CHAPTER 1.7

Harnessing the Power of Big Data in Real Time through In-Memory Technology and Analytics

SAP AG

Companies today have more data on hand than they have ever had before. It is estimated that an average Fortune 500 company has between seven and ten years worth of customer data—data that are often underutilized. In addition, the volume of these data has been growing tremendously. A recent study by the *Economist* estimated that humans created about 150 exabytes of information in the year 2005;[1] in 2011, this is projected to be 1,200 exabytes. Similarly, the research firm IDC estimates that digital content is doubling every 18 months.[2] Gartner projects that, in the future, as much as 80 percent of enterprise data will be unstructured, spanning both traditional and non-traditional sources.[3]

THE EMERGENCE OF BIG DATA

The massive explosion in data is creating manageability issues for companies around the world, particularly in the context of mergers and acquisitions. For some specialized applications, such as telecommunications call data records, data can quadruple in 18 months. At the same time, tighter regulations involving the tracking of financial transactions and customer data have expanded the responsibility of businesses so that they must maintain these data and their accessibility for years on end. Meeting these data-volume challenges can be costly, as companies must purchase and maintain hardware to handle the load. Multiple data warehouses and transaction systems add up to a high total cost of ownership and require constant oversight.

So what are companies to do with the huge amount of data, often called *big data*? As many a shrewd executive realizes, there could be a real business advantage to gaining some quick insight on this issue and moving ahead of competitors.

Until recent advances—such as in-memory technology, which we will address later in this chapter—this was easier said than done. Physical limits of computing—the speed of accessing data from relational databases, processing instructions, and so on—meant that a complex calculation or search of data could not be accomplished in real time. At best, such an operation would take a few hours; at worst, it would take a few days.

Around the world today, there is an overwhelming demand for tools that could help organizations access, analyze, govern, and share information. Big data are everywhere, and, as mentioned, they are mostly unstructured data outside the database. Gartner's 2011 Hype Cycle predicts that big data are maturing quickly and rising to the peak of "inflated expectations."[4] Big data dictate a need for advanced information management and processing. Speed is a key requirement, but speed

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alone is not useful without context. Companies not only want faster access to their data, they also want to understand quickly what the information means and what they can do with it.

Ultimately, the goal for the technology providers of any business is to create a true, real-time enterprise where new insights in big data can be made available at the speed of thought to improve decision making, accelerate performance, and improve productivity and efficiency.

The challenges

Intimately linked to the growth of big data are such technology trends as the growth of mobile technology and wireless devices, the emergence of self-service channels, the wide adoption of cloud-based services, and the expansion of social networking and remote collaboration.

But even before big data assumed their present volume, there was business analytics: the analysis of business data to gain insight. This has been around for at least the last 15 years. Originally called "decision support," its name evolved into "business intelligence" (BI). Over the years, technologies such as business reporting, self-service BI, BI dashboards, budgeting, planning, data integration, and others were consolidated into larger enterprise portfolios offered by software vendors such as SAP. In effect, business users got a taste of the insight they could get from data—but that worked only until the recent explosion of data volumes, preventing any real-time analysis.

We now look a little more closely at the challenges of organizing big data and the demands of the marketplace. Corporate users—typically business analysts—want to be able to run reports themselves instead of through their information technology (IT) departments. They also want to be able to customize their requests, and they want analytic solutions that are easy to use and accessible without the extensive involvement of IT, since users feel that a reliance on IT dramatically slows down their work day.

Users also want data visualization, since it seems now more than ever that organizations and consumers expect high-impact visualizations associated with data—not only in the form of charts, graphs, and heat maps, but also in forms customizable to design preferences. Information design also goes beyond merely displaying the data in graphic form; it includes contextualizing the data with other sources and content to ensure they are relevant in a real-world context and to ensure also that they are updated in real time.

