WHITE PAPER

Faster, Higher, Stronger: In-Memory Computing Disruption and What SAP HANA Means for Your Organization

Sponsored by: SAP AG

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INTRODUCTION

“Citius, Altius, Fortius” (faster, higher, stronger) has been the motto for the modern Olympic Games since their inception in 1896. Baron Pierre de Coubertin, the founder of the modern Olympic Games, pointed out that “Athletes need ‘freedom of excess.’ That is why we gave them this motto … a motto for people who dare to try to break records.” There are lessons to be learned from this motto that can be applied to all fields of human endeavor.

In today’s global economy, success in the form of higher performance is increasingly defined by having this “freedom of excess” to innovate, to provide customers with better (stronger) products and services, and to have the ability to act faster and with greater insight within ever-shorter decision windows in the face of uncertainty within a rapidly evolving economic system. Today, the convergence of intelligent devices, social networking, pervasive broadband networking, and analytics has ushered in a new economic system that is redefining relationships among producers, distributors, and consumers.

In the enterprise, the increase in the speed of change means that managers cannot rely on experience or intuition alone to make decisions. Shorter decision windows demand a rapid, insightful response based on ongoing internal and external events.

This new environment is moving us from the information economy to “the intelligent economy.” What’s different in the intelligent economy is scale and time. "Scale" refers to the amount of data as well as the type and sources of data originating from a large network of people and devices. "Time" refers to the need to analyze the data and act in near real time. The successful realization of the intelligent economy, including its components such as intelligent grids, intelligent retailing, intelligent supply chains, intelligent financial management, and even intelligent defense and law enforcement, will depend on many contractual, social, standardization, and technological factors, including the ability to capture, manage, and analyze the vast amounts of data created as part of the interactions and processes.

We need access to information coupled with the ability to analyze and act upon it — all in real time — to create competitive advantage in commercial transactions, enable sustainable management of communities, and promote appropriate distribution of social, healthcare, and educational services.
The growing network of entities and the relationships among them in the intelligent economy will challenge many of today's existing systems to optimize processes for supporting an integrated set of strategic, operational, and tactical decision-making processes. As a result, a new set of technologies is emerging to address the enterprise decision-making, analytics, and process optimization challenges. Based on in-memory processing, these technologies are creating the "freedom of excess" for organizations across industries to compete at their peak performance.

Technology providers and users have already started to migrate to in-memory technology to better capitalize on the opportunities presented by the intelligent economy. Where it has already been used, in-memory technology has been proven to be effective and has experienced strong growth. In-memory technology platforms and specific applications built on such a platform have begun to significantly change the computing landscape, and we believe they will continue to do so for the foreseeable future.

Over the course of several months in 2011, IDC conducted a research study to identify the opportunities and challenges to adoption of a new technology that changes the way in which traditional business solutions are implemented and used. The results of the study are presented in this white paper.

**METHODOLOGY**

The goal of the research presented in this white paper was to discover how use of analytics, data warehouses, and business applications could be improved through in-memory-based technologies.

IDC began by conducting four focus groups in the United States and Germany that gathered input from both IT managers and line-of-business managers and executives in large public and private organizations across industries to gauge their level of interest in and the perception of the concept of in-memory technology if applied to current analytic and operational processes.

The discoveries made in the focus group, coupled with analyst experience, were used to form a Web-based survey translated into four languages that resulted in an extensive data set from 1,002 respondents worldwide. Business unit–level executives and managers with a stake in issues relevant to analytics, process innovation, and management accounted for 70% of the respondents. IT managers, directors, and executives with responsibility for or knowledge of business process management, business analysis, systems architecture, or application development accounted for 30% of the respondents. The survey was completed in August 2011.
Information Analysis and Management Practices: Industry Leaders Versus Laggards

The information access, analysis, and management challenges of the intelligent economy can overwhelm organizations unprepared for the emerging changes. IDC defines these organizations as "fumblers" compared with "fact finders." As described in IDC's study Analytical Orientation and Competitiveness: The Difference Between Fact Finders and Fumblers (IDC #223408, May 2010), "fact finders" are organizations that have the highest levels of the following characteristics:

- **Reliance on analytics**, which is defined as the degree to which the organization's management-level employees rely on analytics (as opposed to experience or intuition) for decision making

- **Influence on actions**, which is defined as the extent to which the output of the organization's business analytics solutions influences all employees' actions

- **Criticality to competitiveness**, which is defined as the perceived level of criticality of the business analytics solutions to the organization's competitiveness

- **Effectiveness of analysis on decision making**, made at various levels, which is defined as the importance of the organization's business analytics technology and processes in helping to improve individual decision making or in facilitating intragroup or intergroup decision making

Our research demonstrates that, as a group, fact finders are more competitive than fumblers (see Figure 1). Among leaders, 80% are fact finders — 20% more than among laggards. Their competitive differentiation, based on the application of analytics for ad hoc analysis, discovery, or planning processes and embedded into other business applications, will continue to increase in the intelligent economy.
One of the common characteristics of these industry leaders is how they use information. IDC research has shown that leading organizations tend to:

- Base decisions on analytics rather than intuition
- Base decisions on the latest, granular multistructured data
- Rapidly evaluate alternative scenarios
- Frequently reassess forecasts and plans
- Utilize analytics to support a spectrum of strategic, operational, and tactical decision making
These leading companies are not limited by the lack of freshest data because their systems cannot retrieve or combine data into useful forms fast enough. Examples of leaders include:

☒ Financial services firms whose trading systems support buy and sell decisions that are made automatically based on price shift patterns, and where even microseconds count.

