A General Overview of Advanced Computing Technology Issues and Opportunities

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Table of Contents

Kansas, Inc. Issue Paper: A General Overview of Advanced Computing Technology Issues and Opportunities

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Preface

The Kansas, Inc. strategic planning process identified technology and innovation as a critical part of the framework that must surround the state's inherent and emerging strengths in order to contribute to the sustainability and growth of our economy.

> *Technology is no longer an enterprise in and of itself, it is the thread that must be woven through the entire economy with innovation.*
>
> – Kansas, Inc. Strategic Planning[1]

Innovation and technology are crucial to Kansas' economic development efforts. Technological change continues to occur very rapidly, particularly in computing, software, telecommunications, life sciences and biosciences. This change presents the state with two challenges: 1) existing firms require access to new technology to remain competitive, and 2) new technology-based industries and businesses present opportunities for the state.[2]

Public investments in technology, particularly through the state's research universities remain important. These institutions have a critical role in attracting research-based companies that desire to locate near a university to gain access to research and skilled employees. Other entities, including the Kansas Technology Enterprise Corporation (KTEC), the state's technology-based economic development (TBED) entity also have a critical role, along with the regional technology centers, in adapting technology to Kansas companies and creating new businesses.

Inherently, companies that do not keep pace with technological change may be at a competitive disadvantage compared to others, and while the state cannot direct private industry investment, it may be able to provide some of the necessary technology infrastructure and resources to help strategically position business and industry to compete in the global economy.

With economic development, states continually search for the next opportunity, idea or innovation to position themselves for future success. Whether it's building upon past successes or creating new successes, this environment remains competitive and is continually changing. Technologies such as advanced computing[3] or "supercomputing" may provide the means to increase business innovation and competitiveness for small-, medium- and large-sized firms throughout Kansas; and where many businesses may not have the access to the resources or expertise to utilize such infrastructure, the state may be able to provide the link between businesses, universities, and advanced computing opportunities.

[1] *Leveraging our Foundations and Designing the Future: A Kansas Economic Renaissance, The 2007 Kansas Economic Development Strategic Plan,* Kansas, Inc. January 2008.
[2] Krider, Charles, Hurd, Genna, and Dane Hanson. *Trends in the Kansas Economy 1985 – 2006*, Institute for Policy and Social Research, University of Kansas for Kansas, Inc., August 2006.
[3] The terms advanced computing technology, high performance computing (HPC) and supercomputer are synonymous in this report.

Introduction

"Today's economy is rooted in information technologies. While it also is true that information technologies have played a role in the economy since the invention of the telegraph, something happened in the 1990's when semiconductors, computers, software and telecommunications because cheap enough, fast enough and networked enough to become so ubiquitous as to power a surge in productivity growth. Indeed, information technology is not the key technology driving the economy, not just in the IT industry itself – which continues to see high-wage job growth – but also in the use of IT in virtually all sectors to boost productivity, quality and innovation."

– 2008 New State Economy Index

su·per·com·put·er
–noun

A mainframe computer that is among the largest, fastest or most powerful of those available at a given time.[4]

A broad term for one of the fastest computers currently available. Such computers are typically used for number crunching including scientific simulations, (animated) graphics, analysis of geological data (e.g. in petrochemical prospecting), structural analysis, computational fluid dynamics, physics, chemistry, electronic design, nuclear energy research and meteorology.[5]

Today's supercomputer is essentially tomorrow's ordinary computer. The application of advanced computing technology is used to develop solutions for highly calculative intensive tasks whose solutions require semi-infinite computing resources by today's standards. This type of cutting-edge capability is becoming increasingly important for solving complex problems, simulations and computer modeling applications.

The field of advanced computing is not a new industry, but rather an ever-evolving industry that is moving from the scientific laboratory to mainstream businesses. During the past several years, advanced computing technology has migrated from almost exclusively scientific research applications into diversified industries.[6]

The application of advanced computing technologies have provided significant contributions to both academic and scientific research for several years. More recently, the application of advanced computing technologies to business and industry-specific applications have created the potential to increase innovation and competitiveness from broad economic perspective. The ability to perform high-end calculations specific to business and industry examples can enable firms to create and design better products, cut production costs, quickly analyze and solve problems, and streamline overall efficiency. The application of advanced computing technology to industry sectors such as electronics, energy, chemical, pharmaceutical, biomedical, life sciences, aerospace, automotive, entertainment, telecommunications, transportation, financial, military, etc can be a game changing tool that can become the driving force behind innovation and economic competitiveness.

This study seeks to examine opportunities relative to the application of advanced computing technologies from a government, university and business perspective, providing insight to whether the state should make a strategic investment to create or enable access to advanced computing technology for business, industry, and universities, ultimately contributing to the economic growth of the state. This study is not intended to explore the technical aspects of advanced computing technology.

