Boosting the Performance of SAP® S/4HANA and Analytical Banking Applications on SAP HANA®

Content

Introduction

More than ever, running a business today requires thorough availability, transparency, and connectivity of business data, as well as the ability to simulate planning and decision making and to take immediate action on the results. The financial services industry, in particular, relies increasingly on data for an information advantage and a 360-degree view of the business. SAP® S/4HANA, a next-generation business suite, and the SAP Bank Analyzer set of applications use the innovative in-memory technology of the SAP HANA® platform to help businesses Run Simple in the digital economy. This paper examines the impact of Samsung's latest 3DS/TSV DRAM technology, built into Lenovo's cutting-edge servers, for typical environments running SAP S/4HANA and SAP Bank Analyzer, from both a performance and an ecological footprint point of view.

Toward Today's Highest-Density-Memory Server with Improved Performance and Power Consumption

By eliminating the divide between transactions and analytics through its revolutionary in-memory technology, the SAP HANA platform allows employees to respond to business questions anywhere in real time. Real-time and predictive analytics, spatial processing, and data virtualization can be placed on the same architecture, which makes redundant data and servers a thing of the past. Applications are accelerated without manual intervention and tuning, enabling predictable response times for ad hoc queries. As a result, you can get the full picture of your business in real time and answer all data-discovery questions without special data tweaking while gaining the ability to update the same copy of data in real time.

SAP S/4HANA dramatically accelerates core business processes and simplifies IT landscapes, software deployment, and innovation. It can be deployed in the cloud, on premise, or in a hybrid model. As the next-generation business suite, SAP S/4HANA uses the innovative in-memory technology of SAP HANA to the fullest extent. This is why high-end hardware components are a critical prerequisite for a well-performing SAP S/4HANA software environment. At the same time, energy consumption becomes increasingly important as an influencer for the total cost of ownership of running a data center.

This proof-of-concept paper considers a typical usage scenario for SAP S/4HANA and SAP Bank Analyzer. We specifically explore the impact of Samsung's latest 3DS/TSV (3-Dimensional Stacked IC/Through-Silicon Via) DRAM technology, built into Lenovo's cutting-edge servers based on the sixth generation of Enterprise X-Architecture® technology running on Intel Haswell processors. With the latest 128 GB RDIMM modules, the proof of concept described in this paper demonstrates a 4x improvement of memory density for workloads of SAP solutions for analytical banking powered by SAP HANA. This scenario demonstrates a high memory-to-processor ratio, compared with conventional 32 GB configurations.

We begin with a look at the value of this approach throughout the enterprise. We examine the value for the business as a whole, which gains agility; for IT, through a simplified landscape; and for the user, who enjoys a personalized, real-time experience for everyday work. The paper goes on to describe the software that was tested, explaining how in-memory technology from SAP works. It describes the Lenovo System x3850/x3950 X6 server and Samsung 3DS/TSV memory, with a brief overview of the Intel Haswell-EX as the processor of choice. It concludes with the test results and an analysis of those results that show their value to real-world implementations. Those results include significant gains in power consumption and performance, as well as the ability to build denser memory systems for the rising memory demands of financial institutions. Our purpose is to help IT decision makers understand which technology platform is best suited for hosting SAP S/4HANA and SAP software for analytical banking powered by SAP HANA.

A Look at the Wide-Ranging Value of This Approach

Organizations of all types and sizes maintain increasingly large data stores, which are the source of essential information to support business activities and decision making. By speeding up analytical processing and application response time, organizations can make full use of this information to increase their overall agility. This can help them better understand customer behavior, predict demand, and uncover new revenue opportunities, for example. Organizations can provide businesspeople across the enterprise with better decision support and empower them to get answers and respond to queries in real time.

Each industry faces different challenges in simplifying IT landscapes. In financial institutions, the information management landscape is typically very heterogeneous. Solutions for risk, accounting, and regulatory reporting are built and owned by independent departments working in silos, making it difficult to get consistent information and to meet company-wide reporting needs. Additionally, in recent years, federal stress tests have increased and new regulatory requirements have been put in place to improve transparency. Financial institutions are now held more accountable for their actions and have to respond to a growing number of requests from regulators. Today's financial institutions have many reasons to consolidate their information management landscapes, ranging from cost reduction to improving their ability to manage interactions with business partners.

Traditional transactional systems typically cannot fulfill all accounting requirements – especially complex requirements such as reclassifications, multiple ledgers, status changes, or deferrals using the effective interest rate. Manual efforts are often necessary to correctly reflect those requirements on the books. This is time consuming and slows down period-end closing.

With SAP S/4HANA, organizations can resolve all these issues and gain much more. The IT team can take advantage of a simplified IT architecture and landscape, reduced data footprint, and flexible deployment options. Individual departments benefit from increased capacity of their workforce, accelerated business processes, lower total cost of ownership, and increased transparency and insight into their operations. The user discovers unprecedented personalization of workspaces, with the SAP Fiori® user experience providing a consistent interface across all tasks and devices.

When SAP Bank Analyzer is powered by SAP HANA, for instance, business users can do ad hoc, real-time reporting without predefined navigation paths, and they can define any reporting view without help from their IT departments. Faster processing and reporting accelerate cycle times (for example, at period-end close) and enable faster innovation.

For this proof-of-concept paper, we use an example of a high-volume order-to-cash scenario using SAP ERP powered by SAP HANA. This example demonstrates the impact of the top-scoring technology platform provided by Samsung and Lenovo for an SAP S/4HANA software environment with respect to performance and power footprint.

This paper also introduces today's densest x86 server platform for SAP Bank Analyzer powered by SAP HANA with a typical reporting workload in SAP Bank Analyzer on a large data set. This is enabled by the latest memory technology provided by Samsung, allowing manufacture of DRAM modules with unprecedented high density. Plugged into Lenovo's server platform, these modules offer previously unknown possibilities to further reduce the IT system landscape. The result is lower operation costs of scale-out deployments by reducing the number of servers or by eliminating the need to have special systems for building large shared-memory configurations.