☒ Large retail chains that ensure the most competitive prices for their products while closely managing inventory by carefully tracking consumption patterns and shifting items from suppliers to stores in an optimal manner. (Such systems require the very latest data, and the timelier the data is, the easier it is to offer products at the lowest cost while avoiding either overstocking or running out.)

☒ Banks that used to rely on overnight grace periods to reconcile their accounts data for online users, giving such users working estimates rather than actual account balances, which is no longer acceptable. (Managing current account balances while tracking numerous online banking, bill pay, check processing, and ATM transactions demands the fastest data processing capability possible.)

These examples, taken together, demonstrate that businesses do not need to compromise when it comes to timely information. Previous technology constraints dictated how organizations utilized their data. Our research shows that it is possible to be at the top of your field, to be “faster, higher, stronger,” if you have the right data, at the right time, delivered through the right technology.

**Identifying Data, Analytics, and Timeliness Requirements**

Imagine an Olympic sprinter who at the start of the race receives a tenth of a second advantage over her competitors. This could be a significant head start toward victory. However, the same tenth of a second would be meaningless to a marathon runner.

Business decisions are no different. For example, an airline making rapid, ongoing pricing decisions has very different requirements from the airline manufacturer deciding what new airplane model to produce. Figure 2 illustrates the key dimensions for evaluating IT requirements in support of a specific business decision.
Data can be multistructured and multisourced. It can be structured, semistructured, or unstructured; it can come from enterprise applications, point-of-sale systems, clickstream from online commercial and social networking activity, call detail records (CDRs), mobile devices, or sensors. Some of the data, such as CDRs, mobile device activity, or vehicle traffic data, can be considered part of the Big Data trend that emphasizes high-volume or high-velocity data of various types. As the volume, variety, and velocity of data needing to be analyzed increase, so too does the requirement for a system that can handle the corresponding performance and analytic complexity requirements. During one of the focus groups, a manager from a law firm explained how structured and unstructured data from multiple sources impacted performance when he said, "We need to have tools that enable us to track all client billing data from all the relevant client interaction channels, including mobile devices. Inability to do so is directly affecting our profitability."

Analytics can involve relatively simplistic aggregations or complex predictive models, with visual and interactive interfaces when the intended consumer is a human decision maker and in the form of rules or scores when the target is another system that executes the decision automatically. As the complexity of analysis increases, so too does the need for a system that can enable users to perform the analysis rapidly, often over several iterations before a decision can be made. A promotional products wholesaler stated, "We can't just analyze past sales. We need to figure out what sort of sales to expect for the next couple of periods and how hot the particular design is going to be. We need to be able to better plan for what we need to sell or to ship to stores or concert dates. And we..."
need this data by country, by product, by raw material so that we can interactively ‘fly’ through the data without actually having to fly to our suppliers in China, or Indonesia, or Pakistan.”

Timeliness requirements also vary from real time to periodic (hourly, daily, monthly, quarterly) to occasional or very infrequent (e.g., decision to exit a line of business). When the need for analysis approaches real time, then traditional methods may not be sufficient to address the problem. A manager at a financial services company said, “What we really need is instant analytics — the ability to rapidly reassess a portfolio’s value and risk by adding or taking out assets. This instant ability to answer ‘what if?’ questions is key. That’s the kind of stuff we really need — to get an answer right away.”

**Making Applications Smarter with Embedded Analytics**

Most people think analytic processing is just for helping people make better decisions. While this is an important function, at both the strategic level and the tactical level, analytic processing can also be embedded in business processes to make applications smarter. In effect, they can automate many tactical decisions by applying the relevant business intelligence data.

If analytic processing can make applications smarter, why aren’t analytics built in to all applications? The simple answer is that business intelligence data is usually large and complex and takes so much time to navigate through complex queries that the analytic functions would slow down applications too much to be practical, except in a few well-chosen situations.

With in-memory technology, analytic processing can be sped up to the point where it does not represent a drag on business processes. Enhancing analytics with in-memory technology can enable analytics to be inserted wherever it makes sense to make an application smarter. Examples include:

- A retail application with in-store inventory management software that automatically makes stock and pricing decisions based on real-time consumption patterns and trends
- A logistics application that automatically updates truck routes based on traffic analysis and unexpectedly added or deleted deliveries
- A financial services application that automatically adjusts portfolio positions by applying each portfolio’s rules against real-time prices and market trends and makes and executes buy/sell decisions based on that analysis

The key is to align data, analytics, and time with the business response requirements of each decision. Yet achieving such alignment eludes many organizations because of a lack of technology or because of established business processes that would require significant organizational change to restructure.
The Inhibitors to Fast, Intelligent Response

Business Challenges Driven by Technology Limitations

The challenges for most organizations are varied and range from organizational behavior issues to technology shortcomings, and they include the following:

- **Aggregation and loss of granularity.** Traditional data warehousing methods require data to be aggregated and prepared before analysis can be performed against it. This loss of granularity limits the analysis users can perform because assumptions must be made before preparation about how the data will be used. This loss of granularity can lead to decisions that are less effective than when analysis of more granular data is performed. For example, in marketing functions where the trend is increasingly toward more detailed prospect segmentation and personalization, running campaigns based on aggregated demographic segmentation is increasingly proving ineffective. Access to more granular data and analysis of more of the variables that influence buying behavior leads to improvements in the effectiveness of a marketing campaign.