[4] (n.d.). The American Heritage® Dictionary of the English Language, Fourth Edition. Retrieved July 06, 2009, from Dictionary.com website: http://dictionary.reference.com/browse/supercomputer
[5] supercomputer. (n.d.). The Free On-line Dictionary of Computing. Retrieved July 06, 2009, from Dictionary.com website: http://dictionary.reference.com/browse/supercomputer
[6] Texas State Technical College System, Emerging Technology, accessed at: http://system.tstc.edu//forecasting/techbriefs/HPC.asp?p=1 on October 15, 2009.

A Brief Overview of Advanced Computing Technology and Where it is Going

Introduction

Advanced computing technology offers the ability to perform high-end calculations that can further enable business and industry to create and design better products, cut production costs, quickly analyze and solve problems, and streamline overall efficiency. The application of advanced computing technology to industry sectors such as electronics, energy, chemical, pharmaceutical, biomedical, life sciences, aerospace, automotive, entertainment, telecommunications, transportation, financial, military, etc can be a game changing tool that can become the driving force behind innovation and economic competitiveness.

Making the Business Case for High Performance Computing[7]

It is increasingly true that to out-compete, businesses will need to out-compute. For many years, the application of advanced computing technology has made major contributions to both science and national security roles, and more recently, the application of advanced computing technology to business and industry settings has created the potential to increase business innovation and competitiveness. Alongside theory and experimentation, modeling and simulation utilizing advanced computing technologies is becoming the third leg of science and industrial-design engineering.

Several studies have illustrated that the application of advanced computing technology often translates into faster time to market, reduced costs and superior product quality. Businesses that do not apply these technologies to their firms may indeed miss out on the benefits that are increasingly driving innovation and competitiveness.

Currently, firms are utilizing advanced computing technology for applications such as designing cars and aircrafts, finding and extracting new energy sources, forecasting severe weather, medicine discovery and safeguarding our national security. Visionaries foresee equally dramatic advances if massive improvement in computing power can be made available to both the public and private sector. Some examples include:

- Revolutionizing medical procedures and devices, as well as product safety for a variety of consumer products by creating virtual humans;
- Increasing oil recovery by 50 to 75 percent with more accurate seismic modeling of oil reservoirs;
- Creating designer catalysts that selectively interact with molecules in crude oil, allowing greater production of high-value products at lower costs;
- Modeling the spread of epidemics, enabling public health officials to intervene to halt the expansion of life-threatening diseases; and
- Real-time analysis of data traffic flow through thousands of miles of communication links.

Principal barriers that have been identified which may inhibit more widespread use of advanced computing technology include: educational and training hurdles (shortage of computational scientists), technical obstacles (developing code, performance gaps between processors, etc), cost, and ease of use of advanced computing technologies. Within corporations, however, business strategies and decision-making processes can also be a significant obstacle to utilizing advanced computing technology.

[7] Suzy Tichenor, Council on Competitiveness and Albert Reuther, MIT Lincoln Laboratory, *Making the Business Case for High Performance Computing: A Benefit-Cost Analysis Methodology*, CT Watch Quarterly November 2006, accessed at: http://www.ctwatch.org/quarterly on July 10, 2009.

Getting up to Speed: The Future of Supercomputing[8]

A National Research Council (NRC) report identified the need for advanced computing technology to strengthen national defense capabilities and improve future economic competitiveness. The study noted the federal government should provide stable, long-term funding for research and support multiple hardware and software vendors to give scientist and policymakers better tools to solve problems in areas such as intelligence, nuclear stockpile stewardship, design, manufacturing and climate research.

Advanced computing technology is becoming a major contributor to the economic competitiveness of several industries, including automotive, aerospace, medical and pharmaceutical industries. The discovery of new substances and techniques, as well as cost reduction through simulation may underpin progress in several economically important areas. Advanced computing technology is becoming increasingly essential to continuing progress.

The overall recommendation of the NRC report: **To meet current and future needs of the U.S., government agencies that depend on supercomputing, together with the U.S. Congress, need to take primary responsibility for accelerating advances in supercomputing and ensuring that there are multiple strong domestic suppliers of both hardware and software.** Other recommendations within the report included:

- Adequate and sustained funding for the strength and evolution of supercomputing infrastructure;
- Support of the creation and long-term maintenance of supercomputing software;
- Developing a roadmap that identifies key obstacles and synergies;
- Funding basic research; and
- Reducing barriers to collaboration to ensure the availability of leadership and expertise for supercomputing.

While on the federal level, these recommendations could be applied to the state level to address issues to create advanced computing technology resources.

Council on Competitiveness – Reveal, Reflect, Advance

The Council on Competitiveness[9] (Council) is a non-partisan and non-governmental organization consisting of CEO's, university presidents and labor leaders working to ensure U.S. prosperity by setting an action agenda to drive productivity and leadership in world markets and to raise the standard of living for all Americans.

