EXECUTIVE SUMMARY

Digital data is the new frontier. We are creating oceans of it as businesses, government agencies, and individuals interact across public and private networks around the globe. Some of the world's most successful companies owe their success, in part, to the innovative strategies they have developed for accessing, managing, and using select portions of that data to identify opportunities, make better business decisions, and deliver personalized customer experiences.

Innovations are occurring on many fronts to help businesses manage the rising flood of data and use it more effectively. Some of these innovations build on traditional relational database technologies to make use of the rich capabilities of mature solutions. Others take advantage of new database paradigms to meet more extreme requirements. Based on these advances, vendors are delivering new database and analytics solutions that can handle massive data volumes and deliver insights across the enterprise in real-time or near-real-time.

This white paper discusses the opportunities and challenges businesses face in this new world of massive data sets and real-time, data-driven business processes. It explores key technologies and solutions that are changing the landscape of information management. It also outlines the role Intel architecture-based server, storage, and client platforms are playing in enabling enterprise analytics solutions that are more scalable, flexible, energy-efficient, and secure.

Insight Everywhere—the New Business Imperative

Digital data is being created at almost unimaginable rates, and the floodgates continue to open wider. Over the next few years, another billion users will be connecting to the Internet with more and smarter devices, driving online transactions—and the data they generate—to ever-higher levels. The flow of digital information within and between businesses is also growing rapidly. Many companies are integrating sensors into their products and processes, creating new sources of high-volume data flow. According to the McKinsey Global Institute, there are already more than 30 million networked sensor nodes and the number is increasing by more than 30 percent per year.²

All this data holds tremendous potential value. Businesses that can identify, access, filter, analyze, and use select portions of this data effectively will gain powerful business advantages. We already see this strategy at work on the Internet, as some of the world's most successful retailers aggregate and analyze data in real-time to provide information and offers tailored to each visitor.

This move toward real-time, data-driven processes is a revolution in the way companies do business. Online sales and marketing represent the first wave of integration, but the potential value spans the full spectrum of business operations—from optimizing product designs and supply chain operations to establishing and nurturing high-value, personalized relationships with customers. The opportunities are vast, yet there are key challenges that every business will have to overcome.
Three Key Challenges for Next-Generation Analytics

In today's digital world, businesses that want to master the flow of information have to address three key challenges: the explosive growth in data volumes, the need to analyze those growing volumes in real-time, and the need to deliver the resulting insights to users and applications throughout the value chain.

Challenge 1: Explosive Data Growth

To provide some quantitative perspective, IDC is predicting a 44× increase in digital data over the next 10 years.² This growth will occur across a wide range of data types. Core business applications, such as enterprise resource planning (ERP), customer resource management (CRM), and online transaction processing (OLTP) applications, are extending their reach in the enterprise. In the process, they are churning out ever-more data. Growth is even faster for unstructured data, such as that residing in text documents, spreadsheets, emails, and multimedia files. Even larger volumes of unstructured data are coming from social networks, such as Facebook and Twitter, and extensive processing is required to glean insights from these low-density information sources. Over time, new data types and structures will enter the mix, adding to both the scale and complexity of the data management challenge.

Already, many data sets are exceeding the volumes that can be handled by traditional relational database management systems (RDBMS). New technologies and solutions are emerging to handle this “Big Data.” Businesses will have to navigate the many possibilities and determine an appropriate overall strategy for meeting rapidly growing requirements.

Challenge 2: Real-Time Analysis

Insight is useless if it comes too late and a fraction of a second can mean the difference between success and failure in many online scenarios. In fully-automated transactions, such as high-volume financial trading and risk management systems, timing is even more sensitive, and growing regulatory requirements mean banks have to churn through more and more data. To enable real-time, data-driven business decisions within such high-speed business processes, there is a movement toward transactional and analytical concurrency. The goal is to provide insight instantly and in context to improve outcomes.

As part of this move toward real-time analysis, there’s a demand for solutions that can take all threads of information, gather them together, and identify trends and opportunities. Some businesses are developing such solutions to enhance their own business processes. Others are developing them as a core competence, so they can provide data-driven insights to other businesses as a service.

