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White Paper

IBM POWER8: Performance and Cost Advantages in Business Intelligence Systems

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Executive Summary

Business intelligence systems facilitate the collecting, organizing, exploring, and analyzing of massive amounts of data. They enable decision-makers at every level to work, individually or as teams, to visualize information and act in support of business objectives. The systems required for these efforts are based on the most advanced technologies available, such as the new IBM POWER8 microprocessor, the most recent addition to the continuously evolving IBM POWER series. With core performance rivaling two times that of the POWER7, the POWER8 processor has been designed with business intelligence, big data, and analytic applications in mind. This white paper presents the operational, financial, and technological advantages of running business intelligence workloads in a POWER environment using IBM DB2 solutions, versus an x86 environment and traditional relational database solutions.

By using the POWER8 processor in conjunction with IBM Cognos Business Intelligence (Cognos BI) with Dynamic Cubes and IBM DB2 with BLU Acceleration, a telecommunications analytics workload typical of many business intelligence applications was run against the combination of Intel's latest processor, the x86 Ivy Bridge, and traditional relational database technology. This testing demonstrated that IBM POWER technology in combination with DB2 with BLU Acceleration delivers business insights 50 times faster than Intel's latest processor and relational database technology. For results requiring complex business insights, IBM's advantage was even more dramatic. More than two hours was needed by the x86 system to produce a single business intelligence report defined as complex, while the POWER based system was able to complete 202 complex reports per hour.

Overall business value, total cost of acquisition (TCA) and total cost of ownership (TCO) for both configurations were also evaluated. The lower total cost of both acquisition and ownership is impressive, and even more so when considered along with the value delivered by POWER based on price/performance ratios.

Based on the operational, financial, and technological advantages of IBM Power Systems running DB2 with BLU Acceleration, users currently running x86 environments should consider switching to IBM, and users of legacy POWER and DB2 implementations should consider upgrading to the latest Power Systems, and to DB2 with BLU acceleration.

Introduction

Audience

This white paper is intended for IT and line-of-business executives and managers responsible for evaluating, purchasing, acquiring, financing, deploying, and making business operations decisions associated with Business Intelligence analytic applications.

Business Intelligence is Business-Critical

As more and more data continues to become available for analysis, the need for high-performance, diverse, and sophisticated Business Intelligence (BI) tools is more demanding than ever before. Data sources now include a wide range of business data from a myriad of internal and external sources, as well as from user- and machine-behavior patterns characterized by web logs, GPS information, computers, social media, and more. This data is being tracked, stored, examined, analyzed, and reported in a variety of ways within the enterprise.

The information is used for strategic purposes including the following:

- To monitor and improve existing business processes
- To provide better customer service
- To head off outages and failures to deliver
- To identify and act on immediate and short-term opportunities that would otherwise go unexploited
- To provide real-time responses to both internal and external consumers of information
- To discover and invent new ways of doing things

The variety, volume, and speed of acquiring data, coupled with the many applications inherent in strategic and tactical BI systems, have created new demands for existing systems. The pressure is on for innovative systems to exploit new technologies, such as those available in IBM's big data and analytics solutions framework (Framework) and the POWER8 microprocessor architecture.

Traditional business intelligence is generally characterized by data stored in relational database systems, and analyzed and reported on using a variety of BI tools. These

systems are used for routine reporting of business activities to ensure that strategic imperatives are met, as well as for tracking and measuring the success of specific programs. They are also used for ad hoc inquiries, in making tactical decisions, and to explore the data for valuable information not typically extracted in the normal course of business.

IBM has been and continues to be a leader in providing business intelligence technologies, including POWER-based servers, IBM Cognos for BI analytics and reporting, and IBM DB2 for data management.

The IBM POWER8 Microprocessor

Since its inception, the POWER series has logged a number of firsts in microprocessor capabilities, including out-of-order execution, multi-core design, simultaneous multithreading, and other advanced capabilities. The IBM POWER8 processor is the latest in the POWER processor series. It is designed specifically to address the processing and analytic demands of BI and Big Data applications

With the introduction of POWER8, IBM has raised the bar in enterprise microprocessor design again. Among the key improvements is the change from the 32-nanometer processors used for the POWER7+ chips to 22-nanometer processors. This allows for higher clock rates while still conserving power. The IBM POWER8 processors are capable of delivering up to 5.5GHz clocking, but will be available in a variety of clock rates, including a 4GHz version.

