Research Computing Drives *Economic Development* through Novel Collaborations between Governments, Businesses and Higher Education Institutions

Sponsored by IBM

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Executive Summary

To better compete globally with scarce resources in a knowledge economy, higher education institutions are increasingly expected to directly contribute to regional/national economic development. In addition to their traditional mission of creating and disseminating knowledge and training the next-generation workforce, these universities are conducting more interdisciplinary research with industry through cross-institution alliances and public-private collaborations to promote economic growth. These collaborative partnerships help all stakeholders better compete for and leverage limited research funds to drive innovation and better outcomes in their ecosystems.

Research computing is strategic to build world-class research and innovation capability and enhance the economic and competitive positions of states and nations. It helps recruit outstanding faculty, students, and staff and improve brand equity of universities; further enhancing economic development in the region. These industry-government-academic research computing collaborations are the engine of growth across multiple industries from manufacturing to healthcare to energy. They also help governments with their core mission of improving the economic/social well-being of their citizens and public safety.

The needs of research computing continue to drive the envelope of computing in industry, government, and academia but there are several challenges that must be addressed. These include funding pressures, rapid technology changes, complexity of the underlying science and engineering and the availability of skilled professionals to support research computing.

For over 50 years, IBM has partnered with key stakeholders – industry, government and higher education institutions – in the research computing ecosystem through several initiatives and solutions designed to drive economic development and growth through innovation. These include peer-to-peer research collaboration between IBM Research and universities around the globe, the IBM Global Entrepreneur initiative, superior Intellectual Property (IP) management and the broadest portfolio of optimized solutions for research computing.

This article summarizes recent research computing trends and through several case studies illustrates how IBM is actively partnering globally with key stakeholders to drive economic development within the region through public-private partnerships. It is primarily targeted to include leaders in local/state/federal governments, senior university officers (President, Provost, Dean, etc.) and business executives in industry responsible for driving economic development through research and innovation in their respective organizations.

Cabot Partners
Optimizing Business Value

Research Computing Propels Economic Development by Advancing Knowledge

Research Computing drives economic development through innovative products and faster time-to-market.

Higher education-industry-government partnerships are driving economic development and the competitive advantage[1] of states and nations in the global economy as they turn research breakthroughs into new ideas, inventions, and cornerstone patents that are the foundation of intellectual property (IP). These innovations are critical to bring new products to market faster, to foster entrepreneurship, to attract new investments and to grow the entire economy.

IT infrastructure is a key investment that delivers value to all stakeholders

Worldwide, higher education institutions and their major stakeholders (governments and industry) continue to value information technology (IT) investments in research computing as strategic[2] for economic development, to build a world class university, to attract and retain the best students, faculty and research staff, to win prestigious research grants and to enhance the brand-equity of their organizations. A "cyber" infrastructure[3] that constantly benefits from innovations in high performance technical computing is the bedrock upon which researchers work together on solving complex problems. For example, higher energy physicists have teamed together globally to decipher experimental data emanating from the Large Hadron Collider[4]; significantly advancing the state-of-the-art of their science.

Many industries and entrepreneurs across the world benefit; driving economic growth for states and nations

Many collaborative research computing partnerships have helped solve complex interdisciplinary problems that lie at the intersection of multiple industries; sometimes creating whole new industries, e.g. nanotechnology and biotechnology; reinforcing the virtuous cycle of economic development through innovation.

Through these global research computing collaborations, higher education institutions have traditionally made substantial breakthroughs in improving our understanding of the fundamental processes of nature in a wide range of disciplines including astronomy, high energy physics, meteorology, microbiology, interactions of proteins, etc. Now, these institutions are increasingly using research computing to help industry better predict the behavior of complex natural and engineered systems, e.g., nano scale devices, smart products, microbial cells, nuclear reactors, location of petroleum and natural gas resources, healthcare and diagnosis of acute ailments, behavior of financial markets and global economies, etc.

CEOs recognize the game-changing value of technologies like research computing

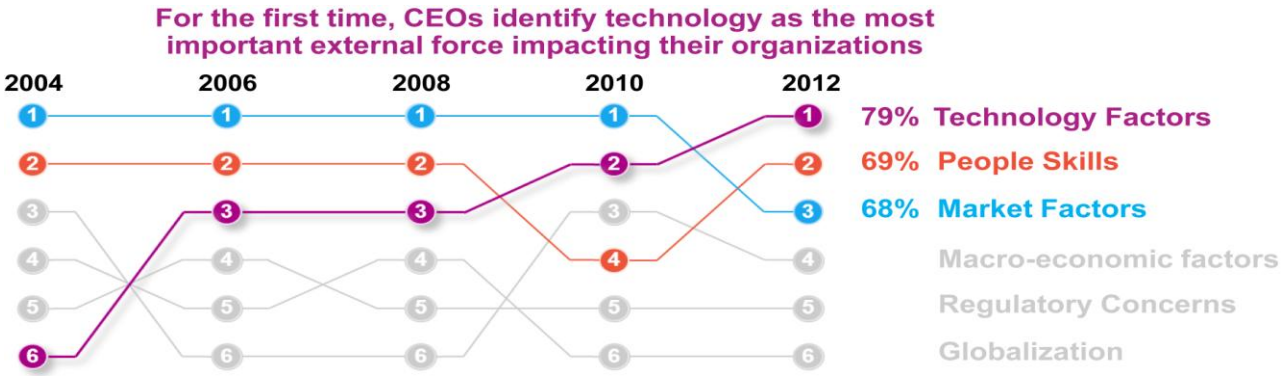


Figure 1: Technology is the most important external force (Source: IBM 2012 CEO Study[5])