Traditional analytics solutions are not designed to deliver insights in real time. Data must first be stored in a database, and, in many cases, moved into a separate data warehouse or data mart. Only then can it be subjected to analysis. Although this model will continue to be important across many analytics scenarios, particularly those requiring deep analysis, it is too slow for real-time requirements. New technologies and solutions are already entering the marketplace to enable faster analyses.

Challenge 3: The Democratization of Analytics

Gleaning insights rapidly from all pertinent data sources is only half the battle. The other half is delivering those insights where, when, and how they are needed to maximize business value. In some cases, the insights must be delivered to people. In others, they must be delivered to other systems or applications to support automated processes.

Analytics applications are being refined to address these requirements. Increasingly, they are designed to support a broad range of users, using customizable tools and interfaces optimized for individuals with diverse needs and skills, from professional data analysts and business managers to sales and service personnel.

The goal is to enable everyone in the enterprise to get the information they need, either by directly querying available data or by receiving information and analyses that have been generated by others.

Integrated tools for automating and optimizing the flow of information are adding to these advances, helping businesses get better value from their data throughout their unique value processes. Businesses will have to keep pace with their competitors as information management becomes increasingly critical to success across diverse industries. The power and flexibility of the IT infrastructure will be important to keep pace with growing requirements. Governance will be equally important to mitigate risk and to ensure investments and solutions are well aligned with business needs.

Emerging Solutions Deliver Speed, Scale, and Value

Database and analytics technologies and solutions are evolving to meet today’s challenges and to support a growing array of data sources (Figure 1). Some of the most important advances are described below.

Innovations in Traditional Database Solutions

Traditional RDBMS solutions will continue to provide the foundation for addressing many enterprise information needs. Key innovations are emerging to support larger data volumes and more time-sensitive analytics scenarios.

• In-Memory Databases. Over the years, storage performance has lagged far behind processor performance. As a result, data access latencies have become a common source of performance bottlenecks in today’s transactional and analytics applications. Recent innovations, such as massively parallel storage architectures and Intel® Solid State Drives, help to address this issue by accelerating data access. Major performance gains are also provided by the new generation of in-memory database solutions. Maintaining data and
key components of the application software in system memory dramatically reduces the need for disk access and enables order-of-magnitude performance improvements.

• In-Database Analytics. With in-database analytics, queries are performed directly on data residing within the database. This eliminates the delays associated with moving data from a data warehouse into a separate analytics system. It can also help to reduce infrastructure and administrative cost and complexity.

• Columnar Database Structures. In a traditional RDBMS, data is accessed by rows. This is a good approach for online transaction processing, but columnar structures enable much faster access to the kinds of data that are typically used in searches and queries.

Open Source Big Data Solutions

New approaches to big data are emerging from the open source community. In general, these solutions are designed to address the same challenges dealt with by emerging RDMS innovations. However, they tend to take a more relaxed approach to data persistence and durability, which may be appropriate in many big data scenarios.

Among the most promising open source big data solutions are distributed RDBMS and No-SQL solutions (such as Hadoop*), both of which use a distributed file system (DFS) to spread data and analytical operations across horizontally scaled server and storage architectures. This distributed approach enables fast performance for complex analytics through massively parallel processing. It also allows database capacity and performance to be scaled incrementally through the addition of more server and storage nodes.

These distributed solutions, which include graph-oriented trend identification, can operate in isolation. Alternatively, they can be integrated with traditional RDMS systems to orchestrate data management and analysis. Businesses looking for ways to handle big data will need to understand the advantages and disadvantages of the different options and implement solutions that best match their policy, persistence, governance, and service level requirements. A key first step is to assess key data types and data feeds and determine the insights desired from each domain.