Overview of Core Findings

The right memory technology can make a big difference for an in-memory database, resulting in:

- Efficiency improvements with up to 28.6% less energy consumption for a DDR4/Haswell configuration, compared to DDR3/Haswell
- Increased low-level memory bandwidth between 11% and 20% across all access patterns, with power consumption benefits of around 25% on average
- Benefits for the SAP HANA® platform from a DDR4/Haswell configuration through reduced CPU workload, resulting in more workload and operational flexibility
- The ability to build today's highest-density memory server while maintaining energy-consumption efficiency and improving low-level performance numbers in a range between 16% and 27%

SAP HANA Platform

The SAP HANA platform is an in-memory column-store database platform that runs massively parallel across multiple nodes in a clustered configuration. Unlike many other solutions in the marketplace, SAP HANA is not just an indexing solution to enhance what is essentially a disk-based, online transaction processing (OLTP) database engine; it was built from the ground up as an in-memory solution. It brings transactional and analytical processing together into a single platform and dramatically lowers the data footprint with its sophisticated data model and data compression technique. This innovative architecture enables a completely new way of designing and developing business applications such as SAP S/4HANA and SAP Bank Analyzer powered by SAP HANA. The result is unprecedented operational speed and a simplified IT landscape, among other benefits. The more powerful your hardware platform is, the better it can make use of the capabilities of solutions based on SAP HANA, and the more flexibility it can offer for right-sizing your IT environment and optimizing your IT total cost of ownership (TCO).

> "Samsung's new 3DS memory offerings provide the high throughput and capacity needed for real-time processing while significantly reducing power consumption. Built into Lenovo's newest server platform, these modules enable deployment of high-density memory server infrastructures, allowing even more-efficient processing in SAP HANA, and together they create a sustainable solution that not only lowers TCO but also contributes to 'green IT.'"
>
> Daniel Schneiss, Senior Vice President, Global Head of SAP HANA Platform and Databases, SAP

Lenovo Server Platform

The Lenovo System X6 server is provided in the form of two base building blocks: x3850 X6 with up to four-socket 4U, and x3950 X6 with up to eight processor sockets in an 8U form factor. These rack-mounted servers represent the sixth generation of the Enterprise X-Architecture. They are designed to help businesses better manage their growing volume of data, regardless of constrained capital and operational resources. X6 platforms, with Intel Xeon processors E7-8800 v3 series, can produce up to 56% faster compute performance than the previous generation of X6 systems with last-generation processors. Yet these X6 platforms accommodate multiple generations of Intel processors (Xeon CPUs, code-named IvyBridge; Haswell; and the next generation) and memory technology (DDR3 and DDR4) in the same chassis.

The X6 portion delivers large-application virtualization and decreases infrastructure costs and complexity, thanks to a combination of new storage and memory technologies. With its agile, modular “book” design, X6 is a resilient platform that supports mission-critical databases, enterprise applications, and virtualized environments.

The X6 servers pack numerous fault-tolerant and high-availability features into a high-density, rack-optimized lidless package that helps reduce the space needed to support massive network computing operations and simplify servicing. This package supports up to four Intel Xeon E7 v3 and v2 high-performance processors and up to 12 TB of memory and 144 cores of processing power.

You can start small with an x3850 X6 dual-processor system and eventually upgrade to four processors. You can even upgrade the system from 4U to 8U (x3950 X6) while maintaining all processor, storage, and I/O books, and maintain a server installation (operating system and applications) through such upgrades. In addition, you can upgrade processor books from E7 v2 (IvyBridge) to E7 v3 (Haswell) and, in the future, to the next generation of Intel processors. You can maintain memory modules with an upgrade from IvyBridge to Haswell to improve overall cost for the upgrade, and you can provide the latest processor performance for demanding applications.

Performance Highlights

Test Type	Score of System x3850 X6	Comparison to Previous Record
SPECvirt_sc2013 (benchmark used to measure performance of virtualized platforms)	2,655 @ 147 virtual machines	27% faster
SAP® BW-EML scale-out @ 1 billion records (standard application benchmark of SAP Business Warehouse [SAP BW] application enhanced mixed load [EML])	1,992,570 nav steps per hour @ 1 billion records	29% faster
SAP BW-EML scale-out @ 10 billion records	269,960 nav steps per hour @ 10 billion records	The first server ever to use 10 billion initial records
ANSYS Fluent x86 R16	Highest performance rate ever for a single x86 server on the fluidized_bed_2m benchmark (ANSYS computational fluid dynamics simulation software for predicting the impact of fluid flows), with a score of 4035.5	19% faster than a similarly configured previous-generation system baselined by Intel (New benchmark; no previous R16 record)

"Early on, SAP and Lenovo engineers collaborated on in-memory technologies that resulted in the availability of the SAP HANA platform in 2011. For SAP HANA, Lenovo delivers the advantage of optimized solutions rather than just servers or components. In addition, Lenovo works closely with technology partners like Samsung to leverage the potential that new technologies enable in solutions such as SAP HANA. Lenovo is a leader in deployments of SAP HANA, with more than 5,000 installations, and is committed to delivering continued innovation to address customers' business growth objectives."

Tom Shell, Senior Vice President, Data Center Product Group, Lenovo

Intel Processor and Memory Bus Technology

Intel's Haswell-EX Xeon E7 v3 processor represents the third generation of the Intel Xeon E7 CPU family. The Haswell processor features up to 18 cores, up to 45 MB of last-level cache, and support for larger amounts of physical memory.

Thanks to its innovative design with 20% more cores and a large and efficient cache hierarchy, the newest generation of the Intel Xeon E7 CPU family delivers exceptional performance improvements for in-memory database processing on the SAP HANA® platform.

The Haswell processor architecture includes the Intel Transactional Synchronization Extensions (TSX) capability, which provides hardware-supported lock elision for improved transactional data processing. This innovative technology boosts the performance of in-memory transactional data processing on systems with high core counts by increasing the scalability of thread synchronization.

SAP HANA uses the Intel TSX capability to improve its existing lock-based programming model, resulting in faster system performance and extended scalability. Another important benefit of the Haswell processor architecture is the enhanced Advanced Vector Extensions 2 (Intel AVX2) processor instructions. AVX2 expands most integer commands to 256 bits, delivering up to 68% more computing power (GFLOPS) to help solve complex technical problems more quickly. The performance of scan operations with SAP HANA, which determine how many items in a database can be scanned per second, has been enhanced to benefit from Intel AVX2 instructions.