[1] High Performance Computing Initiative, http://www.compete.org/about-us/initiatives/hpc/
[2] Bichsel Jacqueline, *Research Computing: The Enabling Role of Information Technology*, http://net.educause.edu/ir/library/pdf/ERS1211/ERS1211.pdf
[3] National Science Foundation, *Cyber Infrastructure*, http://www.nsf.gov/news/special_reports/cyber/
[4] The Large Hadron Collider, http://home.web.cern.ch/about/accelerators/large-hadron-collider
[5] IBM Global CEO Study, 2012, http://www.ibm.com/services/us/en/c-suite/ceostudy2012/

IBM's long-term commitment over the last 50 years to the research computing ecosystem helps spur innovation and economic development

The recent IBM CEO Study indicates that CEOs consider technology factors their most important strategic issue – ahead of market factors. They recognize the value of IT because the time available to capture, interpret and act on the rapidly growing volumes of data is getting shorter. These CEOs are looking for capabilities similar to research computing to derive actionable insights from information to improve profitability and outflank competitors.

Through several academic and innovation initiatives for over fifty years, IBM has been a catalyst to build and nurture many academic-industry-government research computing collaborations across the world. As several supporting case studies here indicate, IBM's rich portfolio of technical computing solutions has also enabled these institutions and their stakeholders to solve many business/scientific challenges and maximize value from their investments. IBM's holistic approach and long-term research computing commitment helps spur innovation and economic development for all stakeholders.

Research Computing Investments Benefit All Stakeholders

The business case for research computing investments need collaboration with all major stakeholders in the ecosystem

Many higher education institutions are beginning to develop the business case for their research computing investments through a collaborative process involving campus IT, end-users and principal investigators, local/state/federal governments, industry, and other stakeholders. This collaborative process helps to jointly justify investment decisions, improves the campus IT organization's effectiveness, and deepens collaboration between all stakeholders, as they all work toward common goals.

The healthcare/life sciences ecosystem leverages research computing to collaborate better to benefit the individual patient

For example, all stakeholders in the healthcare/life sciences ecosystem – providers, payers, governments, biopharmaceutical companies, clinical research organizations (CROs), medical device and diagnostic firms, employers, and other public health organizations – must collaborate in innovative ways to drive better outcomes for the individual patient. Figure 2 depicts how research computing applications (primarily pioneered by academic and research organizations) in disciplines like biology, chemistry, clinical trials, imaging and analytics can benefit this healthcare/life sciences ecosystem.