Advanced Data Delivery and Data Management Functionality

Software innovation is taking place across the analytics solution stack to deliver increasing functionality, better security, and higher value. Key areas of advancement include the following:

• Improved support for secure and compliant data transformations and transfers
• Enhanced analytics algorithms to provide better and faster insights and to operate more efficiently on large data sets
• Tailored visualization to help diverse users understand analytics results more quickly and clearly
• Tighter data compression ratios to improve storage utilization

Pre-Packaged Analytics Solutions

Accessing, managing, and analyzing vast amounts of data is a tough challenge on many levels, and most companies lack the in-house expertise to build high-value solutions from the ground up. Not surprisingly, vendors are stepping in to fill the need in a variety of ways.

• Optimized Analytics Appliances. A number of vendors are developing purpose-built analytics appliances that are engineered specifically to enable fast analytics on large data volumes. These optimized appliances can be deployed quickly and with reduced risk. They often deliver substantial benefits in terms of integration, performance, scalability, and ease of use.

• Industry Solutions. Many vendors are developing data and analytics solutions targeting the needs of specific industries, such as healthcare, energy, manufacturing, and retail. Purpose-built hardware and software help to address specific industry challenges, while eliminating or greatly reducing the cost and complexity of in-house development.

• Data and Insight as a Service. Perhaps the most transformative value will ultimately come from vendors who provide their customers with data or analytics as a service. Value can be delivered in a variety of ways, from identifying, aggregating, qualifying, storing, and delivering raw data, to providing insights tailored to the needs of a particular business or to specific individuals and processes within that business. This is not a new idea. Companies have been offloading data-intensive tasks to qualified service providers for many years. However, we are entering a new era of data exchange and can expect to see explosive growth in the scale, complexity, and value of these interactions. Cloud computing models will help to accelerate this trend, providing new flexibility and efficiencies for accessing data and sharing insights.

Figure 1. Business analytics is expanding to encompass more data sources, including text, voice, video, and sensor data aggregated both from within the business and from across the Internet.
The Need for a Comprehensive Information Strategy

Until recently, businesses have tended to deploy point solutions for analytics, delivering insights in targeted areas to meet particular needs. Now many companies are developing and implementing comprehensive strategies for optimizing the total value of enterprise data. Point solutions may continue to be important, but integrating them into a larger insight framework will help businesses plan more effectively and get better value from their investments.

Because information-focused technologies and usage models are changing so fast, and because enterprise data and information flow is so complex, there are a great many issues to consider. At a high level, businesses will need to consider the following areas.

- **Capturing and extracting data** from qualified and trusted sources, including structured and unstructured data. Since the amount of data businesses generate is more than they can retain, careful attention must be paid to the full information lifecycle, and priority given to the most critical and valuable data.
- **Managing and controlling data workloads, access, and storage** under comprehensive policy and governance guidelines. New “big data” solutions (based on Hadoop or other distributed database technologies) must be integrated with traditional corporate database and analytics solutions within a consistent framework to maximize overall value (Figure 2). With evolving and increasingly global business models, governance issues will become more complex. Efficient, automated, policy-based tools will be essential.
- **Performing integration, analysis, weave processing, transformation, and visualization** to deliver insights where, when, and how they deliver maximum value to the business. This includes the integration of data and insights at many levels of operation based on complex event processing (CEP).

The key levels to consider include data generation (point of capture), data transformation, data delivery, data integration (at the edge of the corporate network), and the points immediately before and after incorporation into structured databases. Ultimately, businesses will need to be able to integrate analytics at all these levels to balance the need for speed against the volume of data and the value of in-depth analysis.

Intel at the Core of Next-Generation Analytics

Businesses have traditionally deployed large, proprietary server and storage architectures for enterprise database and analytics applications. This approach worked when data volumes were growing at a slower pace and when data management and analytics requirements were not changing so rapidly.

More flexible and cost-effective solutions are needed to address the immense and constantly growing requirements of current and next-generation business analytics. That’s why database and analytics vendors and their customers are increasingly relying on Intel architecture at every tier of their solutions, from data delivery, to data management, to data usage.

Intel has been focused on these trends for some time and has integrated an array of technologies to help customers address current and future needs across the full range of analytics requirements at both the data delivery and data management tiers (Figure 3, Table 1).