Memory: Samsung 128 GB 3DS/TSV RDIMMs at 20nm Class

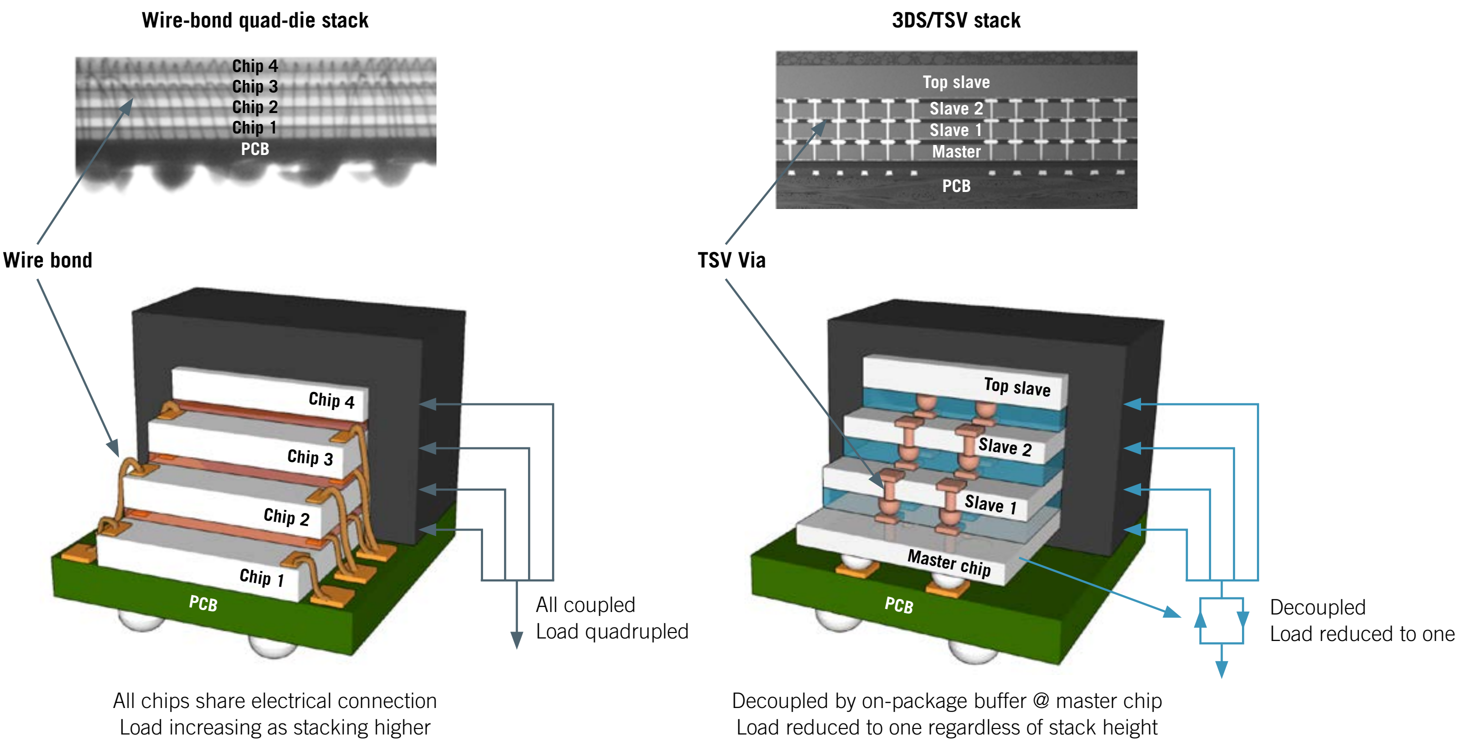
Samsung is introducing the industry's first 128-gigabyte (GB), double data rate-4 (DDR4), registered dual in-line memory modules (RDIMMs) that use 3DS/TSV package technology.

The 3DS/TSV DRAM package includes the DDR4 DRAM dies stacked on top of each other, which are pierced to contain hundreds of fine holes filled with electrodes for vertical interconnect between the DRAM dies. The new RDIMMs include 36 of these 3DS/TSV DDR4 DRAM packages, each of which consists of 4 stacked 8-gigabit (Gb) DDR4 DRAM dies.

The low-power chips are manufactured using Samsung's most advanced 20-nanometer (nm)–class process technology. Samsung 3DS/TSV technology enables multidie DDR4 stacking to create even higher-density and higher-performance DRAM modules with reduced power consumption. This extends the capabilities of computing and analytics in enterprise servers and accelerates expansion of the premium memory market.

As illustrated in Figure 1, conventional wire-bond stacking utilizes gold wires to connect DRAM chips and package substrate (PCB), which can then be surface-mounted on PCB. TSV stacking utilizes the through-silicon vias. These puncture DRAM silicon die and provide electrical connection through the silicon vertically. Each wire-bond is physically 10x larger than one TSV bond and, as a result, a much lower number of connections is allowed and poorer signal integrity is exhibited compared to TSV. Optimized bonds, as well as optimized padding, enable better stacking capability for 3DS TSV DRAM and thus enable higher densities, reaching 128 GB, as shown in this paper.

