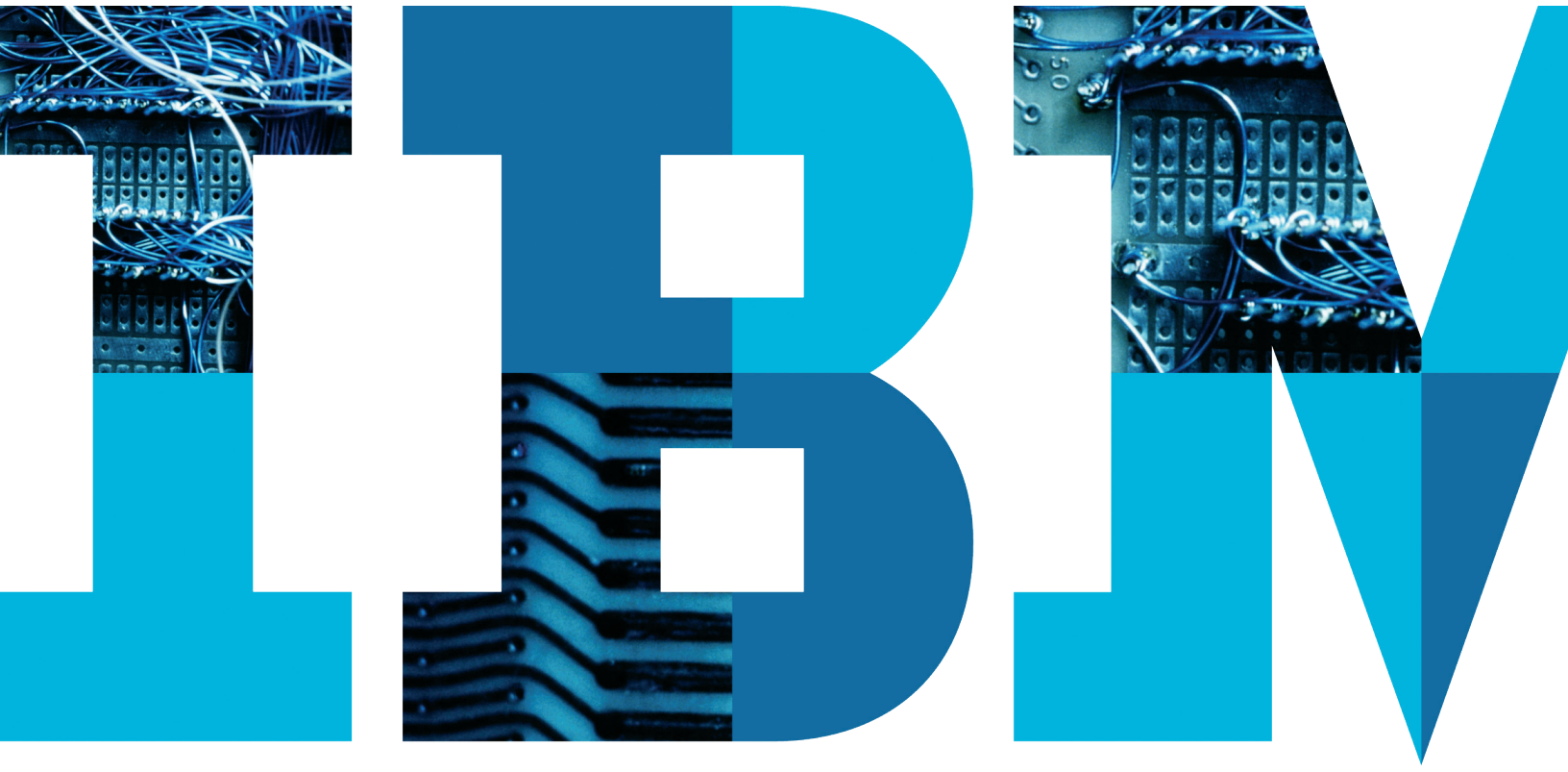
IBM Research

Global Technology Outlook 2013



IBM

The 2013 Global Technology Outlook

Since 1982, IBM Research's worldwide community of top scientists has created the Global Technology Outlook (GTO). The GTO is a comprehensive analysis that identifies and evaluates significant, disruptive technology trends that will lead to industry-changing products and services over a three- to ten-year period. IBM Research considers the societal and business applications in which these technologies could be used – and the impact that they will have on IBM and the world. The GTO has a history of influencing IBM's business and the Information Technology (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.