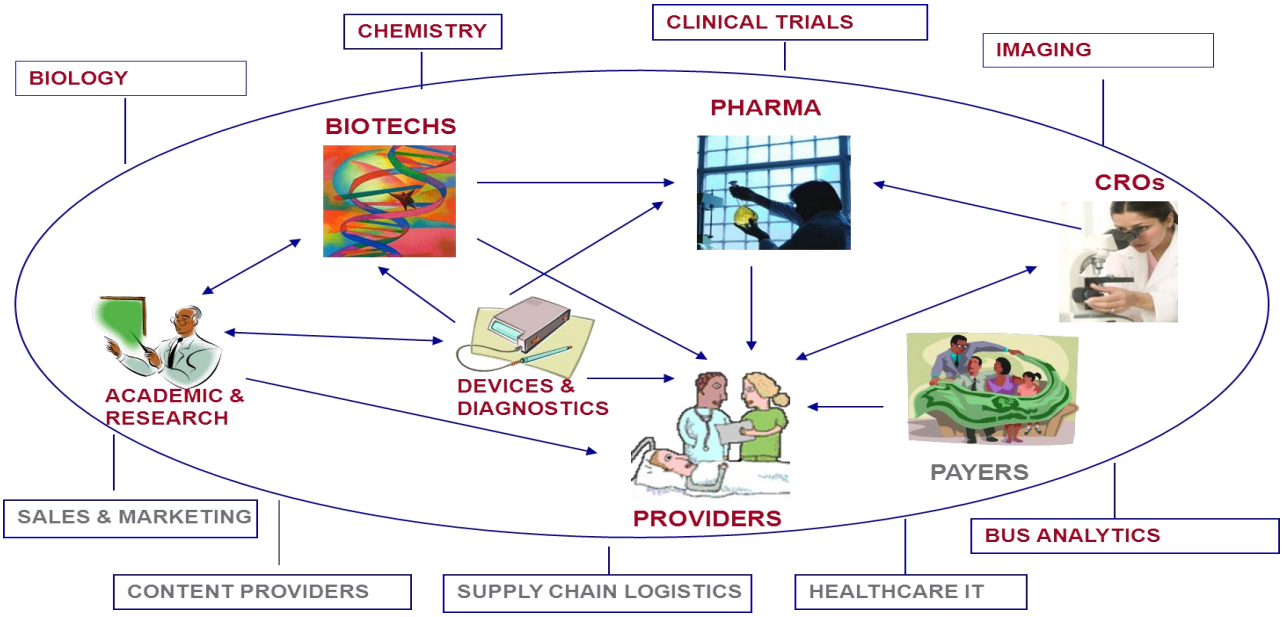


Figure 2: Healthcare/Life Sciences Disciplines/Industries (Red) Benefit from Research Computing

The manufacturing industry ecosystem leverages research computing to develop better products and improve time-to-market

Likewise, all stakeholders in the manufacturing ecosystem – Automotive, Aerospace and Heavy Industry, Suppliers, Government Regulators and Academia – collaborate to design and develop better products that are safe and perform well. Figure 3 portrays how research computing applications (many originally pioneered by academic/research organizations) in disciplines like structures, fluids, crash and design-optimization benefit manufacturing.

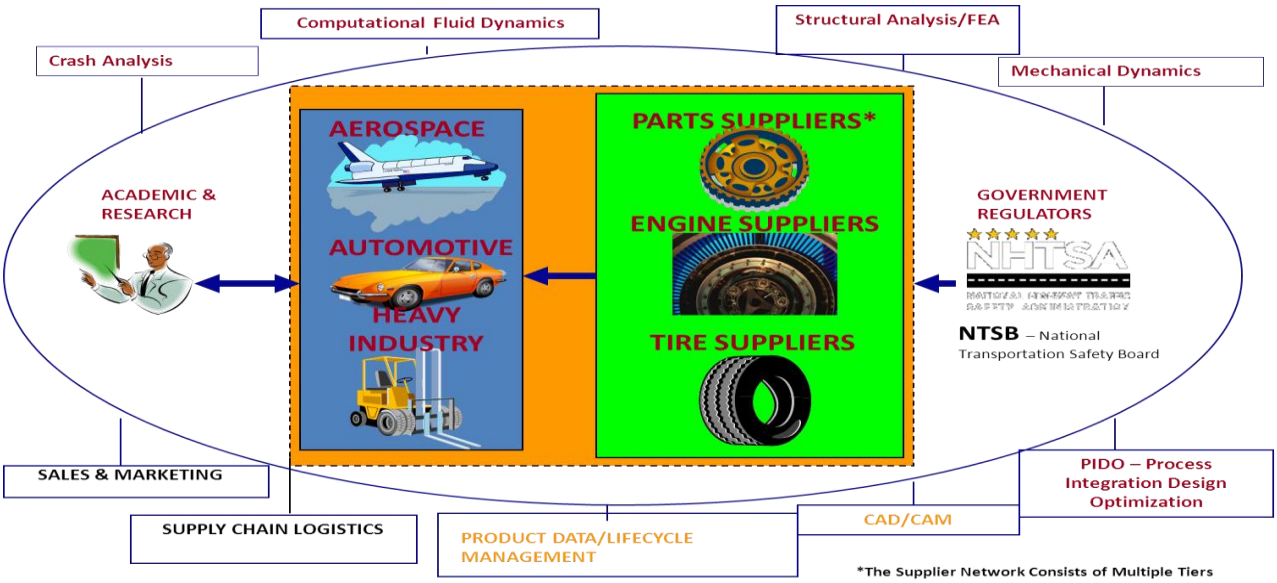


Figure 3: Manufacturing Industries/Disciplines (Red/Orange) Benefit from Research Computing

Higher education institutions must use a framework of inter-related drivers and associated metrics that maximizes the *value* delivered by their research computing investments while minimizing the *total cost of ownership (TCO)* incurred for *all stakeholders*.

Maximize strategic business, research, operational and IT value while minimizing TCO

Stakeholder Value. The business value derived from an investment in centralized research computing comes in one of several forms:

- *Strategic business value:*

  -long-term economic development and well-being of citizens for the state/nation
  -faster time to market, increased profits, improved brand equity, better partnerships with stakeholders, leadership IP portfolio, ability to attract and retain top global scientific/engineering talent for industry
  -ability to attract and retain top faculty and staff, access to increased funding, brand equity, better curricula for the institution.

- *Research value:* breakthrough research and innovation, broader and deeper research collaboration, greater scientific insights, more publications.

- *Operational Value:* faster time to results, reduced cost of research and development, more users supported, improved user productivity, better capacity planning.

