healthcare industry consolidators were under investigation for overcharging Medicare and Medicaid to cover cost overruns.

Conclusion

Shortly after the end of the ATP-funded project, several joint venture participants arranged to use the business process reenginerring (BPR) software in their own internal systems and on some external engagements. Wizdom Systems developed six new products for BPR based on the ATP-funded technology. After the conclusion of the ATP project, Wizdom worked to improve and commercialize their BPR tools across industries, which they continue to sell. These were the only tools that achieved commercial success after the ATP-funded research project ended. By late 1998, industry changes had advanced the healthcare marketplace beyond the Koop Foundation's ability to provide a useful BPR service. Moreover, the Koop Foundation had gone bankrupt by late 2001 for reasons unrelated to this ATP-funded project, and all web sites with the BPR information had been taken off-line.

PROJECT HIGHLIGHTS
Koop Foundation, Inc.

Project Title: Sharing Information and Controlling Costs in the Healthcare Industry (Healthcare Informatics Initiative)

Project: To analyze the healthcare industry from the viewpoint of modern information management and to develop the necessary information models and tools to support the task of reengineering the industry to take best advantage of the developing national information infrastructure.

Duration: 3/1/1995-8/28/1998
ATP Number: 94-04-0037

Funding (in thousands):

ATP Final Cost	$14,379	47%
Participant Final Cost	16,490	53%
Total	$ 30,869	

Accomplishments: This project successfully developed and demonstrated a business process reeingineering (BPR) information technology (IT) application for use by the healthcare industry. The system used an open and extensible architecture in an effort to speed up industry adoption of new IT applications that could achieve business goals. The Koop Foundation joint venture accomplished the following:

- The joint venture conducted a complete healthcare marketplace domain analysis in order to understand why certain systems were used, how they interacted, and what were the benefits and drawbacks of each system.
- The joint venture developed logic that enabled healthcare executives to enter in their strategic business plans and receive a menu of IT applications to achieve their goals.
- The joint venture enabled system and program interoperability for IT solutions for the healthcare industry. These programs could run on any system and could share information regardless of origin or physical location.
- Knowledge spillover occurred in the form of web publication, traditional papers, and presentations, including presentations at numerous conferences.

Outside the joint venture, Wizdom Systems worked to improve its BPR software after the close of the ATP-funded project and eventually commercialized six BPR tools for use across industries. Many are still on the market, after numerous updates.

Commercialization Status: Changes in the healthcare marketplace prevented the Koop Foundation joint venture from commercializing the ATP-funded technology. Aggressive cost cutting had not proven successful for the healthcare providers, and a universal approach to healthcare delivery had faded from the national scene. BPR that was designed to incorporate systems that enable integration and aggressive cost control, therefore, no longer had a role in the marketplace. Due to these changes, the Koop Foundation's BPR tool no longer had a market. Outside the joint venture, however, Wizdom Systems developed six new products for BPR, based in part on the ATP-funded project, that could be used in any industry, not just healthcare. Those products are still on the market.

Outlook: Given the market change, the lasting impact of this project will be the potential for knowledge spillover to other industries that may one day undertake similar BPR projects.

Composite Performance Score: *

Focused Program: Information Infrastructure for Healthcare, 1995

Company:
Koop Foundation, Inc.
15825 Shady Grove Road
Suite 22
Rockville, MD 20850

(The KOOP Foundation, Inc., has ceased operation. This is not related to the ATP-funded joint venture. Other participants in the joint venture would be able to revive the research if they chose to do so.)

Research and data for Status Report 94-04-0037 were collected during April 2002 - June 2002 and March 2003.

Koop Foundation, Inc.

Middleware Solution To Provide Cost and Access Advantages

By the early 1990s, after decades of evolution, the healthcare industry was operating as a fee-for-service system that provided financial incentives for repetitive care. Then the healthcare industry began to see trends toward consolidation and cost containment as payers such as the Federal Government and private insurers started limiting reimbursement. Providers, who found cost cutting extremely difficult, began to pare services to Medicare and Medicaid recipients. The Koop Foundation, with co-funding from ATP, formed a joint venture to create middleware, called Health Object Library ON-Line (HOLON), which could enable information technology migration to systems useful in the emerging integrated delivery system. The joint venture met all technical goals and held successful testbed demonstrations of the middleware. Lumina Decision Systems incorporated the technology into new decision-support products. Shortly after the ATP-funded project ended, however, healthcare industry dynamics changed so drastically that full commercialization did not occur, and Koop Foundation ceased operations.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
*

Research and data for Status Report 95-10-0067 were collected during April - June 2002.

Existing Practices Limited Efficiency of the U.S. Healthcare Industry

In the early 1990s, the nation attempted to move to a universal healthcare system. That effort drew industry attention to the need to control costs, reduce duplicative testing, and provide high-quality care throughout a patient's lifetime. The need to share information became apparent, but patient records were maintained within individual physician's offices, and each visit to a new physician required that patients undergo many repetitive, basic tests. Information systems could not communicate with one another, medical records could not be accessed quickly, and dynamic best-practice care paths were not available to providers across individual information systems, much less across the industry as a whole. This technological hindrance impeded migration to an integrated delivery system.

As of 1994, medical spending exceeded $938 billion; 20 percent of those costs were related to the processing of information. Payers, such as Medicare and private insurers, were just beginning to scale back reimbursement for medical services to limit redundant care. In an attempt to negotiate more favorable reimbursement terms from payers, the healthcare industry was beginning to consolidate, to control costs by eliminating excess staff and services, and to lock patients into health maintenance organizations (HMOs). At the same time, distributed patient data and isolated information systems applications were restraining the evolution of healthcare informatics. Capturing the cost savings would depend on moving from closed, proprietary applications toward open, rapidly customizable software.

Koop Foundation Forms Diverse Joint Venture

The Koop Foundation formed a joint venture in response to the ATP focused program, Information Infrastructure for Healthcare. ATP requested proposals in this area for three main reasons: wide-ranging partnerships were needed to advance the state-of-the-art; significant technical challenges were associated with the development of medicine-related tools; and the resulting new technologies would provide significant economic benefit to the U.S.-based healthcare market.

The joint venture participants included diverse points of view: providers, patients, community service agencies, and information technology developers. Koop Foundation's responsibility was overall project management. The following health systems and companies participated in the joint venture:

- Beth Israel Deaconess Medical Center, Boston, MA
- George Washington University (medical center), Washington, D.C.
- Norwalk Hospital, Norwalk, CT
- Windom Health, Berkeley, CA
- Concept 5, McLean, VA
- Lumina Decisions Systems, Los Altos, CA (relocated to Los Gatos, CA)
- Meta Software Corporation, Cambridge, MA
- Oracle Corporation, Bethesda, MD
- Wizdom Systems, Inc., Alexandria, VA
- @Home, Redwood City, CA

Other firms that participated in the joint venture, but later became inactive or withdrew, included Talisman (Foster City, CA), ForeFront Group (Houston, TX), IntelliTek (Rockville, MD), and Time Warner (Maitland, FL).

Middleware Solution Provides Cost and Access Advantages

Rather than force providers and payers to adopt single software platforms (a notion that would necessitate unacceptable levels of Federal control) the possibility of "middleware" operating between the core data and the myriad existing information systems became an attractive option. Middleware had the advantage of ensuring universal access to usable patient and procedure data within legacy systems and is less expensive and less restrictive than total application migration. The Koop Foundation joint venture was formed to create a library of reusable middleware software objects. These objects would allow developers to:

- Design efficient new systems to focus on integration and cost control
- Plug in desired components

The tools would allow providers to:

- Collaborate across the industry
- Use online multimedia healthcare information to anticipate wellness- and care-related issues
- Access and manipulate distributed health information online in any form (e.g., text, video, data, telemetry, or image), at any time

Software objects to be developed included:

- Advanced user interfaces that enable access anywhere, anytime
- Natural language translation ability to ease data flow
- Decision support to control costs and manage care paths effectively
- Legacy system wrappers to avoid needless migration expense
- Intelligent agents to search for and locate disparate pieces of information

ATP Funding Makes Koop Foundation's Technology Possible

The Koop Foundation designed its joint venture proposal to create an information technology process that could be shared and accessed across the entire healthcare industry to enable the provision of cost-effective, high-quality care within an integrated delivery system. The public benefits of a successful project (tremendous cost savings spread across the industry

and among diverse stakeholders) would be substantial. Because it would have been difficult for private firms to capture many of the benefits derived from the technology, ATP support was important in stimulating this industry initiative and in fostering the collaborative environment of the joint venture.

The Koop Foundation pledged to build open-source software and to distribute information on business process reengineering via the Internet. By using open distribution, even if the project failed, substantial knowledge spillover would occur throughout the healthcare industry. Moreover, entire new industries could develop to enable rapid access to the data. Those access devices envisioned in 1995 included stand-alone kiosks, wireless personal digital assistants (PDAs), interactive televisions, touchscreens, and information-rich text messengers.

ATP support was important in stimulating this industry initiative and in fostering the collaborative environment of the joint venture.

Given HOLON's fit with the healthcare industry's information infrastructure needs, and the potential for broad-based economic benefits across the U.S. economy, ATP awarded the Koop Foundation's joint venture $9.9 million in cost-shared funds to conduct research and to develop a proof of concept for middleware for the healthcare informatics industry.

Koop Foundation Overcomes Technical Obstacles

The idea of middleware was not new at the time of the HOLON project. In fact, there had been partial solutions to the healthcare informatics industry's middleware needs before the ATP award.

By project closeout, the Koop Foundation joint venture had developed several middleware tools.

HOLON sought to incorporate into the middleware as many of the previous solutions as possible and then to add further functionality.

The most significant technical risk involved the need for complex decision-support tools and intelligent search agents that could push useful information to end users without requiring additional search time. The decision-support tool, managed in part by Lumina Decision Systems, required several generations' worth of evolution of standards for medical lexicon, patient information, healthcare objects, and medical logic modules with extensive processing capabilities. The joint venture team created an innovative approach to the back-end Oracle database that successfully enabled decision support. Once the programming was developed to allow decision support within the Oracle database, similar identifiers were then incorporated to enable the intelligent search feature.

The HOLON project included three major testbed deliverables that demonstrated full functional capability. The testbeds grew steadily in size and scope with each successive year.

- The first testbed was the initial version of HOLON, with minimal functional capability for each of the layers of the architecture.
- The second testbed, HOLON version 2, was able to examine a limited form of real-time, data-driven, medical-decision support. It also demonstrated the internal capabilities of natural language search processing, transcription, and speech synthesis.
- The third and final testbed included all functionality, full privacy and security components, and automatic intelligent "anticipatory" data retrieval on patients, illnesses, cost, and care paths.

Conclusion

By project closeout, the Koop Foundation joint venture had developed several middleware tools. Lumina Decisions Systems incorporated the technology into new decision-support products. The joint venture also provided public access to much of the knowledge developed as part of this ATP-funded effort through a series of symposia, reports, and conferences on healthcare informatics.

Although the information generated by the joint venture was available to healthcare market participants, by the time the ATP-funded project ended in 1999, the healthcare industry had undergone a drastic change. The industry's consolidation and cost-control efforts had increased dramatically between 1995 and 1997; however, by early 1998, the national attempt to forge a universal healthcare system had failed, the idea faded from industry discourse, and the largest and most aggressive healthcare industry consolidators were under investigation for overcharging Medicare and Medicaid to cover cost overruns.

Industry changes propelled the healthcare marketplace beyond the Koop Foundation's ability to provide a useful service.

The consolidation trend slowed and information systems constructed to allow consolidation became less useful. By late 1998, industry changes had propelled the healthcare marketplace beyond the Koop Foundation's ability to provide a useful service. The Koop Foundation, Inc., ceased operation in 1999 for reasons unrelated to the ATP-funded project, and the middleware products are no longer available to non-joint-venture participants.

PROJECT HIGHLIGHTS
Koop Foundation, Inc.

Project Title: Middleware Solution To Provide Cost and Access Advantages (Health Object Library ON-Line (HOLON) Project)

Project: To develop an essential middleware framework for the healthcare information infrastructure, including a general architecture that specifies the organization, functions, and interfaces necessary for healthcare middleware and a library of reusable objects to support companies in developing healthcare applications.

Duration: 11/1/1995-4/30/1999
ATP Number: 95-10-0067

Funding (in thousands):

ATP Final Cost	$ 9,882	49%
Participant Final Cost	10,090	51%
Total	$ 19,972	

Accomplishments: This project successfully developed and demonstrated healthcare informatics middleware applications for use within the healthcare marketplace. The system used open architecture in an effort to speed up industry adoption of new information technology applications that could make business goals a reality. The Koop Foundation's joint venture addressed and overcame long-standing barriers to the evolution of healthcare information systems and provided the following benefits:

- By creating effective middleware, the joint venture enabled legacy systems to remain in place for the remainder of their normal useful lives, potentially generating significant cost savings that could be used to acquire new information technology assets.
- The joint venture also extensively modified a standard Oracle database to allow constantly evolving decision-support software on top of the information management capabilities of the HOLON system.
- The joint venture's detailed, intelligent search capability created additional time savings for those in the healthcare market.