Figure 1. Conventional Stack DRAM Versus 3DS/TSV Stack DRAM



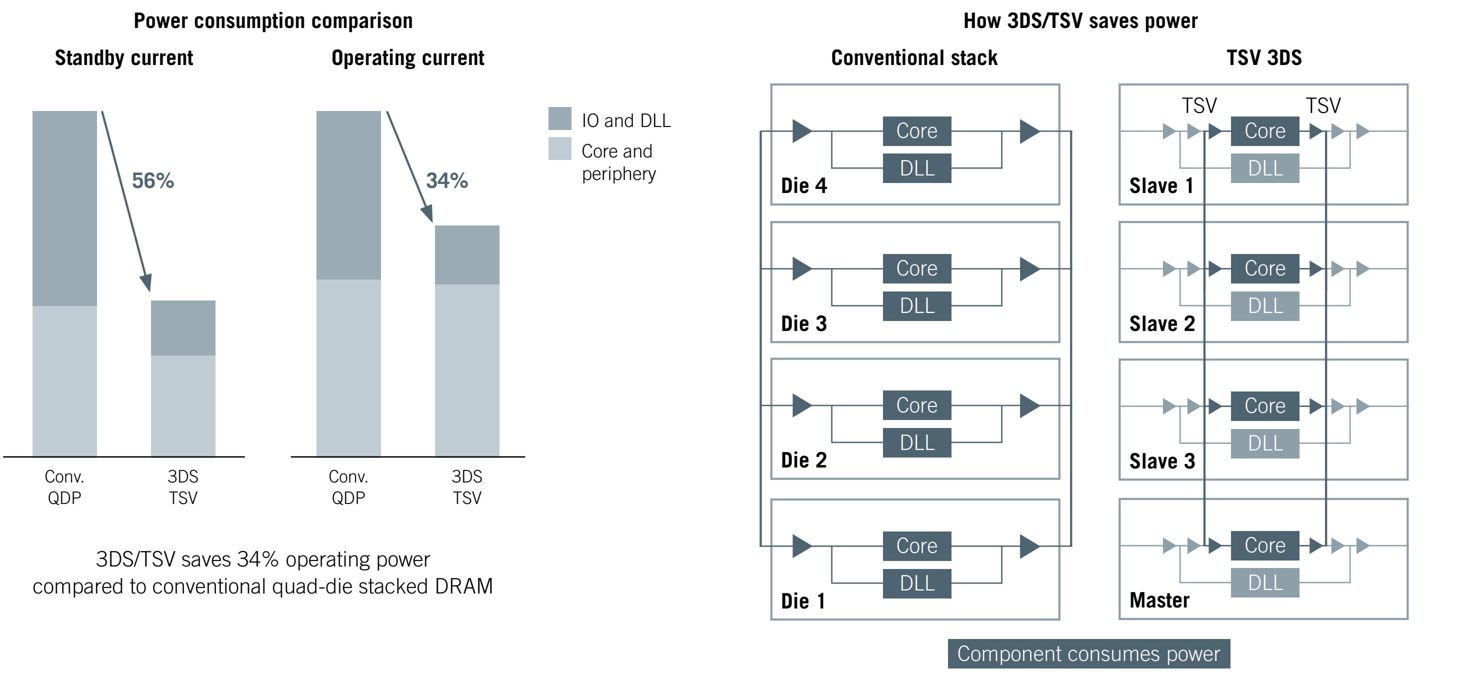
Advantages of 3DS/TSV Versus Conventional Technology

In addition to enabling higher densities, 3DS/TSV DRAM stacking technology enables higher power efficiency, higher performance, and better system scalability for in-memory computing compared to conventional stacking technology:

- **Higher performance** can be achieved by 3DS devices because intrastack operations (that is, signals going through the TSVs) can happen with less delay than interrank operations. This can improve performance, especially for in-memory computing applications.
- **Better scalability** can be achieved by adding capacity without adding bus loading. A key feature of 3DS packaging is that it presents a single load to the bus regardless of how many dies are in the stack.
- **Higher power efficiency** is achieved with 3DS/TSV by turning off unnecessary hardware I/O circuitry. The power savings can reach 56% when the DRAM is idle (on standby) and 34% when the DRAM is operating.

As shown on the left in Figure 2, core and periphery power consumption does not decrease significantly with 3DS/TSV technology, while I/O driver power consumption is reduced dramatically. More specifically, as shown on the right side in Figure 2, 3DS integrates an on-package buffer to the DRAM stack. This way, it can reduce the electrical loading to one (the loading of the buffer) and redistribute the signal internally within the stack effectively with a small consumption of power. Therefore, the signals are buffered in 3DS, and each DRAM in the stack that is not engaged in the signaling can turn off its large signal drivers and utilize small drivers for chip-to-chip signaling to the on-package buffer. On the other hand, conventional stacked DRAM chips try to drive the signals at their full strength.

Figure 2. Conventional Stack DRAM Versus 3DS/TSV Stack DRAM



3DS/TSV saves 34% operating power compared to conventional quad-die stacked DRAM

3DS/TSV turns off unnecessary I/O and saves power

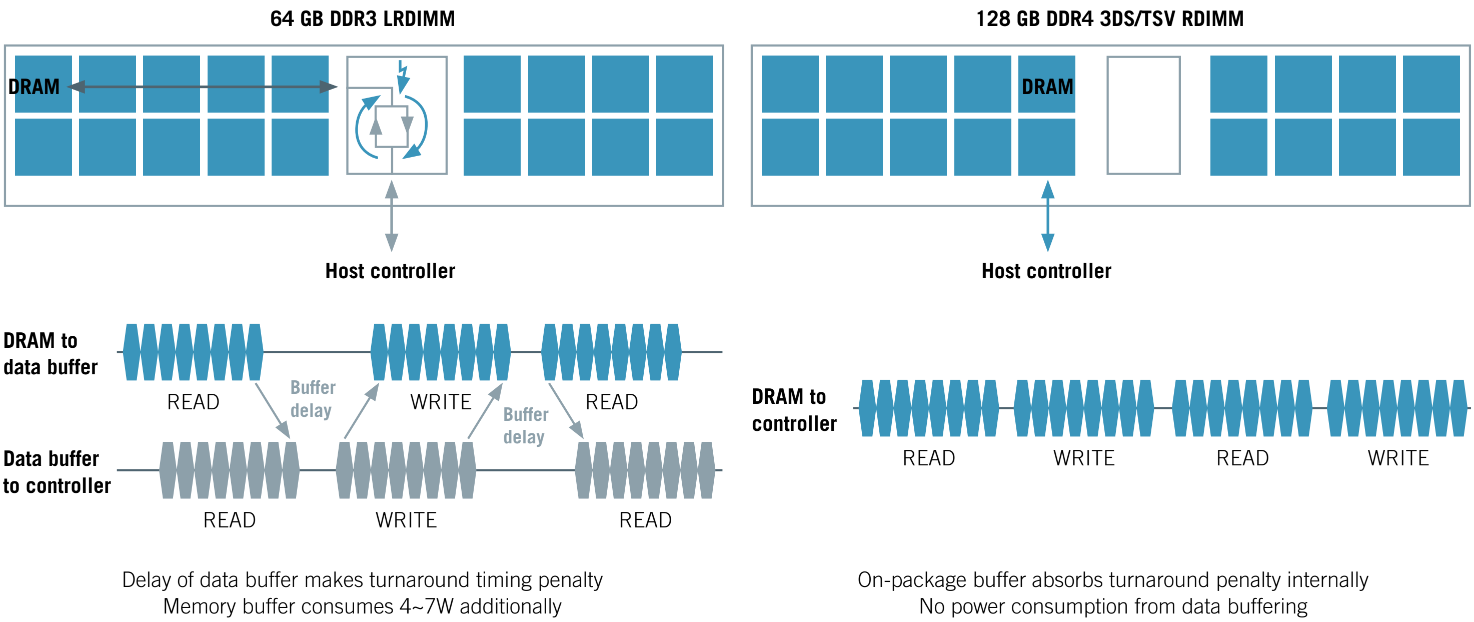
Advantages of 3DS/TSV RDIMM Versus LRDIMM