Intel is working with established and emerging solution providers to help them make optimal use of Intel technologies to improve performance, throughput, reliability, and security across diverse data delivery, management, and usage models. This helps to ensure that customers have flexible choices for growing their database and analytics infrastructure and for structuring and transforming their data to support specific business, social, and ecological goals. With this broad support, they can integrate data of any type and from any location into their insight framework. Core solution requirements, and the value delivered by key Intel technologies, are described below.

**Data Delivery**

Managing enterprise data flows requires high performance infrastructure solutions that are efficient, flexible, secure, and easily adaptable. Intel architecture addresses these requirements across server, storage and client platforms.
Data Efficiency
Handling data efficiently is essential to keep performance high and costs contained for fast-growing enterprise analytics solutions. Intel® Xeon® processors deliver efficient data processing in a variety of ways. The Intel multi-threaded architecture combines with fast per-core response times to provide high-throughput with low latency so data flows more quickly. Intel Xeon processors also provide industry-leading energy-efficiency, which helps to contain costs and simplify data center buildout.

Intel® Intelligent Node Manager and Intel® Data Center Manager add to these advantages by enabling IT to monitor and control server power at all levels, from individual servers, to racks, rows, and entire data centers. These software tools integrate with leading management frameworks and can be used to increase rack densities, adjust cooling based on actual demand, and dynamically balance resources. The result is more computing performance and faster data flows at lower cost.

Data Workload Control and Resource Automation
Data workloads can vary greatly over time, so the ability to scale infrastructure is important to maintain performance. Intel manageability functions simplify resource management in virtualized and cloud environments, providing a foundation for elastic and transparent scalability to meet changing requirements efficiently. Intel Xeon processor-based servers also provide a high level of control efficiency through the broad availability of management software that is optimized for Intel multi-threaded architecture.

Data Access and Storage
Analytics and business intelligence applications typically have fast and secure authentication methods. Intel provides two technologies to strengthen this protection. Intel AES-NI enables pervasive data encryption, as already described. Lost and stolen laptops are among the most common sources of data breaches, and 2nd generation Intel Core processors include Intel® Anti-Theft Technology (Intel® AT) to help keep data safe. With this technology, a laptop can be automatically locked down after a certain number of failed logins or a failure to check in with a central server. A missing laptop can also be locked down remotely with a “poison pill” sent through the cloud. By reducing the risk of a data breach, Intel AT allows businesses to use their information more freely to provide business value in mobile scenarios.

Intel vPro™ technology provides additional protections for the client infrastructure. With compatible management applications, it enables IT to remotely monitor and proactively update client software, even when systems are shut down or an operating system or hard drive has crashed. These capabilities can be used to accelerate patch distribution and provide verification that all PCs have been updated. As a result, IT can maintain secure client configurations more effectively to further reduce the risk of data loss.

Data Trust and Security
High-value analytics requires the rapid movement and broad usage of business data, which introduces risks that must be mitigated. Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI) provides hardware acceleration for encryption and decryption using the AES encryption standard, which is supported in leading operating systems, databases, and analytics applications. This technology enables encryption to be used pervasively to protect network traffic, personal data, and corporate IT infrastructure, without slowing down applications or overloading servers. Intel AES-NI is supported both in Intel Xeon processors and in 2nd generation Intel Core™ processors, so encryption can be extended across the insight framework, all the way from core databases to mobile clients.

