

Global Technology Outlook *2012*

Since 1982, the Global Technology Outlook (GTO) has identified significant technology trends - high-impact disruptive technologies that will lead to industry-changing products and services over a three- to ten-year period.

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

After a year-long study and extensive vetting with IBM's senior leaders, the completed GTO is used within IBM to define our technological areas of focus and investment. Externally, it is shared broadly with a range of IT influencers – including clients, academics and partners – through education programs 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.

However, the GTO is not designed to singularly 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 IT's evolution across businesses, economies and natural systems that has helped make the insights of the GTO so valuable.

Building on past years, the 2012 GTO focus areas share a common theme: analytics. We looked at where the explosion of unstructured - and increasingly uncertain - data will amplify the need for new development models and new classes of computing systems that can handle the unique demands of analytics.

We looked 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.

We considered how these dynamics come together in the Watson computing system as it delivers a new class of decision-making systems that offer interactive dialogue and continuous learning. And we finish this year's GTO with a look into the future of the field of analytics itself.

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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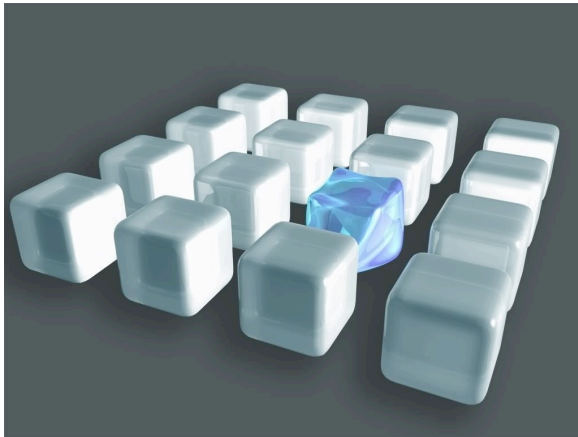
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Managing Uncertain Data at Scale

Analytics opens new opportunities for business insight through the analysis of enterprise data that is constantly growing in dimensions of volume, variety, velocity and veracity. The rise of the first three categories has been evident and widely acknowledged, but veracity represents the fast-growing portion of data that is uncertain.

More and more of the world's data contains uncertainties that arise from such sources as ambiguities found in social media, imprecise data from sensors, or imperfect object recognition in video streams. IBM believes that by 2015, 80% of the world's data will be uncertain.



To make confident business decisions based on real-world data, analyses must necessarily account for many different kinds of uncertainty at scale in real-world data. Analyses based on uncertain data will impact the quality of subsequent decisions, so the degree of inaccuracies in this uncertain data cannot be ignored.

For example, disease trending can help outrun the spread of disease by integrating millions of health-care medical records but the use of different names for the same diseases and medications can limit the forecast's accuracy. 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, whether as individuals or as part of an organization, present notable challenges in the area of uncertainty due to the many dimensions of information about them. Experiments show that an enterprise has to triage millions of social media fragments to obtain one company-specific fact. Finding these nuggets of information about an individual entity often requires enormous computational scale.

Scalable end-to-end uncertainty management

Every second, more data is generated, joining what we already know - offering, if not necessitating, new analyses. As more and more data becomes available, we must integrate new tools and technologies in order to unlock potential value lying within it.

Condensing data from different sources is also a powerful method of reducing uncertainty and gaining broader insight. For instance, the relevance of individual purchase recommendations can increase by reflecting the person's most recent expressions of buying intent while also factoring in similarities in buying patterns derived from analysis of millions of individuals and products.

Conclusion

Data management – and the ability to extract added value in the process – is rapidly emerging as a strategic opportunity for 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 first require the creation of best practices, standards, scalable algorithms for condensing data, new analysis techniques for uncertain data at scale, and consideration of uncertainty throughout the management pipeline. Second, uncertainty management must be embedded into Big Data Analytics platforms. 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 syndicated data and models with enterprise data and models in order to enable enterprises to make confident business decisions.

Systems of People

In the early days of process automation and supply chain management, leaders optimized and automated business processes for the movement of goods. Today, the focus is shifting toward the management and empowerment of people processes – from management of large-scale events to orchestrating the operations of globally-integrated workforces.

