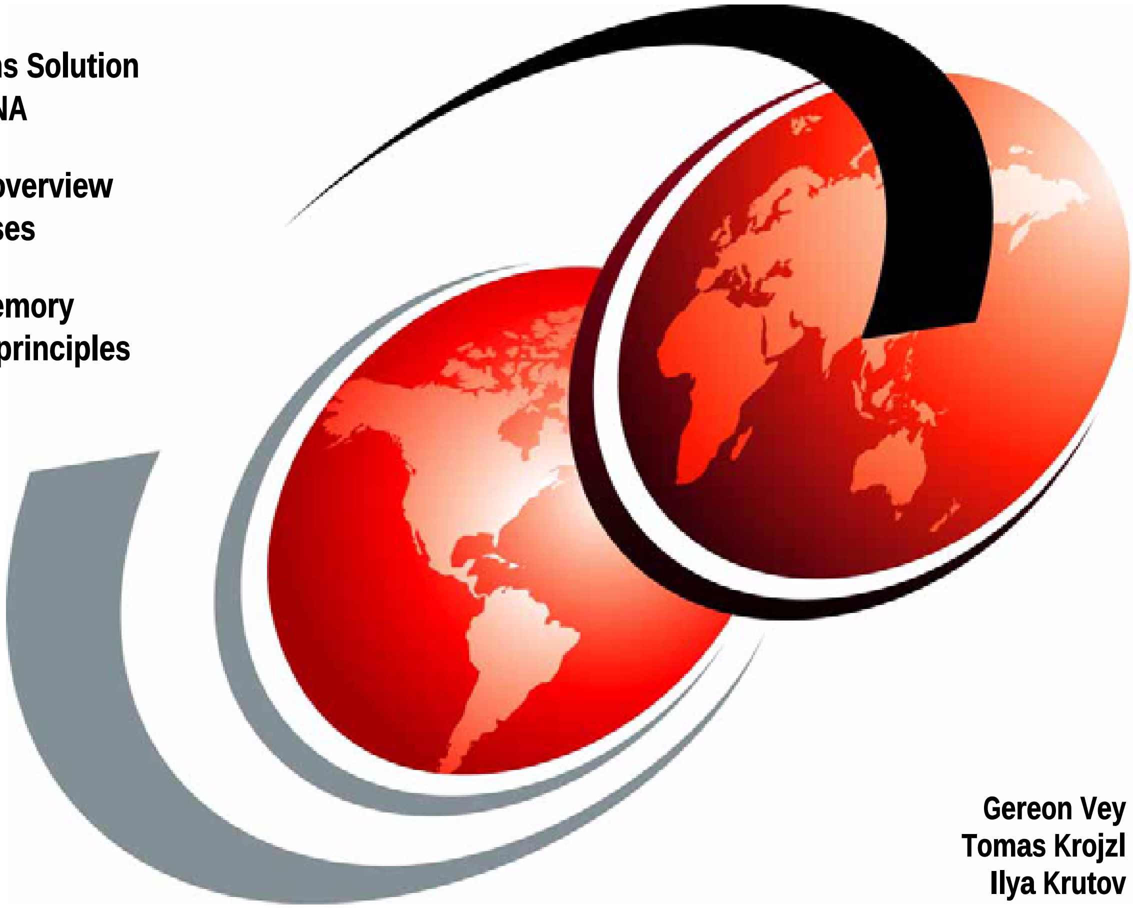
In-memory Computing with SAP HANA on IBM eX5 Systems

IBM Systems Solution for SAP HANA

SAP HANA overview and use cases

Basic in-memory computing principles



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First Edition (January 2013)

This edition applies to IBM System Solution for SAP HANA, an appliance based on IBM System eX5 servers and the SAP HANA offering.

Contents

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Preface

This IBM® Redbooks® publication describes in-memory computing appliances from IBM and SAP that are based on IBM eX5 flagship systems and SAP HANA. We first discuss the history and basic principles of in-memory computing, then we describe the SAP HANA offering, its architecture, sizing methodology, licensing policy, and software components. We also review IBM eX5 hardware offerings from IBM. Then we describe the architecture and components of IBM Systems solution for SAP HANA and its delivery, operational, and support aspects. Finally, we discuss the advantages of using IBM infrastructure platforms for running the SAP HANA solution.

The following topics are covered:

- The history of in-memory computing
- The basic principles of in-memory computing
- The SAP HANA overview
- Software components and replication methods
- SAP HANA use cases and integration scenarios
- The IBM Systems solution for SAP HANA
- SAP HANA operations
- Benefits of using the IBM infrastructure for SAP HANA

This book is intended for SAP administrators and technical solution architects. It is also for IBM Business Partners and IBM employees who want to know more about the SAP HANA offering and other available IBM solutions for SAP customers.