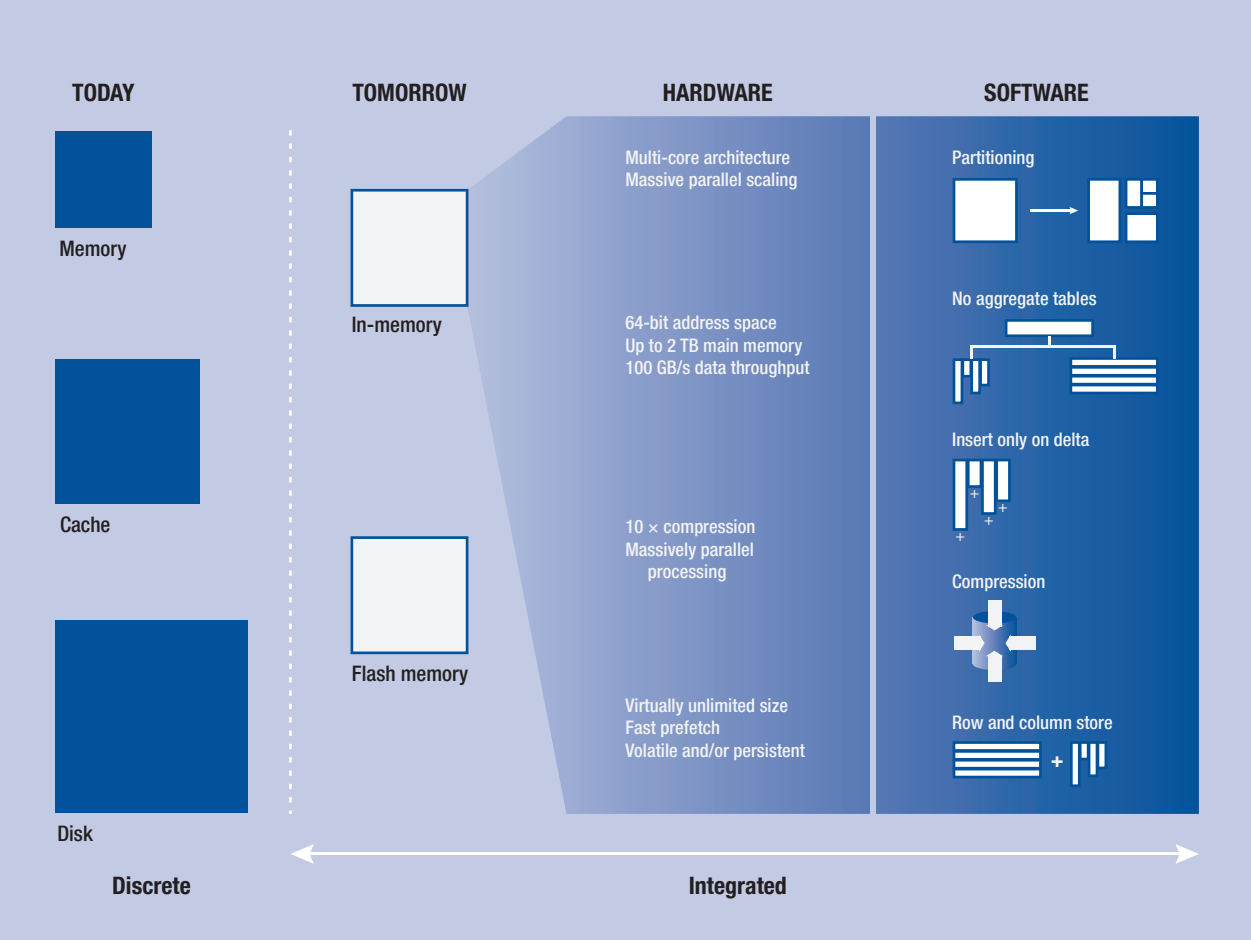
Data points and clear answers are valuable, but today's analytics must go beyond data input and output and maintain relevance to the real world. This means transforming the data into actionable information by coupling them with appropriate additional data from social media analysis, geolocation, customer relationship management systems, and so on. "Contextual engagement" employs feedback data from users and consumers to prioritize the information that a specific user considers most important, cutting through extraneous information and permitting smarter decisions to be made. Providing proper context is becoming more feasible with access to new data sources, such as social media and location and time information, as well as sources that may not be proprietary but may still prove useful (e.g., cell phone information, publically available government data, event streams, images).

Users also want to analyze the information that is coming through social media. There is, of course, the analysis of unstructured text from blogs, Facebook, Twitter, and other websites—an activity presently dominated by small start-up vendors rather than big players. There is also the application of social media–like functionality and processes to team sharing in a business context (e.g., StreamWork, Chatter). For example, many influencers—industry and business analysts—describe "crowdcasting" capabilities that might help teams prioritize analytic reports and data points by allowing individual users to "like" them once they are shared across a team network.