Greater focus on companies' most valued asset

A new dynamic is emerging in the way companies extract value through information technology. There is an increasing shift away from traditional process automation and toward more people- and knowledge-centric processes. The approach is particularly promising in areas like client service, marketing and sales, and product and service innovation.

The rise of social networking and collaboration in business is generating an entirely new stream of information about people – about the ways they work and interact with business processes. While interacting on collaborative platforms or social networks, people exchange information about their expertise, knowledge, opinions, and sentiments, and about who influences them. People also leave footprints within “traditional” process data and within transactional records, such as financial systems, opportunity management systems, and product or service delivery records.



Businesses can apply new kinds of analytics to this type of information to improve planning, execute operations better and enable people like never before. For example, data related to a team project can offer insight into which of the members' individual skills played key roles and how different combinations of the team could positively impact the quality of the project work or the costs in completing it.

Opportunities in Systems of People thinking

Managing these people processes by analyzing this data can enable companies to create repeatable systems to deliver a range of solutions, to different sets of clients, using combinations of processes. Some examples of these Systems of People capabilities include:

- **Smarter sales enablement.** These solutions will combine insights from massive amounts of external client and market data, connecting it to internal knowledge and skill information, enterprise records and demand and inventory information to create actionable insight and analytics decision-support that is hyper-personalized to a particular seller, client, product, situation and device.
- **A new kind of human resources.** Business intelligence and planning capabilities will be enhanced by capturing people content information and applying analytics to create dynamic skill inventories, understand skill shortages in real time, foresee emerging skills, and drive talent and learning initiatives.

- **Next-generation talent development.** These solutions will combine immersive technologies and hyper-personalization with mentoring networks, alumni networks, social learning and gamification to expedite critical skill development in emerging markets.
- **Next-generation inclusive mobile social platforms.** Content delivery will be tailored to diverse constituencies via language translation, text-to-speech, or the spoken web – web site navigation through voice commands. Inclusive mobile social platforms will redefine enterprise mobility, accessibility, delivery of social services, operations in Smarter Cities and Government, and recruiting in emerging markets.

Conclusion

The rise of the social business model has delivered to businesses new streams of useful data and the techniques needed to use that data in the optimization of their people processes in truly transformational ways. Social networking and collaborative platforms will increasingly employ enablement technologies to make them more context-aware and multi-lingual, expanding their reach across different devices, situations and cultures.

Systems of People are built on adaptive social platforms that are instrumented to capture knowledge, 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.

Traditional IT-based services focus on reducing IT costs for the enterprise through automation and standardization. Its 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. But if service providers only adopt more automation and standardization in their services, the growth in value of IT services to the client will continue to slow.



The reality that IT service providers must compete on price is here to stay, but it is increasingly important that they also align their service offerings with measureable enterprise business value.

Increasingly, clients are using measures of revenue, profit goals and other metrics that indicate whether a positive impact on business performance has occurred. This shifting focus is helping leading companies adopting this approach to increase sales, reduce the cost of customer acquisition and more effectively retain the customers they already have.

Clients of IT service providers will consider engaging with providers who deliver business outcomes through new types of services that focus on reducing business costs and increasing business revenue. Since IT assets are selected based on desired business outcomes, the approach can be easily extended to cover multiple business outcomes in a given industry. Leadership in this area demands a deep understanding of the industry, capability in advanced analytical models and the ability to integrate a set of IT assets and services that support the right business outcomes.

Some industries such as healthcare and government are particularly ripe 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 readmitted 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 better manage their patients, with the target to reduce re-admittance rates and avoid penalties. And solutions for clinical trials – once aimed primarily at cutting costs in the trial process – will increasingly focus on revenue growth by focusing on accelerating the launch of a drug, thereby increasing market revenue potential and reducing operational expenses for clients.

Conclusion

The most effective outcome-based service offerings should be developed with a common set of steps. They should begin with examining operational models and identifying value drivers that help reveal the business capabilities most important to clients. Next, clients should help service

providers 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 should select a solution and the configuration and deployment of technology assets to support the client's business outcomes.

These outcome-based services often result in better margins for service providers, longer-term contracts, and lower development and deployment costs as the assets are increasingly replicable. The long-term financial health of these providers helps assure continuity of service for the client 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 than would be possible if approached alone.

