

IBM Research

Global Technology Outlook 2012



Since 1982, IBM Research has marshaled the unique capabilities of its worldwide community of top scientists to create the Global Technology Outlook (GTO). The GTO is a comprehensive analysis that looks three to ten years into the future seeking to identify significant, disruptive technologies that will change IBM and the world.

The result of a year of intensive work—generating ideas, gathering data, and rigorously debating the issues—the final GTO report is submitted to the IBM Chairman and CEO. At each step in the process, the team considers the societal and business implications as well as the technology aspects of each trend.

The completed GTO is used within IBM to define areas of focus and investment and is shared broadly with a range of IT influencers, including clients, academics, and partners, through education programs and client briefings.

In the past, the GTO has predicted such emerging trends as virtual server security, optimized systems, pervasive connectivity, and the rising importance of data and analytics.

However, the GTO is not designed to solely benefit IBM. In many years, some of the trends have gone well beyond IBM's existing scope of business. It is this impartial examination of the evolution of IT across businesses, economies and natural systems that makes the insights of the GTO so extraordinarily valuable.

The 2012 GTO reports on six key findings that share a common theme: analytics. The explosion of unstructured, and increasingly uncertain, data will amplify the need for the development of new models and new classes of computing systems that can handle the unique demands of analytics.

We look deeper in areas where analytics will be particularly disruptive—from optimizing today's socially connected workforce to staying a step ahead of risks only now arising as the world continues along the paths of interconnection and consolidation.

And we finish this year's GTO with a look at how these dynamics come together in the IBM Watson computing system as it delivers a new class of decision support through interactive dialogue and continuous learning.

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



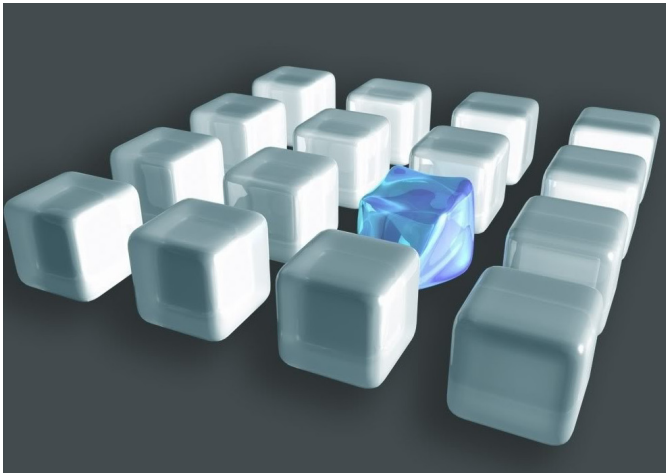
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Managing Uncertain Data at Scale

Analytics provides new opportunities for business insight through the analysis of data that is constantly growing in volume, variety, velocity and uncertainty. Increases associated with the first three categories have been evident and widely acknowledged, but decreases in veracity represent the fastest-growing portion of data that is uncertain.



Today, the world's data contains increasing uncertainties that arise from such sources as ambiguities associated with social media, imprecise data from sensors, imperfect object recognition in video streams, model approximations, and others. Industry analysts believe that by 2015, 80% of the world's data will be uncertain.

In order to make confident business decisions based on real-world data, analyses must necessarily account for many different kinds of uncertainty present in very large amounts of data. Analyses based on uncertain data will have

an affect on the quality of subsequent decisions, so the degree and types of inaccuracies in this uncertain data cannot be ignored.

For example, determining one or more trends for a disease can help decrease the spread of disease through a process that integrates millions of healthcare medical records; however, the use of different names for the same diseases and medications can limit the accuracy of forecasts. In another example, new advances in law enforcement and crime prevention integrate fragments of data from multiple sources, but details described in accident reports, eyewitness accounts, and other individual observations can differ widely and ultimately limit accuracy.

People present notable challenges in the area of uncertainty due to the many dimensions of information with which they are associated. Experiments show that an enterprise must sometimes triage millions of social media fragments to obtain a single useful company-specific fact. Finding these nuggets of information about an individual, and his or her relationship to others, often requires an enormous scale of computation.

Scalable end-to-end uncertainty management

At every instant, more data is generated, which often requires the integration of new analyses, tools, and technologies in order to unlock the potential value lying within the data. The process of data condensation (i.e., gathering data from multiple sources and combining the data to reduce uncertainty) can be used to gain broader insight. For instance, the relevance of individual purchase recommendations can be increased by reflecting a person's most recent expressions of buying intent while also considering similarities in buying patterns derived from analysis of millions of individuals and products.