The true potential of mobile applications is just beginning to be realized—and the current extent of mobile analytics is less far-reaching than might be expected. When referring to analytics and mobility, influencers often are referring to the ability to develop analytics that draw on the behavior of device users in real time (e.g., for advertising and other targeted purposes), rather than mobile analytic applications. Although mobile analytic applications will become increasingly useful, especially to companies with large mobile workforces, the analysis of mobile device usage is now also highly valuable to organizations across multiple industries—especially those in healthcare. Several influencers have noted that the ideal mobile application would include data, information, and location.

The need for industry-specific analytic solutions has been discussed by both the media and analysts, with a focus on solutions in healthcare, energy, sustainability, and the public sector. There has also been a push for analytics that can utilize sensor networks or data drawn from the monitoring of road networks, air traffic, railroads, and so on. It is estimated that, in the next five years, the volume of sensor data will surpass the volume of unstructured data collected from social media. Growth in these sectors is often linked to mobile analytics. In healthcare, mobility provides doctors and other health professionals with the ability to diagnose patients by using an iPad to see relevant information or to remotely monitor patients in real time. Big data testimonials are often associated with these industries, because big data often involve managing years of historical data. Organizations in fields such as healthcare

Figure 1: The inflection point: In-memory computing



Source: Plattner and Zeier, 2011, pp. 102, 110, 139.

and government customarily collect and store massive amounts of information.

Although the analysis of *unstructured data* and *natural language processing* are not the same thing, IBM's Watson—the computer that can compete on the game show *Jeopardy!*—has catapulted both into the mainstream media, resulting in the terms being used somewhat interchangeably.[5] Although not always described in these terms, an intense interest has emerged in the unstructured data associated with social media content, with a multitude of vendors racing to offer "comprehensive" solutions or suites to address the issue. Additionally, natural language processing was listed as a "Technology Trigger" on Gartner's 2011 Hype Cycle,[6] with early adopters investigating its applications.

Another challenge: Building a real-time business

In addition to these issues, business itself is now being transacted at an incredible rate. Businesses increasingly need to react faster to the events that affect their operations. They must be able to identify trends and patterns to improve their planning and forecasting, to reduce their response time to customer requests and complaints, and to provide their sales forces with the information needed to close deals in a timely manner.

To achieve these goals, businesses must be able to assess transactional information as events occur, without waiting to extract those data from data warehouses. However, the volume of available operational data often exceeds the capacity of traditional disk-based systems and data warehouses to process within a useful timeframe. Companies today need to be able to answer questions on the fly based on real-time data.[7]

IN-MEMORY TECHNOLOGY AND BIG DATA

The use of in-memory technology marks an inflection point for enterprise applications, especially in dealing with big data (Figure 1). The availability and capacity per dollar of main memory have increased markedly in the last few years. This growth has led to a rethinking of the way mass data should be stored. Instead of using mechanical disk drives, it is now possible to store a primary database in silicon-based main memory, resulting in an orders-of-magnitude improvement in performance and enabling the development of completely new applications. This change in the way data are stored is having—and will continue to have—a significant impact on

enterprise applications and, ultimately, on the way businesses are run. Having real-time information available at the speed of thought provides decision makers with insights that have not previously been available.

In-memory technology represents a significant milestone for large-scale IT systems. It is the technology that will launch a new era of business management, one in which managers can base their decisions on real-time analyses of complex business data.

Some of the advantages that can be associated with this groundbreaking innovation are:

- tremendous improvements in data-processing speed and volume, linked to the improvements that make processing faster by a factor of 143, seen in individual central processing units since 1990;
- in-memory's ability to handle increasing volumes of information—the consequence of improvements in speed of access on an order of 10,000 times (on-disk technology is unable to handle such volumes); and
- technological advances that result in better price-performance ratios, making real-time analysis cost feasible and ripe for mass adoption—the outcome of significant reductions in the cost of central processing units and memory cost in recent years, combined with multi-core and blade architectures.

In a traditional, disk-based system, information is pulled from operational systems; it is then structured in separate analytical data warehouse systems, which can respond to queries. This means that operational applications are disconnected from the analytical environment, resulting in significant lag time between the gathering of data and the process of generating insights into those data.

However, with the availability of in-memory technology, operational data are held in a single comprehensive database that can handle all the day-to-day transactions and updates, as well as analytical requests, in real time. In-memory computing technology allows for the processing of massive quantities of transactional data in the main memory of the server, thereby providing immediate results from the analysis of these transactions. Since in-memory technology allows data to be accessed directly from memory, query results come back much more quickly than they would from a traditional disk-based warehouse. The time it takes to update the database is also significantly reduced, and the system can handle more queries at one time.