The technology also was shared in the form of Internet resources, conferences, symposia, traditional papers, and presentations.

Commercialization Status: Lumina Decisions Systems incorporated the technology into new decision-support products. Changes in the healthcare marketplace, however, prevented commercialization of the results of the Koop Foundation's joint venture. Aggressive cost cutting had not proved successful for healthcare providers, and a universal approach to healthcare delivery had faded from the national scene. Middleware designed to enable integration and aggressive cost control, therefore, no longer had a role in the marketplace.

Outlook: Because the middleware products are no longer available to non-joint-venture participants, the outlook for this technology is poor.

Composite Performance Score: *

Company:
Koop Foundation, Inc.
Rockville, MD
(The company is no longer in existence.)

Joint Venture Partners:

- Beth Israel Deaconess Medical Center, Boston, MA
- George Washington University (medical center), Washington, D.C.
- Norwalk Hospital, Norwalk, CT
- Windom Health, Berkeley, CA
- Concept 5, McLean, VA
- Lumina Decisions Systems, Los Altos, CA (recently relocated to Los Gatos, CA)
- Meta Software Corporation, Cambridge, MA
- Oracle Corporation, Bethesda, MD
- Wizdom Systems, Inc., Alexandria, VA
- @Home, Redwood City, CA

The Koop Foundation, Inc., has ceased operation, an action that was not related to the ATP-funded joint venture. Other participants in the joint venture are able to revive the research if they chose to do so.

Research and data for Status Report 95-10-0067 were collected during April - June 2002.

Kurzweil Applied Intelligence, Inc.

Developing Continuous Speech Recognition Technology that Uses Natural Language Processing Commands

During the early 1990s, tremendous market opportunities emerged for speech recognition computer technology, yet no company had been able to develop a system that could recognize natural language continuous speech commands. Development of this type of technology presented too high a level of scientific risk to attract private investment. Therefore, in 1994, Kurzweil Applied Intelligence, Inc., applied for and was awarded cost-shared funding from the Advanced Technology Program (ATP) to pursue a three-year development project. With the help of ATP funding, Kurzweil successfully developed fully operational continuous dictation technology. The technology has since been integrated into Lernout & Hauspie's VoiceXpress™ product, which allows voice control of Microsoft and Corel Office software products.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 93-01-0101 were collected during July – September 2001 and April - June 2002.

Speech Recognition Technology To Provide Widespread Benefits

The benefits of developing speech recognition technology would be widespread. For example, the technology has the potential to encourage novices to use computers, and it can simplify the tasks that more experienced users encounter. Furthermore, speech recognition applications can provide expanded opportunities for the severely disabled to participate more fully in the marketplace. Finally, technology advancements offer cost savings associated with reducing repetitive motion injuries.

The technical hurdle for the industry was to craft an interface that enables personal computer (PC) users to communicate with their machines by speaking natural language commands recognized by the system. Kurzweil Applied Intelligence, Inc., proposed to create continuous speech recognition (CSR) technology referred to as Talking, Touching, and Typing ("T3"). T3 would allow a user to interact with an application by talking (saying phrases in a natural language), touching (perhaps by pen or mouse), and typing.

Existing Speech Recognition Systems Offer Limited Capabilities

Speech recognition systems are generally classified as discrete or continuous systems that are speaker dependent, independent, or adaptive. Discrete systems maintain a separate acoustic model for each word, combination of words, or phrases and are referred to as isolated (word) speech recognition (ISR). CSR systems, on the other hand, respond to a user who pronounces words, phrases, or sentences that are in a series or specific order and are dependent on each other, as if linked together.

A speaker-dependent system requires that the user record an example of the word, sentence, or phrase prior to its being recognized by the system; that is, the user "trains" the system. Some speaker-dependent systems require only that the user record a subset of system vocabulary to make the entire vocabulary recognizable. A speaker-independent system does not require any recording prior to system use. Instead, when a user identifies himself or herself, a speaker-adaptive system adapts the word, sentence, or phrase

to the user's voice as the user corrects recognition errors.

ISR systems present a considerably easier task for machines than do CSR systems. Speaker-dependent systems are simpler to construct and use and are more accurate than speaker-independent systems. As a result, the focus of early voice recognition systems was primarily speaker-dependent isolated word systems that used limited vocabulary. At the time, overcoming the restrictions in the state of technology required a greater focus on human-to-computer interaction. The challenge was to identify how improved speech recognition technology could be used to support the enhancement of human interaction with machines.

The most desirable approach is where the user interacts with the PC by accomplishing a set of formal operations that are limited in scope. Kurzweil sought to accomplish this task through a natural mode of interaction that is expressive and understandable. The key was to develop a technology that balances simplicity against the robustness of the response. A command language that is too simple may not be useful. On the other hand, if the language used to give commands is too complex, it is useful only to those who understand it.

Approach Combines Human Factors Experimentation and Technology Development

Kurzweil submitted a proposal to ATP's 1993 General Competition. The company's proposed approach was to build on existing speech recognition technologies, determine the necessary parameters and restrictions required to incorporate natural language processing (NLP) commands, and integrate CSR and NLP into an interface to create the T3 technology. Some of the pivotal issues leading to this ATP award included the integration and unique combination of the technologies to be studied, as well as the understanding and commitment to human interaction as it relates to PCs in today's information-rich society. Kurzweil's proposal demonstrated an awareness of combining human factors experimentation (conducted by User Interface Engineering in a subcontractor role) and technology development throughout the project. Therefore, ATP awarded funding for a three-year period beginning in March 1994, with Kurzweil covering its indirect costs.

Kurzweil's Market Presence Enhances the Effort

Kurzweil was founded in 1982 and proposed to use its experience, industry knowledge, and market presence to leverage the production of the interface. In 1985, the company had introduced Kurzweil Voice System, the first 1,000-word discrete-speech recognizer. This interface, adaptable to many applications, allowed the user to control the application by voice without modifying the operating system or software.

In 1987, Kurzweil introduced the first 20,000-word discrete-speech recognizer, which was incorporated into Kurzweil Voice Report software and allowed users to create structured reports by voice. A component of this technology was the Structured Report Generator (SRG). One of the key features of Kurzweil's SRG software was its ability to respond to a "trigger phrase," which is a spoken word or phrase that triggers an entire predefined report segment. Trigger phrases are designed to elicit multiple choices and alternatives as well as highlighted, fill-in-the-blank fields. The use of trigger phrases, along with word-by-word dictation, has the potential to allow users to generate custom reports by using a few spoken words. The project team built on these past efforts to develop the proposed technologies under the ATP project.

Project Succeeds in Developing Fully Functional Interface

Aided by ATP funding, the project team established a framework for technical development that included the following stages: hardware acquisition, technical planning, usability testing, and software compilation. During the technical software development stage, Kurzweil completed the construction of a continuous-speech recognizer. The company made modifications to this software throughout the project to enhance its range of accuracy. These enhancements were pivotal because the software served as the cornerstone of the spoken language interface. Kurzweil continued to make substantial progress, including the following accomplishments:

- Designed and constructed a prototype that allowed for continuous speech control of Microsoft Word and the testing of recognition accuracy

Some speaker-dependent systems require only that the user record a subset of system vocabulary to make the entire vocabulary recognizable.

- Produced both a standard and an extended speech application program interface (SAPI), in open-market format, to meet the needs of the marketplace

- Integrated several graphic user interface components with an NLP for all versions of Microsoft Word

Although the ATP project ended in February 1997, the team continued its development efforts, which resulted in a fully functional spoken language user interface system.

Acquisition and Additional Funding Advance Technology Development

In July 1997, Lernout & Hauspie acquired Kurzweil. That same year, Microsoft invested $45 million in the company, based in part on the work done in the area of a SAPI- compliant speech recognition system. The combined resources of Lernout & Hauspie and Microsoft enhanced the development and marketing of continuous command and control technologies using natural language.

The team continued its development efforts, which resulted in a fully functional spoken language user interface system.

Developing this technology involved a level of technical risk that was too high to attract private funding. Without ATP funding, Kurzweil would probably not have advanced its speech recognition technology or attracted the attention of either Lernout & Hauspie or Microsoft.

Use of Voice Technologies Continues to Grow

In September 1997, Lernout & Hauspie initially released its spoken language system as Voice Commands™, a shrink-wrapped product that allowed users to interact with PCs and word processing systems by using natural language and CSR to accomplish complex formatting and editing functions. At the time of release, however, the market was looking for a product with not only Voice Commands™ functions, but also with continuous dictation. Subsequently, the company integrated Voice Commands™ capabilities and the natural language technology into VoiceXpress™, a product that features a dictation component and grammar development tools. Lernout & Hauspie successfully marketed this product in seven languages.

These "Say it Your Way" products use patented natural language technology that enables users to dictate into a Windows-based program and allows for voice control of applications from Microsoft (Excel, PowerPoint, and Word) and Corel (WordPerfect). By 1999, Lernout & Hauspie had sold 150,000 units of VoiceXpress™ and had captured approximately 25 percent of the world market for voice recognition products.

Conclusion

In 2001, Lernout & Hauspie encountered financial troubles. The company filed for bankruptcy and was purchased for $39.5 million in assets by ScanSoft, a company known for its OmniPage optical character reader (OCR) scanning software and its digital document management software. ScanSoft intends to utilize Lernout & Hauspie's natural language technology to add dictation functions to its existing product lines. ScanSoft also is exploring putting speech recognition into automobiles and developing telephony-based products. Lernout & Hauspie was considering the development of both of these initiatives at the time of its bankruptcy.

PROJECT HIGHLIGHTS
Kurzweil Applied Intelligence, Inc.

Project Title: Developing Continuous Speech Recognition Technology that Uses Natural Language Processing Commands(Advanced Spoken Language User Interfaces for Computer Applications)

Project: To enhance human interaction with PCs by integrating advances in speech recognition using natural language technology. "Talk, Touch, and Type" interfaces allow a user to interact with an application by talking (saying phrases in a natural language), touching (perhaps by pen or mouse), and typing. The commands are not designed to handle every valid English phrase, but rather to define a simple, easily learned subset of the language to control widely used PC applications, such as word processing software and computer-aided design programs.

Duration: 3/1/1994-2/28/1997
ATP Number: 93-01-0101

Funding (in thousands):

ATP Final Cost	$1,734	72%
Participant Final Cost	664	28%
Total	$2,398	

Accomplishments: Kurzweil developed an advanced spoken language interface that is capable of responding to a user's natural language and that incorporates continuous speech recognition. The product recognizes key words in natural speech, enabling the user to request an action in multiple ways. The patented natural language technology was initially released as Voice Commands™. It was subsequently incorporated into VoiceXpress™, which the company marketed in seven languages. VoiceXpress™ features natural language technology along with a dictation component and grammar development tools. Kurzweil received the following patents for technologies resulting from this ATP-funded project:

- "Speech system distinguishing dictation from commands by arbitration between continuous speech and isolated word modules"
  (No. 5,794,196: filed June 24, 1996, granted August 11, 1998)
- "System and method for remotely grouping contents of an action history stack"
  (No. 5,890,181: filed November 14, 1996, granted March 20, 1999)
- "Command parsing and rewrite system"
  (No. 6,138,098: filed June 30, 1997, granted October 24, 2000)
- "Pronoun semantic analysis system and method"
  (No. 6,125,342: filed November 18, 1997, granted November 26, 2000)

Commercialization Status: In September 1997, Lemout & Hauspie shipped its Voice Commands ™ to market. Because of its restricted utility subsequently incorporated into Lernout & Hauspie's VoiceXpress™, which entered the market in 1998 and had more than 100,000 customers by 2000 (25 percent of VoiceXpress™ was ATP-funded technology). In 2001, Lernout & Hauspie struggled to recover from financial troubles, a situation that led to insolvency and dissolution by the courts. ScanSoft, a company known for its OmniPage OCR scanning software and its digital document management software, acquired the Lernout & Hauspie voice recognition assets for $39.5 million in the court sale.

VoiceXpress™ faced strong competition from IBM's ViaVoice products. In 2001, the IBM voice products had only a narrow sales lead over VoiceXpress™, according to NPD Intelect, but IBM benefited from Lernout & Hauspie's business failure. As of summer 2002, IBM had 53 percent of the U.S. retail sales market, compared with a 27-percent share in 2001.

Outlook: The future of Lernout & Hauspie's natural language technology appeared uncertain as the company faced dissolution. Since its purchase by ScanSoft, however, the outlook for the patented technology is more promising. ScanSoft plans to further enhance Lernout & Hauspie's technology by creating state-of-the-art digital imaging and speech and language solutions. ScanSoft also is considering putting speech recognition into automobiles and developing telephony-based products.

Composite Performance Score: * * *

Number of Employees: 100 employees at project start, 500 as of June 2002.

Company:
Scansoft, Inc.
400 5th Avenue
Waltham, MA 02451-8706

Contact: Dr. Francis Ganong
Phone: (781) 203-5110

Subcontractors:
User Interface Engineering

Research and data for Status Report 93-01-0101 were collected July – September 2001 and April – June 2002.