- *IT Value:* improved system management, administration, and provisioning; enhanced security; higher utilization; scalability; reduced downtime; access to robust proven technology and infrastructure management expertise

Several investments in IT infrastructure drive regional & national economic development

Total Cost of Ownership (TCO). If research computing infrastructure is built on-premises, IT investments include:

- *Data centers*: new servers, storage, networks, power distribution units, chillers, software purchase, etc.
- *Data center facilities:* land, buildings, containers, facilities maintenance, etc.
- *Operational costs:* labor (salaries for end-users and IT staff), energy, IT hardware and software maintenance, software license, etc.
- *Other costs:* deployment and training, downtime, bandwidth, etc.

Higher education institutions are now continually evaluating the TCO and value of research computing within this broad cost–benefit framework. They increasingly focus on maximizing *value* not just for one application instance but a collection of applications that can benefit all key stakeholders while ensuring their data centers minimize energy consumption to help build a socially responsible, greener and more sustainable environment. This is driving many to centralize, build regional/national grids, virtualize their IT resources and implement cloud computing; further enhancing collaborative innovation.

How Research Computing Drives Value for All Stakeholders

Governments, industry and higher education institutions benefit from research computing in numerous ways

Research computing continues to play a crucial role for higher education institutions, faculty, students and staff; advancing science, engineering, business and even humanities. It is an engine of growth, spurs innovation in multiple industries, and even helps create entirely new industries that rely on the IP derived from research computing. Recently, many governments from local-state-national have recognized this and proactively partner with universities in their jurisdiction to invest in research computing. These governments and the societies they serve also benefit from other applications of research computing such as weather forecasting, emergency response, energy production and conservation, etc. The social good[6] of research computing and analytics is just being taught at universities.

Governments. As industry prospers through research computing, associated local-state-federal governments do benefit from this economic development by generating more and better jobs for citizens, improved productivity and more tax revenues. In addition, governments also use research computing for several applications crucial to national security, public safety and the environment. Some of these include:

Long-term economic development and well-being and safety of citizens for the state/nation

Emergency Response: Many emergency search, rescue, relief operations in response to natural disasters or crimes require the ability to make rapid, on-the-scene decisions.[7]

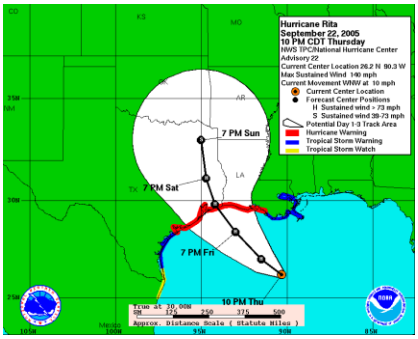
Examples include major road accidents, tornados, floods, earthquakes, terrorist strikes and fires. Faster than real-time simulation (using research computing type solutions) of these events is needed so that response strategies can be rapidly evaluated and the best plan of action is put in place. Emergency response teams can go through virtual training drills so that they are better prepared and equipped to respond to an actual emergency as and when it happens.

[6] Greenwald Ted, Data Won the U.S. Election. Now Can It Save the World?, MIT Technology Review, http://www.technologyreview.com/news/514406/data-won-the-us-election-now-can-it-save-the-world/

[7] Mark Sawyer and Mark Parsons, A Strategy for Research and Innovation through High Performance Computing, http://cordis.europa.eu/fp7/ict/computing/documents/planethpc-strategy.pdf

Critical decisions made from weather and climate prediction help save thousands of lives and collateral damage in the billions while driving economic development in the energy and agricultural sectors

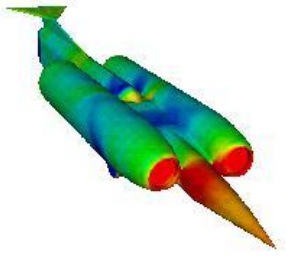
- *Weather and Climate Prediction:* Many economic sectors routinely use weather[8] and climate predictions[9] to make critical business decisions. The agricultural sector uses these forecasts to determine when to plant, irrigate, and mitigate frost damages. The transportation industry makes routing decisions to avoid severe weather events. And the energy sector estimates peak demands geographically to balance load. Likewise, anticipated climatic changes – from rising sea levels to stronger and more frequent storms and extreme temperature events – will have real impact on the natural environment as well as on human-made infrastructure and their ability to contribute to economic activity and quality of life. Governments, the private sector, and citizens face the full spectrum of direct and indirect costs accrued from increasing environmental damage and disruption. For instance, the economic cost estimates from Hurricane Katrina range upward of $200 billion, or over 1% of US gross domestic product[10] and the damages from the recent Hurricane Sandy are estimated[11] to be about $50 billion.



Industry/Businesses. By collaborating closely with higher education institutions and others, research computing helps industry develop and leverage a unique IP portfolio that is the foundation of innovative products and services. Through research computing, many firms across various industries have realized faster time to market and greater profits. It also helps build the firm's brand equity as an innovator, which in turn helps attract and retain top global scientific/engineering talent. Key industry research computing applications[12] are:

Many firms across several industries realize faster time-to-market and greater profitability; improving brand equity and access to highly skilled workforce

- *Engineering Analysis:* Manufacturers increasingly use systems engineering design and analysis approaches to tackle the ever-growing complexity and sophistication of smart products, to improve quality and reliability. Computational Fluid Dynamics (CFD) is typically used in parametric or design optimization studies of aircrafts, jets and other vehicles. Additionally, for safety and performance, they need to solve larger and more complex problems involving combustion, turbulence, and aircraft flutter. Likewise, in structural analysis, full vehicle dynamic response and crash analysis with occupant models are used in iterative design optimization studies for automobiles.