- **Inability to complete analysis within given time windows** (for decision and action). Many operational and tactical decision-making processes require real-time (subsecond or any intraday interval) information access and analysis capabilities. When a data mart or warehouse takes hours or even days to load, the quality of the data and analysis can become irrelevant to decision makers acting in real time. If the information is not available on a timely basis to drive business decisions, it might as well not exist at all.

- **IT's inability to provide timely response to end-user requirements.** The relationship between business and IT is one of the ongoing tension points for most organizations. Finger-pointing and blaming the other side are often the results of a lack of communication. However, even the best-intentioned IT groups cannot provide the level of service necessary to match end users’ expectations without the appropriate tools. Only less than a third of organizations completely agree that the speed of their IT department's response to information access and analysis requests meets end-user expectations. Disturbingly, that percentage decreases to 17% among respondents from CRM-related business functions such as sales, marketing, and customer service. In addition, there's a 10% difference between the results from the most competitive organizations (leaders) versus the rest of organizations. A financial services firm stated, "We can't rely on IT to support every new request for a specialized application based on a proposal and the potential to create great value. IT is already overwhelmed. If we can't get onto IT's top 20 list, we might as well forget about the project."

- **Misallocation of resources** in the line of business, information management infrastructure, and the IT department can lead to a range of business workarounds to generate timely information analysis. This includes manual efforts undertaken by business experts to collect, cleanse, and aggregate data. It also includes forgoing requests from lines of business due to previously unfulfilled requests and resulting frustration. At the same time, IT resources are often wasted on the creation of an ever-growing set of reports, dashboards, and other business intelligence interfaces rather than systems administration, new application development, security management, and data integration.
These inhibitors can lead to suboptimal strategic, operational, and tactical decisions, which in turn negatively affect the downstream actions taken by employees executing their organization's strategy. More than half of the respondents in our research agree that their planning processes can be improved the most by having improved access to information; this shows in-memory as a potential displacer for traditional OLAP-based planning. But there is opportunity to improve all major decision support and decision automation activities, as shown in Figure 3.

**FIGURE 3**

**Decision Support Processes with Greatest Expected Improvements**

Q. Which of the following analytic, planning, or decision support processes could be most improved if the performance of your technology and access to the right information at the right time was improved?

![Bar chart showing decision support processes with greatest expected improvements.]

Planning
Reporting
Forecasting
Predictive modeling
Ad hoc analysis

n = 1,002
Source: IDC’s SAP HANA Market Assessment, August 2011

More than half of the respondents in our research agree that their planning processes can be improved the most by having improved access to information.

The misalignment between business requirements for timely analysis and the capability of IT systems is not only an organizational issue. There is a technology dimension to this misalignment, and a significant factor resides in the limitations of disk-based database technology.
**Business Impact of Disk-Based Versus In-Memory Technology**

Often, business analysis and decision making are done using managed data structures such as data marts or analytic cubes, which, in turn, are fed from data in an enterprise data warehouse or operational data sources of various kinds. Building or refreshing these structures takes time and staff resources and usually must be scheduled in advance. The problem is that business issues can arise suddenly and requirements can change quickly, and a system too slow to react to business changes can derail the achievement of business goals.

Many managers and analysts resort to getting subsets of data in one way or another and often build their own spreadsheets rather than rely on IT to build the structures they need. As a result, they sometimes base key decisions on data that is ill-formed, incomplete, and often inconsistent. Access to more granular data available through in-memory technology makes it possible to drive focused decisions and take actions quickly.

During the focus groups, we asked participants to imagine scenarios in their business where real-time access or rapid analyses were made possible. There were very personal reactions to the impact that capability would bring to their professional careers. From a manufacturer thinking about how a change in a large customer order hitting the transactional system would immediately be reflected in production plans across the organization to a hedge fund manager needing to analyze derivatives containing investment strategies within investment strategies to truly understand the risk they carry at any given time, the excitement of the possibilities was present in managers across industries. IT was a little more skeptical and understandably so because adopting in-memory databases (IMDBs) means a shift from traditional database management techniques to something disruptive and revolutionary.

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**SAP HANA Software: A Platform for Real-Time Analytics and Real-Time Applications**

SAP HANA is a new software platform specifically designed to support both operational and analytic applications. It makes possible instant analysis of large amounts of multistructured data and the embedding of analytics into operational applications. The SAP HANA appliance enables organizations to analyze their business operations using huge volumes of detailed operational data in real time, while business is happening. Operational data is captured in memory and made available for instant analysis, eliminating the typical lag time between when data is captured in business applications and analysis of that data from reporting systems. It provides insight into business operations directly from the production database. This in-memory appliance combines SAP software with hardware from the company's strategic hardware partners.