MediaBin (formerly Iterated Systems, Inc.)

Fractal-Based Technology to Compress Digital Image Files

In the early 1990s, when personal computers (PCs) were becoming increasingly commonplace at home and at work, the demand for more pictures and videos in personal computing applications increased. Computing technology at the time, however, was not able to process, display, or store image files because they were significantly larger than text files. Early modems, which operated at speeds such as 14.4 kilobits per second over analog phone lines, could not transmit large image files. In 1991, Iterated Systems, Inc. (ISI) proposed a research project to the Advanced Technology Program (ATP) to exploit common patterns in image files, reducing them and converting them to their fractal codes. The codes would then be stored in a separate chip, rather than in the computer's memory chip, to allow an easy transition to newer machines as memory, software, and hardware improved. ATP awarded ISI cost-shared funds because of the technology's high technical risk and potential applications for image databases within the real estate, automobile insurance, desktop publishing, medical, defense, and other diverse industries. ISI succeeded in developing compression technology that enabled the fast transmission of relatively high-quality (though not fully high-fidelity) images. However, changes in the market made ISI's innovation obsolete. By the end of the ATP-funded project in 1995, use of the Internet had become widespread, thus reducing the need to store vast image libraries on PCs. ISI decided not to pursue further research into high-fidelity digital image compression using fractal-based codes, and the company never commercialized the technology.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)

No Star

Research and data for Status Report 91-01-0057 were collected during October - December 2001.

Technology Unable To Transmit and Store Images

In 1990, image compression (that is, the ability to reduce the size of large, graphics-heavy files for easier storage and transmission) was one of the keystones in the development of future computer imagery. The need to share images and video between PCs and to electronically store them was increasing in those industries that relied on image databases, such as real estate, automobile insurance, desktop publishing, medical, and defense. The demand for image compression, transmission, and storage was increasing, in part because uncompressed digital images and videos required much more memory and internal storage space than PCs could provide. Moreover, memory and storage space requirements were much higher than the complexity of the images seemed to require. At the time, there was no adequate technology that could compress images into manageable sizes in order to easily store them or transmit them across analog lines.

ISI's Unique Idea Involves Mathematical Approaches

When ISI applied for ATP funding in 1991, they proposed a unique idea for using mathematical approaches to image compression. Although mathematicians worldwide were beginning to use fractals to attempt to compress images, at the time of ISI's ATP application, these mathematical methods represented too high a risk for traditional sources of venture capital. ATP funding, ISI suggested, would accelerate potential advances in fractal-based image

compression by up to two years. ATP considered the technology's immediate benefits as well as its possible widespread application throughout many diverse industries and awarded $1.57 million to ISI for a three-year research project.

Memory Device Will Compress and Decompress Images

ISI's ATP award would allow the company to conduct research into fractal-based image compression in order to produce high-fidelity images with small file sizes. Specific end results of the proposed project would include building prototypes of a low-cost, real-time decompression chip and a compression system based on the algorithms developed in the basic research phase of the project. ISI envisioned that the decompression chip would not require multiple frame buffers for video decompression, greatly reducing the chip memory required and enabling it to handle both video and still images quickly and easily. ISI proposed to create a memory device that would have the ability to compress and decompress video images. This memory device would keep the images separate from the PC's hard drive; would handle the conversion of large and cumbersome viewable images into small, storable files; and would easily store coded compressions of images and videos.

In addition to the substantial reduction in storage space offered by a fractal-based compression system was the appeal of decompression that was not dependent on a specific degree of resolution. ISI demonstrated with a photograph of a gecko that a poster-size blow-up of the gecko's eye could have the same resolution as the full body shown in the original postcard. This ability to provide any degree of resolution desired by the end user would support manipulation of image size. Since image-viewing software was projected to evolve rapidly throughout the early 1990s, resolution-independent storage would allow the end user to decide how much computer memory would be used in viewing each photo and would allow the image to be viewed by future generations of ever-improving display software. ATP saw ISI's proposed further development of the fractal image-compression technology as a potential springboard to industry-wide improvements in image processing and communication.

Image Compression Could Enable Computerized Image Libraries

Image compression had immediate potential applications in several industries that rely on image databases. For example, there was a daily need to store, catalog, use, and transmit large numbers of images within industries such as real estate, automobile insurance, desktop publishing, medical, and defense. In order to use PCs to speed these processes, images needed to be stored and transmitted over a standard analog line. Without improved compression and storage software, a relatively small image library of a dozen images or even one video would completely fill the PC's hard drive and would take hours to transmit over analog lines; thus, these excessive storage requirements precluded the widespread use of computerized image libraries.

Technical Challenges Posed by Fractal Codes

The Fractal Transform method for image compression, created by ISI in1990 (prior to the ATP-funded project), held promise for achieving very large compression ratios for still and video images, while maintaining high fidelity to the original, especially in the case of high-resolution images. The higher the compression ratio, the less space the compressed image requires within operating memory and computer storage. The problem in the past, however, was that the image degraded at higher compression ratios, making high-fidelity images impossible to compress and maintain.

Image compression had immediate potential applications in several industries that rely on image databases.

The Fractal Transform method exploited redundancies in two- and three-dimensional images to generate a representation in terms of readily decompressed fractal codes. ISI's initial success in using common image patterns to compress images accurately convinced the company's software engineers that they could develop a solution to the image compression and storage problems that would be welcome in the PC marketplace.

ISI's three technical challenges, however, were daunting. The first challenge was to develop fractal codes that could accurately compress and decompress all image-based still and video media that could possibly be used within a computer. Because PCs enabled the use of both still images and videos as part of daily operations, any compression software would need to handle both media with nearly perfect accuracy. The second challenge was to create a chip that could sit as a separate entity from the PC's hard drive and could compress and decompress large-scale images and videos using fractal codes. This would enable the compression and decompression to operate as a stand-alone image/video storage device that could remain within the PC even as hard drives were updated and as software evolved. The third challenge was to create a hardware-based, real-time compression system for high-resolution video images. This compression system would allow the immediate creation of video databases directly from the recording media that could then be accessed and manipulated by the memory-decompressor chip.

ATP saw ISI's proposed further development of the fractal image-compression technology as a potential springboard to industry-wide improvements.

In 1991, ISI believed that its Fractal Transform method could possibly meet these technical challenges. However, the technology at that time was not advanced enough to be used as anything but baseline technology from which to research fractal-based compression. The technology still required innovative algorithms developed by mathematicians, engineers, and computer professionals that could compress and decompress images and code them in a fashion that was compatible with the PC industry.

ISI Pursues Multiple Research Approaches

ISI pursued multiple paths in its research. For still image research, the company undertook two approaches: a conservative approach, which built on the existing idea of fractal-based compression; and a more speculative approach, which combined the best of fractal technology with the best of other technologies.

The conservative approach did not produce results that were cost competitive with technology already in the market; therefore, ISI concentrated on the more speculative approach. After 15 months, ISI was able to produce prototypes of compressors and decompressors that proved superior to other available technologies. However, the company was not able to maintain high fidelity to the original images because nonfractal conversions were also used. Therefore, ISI decided not to pursue development along this path.

The company also pursued two approaches to its research into video compression. As with still-image compression, purely fractal-based compression costs too much to produce. The approach that combined motion tracking with fractal-based compression offered the most promise. It used a new class of image maps, which enabled previously created detail to be moved instead of reconstructing new detail. ISI's efforts were directed at increasing compression speeds. Ultimately, speeds on the order of 25 seconds per frame were achieved on Pentium 90-equipped PCs for single color frames with a resolution of 320x240 dots per inch. At the time, these results were excellent, as well as highly encouraging.

Finally, the major goal of ISI's ATP-funded project was to produce a prototype, low-cost decompressor chip, implementing the algorithm produced by these research efforts. Researchers envisioned a chip that could store fractal codes and could produce images from them without requiring a significant amount of memory. ISI evaluated three alternatives during the development of this chip: the first alternative was for low-resolution images, the second was for high resolution, and the third was for enhanced resolution.

ISI did reach new heights in compression time and image clarity, and this technology is still in use in some image libraries.

Testing revealed that the best route to pursue was the development of a high-resolution chip. ISI completed and tested the core design, but by the time its ATP-funded research ended in 1995, use of the Internet had become widespread and market demand for image compression had shifted to small pictures for web

pages at low bit rates for mass Internet application. Since the ATP-funded research was geared towards high-bit-rate transmission of large images in high fidelity, the market shift was so great that the ATP-funded research no longer applied.

ISI Attracts Additional Funding

Even though the market shifted and made ISI's research somewhat inapplicable, the project helped ISI to attract additional funding. First, the company gave a presentation at a 1995 fractal image encoding conference at the North Atlantic Treaty Organization (NATO) Advanced Study Institute in Norway and gained enough credibility through its early-stage image compression technology that it was able to initiate a public offering listed on the speculative Norwegian stock exchange. Second, ISI secured a $36 million contract with MCI to work on image compression. ISI disclosed its research from the ATP-funded project to MCI as part of the due diligence process before the contract was approved, providing MCI with 25 internal technology research reports.

Conclusion

ISI received an ATP award to pursue a research plan that would attempt to use fractal codes to compress, store, and transmit image files. Ultimately, fractal codes could not be used without incorporating some nonfractal-based coding. This caused image deterioration and prevented true high-fidelity image storage. Even without full high fidelity, ISI did reach new heights in compression time and image clarity, and this technology is still in use in some image libraries. The emergence of the Internet and broadband connections, however, reduced much of the mass-market potential for computerized image libraries.

PROJECT HIGHLIGHTS
MediaBin (formerly Iterated Systems, Inc.)

Project Title: New Technology To Compress Digital Image Files (High-Fidelity Digital Image Compression)

Project: To develop a prototype digital image storage and decompression chip using fractal transform image compression technology.

Duration: 7/1/1992-6/30/1995
ATP Number: 91-01-0057

Funding (in thousands):

ATP Final Cost	$ 1,568	73%
Participant Final Cost	586	27%
Total	$ 2,154	

Accomplishments: With ATP funding, ISI accomplished the following:

- Produced prototypes of compressors and decompressors using a combination of fractal and nonfractal elements, which proved to be superior when benchmarked against other available technologies.
- Created more than 25 internal technology research reports that summarized the results of experiments conducted during the research and development process.
- Secured a $36 million contract with MCI, closed other large deals, and attracted business talent for the company based on increased credibility that resulted from this project.
- Disseminated project knowledge in July 1995 at a fractal image encoding conference at the NATO Advanced Study Institute in Norway. The transcript of that talk is publicly available worldwide.

Commercialization Status: Prior to the ATP project, ISI did not have any commercial products on the market that were based on fractal-compression techniques. During the project, ISI developed fractal techniques for image compression and decompression. However, the company later changed its business goals and discontinued further development of the technology.

Outlook: Fractal technologies have had some commercial use. In 1992, Microsoft used its own fractal-compression techniques to enable the release of its CD-ROM-based encyclopedia, Encarta. Several other vendors that offer fractal compression market their products for dynamic resizing of images for applications such as billboard manufacturing and company web sites. Experts in the field, however, predict that techniques based on wavelets and object-based technologies will continue to maintain their strong lead in compression technology research, making it harder, but not impossible, for fractal techniques to compete.

Composite Performance Score: No Stars

Number of Employees: 39 employees at project start, 55 as of December 2001

Company:
MediaBin, Inc.
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Atlanta, GA 30305-1530

Contact: Alan Sloan
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Research and data for Status Report 91-01-0057 were collected during October - December 2001.

PPD Informatics, a Division of Pharmaceutical Product Development, Inc.
(formerly Belmont Research, Inc.)

Browsing and Automatically Extracting Healthcare Data from Scattered Databases

Healthcare directives in the mid-1990s called for a reduction in cost and an improvement in the quality and efficiency of healthcare. Making these changes critically depended on convenient access to and the integration of detailed administrative, financial, and clinical data. Although sophisticated databases had been developed for each function, the lack of interoperability made it impossible to integrate data from various databases in the campaign to manage rising healthcare costs. The capability to browse and extract data from a multitude of databases would provide access to comprehensive, accurate information, while improving the overall quality of patient care and lowering costs through time savings and easily accessible resources.

The Belmont Research, Inc. Voyager project addressed the problem of data integration by creating a software tool that could be used to browse and automatically extract healthcare data from scattered databases without altering the existing systems. Because private capital was not forthcoming, Belmont turned to the Advanced Technology Program (ATP) for funding. ATP recognized the potentially large economic benefits and funded the project, which successfully developed a visual-data-retrieval and transformation system that assists healthcare providers in browsing and extracting information from scattered clinical and administrative databases. This technology was later commercialized as Table Trans™. In the process of developing Table Trans™, Belmont also developed a spin-off technology referred to as "Auto Coder," which addresses the problem of medical vocabulary coding. Belmont was acquired by Pharmaceutical Product Development, Inc. (PPD), and is marketing these products under the company name PPD Informatics.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 94-04-0024 were collected during March - April 2002.