- *Upstream Petroleum:* Many hydrocarbon exploration and production problems require large scale research computing for multi-dimensional pre-stack, time and depth seismic migration studies. Oil and Gas firms need modern seismic surveys are vast and deep. In addition, they must solve basin-wide reservoir optimization problems with multi-physics to maximize the probability of finding and recovering oil and gas.

[8] Laurie L. Houston, Richard M. Adams, and Rodney F. Weiher, "The Economic Benefits of Weather Forecasts: Implications for Investments in Rusohydromet Services", Report prepared for NOAA and World Bank, May, 2004.
[9] "Financial Risks of Climate Change", Summary Report, Association of British Insurers, June, 2005.
[10] Matthias Ruth, Dana Coelho, and Daria Karetnikov, "The US Economic Impacts of Climate Change and the Costs of Inaction", Center for Integrative Environmental Research (CIER) at the University of Maryland, October 2007.
[11] http://www.huffingtonpost.com/2013/02/12/hurricane-sandy-second-costliest_n_2669686.html
[12] Mark Sawyer and Mark Parsons, A Strategy for Research and Innovation through High Performance Computing, http://cordis.europa.eu/fp7/ict/computing/documents/planethpc-strategy.pdf

Rapidly glean insights from the growing volumes of data to make better and quicker decisions across several industries

- *Life Sciences*: Researchers frequently use bioinformatics applications that use parallel pattern recognition; search; and data mining algorithms based on data-decomposition and distributed query techniques. These along with imaging analysis - high content analysis, storage, and retrieval of voluminous and unstructured image data for both molecular imaging and diagnostic imaging - are some of the challenging applications. Bio-pharmaceutical firms can rapidly glean valuable insights that are crucial for drug discovery and development and personalized medicine from a wide array of exploding and diverse data sources.

- *Financial Services:* Applications include risk management, complex asset valuation, Monte Carlo simulations, fraud detection and anti-money laundering. Ultra low-latency financial trading execution environments typically found in research computing are becoming commonplace to support high frequency trading at investment banks and insurance companies as they struggle to compete globally.

Higher Education Institutions. Research computing helps institutions in some key ways to:

Develop and maintain highly skilled talent crucial for economic development and competitiveness in the global knowledge economy

- *Attract and retain top faculty and staff:* With research computing facilities, institutions are more competitive in recruiting and retaining faculty especially new recruits who are significantly vested in research computing to advance their field of study. Faculty members who are provided additional specialized technical support personnel such as systems programmers, application scientists, etc. are even more loyal to the institutions, since they get more time to spend in pursuing their primary research and working on writing proposals for research grants; thereby improving their productivity.

- *Find innovative ways to increase funding:* Research computing centers, particularly at a campus or regional level, have increased collaboration with individual researchers to jointly write research grant proposals from sponsoring funding agencies with a focus on specific application domains that are crucial to state/local government initiatives.

- *Grow user base, improve curricula and build highly-skilled workforce:* Many research computing centers have targeted programs to recruit new users. They invest in business development and outreach to recruit industry users and users from other collaborating institutions. In addition, as research computing on campus is increasingly being used in non-traditional disciplines such as the humanities, social sciences, and economics, many centers provide proactive support, skills-training workshops, and even one-on-one mentoring to encourage computing use among these new and non-traditional users.

- *Enhance brand equity/reputation at multiple levels with stakeholders:* Research center directors in higher education institutions – many of whom are faculty members - spend significant efforts to educate key university decision makers such as the Provost and President, other senior university and government stakeholders on the *strategic value* of research computing. To promote the center's capabilities and *research and operational value*, most centers hold seminars, workshops, and educational events to expand reach

Enhance brand equity and reputation for all stakeholders

with non-traditional users while improving loyalty with the current user base. The more mature centers have hired computational application scientists and domain experts to interface and deepen collaboration with researchers and industry. They also have on staff seasoned marketing and business development professionals for increasing awareness of their centers and managing relationships with all key stakeholders in their ecosystem. In addition, many centers provide premier IT support and services, often 24 by 7, staffed by a pool of systems administrators who ensure that *IT value* is maximized; further enhancing the institution's reputation with the broader community.