SAP HANA software is being deployed today as a platform for SAP NetWeaver Business Warehouse (SAP NetWeaver BW), as SAP-developed prepackaged applications, and as a platform for SAP customers and partners to develop their own applications.
SAP HANA and SAP NetWeaver Business Warehouse

SAP NetWeaver BW enables users to model, build, populate, and query a data warehouse or a data mart. Normally, this involves creating a relational database to manage the warehouse. Querying and reporting involves executing some fairly complex SQL SELECT statements. These statements can take quite a while to execute because of the nature of how data is stored and retrieved on disk, using table rows and indexes.

SAP HANA represents a completely different way of managing data warehouse data. Rather than the data being mapped to relational tables stored on disk, the data is kept in column-wise memory structures. Rather than searching for data by looking up index entries and using indirect references to find the disk pages where the data resides, SAP HANA jumps around the memory structure, scanning quickly through columns and following memory pointers, to quickly assemble the desired data. The result is that queries will run at a significantly faster rate compared with their disk-based relational database equivalents, yet the process of modeling and reporting data remains just as straightforward to the user. SAP NetWeaver BW is not a new product, but the deployment of SAP NetWeaver BW on SAP HANA is new and involves characteristics such as faster query performance and data-loading processes and features such as running planning functions and having write-back functionality in memory. As an example, this technology enables faster and more integrated planning for use cases such as trade promotion planning or assortment planning.

SAP Applications Powered by SAP HANA

SAP offers several applications that benefit from its in-memory SAP HANA technology. The applications solve problems across disparate processes by either enabling real-time analysis of sensor-based data or offering the means to conduct multiple scenario analyses rapidly to improve planning.

- SAP BusinessObjects Strategic Workforce Planning was the first application introduced that takes advantage of SAP HANA. The application enables rapid analysis of possible human resource (HR) supply trends and compares them with anticipated organizational demand. Through this analysis, an organization can improve its ability to capitalize on opportunities and reduce HR costs. Improved understanding of the financial impact of future HR costs also benefits the financial planning process as HR costs, including compensation, training, and recruitment, often account for a significant expense. Furthermore, organizations will often have portions of the workforce that need more transparency. These employees are strategic to operations because of specialized skill sets or experience levels where negative changes in turnover must be anticipated and avoided before the organization faces degraded operational performance or sudden spikes in recruitment costs.

- SAP Smart Meter Analytics was designed for utility companies facing an exponential increase in data volume driven by the deployment of smart meters. This new application enables utility companies to turn massive volumes of smart meter data into actionable insights and transform how they engage customers.
and run their businesses. SAP Smart Meter Analytics delivers the following capabilities to utility companies:

- Instantly aggregates time-of-use blocks and total consumption profiles to analyze customers’ energy usage by what neighborhood they are in, the size of their homes or businesses, building type, and any other dimension and at any level of granularity

- Segments customers with precision based on energy consumption patterns that are automatically generated by identifying customers that have similar energy usage behavior

- Provides energy-efficiency benchmarking based on statistical analysis so that utility companies can help their customers understand where they stand compared with their peers and how they can improve their energy efficiency

- Empowers customers with direct access to energy usage insights via Web portals and mobile devices connected to SAP Smart Meter Analytics via Web services

These capabilities delivered by SAP Smart Meter Analytics enable utility companies to increase adoption of service options such as demand response programs, launch targeted energy-efficiency programs, improve fraud detection capabilities, and develop new tariffs and more accurate load forecasts.

SAP Dynamic Cash Management provides the office of finance with a greater level of insight into the variables that impact cash flow rather than relying solely on historically based high-level models to improve cash management operations. Cash payments based on multiple dimensions such as product, customer, partner, or geography can be incorporated into the analysis and planning process. The higher level of granularity in the data used to inform a plan can improve accuracy and ultimately organizational liquidity.

These are just a few examples of applications developed by SAP on the SAP HANA platform. Many other applications are being developed on SAP HANA by SAP, its customers, and partners. Some of these applications are enhanced versions of existing applications; others are new applications that were not feasible in the past. Examples of the latter include dynamic cash management, vehicle traffic management, and clinical trials analysis. Figure 4 shows applications that our research participants expect to benefit most from in-memory technology.
**Applications with Greatest Potential to Benefit from In-Memory Technology**

Q. Which types of applications would benefit your organization or business unit the most from in-memory technology?

- **Customer service analytics**
- **Financial analytics (planning, consolidation, and close)**
- **Marketing analytics**
- **Supply chain and operations analytics (e.g., inventory, logistics, fraud detection)**
- **Pricing analytics and optimization**
- **Sales analytics**
- **Profitability analytics (customer or product profitability)**
- **Analytics for treasury (cash management and risk management)**
- **Web site clickstream analytics**

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**SAP Rapid Deployment Solutions for SAP HANA**

SAP rapid deployment solutions (RDS) are offerings that bring together software, templates, and guides that capture best practices along with prepriced, packaged services for fixed-time, fixed-cost implementation.

The first two SAP RDS for SAP HANA offerings that target popular use cases are:

- **ERP operational reporting with SAP HANA.** ERP operational reports can often take a significant amount of time to process and deliver. The SAP ERP rapid deployment solution for operational reporting with SAP HANA adds SAP HANA and fixed-time, fixed-cost services from SAP. With that, organizations can accelerate the time to generate and deliver common operational reports, such as sales order per customer, fulfillment rate, flexible customer open item, customer open item analysis, goods receipt, and invoice overview.