The IBM POWER8 microprocessor also provides up to eight threads per core across the 12 cores in the chip, providing a total of 96 threads of coherent execution. The cores have significantly improved branch prediction, and pre-fetching of instructions and data. Based on actual execution patterns, cores will step down the threading and run it with one, two, or four processor threads to conserve power and boost thread performance. These enhancements make the POWER8 microprocessor a superior choice for managing relational and unstructured workloads that require highly parallel execution while ensuring efficiency in power consumption.

Extensive improvements in data transfer rates, memory bandwidth, and caching design allow for data to be streamed more effectively from persistent storage, to and between microprocessor cores and main memory.[1] As part of the IBM POWER8 architecture, IBM is introducing the new Centaur memory buffer/controller chip.[2] Each IBM POWER8 chip can have up to eight Centaur chips, for a total of 128MB of L4 cache in a fully loaded socket. This provides a cost effective upgrade path to DDR4.

[1] At 64KB, the IBM POWER8 core has twice as much L1 data cache compared to the IBM POWER7 series. Data buses from L1 to L2 cache on the die are now twice as wide, at 64 bytes. At a 4GHz clock speed, data moves from L4 cache to L3 at 128GB/sec and from the L3 cache out to L4 at 64GB/sec. Data transfers between L2 and L3 cache are at 128GB/sec. Finally, data from the L2 cache gets to the cores at 256GB/sec.

[2] The Centaur chip is implementing DDR3 main memory, but can support DDR4 without upgrading the IBM POWER8 microprocessors. The link between the IBM POWER8 microprocessor and the Centaur chip has only a 40-nanosecond latency and provides 9.6GB/sec of bandwidth.

The IBM POWER8 microprocessor also features PCI-Express 3.0 controllers directly on the die, a coherent memory protocol to external accelerators, and a new cache hierarchy that goes all the way to the L4 cache. The PCI-Express ports have an aggregate of 48GB/sec of I/O bandwidth, significantly more than the 20GB/sec of its predecessor the POWER7. The PCI-Express controllers can also be used to implement the IBM Coherent Accelerator Processor Interface, or CAPI, which allows accelerators plugged into the PCI bus of a system to access data in main memory, just like the processor cores. The more than doubling of the I/O bandwidth allows for faster data transfer from persistent storage to and from the POWER8 cores for data processing. The addition of CAPI paves the way for data processing accelerators based on alternative technologies like GPU, FPGA, and specialized ASICs for acceleration of specific workloads.

POWER8 and IBM Big Data and Analytics Solutions Framework

IBM's big data and analytics solutions integrate a best-of-breed stack of integrated and cross-functioning IBM hardware and software. Together, they support advanced analytical applications including business intelligence reporting, data searching, visualization, and analysis, generic and industry-related applications, predictive analytics, and content analytics. Since the IBM POWER8 product line is optimized for big data and analytics performance, it is an ideal hardware environment for all of the IBM big data and analytic workloads shown in Figure 1.