Conclusion

Data management, along with the ability to derive additional value in the management process, is rapidly evolving as a strategic opportunity for both new and established enterprises. New business models are emerging in which a company's value is based on the amount of information it can store and exploit.

Managing uncertain data at scale will require the creation of best practices, standards, and scalable algorithms for condensing data, along with new analysis techniques for uncertain data at massive scales, and consideration of uncertainty throughout the management pipeline. Additionally, uncertainty management technologies must be embedded within "Big Data Analytics" platforms that are readily available for use. Finally, managing uncertain data at scale will require new tools, new skills, and a greater need for data-science practitioners. These practitioners will be able to use uncertainty management to integrate enterprise models and data with syndicated models and data in order to enable enterprises to make confident business decisions.

Systems of People

Beyond business process automation or supply chain management, future businesses will derive increased efficiency and value by optimization along the social dimension of their workforce. The power of Internet-based social networks and social applications has been demonstrated, but businesses are only beginning to think of themselves as social systems of individual people that can be studied, analyzed and improved. The information technology to enable this optimization is beginning to emerge.

Greater focus on a company's most valued assets

There is a rich stream of information about individual people flowing through online collaboration and enterprise systems (e.g., their expertise, work patterns, response to incentives, digital reputation, their contacts, whom they work with, and whom they consult). Capturing this information will enable analytics to be applied to people-centric processes. Adaptive social platforms instrumented with knowledge capture, interconnected with enterprise data and processes, and made intelligent through differentiating analytics

will transform business by enabling optimization of the system of people.



New applications will have capabilities to create a representation of a person's skills and experiences in a structured and organized way and adapt that content for situations and needs, and to enhance communication over many devices, across diverse pools of talent. New applications also will allow people-centric process optimization within an analytics platform for rapid, on-demand deployment.

Opportunities in thinking about Systems of People

Analyzing this new type of data will enable companies to better manage people processes. Some examples of these Systems of People capabilities include:

- **Smarter sales enablement.** Massive amounts of external client and market data will be connected to internal knowledge and skill information, enterprise records, and demand and inventory information to create actionable insight and analytics decision support that is sharply focused and personalized to a particular seller, client, product, or situation.
- **New approach to human resources.** Business intelligence and planning capabilities will be enhanced by capturing information about individual people and applying analytics to create dynamic skill inventories, understand skill shortages in real time, foresee emerging skills, and drive talent and learning initiatives.
- **Growth in emerging markets.** The problem of recreating an organization with consistent business processes in emerging markets will be greatly enhanced with rich personnel content, people-enablement technology, mentoring networks, alumni networks, social learning, and critical skill development.
- **Next-generation inclusive mobile social platforms.** Content delivery will be tailored to diverse constituencies via language translation, text-to-speech technology, or the spoken Web (Web site navigation through voice commands). Inclusive mobile social platforms will redefine enterprise mobility, accessibility, and delivery of services, as well as operations in smarter cities and governments.

Conclusion

Systems of People will be built on adaptive social platforms that are instrumented to capture knowledge about individual people, connected with business processes, and capable of extracting intelligence. They are the next phase in the evolution of social business and promise to redefine how work is done, how people are managed, and how processes are optimized to drive greater business value. Business leaders will take this opportunity to make collaborative environments more intelligent by adopting and embedding emerging analytics applications.

Outcome-based Business

There is a shift taking place in the services industry, away from a focus on the delivery of IT outcomes and toward an increased focus on the delivery of business outcomes that result from IT services.

Traditional IT-based services focus on reducing IT costs for the enterprise through automation and standardization. The performance metrics are not surprisingly in the language of IT: mean-time-between-failures, average server utilization, average storage utilization, the service-level agreements, or the number of servers that can be managed by a system administrator. However, if service providers only adopt more automation and standardization in their services, the growth in value of IT services to the client will begin to slow.



Although IT service providers always will compete on price, it also is important that they align their service offerings with measureable enterprise business value.

Clients are increasingly using measures of revenue, profit goals, and other metrics that indicate positive impact on business performance. This shifting focus is helping companies that adopt this approach to increase sales, reduce the cost of customer acquisition, and more effectively retain existing customers.

Clients of IT service providers will consider engaging with providers who deliver enhanced business outcomes through new types of services. Leading service providers will understand the causal relationships between their client's business metrics and their IT capabilities. In addition to a deep understanding of the industry, these service providers will have capability in advanced analytical models and the ability to integrate a set of IT assets and services that support the desired business results.