Resilient Business and Services

Globalization and consolidation trends increase enterprise exposure to natural disasters and cyber attack, and therefore heighten the need for resiliency. A new breed of approaches is taking shape, built on the notion that any part of these complex, interrelated systems can threaten all of the others.

Infrastructures are increasingly vulnerable

Global connectivity is stressing the resilience of infrastructures at every level of business and government. As the world's systems become increasingly interconnected, they are also 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 assume that any component, including human operations, may fail. These systems then take control by isolating faults, migrating functions and then resuming operations. These principles are equally applicable to both IT systems and physical systems.



Resilient information technology

Recent years have seen rapid growth of enterprise IT consolidation and virtualization techniques, a trend that will only accelerate in the future. Already, the number of virtual machines in data centers exceeds the number of physical machines. As a result, a higher percentage of hardware systems are running multiple workloads. This is contributing to an increased interdependence among IT systems themselves, not to mention factors such as increasingly complex workloads and human operations.

Integrated management for IT workloads

Integrated management is key to addressing workload resiliency and security vulnerabilities while maintaining efficiency. IT systems must improve in both resiliency and efficiency, and these systems must be designed to be more predictive of threats and prescriptive of optimal responses.

Opportunities in enhanced resiliency in business and services

Coupled with IT resiliency, we must build solutions that increase the resilience of key systems such as cities, energy, transportation, supply chain, and more. The new approach is to build robust

systems that can conduct continuous sensing, model-based prediction, then and orchestrate suitable responses.

Businesses need to quickly identify and isolate failures and avoid cascading disasters by applying these tools in coordinated ways across IT systems and physical systems – as well as to business applications and services. In addition, resiliency and efficiency may be heavily interdependent, creating opportunities to add more value. Systems can be built that help resiliency and disasters and at the same time pay for themselves with efficiency improvements every day. For example:

- **City command centers.** Command centers already integrate live data feeds from individual government agencies - they will increasingly apply data from social networks to increase focus on preparedness in disaster response planning. These systems also help with traffic management, event safety or public services such as road maintenance and garbage collection.
- **Energy and utilities.** Power outages cost the United States \$80 billion per year. But new technology such as fine-grain 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. In energy and utilities, new opportunities are developing in supply and demand optimization.

Conclusion

Businesses must broadly focus on improving the self-contained resilience of IT system components and take the next step in applying them to important physical infrastructure, businesses and services systems. The backbone of more resilient systems is 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 to generate business value, reduce costs, and improve efficiency through the deployment of analytics-based applications.

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



The future of analytics will be driven by three trends: the explosion 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

More and more data is being collected through automated business processes including web applications, through user-generated content and through instrumentation of the physical infrastructure. This data opens new opportunities for analytics. It enables the enterprise to do things it couldn't do before with a better understanding of the current state of the business and the impact of past actions. It also provides a better view of future uncertainty and a better knowledge of their clients, partners and competitors.

Consumable analytics platform

There are challenges in creating, deploying and maintaining analytics applications within an enterprise. Like all IT applications, analytics must provide high value relative to its cost. However, unlike other application areas, business analytics must address rapidly expanding opportunities amidst a limited and slowly growing supply of skills. The long-term solution is to make the world more analytics, data and modeling-literate, but that will be a long process. So the near-term solution must be to increase impact of the skills already existing in the enterprise by producing tools that make analytics easier to build, manage, and consume.

Optimizing across the stack to deploy analytics applications at scale

As it becomes the dominant workload, analytics needs to make design needs and computational requirements more apparent. Increasingly, new systems are being designed to account for this.

Analytics applications of the future will be multi-modal, using multiple forms of data and multiple analysis methods, and enabling collaborative decision making by multiple stakeholders. The applications will increasingly employ new forms of data and new forms of feedback and learning.

Unstructured data is extracted in many forms. At the decision point, it must be decided which to use in support of a given decision. Not all data can or should be included for a given decision. One may create predictive models as a part of this - or go a step further in actually providing suggested actions and the probabilities associated with taking these actions.

The value of analytics grows by incorporating new sources of data. This includes understanding what works, what brings value, and asking what we can learn from the decisions and their outcomes - and feeding those new findings back into the system.