IBM Actively Promotes Research Computing Collaborations

Higher education institutions often develop long-term strategic partnerships with research computing solution providers such as IBM. These collaborations are crucial to manage the rapid changes in technology and keep up with the needs of innovation and discovery at every level in the research computing ecosystem. In addition to providing a comprehensive portfolio of research computing solutions, IBM has unique capabilities and initiatives unmatched by its competitors:

Collaborations in new cognitive computing areas and IBM Watson can accelerate economic development by transforming healthcare, finance and other industries

Peer-to-peer Research Collaboration with Academia. Researchers at IBM laboratories (12 labs over 6 continents) work with peers in universities around the world. These collaborative relationships are often nurtured over time through fellowships, grants, and funding for programs of shared interest including supercomputing and the exploitation of multi-core technologies. Cognitive Computing[13] is another key strategic thrust at IBM Research. This refers to a new generation of computing systems emerging with embedded data analytics, automated management and data-centric architectures in which the storage, memory, switching and processing are closer to the data. Cognitive systems have breakthrough promise to solve current and future Big Data Analytics challenges.

IBM Watson[14]. Cognitive systems like Watson have the potential to transform how organizations think, act, and operate in the future. Learning through interactions, they deliver evidence-based responses driving better outcomes. This natural language supercomputer is being used for several innovative applications in healthcare, finance and customer engagement.

Superior IP management provide unique insights to identify new opportunities in information-intensive industries

Superior IP Management. Many universities are under intense pressure to improve their research and development programs with fewer resources and diminished funding. They must constantly derive insights and white space opportunities for innovative research from the growing content in scientific literature and patents. IBM, with its unparalleled track record of 6478 total patents (over 500 directly related to analytics and research computing) in the U.S. in 2012 and 20th consecutive year of patent leadership[15], proactively collaborates with universities around the world to share best practices in IP management. IBM Strategic IP Insight Platform (SIIP)[16] applies deep analytics on patent and scientific literature to provide clients with more information and insights than they could derive manually and has very unique capabilities to extract and analyze chemical and biological data.

[13] IBM Research, http://www.research.ibm.com/new-era-of-computing.shtml
[14] IBM Watson – ushering in a new era of computing, http://www.ibm.com/innovation/us/watson/
[15] IBM Research, 20 Years of Patent leadership, http://www.research.ibm.com/articles/patents.shtml
[16] IBM Strategic Insight IP Platform, http://www.ibm.com/services/us/gbs/bao/siip/

IBM provides regular access to a broad portfolio of optimized research computing solutions and highly-skilled people to entrepreneurs, universities and governments to drive economic development through innovation

Global Entrepreneur Initiative: The IBM Global Entrepreneur Program[17] provides resources to early stage entrepreneurs looking to bring the next big idea to market. Resources include access to IBM products, people, and promotion venues that help entrepreneurs extend the size and reach of their companies to outflank their competitors. The program includes several local ecosystem networking events that bring together academia, government agencies, venture capitalists and startups in the community.

Broad Portfolio of Optimized Solutions for Research Computing: IBM offers a wide array of research computing solutions[18] through its multi-core processor systems, large storage systems, support for a broad range of operating systems, visualization, innovative applications, middleware and partner ISVs with proven expertise and deep industry presence. IBM has the leading portfolio of research computing architectures, systems, and software -- the IBM System x Intelligent Cluster[19], IBM Blades, IBM System x iDataPlex[20], IBM Power Systems[21], IBM PureSystems[22], IBM System Storage[23] including the IBM System x General Parallel File System (GPFS) Storage Server[24] and IBM Blue Gene.[25] This portfolio supports a range of operating systems including Linux, AIX and Windows, together with management software from IBM Platform Computing[26] for clusters, grids and clouds, a high-performance shared-disk clustered file system - IBM GPFS[27] and optimized scientific and engineering libraries. In addition, IBM has a worldwide research and technical staff of domain experts to collaborate with researchers to migrate and optimize their applications on the IBM portfolio to solve their largest and most challenging problems.

[17] IBM Global Entrepreneur Program, http://www..ibm.com/partnerworld/wps/servlet/ContentHandler/isv_com_smp_startup_start
[18] IBM Technical Computing, http://www.ibm.com/systems/technicalcomputing/
[19] IBM Intelligent Cluster, http://www.ibm.com/systems/x/hardware/largescale/cluster/
[20] The IBM System x iDataPlex, http://www.ibm.com/systems/x/hardware/rack/dx360m4/
[21] IBM Power Systems for Technical Computing, http://www..ibm.com/systems/power/hardware/hpc.html
[22] IBM PureSystems, http://www.ibm.com/ibm/puresystems/us/en/pf_overview.html
[23] IBM System Storage, http://www.ibm.com/systems/storage/
[24] IBM System x GPFS Storage Server, http://www.ibm.com/systems/x/hardware/largescale/gpfsstorage/
[25] The IBM Blue Gene, http://www.ibm.com/systems/technicalcomputing/solutions/bluegene/index.html
[26] IBM Platform Computing, http://www.ibm.com/systems/technicalcomputing/platformcomputing/
[27] IBM General Parallel File System (GPFS), http://www.ibm.com/systems/software/gpfs/

IBM Research Computing Collaborations: Customer Cases

IBM's collaborations with higher education institutions are broad, global, and very deep. Here are a few examples covering the range of IBM research computing capabilities.