The Council provided three studies with a vision for the future, introducing simulation as a key pillar for scientific research and industry, which would greatly inform theory and experimentation. The introduction of more advanced simulation models through the application of advanced computing technology could help position the U.S. to sustain its computational leadership and economic competitiveness. The Council confirmed that nearly all companies that have adopted advanced computing technology consider it indispensable for their ability to innovate, compete and survive. The studies noted a relatively small contingent of experienced industrial users are pushing the frontiers of innovation through modeling and simulation with advanced computing systems, and while there are a large number of firms using entry-level advanced computing systems to advance their productivity and competitiveness, an even larger group of firms haven't tapped into the benefits of advanced computing technology.

[8] Susan L. Graham, Marc Snir, and Cynthia A. Patterson, *Getting up to Speed: The Future of Supercomputing*, Committee on the Future of Supercomputing, National Research Council, November 2004.
[9] Council on Competitiveness, accessed at: http://www.compete.org/

Reveal. A Broad Study of Desktop Technical Computing End Users and HPC[10]

The first study by the Council analyzed the findings of a broad-based survey in which 77 companies from 11 different business sectors reported on their technical computing needs and practices. The study investigated the following questions:

- What are the demographics of "desktop only" technical computing users? What are the environments in which desktop technical computing is being used by businesses?
- Do these companies have important problems that cannot be solved on desktop computers?
- How many of the companies plan to move up to doing advanced computing on technical servers?
- What are the main barriers to adopting advanced computing technology, and what would motivate desktop technical computing users to overcome these barriers?

The study revealed that desktop technical computing users are a diverse group, existing in settings ranging from several employee engineering service firms to multi-billion dollar global corporations. These firms have much experience with desktop computers, but more than half of them have problems that cannot be solved on a traditional desktop computer. These firms face systematic barriers to move forward with advanced computing technology, such as lack of easy-to-use application software, lack of sufficient human expertise and the overall costs with adopting new technology.

While many firms would be willing to adopt advanced computing technology, in order to overcome systemic barriers, many firms need an external enabling function that could provide low risk access to technology and expertise. Whether this enabling function emerges through public-private partnerships or strictly through private sector initiatives, the stakes are high for moving more companies to adopt advanced computing technologies. Unless these firms can learn to apply at least entry-level advanced computing technology to their unsolved problems, critical U.S. supply chains and the leadership of many U.S. industries will be at greater risk from international competitors, and the U.S. will be missing a rare opportunity to make a quantum leap forward in innovation and productivity for global competitive gain.

The large contingent of desktop-only companies and entry-level advanced computing technology users represents rare, important opportunities to boost U.S. business productivity and global competitiveness. A public-private partnership may be the most effective way to exploit these opportunities. Successful programs involving public-private partnerships already exist for companies with advanced computing technology experience, such as the U.S. Department of Energy's INCITE program and programs administered by the National Science Foundation and the National Nuclear Security Administration. These and other national programs, as well as programs at the state and regional levels, could provide models for helping firms, such as those surveyed in this study in making the productivity-enhancing transition to advanced computing technology.

Reflect. An In-Depth Study of Technical Computing End Users and HPC[11]

The second study provided further insight into a predefined group of both desktop-only and entry-level advanced computing users to identify significant differences from the multi-sector group assessed in the first study. The predefined group in this study consisted of customers of the Edison Welding Institute (EWI) of Columbus, OH, which is dedicated to materials joining research and development. The study investigated the following questions:

[10] Earl Joseph Ph.D., Steve Conway, Jie Wu and Suzy Tichenor. *Reveal. Council on Competitiveness and USC-ISI Broad Study of Desktop Technical Computing End Users and HPC*, Council on Competitiveness, February 2008.
[11] Earl Joseph Ph.D., Steve Conway, Jie Wu and Suzy Tichenor. *Reflect. Council on Competitiveness and USC-ISI Broad Study of Desktop Technical Computing End Users and HPC,* Council on Competitiveness, February 2008.

- What are the demographics of EWI member companies? How are they using desktop technical computers? How many are also using entry-level advanced computing technology?

- Do these companies have important problems that cannot be solved on desktop computers?

- How many of the companies plan to move up to using advanced computing technology?

- What are the main barriers to adopting advanced computing technology, and what would motivate desktop technical computing users to overcome these barriers?

- Are there significant differences between this "drill-down" group of companies and the firms in the broader, multi-sector study of desktop technical computing users?

The study revealed that EWI members, despite their common focus, are a diverse group that exists in settings ranging from several employee engineering service firms to multi-billion dollar global corporations. About half used only desktop computer systems for technical computing, while about 20 percent also used in-house advanced computing technology (the rest outsourced some of all of this work to others). The firms using desktop computers cited the same set of systemic barriers to advanced computing technology, including: lack of application software, lack of sufficient human expertise, and overall costs.

Similar to the first study, to overcome systemic barriers, most EWI member firms would need an external enabling function. Whether this function is provided by EWI or through other public-private sector initiatives, the stakes are high for moving more companies to adopt advanced computing technology. In addition, the study produced several salient findings:

- "Desktop-only" companies represent both large and small firms, many with years of desktop technical computing experience.

- Nearly every firm surveyed used digital virtual prototyping and/or large-scale data modeling, which are the prerequisites for high performance computing. In many firms these activities are increasing.