In the last half century there have been three major waves of technology that have defined computing in the enterprise. The advent of the IBM System 360 in the 1960s enabled the systems management of business processes and so-called "back office" computing. The birth of the personal computer in the 1980s ushered in client-server computing. In the 1990s and early 2000s, the commercialization of the Internet fueled the growth of the World Wide Web, revolutionizing culture and helping to create e-business.

Today we have reached a new inflection point and sit on the cusp of a fourth wave. This wave is characterized by the confluence of social, mobile and cloud technologies, the rise of Big Data and the new kinds of analytics needed to create value in this environment. The GTO 2013 focuses on this confluence, which is transforming the way companies deliver millions of systems, software, and services to billions of users. While each technology driver is important when considered individually, this confluence is fueling four "mega-trends" with significant implications for enterprises:

- **Growing Scale / Lower Barrier of Entry:** A massive expansion in the number of smart devices, sensors, transactions and users of digital technologies is creating huge amounts of structured and unstructured data — while the rise of easy-to-use and affordable programming interfaces is simultaneously lowering the barrier of entry for companies to create applications and services that derive value from this data.

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- **Increasing Complexity / Yet More Consumable:** While the volume, variety, velocity, and veracity of data is contributing to the increasing complexity of data management and workloads—creating a greater need for advanced analytics to discover insights—mobile devices have made technology more consumable, creating user demand for interactive tools for visual analytics.
- **Fast Pace:** Change is coming faster than ever—disruptive models for the development and consumption of technology are emerging to penetrate global enterprise ecosystems, resulting in rapid innovation and decreased time-to-value. Open online courses are experiencing exponential growth making education and training more accessible.
- **Contextual Overload:** The proliferation of sensors and devices and the explosive growth in structured and unstructured data are causing information and contextual overload. With the increasing affordability and sophistication of smart devices, new opportunities exist to provide contextually aware and personalized services based on user views, desires, preferences and location, delivered just-in-time.

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

Dr. William R. LaFontaine
Vice President, Technical Strategy
IBM Research

Mobile First

Introduction: A new inflection point

In the fourth quarter of 2010, for the first time ever, global shipments of smart phones surpassed desktop personal computers and notebooks. This was an inflection point in the IT and communications industries, with the mobile device emerging as the new primary design point for end-user access to information technology. One need look no further than China, home to the world's largest population of Internet users, where more people access the web on mobile phones than on personal computers.

What is Mobile First?

Mobile First is about much more than adding a new access point to view existing back-end systems and applications. Mobile First is about re-imagining businesses around constantly connected employees and customers, and creating new ways to deliver value to customers who are often looking to quickly accomplish a single task and then move on. Trends like these are often widely seen first in what are primarily consumer applications—Instagram, for instance, which radically simplified the process for sharing pictures.

Mobile First is accelerating the integration of cloud, social, and analytics in a way that requires companies to re-think how value is created within a larger ecosystem. It places an emphasis on speed—in understanding rapid industry shifts and in creating new solutions and integration models. It will require companies to redesign their infrastructure, their service delivery business models, and how individual services can be used to compose new applications.