With this vast improvement in process speed, query quality, and business insight, in-memory database management systems promise performance that is 10 to 20 times faster than traditional disk-based models.

The elements of in-memory computing are not new, but they have now been developed to a point where common adoption is possible. Recent improvements in hardware economics and innovations in software have now made it possible for massive amounts of data to be sifted, correlated, and updated in seconds with in-memory technology. Technological advances in main memory, multi-core processing, and data management have combined to deliver dramatic increases in performance.

HOW DO BUSINESSES BENEFIT?

In-memory technology promises impressive benefits in many areas. The most significant are cost savings, enhanced efficiency, and greater immediate visibility of a sort that can enable improved decision-making.

Cost savings

Business of all sizes and across all industries can benefit from the cost savings obtainable through in-memory technology. Database management currently accounts for more than 25 percent of most companies' IT budgets. Since in-memory databases use hardware systems that require far less power than traditional database management systems, they dramatically reduce hardware and maintenance costs.

In-memory databases also reduce the burden on a company's overall IT landscape, freeing up resources previously devoted to responding to requests for reports. And since in-memory solutions are based on proven, mature technology, the implementations are non-disruptive, allowing companies to return to operations quickly and easily.

Increased simplicity and efficiency

Any company with operations that depend on frequent data updates will be able to run more efficiently with in-memory technology. The conversion to in-memory technology allows an entire technological layer to be removed from a company's IT architecture, reducing complexity and infrastructure that traditional systems require. This reduced complexity allows data to be retrieved nearly instantaneously, making all teams across the business more efficient.

In-memory computing allows any business user to easily carve out subsets of BI for convenient departmental usage. Workgroups can operate autonomously without affecting the workload imposed on a central data warehouse. And, perhaps most importantly, business users no longer have to call for IT support to gain relevant insight into business data.

These performance gains also allow business users on the road to retrieve more useful information via their mobile devices, an ability that is increasingly important as more businesses incorporate mobile technologies into their operations.

Improved visibility to facilitate better business decisions

In-memory technology makes it easier for organizations to compile a comprehensive overview of their business data, instead of being limited to subsets of data that have been compartmentalized in a data warehouse. With this improved visibility, businesses can shift from after-event analysis to real-time decision-making—and make their business models predictive rather than response-based.

When combined with easy-to-use analytic solutions on the front end, anyone in the organization can build their own queries and dashboards with very little expertise.

IMPACT ON LINES OF BUSINESS

Businesses also benefit from in-memory technology because it allows for greater specificity of information, so that the data are tailored to both the customer and the business user's individual needs. A particular department or line of business may have a specific need that can be addressed. This affects account executives, supply chain management, and financial operations.

Customer account management

With in-memory technology, customer teams can combine different sets of data quickly and easily to analyze a customer's past and current business conditions, either in the office or from the road via mobile devices. Because business users can now interact with the data directly, they can experiment with them to create more insightful sales and marketing campaigns. Sales teams have instant access to the information they need, leading to an entirely new level of customer insight that can maximize revenue growth by enabling more powerful up-selling and cross-selling.

Supply chain management

With traditional disk-based systems, data are processed in nightly operations that can result in businesses being late to react to important supply alerts. With in-memory technology, businesses have full visibility into their supply and demand chains on a second-by-second basis. They gain insight in real time to changing business conditions—for instance, in the form of an early warning to restock a specific product—and can respond accordingly.

Finance

Financial controllers are hit particularly hard by increased data volumes. Because of slow data-response times, they can be forced to limit their analysis timeframes to several days, rather than more useful months or quarters. This can lead to a variety of delays, particularly at the closing of financial periods. In-memory technology, large-volume data analysis, and a flexible modeling environment can result in faster-closing financial quarters and better visibility into detailed finance data across extended time periods.

IMPACT ACROSS INDUSTRIES

In-memory technology has the potential to help businesses across industries operate more efficiently, from consumer products and retailing to manufacturing and financial services.

Consumer products companies can use in-memory technology to manage their suppliers, track and trace products, manage promotions, provide support in complying with US Environmental Protection Agency standards, and perform analyses on defective and under-warranty products. Retail companies can manage store operations across multiple locations; conduct point-of-sale analytics; perform multi-channel pricing analyses; and track damaged, spoiled, and returned products. Manufacturing organizations can use in-memory technology to ensure operational performance management, conduct analytics on production and maintenance, and perform real-time asset utilization studies. Financial services companies can conduct hedge fund trading analyses such as managing client exposures to currencies, equities, derivatives, and other instruments. Using information accessed from in-memory, they can conduct real-time systematic risk management and reporting based on market trading exposure.