- Many companies have advanced problems that cannot be solved on desktop computers.

- There are three systemic barriers stalling high performance computing adoption: 1) lack of application software; 2) lack of sufficient talent; and 3) overall cost constraints.

- An enabling function is needed to help firms overcome barriers to adopting high performance computing.

- A substantial minority of companies would be willing to pay outside organizations to help them explore the benefits of advanced computing technologies.

Several fields can benefit from the increased application of advanced computing technology. Technical computing plays a key role in designing and improving many industrial products – from automobiles to airplanes, pharmaceutical drugs, microprocessors, computers, implantable medical devices, golf clubs and household appliances. Also, several industrial processes can benefit from the application of advanced computing technology – finding and extracting oil and gas, manufacturing consumer products, modeling complex financial scenarios and investment instruments, planning store inventories for large retail chains, creating animated films and forecasting the weather. Using advanced computing technologies to pursue these activities through virtual prototyping and large-scale data modeling to create digital models of products or processes that can then be evaluated by manipulating these computer models exhibits the broad and expanding range of high-value economic activities that technical computing can add to U.S. innovation, productivity and competitiveness.

Yet, even if business and technical drivers were in place, firms would still face systemic barriers that would not be overcome without the help of one or more outside parties, such as the costs of advanced computing hardware, software and human talent/expertise. These barriers could be addressed through partnerships on a state, regional and national level. In the meantime, a company's confinement to desktop technical computing leaves them vulnerable to more agile, determined competitors from the U.S. and abroad.

Advance. Benchmarking Industrial Use of High Performance Computing for Innovation[12]

The third study confirmed the vital role that advanced computing technology could play in driving private sector competitiveness. Virtually all businesses, large and small, that adopt and apply advanced computing technology consider it indispensable for their ability to compete and survive. Advanced computing technology is a proven game-changing technology.

Advanced computing technology applied to virtual prototyping and large-scale data modeling can provide breakthrough insights that dramatically accelerate and streamline upstream R&D and engineering, but also downstream business processes such as data mining, logistics and custom manufacturing. Specific examples include:

- Boeing utilizing advanced computing technology in the modeling and simulation of many design areas for the new Boeing 787 Dreamliner aircraft. Advanced computing technology resulted in the company performing expensive "live" experimental tests on only 11 prototype wing designs, versus 77 wing designs on the prior generation Boeing 777.

- Whirlpool found that a high percentage of its washing machines were being dented between the factor and the retailer, and through modeling and simulation with advanced computing technology, the company saved millions by redesigning packaging materials and clamps used by the firms global network of distributors.

- Advanced computing technology has given Wal-Mart the capacity to manage its stores worldwide from its headquarters in Bentonville, AR, from turning on the lights, determining shelf space, store planning and resource management.

- Chevron and two partners used advanced computing technology to discover a new field in the Gulf of Mexico that could yield up to 15 billion barrels of oil, boosting U.S. reserves by up to half. Processing the massive data sets needed for this discovery was impossible before advances in computing capabilities and related visualization technologies.

For the U.S. to compete successfully in the global economy, the usage of advanced computing technology must be pervasive across and within industries; therefore it is crucial to understand the extent of that penetration in order to improve innovation and how U.S. companies utilize advanced computing technology.

This study targeted four economically important industries – aerospace, automotive, bio-life sciences and energy – whose leading firms have a known history of advanced computing technology usage. What emerged from this study is a picture of mixed progress and strong opportunity for the U.S. business community to bolster its competitiveness by applying advanced computing technology more pervasively and aggressively. A decade ago, the use of advanced computing technology in the private sector was limited to a handful of industries; since then, the market has grown dramatically, and while the U.S. remains the largest consume of advanced computing technology, overall and within industry, the study revealed that U.S. firms as a group are not applying advanced computing technology as aggressively as they could.

[12] Earl Joseph Ph.D., Steve Conway, Jie Wu and Suzy Tichenor. *Advance. Benchmarking Industrial Use of High Performance Computing for Innovation,* Council on Competitiveness, May 2008.

In order to seize this important opportunity, businesses must increase their understanding of advanced computing technology's potential for propelling innovation and transforming competitiveness. U.S. firms must repeatedly reinvent themselves through continuous, rapid innovation. U.S. industry is in the midst of a new, 21st century industrial revolution driven by the application of computer technology to industrial and business problems.

Advanced computing technology will continue to play a key role in designing and improving many industrial products, as well as industrial business processes. Given their broad and expanding range of high-value economic activities, advanced computing technology users are increasingly crucial for innovation, productivity and competitiveness. Heightened competition from other countries has made it urgent to accelerate innovation and elevate productivity within the private sector. The failure of companies of all sizes to exploit advanced computing technology more thoroughly for increased innovation will put major U.S. industries at greater risk, and sacrifice a rare opportunity for the U.S. to make a quantum leap forward in innovation, productivity and competitiveness.