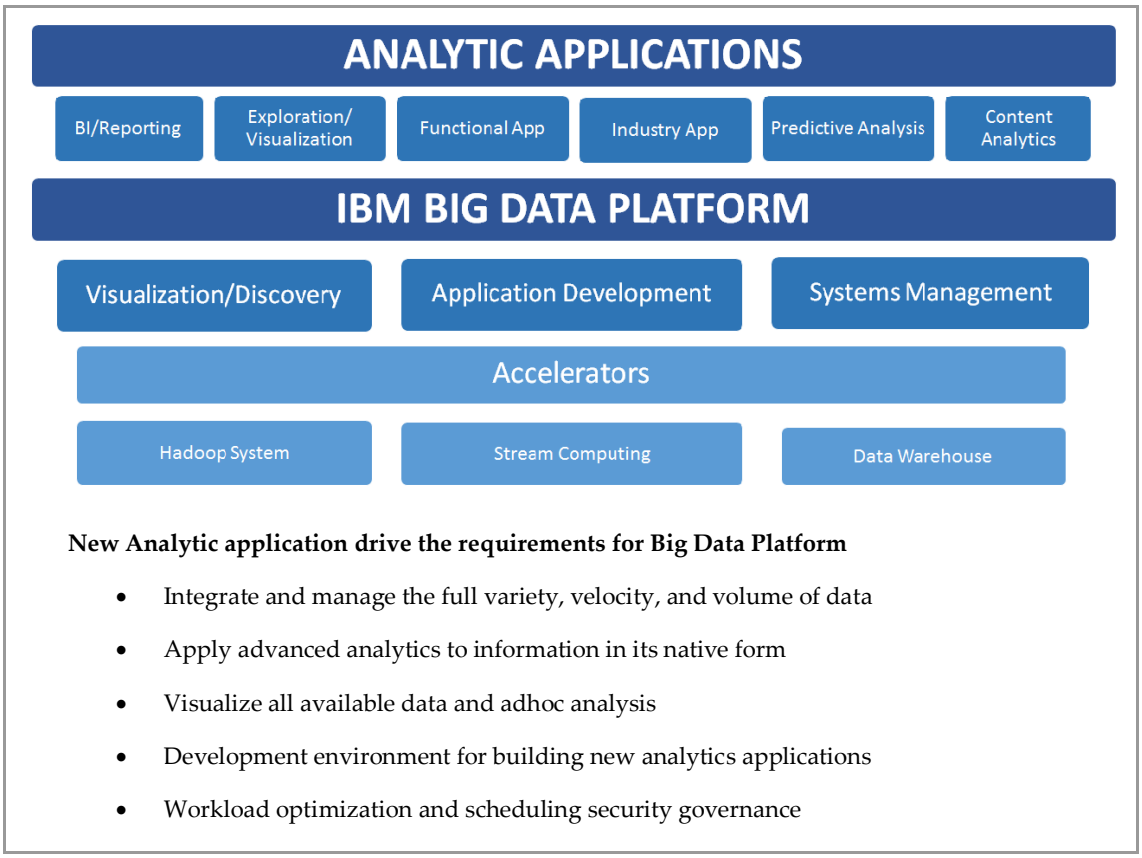

Figure 1: The IBM Big Data and Analytics Solutions Framework

Two key IBM products, IBM Cognos Business Intelligence, and IBM DB2 with BLU Acceleration are highlighted in this paper. A brief overview of each follows.

IBM Cognos Business Intelligence

IBM Cognos Business Intelligence (Cognos BI) provides a unified workspace for business intelligence and analytics. This highly advanced business intelligence tool enables business analysts and decision-makers to assemble and analyze huge quantities of data, with the ability to create a wide variety of custom reports and data visualizations. This enables business executives to make a wide variety of timely, fact-based strategic and tactical decisions and recommendations to drive business plans and forecasts. Popular BI applications include: personal productivity planning, pricing, risk and credit analysis, transportation analytics, call center management, workforce management, supply chain management and procurement, marketing automation, sales force management, and financial management. In most enterprises, and with most applications, the ability to integrate with Enterprise Resource Planning (ERP) systems is a high priority, as well.

Using IBM Cognos BI, reports can be made available on mobile devices, within office applications, or as part of embedded business intelligence systems. Data visualizations can be easily added. Virtually all types of data can be accessed. Performance metrics and other business information can be viewed in tables, graphs, or charts, depending on user preferences. Sophisticated analytical capabilities enable users to assess business situations with advanced, predictive, and what-if analysis. Information can be viewed by cross-enterprise teams who can participate in decision-making, evaluations, and assessments. A user-friendly interface provides the ability to merge external data with dimensional and relational sources, without the help of IT professionals. Comprehensive data analysis and what-if testing can be used to support strategies and hypotheses.

IBM Cognos BI provides support for all popular data warehouse and Big Data sources. A single, integrated platform can be used to consolidate data and Big Data from multiple sources such as Hadoop environments, personal data, spreadsheets, ERP systems, and all pertinent IBM applications.

To accelerate performance, IBM Cognos BI adds the concept of Dynamic Cubes, (an in-memory relational Online Analytical Processing (OLAP) component) to a dynamic query-mode server. This provides a multidimensional view of relational data warehouses. OLAP analyses are then able to exploit a Cognos Dynamic Cubes server, which also provides increased scalability, the ability to share data and a more robust set of modeling options.