CHANGING THE WAY BUSINESS WORKS: EXAMPLES OF IN-MEMORY TECHNOLOGY IN USE

In-memory technology is already being adopted to deliver impressive results. Examples of use that support this paradigm vary across industries and lines of business. For example, a large global consumer products company can leverage in-memory computing to process and analyze large volumes of point-of-sale data during a countrywide trade promotion. The company can collect data on every sale of every product in its portfolio. It knows the average sales history of a particular product for a particular store in any given week, and can make year-over-year comparisons. However, using conventional computational methods—batch process–based analysis that makes calls to relational databases—it takes a minimum of 4 hours to get a particular result. The usual time is 6–12 hours. With in-memory technology, the company can get analysis times that are, on average, 20 times faster. Furthermore, the retailer has reduced shelf turnaround time from five to two days (if a particular product is not doing well, it can be pulled). Moreover, it has eliminated any out-of-stock problems during the promotion—the bane of a retailer. The company can analyze social media feeds and sentiment in real time, as well as improve stock predictive analysis, product affinity insights, and the sales forecast.

In just one example, Yodobashi, a leading retailer in Japan, utilized an in-memory database to calculate

loyalty card points for 5 million members.[8] This process used to take three days on a traditional database; it was performed once a month, as a batch process, to calculate and mail the reward points to customers. With in-memory, this calculation can be now done reliably in two seconds, turning a batch process into a real-time process, where loyalty points can be calculated as and when needed. For example, it can be computing on demand, when a customer enters the store, and the customer can be provided real-time offers based on loyalty status and specific store inventory, thereby altering the business process fundamentally to be more customer oriented and innovative.

NongFu Spring is a leading provider of bottled water and other beverages in China.[9] For NongFu Spring, the ability to have real-time visibility into data was critical for the company to grow and to improve efficiency and reduce costs. The ability to move bottled water from bottling plants to points of consumption is very important for cost savings; however, because of the large volume of data produced in its supply chain, it took more than a day for Nongfu Spring to work with its point-of-sale and channel sale data to display business insights and take action. Executives realized that they would gain significant advantages from having a real-time view into the business, so they looked for in-memory computing to reduce data latency and improve data query and business logic processing speed.

Patrick Hoo, Chief Information Officer at Nongfu Spring, said that the company was able to replace its data mart based on a relational database with in-memory technology and "achieved three goals: fast data display, highly efficient business logic operations and real-time data synchronization." He pointed out that the same script with in-memory technology was returning results 200 to 300 times faster than it was when run on a relational database, and "this query performance improvement was consistent across our 150 reports. We are seeing smooth operations, accurate data and fast performance in our production environment."[10]

For Nongfu Spring, freight calculation procedures and functions that previously took 24 hours to execute were completed in as little as 37 seconds using in-memory, which enabled the company to reduce its account reconciliation process by one day. Additionally, the in-memory platform enabled NongFu Spring to bypass the traditional IT maintenance and data latency issues by synchronizing data from heterogeneous data sources into the in-memory platform instantly.

Another use of in-memory technology is that of Centrica, a large utility company in United Kingdom.[11] Energy markets are deregulated in the United Kingdom, and it is important for utilities to differentiate themselves by offering superior services to their business and residential customers. Centrica is rolling out smart meter technology across the United Kingdom. It is collecting information every 15 minutes from each smart meter, and has fine-grained information on consumption patterns across homes and businesses. This information can be utilized to better segment customers and offer customized pricing plans and energy conservation services to better appeal to different needs. It used to take Centrica three days to do pricing simulations on vast amounts of energy data; these simulations can now be done in seconds. The company also finds that it can perform an instant analysis of huge volumes of data generated by smart meters at any level of granularity. This capability allows the utility to do energy efficiency benchmarking that compares customers with their peer groups and both share that information with customers as well as deliver targeted energy management services. In-memory technology has improved the design of electricity rates and improved load forecast accuracy. It has also decreased customer churn rates.

Wireless provider T-Mobile turned to in-memory when the company set out to implement an aggressive marketing initiative.[12] The goal was to deliver highly targeted offers to more than 21 million customers via channels such as retail stores, customer care centers, and eventually text messages. Such a campaign would require rapid analytical capability so that offers could be fine-tuned on the fly for improved customer adoption, profitability, and retention.