What are Others Doing – Specific Examples of Advanced Computing Initiatives

This section provides a brief overview of what various other states are doing in regards to advanced computing technology applications and infrastructure. This is provided for informational purposes only, and is not a comprehensive review, nor evaluation of each state's initiatives and results.

The following viewpoint on supercomputing is provided by Stanley Ahalt, Executive Director of the Ohio Supercomputer Center, a technology initiative of the Ohio Board of Regents that connects high performance computing, a state-of-the-art research network, and a deep pool of expertise dedicated to advanced research in the public and private sectors.

Viewpoint – Supercomputing: The Next Industrial Revolution[13]

> Utilizing advanced computing technology can help put the U.S. back on competitive footing in the modern economy. Throughout the country – small and medium-sized companies in automotive, manufacturing and other assembly line industries are suffering through tough economic times due to increasing global competition. Businesses struggle to remain competitive with higher labor overhead, rising production costs and outdated technology. To reverse this trend and remain viable, businesses must take an evolutionary step and start looking towards technologies that can enable them to build better products, cut production costs, quickly analyze and solve assembly problems and streamline overall efficiency.
>
> Computer modeling and simulations, made possible by advanced computing technology are becoming increasingly scalable to businesses of all sizes with a limitless spectrum of uses, much like personal computers have become smaller, sleeker and more affordable to consumers. Recognizing these opportunities, a 2005 National Academies of Sciences report urged Congress to facilitate the deployment of advanced computing technology in the U.S.
>
> Applications using advanced computing technology can help improve virtually all aspects of the production process. Advanced computing technology can produce virtual prototypes of parts and products, reducing the time and effort to bring products to market. Better analysis and documentation of capabilities can help with efficiency. Improved factory and workflow layouts can increase productivity. All of these factors can dramatically improve a company's bottom line and increase its competitive edge in the global marketplace.
>
> Advanced computing technology can also breathe life into small- and medium-sized companies, whose technologies may be considered prehistoric by today's standards. The National Science Foundation (NSF) findings echo numerous independent studies that have concluded that computer modeling and simulation are the key elements for achieving progress in engineering and science.
>
> The development of programs that help small- and medium-sized companies gain access to advanced computing technology at an affordable cost is critical. With improved software development, training, outreach and partnerships, the application of advanced computing technology can become a reality on a smaller scale for many industrial clients.
>
> *During the industrial revolution, visionary companies that adopted bold innovations were able to reduce assembly line time, fix production headaches or simply build a better mousetrap. Companies that embrace the endless possibilities of new technologies such as advanced computing can reap these benefits once again and help put U.S. industry back on competitive footing in the modern economy.*

[13] Ahalt, Stanley. *Viewpoint – Supercomputing: The Next Industrial Revolution*. IndustryWeek Leadership in Manufacturing, September 13, 2006. accessed at: http://www.industryweek.com/articles/viewpoint_--_supercomputing_the_next_industrial_revolution_12629.aspx

Ohio – Ohio Supercomputer Center (OSC)[14]

The Ohio Supercomputer Center is a catalytic partner of Ohio universities and industries that provides a reliable high-performance computing infrastructure for a diverse statewide/regional community. Funded by the Ohio Board of Regents, OSC promotes and stimulates computational research and education in order to act as a key enabler for the state's aspirations in advanced technology, information systems and advanced industries.

OSC was established in 1987 as a statewide resource designated to place Ohio's research universities and private industry in the forefront of computational research. Today, OSC is a fully scalable center with mid-range machines to match those found at NSF centers and other national labs. During its first 10 years, OSC focused primarily on providing high quality computing and networking services to its users, and recently OSC has expanded its role to provide services to national high performance computing and networking groups with extensive research and educational resources.

- Supercomputing – OSC provides computational power and storage that scientists need to meet research goals through various hardware and software solutions.

- Research – OSC has a staff of high performance computing and networking research experts to maintain active research programs in high performance computing and networking, homeland security and defense, environmental sciences, engineering, and life sciences. The goal is to lead science and engineering research efforts, assist researchers with custom needs, and collaborate with regional, national and international researchers in groundbreaking initiatives.

- Education – OSC maintains a national reputation for training and education programs through scientific computing workshops, one-on-one classes and web-based portal training to enable students to gain exposure to the world of high performance computing and networking.

New Mexico – New Mexico Computing Applications Center (NMCAC)[15]

The New Mexico Computing Applications Center was approved by New Mexico's Legislature in 2007 and began operations in 2008 as a resource for applications-driven high-speed computer problem solving. Working closely with the Los Alamos National Laboratory, Sandia National Labs and the state's research universities, NMCAC is dedicated to serving the needs of the citizens of New Mexico as well as tackling issues such as energy and the environment through high-speed computing. Working with federal institutions, other states, and private businesses, NMCAC runs and develops applications with its supercomputer named "Encanto," based at Intel's New Mexico headquarters.

NMCAC is also committed to supporting the state's education, health and economic development initiatives, through plans to set up 44 remote "gateways" at state universities and community colleges. The goal is to create mutually beneficial relationships with companies and organizations by providing applications solutions through using institutional expertise.