Existing Healthcare Database Capabilities Are Limited and Disparate

Prior to the Voyager project, attempts had been made to address the issues related to database integration. However, no existing medical systems could transfer, query, and mine complex data from a multitude of scattered clinical and administrative databases without requiring changes to the existing systems. Although inputting healthcare information into databases organized the information, without interoperability, an individual hospital with numerous databases lacked the required level of integration to effectively and efficiently collect and interpret all the data. Moreover, there were many challenges in integrating healthcare systems. For example, hospitals have made large investments in information systems that are often inflexible. As a result, the hospitals are hesitant to replace these systems because they perform adequately, and the cost of implementing new systems is extremely high. Furthermore, various departments within the healthcare systems often have competing priorities, and,

consequently, computer systems are often selected to meet the needs of only one group of end users.

Voyager Project Could Improve the Quality of Healthcare Information

Belmont's goal was to develop a tool that addressed interoperability among healthcare administrative, financial, and clinical data. The Voyager project would augment the healthcare information infrastructure by providing a tool that enabled healthcare providers and quality/cost monitors to browse and automatically extract data from a multitude of scattered clinical and administrative databases without requiring changes to the existing databases. Belmont's intent was fourfold: 1) design a client/server architecture that supported flexible integration of healthcare data from multiple data sources represented in various data layouts; 2) implement software that provided high performance in data extraction and transformation, as well as ease of use for users; 3) develop specialized components to support the processing of temporal data, free-text data, and medical terminology; and 4) produce an integrated prototype to demonstrate the Voyager infrastructure in the context of a sample set of healthcare databases.

At the end of the project, Belmont expected to have a tool that would incorporate browsing and automated extraction for scattered databases, free-text search capabilities, sequence-query ability, and Metathesaurus support (that is, a database of information on concepts that appear in one or more of several different controlled vocabularies and classifications used in the field of biomedicine). If Belmont was successful, they could provide the medical community with a powerful tool that would directly respond to the needs of the healthcare industry.

Belmont Identifies Need for ATP Funding

When Belmont decided to move forward with the Voyager project, they had a sound plan for developing the technology. While many tools were being developed that addressed some aspects of Belmont's goal, the company's Voyager project incorporated several components not available concurrently in a single tool. However, in 1994, market emphasis was placed on the creation of Internet applications, and investors were unwilling to fund Belmont because it did not intend to create a web application tool. Because the government and healthcare providers had not defined standards for security, accuracy, integrity, and accessibility of healthcare information via the Internet, Belmont believed that a web tool would not be practical. Moreover, because Belmont was predominantly a research-oriented company at that time, it lacked the resources to undertake the Voyager project alone. As a result, Belmont submitted a proposal to ATP for funding support and received $1.9 million for a three-year project.

Belmont's goal was to develop a tool that addressed interoperability among healthcare administrative, financial, and clinical data.

With financial support from ATP, the company expanded their resources and overcame their research obstacles. Belmont's Jeremy Poole stated, "Without ATP funding, a development group of our size would not have proceeded with such a large and complex project."

Voyager's Potential for Broad-Based Benefits

The Belmont tool would enable interoperability of proprietary systems without requiring changes to existing systems. This would promote interoperability and encourage collaborative efforts within healthcare institutions, resulting in improved efficiency and quality of healthcare, while reducing overhead costs and enhancing the effectiveness of databases already in place. In addition, the healthcare facilities' improved internal operations would raise the quality of patients' care by potentially reducing medical errors.

"Without ATP funding, a development group of our size would not have proceeded with such a large and complex project."
-Belmont's Jeremy Poole

If the technology proved successful, it would enable a broad range of opportunities in healthcare and other markets, such as manufacturing and financial services. These markets tend to have difficulty developing

quality-improvement programs and creating new applications that integrate administrative and financial information.

Collaborator Support Crucial in Achieving Technical Goals

In order to bring together the right combination of information technology and healthcare expertise to successfully deploy the Voyager project, Belmont collaborated with Children's Hospital and Beth Israel Hospital in Boston, Lexical Technology (currently known as Apelon, Inc.), and the University of Massachusetts. The work of Children's Hospital on database integration would serve as the starting point for defining a query language and protocol to be used with Voyager client software.

Belmont was a member of the Center for Intelligent Information Retrieval at the University of Massachusetts (a consortium for the development and application of information retrieval) and had a relationship with Applied Computing Systems Institute of Massachusetts, Inc. This gave Belmont access to these groups' technology and expertise in developing free-text searches that would allow the automatic screening of words or phrases that appear in available databases. Belmont was quite familiar with efforts in time-oriented data management and intended to develop technologies for time-oriented clinical data visualization to be used in the Voyager project. Belmont also collaborated with Lexical Technology to overcome difficulties of clinical data representation that were complicated by the fact that clinical information systems tended to use different conventions and vocabularies, especially with medical coding.

Belmont Succeeds in Developing Voyager

Belmont successfully developed prototypes for two data management tools. The first tool has a visual-data-retrieval and transformation system that allows users to conduct complex database retrievals, derivations, and transformations. The system helps users unlock information by allowing them to specify sophisticated transformations step by step, browse data and meta data, and visualize complex transformation logic. The second tool, Auto Coder, addresses the problem of medical vocabulary coding. It has the capability to support the intelligent translation of clinical data representations. With Auto Coder, Belmont made substantial progress in translating clinical data representations and in developing a visual environment for designing and running autocoding algorithms.

Belmont's two main performance goals for the Voyager project were to demonstrate usefulness and to demonstrate scalability and robustness. The usefulness of the Voyager technology was demonstrated in 1997 when the U.S. Food and Drug Administration used a beta version of Voyager to verify the life-threatening consequences of using the fenfluramine and phentermine diet drugs in combination. Furthermore, Voyager's robustness was proven when Belmont used the technology to convert a client's data from one medical-problem-reporting software package to the BBN/ClinTRACE adverse-event-reporting application. Belmont not only completed the task, but the team estimated that they were able to convert the data in approximately half the time that would have been required without the Voyager technology.

In early 1997, Belmont launched a parallel project to commercialize the technology developed during the Voyager project. Table Trans™, the commercialized version of the Voyager technology, incorporated the visual programming interface and was intended to support database transformation, database integration, and complex database query creation and management.

Belmont Encounters Obstacles to Commercialization

Belmont felt they could commercialize Table Trans™ more effectively by aligning themselves with a larger company. In 1997, Pharmaceutical Product Development, Inc. (PPD) acquired Belmont (now PPD Informatics) for an undisclosed amount. The Voyager technology was a major part of Belmont's attraction. The new partnership arrangement, Belmont management believed, would allow them to significantly expand their commercialization efforts while at the same time giving them the freedom to continue development of healthcare software solutions.

The Voyager technology also led IBM to form a strategic partnership with Belmont. Belmont began

negotiations with an operating unit of IBM to become the exclusive distributor of the Table Trans™ software in the United States and Europe. Under this arrangement, Table Trans™ would be integrated into the IBM Healthcare product line and IBM sales and technical staff would be trained to support the sale and application of the technology. IBM was also interested in using the Table Trans™ technology in other data-intensive industries such as sales tracking, market analysis, and data warehousing. Unfortunately, the IBM partnership did not prove as successful as Belmont had initially hoped, because the company encountered difficulty incorporating Table Trans™ into their suite of tools.

As a result, Belmont decided to refocus its attention on supporting clinical trials data. Although this technology has proven valuable, it was still a challenge to sell it within the pharmaceutical industry. Therefore, Belmont concentrated on consulting opportunities, with the Table Trans™ software as a part of their service offerings. This method allowed companies to obtain the benefits of the software, but to have Belmont support the technology. Belmont continues to sell the tool separately, yet they focus on offering it through consulting services. The company's current customers who use Table Trans™ have noted that the software expedites the migration of data, minimizing the need for costly and time-consuming programming.

In July 2001, PPD Informatics released Table Trans™ version 2.1. The new features of Table Trans™ enable users to configure the software to their specific requirements for security, user access, and auditing in order to comply with Federal regulations issued in 21 Code of Federal Regulations (CFR) Part 11.

DSstar, a leading publication for the data mining, data warehousing, and business intelligence communities, has written an article on Table Trans™ version 2.1 titled, "PPD Informatics' Table Trans 2.1 Provides Advanced Security."

Conclusion

When Belmont was unable to secure external funding, the ATP award allowed the company to develop an innovative product for the healthcare industry. ATP's support helped the small research firm design a system that created significant interest in the healthcare informatics market. The company's successful development of Table Trans™ led to Belmont's acquisition by PPD, which enabled Belmont to obtain the market position they needed to commercialize their product and to penetrate an established customer base.

PROJECT HIGHLIGHTS
PPD Informatics, a Division of Pharmaceutical Product Development, Inc. (formerly Belmont Research, Inc.)

Project Title: Browsing and Automatically Extracting Healthcare Data from Scattered Databases

Project: To enable healthcare providers and quality/cost monitors to browse and to extract data automatically from many scattered clinical and administrative databases, without requiring changes to the existing databases.

Duration: 01/01/1995-12/31/1997
ATP Number: 94-04-0024

Funding (in thousands):

ATP Final Cost	$1,978	77%
Participant Final Cost	603	23%
Total	$2,581	

Accomplishments: Belmont Research successfully developed prototypes of two healthcare data management tools that are being commercialized in the clinical data industry. ATP funding allowed Belmont to create a faster, yet more reliable, tool for clinical data migration. The first product, Table Trans™, is a visual-data-retrieval and transformation system that allows users to carry out complex database retrievals, derivations, and database integration. The spin-off tool, Auto Coder, is a set of automated and interactive components for classifying and coding clinical data to address the problem of medical vocabulary coding.

Commercialization Status: Belmont chose to be acquired by PPD so that it could commercialize Table Trans™ more effectively. PPD Informatics continues to market both Table Trans™ and Auto Coder to the clinical research industry; however, the company has decided to focus on offering the tool mainly through their consulting services. PPD Informatics continues to enhance Table Trans™ to meet the unique access control requirements defined by Federal, state, and local regulations, as well as industry standards. In July 2001, PPD Informatics released Table Trans™ version 2.1. The new features of Table Trans™ enable users to configure the software to their specific requirements for security, user access, and auditing in order to comply with Federal regulations issued in 21 Code of Federal Regulations (CFR) Part 11.

Outlook: PPD Informatics continues to support enhancements to Table Trans™. The healthcare infrastructure technology developed with the help of ATP funding has received considerable interest. For example, DSstar, a leading publication for the data mining, data warehousing, and business intelligence communities, has written an article on Table Trans™ version 2.1 titled, "PPD Informatics' Table Trans 2.1 Provides Advanced Security." With the support of its parent company PPD, PPD Informatics will continue to make inroads in the healthcare informatics industry.

Composite Performance Score: * * *

Number of Employees: 15 employees at project start, 35 as of April 2002

Focused Program: Information Infrastructure for Healthcare, 1994

Company:
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Cambridge, MA 02140

Contact: Jeremy Poole
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Research and data for Status Report 94-04-0024 were collected during March - April 2002.

Reasoning Systems, Inc.

Reengineering and Rewriting Legacy Software Systems

One of the key issues in significantly changing how software is composed and used is what to do about the existing software. The installed systems and data files—the so-called "legacy systems"—represent far too great an investment to be discarded, regardless of how useful the new software technology may be. A major difficulty is the wide variety of legacy systems, which might be written in any of dozens of computer languages and language "dialects," as well as countless specialized data formats. In 1984, Reasoning Systems, Inc., was launched to develop programs to fix software problems related to complex legacy systems. During the late 1980s, Reasoning created a family of reusable components for reengineering in the COBOL, C, FORTRAN, and Ada programming languages. These components were designed for the customization of specific reengineering tasks.

In 1995, Reasoning submitted a proposal to the Advanced Technology Program (ATP) to undertake technically high-risk research to develop software that would automate the reengineering and rewriting of legacy software systems. ATP awarded cost-shared funding to Reasoning through its focused program, Component-Based Software, which enabled the company to strategically position itself for the burgeoning Year 2000 (Y2K) repair market. Reasoning subsequently received more than $22 million in venture capital financing between 1996 and 2000 and grew from 12 people at the time of the ATP proposal in 1995 to more than 100 by 2000. At its peak, Reasoning made a significant impact as a leader in the Y2K software repair market, both as a seller of effective, low-cost software toolsets and as an innovator in software inspection tools. Today, after a sharp drop-off in the transformational software purchasing that had fueled its explosive pre-2000 growth, a leaner Reasoning has refocused its business model, secured an additional $9 million in venture funding, and continues to commercially market the software technology developed during the ATP project.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* *

Research and data for Status Report 94-06-0026 were collected during January 2002.

Legacy Systems Consume High Percentage of Corporate Resources

One of the key issues in significantly changing how software is composed and used is what to do with legacy systems. This is a problem not only for new software technologies, but also for day-to-day maintenance operations. In many large organizations, maintenance of legacy systems consumes more then 90 percent of information systems resources. A major difficulty is the wide variety of legacy systems, which might be written in any of dozens of computer languages and language "dialects," as well as countless specialized data formats. Companies that optimize business processes must often change legacy information systems to support the new processes. The required changes can involve new features, porting, performance optimization, or bug fixes. Minor changes can often be accomplished in a relatively painless fashion by modifying a small amount of code. However, major changes—such as porting a COBOL mainframe-based system to a UNIX client/server-based architecture built on a relational database—are typically very difficult, expensive, and risky.