Some industries such as healthcare and government are particularly ready for an outcome-based model as they seek to contain costs while simultaneously investing in projects that add value to the organization. To reduce costly patient re-admittance rates, for example, government agencies have passed laws that penalize hospitals if a patient is re-admitted within 30 days with an estimated savings of \$8 billion over ten years.

IT services solutions that address patient transition care are designed to allow hospitals to manage their patients more effectively, with the objective to reduce re-admittance rates and avoid penalties. Another example is services solutions for clinical trials of drugs, which once were aimed primarily at cutting costs in the trial process but increasingly will target revenue growth by focusing on accelerating the launch of a new drug, thereby increasing market revenue potential and reducing operational expenses for clients.

Conclusion

The most effective outcome-based service offerings will be developed with a common set of steps. They will begin by examining operational models and identifying what increases value in order to reveal the business capabilities most important to clients. Next, clients, together with service providers, will analyze the enterprises' IT requirements in light of these desired business outcomes and the available portfolio of products and services offered by the provider. Finally, service providers will select a solution and the configuration and deployment of technology assets to support the clients' business outcomes.

These outcome-based services will result in better margins for service providers, longer-term contracts, and lower development and deployment costs, because the assets are replicable. The long-term financial health of these providers will help improve the continuity of service for clients and the flexibility for lower future costs. Clients will benefit from these shared risk/reward offerings, as they are able to pursue more innovative projects in collaboration with service providers than would be possible if approached alone.

Resilient Business and Services

Globalization, along with consolidation of business workloads in fewer data centers and servers, increases enterprise exposure to natural disasters and therefore heightens the need for resiliency. A new breed of business and technical approaches is being developed, built on the notion that any part of these complex, interrelated systems can threaten all of the others.

Increasingly vulnerable infrastructures

Global connectivity is decreasing the resilience of infrastructures at every level of business and government. As the world's systems become more interconnected, they also are becoming interdependent and therefore more challenging to secure and insulate from threats and disruptions.

This dynamic is leading directly to significant increases in large-scale and cascading failures of both digital and physical systems. The key catalysts for these failures include natural disasters, failures of communications or IT infrastructure, and human errors.

These problems can be addressed by building oversight systems that take into account the fact that any component, including human operations, may fail. These systems then isolate faults, migrate functions, and then resume operations. These principles are applicable to both IT systems and physical systems such as energy and utilities infrastructures, transportation systems, and buildings.



The need for resilient information technology

In recent years, there has been a rapid growth of enterprise IT consolidation and virtualization techniques, a trend that will continue to accelerate. Already, the number of virtual machines in data centers exceeds the number of physical machines. As a result, a higher percentage of hardware systems run multiple workloads. This contributes to an increased interdependence among IT systems, more complex workloads and greater responsibilities of operations personnel.

Integrated management for IT workloads

Integrated management is key to addressing workload resiliency and security vulnerabilities while maintaining efficiency. IT systems must improve with respect to resiliency and efficiency, and these systems must be designed to predict threats and prescribe optimal responses.

Opportunities in enhanced resiliency in business and services

Coupled with IT resiliency, solutions must be developed that increase the resilience of key systems such as those involving cities, energy, transportation, supply chain, and more. New approaches involve the building of robust systems that can conduct continuous sensing and model-based prediction and subsequently orchestrate suitable responses.

Businesses need to identify and isolate failures early and avoid cascading disasters by applying these tools in coordinated ways across IT systems and physical systems, as well as business applications and services. In addition, resiliency and efficiency may be heavily interdependent concepts and tasks, thus creating opportunities for increasing the value of such processes. Systems can be built that foster resiliency and disaster mitigation and at the same time pay for themselves with efficiency improvements. For example:

- **City command centers.** Command centers already integrate live-data feeds from individual government agencies. These systems will apply data from social networks to increase focus on preparedness in disaster response planning. These systems also assist with traffic management, event safety, and public services such as road maintenance and garbage collection.
- **Energy and utilities.** Power outages cost the United States \$80 billion per year. However, new technologies such as high-resolution weather prediction and regional tree-growth forecasting can play important roles in orchestrating the equipment, materials and manpower to maintain consistent and safe electrical power. New opportunities for energy utilities also are developing in the areas of supply and demand optimization.

Conclusion

Businesses must broadly focus on improving the resilience of IT system components and take the next step in applying improvements to important physical infrastructure, businesses, and services systems. The backbone of resilient systems involves a blend of continuous monitoring and predictive analytics, model-based reasoning, and the orchestration of proactive responses.

The Future of Analytics

The explosion of unstructured data, the proliferation of new decision contexts, and the availability of increased computing power is leading to unprecedented opportunities for generating business value, reducing costs, and improving efficiency through the deployment of analytics-based solutions.