Lost and stolen laptops are among the most common sources of data breaches, and 2nd generation Intel Core processors

Data Delivery
- Decision Support
- CRM
- ERP, OLTP, Batch
- Source Big Data

Data Management
- Intel Xeon
- Analysis Integration
- Query Transformation
- Data Marts

Data Usage
- Enterprise Perf.
- Management
- Business Strategy
- KPIs
- LOB Reporting

Intel Technology and Benefits
- Reliability, Availability, and Serviceability
  Intel® Machine Check Architecture-Recovery
- Power Management
  Intel® Intelligent Power Node Manager
- Performance
  Intel® Turbo Boost Technology
  Intel® Hyper-Threading Technology
  Intel® QuickPath Interconnect Technology
  Intel® Storage Solutions—Balancing Data Type and Capacity
  In-Memory Optimized Solutions

Endpoit Security
- Intel® Identity Protection
- Intel® Trusted Execution Technology
  Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI)

Figure 3. Intel has integrated an array of technologies to help customers address current and future needs across the full range of analytics requirements, including data delivery, management, and usage.
Intel® Identity Protection Technology (Intel® IPT) supports simple, strong, two-factor authentication to improve upon existing access-control solutions. The client system acts as a second security key (in addition to the user’s name and password). With this protection, only authorized PCs can be used to access internal networks and applications. Even if hackers were to steal or spoof a user’s name and password, they would not be able to gain access.

Scalable and efficient storage is another fundamental requirement for handling the rising flood of data and delivering it efficiently to users and applications. A number of advanced storage technologies have emerged to help address these requirements, such as thin provisioning, automated tiering, data deduplication, and compression. Other integrated storage capabilities, such as encryption and erasure code, help to protect data from corruption and tampering. These technologies add substantially to compute requirements in the storage infrastructure, which is why storage vendors have largely transitioned to Intel Xeon processors to provide better performance at lower cost.

Businesses need storage solutions that are capable of meeting the performance and capacity needs across a variety of usage models. At one extreme are the high performance requirements of online transaction processing (OLTP) and online analytical processing (OLAP). High performance is essential for these systems, so they tend to be based on large, multi-socket Intel Xeon processor-based servers with 10 Gigabit Ethernet support and fast, Intel® Solid State Drives (Intel® SSDs). On the other hand, storage solutions for big data analytics tend to have lower performance requirements, but higher capacity demands. A distributed storage architecture based on single-socket servers, single-core Intel Xeon processors, Gigabit Ethernet and high capacity SATA drives may be more appropriate in some cases.

The broad range of Intel Xeon processor-based storage solutions helps to simplify enterprise storage by making it easier to support all requirements on a common platform. IT can more easily match storage capabilities to application requirements. They can also take advantage of converged storage solutions that unify storage across multiple systems and storage technologies to address a wider range of performance and capacity requirements more efficiently.

Data Policy and Governance
Maintaining governance in an increasingly dynamic information environment is a tough challenge. Real-time analytics place particularly stringent performance requirements on the application suites used to manage data flow and policy. Performance-enhancing technologies, such as Intel® Hyper-Threading Technology (Intel® HT) and Intel® Turbo Boost Technology, provide high value for meeting these requirements. By automatically adapting to workloads, they help to deliver higher performance as needed to maintain effective governance as data flows become faster and more complex.

Data Tools and Maintenance
Database administrators and information analysts must be able to adapt their analytical models and data integration suites efficiently to keep pace with change. Development tools that have been optimized for Intel multi-threaded architecture allow for faster software development and higher performance to keep these efforts on track.

Data Management
Data management infrastructure must be powerful, scalable, and highly reliable to support growing workloads and increasingly stringent response-time windows, while delivering uninterrupted support to the business. The latest generation of Intel Xeon processor-based servers provides robust support for these mission-critical requirements.

Scalable Data Warehouse and Data Mart Solutions
Data warehouses and data marts will continue to play central roles in the enterprise analytics infrastructure, providing the deep analysis needed to get full value from business data. Trust and scale for these large, centralized solutions can be enhanced using the wide range of software solutions optimized for Intel multi-threaded architecture. Two-socket, four-socket, eight-socket, and larger servers based on the Intel® Xeon® processor E7-8800/4800/2800 product families provide particularly robust support for these demanding environments. With up to 80 cores, 160 threads, and 4 TB of memory in an eight-socket server, these processors deliver the high-end scalability needed to support growth. Intel® QuickPath Interconnect technology provides high-bandwidth, low-latency system communications to meet the heavy I/O requirements of database and analytics solutions running on these large, highly parallel system architectures.