Conclusion

The explosion of unstructured data is giving rise to new analytics opportunities. An ecosystem of application providers is emerging. Increasingly, enterprises will support application developers with comprehensive and extensible analytics platforms. To seize this opportunity, despite the limited supply of analytics application development skills currently available, the analytics platform must be agile for the developer, adaptive for the user, aware of the data, and accelerated through leveraging the hardware.

Easier consumption of analytics solutions, more efficient and less complex development and reduced cost of operation. CIOs will reduce cost and add value to analytics by supporting collaboration and the sharing of data and analyses.

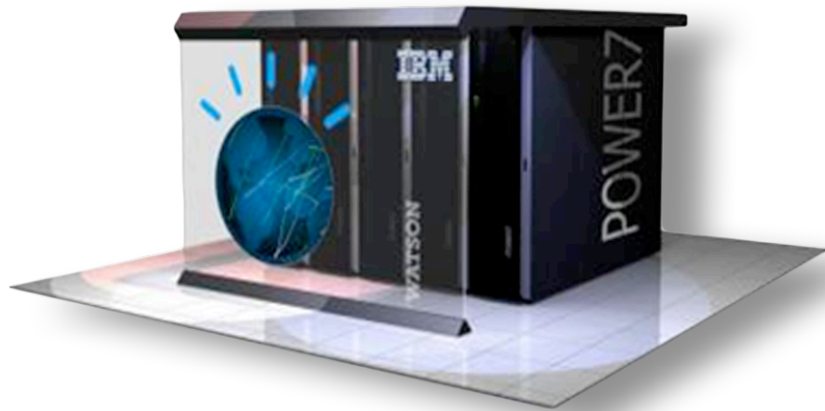
The Future Watson

In 2007, IBM began a quest to push the boundaries of open-domain question answering by creating computing technology that delivers human-level capabilities. Four years later IBM introduced Watson and pitted it against the Jeopardy! Quiz show's most successful players. Watson was victorious in this historic match - a major landmark in open-domain question answering.

Watson's performance has piqued interest in its potential with commercial applications, as scientists and business people alike continue to gain appreciation for technologies that tap into the wealth of knowledge buried in text and other unstructured data sources.

However, business questions are far more complex than the specific question and specific answer model of Jeopardy!. For enterprise users to adopt Q&A technology to address business challenges Watson technology must evolve to consider richer problem scenarios, interact naturally

with its users and deliver results that are based on evidence profiles rather than precise answers with probabilities. Finally, 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 harder, multi-dimensional questions. This capability will allow Watson to process complex decision support tasks that depend on many factors and consider varying inputs such as video and voice data.

Interacting in natural language with users

A critical next step in Watson's evolution will be the evolution from simple 'question-in/answer-out' methods to interactive dialog with the user. Watson will facilitate finding high-value results by asking follow-up questions that it generated during analysis of the various factors in a given problem. 'Teach Watson' is an underlying technology being developed to analyze evidence, form intermediate hypotheses and to dialogue with the user to formulate better answers. Through collaboration between Watson and the user, one can drive toward answers that are rationalized or justified – a key to Watson's opportunity in the enterprise.

From precise answers to evidence profiles

The Future Watson will have a greater ability to explain its results and confidences using rich evidence profiles that explain the current set of possible results and enable powerful exploration of Watson's evidence and reasoning process. Business users will want to know what is behind the

answers - the evidence that Watson collected, how it analyzed the information and why it delivered each of its answers – in the name of more informed decision making.

Continuous learning replaces batch training

Watson's performance on Jeopardy! was made possible by the intake of vast yet specific stores of structured and unstructured data pertaining to potential Jeopardy! clues. This 'training' was largely concluded before Watson competed. However, as demand for Watson's enterprise potential increases in a number of industries, Watson's learning model must account for an accelerated 'ramp-up' of its domain expertise in a given industry. Rather than pre-event training, learning must be integrated into Watson's workflow with the users and other human experts – so that it continues to get better over time.

Conclusion

Underpinning the evolution of Watson along these four dimensions is a formal domain adaptation methodology, now being tested in clinical decision support in medicine as well as with financial services processes. This adaptation will continue as Watson's capabilities extend to a wider range of problems. Watson's early experience in this area is encouraging and is proving to produce significant value for clients and society.