The value of analytics grows by incorporating new sources of data, combining a variety of techniques, spanning organizational silos, and enabling iterative, user-guided interaction.

The future of analytics will be driven by three trends: the rapid growth of unstructured data; innovation in consistent, extensible, and consumable analytics platforms; and the optimization of analytics across the full stack of IT resources.

Explosion of unstructured data

Increasingly, data is being collected through automated business processes, Web applications, user-generated content, and instrumentation of the physical infrastructure. These data present new opportunities for analytics and enable the enterprise to accomplish new tasks with a better understanding of the current state of the business and the impact of past actions. They also provide an improved view of future uncertainty and a better knowledge of clients, partners and competitors.



Consumable analytics platform

Many challenges exist for creating, deploying, and maintaining analytics solutions within an enterprise. Like all IT solutions, analytics must provide high value relative to its cost. However, unlike other solution areas, business analytics must address rapidly expanding opportunities amidst a limited and slowly growing supply of skills. The long-term answer is to develop more analytics data and modeling expertise. A shorter-term answer is to increase the impact of the skills already existing in the enterprise by producing tools that make analytics solutions easier to build, manage, and use.

Optimizing across the stack to deploy analytics solutions at scale

As analytics becomes one of the dominant workloads, platform design needs and computational requirements will become more apparent. Increasingly, new systems are being designed to account for the special needs of analytics workloads.

Conclusion

The growth of unstructured data produces new analytics opportunities. More and more, enterprises will require comprehensive and extensible analytics platforms to support multiple stakeholders, each with specific requirements. The analytic processes must be supported by data-centric, workflow-optimized systems. To benefit from these opportunities, despite the limited supply of analytic skills currently available, developers must find the analytics platforms versatile and easy to use, adaptive for the user, and designed to take into account the multiple forms of data.

The Future Watson

The goal of artificial intelligence, namely a machine that accurately emulates human intelligence, was never closer to achievement than in 2011 when IBM Watson defeated the best human contestants in the TV quiz show Jeopardy!. Watson's performance naturally generated interest in its potential for commercial applications, as scientists and business people alike gained appreciation for technologies that tap into the wealth of knowledge buried in text and other unstructured data sources.

Business problems, however, may be far more complex than the specific-question-in and precise-answer-out model of Jeopardy!. For enterprise users to adopt Watson technology to address their business challenges, the technology must evolve to consider rich problem scenarios, interact naturally with its users, and deliver results that are justified and explained by intuitive supporting evidence. Moreover, these systems must advance upon Watson's learning model, shifting from one-time batch training to continuous learning and adaptation through experience.



Understanding rich problem scenarios

To perform on Jeopardy!, Watson was designed to provide precise answers to specific questions. To perform in business, Watson's capability will be extended to understand much more difficult, multi-dimensional questions. This capability will allow Watson to process complex decision-support tasks that depend on many factors and to consider a variety of inputs including video and voice data.

Interacting in natural language with users

Watson technology will transition from simple “question-in/answer-out” methods to interactive dialogue with users. Watson will facilitate finding high-value results by asking follow-up questions that it generates during analysis of the various factors in a given problem. “Teach Watson” is an underlying technology now being developed to analyze evidence, form intermediate hypotheses, and carry out a dialogue with the user to formulate better answers. Through collaboration with the user, Watson will provide answers that are rationalized or justified.

From precise answers to evidence profiles

The future Watson will have a greater ability to explain its results and confidence levels using rich evidence profiles that provide insight into the set of possible results and allow the exploration of Watson’s evidence and reasoning process. For more informed decision making, business users will want to know what is behind the answers, what evidence Watson collected, how it analyzed the information, and why it delivered each of its answers.

Continuous learning replaces batch training

Watson’s performance on Jeopardy! was made possible by the ingestion of structured and unstructured data relevant to the Jeopardy! domain, combined with automatic analysis of example Jeopardy! clues to train Watson. This ingestion and training was conducted before Watson competed. In the future, when Watson technology will be focused in a number of industries, Watson’s learning model will enable accelerated growth of its domain expertise in a given industry. Rather than pre-event training, learning will be integrated into Watson’s workflow with the users and other human experts so that it continues to improve.

Conclusion

underpinning the commercial evolution of Watson along the four dimensions described above is a formal domain adaptation methodology currently being tested for clinical medicine as well as financial services processes. Such adaptations will continue as Watson’s capabilities extend to a wider range of problems in the future. Watson’s early experience in these new areas is encouraging and is proving to produce significant value for clients and society.