The Intel Xeon processor E7-8800/4800/2800 product families also include advanced reliability technologies specifically designed to deliver the levels of data integrity and uptime needed for mission-critical database and analytics solutions. Error monitoring, correction, and containment are integrated across...
all key components and communications pathways to provide advanced data integrity and system resilience. Intel’s Machine Check Architecture-Recovery works in combination with leading operating systems to enable system recovery in more complex error scenarios.

Data Integration
In enterprise-wide analytics environments, data is gathered in disparate formats from many sources and must be processed and transferred quickly to accelerate insight delivery. Intel multi-threaded architecture supports fast, high-volume processing to speed integration. Intel Xeon processors also provide optimized support for in-memory solution constructs, which enable faster analytical processing of digital content.

Data Transformation
As with data integration, data transformation can involve large volumes of data and fast performance is important for accelerating time to insight. Intel Xeon processors support a variety of specialized instructions that enable faster ordering and formatting of qualified data structures. Intel Turbo Boost Technology adds to these advantages by delivering faster performance on-demand for peak workloads.

Data Analysis
Memory-intensive analytical workloads benefit from the integrated memory architecture of the Intel Xeon processor, which optimizes memory allocation and access across large numbers of processing cores. Fast, nearby memory is allocated to each core to accelerate throughput, yet memory resources are still shared efficiently across all cores. This leads to faster overall performance for complex business intelligence structures, such as those used for decision prediction.

Data Query and Query Processing
Fast response times for information analysis depend on high-performance across both the server and client infrastructure. Many of the technologies already discussed are included in both the Intel Xeon processor and the Intel Core processor to boost end-to-end performance. Key examples include Intel multi-threaded architecture and Intel Turbo Boost technology.

Table 1. Intel technologies deliver benefits across the full range of analytical workloads to help companies speed time to insight while handling ever-larger data volumes.

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Data Visualization

Analytics results can be quite complex. Many vendors are using advanced visualization technologies to present complex results in more intuitive formats, so users can quickly see relationships and understand implications. Intel® HD Graphics provides built-in support for responsive, high-definition visualization, so users get the full benefit of these new capabilities, without the added cost and complexity of dedicated graphics accelerators. For the most demanding scenarios, users can take advantage of Intel Xeon processor-based workstations with up to 12 processing cores and 192 GB of memory to deliver truly powerful analytics and visualization on the desktop.

Enterprise Solutions from a Broad Ecosystem of Vendors

Many hardware and software vendors are focused on delivering next-generation database and analytics solutions. Intel is strongly engaged with leaders throughout the ecosystem to ensure optimized support for Intel processor-based servers, storage systems, and PCs. These engagements help to improve integration and value across all aspects of the insight framework. Intel also works with select vendors to help them engineer optimized appliances and reference architectures that let customers deploy new solutions faster, at lower cost, and with less risk.

Ongoing innovation will be essential to support exploding data volumes and increasing analytics needs. Intel plays a central role in developing key technologies and working with vendors and standards-bodies to ensure broad adoption. Integrating these forward-thinking technologies into silicon helps to ensure that each new Intel product generation delivers not only better performance and scalability, but also new features that provide additional value across critical requirements. As businesses deploy Intel processor-based servers, storage systems, and PCs, they automatically lay a foundation for advanced functionality that will help them meet next-generation needs.

Conclusion

We are in the midst of a revolution in the way companies access, manage, and use data. Simply keeping up with the explosive growth in data volumes will be an ongoing challenge, yet the true winners will be those that master the flow of information and the use of analytics throughout their value chain. Innovations are emerging to enable deeper and faster analytics and to handle massive and growing data volumes without breaking IT budgets.

Intel architecture lies at the heart of these innovations, providing the robust capabilities needed for mission-critical database and analytics solutions, along with the flexibility to support the full range of requirements. Generation-to-generation performance gains provide a reliable foundation for growth, and an array of built-in technologies help customers address performance, reliability, and security needs more easily and cost-effectively. In a world where opportunities and challenges are in constant flux, there is no better foundation for success.