Major changes often require a switch not only of code, but also of supporting tools (e.g., compilers and editors), development processes (testing and version

control), and personnel. A major change is usually made by some combination of discarding part or all of the existing system, modifying existing parts, writing new parts, and purchasing new or improved parts from external vendors. If the change is accomplished primarily through discarding the existing system and buying or building new parts, the project is characterized as a rewrite or redevelopment. If the change is accomplished primarily by modifying the existing system, the project is characterized as a reengineering project. Rewriting and reengineering are the extremes along a spectrum of strategies for change; most major upgrades are accomplished by some combination of the two.

Reasoning offered software technology that would automate the rewriting and reengineering process for companies who needed to update legacy systems. However, to enter the larger software engineering market, it needed to make significant advances in its technological capabilities.

Expanding the Application of Data-Slicing Software

An organization's business policies, processes, and procedures are often maintained on its legacy systems, and it is inconceivable that these systems can simply be abandoned when a new system is purchased. It is equally implausible that all of an organization's legacy systems and applications can be rewritten or replaced as technology and business processes change. Therefore, maintaining, reengineering, and migrating these systems in a cost-effective and efficient manner is an important option.

In its 1995 ATP proposal, Reasoning proposed to apply the component-based automated code transformation technology that it had been refining since 1984 to the larger software reengineering industry. Reasoning proposed to use the principles of reusable software components and automated software composition to solve this pervasive problem by establishing the framework to easily create customized software reengineering tools. The company would create individual software components to handle interfaces with standard languages such as C, COBOL, and FORTRAN, and other components that implement sophisticated reengineering techniques, such as program data slicing, to build semantic models of the legacy system. Other companies would then be able to use these components to generate specific solutions for their customers; one application, for example, might be a software tool that extracts the implicit "business rules" from existing systems with a particular COBOL dialect and database.

An organization's business policies, processes, and procedures are often maintained on its legacy systems, and it is inconceivable that these systems can simply be abandoned when a new system is purchased.

In order to achieve its goal, Reasoning needed a combination of static and dynamic semantic analysis of software. The highlights of Reasoning's technical approach were the following:

- Automatic composition of reengineering tool components to support customization to specific jobs and reuse across multiple languages
- Use of program slicing and path feasibility analysis to derive semantic models of legacy code, such as business rules and system invariants
- Animation of code execution in terms of derived semantic models
- Analysis of derived semantic models to support reengineering and composition of the underlying legacy systems

Reasoning Proposes to Develop Slicing and Data Flow

Program slicing has been recognized in computer science research as a powerful technique for understanding programs. This technique allows the dissection and analysis of a program based on data flow. Using the analysis, it is then possible to answer many questions about how a program works. A key problem with program slicing, however, has been performance because the data-flow analysis necessary for program slicing is computationally intensive. To

overcome performance issues with program slicing, Reasoning took a creative approach. It made the data-flow analysis incremental, an approach contrary to typical algorithms at the time that effectively computed the entire data-dependency graph for a program. Reasoning hoped that its advanced research on program slicing and its application to transformation systems would be a key differentiator in the marketplace.

Applications of the ATP-Funded Technology Could Be Diverse

By creating reusable components and automated composition techniques for adapting reengineering capabilities to diverse languages and databases, Reasoning's technology could reduce the time, cost, and risk of reengineering across a wide variety of legacy systems (e.g., COBOL-based business applications and FORTRAN scientific applications). First, improved reengineering productivity would lead to increased reuse of legacy systems, fewer disastrous "big-bang" redevelopment projects, extraction and exposure of business logic from legacy systems, and increased allocation of information systems resources to develop new systems instead of maintaining legacy systems. Second, by enabling cost-effective migration of legacy systems to new information technologies, demand for those technologies would be increased.

By creating reusable components and automated composition techniques, Reasoning's technology could reduce the time, cost, and risk of reengineering across a wide variety of legacy systems.

This would spur growth in high-value industries such as personal computers, workstations, networks, databases, multimedia, and software development. This growth would lead to higher investment in research and development (R&D), which would yield technological advances in those areas. Third, this technology would enable cost-effective migration of scientific software to new computing technologies, such as massively parallel computers that increase the productivity of scientists in software-intensive fields, from weather simulation to molecular biology.

ATP Support Accelerates Technology Development

To achieve commercial viability, however, Reasoning needed an infusion of capital to complete the research quickly before its international competitors caught up and eliminated its competitive advantage. Because the high-risk nature of this R&D project discouraged venture capitalists, Reasoning proposed a $2 million, three-year project to ATP. Without ATP funding, Reasoning would have pursued many of the same technical objectives of the project, but at only 10 to 20 percent of the funding level provided by the ATP award. This lower funding level would have significantly extended the schedule for delivering practical products. Reasoning's proposed technology was promising and the commercial advantage of rapid R&D was clear. Moreover, future applications of the technology had the potential to produce broad-based economic benefits beyond its own market by improving end-user and programmer productivity, as well as reducing high hardware and software maintenance costs.

Reasoning Achieves Technical Success

Bringing control to reengineering and rewriting projects through automation was Reasoning's stated high-level goal for the ATP-funded project. Furthermore, the company sought to design and prototype a framework and a set of components to formally capture legacy software systems and to build software reengineering, reverse engineering, and migration applications.

Reasoning achieved its objectives. Perhaps the most important goal that the company attained was the ability to help programs meet quality and dependability requirements by identifying and repairing defects in legacy systems. The company also built a framework that could easily be adapted to nonstandard languages and operating systems. No two legacy software systems are alike, and the problems that these systems manifest are diverse. Therefore, in order to successfully address legacy software, a toolset must be very flexible so that it can adapt to a variety of situations. Several of the key components that were developed demonstrated this power of flexibility.

ATP-Funded Technology Helps To Solve Y2K Problem

In 1996, companies were just beginning to address the Y2K problem. Reasoning's management identified this niche as a potential market for its ATP-funded technology, and, in 1999, began to target this profitable business. Reasoning attracted some top talent to drive this change in strategy and soon obtained venture capital support to begin commercializing its core technology to analyze, identify, and repair Y2K bugs in corporate computer systems. Analysts predicted that this market could be $300 to $900 billion in the years preceding 2000. Reasoning's growth was rapid. In three years, the company raised almost $23 million in venture capital investment, increased its staff from 12 to more than 100, and established a national presence with offices across the country. Reasoning successfully developed and marketed its Y2K solution and made a significant impact as a leader in the Y2K software repair market both as a seller of effective, low-cost software toolsets and as an innovator in software inspection tools. Reasoning's unique approach to solving the Y2K problem was based on the R&D conducted during the ATP project.

Investors Continue To Commit Funds to Inspection Tool

Reasoning transitioned its original software tool from a transformation tool to a Y2K tool, and, finally, to an inspection tool. ATP's funding support during the technology's critical years helped Reasoning create an innovative automated software inspection service that enables major technology companies to dramatically reduce the time, effort, and cost required to produce quality software.

Reasoning's unique approach to solving the Y2K problem was based on the R&D conducted during the ATP project.

Reasoning's solutions analyze the source code and pinpoint the exact location of crash-causing and data-corrupting defects before testing. With Reasoning's inspection database, a company can benchmark software quality across projects, companies, and industries.

Despite a reduction in force since 2000, Reasoning has reinvented itself and its technology several times in order to anticipate and react to changing market needs and conditions. A venture capital round of investment of $9.2 million in 2001 reaffirmed investors' commitment to Reasoning's technology. Reasoning is still developing the inspection tool with a restructured workforce of approximately 20 persons. The company remains hopeful that spending in the market will recover to pre-September 2001 spending levels.

Conclusion

What began as a highly academic and technical company became a fast-growing software firm that attracted top venture capital investors and recruited a proven management team from larger, public companies. ATP funding was the catalyst for Reasoning's new R&D capabilities and enabled it to become a viable software firm worthy of investment. As of January 2002, Reasoning continues to market the technology developed during the ATP project.

PROJECT HIGHLIGHTS
Reasoning Systems, Inc.

Project Title: Reengineering and Rewriting Legacy Software Systems (Component-Based Reengineering Technology)

Project: To use the principles of reusable software components and automated software composition to tackle the problem of numerous legacy systems within a corporation by establishing the framework for easily creating customized software reengineering tools.

Duration: 1/1/1995-12/31/1997
ATP Number: 94-06-0026

Funding (in thousands):

ATP Final Cost	$ 2,000	58%
Participant Final Cost	1,443	42%
Total	$ 3,443	

Accomplishments: Reasoning achieved the following goals during the ATP-funded project:

- Reduced the time, cost, and risk of reengineering across a wide variety of legacy systems by creating reusable components and automated composition techniques for adapting reengineering capabilities to diverse languages and databases
- Enabled cost-effective migration of scientific software to new computing platforms, such as massively parallel computers that increase the productivity of scientists in software-intensive fields, from weather simulation to molecular biology

Commercialization Status: Reasoning applied its ATP-funded technology to the Y2K problem. Since then, the company has marketed the technology developed during the ATP project. After being re-branded several times, the new technology provides automated software inspection services that enable major technology companies to dramatically reduce the time, effort, and cost required to produce quality software.

Outlook: Reasoning transitioned its original software tool from a transformation tool to a Y2K tool and, finally, to an inspection tool. The company has reinvented itself and its technology several times to anticipate and react to changing market needs and conditions. After receiving $23 million in venture capital investment between 1996 and 2000, a venture capital round of investment of $9.2 million in 2001 reaffirms the investment community's commitment to this technology as Reasoning refocuses on a new market.

Composite Performance Score: * *

Number of Employees: 12 employees at project start, 20 as of January 2002

Focused Program: Component-Based Software, 1994

Company:
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Research and data for Status Report 94-06-0026 were collected during January 2002.

Surgency (formerly Benchmarking Partners)

A Collaborative Model To Integrate Delivery Chain Information

As healthcare reform prompted the consolidation of independent regional healthcare providers into integrated delivery networks, the incompatibility of countless healthcare information systems posed crippling difficulties for the continued delivery of quality, cost-effective care. The development of a standard framework to integrate the industry's disparate information systems became crucial to the rapidly evolving U.S. healthcare system. The Patient-Oriented Management System (POMS), an innovative patient-focused integration effort, brought together hundreds of healthcare professionals to develop an infrastructure that would allow the sophisticated, rapid exchange of data for real-time decision support across the healthcare delivery chain. Although the technological risk was high, Benchmarking Partners, with co-funding from the Advanced Technology Program (ATP), prototyped the POMS technology. As part of ATP's Focused Program, Information Infrastructure for Healthcare, the original healthcare-focused project encountered implementation obstacles, but a spin-off technology, Collaborative Planning, Forecasting, and Replenishment (CPFR®), met with significant commercial success and continues to improve the efficiency of supply chains in a wide variety of industries.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 94-04-0046 were collected during October - December 2001.

Improved Communication Promises Significant Cost Savings

Restructuring the U.S. healthcare system into integrated delivery networks, formed to improve the efficiency of the industry, presented the mammoth challenge of establishing interoperability among the many entities in the healthcare delivery chain. Effective operation requires rapid exchange of data among clinicians, financial providers, suppliers, pharmaceutical companies, and other components of the healthcare system. The existing framework, composed of disparate legacy systems, lacked the information infrastructure to support adequate communication within and across organizational components, prohibiting the real-time decision-making necessary to preserve quality of care while maintaining cost effectiveness.

The current system required that clinicians spend a great deal of time tracking down patient records or repeating tests because of incompatible diagnostic procedures across institutions. This inadequately managed information system presented a significant opportunity for cost savings. In its proposal to ATP's Focused Program for Healthcare Information Infrastructure, Benchmarking Partners estimated that the industry could save $80 billion annually through better information management, an amount the company considered conservative, because it did not include the benefits of real-time decision support.[1] While the 1993 Working Group on Computer-Based Patient Records' report to the Secretary of Health and Human Services estimated that the task of developing an information infrastructure would take 15 years and would cost $100 million, Benchmarking Partners anticipated a solution in 3 years at a fraction of the cost.

1. *The company is referred to as Benchmarking Partners in this Status Report. After the ATP project concluded, the company changed its name to Surgency.*

Benchmarking Partners identified integration at the information management level as the greatest challenge facing the healthcare industry. Though various groups attempted to construct laboratory, instrument, and medical record structure standards to coordinate their systems, no model existed that comprehensively addressed the integration problem. Benchmarking Partners recognized that an innovative framework capable of integrating an array of legacy systems was the keystone for improving the delivery of quality and cost-effective healthcare. The company applied to ATP for funding the development of the technology to achieve this framework and received a three-year award in 1994.