Improved traffic and urban planning; Better public services management – water, energy and health with the Blue Gene/Q

Governments of Canada and Ontario

Challenges	• Rapid urbanization and aging structures • Escalating healthcare costs due to chronic diseases and long development time for new drugs • Conserve water and manage efficiently for wildlife, domestic and industrial use.
Objectives	• To address above challenges by building specialized tailored application software.
Solution	• IBM is developing a high technology research center named "IBM Canada Research and Development Center" to serve as a foundation for this research initiative. • The Government of Canada along with a consortium of seven southern Ontario post-secondary institutions along with IBM will install two high performance IBM Blue Gene/Q supercomputers and develop a cloud computing and agile computing platform to underpin the initiative's research collaboration.
Benefits	• Urban planning and traffic management for intelligent cities • Better water monitoring, management and distribution • Efficient energy monitoring and management • Reduced wastage in resources • Novel research in brain science with artificial intelligence • Accelerate Canada's digital infrastructure

Optimizing use of natural resources, protecting against natural disasters and better public healthcare using the IBM iDataPlex and Blue Gene systems

University of Melbourne, Australia - IBM Global R&D Laboratory

Challenges	• Need better technology for natural resource management • Integrate current expertise in areas such as real-time event processing, weather modeling, traffic management and mobility • Plan and manage evacuation, communication and emergency response
Objectives	• Establish a combined R&D laboratory In collaboration with the University of Melbourne • Develop a smart planet vision, use advanced techniques in monitoring, analytics and automation • Smarter natural resources management, by applying technology in oil and natural gas, minerals, water and food, etc. • Smarter natural disaster management • Broader research into healthcare and life sciences
Solution	• Accelerate innovation with the establishment of the IBM Global R&D laboratory using IBM iDataPlex clusters and the Blue Gene • Use advanced techniques for smarter monitoring, analytics and management of natural resources and in other areas.

Benefits	• Realizing better results in the discovery, production, supply and utilization of natural resources such as oil and gas, water, food and minerals • Expert research in weather modeling and real-time event processing better assists in planning and execution disaster management • Healthcare and life sciences now uses advanced research techniques to get better results.

Science & Technology Facilities Council (STFC), Hartree Center, UK

Challenges	• Establish a major center in Technical Computing Science with significant HPC and Big Data resources dedicated to working with industry to tackle the next wave of scientific challenges. • Provide broader access to industrial HPC users and independent software vendors (ISVs) through a program of collaborative partnerships • Make technical computing users more productive by creating new tools, training and development environments.
Objectives	• Develop a research center and an entry point for businesses of all sizes to use research computing focused in the UK • To support the development of new applications that will exploit research computing infrastructures • Develop an energy-efficient computing infrastructure to address both general computing and research in big data challenges such as analyzing weather and climate data and performing complex aerodynamic modeling for the aviation and automotive industries.
Solution	• Establish the Hartree Center in 2012 for Research collaboration between the UK Science & Technology Council (STFC) and IBM. The center uses the following: - Hardware: IBM System Blue Gene/Q, IBM System x iDataPlex dx360 M4, IBM System Storage TS300 tape library with TS1140 Enterprise tape drives, DataDirect Networks SFA 10K-X disk systems - Software: IBM General Parallel File System, IBM Platform HPC, ScaleMP vSMP software and Red Hat Enterprise Linux
Benefits	• Provides an entry point for technical computing and a general purpose big data research cluster for businesses of all sizes in the UK - Unilever uses this to improve consumer products. • Supports development of business applications capable of taking advantage of technical computing architectures and complies with “Green IT” initiatives in Europe.

Provides businesses in the UK affordable access to general purpose research computing with the IBM Blue Gene/Q, IBM iDataPlex and IBM Storage; Unilever uses this center to improve consumer products

Improves economic development and high level job opportunities in Nevada; the IBM PureSystem helps drive new revenue in energy, water resources and weather research

Desert Research Institute (DRI), Nevada

Challenges	• Need a simplified yet highly scalable solution to analyze large volumes of research data with limited technical resources. • Dynamic resource scaling and consistent application deployments were hard to achieve.
Objectives	• Advance research and technology commercialization and support the State's Innovation Based Economic Development. • DRI and Nevada System of Higher Education (NSHE), working in concert with the Governor's Office of Economic Development (GOED), wants to be a pioneer to employ advanced technology in establishing data driven public policy and education reform.
Solution	• IBM PureSystems provide DRI a streamlined improved technology framework for capturing, managing and applying scientific research data -- in fields ranging from hydrology and water efficiency to archaeology and renewable energy. • An integrated infrastructure system that combines compute, storage, networking, virtualization and management. IBM PureApplication System serves as a fully integrated application platform with IBM middleware, and IBM PureData System for Transactions is optimized for delivering data services to DRI.
Benefits	• An increase in higher level jobs throughout the State of Nevada. • Improved results in application development, deployment, and overall system administration and management, • Increased exposure for the University of Nevada's top talent brought on by access to this advanced technology, • Incremental revenue and funding by developing scientific patterns in such areas as weather research.