For 3DS/TSV-based DRAM, we select RDIMM modules versus LRDIMM modules because of improved bandwidth and power consumption:

- **Improved bandwidth** is achieved with the RDIMM configuration by eliminating the additional data buffer that is used by LRDIMM configurations. The data buffer is situated between the DRAM and the host controller (highlighted in gray in Figure 3) and introduces extra delay, which eventually degrades the bandwidth.
- **Improved power consumption** is achieved with the RDIMM configuration by eliminating the additional data buffering, which consumes approximately an extra 4~5W.

For conventional stacked DRAMs, that additional data buffer is a requirement to mitigate the signaling problems from large electrical loading. On the other hand, 3DS/TSV DRAM packages do not require these additional data buffers, as they already integrate an on-package buffer. Potential concerns regarding high-speed operation without data buffers are solved by Samsung 3DS/TSV DRAM, utilizing I/O receiver equalization technology to achieve high-speed operation in heavy loading conditions.

Figure 3. LRDIMM and RDIMM Configuration per Different Stacking Technologies



"Samsung has been leading the memory industry with innovative memory products built on cutting-edge technologies, and we proudly introduce 128 GB 3DS/TSV RDIMM, a great accomplishment in the history of DRAM. Samsung 128 GB 3DS/TSV RDIMM enables 12 TB of total system memory in a single 4U Server – as much DRAM capacity as in an entire small data center not long ago. The product is now opening a broad span of possibilities to state-of-the-art computing applications, such as Big Data analytics, artificial intelligence, and deep learning, with its high density, energy efficiency, and high performance. This paper shows how our new 128 GB 3DS/TSV RDIMM with TSV technology is a perfect match for SAP HANA, a leading in-memory database."

Dr. JungBae Lee, Senior Vice President and Head of the Memory Product Planning and Application Engineering Team, Samsung Electronics

Test Environment

The proof-of-concept database system was a four-way Lenovo System x3850 X6, configured with the components shown in the following table. The operating system was a SUSE Linux Enterprise Server 12 with the most-recent maintenance kernel.

The proof-of-concept system had been tested with different combinations of CPU and memory DIMMs from Samsung. The idea was to show the impact of using the most-recent DDR4 memory technology compared to DDR3 on the same processor technology (Intel Haswell CPU) for power consumption and performance.

To complement the results, we also considered extending the analysis for the previous generation of Intel Xeon CPUs, code-named IvyBridge EX, which supports only DDR3 memory technology.

Finally, we showed the performance and power-consumption benefits of the new memory technology by comparing equal-size module density. We used a reporting workload in SAP Bank Analyzer to demonstrate that such a system can handle the required performance for financial institutions using the current biggest module density, with fully populated DIMMs slots. This, in fact, created today's highest-density x86 server.

Processors	Memory Modules	SAP® Software
Intel Xeon processors E7-8890 v3 @ 2.5 GHz Intel Xeon processors E7-8890 v2 @ 2.8 GHz	Samsung 25-nm-class 4-Gb (QDP) 64 GB DDR3 LRDIMM (Part #: M386B8G70DE0-YH9) Samsung 20-nm-class 4-Gb (4h) 64 GB DDR4 TSV (Part #: M393A8G40D40-YH9) Samsung 20-nm-class 4-Gb (4h) 128 GB DDR4 TSV (Part #: M393AAK40B41-CTC)	SAP HANA® platform, developer edition

High-Volume Order-to-Cash Scenario in SAP S/4HANA

The order-to-cash scenario is one of many fundamental business processes that are implemented in enterprise resource planning (ERP) systems such as the one running SAP S/4HANA that we used. While it is not necessarily relevant to financial services, it is a good test example showing the power consumption benefits during high load for the 3DS DDR4 64 GB RDIMM modules. This business process covers sell orders being received and processed through customer sales channels, followed by the creation of the delivery request for logistics and shipping. Once the delivery is processed and completed, an invoice is generated and booked.

For this analysis, we simulated all steps with real-world input, from creating multiple orders to processing all above-mentioned steps and creating the invoice in a high-load manner to cover a typical load for midsize to large retail companies.

The testing used two servers: one that hosted the SAP S/4HANA software and one that hosted the SAP HANA database. The performance and power consumption impact was measured on the database server. The database size was around 1 TB. During the creation of the orders and invoices and the internal processing in the database, stress was put on the memory and CPU subsystem. Therefore, SAP HANA benefited from a scalable memory technology that has good performance-per-watt characteristics and new features in the Intel Xeon processor E7 family.