IBM DB2 with BLU Acceleration

BLU Acceleration is included in the most recent release of IBM DB2 and is an enhancement to the designed to greatly improve DB2 and its ability to handle Big Data and complex business intelligence analytic queries. BLU Acceleration is an in-memory database that dramatically improves query, analytical, and reporting speeds. This enables business decisions based on business intelligence, Big Data, and analytics to be made faster and with greater confidence than ever before. For example, compared to DB2 alone, DB2 with BLU Acceleration offers eight to 25 times faster reporting and analytics speeds on the same platform. Moreover, there have been cases where queries have been answered more than 1,000 times faster than with traditional relational database technologies.[3] And, as a significant ancillary benefit, IT organizations have reduced storage costs due to substantially lower storage requirements.

Combined with the new IBM POWER8 microprocessors, DB2 with BLU Acceleration offers a superior choice in data management technology for BI applications. For example, BLU Acceleration complements the in-memory Dynamic Cubes concept available in IBM Cognos BI, yielding an average of 38 times faster query performance.[4]

DB2 with BLU Acceleration can be deployed on existing IT infrastructures without complex changes to hardware configurations. An Advanced Workload Management capability supports more concurrent users at higher service levels for a wider range of queries. In contrast to DB2 alone, this yields a higher performance environment for transactional and analytics applications. The key features of DB2 with BLU Acceleration are:

- **Dynamic In-Memory Processing**: Enables processing of data at in-memory speed even when data does not fit entirely in memory. Pre-fetches and streams data into its processing engine. Uses in-CPU memory optimization techniques. There are no limits to data size.

- **Actionable Compression**: Encoded compression enables comparative operations without the need to decompress the data. Incorporates highly efficient use of CPU memory and registers, which speeds up evaluations, reduces memory requirements, and lowers overall query-processing requirements.

[3] http://public.dhe.ibm.com/common/ssi/ecm/en/imd14435usen/IMD14435USEN.PDF

[4] Performance is based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon many factors, including considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve results similar to those stated here.

- **Parallel Vector Processing**: Extends the parallel processing capabilities of DB2 to allow vectors of values to be evaluated in parallel. This enables the evaluation of up to 128 values in a single instruction. Uses all available processor cores, CPU memory, and threads for maximum parallelization and throughput. Fully exploits the superior in-memory architecture of IBM Power Systems.

- **Data Skipping**: Eliminates the need to read and evaluate each entire block of data. Only the blocks of data essential to answering the query are examined. Allows the total data requirement to scale without requiring a corresponding increase in memory or processor resources.

The speed and method of deploying DB2 with BLU Acceleration is left to the customer's discretion. Based on business requirements and resource availability, users can choose to convert one table at a time or convert all tables to column-based BLU tables. Either way, DB2 with BLU Acceleration includes tools that help assess the performance benefits of using BLU tables.

Accommodating Relational Databases

DB2 with BLU Acceleration can also be used in conjunction with traditional relational databases. In these environments it is recommended that the traditional databases continue be used for transaction processing, but that the data be extracted from these databases, and moved onto an IBM POWER8 system hosting DB2 with BLU Acceleration for use in BI applications.

In cases where the enterprise continues to operate in conjunction with traditional relational databases, the cost/benefit tradeoff must be evaluated further. For example, if the enterprise already has DB2 with BLU Acceleration available, the benefits can be readily realized. The improvement in query performance would justify the cost of extracting and re-loading the data.

There are time and cost savings associated with querying the DB2 with BLU Acceleration database, versus the traditional database. The improvement in competitive advantage, business operations, profitability, sales, and a host of other business considerations should provide compelling advantages to add DB2 with BLU Acceleration.

Performance Comparison: Business Intelligence Application

Competing Systems

The tables below show the configurations of the systems used in the comparison. Each configuration consists of a database server and an application server. The systems are equal in CPU core count, RAM, storage, and other peripherals. All cores were licensed during performance testing to measure a range of performance test points.