The team who wrote this book

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, Raleigh Center.

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- Gereon Vey
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History of in-memory computing at SAP

In-memory computing has a long history at SAP. This chapter provides a short overview of the history of SAP in-memory computing. It describes the evolution of SAP in-memory computing and gives an overview of SAP products involved in this process:

1.1 SAP Search and Classification (TREX)

SAP first made SAP In-Memory Computing available in product form with the introduction of SAP Search and Classification, better known as Text Retrieval and Information Extraction (TREX). TREX is a search engine for both structured and unstructured data. It provides SAP applications with numerous services for searching and classifying large collections of documents (unstructured data) and for searching and aggregating business data (structured data).

TREX offers a flexible architecture that enables a distributed installation, which can be modified to match various requirements. A minimal system consists of a single host that provides all TREX functions. Starting with a single-host system, you can extend TREX to be a distributed system and thus increase its capacity. TREX stores its data, usually referred to as indexes, not in the way traditional databases do, but merely as flat files in a file system. For a distributed system, the file system must be a clustered or shared file system, which presents all files to all nodes of the distributed system.

For performance reasons, TREX indexes are loaded to working memories. Indexes for structured data are implemented compactly using data compression, and the data can be aggregated in linear time to enable large volumes of data to be processed entirely in memory.

Earlier TREX releases (TREX 7.0 and earlier) are supported on a variety of platforms (such as IBM AIX®, HP-UX, SOLARIS, Linux, and Windows). To optimize the performance of the search and indexing functions provided by the TREX engine, SAP decided to concentrate on the Intel platform to optimally utilize the CPU architecture. Therefore, the newest version of TREX (Version 7.10) is only available on Windows and Linux 64-bit operating systems.

TREX as a search engine component is used as an integral part of various SAP software offerings, such as SAP NetWeaver Enterprise Search. TREX as an SAP NetWeaver stand-alone engine is a significant part of most search features in SAP applications.

1.2 SAP liveCache

SAP liveCache technology can be characterized by a hybrid main-memory database with intensive use of database procedures. It is based on MaxDB, which is a relational database owned by SAP, introducing a combination of in-memory data storage with special object-oriented database technologies supporting the application logic. This hybrid database system can process enormous volumes of information, such as planning data. It significantly increases the speed of the algorithmically complex, data-intensive and runtime-intensive functions of various SAP applications, especially within SAP Supply Chain Management (SAP SCM) and SAP Advanced Planning and Optimization (SAP APO). The SAP APO/liveCache architecture consists of these major components:

- ABAP code in SAP APO, which deals with SAP APO functionality
- Application functions providing extended database functionality to manipulate business objects
- SAP liveCache's special SAP MaxDB implementation, providing a memory resident database for fast data processing

From the view of the SAP APO application servers, the SAP liveCache database appears as a second database connection. SAP liveCache provides a native SQL interface, which also allows the application servers to trigger object-oriented functions at the database level. These functions are provided by means of C++ code running on the SAP liveCache server with extremely fast access to the objects in its memory. This is the functionality, which that allows processing load to be passed from the application server to the SAP LiveCache server, rather than just accessing database data. This functionality, referred to as the *COM-Modules* or *SAP liveCache Applications*, supports the manipulation of memory resident objects and datacubes and significantly increases the speed of the algorithmically complex, data-intensive, and runtime-intensive functions.

SAP APO transfers performance-critical application logic to the SAP liveCache. Data needed for these operations is sent to SAP liveCache and kept in-memory. This ensures that the processing happens where the data is, to deliver the highest possible performance. The object-oriented nature of the application functions enable parallel processing so that modern multi-core architectures can be leveraged.

1.3 SAP NetWeaver Business Warehouse Accelerator

The two primary drivers of the demand for business analytics solutions are increasing data volumes and user populations. These drivers place new performance requirements on existing analytic platforms. To address these requirements, SAP introduced SAP NetWeaver Business Warehouse Accelerator[1] (SAP NetWeaver BW Accelerator) in 2006, deployed as an integrated solution combining software and hardware to increase the

1 Formerly named SAP NetWeaver Business Intelligence Accelerator, SAP changed the software solution name in 2009 to SAP NetWeaver Business Warehouse Accelerator. The solution functions remain the same.

performance characteristics of SAP NetWeaver Business Warehouse deployments.

