Global Technology Outlook 2011

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Since 1982, The Global Technology Outlook had identified significant technology trends five to even 10 years before they have come to realization. It has looked for and examined high-impact, disruptive technologies that have led to the creation of industry-changing products and services.

IBM Research, through its global community of some of the world's top scientists, considers the cultural and business applications in which these technologies could be used – and the impact they will have on IBM and the world.

After the team's year-long study and extensive vetting with Chairman and CEO Samuel Palmisano, the completed GTO is used to define IBM's technological areas of focus and investment. Externally, it is also shared broadly with a range of IT influencers – including clients, academics, and partners – through education and client briefings.

The GTO has a history of impacting IBM's business and the IT industry. In past years it has predicted such emerging trends as virtual server security, optimized systems, pervasive connectivity and the rising importance of data and analytics. When IBM set its sights on helping to create a smarter planet three years ago, we had already predicted the evolution of an increasingly instrumented, intelligent and interconnected world. Since that time, the application of technology has led to new Business Analytics and Optimization services and business analytics centers; new cloud services and offerings; and even the recommendations on acquisitions to complement IBM's portfolio of offerings.

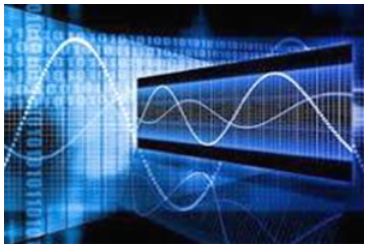
But the GTO is not designed to singularly benefit IBM. In fact, some of the trends explored may be well beyond IBM's current scope of business. And that's what makes the GTO such a success each year – providing clients and partners with an impartial take of the world and the evolution of IT across business, economic and natural systems.

The 2011 GTO is set to build not only on its 29 predecessors, but the 100 years of IBM innovation. Can analytics push the petascale barrier? What else can benefit from an Internet infrastructure? How much value is buried in the volumes of unstructured data?

This report is designed for your organization to benefit from the exploration of these insights, just as we have at IBM.

Dr. Mark Dean, PhD
IBM Fellow and Vice President

Socially Synergistic Enterprise Solutions



We are at a tipping point in which traditional structured business data and unstructured information created by and about people and their social networks can be brought together with analytics in new ways – leading to socially synergistic enterprise systems. These systems will allow businesses to integrate computation with human cognition, and take actions to gain deeper insight into the value of their products and services. This can transform how they involve their customers, employees and partners to increase their mutual success.

Socially synergistic enterprise solutions address the human side of a smarter planet, bringing what people do in social networks into the mix along with the sensor and streaming data that organizations are gathering and analyzing.

The human side of the smarter planet

Businesses are beginning to realize the potential in aggregating, correlating and analyzing data generated from their assets (their physical devices), from their enterprise (their structured information), and from social networks (unstructured information about the business from employees, consumers and the general public). This integration can enable businesses to:

- **Gain new insight:** Discussions about a product on Twitter or Facebook, for example, can lead to new understanding of how a brand is perceived. Analyzing this data can uncover previously unknown influencers on sales by understanding and tracking topic evolution in response to campaigns, statements, finding root causes, and having advance warning of emerging problems or opportunities.

- **Influence new behavior:** Organizations can take advantage of emerging techniques in social software to involve people in activities that, for example, conserve natural resources. Dubuque, Iowa is combining sensor data, analytics, and techniques taken from digital games to make citizens active participants in reducing water usage.

Deeper customer relationships, better products and services, and more effective marketing efforts can result by effectively blending and analyzing social information with traditional data.

- **Optimize its workforce:** Internal synergistic solutions could help a company create more effective project teams through analysis of employee contributions to past projects; employee collaboration patterns, the interests of the people involved and the broader development goals of the organization. These capabilities could also determine when techniques such as crowdsourcing would make sense.

Conclusion

Many of these socially synergistic capabilities currently exist, though often in pieces and in separate organizational silos. Securely and privately connecting the dots to create a holistic understanding of the relationships between a person, a process, a product, and an organization is still a challenge. In some cases, additional research is needed to understand how best to support higher level functions, such as collaborative reasoning, group decision making, effective crowdsourcing, and structuring a complex work process.

To address these challenges, a framework for constructing socially synergistic enterprise systems will let businesses draw from the growing pool of social technologies and blend them into specific solutions. This framework will also take advantage of emerging social software techniques as they arise or are invented – allowing businesses to incorporate capabilities from outside partners and integrate with existing systems. Socially synergistic enterprise solutions that analyze, understand, and learn from ongoing human behavior – and that offer new ways to involve human action and creativity – will successfully influence and improve a business through increased understanding of perception and knowledge of their products.

Petascale Analytics Appliance and Ecosystem

Big Data is the new resource. The amount of data produced is growing ten-fold every five years – from the 800 billion gigabytes created in the last two years to petabytes of both structured and unstructured data fused from many different sources. Big Analytics, the techniques for extracting business value from Big Data, is the new competitive opportunity.