Implications for the enterprise

Mobile First service delivery models will span traditional IT services and line-of-business applications, with a convergence of consumers and enterprise ecosystems. Enterprise app stores could support numerous industries with companies hosting and delivering application ecosystems for third-party developers that support service componentization, application orchestration and distributed service composition. The convergence that enables consumer access to enterprise data creates an increasing need for enterprise-level security and control. Security services are needed for secure composition of applications and services, and for incorporating end-to-end, role-specific security into development, enterprise catalogs and application runtimes.

What will it take to succeed?

Success in delivering on a Mobile First strategy that achieves differentiation in the marketplace will require a novel blend of software, hardware and services. The solutions will need to handle the scale requirements associated with mobile, providing end-to-end security throughout the Mobile First ecosystem, and integrate a new development environment to support multiple application development ecosystems.

60%

of large companies are making their internal line-of-business applications accessible to workers on smart phones and tablets.

There will be more mobile phones than humans by 2015.

300k

APIs are projected to be registered by 2020.*

*Analysis from programmableweb.com registry data. 3Q 2012

Open APIs will encourage experimentation and collaborative development between enterprises and third parties to augment and enhance each other's value and dramatically broaden distribution.

Scalable Services Ecosystems (SSE)

Introduction: A disruptive trend breaks through in the enterprise

A few years ago, web services "mash-ups" were the first signs of an entirely new services economy built on IT. Freely available application programming interfaces (APIs), openly available data, and a willingness to experiment with non-traditional business models were among the early drivers of this new paradigm. This trend of rapidly composed and flexibly managed services is emerging now in the mainstream of enterprise computing, and the resulting Scalable Services Ecosystems are presenting a disruptive, fast-changing and agile way of composing business solutions.

What are Scalable Services Ecosystems?

Scalable Services Ecosystems describe open clusters of enterprises, including partners and value-added firms, where business functions are delivered as API-centric services, enabling businesses to co-create customer value with speed and agility.

The confluence of social, mobile and cloud is fueling the hyper-growth of a new business-as-a-service economy where enterprises externalize APIs to their business processes. Other solution providers easily consume the available APIs to compose and deliver new business capabilities and solutions and build new business relationships.

APIs have evolved from those supporting services oriented architecture (SOA) and technologies such as representational state transfer (REST) to permit easy externalization of core services, causing a disruption to traditional business models and the IT systems that support them.

Implications for the enterprise

Scalable Services Ecosystems will have profound effects on many industries including retail, travel and transportation, telecommunications and banking. Using location and context-enabled social media, organizations will be able to target specific individuals with custom-tailored offers, often involving partnerships with other firms in retail and consumer goods. Through open APIs available to affiliate networks and developers, firms will enable relationships to be forged through in-market experimentation. The popular APIs and capabilities will be hardened and have the potential to provide both increased revenue and transactions along with new innovative business models.

What will it take to succeed?

A successful strategy using API-based ecosystems will depend on trusted providers of value-added services. Open standards-based service fabrics will allow for easy composition, deployment and management of scalable services through predefined patterns, tools and analytics. Enterprises will depend on expertise to rapidly identify and externalize targeted business capabilities and also to compose and consume business services.

Driven by the extreme pace of activity that surrounds the mobile, cloud and social technologies, client opportunity is presenting itself more and more "on the spot and in the moment." The barriers to entry are low, and the level of specialization is high and getting higher. If an established player isn't agile and precise in meeting this client need, someone else will seize the opportunity.

$15M

The savings realized over three years by a major IBM insurance client after they migrated from three thousand x86 servers to a heterogeneous private cloud, constructed out of IBM Systems x and z.

IBM has a strategic commitment to OpenStack, a cloud operating system that controls large pools of compute, storage and networking resources throughout a datacenter.

Software Defined Environments (SDE)

Introduction: Software defined revolution

Cloud computing as currently defined represents only the very early stage of a major revolution in how information technology systems are architected, developed, deployed and used. The last few years have seen the emergence of Software Defined Networks (SDN), Software Defined Storage (SDS) and Software Defined Compute (SDC). SDN are disrupting traditional switch and router vendors by moving the network control plane away from the switch to the software for improved programmability, efficiency and extensibility. SDS is disrupting traditional storage providers by enabling developers to build their own control software to customize, optimize and integrate off-the-shelf storage components. SDC automatically selects the best system based upon the attributes and capabilities needed for the computation.