Test Results

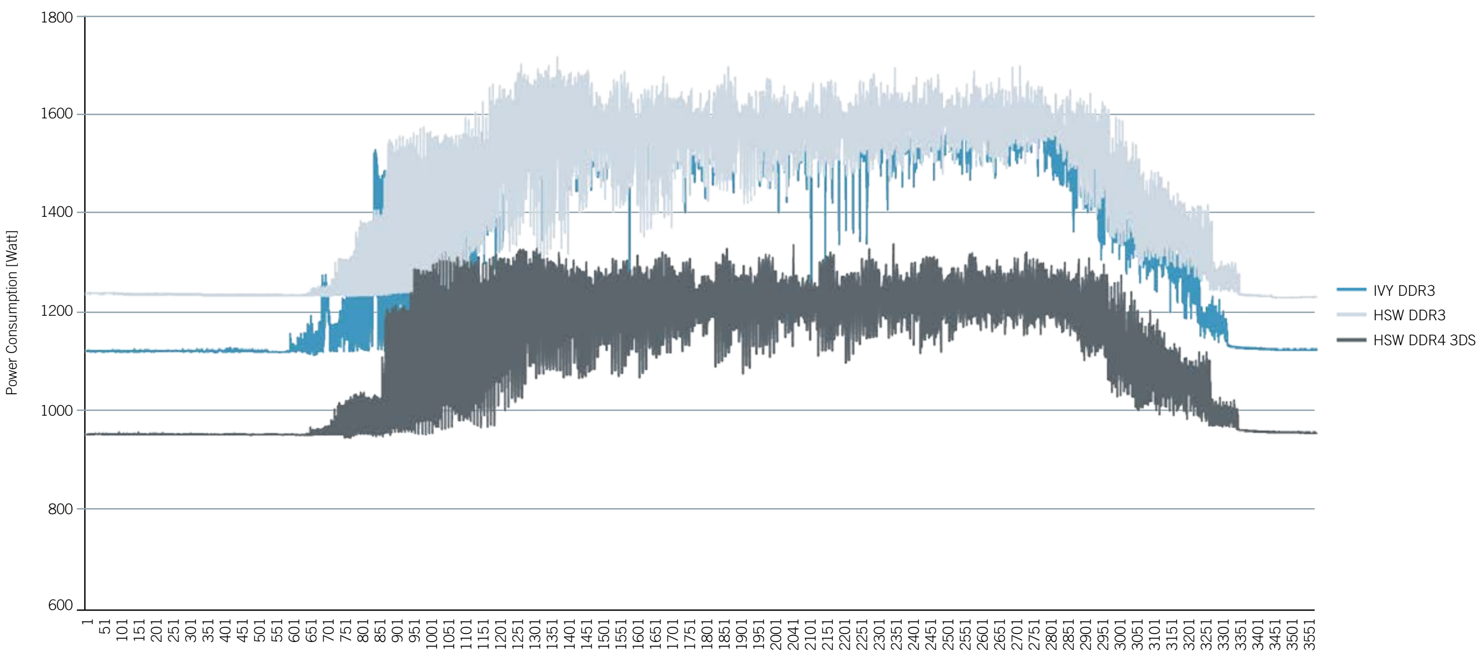
As described in the "Test Environment" section, the testing was conducted using three different configurations:

- IvyBridge-based CPUs with DDR3 memory technology, which is the current, most common configuration
- The new Haswell processors that can be inserted in the same server due to the socket compatibility running with DDR3 memory technology
- The configuration using the new Haswell processors and the new 3DS DDR4 memory technology from Samsung

Before elaborating on the impact of performance per watt with the above-mentioned workloads, we highlighted the average power consumption in idle mode. There was already a significant power reduction using the different DIMMs and CPUs. Comparing the older IvyBridge DDR3 with the newer Haswell DDR3 showed a 4.1% increase of power consumption in idle mode. Figure 4 indicates that CPU and memory have different performance characteristics on idle systems, with the power efficiency benefits of 29.9% using DDR4 compared to the Haswell DDR3. Since not all enterprise systems are in heavy load all the time, we consider this to be very important as well.

The simulated order-to-cash workload was running with a constant load to make the results comparable. The runtime of the highly concurrent user test was controlled through the simulation tool and was comparable for all runs. During the desired high load, we observed 25 million memory allocations and deallocations per second in the memory manager statistics for SAP HANA. The power consumption curve in Figure 4 clearly shows that the power consumption benefits were also maintained during high load for the 3DS DDR4 64 GB RDIMM modules.

Figure 4. Power Profile for Order-to-Cash Workload



With the IvyBridge-based configuration, we were saturating the CPU up to 80% with the chosen workload. The Haswell-based machines were using only half of the CPU resources while being able to serve the same load. The higher resource efficiency of SAP HANA was mainly due to the optimization of the Intel Transactional Synchronization Extensions (TSX) for database insert performance. This enabled enough room for going into higher load or to perform analytics on the same system in parallel with less impact on the order-to-cash workload. The observed power consumption benefit was 23.3% comparing DDR4 with Haswell CPUs to the IvyBridge-based CPU with DDR3. The results stayed consistent with multiple iterations of test runs on each configuration.

We observed an average of 28.6% lower power consumption comparing the newer-generation memory technology based on the 3DS DDR4 64 GB RDIMM modules with DDR3 (see Figure 5).

For the second workload chosen, the Intel Memory Latency Checker (Intel MLC) test, we modified the BIOS configuration to run the two different memory technologies, DDR3 and 3DS DDR4, with the same frequency (1,333 MHz) on the Intel Haswell processor. The 3DS DDR4 memory technology was able to hold the frequency of 1,600 MHz even with three DIMMs per channel; but for a fair performance comparison, we decided to compare the technology with the same frequency. The observed power-consumption benefits using the 3DS DDR4 memory were very similar to the previous workload, with an average of around 25% during the bandwidth test. Latency for both memory technologies was exactly the same. However, the bandwidth was higher, with up to an 11% increase for read-only access. The performance increase was even more once we considered adding write access. Figure 6 shows the performance benefits comparing DDR3 LRDIMMs and 3DS DDR4 RDIMMs on the Haswell processor. We deduced that using 3DS memory and running them with the same frequency compared to DDR3 LRDIMMs increased low-level bandwidth between 11% and 20% depending on the access pattern. And the fact that the performance increase consumed an average of 25% less power highlights that 3DS technology from Samsung has, compared to its predecessor, excellent performance-per-watt characteristics.