POMA Provides Framework for Data Exchange

In response to the healthcare industry's need for an information infrastructure, Benchmarking Partners devised the Patient-Oriented Management System (POMS), later renamed Patient-Oriented Management Architecture (POMA). POMA was to provide a standard framework for the exchange of data between disparate legacy systems by creating an interface to define the communication between applications, such as a clinical diagnostic tool and a cost management system.

The existing framework, composed of disparate legacy systems, lacked the information infrastructure to support adequate communication.

POMA aimed to break the boundaries between these disengaged information systems through its patient-focused reference model. This goal involved significant technical risk, because transforming important data into a widely accessible format required the integration of hundreds of deeply entrenched legacy systems.

The POMA framework approached the challenge by creating object-oriented interfaces that define communication between six enterprise systems: finance and administration, clinical care, services and plans, resource management, contracting and suppliers, and research and education. Ideally, the framework could support a system in which a healthcare professional could simply type in a patient's name to access information ranging from diagnostic tests previously performed at other facilities, to the availability of an uncommon prescription drug at the local pharmacy. The system also provided protection of proprietary information and safeguards for patient privacy, allowing critical disclosures between appropriate parties while preserving confidentiality.

Project Focus Is Redirected to Retail Industry

Benchmarking Partners successfully developed the prototype software for the POMA model and formed a working group of more than 300 members that met regularly to plan strategies to implement the technology across the healthcare chain. However, the project met resistance from healthcare application vendors who hesitated to integrate with their competitors.

Transforming important data into a widely accessible format required the integration of hundreds of deeply entrenched legacy systems.

With permission from ATP, Benchmarking Partners shifted its focus from the healthcare delivery chain specifically to a universal component of any delivery chain: the relationship between manufacturers and retailers. Having observed the inefficient interaction between manufacturers of medical and surgical supplies and the supply departments in healthcare facilities, Benchmarking Partners estimated that the development of a stockless inventory system based on just-in-time delivery could reduce monthly stocking costs by tens of thousands of dollars per healthcare facility. Moreover, they recognized the opportunity for broad-based improvement of all delivery chains through the implementation of a generic model to enhance communication between supply and demand components.

While real-time communication across the supply chain would provide multiple benefits, it required the significant technical task of integrating valuable information into a standard, accessible, and useful format. Selecting the retail industry's delivery chain as their pilot focus, Benchmarking Partners directed its efforts toward developing an Internet-based collaborative model that would synchronize manufacturers' forecasting and replenishment planning processes with those of their retailers.

Spin-off CPFR® Technology Increases Supply Chain Efficiency

In late 1997, Benchmarking Partners began developing the Collaborative Planning, Forecasting, and Replenishment (CPFR®) technology. This spin-off technology originated through Benchmarking Partners' ATP-funded effort to improve efficiency by developing technology to support real-time collaboration across a delivery chain. CPFR® increases the efficiency of supply chains by allowing manufacturers and retailers to use the Internet for real-time synchronization of sales forecasts and business plans.

As part of its refocused project, Benchmarking Partners formed an alliance with SAP America, Manuguistics, Wal-Mart, and Warner-Lambert to organize the Retail Working Group, the first retail business-to-business collaboration initiative. The Retail Working Group established a pilot project to explore the potential for retailers and manufacturers to collaborate on a supply and demand forecast, based on participation between Wal-Mart and Warner-Lambert. The pilot prototype worked by importing initial forecasts from each end of the supply chain and scanning them to detect any discrepancies in supply or demand figures that exceeded preset exception thresholds. If exceptions were found, the software generated a notification to the appropriate trading partners, who then proposed revisions until they reached a shared forecast.

Successful Pilots Elevate CPFR® Technology to Mainstream

The success of the Retail Working Group in quantifying and proving the business benefits of supply and demand forecast collaboration prompted the formation of the Voluntary Interindustry Commerce Standards (VICS) CPFR® committee. Benchmarking Partners published a protocol from its pilot on its web site and shared process models and other documented results with the committee. This diffusion of knowledge led to the VICS committee's involvement in another pilot effort undertaken by Wal-Mart, Lucent Technologies, Sara Lee Corporation, Ernst & Young, SAP America, and Sun Microsystems. Wal-Mart and Sara Lee, the collaborative participants in this initiative, reported a 14-percent reduction in store-level inventory with a 32-percent increase in sales during the pilot test.

Encouraged by this success, the VICS committee published a CPFR® manual to explain the process and its implementation and to assist companies in determining how CPFR® could impact their business.

With low barriers to participation and benefits of a quick return on investment demonstrated by Wal-Mart's leading initiative, other pilot projects followed. CPFR® technology rapidly became a mainstream business practice within the retail industry. The VICS CPFR® manual was made available for free online or for purchase in hard copy. To date, more than 110 major corporations have joined the VICS association as a starting point for implementing CPFR® practices to improve their supply chains.

CPFR® Technology Is Successfully Commercialized

In 1998, Matt Johnson, a partner of Benchmarking Partners during the ATP project and a key player in the company's involvement with CPFR®, joined with other industry leaders to launch Syncra Systems. Syncra successfully commercialized collaborative technology with its flagship product, Syncra Ct®, the first 100-percent-compliant, vendor-neutral solution to support VICS guidelines for CPFR® implementation. Today, Syncra is a premier provider of supply chain collaboration solutions with $4.6 million in annual revenues and 35 employees. Syncra projects that in the next decade its collaborative technology and services will enable inventory reductions, service-level improvements, and sales increases that are expected to result in more than $100 billion in economic gains worldwide.

Technology Provides Broad-Based Benefits

The implementation of collaborative practices offers a high return on investment by achieving cost-saving reductions of inventory at a relatively low start-up price. Because CPFR® guidelines are easily accessible, this technology has the potential to benefit the entire manufacturing and retail supply chain. Industry research suggests that $1 trillion of goods are kept in inventory across the supply chain at any given time. Syncra estimates that 15 to 20 percent, or $150 to $200 billion, of held inventory could be eliminated through improved planning, forecasting, and replenishment

practices. With a 25-percent annual carrying cost, such a reduction of inventory could save the industry $40 to $50 billion in the United States alone.

This technology has the potential to benefit the entire manufacturing and retail supply chain.

By reducing demand uncertainty and increasing the operational effectiveness of both ends of the supply chain, collaborative practices benefit both retailers and manufacturers. The end result of collaboration is lower prices of retail goods to the ultimate benefit of the consumer.

Collaborative Practices Become a Trend Across Industries

Collaborative practices that emerged as a result of this ATP-funded project have become standard in the retail industry, providing significant savings to manufacturers and retailers alike. Furthermore, other industries have quickly adopted these strategies. Cutting-edge manufacturers have turned to their own suppliers to expand forecast collaboration capabilities to encompass the entire supply chain. For example, the high-tech industry has incorporated CPFR® business practices, as demonstrated by the consortium, RosettaNet. This consortium of information technology, electronic components, and semiconductor manufacturing companies works to align processes between supply chain partners on a global basis.

Diffusion of Collaboration Strategies Continues

In addition to the online accessibility of CPFR® guidelines available through VICS, Benchmarking Partners continues to offer consulting services and collaborative software to accelerate the implementation of collaborative strategies that emerged from its ATP project. Because of its expansion into the collaborative strategies market, Benchmarking Partners attracted venture capital from Cisco Systems, Inc., and the Internet Capital Group, who are now strategic partners of the company.

Ted Rybeck, chairman and founder of Benchmarking Partners, originally applied to ATP for funding the development of Internet-based collaborative models. He continues as chairman of Surgency (the new company name, which reflects the expansion of its services) and currently teaches courses on value chain collaboration strategy at the Wharton School and the Massachusetts Institute of Technology.

Alliance with ATP Leads to Pioneering Efforts

The alliance with ATP permitted Benchmarking Partners to pioneer efforts to develop Internet-based collaborative strategies and to overcome the technical challenge of integrating valuable data from disparate forecast systems into a standard, accessible, and useful format.

The ATP award was influential in the company's ability to attract sponsorship from the leading applications provider, SAP America. This partnership led to the larger alliance between Benchmarking Partners, SAP America, Manuguistics, Wal-Mart, and Warner-Lambert. Furthermore, it led to the creation of the Retail Working Group, which piloted the implementation of CPFR® technology, prompting the formation of the VICS CPFR® committee.

Conclusion

According to Benchmarking Partners, "The market success of collaborative forecasting and replenishment and the recent commercial investment in Benchmarking Partners demonstrates the effectiveness of programs like the Advanced Technology Program. By identifying and supporting innovation at the pre-commercial stage, ATP grants allow companies like Benchmarking Partners to take substantial risks and develop new market opportunities.

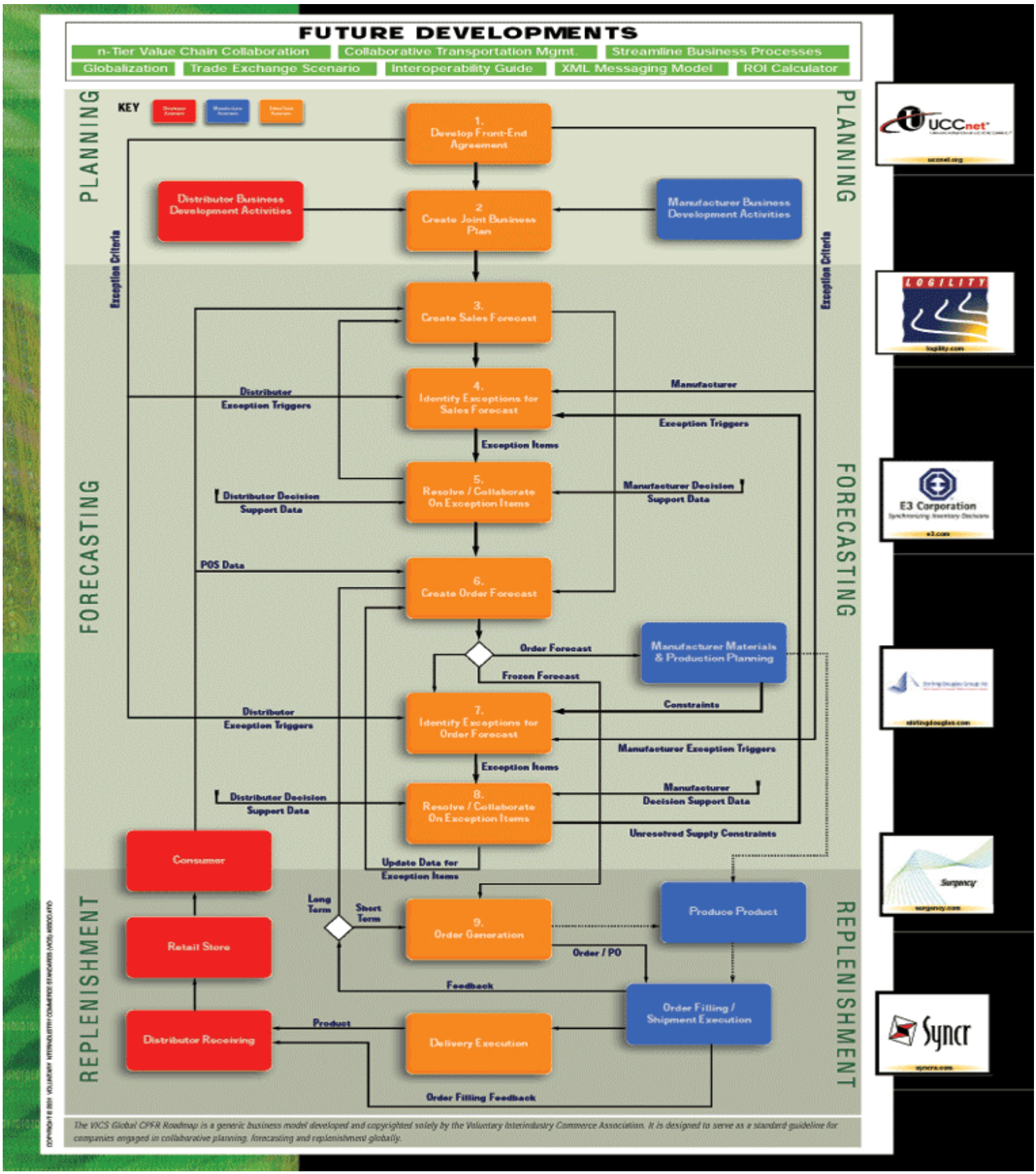

Figure 1. The VICS Global CPFR® guidelines.

PROJECT HIGHLIGHTS
Surgency (formerly Benchmarking Partners)

Project Title: A Collaborative Model to Integrate Delivery Chain Information (Patient-Oriented Management Systems: An Integration Infrastructure for Healthcare)

Project: To develop a reference model that defines the necessary communication of healthcare information for the purpose of integrating the healthcare industry's incompatible legacy information systems.