What are Software Defined Environments?

When the entire infrastructure including compute, storage and network becomes software defined and programmable in the cloud, a new unified control plane emerges which is highly configurable and fully programmable with the workloads being compiled onto it. This is the foundation of Software Defined Environments (SDE).

Two simultaneous phenomena are driving this new environment. First, enterprises are moving both their mission critical Systems of Record and performance sensitive applications to the cloud. This is creating the requirement that cloud infrastructures have the same robust system attributes traditionally associated with enterprise-grade IT: reliability, availability, scalability and so on. Second, many new mobile, social and analytics applications—referred to collectively as Systems of Engagement and driven by the trend toward digitization of the front office—are being directly developed on the cloud, leveraging the agility that has become the hallmark of cloud-based environments. This is characterized by a focus on DevOps, mobile and web-centric platforms, and as-a-service business models.

Implications for the enterprise

As enterprise workloads evolve from being Systems of Record only to dynamic and volatile Systems of record and engagement, simultaneous achievement of agility and optimization will be critical. This will be achieved through flexible and scalable infrastructures with underlying resources that are optimized for performance. As system infrastructures become more composable, programmable and heterogeneous, an automated approach to compile workloads has promise to drive optimized outcomes, increased security and resilience, and an overall reduction in operational expenses.

What will it take to succeed?

Clients should look to Software Defined Environments as a means of achieving a balanced system that is agile, robust and optimized, and investigate OpenStack as the industry standard approach to control layer programmability. Open standards are the path to achieving the benefits of these new environments. They create a level playing field, prevent vendor lock-in, and lead to modular and flexible approaches to extending system capabilities and capacities.

Data

- Multimedia makes up 60% of internet traffic, 70% of mobile phone traffic and 70% of available unstructured data
- 3 billion Facebook photo uploads are made per month, or 100 million photos per day
- 72 hours of video are uploaded to YouTube every minute
- 1 billion medical images are generated every year

Multimedia and Visual Analytics

In recent years, there has been an explosion of multimedia data, accounting for 70% of available unstructured data. This data comes from sources as varied as security cameras, medical image applications and individuals uploading media to social networks. In the past, computers weren't able to make sense of this data and could only decipher it through metadata, which had to be manually created by people. However, using multimedia analytics, companies can begin to make sense of this data at scale and in an automated fashion.

As data sets become more complex, there is a growing need for visual analytics by both business and scientific users. The use of visual analytics improves the comprehension, appreciation and trust in the analytics results and helps improve communication and collaboration around business insights. Since the tools will become more focused on domain user needs and less on visualization and analysis experts, the tools must have high levels of interactivity, simplicity, responsiveness, and collaboration.

What are multimedia and visual analytics?

Multimedia analytics and visual analytics address two emerging needs in analyzing data. Multimedia analytics is about computers making sense of images and videos, and being able to extract information and insights from those sources, whereas visual analytics is about humans using visual interfaces to consume and make sense of complex data and analytics.

Implications for the enterprise

Multimedia analytics has a wide range of potential in industries ranging from insurance to transportation. Home, auto and marine insurance providers, for example, can improve their processes by using video from policy holders to document their insured items and then automatically turns those videos into the basis for appraisals and claims.

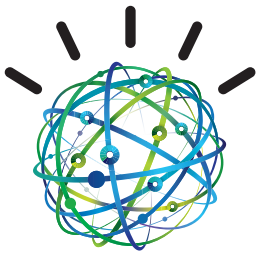
In transportation and manufacturing, suspicious activity can be detected and safety concerns can be identified in real-time using security cameras. This allows companies to have an integrated view of their operations and perform complex behavior analysis that has the ability better manage crowd conditions and potentially save lives.