- **Profitability analysis with SAP HANA.** With the SAP CO-PA Accelerator, companies can engage in faster and more efficient profitability cycles and month-end closing processes. Armoured with deeper insights in real time, companies can...
unlock new opportunities to maximize profitability, optimizing decisions related to product mix, pricing, and sales strategy. The SAP ERP rapid deployment solution for profitability analysis with SAP HANA combines the SAP CO-PA Accelerator with prepriced, fixed-time services for fast implementation.

MARKET OUTLOOK

**In-Memory Technology as a Platform for a New Generation of Information Analysis and Business Applications**

The goal of the modern Olympics has always been to provide an international forum where the world's elite athletes could come together and compete — which is what Pierre de Coubertin meant by "freedom of excess." Similarly, to be leaders and to compete at the highest level in today's intelligent economy, organizations need to have a platform that enables top performance. One of the key components of such a platform is in-memory technology.

In-memory technology can be applied to any decision type, in any line of business, and in any industry. As shown in Figure 5, the expected business benefits of using in-memory technology can lead to measurable returns as well as more accurate and faster analysis of business data. The most frequently mentioned of these business benefits is improved planning accuracy, which is a key input to better decision making for executives, line-of-business managers, and operational analysts.

These benefits represent a mix of business process improvements and productivity or efficiency gains. For example, the second most frequently mentioned benefit is a reduction in time spent by business staff on data integration and aggregation. This is a notorious time sink that forces business staff to waste considerable time on tasks that would be better performed by the technology itself and by IT staff supporting the technology.

Our research uncovered a strong theme focused on the need to do more frequent what-if modeling on granular data. The ability to perform what-if analysis as needed with highly granular data, run multiple scenarios, and ultimately address a business problem or understand the potential that a new opportunity may hold was a key requirement across industries, geographic regions, and company sizes. This sentiment was repeated in both the focus groups and the survey data.

Conversely, respondents who felt they didn't have access to the right information at the right time also said that relevant information wasn't aggregated in the manner they required it. These respondents want the limitations removed that aggregated data poses to their ability to evaluate alternative action plans, make discoveries, make informed decisions, and mitigate risks.
Similarly, the IT benefits of in-memory technology, as shown in Figure 6, can provide important cost savings and better IT staff allocation. The top two IT benefits are less time spent on creating data aggregations and less time spent on database administration. Both of these issues, discussed in more detail elsewhere in the paper, point to key shortcomings of existing methods of information management and analysis that require strategies to address performance limitations of disk-based systems.

Both business benefits and IT benefits are important. Although IT benefits are more immediately tangible than business benefits, IT benefits have a limit. For example, there's only so much you can save by moving database administrators (DBAs) to technology consolidation or reduction projects and user support rather than storage tuning. In the end, the business benefits derived from better customer interactions, more optimized operations, or better, risk-adjusted financial management will increase organizational value.
The power of in-memory computing is that it can enable new processes where analysis and decision making happen at a point in a process before action is taken rather than performing analysis after the result of the action has been realized. Examples of processes that could be improved by moving the analytics into an operational process include:

- **Fraud detection.** For example, consider an insurance company that makes a strategic decision to offer claims payments within 24 hours of receiving the claim. Prior to implementing an in-memory-based solution, it would make the payment as promised and then later analyze the claim for possible fraud. After an in-memory-based solution is implemented, the company can analyze the claim as it comes in, score claims based on their likelihood of being fraudulent, and avoid payouts to the highest-risk claimants in the first place. In addition, the organization can begin to incorporate more sources of data to help improve fraud detection, all the while maintaining its high level of service to legitimate customers.
Customer revenue performance management. For example, consider a retailer conducting an email marketing campaign that may not be meeting targets for sales of a particular product. Without rapid analysis, it may take several days or weeks before actual performance can be benchmarked against the plan. But transactions are happening throughout any given day. An in-memory-based solution would provide the retailer with daily performance insight in near real time and allow for several actions to occur independently or together based on the retailer’s goals. For example, the retailer could decide to expand its promotion of the product to customers that bought related goods recently or who are likely to be ready to make another purchase based on past performance. The retailer can further adjust pricing to maximize revenue and meet sales targets. The ability to do multiple scenario analyses of the results that any of these decisions could influence requires rapid analysis and real-time data access that an in-memory solution can provide.

In-Memory Technology Market Outlook

The database management system (DBMS) software industry has long been held back by the relational paradigm, which has proven to be both a blessing and a curse. The blessing of the relational DBMS model is that its simplicity and broad applicability have enabled DBMS technology to become the standard way that a business application is stored and managed, which brings order and manageability to both the data and the applications that use it. The curse is that relational databases are unable to hold semantic metadata (which describes the data in meaningful terms) or directly represent data organization concepts such as multidimensionality, containment, derivation, recursion, or collection.

This limitation has forced DBAs to store data that reflects such concepts in arcane combinations of cross-reference tables that require multiple complex joins to navigate and to encapsulate the management of such table relationship combinations in program code or stored procedures, both of which, in the absence of detailed documentation, tend to mask the actual nature of the way the data is logically organized.

In-memory DBMS is an important dimension of the DBMS landscape and will become more important in the coming years. The shift in computing economics that make processors and memory abundant will compel every DBMS vendor to move in this direction in the future. It is likely that as solid state memory (SSM) drops in price, main memory will be seen as the primary “home” of a database, solid state memory will be seen as the overflow area, and disks will be relegated to recovery functions only. IMDB is becoming regarded as an inevitable stage in the evolution of database management.