Leadership in the era of Big Analytics will require the development of a Petascale Analytics Appliance – a system well-populated with both Big Data and Big Analytics, embedded within a rich ecosystem of skilled professionals.

Extracting maximum insight from Big Data

Big Data exists at a scale up to 10,000 times larger than a typical enterprise database. It can also be generated at extremely high rates such as in mobile device networks, which require rapid analysis and throughput up to 10,000 times faster than traditional systems. Along with this high volume and high velocity comes a wide variety of data from sources such as relational tables, documents, log files, sensor readings, blogs, tweets, digital photos, webcam videos and more, which must be combined for maximum insight.

To extract business value from such a huge volume of data, businesses need high capacity and massively parallel systems dedicated to running two types of Big Analytics: Reactive Analytics for fast moving data streams, and Deep Analytics for the oceans of historical data already collected.

Where is Big Analytics?

Homeland Security
- 600K records/second
- 50B records/day
- 1-2 milliseconds/decision

Telco Promotions
- 100K records/second
- 6B records/day
- 10 milliseconds/decision

Smart Traffic Systems
- 250K GPS probes/second
- 630K segments/second
- 2 milliseconds/decision per 4K vehicles

To extract maximum insight from Big Data, businesses must continually integrate the predictive models generated from Deep Analytics with the real-time monitoring and responsiveness of Reactive Analytics. The Petascale Analytics Appliance will be highly optimized for processing that integrated workload.

A Petascale Analytics Appliance by 2015

Today, the movement of Big Data often swamps business application processing time, dominating performance cost. To handle this extreme workload, we envision by 2015 a data-centric Petascale Analytics Appliance capable of applying a Petaflop of computing power – roughly equivalent to the computing power of 100,000 laptops – over a Petabyte of memory. (A Petabyte is 1,000,000,000,000,000 bytes, or roughly equivalent to the

memory of 500,000 laptops with 2 Gigabytes of RAM each). By comparison, most data warehouses today weigh in at only a few hundred Terabytes and only the world's largest supercomputers, used almost exclusively by government entities, can provide a Petaflop of performance.

With the anticipated arrival in 2014 of large scale Storage Class Memory (also known as Phase Change Memory), and the advances in compute density being developed for next generation supercomputers such as IBM's BlueGene/Q, such Petascale systems can be widely available by 2015.

Rich Ecosystem Required

Even when a Petascale Analytics Appliance is available, smarter planet solutions will require access to rich sources of Big Data not only from existing data warehouses, but also from online transaction processing systems, sensors, and other sources across the Internet. Professionals will also need new Big Analytics skills and know-how to develop new Big Data solutions. Commercial Data-as-a-Service and Analytics-as-a-Service offerings are already emerging in the marketplace, and these will grow to be an essential component of the complete Big Analytics ecosystem.

Conclusion

Industry investment in Big Analytics is expected to double by 2015, reaching $18 billion. With the arrival of Petascale Analytics Appliances and their supporting ecosystem of skills, data and algorithms, businesses will have a unique opportunity to maximize insight using Big Analytics for maximum competitive advantage.

Natural Resources Transformation & Management

Growing world prosperity – some 90 million people are added to the middle class each year – is increasing demand for natural resources at the same time that the scarcity of these resources is increasing. Therefore, natural resource firms need to dig or drill deeper, and do so in increasingly remote locations, facts that are contributing to a growing skills shortage and rising labor costs. Simultaneously, increasing levels of government regulation and public oversight are adding complexity and cost to operations. This "perfect storm" threatens the ability of natural resource firms to fuel, feed, and help build the world that we live in.

Natural resources industries are among the most asset-intensive industries in the world. IT can help these companies improve their asset utilization and achieve dramatic improvements in production and operational efficiency. This can be accomplished through a new combination of advanced industrial equipment modeling, a system for continually improving the models based on real-time streaming data, and the integration of analytics across business and operational functions.

Highly asset-intensive firms, such as those in mining or oil and gas industries, have traditionally managed information technology separately from the operational or revenue-generating side of the business. However, rapidly rising levels of equipment instrumentation, and an increasing need to integrate information from different sites, is driving a need to converge IT with operational technology.

Advancing value

The pathway to more effective use of IT starts with a business' existing asset management and condition-based maintenance capabilities. The business must then add depth, accuracy, and a prescriptive ability to the models – integrating across physical locations, operational functions, and business functions.

This approach permits a level of holistic business and operational optimization currently unheard of in industries such as mining, oil and gas, or agriculture. With the enormous size of the asset base in natural resource industries, trillion-dollar impact levels are possible.

Natural resource firms are exploring new business models to improve their use of capital, and increase their production and profits. They are increasingly asking their vendors to get more deeply involved in supporting areas such as maintenance outsourcing, "equipment as a service," operational outcome-based models, and greater levels of

operational outsourcing. For example, a mining truck company might change its business model to charge a mining firm by the amount of ore moved, and take over all management of truck deployment, maintenance, and perhaps even operation.