The ability for business users to make sense of complex analytics through visual interfaces is revolutionizing how decisions are made in a variety of industries. Oil and gas companies, for example, are using geographical visualizations to increase the success rate of their drilling and optimize their reservoir production. Doctors are using visual analytics to analyze patient records to gain insight into treatments plans and understand the progress of a disease.

What will it take to succeed?

Multimedia analytics will require systems to learn which image features are important in these different settings and industries, and recognize variations of those features so they can be properly labeled. Visual analytics will require systems to automatically determine what to visualize, pick the right visual metaphor based on user context and show changes over time and uncertainty.

Innovation in four key areas is needed to address visual analytics requirements: visual comprehension, visualizing aspects of time, visual analytics at scale, and visualizing uncertainty and predictions. Industries should explore different applications of visual analytics to their data and use cases, with a view to transform their decision-making and analytics.



Watson

Early contextual computing, processing natural language.

Contextual Enterprise

Introduction: How Watson created data

When IBM's question answer computing system Watson defeated the reigning champions of the American television quiz program Jeopardy!, viewers were largely unaware that what they were witnessing was an early example of contextual computing. Despite being disconnected from the Internet during the contest, Watson's own feature extraction and contextualization capabilities created a 10:1 increase in the data and metadata available for reasoning based solely on connecting the information it had already learned and drawing context from that data. Contextual computing is the application of a similar paradigm to every aspect of our daily life.

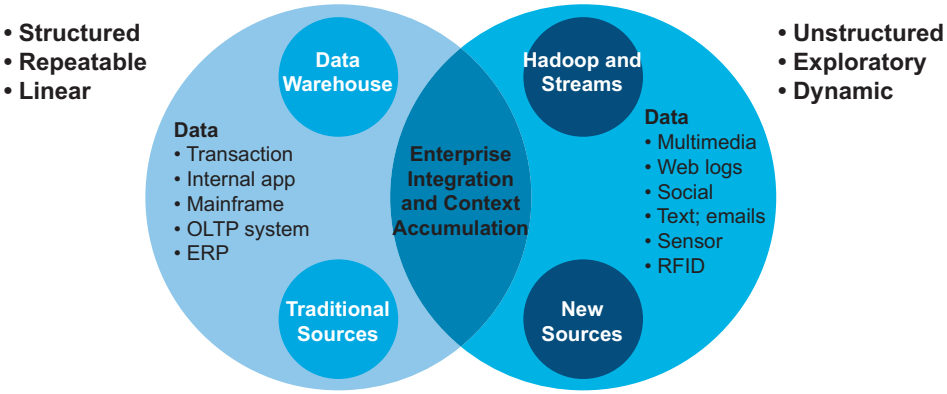
What is Contextual Enterprise?

Contextual computing is about the relationships between the data, and how different processes operate on that data and with each other. Data without any context is not only meaningless, it is worthless.

In a human setting, a social worker faced with a problem family scenario requires much more context than either taking the situation at face value or the testimony of only one person involved. That social worker needs to understand the other personalities involved, existing conditions, previous relationships, and influencing environments before coming to a useful course of action. As Watson demonstrated by delivering answers to questions containing the complexities of natural language, contextual computing replicates these actions using data driven analytics.

The smart devices we carry today are at the center of the social, mobile and cloud confluence. They carry our personal context in form of our interests, calendars, contacts, history, preferences and location. As natural aggregators of this data, such devices could well be used to deliver information to create context applied to broader applications.

Relationships between people, places, and organizations provide the context for deeper situational understanding, which drives better decisions and more effective actions.



"Data without any context is not only meaningless, it is worthless."