Challenges and Opportunities

The opportunities to employ in-memory technology are not without challenges. There are several potential issues, whether perceived or real, that need to be overcome by organizations looking to deploy in-memory technology including SAP HANA. For example, there are trade-offs with respect to the mechanisms and recommended frequency of refresh of SAP HANA (from multiple sources) versus determining an acceptable level of latency (from a business perspective) between refreshes.
Additionally, traditional methods for building and maintaining a computing infrastructure in support of analytics and applications will not be suitable when shifting to in-memory technology. Established IT practices have led potential adopters of in-memory technology to have common misconceptions about the technology that they cite as challenges to deployment. IDC discovered the following misconceptions both in the focus groups and among survey respondents over the course of conducting this study (see Figure 7):

- **Cost of the technology itself.** Most respondents (35%) expect the cost of the in-memory technology described to them to be a challenge for their organization or business unit when deciding to purchase and deploy this technology. While it is true that there is cost with any new computing resource, the business benefits should be considered to determine if there is a suitable return on investment. Considering the application of the technology to a specific business problem will generate appropriate financial decisions. The IT department can further explain how in-memory technologies can better align DBA resources and handle more data with fewer computing resources.

- **Multisource and multistructured data integration.** The next two most frequently mentioned expected challenges are integration of data from various sources and integration of data of various types. Integration of various data sources has always been a problem using traditional data warehousing techniques. And while IMDB doesn't make this problem disappear, it can make it easier to relate more data with fewer aggregations requiring up-front planning in anticipation of the queries users might pose.

- **Scalability to handle large data sets and Big Data use cases.** It was interesting to discover over the course of this research study that potential in-memory users thought scalability might be an issue when the very goal of IMDB technology is to make more data available even as the frequency of analysis performed against it increases. Focus group discussions revealed that many in IT feel that there isn’t an elimination of the bottlenecks to traditional disk-based databases. Seeing the technology in action may be the only way to overcome this misconception.

- **User access and security management.** Most IT managers would expect an enterprise-ready system to manage user access and security with de facto industry-standard integrations, and IMDB technologies support this functionality. However, the focus groups revealed that real-time access to data could lead to misuse, especially in financial services, where a trader may take an action in real time before a compliance system can react and prevent a risky action. Or someone running analysis on internal production data could make a decision or run a report at any point in time and that data would vary from someone running the same report a few minutes later who comes to a different conclusion. IT will need to delineate the difference between real-time analysis for what-if scenarios versus time-stamped, compliant production or operational reports. There is a loss of some control when freedom to information is made widely available, but it is an issue of policy and user education, not a technology shortcoming.
** FIGURE 7 **

Common Misconceptions to Adopting In-Memory Technology

Q. What would you expect to be the greatest challenges with in-memory technology for your organization or business unit?

<table>
<thead>
<tr>
<th>Perceived Inhibitor</th>
<th>% of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractive ROI and TCO, including lower overhead and administrative costs. Decreasing cost of memory. Appliance form factor.</td>
<td>35.2</td>
</tr>
<tr>
<td>Relating data is easier with IMDB than in a traditional data warehouse, and less time is spent on aggregation.</td>
<td>33.0</td>
</tr>
<tr>
<td>Can access, manage, and analyze multiple data structures, including operational and sensor data.</td>
<td>28.0</td>
</tr>
<tr>
<td>Customer use cases include the largest CPG, utilities, resources, and government agencies — all with large data volumes.</td>
<td>25.9</td>
</tr>
<tr>
<td>SAP provides tools and integration points for user access management.</td>
<td>25.5</td>
</tr>
<tr>
<td>Applications can be rewritten to leverage all IMDB benefits, and new applications have been created that are made possible by IMDB.</td>
<td>24.7</td>
</tr>
<tr>
<td>SAP HANA is enterprise ready and will support backup and recovery needs.</td>
<td>23.6</td>
</tr>
<tr>
<td>Replace when necessary, add solutions around existing implementations to take advantage of real-time applications.</td>
<td>23.4</td>
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<tr>
<td>Integrating multiple sources of data</td>
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<tr>
<td>Integrating multiple types of data (e.g., structured operational data with unstructured text data)</td>
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<tr>
<td>Scalability of such technology (to large and very large volumes of data)</td>
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<tr>
<td>Managing user access rights/security</td>
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<tr>
<td>Potential need to rewrite existing applications</td>
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<tr>
<td>Potential problems with data backup and recovery</td>
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<tr>
<td>Deciding what to do with existing investments in data integrations, data marts, data warehouses</td>
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n = 1,002
Source: IDC's SAP HANA Market Assessment, August 2011

** Need to rewrite existing applications. ** There are already and will be two groups of applications built on in-memory technology. The first group will include currently available applications that will require some level of modification to enable all the benefits of the in-memory platform on which they are built. The second group will include new applications that were not feasible without in-memory technology. So rewrite when necessary, but new applications may hold the key to opening the greatest opportunities for the organization.