Duration: 12/15/1994-12/14/1997
ATP Number: 94-04-0046

Funding (in thousands):

ATP Final Cost	$2,000	41%
Participant Final Cost	$2,872	59%
Total	$4,872	

Accomplishments: Although it was funded under the ATP's Information Infrastructure for Healthcare focused program to develop technologies to improve information services across the healthcare industry, this successful ATP project has had the greatest impact in manufacturing and retail operations. Benchmarking Partners' software product, CPFR®, is marketed through spin-off company Syncra. It is being used by dozens of large companies—from Sara Lee to Wal-Mart—to improve communications and to forecast accuracy across their supply chains. The product has generated tens of millions of dollars in sales revenue for Benchmarking Partners and its subsidiaries.

Early adopters of the software are experiencing the following measurable benefits:

- Increased sales by preventing products from being out-of-stock, especially during promotions
- Improved returns on assets due to higher sales volumes relative to inventory levels

Test results from actual use are promising. For example, an application in the food industry resulted in a 17-percent increase in sales and an 18-percent decrease in inventory, and an application in the women's clothing industry resulted in a 45-percent increase in sales and a 23-percent decrease in inventory.

Commercialization Status: Benchmarking Partners achieved commercialization via the collaborative forecasting and replenishment component of the original Patient-Oriented Management Architecture (POMA) initiative. Warner-Lambert purchased a pilot version of its collaborative technology, and Kmart, Gillette Corporation, and others paid for executive briefings, access to collaborative process models, and consulting services. Benchmarking Partners, which has since changed its name to Surgency to reflect the expansion of its services, continues to offer consulting and collaborative software to expand the commercialization of its CPFR® technology.

Additionally, former Benchmarking Partners spun off Syncra Systems following the company's work on the ATP project. Syncra has commercialized several collaborative technology products, including its flagship Syncra Ct® software, which is based on the ATP-funded technology.

Outlook: The Internet-based collaboration approach pioneered by Benchmarking Partners as a result of this ATP project has revolutionized the manufacturer/retail supply chain model, making collaborative planning, forecasting, and replenishment practices standard for the industry. With its proven capability to reduce inventory costs, improve customer service levels, and increase sales, the outlook for continued development of the CPFR® technology is excellent.

Composite Performance Score: * * *

Number of Employees: 25 employees at project start, 25 as of December 2001

Focused Program: Information Infrastructure for Healthcare, 1994

Company:
Surgency
One Main Street
Cambridge, MA 02142

Contact: Ted Rybeck
Phone: (617) 225-7800

Research and data for Status Report 94-04-0046 were collected during October - December 2001.

TopicalNet, Inc. (formerly Continuum Software, Inc.)

Design of Scalable, Parallel-Computing Software Development Tool

Since the mid-1990s, U.S. businesses have sought parallel processing, a computing technique used mainly for scientific computing, for its potential to increase computational performance. Parallel processing speeds the execution of a program by dividing the program into multiple segments that can be executed simultaneously, each on a separate processor. As businesses anticipated database growth into tens and even hundreds of terabytes (one trillion bytes), they seriously considered adopting parallel processing to reduce the time needed to analyze these exponentially large amounts of data. Although many businesses had computers with multiple central processing units (CPUs), use of parallel computing had been limited because it required that programmers learn parallel-processing techniques for writing software. Companies that had invested large amounts of resources in business applications and systems were wary of having to rewrite their existing serial code into parallel code, because this meant finding and hiring programmers from the limited pool of those skilled in parallel programming.

In 1995, Continuum Software, Inc., received a $2 million award from the Advanced Technology Program (ATP) for a three-year project to design tools for easy development of scalable, parallel software systems for business applications. By the project's end in 1997, Continuum had successfully developed Multiply™, a software development tool to create scalable business applications from existing serial code for a wide range of parallel architectures. Using Multiply™, the average business programmer could develop scalable software applications without having to learn parallel programming. However, when companies began focusing their software investments on the Y2K problems instead of on parallel computing, Continuum (which was later renamed TopicalNet) refocused its efforts on Internet applications and stopped marketing Multiply™.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* *

Research and data for Status Report 94-06-0034 were collected during April - June 2002.

Existing Support Systems Are Slow and Costly

Decision-support systems are used by businesses in their planning, design, marketing, and distribution operations. Depending on the quantity and complexity of the data used in the analysis, however, these systems can take several days to produce responses, resulting in delays in the business's ability to optimize prices, calculate forecasts, and respond to customer needs. Because parallel computing can increase computer performance, it could potentially solve this problem. By the early 1990s, many businesses had tried, with limited success, to build software that would execute efficiently on parallel machines. Lack of success resulted from the limited use of parallel computing in business applications and, more important, unfamiliarity among software developers in programming scalable, parallel systems.

Continuum's founders, a three-member team that had previously worked for a parallel computing company, understood the complexities and difficulties of parallel programming. They understood that rewriting a company's existing business applications into parallel code would be an enormous task. At the same time, Continuum recognized parallel computing's potential

power to execute time-critical business applications. John Mucci, co-founder of Continuum, stated, "Our team knew if we were able to create software that could effectively harness the power of multiple CPUs present in most company computers, businesses would be able to run critical enterprise planning applications such as payroll, inventory, and customer transaction history programs in a matter of hours, not days.

Continuum Proposes Object-Oriented Technology

Continuum aimed to create a tool to shorten the development time of efficient, reusable software that could be used on a wide variety of scalable, parallel computer servers. To overcome the peculiarities of parallel programming, the company proposed to utilize object-oriented (OO) technology, a special type of programming that combines data structures with functions to create reusable objects.

Continuum recognized parallel computing's potential power to execute time-critical business applications.

The company believed that OO software and development methods had the potential to greatly improve the productivity of application developers. Continuum also recognized the potential of OO development tools and languages to provide reusable software, thus simplifying the software development process. The company believed that OO technology would ensure easier modeling, shorter development time, higher quality, increased functionality, portability, and lower cost. These capabilities would allow Continuum to encapsulate key business functions, making them scalable and portable across parallel-computing platforms.

Integration of Three Technologies Poses High Risk

The proposed project was risky because Continuum planned to successfully integrate three innovative technology subjects into one tool: OO software, client-server application development tools, and scalable systems and software. Although venture capitalists might have funded a project involving one or two of these technologies, there were significant technical risks in attempting to successfully integrate all three technologies. Therefore, in response to these challenges, Continuum sought alternate venues for funding and submitted a proposal to ATP.

The proposed project was risky because Continuum planned to successfully integrate three innovative technology subjects into one tool.

Continuum's proposed project responded to concerns regarding the lack of software development tools. Common concerns included the need for more systematic reuse, interoperation, automation, and semantic approaches in software development to be made available to all programmers.

If Continuum's project proved successful, the technology would offer important advances in data analysis to many industries, including manufacturing, finance, and healthcare. Additionally, the tool promised to provide end users with quick and timely responses to time-sensitive tasks and calculations that were needed for resource optimization.

Continuum's Development Approach Addresses Parallel Applications

One technical goal of the project was the creation of a software development tool using OO technology to provide efficient, scalable, parallel-computing software that could be readily used with existing business applications, thus reducing the need for specialized knowledge of parallel programming. The company planned to solve the problem of the programmer's unfamiliarity with parallel programming by using well-known programming languages.

In creating its scalable software development tool, Continuum:

- Developed effective user interfaces for connecting new parallel systems to legacy systems so that investment would not be lost and users could access new systems through familiar interfaces.

- Formulated adaptive algorithms that could be used across multiple parallel platforms to perform business functions. These algorithms could be automatically configured for a particular platform to meet the needs of a specific business.

- Developed a method to encapsulate parallel platform characteristics using OO technology in order to conceal from the programmer the complexity of writing code for each specific parallel system. The programmer, therefore, did not need to know the details of the system, only the business logic required for supporting specific business functions.

- Created a technique to support a graphical, scalable server application development tool. This tool provided the developer with a simple front end for powerful, complex functionalities.

The initial infrastructure that Continuum developed during the ATP project was called Scaleworks. It was to house the generic parallel algorithms required to respond to various queries. Scaleworks was designed to automatically route queries to specific algorithms on the basis of which ones could most effectively process the end user's request given the specifics of the data.

However, Scaleworks was complex. Understanding that the complexity of Scaleworks might frustrate potential users, Continuum developed mechanisms for reducing the complexity of the interface without sacrificing the power and flexibility of the system.

Continuum Develops Multiply™

Continuum successfully developed an interface that was capable of integrating with the Scaleworks infrastructure. The company then created a demonstrable prototype of a scalable and portable component-based software development environment. The final tool was a software environment that used a computer's hardware to process information from its existing applications without having to reprogram the data for parallel processing. This tool allowed end users to continue to use existing legacy systems without recoding the systems. As a result, the software development environment (that Continuum ultimately named Multiply™) provides end users with access to the power of parallel processing, without having to learn parallel programming and, more important, without the need to replace legacy systems.

In early 1997, Continuum demonstrated the time saved by running certain business applications via Multiply™. For example, one company could run its inventory application in a record 15 minutes using Multiply™, a task that previously took one hour to complete. Thus, the company's response time to customers and suppliers was improved by 75 percent.

Y2K Concerns Overshadow Multiply™ Prospects

By the end of 1997, commercial prospects for Multiply™ looked promising. Continuum demonstrated its functionalities to several potential customers. The company successfully obtained $3.1 million in additional funding from venture capitalists and angel investors and hired marketing and business and sales development experts. Continuum also sold and implemented Multiply™ to several companies and a U.S. government agency to enhance the agency's existing supply chain application. Once the Y2K problem became an issue for companies, however, Continuum noticed a shift in information technology spending. Several potential customers decided to allocate their information technology resources to Y2K preparedness, and they ceased negotiations for Multiply™.

Continuum knew that achieving long-term success was rare for a start-up software tool company. Although it was able to capture additional funding after the ATP project ended, the company's resources were inadequate to sustain its operating costs for an extended period. Because of the lack of sales and the waning interest displayed by potential Multiply™ customers, the company shifted its strategy and decided to discontinue further spending on commercializing Multiply™. The exponential growth of the Internet in the late 1990s afforded new opportunities, and Continuum refocused its efforts and began research and development of Internet applications. The company found that it could apply the knowledge it gained during its ATP-funded project to

the processing required to evaluate large volumes of data from Internet web pages.

Multiply™ provides end users with access to the power of parallel processing, without having to learn parallel programming and, more important, without the need to replace legacy systems.

During 2001, Continuum (which by then had changed its name to TopicalNet) acquired several companies, and now it is focusing on providing its customers with traffic verification, analysis, and research solutions for the World Wide Web.

Conclusion

With ATP's assistance, Continuum created a software development tool that allows companies to utilize the power of parallel computation without having to replace existing legacy systems or having to learn the complexities of parallel programming. Because the company was small, however, Y2K overshadowed its technology at the time. The company identified a better market opportunity, and TopicalNet is no longer pursuing the original technology.

PROJECT HIGHLIGHTS
TopicalNet, Inc. (formerly Continuum Software)

Project Title: Design of Scalable, Parallel-Computing Software Development Tool (Scalable Business Application Development Components and Tools)

Project: To apply object-oriented technology to provide efficient, scalable parallel-computing software and algorithms that can be incorporated easily into business applications that are hardware-systems independent.

Duration: 1/1/1995-12/31/1997
ATP Number: 94-06-0034

Funding (in thousands):

ATP Final Cost	$ 2,000	60%
Participant Final Cost	1,359	40%
Total	$ 3,359	

Accomplishments: ATP funding enabled Continuum to develop Multiply™. Using this technology, average programmers could productively develop scalable business applications without having to learn parallel programming. Furthermore, companies using Multiply™ would not have to replace legacy systems.

The accomplishments of this ATP-funded project led to one patent:

- "System and method for developing computer programs for execution on parallel processing systems"
  (No. 5,999,729: filed March 6, 1997; granted December 7, 1999)

Commercialization Status: Continuum did not successfully market the Multiply™ tool for several reasons. When the project was completed, information technology venture capital was not available because the computer industry was focused on Y2K compliance, thus making it difficult for the small start-up company to market its innovative software application. In the late 1990s, focus in the computer technology market turned to Internet applications. Continuum decided to refocus on developing web-based applications, and the company discontinued its efforts to commercialize Multiply™. Although Continuum discontinued market development of the product, the company continues to use the knowledge gained from the project.

Outlook: Other firms are finding that the market for parallel computing continues to develop. Companies are successfully using parallel computing in commercial environments, and its use continues to grow in the areas of database applications, finance applications, image processing, and World Wide Web servers. TopicalNet, however, has no plans to further commercialize the Multiply™ technology

Composite Performance Score: * *

Number of Employees: Three employees at project start; 70 as of June 2002.

Company:
Topical Net, Inc.
800 West Cummings Park, Suite 2900
Woburn, MA 01801

Contact: Dr. John F. Mucci
Phone: (781) 932-8400

Research and data for Status Report 94-06-0034 were collected during April - June 2002.

TopicalNet, Inc (formerly Continuum Software, Inc.)