Indiana – Indiana Initiative for Economic Development (IIED)[16]

The Indiana Initiative for Economic Development is an economic development program designed to foster technology development and job growth, by making available advanced computing technology and expertise to companies whose proposed projects advance the Indiana economy, foster job creation in high-tech jobs, and show promise in creating new technologies. The Initiative is a partnership among IBM, Indiana University, Purdue University and the Indiana Economic Development Corporation (IEDC). Computing resources are jointly owned by Purdue University and Indiana University, and are configured for maximum flexibility to develop industry partnerships independently or in a collaborative effort.

[14] Ohio Supercomputer Center, accessed at: http://www.osc.edu/
[15] New Mexico Computing Applications Center, accessed at: http://newmexicosupercomputer.com/index.html
[16] Indiana Economic Development Corporation, accessed at: http://rtinfo.indiana.edu/IIED/

IIED is open to Indiana companies of any size, new or established, as well as startups. IIED resources are ideal for manufacturing R&D, drug discovery, engine and vehicle design, and other technical development. The program offers time on one of the top university-owned supercomputers in the nation, as well as support in using the machine, all at no cost for projects that qualify under the Initiative's guidelines. Participating industries or companies that wish to pursue these opportunities will typically forge an agreement with the university to gain access to the supercomputer, and will receive full operational support and draw upon the expertise of computational researchers assigned specifically to this Initiative.

New York – Rensselaer Polytechnic Institute[17]

Rensselaer Polytechnic Institute, in collaboration with IBM and the State of New York have created one of the world's most powerful university-based supercomputing centers with the Computational Center for Nanotechnology Innovations (CCNI). The fundamental goal of CCNI is to help significantly accelerate industrial investments in the area of nanotechnology and nanoelectronics by addressing fundamental computational aspects related to nanodevices and nanoscale processes.

The Center is an important resource for companies of any size – from startups to established firms – to perform research that would be impossible without both the computing power and expert researchers at CCNI. As part of the state's investment at CCNI, the state was allocated 20 percent usage of the supercomputer, with a usage policy that gives preference to economic development and also includes use for state agencies to conduct research.

Supercomputers are playing an increasingly important role in scientific and business research by allowing researchers to create more accurate models of complex processes, simulate problems once thought impossible to solve, and analyze increasing amounts of date generated by experiments. CCNI is an example of collaboration and joint investments between higher education, government and industry that can potentially hasten scientific advances by extending human insight and discovery through the use of supercomputing technology.

Montana – Rocky Mountain Supercomputing Center (RMSC)[18]

The Rocky Mountain Supercomputing Center is pioneering Montana's advanced technology frontier by providing university, government, corporate and industrial researchers with access to advanced computing technology. RMSC's mission is to enable next-generation discoveries, advancements and solutions for commercial, academic and governmental customers through the use of supercomputing applications via an on-demand services model.

RMSC users have access to in-state resources, as well as IBM Computing on Demand (CoD) computing assets, which provides supercomputing consumers a seamless method to scale and outperform the competition while transacted on a pay-as-you-use market-based fee model for supercomputing. RMSC's unique public-private partnership directly supports research and development by flattening the playing field for entrepreneurs, small and medium-sized businesses, and academia, by leveraging supercomputing resources cost effectively.

Alabama – Alabama Supercomputer Authority (ASA)[19]

The ASA is a public corporation with the mission to develop and operate the statewide Alabama Research and Education Network and the Alabama Supercomputer Center. The mission of the ASA is to provide a professional portfolio of information technology resources and services for the advancement of education, research, and economic development in Alabama. The Alabama Supercomputer Center

[17] Rensselaer Polytechnic Institute, Computational Center for Nanotechnology Innovations, accessed at: http://www.rpi.edu/research/ccni/
[18] Rocky Mountain Supercomputing Center, accessed at: http://www.rmscinc.org/
[19] Alabama Supercomputer Authority, assessed at: http://www.asc.edu/index.shtml

(ASC) provides state-of-the-art high performance computing resources to state academic users, state government agencies, national industrial users, and federal government agencies. The ASC also provides networking, consulting and specialized training opportunities.

Through creating a shared resource for academic research, Alabama has been successful in providing cutting-edge computational science tools and technology for all public education institutions. This shared access allows researchers and students at smaller regional universities the same access as institutions with much larger research and development programs.

U.S. Department of Energy (DOE) – Innovative and Novel Computational Impact on Theory and Experiment (INSITE) Program[20]

Over the past 30 years, DOE's supercomputing program has played an increasingly important role in scientific research by allowing scientist to create more accurate models of complex processes, simulate problems once thought to be impossible and to analyze the increasing amount of data generated by experiments.

In 2003, the INCITE Program was launched to specifically seek out computationally intensive, large-scale research projects with the potential to significantly advance key areas in science and engineering, through encouraging proposals from universities, other research institutions and industry.