Figure 5: Test Results – Average Power Consumption with 3DS DDR4 Technology

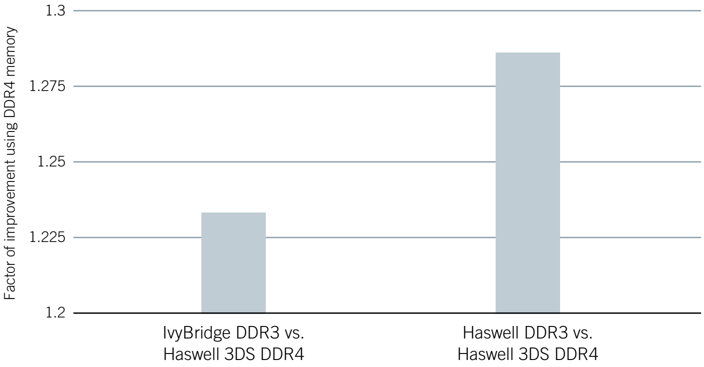
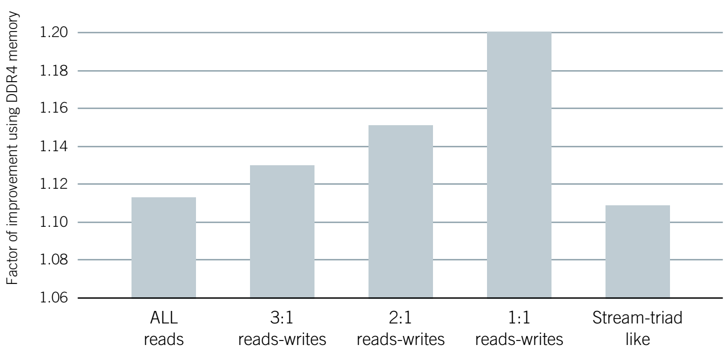


Figure 6: Bandwidth Performance Improvements with 3DS DDR4 64 GB Modules (Intel MLC)



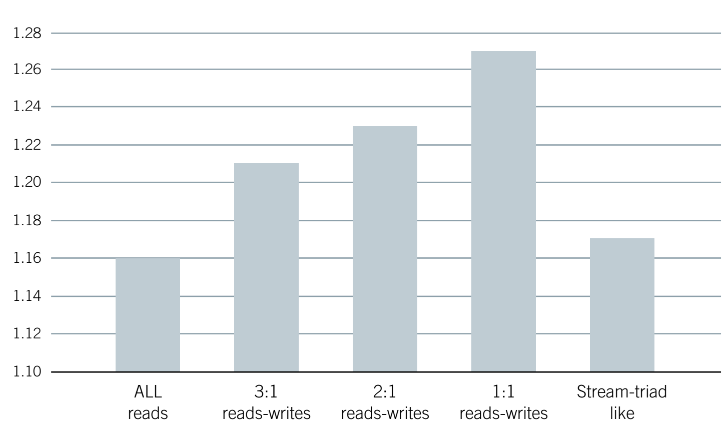
Building a Highest-Memory-Density System on x86 for Banking Applications

In the previous section, we demonstrated that the memory technology from Samsung built into the latest Haswell-based server platform from Lenovo clearly shows performance and power benefits. In this section, we shift our focus to building today's first highest-memory-density system on x86 using the above-mentioned four-socket Haswell system from Lenovo and the new 128 GB 3DS/TSV memory modules from Samsung. Combining these technologies allows the configuring of a 12 TB single-server system using four Intel Haswell CPUs.

For this use case, we made a comparison of power consumption against a white-box Intel system using eight sockets with 12 TB. To compare the power consumption differences, we used a different workload.

The new data set used is a system running SAP Bank Analyzer with 100 billion payments, where monthly period-end processing is executed and new payments are inserted. This scenario simulates a subset of an active banking system in a large financial institution. This experiment showed that such a dense system with only four CPUs could process the required monthly period-end workload while maintaining a low power envelope compared to a system using eight sockets and the same amount of memory.

Figure 7: Bandwidth Performance Improvements with DDR4 3DS/TSV 128 GB Modules



The eight-socket system was equipped with 64 GB DIMM DDR3 modules fully populated. The expectation was that the power envelope for double the CPU and double the memory modules would be much higher than the four-socket system using the new 128 GB 3DS/TSV modules.

Before starting the power comparison with the abovementioned workload in SAP Bank Analyzer, an Intel MLC performance comparison was made for the above-mentioned DDR3 64 GB LRDIMM and DDR4 3DS/TSV 128 GB RDIMM modules.

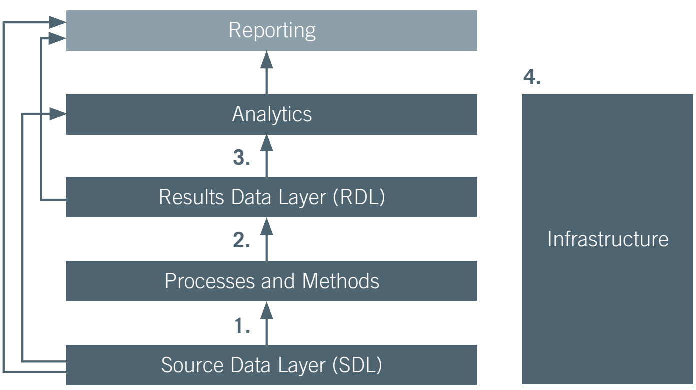
In Figure 7, compared to Figure 6, we can see clearly that the 3DS technology enables better usage of the memory channels with higher capacity. In this comparison, we configured both types of DIMMs to run with the highest frequency in 3 DIMMs per channel. The improvements shown here are slightly better than the previous comparison with a maximum of 27% in the 1:1 read-write ratio test.

The scenario for this experiment is to load original data from operational systems or source systems into the source data layer (SDL). The SDL is the original data basis for the processes and methods of SAP Bank Analyzer. The valuation results of processes and methods are stored in the results data layer (RDL). These structures help ensure that original data, methods, and valuation results are clearly separated.

The second part of the experiment is to transform the data from the SDL to the RDL and then to run selected reporting queries against the RDL to get good coverage of the process chain. The workflow in SAP Bank Analyzer is shown in Figure 8. It starts from being very OLTP dominant in the beginning in the SDL and in the transformation part, and it goes over into online analytical processing (OLAP) with reporting from the RDL.

The SDL manages the basic data for the valuation of financial products. This data is loaded from the operational source systems by means of extraction, transformation, and loading (ETL) processes. The SDL is the source for semantically integrated data for all valuation processes that are based on financial products, as well as a central consolidated source for valuations.