Building a Database to Predict Customer Needs

Since the early 1990s, organizations have used data warehouses and data-mining tools for business planning and decision-making. For example, more than 95 percent of the 250 companies surveyed by the Meta Group in 1995 said they planned to build a data warehouse, up from only 15 percent in 1994. Data warehouses and data-mining tools are able to provide a retrospective look at customer behavior through online analytical processing and other common statistical tools, but businesses want to forecast production changes and anticipate customer needs. Continuum Software, Inc., decided to construct a predictive modeling tool that the average business user could use easily. The technology was seen as too high risk, however, to attract private sources of capital, and so, in 1997, Continuum applied for and received an Advanced Technology Program (ATP) award. By mid-2000, Continuum's research in predictive models had led to the development of patented technology that classified tens of millions of web pages solely on the basis of predicted user interest. This technology also aided in the development of a classification tool that automatically classifies content from any text-based electronic document and assigns it to a topic to aid in the organization of electronic data. During 2001, Continuum (which by then had changed its name to TopicalNet) acquired several companies. TopicalNet's ATP-supported technology and its subsequent acquisitions have allowed the company to provide its customers with traffic verification, analysis, and research solutions for the World Wide Web.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
* * *

Research and data for Status Report 97-01-0087 were collected during April - June 2002.

Traditional Data-Mining Tools Are Too Complex for Nonexperts

Many companies store information in data warehouses in an attempt to derive value from the massive amount of transactional data collected. Companies want answers to key business questions, such as: Who are our most valuable customers? How can we design and target promotions to increase sales? Which customers are most likely to leave in the future and how can these customers be retained? Corporations could get some answers to these questions by taking a retrospective look at already collected data. Relational databases, online analytical processing (OLAP), and statistical tools are used for historical data analysis, which assists users in answering questions such as: How much did sales increase in the eastern region over the past two quarters? These tools have become invaluable because they have sophisticated graphical user interfaces that lead the person with the question directly to the answer, making historical information accessible to the average businessperson.

By 1996, several generic data-mining tools were available to predict future behavior, but, to be used effectively, they required scarce and expensive artificial intelligence and machine-learning expertise. Predictive models based on traditional data-mining tools pose two significant limitations: they require knowledge in machine-learning technology, a skill the average business user does not possess; and, for every query the business user poses, a specific model responsive to the query has to be built.

Building separate models in response to each query is time consuming and requires input from data-mining experts. Continuum recognized that the lengthy process of hiring experts and building specific models was too slow for this age of rapid data exchange. By the time a question has been asked and then simulated, the answer is often irrelevant, thereby thwarting the company's ability to gain a competitive advantage.

Continuum Intends to Predict Customer Behavior with Future Database

Using machine-learning, statistical, and visualization techniques to discover and present knowledge in a form that could be accessed quickly and is easily comprehensible, however, required an innovative approach.

Generic data-mining tools were available to predict future behavior, but they required scarce and expensive artificial intelligence and machine-learning expertise.

Continuum planned to create a unique application to build simulators using data-driven, machine-learning technology. The simulators would be used to simulate what customer behavior would be like months into the future by extrapolating from the behavior of existing customers. That information would then be used to create a predictive database in the same format as a historical database.

The business user would be able to extract, display, and analyze information from this future database using the same familiar relational, OLAP, and statistical tools that are currently used for extracting information from historical databases. Continuum's simulator also would be able to respond to questions that involve dynamic situations, unlike conventional data-mining models, which are only capable of analyzing problems involving static situations. The future database could answer a question such as: What would happen if a company lowered its prices? To answer the question, a company would start its projection with the original customer base and would project results both with and without the hypothetical event of lowering prices. Then the company could compare the two projected futures, identify the customers who would respond to the lower prices, and determine what total revenues and costs would be with and without the action.

Continuum planned to investigate extending current technology to handle huge amounts of customer data found in data warehouses to enable the construction of simulators for creating a future database of those customer records. The future database would contain future records projected from current records using projective visualization (PV), a new and unique application of machine learning that is able to analyze huge amounts of warehoused data, even when the records in the warehouse are incomplete. Unlike conventional machine-learning techniques, which only provide an answer to the specific question for which they are created, PV could be used to answer many questions, just like historical databases.

Prior to the ATP project, Continuum had already received the enthusiastic support of companies intrigued with the potential impact the future database could have on their businesses, but the nature of the research was still too high risk to attract funding. To demonstrate the applicability of the future database technology, Continuum planned to work with Switchboard.com to provide training sets of data and test domains for the application of the future database. Because Links2Go was the most promising test domain, Continuum decided to work with it rather than with Switchboard’s. However, Continuum's relationship with Switchboard ended amicably.

Predictive Simulation Tools Promise Powerful, New Data-Analysis Capabilities

When Continuum approached ATP for funding to continue its research and development in 1997, ATP recognized that the company's machine-learning techniques would advance the slow and costly practice of building simulation models to analyze customer behavior. Continuum could tap into the explosive use of the Internet, and the increasing volume of data being generated and warehoused in numerous web sites, to address new opportunities that were impossible with the data-analysis methods then available.

The market for data-analysis tools was growing rapidly, and the commercialization of Continuum's predictive data models also had potential for market spillover.

Continuum organized and classified tens of millions of web pages solely on predicted user interest.

Continuum Validates Projective Visualization

The principal technical goal of this project was to develop a software tool that would enable the creation of databases that could predict future behavior. The following requirements had to be fulfilled to validate the use of PV:

1. *Increase the quantity of training data.* ***Results:*** The company made significant progress in its ability to load and analyze large training sets of data in a reasonable time. At the beginning of the project, Continuum was able to analyze 600,000 training instances on a machine with 1 gigabyte (GB) of random access memory (RAM). By the end of the project, it was able to analyze 7 million instances per GB of RAM and had built systems with as many as 40 million training instances (almost a hundredfold increase).

2. *Increase the quality of training data.* ***Results:*** The company developed numerous automated and semi-automated techniques for enriching data sources and for fusing additional data sources, allowing systems with greater accuracy to be built for fixed training sets.

3. *Identify the most effective machine-learning techniques for specific problem types.* ***Results:*** Continuum examined a large number of alternative machine-learning techniques and integrated the best ones into a unified tool set that can be applied to a wide variety of problems.

4. *Develop effective user interfaces for complex information.* ***Results:*** The company developed and deployed interfaces for visualization and manipulation of the system during the course of development.

5. *Validate results on selected test domains.* ***Results:*** Continuum monitored software performance by applying the predictive technology to selected test domains to examine its applicability and to receive feedback on the system's functionality.

Continuum achieved these technical requirements and developed a software tool that uses PV to project the effects of an action on the basis of prior behavior. Not only was Continuum able to develop the necessary tools for a future database, it also organized and classified tens of millions of web pages solely on predicted user interest.

Continuum Refocuses on Content Classification

In one of the initial test domains, referred to as Links2Go, the results of the company's work far exceeded any of the other test domains. Continuum realized that its technology also could be used to project user interest in sets of topics and pages in the context of an online research tool, which would allow the classification of related web data. Continuum was so impressed with the capabilities of the research tool that it set out to further develop and commercialize the technology for the classification of web content.

The Links2Go test site was well received because it had the ability to automatically organize web content and to provide end users with highly relevant links pertaining to the topic of their query. Typical search directories rely heavily on human editors; these directories have the ability to manually classify several million pages and are organized on the basis of the editor's subjectivity. In contrast, the Links2Go directory automatically organized 70 million web pages by topic, thus providing a significantly higher number of relevant retrievals. Furthermore, competing search engines typically refresh their web pages every 30 days; during this lag time, they could potentially send web users to expired uniform resource locators (URLs). The Links2Go directory was refreshed overnight, thus ensuring that users were viewing the most current versions of the web pages in the directory. With no marketing or public relations effort, the Links2Go web

site experienced more than one million distinct visitors per month.

Continuum was gaining a tremendous amount of knowledge about various topics through the organization of these web pages. Subsequently, the company was able to use the technology from this project to develop a classifier software tool, which could automatically classify arbitrary, unstructured documents.

TopicalNet used the predictive technology developed as a result of the ATP project to provide businesses with a software solution to classify massive amounts of related, electronically stored data into easily accessible topics.

The tool was able to read a document and assign it to a topic on the basis of knowledge gained from the topical directory. The tool also could build a taxonomy and decide where the document should fit within that categorization scheme.

Test Domain Leads to Compelling Business Opportunities

By the midpoint of the project in 1999, Continuum executives decided that the commercial consequences of the technology emerging from the ATP project were so significant that they formed a new company. In August 1999, Continuum Software, Inc., became Links2Go.com, Inc. The new company decided to focus on the Links2Go web site after it closed a $4 million investment deal with the venture capital firm, Bertelsmann, Inc. This investment financing enabled Links2Go to begin to aggressively commercialize the initial outcomes of its research. Links2Go not only provided end users with a powerful topical search and directory tool, it also offered businesses a variety of unique options such as targeted web advertising.

The Links2Go directory gave businesses the opportunity to advertise and receive competitive intelligence. Businesses were able to target their web advertisements to all links and keyword searches on topics related to their particular business areas. The businesses would receive substantial access to their specific markets by targeting web users with an interest in topics pertaining to the companies' scope of business. Links2Go also offered statistics on a company's web site traffic and how the site compared with competitors' sites.

Links2Go approached several companies in the WWW market segment that could benefit from its technology. Links2Go proposed to allow these companies to use Links2Go's vertical technology for six months at no cost, with payment to begin after the trial period. After the six months was up, however, Links2Go had difficulty collecting payment for its tool. It continued to market its services, with limited success. When new Chief Executive Officer Ray Kingman joined the organization in October 2000, the company began to change its focus to further expand the classifier technology developed during the ATP-funded project. At this time, the company was renamed TopicalNet, Inc., to commemorate a new step in its path to commercialization.

TopicalNet used the predictive technology developed as a result of the ATP project to provide businesses with a software solution to classify massive amounts of related, electronically stored data into easily accessible topics. The technology can classify information from the Internet, corporate intranets, and extranets. Content classification is an ever-increasing need among businesses and end users; in fact, it is estimated that 80 percent of the content within an enterprise is unstructured. As information continues to be created and stored, content classification is essential in quickly obtaining accurate, relevant information. By 2004, the content classification and web analytics industry is predicted to grow to an estimated $2.2 billion. TopicalNet's technology has the potential to significantly impact this new and expanding market.

Conclusion

The ATP grant offered Continuum (later renamed Links2Go and then TopicalNet) the means to explore the possibilities of a predictive modeling tool, which led to the development and commercialization of the company's content classification technology. ATP's support permitted the company to examine the benefits of this technology without assuming the total risk. The project's successful completion led to additional funding and commercial viability in the content application and web analytics industry. TopicalNet's future is bright as it makes inroads in this growing market.

PROJECT HIGHLIGHTS
TopicalNet (formerly Continuum Software)

Project Title: Building a Database to Predict Customer Needs (Building a Future Database)

Project: To develop software tools that apply new techniques in machine learning and data mining to give business managers powerful, predictive data models represented as common business databases that can be queried with familiar database tools.

Duration: 10/01/1997-9/30/2000
ATP Number: 97-01-0087

Funding (in thousands):

ATP Final Cost	$ 1,164	70%
Participant Final Cost	500	30%
Total	$ 1,664	

Accomplishments: This project successfully developed the patented technology used to create projective software tools. The funding enabled TopicalNet, Inc., to create a search and directory service with technology that automatically created large topic directories from web page analysis and automatically extracted and classified text in documents on the Internet. TopicalNet's technology automatically and accurately classifies electronic documents more quickly and reliably than do human editors, and it increases the relevancy of the results from search inquiries.

The following patent was awarded as a result of this ATP project:

- "World wide web link referral system and method for generating and providing related links for links identified in web pages" (No. 5,999,929: filed September 29,1997, granted December 7, 1999)

Commercialization Status: Since completion of the ATP-funded project, TopicalNet has not proceeded with any further commercialization of the Links2Go directory; however, the company is aggressively pursuing enhancements to the classification technology. TopicalNet continues to make advancements in the web analytics market as the company positions itself to acquire other companies with capabilities that further enhance the classifier technology. During 2001, TopicalNet acquired the following companies: I/PRO, Inc. (technology used for site measurement, advanced customer analytics, and online audit services); TeraLytics, Inc. (applications that analyze large volumes of customer information to help plan successful sales strategies); and Collectively Sharper, Inc. (experts in the content integration field). TopicalNet's ATP-supported technology, combined with its 2001 acquisitions, has allowed the company to provide customers with advanced software solutions to help them manage their own proprietary data as well as the data they may package and sell to customers. The company also provides customers with web site traffic verification, analysis, and research solutions.

TopicalNet customers include Fortune 100 companies and well-known Web-based businesses. Marketed as an automated, out-of-the-box solution, TopicalNet's classification solution can be up and running in about an hour. Its robust taxonomy of more than one million topics helps customers save considerable time, energy, and resources traditionally required to learn and use other classification methods and applications.

Outlook: The outlook for TopicalNet is strong. The company continues to grow within the content application and web analytics industry. The technology developed as a result of the ATP-supported project has enhanced TopicalNet's stature and helped it to attract venture capital opportunities. As the market for content application and web analytics grows, TopicalNet continues to prove it has the technological innovation and business confidence to successfully compete in this area.

Composite Performance Score: * * *

Number of Employees: Five employees at project start, 70 as of June 2002.

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