** Backup, recovery, availability. ** A common misconception regarding IMDB is that it lacks the atomicity, consistency, isolation, and durability (ACID) properties of a transactional database. This is not true. Most IMDB implementations used for transaction processing still have transaction logs for error recovery and can stream the logs to physically persistent storage such as SSM or spinning disk. A very few provide full recoverability by nonlogging means. They also commonly replicate their memory contents to other servers to provide high-availability functionality through failover support.
In addition to IMDB replicating data for high-availability purposes, some IMDB products also operate as shared-nothing clusters, which means that even the large-memory models of 64-bit systems are not a limitation; they can handle databases that are many times the size of their own main memory.

- **Existing investments.** IT has built data warehouses and data marts across the organization, and they cost money and time. Building around, or in support of, these existing investments to take advantage of real-time access or rapid analysis where a business process could benefit from it will enable those investments to be valuable data sources, retain their current purpose, and be enhanced by IMDB where needed. SAP customers can expect a more tangible technical response during this year that demonstrates how existing structures can be easily migrated to SAP HANA.

**RECOMMENDATIONS**

**Recommendations for Business Managers**

SAP HANA is a technology that can be applied to solve many business problems. When weighing whether the technology is appropriate for improving specific business processes, consider the following:

- Examine the process to identify where decisions are made and question whether that is the optimal time at which a decision should be made within a process and whether or not that decision is supported by relevant, timely information. Often, a process with an inherent service-level agreement will have a scenario where the service level could be maintained at lower risk or cost or improved for competitive differentiation if analysis related to decisions impacting that service level is performed faster or with better accuracy. Adding an IMDB technology at this decision point is more likely to lead to business improvements.

- Examine where real-time data access is a necessity in a process. It may not seem possible to get access to real-time data for processes that could benefit from it, but if the barrier is technology related, then an IMDB technology is applicable. If other processes or even external sources of data are bottlenecks to your process, consider how the application of IMDB technology to those variables could result in downstream improvements in your own business.

- Examine a process where people perform analysis less frequently than actual changes within a process occur and IMDB can solve this problem. For example, inventory management is often done based on latent aggregation of supply and demand data. But when decisions can be made based on actual inventory flows during a day, then there could be reductions in out-of-stock events or early warnings of supplier performance degradation.

The processes that can make your organization run faster, higher, and stronger are often those closest to the customer, the office of finance, or core operations. Focusing on one process to improve first can lead to demonstrable results and invaluable experience that will lead to a winning organization.
Recommendations for IT Managers

The emergence of in-memory DBMS as a dominant form will not happen all at once. IT managers should consider how they might evolve their IT systems in such a way as to exploit IMDB technology both now and in the future. SAP HANA’s current columnar approach is well suited to the analytic workload, but as SAP HANA evolves, different models for organizing the data could serve operational and nonschematic (or NoSQL) workloads with equal effectiveness.

- Businesses should challenge their existing DBMS vendors to provide a road map for IMDB and explain how they plan to get there.

- Not all data is created equal. Some is seldom accessed and may be maintained on disk because it is nonvolatile and disk is cheap. Some is accessed a bit more frequently and may be kept in solid state memory (also called flash memory). Dynamic, online data will increasingly need to be held in memory all the time. IT managers should consider how much of each they have — and are likely to have going forward — and plan accordingly.

- High-speed data access and movement technologies are arising in many quarters. So-called “Big Data” technologies address some challenges never before thought possible. Data is increasing in volume and complexity, and business competitiveness requires the ability to access data on a granular level and on a very timely basis. In-memory technology is essential to meeting that requirement, and SAP HANA is a clear example of that technology at work today.

The problem is that business issues can arise suddenly, requirements can change quickly, and a system that requires a batch unload from a disk-based database, followed by construction of a disk-based cube or loading of a disk-based data mart, requires so much time that the window of opportunity may be passed before the data is available to take action.

Disk-based systems require long-running batch jobs for data movement as well as time and effort to load the data onto disk volumes. But suppose there were no disk volumes. Suppose the data could be moved at the speed of the processors and internal network and laid out dynamically in memory for rapid analysis. That is the idea behind in-memory database systems. This approach greatly accelerates both the preparation of analytic data and the access to that data.

Because data can be loaded and adjusted in greater volumes, and accessed more quickly with in-memory technology than with disk-based technology, it becomes possible to manage more data at a more granular level. This results in greater precision and the ability to drive focused decisions and business actions quickly.

In-memory database technology has emerged as a key means of boosting performance and scalability and containing storage costs. This technology has evolved from use only for caching, or for extremely high-speed data systems, to much more mainstream IT applications. IMDB usage is now applied in ways that deliver better performance and responds flexibly to increased user demand at low incremental cost. Today, processors are orders of magnitude faster than they were.
just a decade ago. Most systems have multiple processors and multiple cores per processor. Enterprise servers typically use 64-bit memory addressing and are stocked with multiple gigabytes of main memory. This means that the economics of computing have swung in favor of in-memory databases for many workloads.

**IT Benefits to IMDB Usage**

- **Reduces operational cost.** A key requirement of datacenters today is that of managing, or even reducing, the physical footprint and the operational cost of databases while dealing with their continued growth in size and user demand for better performance. The new economics of computing, which derive from large memory models, 64-bit addressability, fast processors, and cheap memory, make it possible to design database technology that is far faster and more scalable than was possible when the only option was to base data management on spinning disks.