Database System Components	IBM POWER8 System	HP ProLiant DL380p
Chassis	IBM Power System S824	HP ProLiant DL380p Gen8
Processor	24 cores (2 x 12-core 3.4 GHz POWER8 Processor Module)	24 cores (2 x 12 core 2.7 GHz Intel Xeon E5-2697v2 processor)
RAM	256 GB (8 x 32GB)	256 GB (16 x 16GB)
Storage: Magnetic	2 x 1 TB 15K RPM SFF SAS Disk Drives Internal DS3500 with 24 x 300 GB 10K RPM SFF SAS Disk Drives External	4 x 300GB 15K RPM SFF SAS Disk Drives Internal V5000 with 24 x 600GB 10K RPM SFF SAS Disk Drives External
Fibre Channel	PCIe LP 8Gb 2-Port Fibre Channel Adapter	PCIe LP 8Gb 2-Port Fibre Channel Adapter
Network Adapter	PCIe2 LP 4-port 10GbE Adapter	HP Ethernet 10Gb 4-port Adaptor
Operating System	AIX 7.1 TL03 SP02	SuSE Enterprise Linux 11 SP3
Database	DB2 10.5 AESE with BLU Acceleration	Competitor Traditional row-store database

Table 1: Database Server Hardware and Software Configurations

BI & CM System Components	IBM POWER8 System	HP ProLiant DL380p
Chassis	IBM Power System S822L	HP ProLiant DL380p Gen8
Processor	20 cores, 16 cores active (2 x 10-core 3.4 GHz POWER8 Processor Module)	16 cores (2 x 8 core 3.3 Ghz Intel Xeon E5-2667v2 processor)
RAM	256GB (8 x 32GB)	256GB (16 x 16GB)
Storage: Magnetic	2 x 1 TB 15K RPM SFF SAS Disk Drives	4 x 300GB SAS 15K SFF hot-plug Smart Drive SC Enterprise disk drive (2.5")
Operating System	SuSE Enterprise Linux 11 SP3	SuSE Enterprise Linux 11 SP3
Application Software	Cognos BI Server 10.2.1 FP1	Cognos BI Server 10.2.1 FP1

Table 2: Business Intelligence Application Server Hardware and Software Configurations

For the purposes of benchmark testing, 16 cores were used on both IBM Cognos BI systems and all available cores were used on the database systems. Administrator utilities of the virtualization software were used to control the number of physical cores actually used during each benchmark run.

The Business Intelligence Benchmark

Benchmark tests were conducted to characterize IBM POWER8-based systems in addressing the requirements of advanced business intelligence systems. The business intelligence workload benchmark compared IBM Power Systems running IBM Cognos BI Server 10.2.1, using the latest analytic database acceleration product from IBM: IBM DB2 with BLU Acceleration 10.5 to a competitive stack that used HP ProLiant Gen8 running IBM Cognos BI Server 10.2.1 and a relational database.

The Business Intelligence Workload: Application Criteria

The business intelligence workload benchmark was based on 60 concurrent users querying 2.6 terabytes of data modeled on real-world usage. The data contained information about network and handset performance, customer experiences and behavior, and other transactional and operational facts. The benchmark was designed around the generation of 60 typical business intelligence reports, to support strategic and tactical business decisions based on the data. Of these reports, 70 percent were defined as simple, 25 percent were intermediate, and 5 percent were defined as complex, based on the relative complexity of the query workload and expected demands on the databases providing the query results.

Each report was based on one or more SQL queries that queried a fact table and joined one or more dimension tables. Simple SQL queries addressed a small range of data (e.g., one week of data) and a limited number of joined dimension tables. Intermediate SQL queries were designed to query a moderate amount of data that covered a longer time frame (e.g. one quarter to one year), and involved more joins and statement complexity. Complex SQL queries addressed a large number of tables and joins that generally involved the entire fact table.

The business intelligence benchmark was designed to simulate the activity of 60 users by continuously submitting a report request stream for the duration of the benchmark test. As each report request completed, two seconds of "think time" were allowed to lapse before submitting the next report request. The benchmark was run continuously for two hours; then the report request stream was turned off. The system was then permitted to run until all the report requests were completed.

The Business Intelligence Workload: Results

The benchmark measurement is based on the number of reports generated per hour, as well as an average of the query execution time that each system was able to achieve. Performance improvement figures are cumulative over all queries in the workload. Overall, the IBM POWER8 based solution achieved performance of more than 50 times greater than the competitive stack.