To advance scientific discovery, DOE supports and provides access to a portfolio of national high performance computing facilities housing some of the world's most advanced supercomputers. Another key aspect of the program is to connect leaders of the projects with scientific and technical staff at the computing facilities, who are often scientists with a strong interest in computing, to maximize the scientific output from the computers.

[20] Office of Science, U.S. Department of Energy, accessed at: http://www.sc.doe.gov/News_Information/News_Room/2007/iter/INCITE_HPC_factsheet_final%20_5_.pdf

Current State Resources

Similar to other states, Kansas has a level of advanced computing technology, resources and expertise at its universities; however, the level of this technology, as well as access, utilization and expertise varies among universities. Specific to this study, the University of Kansas Information and Telecommunication Technology Center (ITTC) appeared to be most aligned with the subject of this research.

University of Kansas Information and Telecommunication Technology Center (ITTC)

ITTC is a KTEC Centers of Excellence designed to conduct innovative research and provide technical assistance with the overlapping aims of creating new companies, strengthening existing companies and serve as expert resources. ITTC focuses on facilitation of economic growth in Kansas through the transfer of know-how and inventions to existing industry and start-up companies. The Center's technical focus is on advancing knowledge and innovation in the areas of computing, communications and sensors.

The Bioinformatics[21] Cluster at ITTC was implemented to provide a high-performance computing environment, coupled with high-availability storage and backup solution. The cluster is open to ITTC faculty, students and staff, as well as any academic researcher approved by the ITTC Director. Fee-based access is available to non-academic users, for example, researchers at Hill's Pet Food and Porter McGuffy have obtained fee-based access to the system.

During 2009, ITTC submitted a $7 million proposal to the National Science Foundation (NSF) to renovate and expand its capabilities. The renovated space would support computationally intensive multidisciplinary and integrative research projects in life sciences across the University of Kansas and the University of Kansas Medical Center. The BCF supports four dozen National Institutes of Health (NIH) projects, two National Center for Research Resources Centers of Biomedical Research Excellence grants, a NIH National Institute of General Medical Sciences Chemical Methodologies and Library Development (CMLD) project, a Molecular Libraries Implementation and Imaging Initiative (MLI) Specialized Chemistry Center and 10 core service laboratories[22].

[21] Bioinformatics integrates computers, software tools, and databases to examine and store biological information. It turns data generated in molecular biology, genetics, and other life-sciences into useful knowledge.

[22] Laboratories provide analytical instrumentation and technical services such as molecular interrogation, high throughput screening, microscopy and biomolecular sequencing.

Conclusions and Recommendations

Advanced computing is not a new industry, but rather an ever-evolving industry that is moving from the scientific laboratory to the mainstream. The application of advanced computing technology to develop business and industry solutions may hold great promise for developing, maintaining and expanding a competitive advantage.

Within economic development, states continually search for the next opportunity, idea or innovation to position themselves for future success. Whether it's building upon past successes or creating new successes, this environment remains competitive and is continually changing. Technologies such as advanced computing may provide the means to increase business innovation and competitiveness for small-, medium- and large-sized firms throughout Kansas; and where many businesses may not have the access to the resources or expertise to utilize such infrastructure, the state may be able to provide the link between businesses, universities and advanced computing opportunities.

The state can serve as an enabler, by creating a means for business and industry to collaborate with both universities and government to access and utilize advanced computing technology. However, the state must take a strategic approach in leveraging this technology to solve practical problems and create new opportunities.

A state investment in high performance computing would support a research infrastructure that would be leveraged by wide range of stakeholders, including researchers and business users. Having such a resource available to industry would provide a competitive advantage to those that can leverage such a resource.

It's important to realize that the true value in having a high performance computing facility isn't merely having the hardware, but rather having the staff with the needed unique skill sets available to support all users. This lowers the barriers-to-entry and utility of the facility to a broader community.

Would the state benefit from an investment in advanced computing technology?

The general answer is yes, if the state were to make a strategic investment to create or enable access to advanced computing technology for business and industry, it would ultimately contribute to the economic growth of the state.

Several studies have shown the application of advanced computing technology is a game changing technology.[23] The application of advanced computing technology to industry sectors such as electronics, energy, chemical, pharmaceutical, biomedical, life sciences, aerospace, automotive, entertainment, telecommunications, transportation, financial, military, etc can be a game-changing tool that can become the driving force behind innovation and economic competitiveness.

Would an investment in advanced computing technology attract research dollars to the state's universities, benefit private sector businesses, and attract new businesses to Kansas?

The general answer is yes, a strategic investment in advanced computing technology would have the potential to attract globally available research dollars to the state's universities, benefit private sector businesses, and attract new businesses to Kansas. Advanced computing technology has provided significant contributions to academic and scientific research for years, and the application of this technology to business and industry has created the potential to increase innovation and competitiveness.

Enhancing a university's infrastructure or research capability through advanced computing technology can create the potential to attract additional research dollars, researchers and other opportunities that can have a positive impact on the institution, state and region.

[23] See pgs 4-8.