"We recognized that being able to respond to the needs of our customers in real time would give us an incredible competitive advantage and improve the quality of the customer experience," said Jeff Wiggin, vice president, Enterprise Information Technology, T-Mobile USA, Inc. "In order to deliver that kind of experience, we needed an underlying platform behind our sales and marketing efforts, allowing us to uncover customer insights and then act on those insights in minutes, not weeks."[13]

In-memory technology delivered just that and, in three months, T-Mobile shifted 2 billion customer records to an automated system. This allowed the company to run the necessary reports with an average response time of just five seconds. Additionally, the wireless provider is now able to scan 24 months worth of customer records, up dramatically from the three months previously available, thus providing a much larger sample and a more accurate picture of how customers respond to incentives.

CONCLUSION

Continuing advances in technology—from touch-based smartphones and tablets to search engines and social networks—have changed people's perceptions of technology and how it can be harnessed. These expectations apply not just to the consumer world, but to the workplace as well. The increasing demand for an "instant results" experience is driving many trends today. And

with massive amounts of new data coming online every moment, people expect a way to search and sift through it all meaningfully.

In-memory technology offers the best available alternative to slow, costly disk-based data management systems. For those who move first to in-memory technology, the resulting boost in business insight, increased efficiency, and reduced IT costs will provide a true competitive advantage.

According to one estimate, approximately 30 percent of enterprises will have one or more critical applications running on an in-memory database in the next five years; by 2014, 30 percent of analytic applications will use in-memory functions to add scale and computational speed.

Almost three decades ago, Jim Gray defined the "five-minute rule," which demonstrated that any data that was touched with a frequency of five minutes or less could more cost-effectively be stored in active memory rather than on disk.[14] That was when main memory cost over $5,000 dollars per gigabyte. Today it costs less than one penny. Boards that effectively contain more than 1,000 cores are on the horizon; they should be operational within the next 24 months. Taken together, these two trends—declining memory costs and the ascendency of massively multi-core processor architectures—are as transformative to enterprise software as the move to a client-server model was a generation ago. As was done in the client-server revolution of the early 1990s, software needs to be fundamentally redesigned to exploit these hardware innovations. In-memory technology does that.

One of the main benefits of in-memory is speed. In addition to the benefits of speed, in-memory offers significant performance improvements regarding the "reach" of the information that is stored in back-end systems. *Reach* can essentially be defined as the number of people who can access and use these data, multiplied by the scope of usage scenarios that are available to them. Another important benefit derived from the raw performance of in-memory computing is responsiveness.

Additional value is derived by enabling IT organizations to rethink how they deliver services and capabilities to their internal stakeholders. The enterprise data warehouse (EDW) is an almost universal component of most enterprise BI deployments. As part of the EDW approach, data are copied, transformed, aggregated, and tuned across a supply chain that starts with transactional applications such as enterprise resource planning and ends with business information query and analysis tools.

One of the core functions performed by this supply chain is performance optimization. For queries to run fast, the underlying data model needs to be designed, optimized, and maintained for query performance. As a result, when a line of business needs to change the scope or types of data to be analyzed, they have to appeal to IT. At a large, data-intensive company, this process can take weeks. With in-memory computing, performance tweaks and complex views are no longer required to deliver high-performance solutions to business problems. Users can now access and work with data without IT assistance. The result of enabling the business lines is a great reduction in time between identifying and solving a problem. At the same time, IT no longer has to spend valuable time staffing the EDW supply chain and can focus on more strategic tasks.

In-memory computing allows a company to run existing scenarios much more quickly and cost effectively than traditional, on-disk technology. Even more compelling is the fact that in-memory can enable completely new activities and processes. Delivering on this vision requires new applications that are built from the ground up around an in-memory, real-time design center.

In the coming years, we will see more and more such applications in all fields as organizations learn to sift through big data in real time. The world has just begun to learn how to cope with big data, and in future we will see how organizations tap big data and use it to their advantage.

NOTES

1 The Economist 2010, 2011.

2 IDC 2011.

3 Gartner 2011.

4 Gartner 2011.

5 See IBM Watson, available at http://www-03.ibm.com/innovation/us/watson/index.html.

6 Gartner 2011.

7 Sviokla; Manyika et al. 2011.

8 Yodobashi, internal communication.

9 SAP AG 2011a.

10 SAP AG 2011a.

11 SAP N.D.

12 SAP HANA N.D.

13 SAP AG 2011b.

14 Gray and Putzolu 1987.

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