Figure 8: Workflow in SAP® Bank Analyzer



As shown in Figure 8:

1. The SDL is not a data store for data that has already been completely valuated. This is stored in the RDL.
2. The RDL manages consistent and reusable financial and risk data from various calculation and valuation processes for financial instruments and financial transactions.
3. Reporting and analytics read results data from the RDL. The analytics layer contains analytics applications that call results from the RDL and process them, if necessary. This means that results data is analyzed specifically for each application.
4. Infrastructure and tools provide central services and utilities for the various components of SAP Bank Analyzer.

During the experiment, the simulated loading of new payments into the data set (SDL) was running with a constant workload on both systems to make the results comparable. The runtime of the load phase was comparable on both systems, and there was no negative effect using a smaller number of CPUs. The CPU consumption was around 60% on average on the high-density four-socket server and around 35% on the eight-socket system. The insertion of new payments is not very CPU intensive; the same is true for the transformation part in the process and methods layer. Using the TSX lock elision, the inserts and updates are processed quickly. We observed around 18 million memory allocations and deal locations per second in the memory manager statistics for SAP HANA.

This was similar to the SAP S/4HANA workload in the previous performance test, but with higher allocation sizes. The nature of the higher allocations can be explained with the bigger footprint of a single payment in banking than the orders used in the system running SAP S/4HANA. From the ecological point of view, the system with denser memory and four sockets reduces the power consumption of the system significantly. On the idle system, 66% less power is consumed. During high-load OLTP phases in the load-and-transform steps, the power consumption savings rate is even higher at 70%. This clearly demonstrates the benefits of using the 3DS DDR4 128 GB RDIMM modules on a four-socket system compared to an eight-socket system with DDR3 64 GB LRDIMMs.

During the experiment, the idle and high-load phase, using systems with higher memory density clearly reduces power consumption without having any impact on the transactional performance of the required throughput in our simulated test. In that test, we simulated the insertion of payments and the transformation to the RDL generated over several days that we can observe in several big financial institutions.

The final part was to simulate reporting with selected queries on this data set with more than 100 billion payments in the RDL. This type of workload is OLAP in nature, and clearly CPU- and memory-bandwidth intensive. We assume that having fewer CPUs available will have an impact on runtime.

Our observation shows that SAP HANA is making good use of the four additional CPUs that are available on the eight-socket system and that this affects the overall runtime. However, the impact is not to the extent we initially expected. We also expect that the next-generation Intel Xeon processors will fill the performance gap introduced by the lower number of CPUs in the system.

Both systems had an average CPU usage of 80% at the reporting phase. The power-consumption benefits are reduced to approximately 20%, considering the longer runtimes. The overall runtime of the month-end processing was fast enough for most key performance indicators (KPIs), even with the 28% slower runtime.

Analysis and Conclusions

The test results clearly reconfirmed that Lenovo System x3850/3950 X6 servers running on Intel's Haswell processor architecture, and the new Samsung 3DS/TSV DDR4 RDIMM, are the top choice for high-end enterprise IT platforms such as SAP S/4HANA and for the SAP Bank Analyzer set of applications powered by SAP HANA.

The power savings of the Samsung 64 GB DDR4 chips of 28.6% on average on Haswell, compared to a DDR3 chipset, are even more impressive than the 23.3%, compared to an IvyBridge platform with DDR3 chipset. At the same time, the Haswell architecture allows almost double the data rate and core-to-main-memory ratio for analytical workloads, compared to its predecessor architecture IvyBridge. Plus, the memory technology of the 64 GB RDIMMs enables an increased low-level bandwidth between 11% and 20% across all memory access patterns, with power consumption benefits of around 25% on average. The combination of both technologies provides efficient execution, enabling room for even higher workloads and 3DS memory operation frequency. This allows running analytics and order-to-cash transactions at the same time, for instance, with little measurable impact.

The tested workloads for the financial services scenario have a high memory-to-processor ratio, and thus benefit greatly from the new 128 GB 3DS/TSV modules compared to conventional 32 GB configurations. The CPU consumption rate for a transactions-oriented workload was around 60% on average with a four-socket Haswell system and the new 128 GB 3DS/TSV memory modules. Yet it was around 35% on the eight-socket system with 64 GB modules, and the overall energy consumption rate was reduced drastically at the same time. The analytical workload exercise showed a CPU usage of 80% on average for both configurations, while energy consumption was reduced by at least 20% for the 128 GB four-socket configuration. This can still be considered significant, given that the runtime decelerated by only 28%. We expect that this performance difference will be reduced even further with the next generation of Intel CPUs.

Probably the most impressive figures are the power consumption savings of the four-socket configuration compared to its counterpart: 66% in the idle state and 70% in high-load OLTP phases.

This latest generation of 3DS/TSV RDIMM modules opens new opportunities for building ultralarge scale-up configurations with a reduced set of CPU nodes. This cuts down the requirements of server infrastructure by half without compromising the performance of analytical processing, and with manageable impact on transactional workloads. This is especially true for data-driven usage scenarios like those in the financial services industry.

In a nutshell, Samsung 3DS/TSV DDR4 on Haswell is the new "dream team" for enterprise IT hardware platforms, and Lenovo brings both innovations together in its x3850/x3950 servers. The new platform enables superior IT performance while significantly reducing power consumption. This not only makes the most of the outstanding performance of SAP S/4HANA and the SAP Bank Analyzer set of applications powered by SAP HANA. It also brings down the TCO of enterprise IT through reduced energy consumption and decreased cooling efforts, supporting a higher integration of hardware components and further reduction in IT cost, enabling a step toward greener IT.

As a result, everybody is happy. The IT department saves energy and space. The lines of business benefit from more-effective business operations at lower cost. Users enjoy real-time performance of their business applications. And the organization as a whole reduces its carbon footprint while increasing competitiveness.

This clearly demonstrates the leadership and distinguished partnership of SAP, Lenovo, and Samsung as providers of superior IT platforms where software applications and hardware components are perfectly synchronized to match high-end business needs. It is part of continuous improvement to a degree that has not been achieved previously, pushing the boundaries of performance. And all this enables previously unseen innovation and operational efficiency.

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