- **Slashes overhead to dramatically improve data access speed.** An IMDB manages its data in main memory. Indexes contain memory pointers instead of disk page and line references. Data is shifted around according to memory optimization rather than disk optimization strategies. An IMDB is typically dramatically faster than a disk-based database, depending on the workload. The reason for this has to do with its internal storage architecture. A disk-based database is designed from the ground up to optimize its data management based on an optimal disk layout and I/O minimization strategy.

- **Reduces DBA backlogs.** A fundamental barrier to scalability for a disk-based database is the bottleneck represented by the storage system. DBAs spend an enormous amount of their time rebuilding indexes, unloading and reloading data, and reallocating data across storage volumes to minimize I/O time. This results in a backlog of more high-value tasks that they could be performing, if not for these essential "keep the lights on" activities.

Most database tuning for scalability involves strategies around the distribution of data across disk volumes, the collocation of related data to reduce the possibility of cross-volume queries, the sparse scattering of frequently but randomly accessed data to reduce head contention, and so on. Even with all this, funneling data access through the I/O channels adds unavoidable overhead. Keeping data in memory and avoiding not only all the I/O activity but also all the work that the DBMS core must do to map data to and from disk or to find the right volume for each element of a query or update results in a system that not only is much more efficient but also scales with increases in demand and increases in data volume, without requiring special storage tuning efforts by the DBA.

An IMDB typically uses disk only for recovery. It writes the log (if there is one) to disk, and it dumps its memory contents to disk from time to time. Because the disk is not involved in database transactions, the data that is dumped to disk can be packed together. As a result, there is no problem with filling a volume right up to the brim. Also, because the disk has no impact on performance, cheap lower-tier storage may be used. In scale-out situations, where clustered databases use partitioned and redundantly stored data, this savings effect is compounded.
Understanding SAP HANA Features

In addition to utilizing in-memory computing technology, SAP HANA offers the following features and functionality:

- **High level of data compression and columnar storage allowing all relevant data to be held in main memory.** Storing table rows as blocks with selected indexed columns is a spectacularly inefficient approach for databases that are commonly used for analytic workloads. This is because many analytic database operations scan tables, performing aggregate operations on the data, usually in select columns, and because when they randomly select rows, it is normally for only a few columns in that row and not for the whole row. Columnar data storage involves storing tables as blocks by column rather than by row. One advantage is that operations on a column of data can be carried out with very few I/O operations. Another is that since the column contains all data of the same type, it can be very easily compressed to a tiny fraction of its size by using indexing to eliminate duplicate values and then compressing the values themselves. Once that is done, any random select on the table will result in a very quick result because every column, in effect, is indexed. The index structures that define the columns can themselves be cross-indexed, further optimizing access.

- **Ability to partition data to enable rapid parallel processing and calculation on-the-fly using multicore processors.** A number of disk-based databases achieve scalability by partitioning the data across volumes. SAP HANA uses this technique to extend its data across servers in a cluster. This not only enables better parallel execution of data operations but also enables SAP HANA to scale to much larger data sizes than can be addressed by any single server. This approach also ensures recoverability because the data managed by one server is replicated to one or more other servers that can act as standby servers in case the primary server fails.

- **Near-zero latency between transactions and analytics with real-time replication of data from business systems.** Because there is no I/O involved, business systems can access data instantly in SAP HANA. The replication capability not only ensures failover capability (as described earlier) but also enables a high degree of data sharing among different applications and databases that use the same underlying data.

A primary enabler of real-time access and analysis of data and rapid response to changing business conditions is in-memory technology. Most enterprise data is managed on disk-based storage systems today. This has been the paradigm for data management since the 1960s and has served us well. But as the pace of business increases, keeping data on disk presents several obstacles to its efficient use:

- **Disk-based databases are optimized to move data between memory and disk, using a lot of computer instructions to do so.** This results in considerable processing overhead within a database server just to keep track of disk-based data. It has been estimated that over 90% of the instructions executed by a disk-based DBMS involve some aspect of the management of data on disk.
When disk-based data definitions are changed, the data must be unloaded and reloaded to convert it to the new format, and sometimes indexes must be rebuilt. All this takes staff and system time and results in a period during which the data is unavailable.

The data must be allocated to volumes, and if the distribution or size of the data set changes, it needs to be reallocated for efficient use. Such reallocation costs both staff and system time and can disrupt IT operations.

By contrast, in-memory databases require no disk management overhead, format changes can be supported in memory requiring no restructuring, and data does not need to be reallocated as it grows or as value distributions change. In addition, of course, in-memory databases require no I/O wait time, thus greatly increasing and smoothing data throughput. Over time a business will grow the volume of data under management. Then, as demand for timely access and analysis to that data increases, in-memory becomes an increasingly attractive alternative to disk-based systems.

CONCLUSION

During 2012, we’ll see exciting use of data visualization, interactive discovery, geospatial analytics, mobile analytics, and predictive analytics evaluating performance in real time — and that’s just from following coverage of the Summer Games in London. This should help to reinforce the need for organizations to reevaluate their existing IT systems for business analytics and operational optimization. Inevitably, in-memory technology for enterprises in private and public sectors will enable management to move its organization to the highest levels of competitiveness through “freedom of excess.” The performance-enhancing platforms that foster innovation, reduce IT compromises, and enable access to information by the right people at the right time will make it possible.