Successful deployment of these new business models requires IT to drive higher levels of quantitative understanding of the industry, as well as an ability to remotely gather data and remotely mange equipment and operations – which requires a further convergence of IT and operational technology.

Conclusion

Natural resources transformation and management is an area with enormous potential for value creation through greater use of IT and its application to the operational side of a business. This transformation will also play a vital role in the continuing effort to maintain an improving the quality of life for millions of people across the globe.

Internet of Things

Various studies have predicted that tens of billions of Internet-connected devices will be deployed across the globe over the next five to 10 years. The Internet of Things (IoT) is a term used to describe this emerging new reality, but in order to enable such a large number of interconnected devices to work properly and effectively, a new foundational end-to-end infrastructure is required.

With this infrastructure in place, an IoT can become an enabling technology and an important component in the huge technology build up already happening, particularly in growth markets such as China. These newly interconnected devices will help monitor the physical world, and manage business processes in areas such as energy distribution and management, natural resource management, healthcare, and transportation.

It will help transform traditional industries by reducing cost, improving efficiency and generating new business opportunities not possible with today's infrastructure. For example:

- An IoT system for a smart grid could monitor and manage the whole life cycle of power generation, transmission, distribution and power consumption, for potentially hundreds of cities.

- An IoT system for smart healthcare could monitor and manage chronic diseases for millions of patients based on real-time data collected from medical devices installed in their homes, along with the data from medical records of their family members.

- An IoT system for a shipping company could enhance asset management and improve operational efficiency through advanced planning and scheduling.

A common IoT architecture can be applied across multiple industries, using access appliances and application gateways as critical building blocks. The IoT infrastructure will have built-in functions to support system resilience and end-to-end security to protect against unreliable devices and insecure environments.

Conclusion

Building and deploying an IoT system will be challenging due to current issues of IT heterogeneity, global distribution of devices, scale, management and security. Questions such as how an IoT system will automatically perform firmware upgrade operations for millions of on-line and off-line devices; and how an IoT system will proactively identify security risks and take proper actions, remain to be answered.

Frontiers of IT

IBM envisions a future in which advances in technology will create a new class of systems that can learn. These systems will be designed to augment human intelligence with people as an integral and central part of the system. These systems will go beyond capacity, speed, and complex analytics to contribute to humanity's creativity, innovation and ingenuity.

A paradigm shift from calculators to learning systems

The 21st century presents us with a defining challenge: how will we achieve our desired outcomes in the context of the massively complex and interdependent world we have built? The combination of mechanization, vast increases in energy utilization, and advances in information and communication technologies have reshaped the world.

However, decision-making has been greatly complicated as a result of what we have created. Given this context, are the tools we use today the right ones to help us advance our creativity, innovation and ingenuity in this new world? How will we find the right ideas and solutions for our most pressing challenges?

We envision a roadmap that will progress towards increasingly dynamic learning capabilities, eventually achieving systems will be able to learn autonomously across arbitrary domains.

We are faced daily with a torrent of unstructured data containing complex interrelationships and correlations. This data is valuable, and can be mined to improve decisions and provide better outcomes for businesses, institutions and individuals. Unfortunately, present computing systems, which are based on a "calculator" paradigm, cannot learn how to interpret and find value in these relationships from this sea of data. The best we can do is to deploy expert programmers to create a constellation of targeted applications to analyze specific domains.

Fortunately, our expanding technology frontiers are providing us with the right tools to meet the new century's challenges. We anticipate that it will be possible to build a new class of systems that can learn from both structured and unstructured data, find important correlations, create hypotheses for these correlations, and suggest and measure actions to enable better outcomes for users. Systems with these capabilities will transform our view of computers from "calculators" to "learning systems" – a shift that will radically alter our expectations of what computing ought to do for humanity.

IBM’s DeepQA system, Watson, is a powerful demonstration that the era of learning systems is indeed upon us. Watson’s ability to compete with the best human champions in US quiz show Jeopardy! represents both a milestone in artificial intelligence and the beginning of this technological revolution.

Breakthroughs in computing systems that exhibit intelligent behavior will require new learning algorithms and architectures; expanded data input and output modalities (e.g. the ability to process text, graphs, images, video, sound, and other sensory information), and novel device technologies that will exploit the latest semiconductor and nanotechnology advances. We envision a roadmap that will progress towards increasingly dynamic learning capabilities, eventually achieving systems will be able to learn autonomously across arbitrary domains.

Conclusion

Learning systems will impact virtually every sector of the economy, enabling a multitude of applications and services that will range from preventing fraud and providing better security in a more complex world, to improving sales and helping launch products, to improved medical diagnosis.

It is not far fetched to think that these learning systems will become our partners in expanding the horizon of human cognition. This partnership, anchored in the belief that computing ought to do much more for us and that it should do it on our terms, is the new frontier of information technology.