Business Intelligence Workload Benchmark Results (Concurrency Test based on 60 Concurrent Users)				
	System	**Simple Query**	**Intermediate Query**	**Complex Query**
Number of Reports Generated per Hour	IBM POWER8	42,750	7,408	202
	Intel x86 Ivy Bridge	2,267	184	0.27
Report Generation Performance Ratio		18x	40x	747x

Table 3: Comparisons of Simple, Intermediate, and Complex Reports Generated per Hour

The following conclusions were drawn from the results displayed in Table 3:

- Eighteen times more simple reports were generated on the IBM POWER8 system
- Forty times more intermediate reports were generated on the IBM POWER8 system
- Seven hundred forty-seven times more complex reports were generated on the IBM POWER8 system
- The Intel x86 Ivy Bridge systems needed more than two hours to generate a single complete complex report. In stark contrast, the IBM POWER8 system was able to generate 202 complex reports per hour

TCA and TCO Analyses

Introduction

TCA (Total Cost of Acquisition) analysis captures the out-of-pocket costs incurred at the time of purchase, including upfront costs for initial maintenance contracts. TCO (Total Cost of Ownership) analysis reviews all of the costs involved in the acquisition, installation, licensing, maintenance, and bricks-and-mortar infrastructure needs of a server solution, for a fixed period of time. These TCA and TCO analyses compare IBM Power 8 Servers to HP ProLiant DL380p servers for the solutions benchmarked in this paper.

Total Cost of Acquisition and Ownership

With TCA, there is no accounting treatment of, and therefore no need to differentiate, the cost components into capital and/or operating categories. In the case of multi-year maintenance agreements, the full cost of the contract has to be paid up front, so it is included as a part of the TCA. Rents, power, and personnel are not included, as they are paid as a part of daily operations, not upfront.

For this study, TCO consists of the costs for software and hardware support and maintenance not purchased at acquisition time, and the costs for rent, power and personnel.

Analysis

Edison's analysis revealed that the acquisition costs of the complete IBM solution to be $286,848 – 65 percent less than the HP x86 solution, which comes in at $828,794. Similarly, the IBM solution's total TCA/TCO over three years is $373,171 – 67 percent less than the HP x86 solution, which comes in at $1,127,074.

Price/Performance

In addition to the threefold cost of ownership advantage, the value delivered by POWER8-based systems is exceptional when considered from the perspective of price/performance ratios. Given the workload of the business intelligence benchmark, the IBM POWER8 system provides huge cost per transaction savings over the HP ProLiant solution.

Further, the POWER8 system demonstrated an average performance improvement of more than 50 times on report generation providing a much higher rate of delivery of value. The ability of the POWER8 system to provide greater throughput translates directly into a much higher value. Even without the cost of ownership advantage, the POWER8 system is capable of supporting significantly greater workloads for either a larger number of users or a much higher volume of reporting requests.

The ability for the POWER8 system to deliver this value is derived from a combination of the POWER8 architecture and the advanced IBM DB2 with BLU Acceleration. The POWER8 architecture has been specifically designed for managing big data and complex query workloads. The additional memory bandwidth and speeds, improved microprocessor design for concurrent queries and other advantages of the POWER8 system architecture contribute directly to the improvement in price-performance. Further, the advanced BLU Acceleration now available in DB2 is far superior to traditional database design for business intelligence data processing and workloads. The combination of the POWER8 architecture and DB2 with BLU Acceleration result in a superior solution and value for business intelligence applications.

Conclusions and Recommendations

- Users currently running x86 environments should consider switching to IBM POWER8-based systems by closely evaluating the cost/benefits as well as the performance and overall business value of IBM POWER technology.
- For the next several years IBM's analytics and big data strategy will evolve around a family of IBM POWER8-based systems. IT organizations considering standardizing on a big data and analytics platform should closely consider the advantages of the IBM Power Systems running IBM DB2 with BLU Acceleration, as the associated products and industry-specific solutions will evolve to be increasingly more comprehensive, capable, sophisticated, and compatible.
- The total cost of acquisition and ownership favors IBM Power Systems, and the business value of IBM POWER8-based systems in Big Data and analytics environments will continue to exceed that of x86 environments – especially in applications where complex queries and reports are essential.
- To significantly improve the performance of business intelligence applications based on traditional relational databases, users should assess the cost/benefits of transferring data from traditional databases to IBM DB2 with BLU Acceleration. The performance improvements that can be achieved will likely be worthwhile, especially in applications where timeliness, responsiveness, and cost-per-report are critical.