Moreover, several fields, both public and private, can benefit from the increased application of advanced computing technology. Technical computing plays a key role in designing and improving many industrial products – from automobiles to airplanes, pharmaceutical drugs, microprocessors, computers, implantable medical devices, golf clubs and household appliances. Several industrial processes can also benefit from the application of advanced computing technology – finding and extracting oil and gas, manufacturing consumer products, modeling highly complex financial scenarios and investment instruments, planning store inventories for large retail chains, creating animated films and even forecasting the weather.

Would the state benefit from marketing advanced computing technology and providing access and expertise to the private sector?

The general answer is yes, the state would have the potential to benefit from marketing advanced computing technology and enabling access to the private sector. Several states, including Kansas have some level of advanced computing technology capability and expertise within their universities or other governmental organizations. While these initiatives vary in scope, capability and expertise, research has shown the development of programs that help small- and medium-sized companies gain access to advanced computing technology is becoming increasingly important.

Successful programs involving public-private partnerships already exist for companies with advanced computing technology experience, such as the U.S. Department of Energy's INCITE program and programs administered by the National Science Foundation and the National Nuclear Security Administration. These and other national programs, as well as programs at the state and regional levels, could provide models for helping firms, such as those surveyed in this study in making the productivity-enhancing transition to advanced computing technology.

What are some of the common barriers to adopting advanced computing technology?

There are several barriers which have been identified that inhibit more widespread use of advanced computing technology in business and industry, including: educational and training hurdles, technical obstacles, cost, and ease of use.

Studies have shown that many firms face systemic barriers to moving forward with advanced computing technology such as lack of easy-to-use application software, lack of sufficient human expertise and the overall costs with adopting new technology. While many firms would be willing to adopt advanced computing technology, in order to overcome systemic barriers, many firms need an external enabling function that could provide low risk access to technology and expertise. Whether this enabling function emerges through public-private partnerships or strictly through private sector initiatives, the stakes are high for moving more companies to adopt advanced computing technologies.

Further points to consider

While the following points have been answered in a very basic method through this research, further research directed at these questions could provide strategic insight towards building a roadmap to enhance advanced computing technology in Kansas.

- What does the state currently invest in advanced computing technology (infrastructure, expertise, funding, programs, etc) and what is the scope and impact measurement of this investment?

- What would be the impact of a targeted investment in advanced computing technology (infrastructure, expertise, funding, programs, etc) beyond the results of our current initiatives?

Overall, it's important to realize that the true value in having a high performance computing facility isn't merely having the hardware, but rather having the staff with the needed unique skill sets available to support all users. This lowers the barriers-to-entry and utility of the facility to a broader community.

Key principles that could be applied to an advanced computing initiative

A strategic investment in advanced computing technology would have the potential to create innovative opportunities that would otherwise likely be unattainable for business and industry, as well as universities and government that could ultimately contribute to the economic growth of the state. A state investment in high performance computing would support a research infrastructure that would be leveraged by wide range of stakeholders, including researchers and business users. Having such a resource available to industry would provide a competitive advantage to those that can leverage such a resource. The state must approach this both strategically and realistically to ensure the maximum impact for the resources applied to the initiative.

- With respect to advanced computing technology, the state must identify the strengths and weaknesses associated with its current assets, infrastructure, expertise, networks, funding, and other items relevant to building and designing a statewide platform of advanced computing technology that business and industry, as well as universities and government, could leverage to maximize the impact of any initiative. Assessing the state's current resources and expertise can help identify gaps and overlap, ultimately providing insight where the state could make the maximum impact with this initiative.

- The state should serve as an enabler, developing a platform that provides access to technology and expertise. Whether this enabling function emerges through a public-private partnership or other means, the state has a vested interest in providing expertise and knowledge to all potential users of advanced computing technology. Studies have shown that many firms face systemic barriers to moving forward with advanced computing technology, and the state's resources can assist in minimizing these barriers.

- The state should more effectively understand and leverage existing expertise, partnerships, networks and other resources relevant to advanced computing technology. An assessment of existing resources may identify where Kansas should ultimately focus its efforts and quantify the level and type of resources that should be committed. This may be the most efficient way to build a national presence in advanced computing technology.

- The development of public-private partnerships between business and industry, as well as government and university can enhance innovation and competitiveness for all parties involved. Developing partnerships provides an enabling function that can enhance the application and impact of advanced computing technology initiatives.

- The human expertise needed to apply, understand and educate on this technology may be the most significant aspect of developing a statewide advanced computing technology platform. While significant costs are associated with purchasing and maintaining advanced computing infrastructure, these costs may pale in comparison to the costs associated with ensuring a pipeline of qualified individuals are available in order to leverage advanced computing technology infrastructure. If the state is willing to invest in advanced computing infrastructure, then it must be willing to invest in a pipeline of individuals qualified to operate it.

- The development of a comprehensive plan with respect to advanced computing technology could be warranted if the state were to pursue a major initiative beyond its current commitment relative to advanced computing technology. Outside of providing leadership and focus, the plan would include measurable results and benchmarks relative to advanced computing in order to track the state's progress and impact of an advanced computing initiative.

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