Propel the region into a knowledge based economy using the IBM Blue Gene/Q in areas such as energy, life sciences and manufacturing

King Abdullah University of Science and Technology (KAUST) in Jeddah, Saudi Arabia

Challenges	• Enable scientific, economic and social advances through the development and application of research computing solutions • Help the university's scientific researchers tackle problems of extreme complexity across dozens of disciplines
Objectives	• To derive value buried in growing volumes of data and advance new innovations in computational life sciences • To improve the knowledge based economy in Saudi Arabia
Solution	• Collaboration between KAUST and IBM • A research computing system (Shaheen) - a 16 rack IBM Blue Gene/P system with a processing power of 185 Teraflops and 10 Gbps access to the world's academic and research networks
Benefits	• Large-scale computing capabilities of Shaheen unite business and scientific computing techniques to analyze huge volumes of data and synthesize information to solve real-world problems • Deliver the best computing capabilities to the community at KAUST to propel the region into a knowledge based economy.

Solves complex problems in health, environment and energy using the most powerful IBM Blue Gene/Q in Europe to benefit society and governments

Forschungszentrum Julich GmbH (FZJ), Germany

Challenges	• Need for a powerful supercomputer to help scientists and researchers working on the world's most challenging problems. • Overcome problems with computing capacity, storage and people expertise that are limiting the center's capabilities. • Deploy a system that can quadruple existing processing power with a smart, economical way to deploy and manage this new capacity.
Objectives	• Drive research in energy, environment, information technology and health • Make available tools, processing capacity and expertise to academic researchers across Europe • To get the best computing infrastructure with the lowest energy consumption and budget
Solution	• The fastest supercomputer for non-classified research in Europe • IBM's research computing solutions include: - Hardware: 24 racks of the IBM Blue Gene/Q, IBM Power 550 Express, IBM Power 570, IBM system Storage DS5300, BM System Storage DS4700 Express - Software: IBM General Parallel File System (GPFS), IBM Tivoli Workload Scheduler, IBM AIX, SUSE Linux Enterprise Server
Benefits	• Helps scientists in solving some of the most challenging problems and drives advanced research in health, environment, information technology and energy • Researchers are able to run complex simulations to understand the physical world – an understanding they apply to solving problems that affect individuals and society as a whole

Cracks complex problems in aerospace, automotive and healthcare with a general purpose supercomputer – the water cooled iDataPlex while minimizing environmental impacts

Leibniz Supercomputing Centre (LRZ), Germany

Challenges	• Need a large-scale supercomputer to support extensive research in energy efficiency and enhance research computing resources in Germany within allotted funding
Objectives	• To build a low cost energy-efficient system • To probe questions around the evolution of matter, characteristics of viruses and automotive/aerospace industries
Solution	• IBM deployed the direct water-cooled (DWC) iDataPlex with 150,000 processor cores and 300 terabytes of memory
Benefits	• Standards based architecture of the IBM system give the flexibility to support a wider array of research projects -more than 200 researchers can run their applications simultaneously • Large scale research in medicine, engineering and other areas with large workloads run easily on this standard architecture • Operating cost and environmental impact is extremely low.

Conclusions – Research Computing Powers a Virtuous Cycle of Economic Development

In a highly competitive knowledge based economy, governments across the world are constantly challenged to develop and grow their economies with fewer resources. Continuous innovation in major industries such as manufacturing, healthcare, energy, etc. at a regional level is needed to spur economic development. Many governments across the world realize that this requires them to actively partner with industry and academia within their regions. These sustained long-term collaborations and the concomitant investments in IT and research computing are strategic to regional economic development in several ways:

- The IP resulting from research computing is the foundation of new ideas and innovation across several industries resulting in better products/services and faster time-to-market; improving the profitability and competitive position of regional firms and the creation of new companies.
- As regional firms prosper through innovation, they need more highly-skilled talent which in turn results in higher paying jobs in the region.
- To keep up with this increasing demand for a highly-skilled workforce, higher education institutions must recruit and attract better faculty and staff, invest in infrastructure and create better curricula tailored to prepare students for the knowledge based economy.

With increasing economic development, regional governments get increased tax revenues and can provide better public services (in part by leveraging research computing) to their constituents to improve their well-being and safety. Research computing helps higher education institutions enhance brand equity which helps attract better students and faculty/staff.

The many case studies around the world clearly illustrate that IBM is very active in creating and supporting many academic-industry-government research computing collaborations to drive regional economic development. Based on over 50 years of experience, IBM has many unique capabilities and initiatives to offer. These include peer-to-peer collaboration between IBM staff and academia, Sponsored University Research (SUR) grants for hardware and software, the Global Entrepreneur program, superior IP management software and the broadest portfolio of research computing solutions for today and into the new era of cognitive computing.

For More Information

To learn more about IBM initiatives for education, please visit: www.ibm.com/education

To learn more about IBM solutions for Research Computing, please visit: www.ibm.com/technicalcomputing

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