Contextual computing accelerates the detection of complex patterns in both data and processes through four main activities:

- **Gathering:** Collecting relevant data from a variety of sources and keeping it as long as possible.
- **Connecting:** Extracting features and creating metadata from diverse data sources to continually build and update context.
- **Reasoning:** Analyzing data in context to uncover hidden information and find new relationships. Additional analytics add to context via metadata extraction, and uses existing context to broaden information exploitation.
- **Adapting:** Composing recommendations and using context to deliver insights to the point of action, whether the client is a system or a human decision-maker.

In all four activities, systems continually learn from user behavior and interaction patterns to enhance the context over time. This wave is now touching enterprise business processes and making them smarter and more aware

$24B

International Data Corporation has estimated that spending on Big Data technologies and services will reach almost $24 billion in 2016.*

*gigaom.com, Jan. 8, 2013

Implications for the enterprise

Clients will soon be able to access more accurate, relevant and insightful data about their customers, processes and social networks. Given the accelerating trends toward more open data and more open APIs, business processes are becoming more open and provide context for the rapid assembly of novel solutions.

What will it take to succeed?

While there has always been context around any business process, it typically has been captured in a very fixed and rigid fashion. Achieving the full promise of the contextual enterprise will require innovation to integrate gathering, connecting, reasoning and adapting.

80%

The certainty with which American Public University can predict whether a student needs intervention strategies to avoid dropping out.

- Desire2Learn's learning management system program has more than 8 million learners spread around more than 20 countries
- The Qatar Supreme Education Council uses longitudinal student data systems to track lifelong learning for more than 50,000 students across over 100 schools
- The Alabama State Education Department uses analytics to aggregate academic, disciplinary and attendance data from all school districts and measure about 150 key metrics

Personalized Education

Introduction: An industry at the brink of transformation

The education industry is at the brink of an IT-enabled transformation. This transformation is driven by a demand for quality education that outstrips supply especially in the growth markets, misalignment between education and employment needs, and impatience with inefficiencies of education systems. For example, the government of Brazil is already funding students to go abroad because of a shortage of education infrastructure and quality educators. If growth continues to follow the existing trajectory, India will need about 800 more traditional universities than current levels today of about 350 universities.

Today, the most talked about application of technology to address these gaps is the advent of Massive Open Online Courses, or MOOC, which are growing rapidly. Several startups have emerged including Udacity, Khan Academy and Coursera, with millions of students enrolled across hundreds of countries. Large amounts of new data are being created, which thus far is untapped for its potential.

What is Personalized Education

Education today is mainly delivered on a one size fits all basis. This is a key cause of the poor quality and inefficiencies associated with the industry. Educational institutions can learn from healthcare by drawing the parallels of doctors to educators, patients to learners, medicine/treatment to courses/learning, and payers to education loan providers. From a technology point of view, the use of electronic health data to form patient records, derive evidence, and provide patient-centric personalized healthcare can be extended to education, with the formulation of digital student records helping to inform and provide personalized learning pathways based on the capabilities of the learner and the desired outcomes.

Implications for the industry

The education industry is ripe for innovation, as new business models are instantiated on the emerging new sources of data, in particular the longitudinal learning data (tracking student information over multiple years in multiple schools). Predictive and prescriptive analytics will be applied to improve outcomes and efficiency. Clustering learners into groups, assigning new learners to existing clusters, identifying when a learner is deviating from a particular path are some possible outcomes. Prescriptive analytics would identify personalized learning pathways, track progress, and provide feedback to ultimately improve timely graduations and employability. Combined with industry demand data, supply estimates could be provided and targeted courses created with intakes tweaked to meet estimated demand.

What will it take to succeed?

Ultimately there are many stakeholders who will be involved in improving education. This includes academic institutions, state education departments, students, learning management systems (LMS) and MOOC providers, government social service agencies and corporations. In order to achieve their often-shared goals, particularly to improve graduation and employment rates, they'll need to come together to create an open platform for sharing this data and insights from the analytics.

For more information

To learn more about the GTO, contact your IBM client rrepresentative or visit **research.ibm.com**.

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