The SAP NetWeaver BW Accelerator is based on TREX technology. SAP used this existing technology and extended it with more functionality to efficiently support the querying of massive amounts of data and to perform simple operations on the data frequently used in a business analytics environment.

The software's engine decomposes table data vertically into columns that are stored separately. This makes more efficient use of memory space than row-based storage because the engine needs to load only the data for relevant attributes or characteristics into memory. In general, this is a good idea for analytics, where most users want to see only a selection of data. We discuss the technology and advantages of column-based storage in Chapter 2, "Basic concepts" on page 9, along with other basic in-memory computing principles employed by SAP NetWeaver BW Accelerator.

SAP NetWeaver BW Accelerator is built for a special use case, speeding up queries and reports in SAP NetWeaver BW. In a nutshell, after connecting the SAP NetWeaver BW Accelerator to the BW system, InfoCubes can be marked to be indexed in SAP NetWeaver BW Accelerator, and subsequently all database-bound queries (or even parts of queries) that operate on the indexed InfoCubes actually get executed in-memory by the SAP NetWeaver BW Accelerator.

Because of this tight integration with SAP NetWeaver BW and the appliance-like delivery model, SAP NetWeaver BW Accelerator requires minimal configuration and set up. Intel helped develop this solution with SAP, so it is optimized for, and only available on, Intel® Xeon® processor-based technology. SAP partners with several hardware vendors to supply the infrastructure for the SAP NetWeaver BW Accelerator software. Customers acquire the SAP software license from SAP, and the hardware partner delivers a pre-configured and pre-installed solution.

The IBM Systems solution for SAP NetWeaver BW Accelerator helps provide customers with near real-time business intelligence for those companies that need timely answers to vital business questions. It allows customers to perform queries in seconds rather than tens of minutes and gives them better visibility into their business.

IBM has significant competitive advantages with our IBM BladeCenter-based implementation:

- Better density
- More reliable cooling
- Fibre storage switching

- Fully redundant enterprise class chassis
- Systems management

SAP NetWeaver BW Accelerator plugs into existing SAP NetWeaver Business Warehouse environments regardless of the server platform used in that environment.

The IBM solution consists of these components:

- IBM BladeCenter chassis with HS23 blade servers with Intel Xeon processors, available in standard configurations scaling from 2 to 28 blades and custom configurations up to 140 blades
- IBM DS3524 with scalable disk
- SUSE Linux Enterprise Server as the operating system
- IBM General Parallel File System (GPFS™)
- IBM Services including Lab Services, IBM Global Business Services® (GBS), IBM Global Technology Services® (GTS) offerings, and IBM Intelligent Cluster™ enablement team services

This intelligent scalable design is based around the IBM General Parallel File System, exclusive from IBM. GPFS is a highly scalable, high-performance shared disk file system, powering many of the world's largest supercomputing clusters. Its advanced high-availability and data replication features are a key differentiator for the IBM offering. GPFS not only provides scalability, but also offers exclusive levels of availability that are easy to implement with no manual intervention or scripting.

IBM has shown linear scalability for the SAP NetWeaver BW Accelerator through 140 blades[2]. Unlike all other SAP NetWeaver BW Accelerator providers, the IBM solution provides a seamless growth path for customers from two blades to 140 blades with no significant changes in the hardware or software infrastructure.

1.3.1 SAP BusinessObjects Explorer Accelerated

To extend the functionality of SAP NetWeaver BW Accelerator, SAP created a special version of the SAP BusinessObjects Explorer, which can connect directly to the SAP NetWeaver BW Accelerator using its proprietary communication protocol. SAP BusinessObjects Explorer, accelerated version, provides an alternative front end to navigate through the data contained in SAP NetWeaver BW Accelerator, with a much simpler, web-based user interface than the SAP

[2] WinterCorp white paper: "Large-Scale Testing of the SAP NetWeaver BW Accelerator on an IBM Platform," available at
`ftp://ftp.software.ibm.com/common/ssi/sa/wh/n/spw03004usen/SPW03004USEN.PDF`

NetWeaver BW front ends can provide. This broadens the user base towards the less experienced BI users.

1.3.2 SAP BusinessObjects Accelerator

SAP enabled the combination of SAP NetWeaver BW Accelerator and SAP BusinessObjects Data Services to load data into SAP NetWeaver BW Accelerator from virtually any data source, both SAP and non-SAP data sources. In combination with BO Explorer as an independent front end, the addition of SAP BusinessObjects Data Services created a solution that is independent of SAP NetWeaver BW.

This combination of SAP NetWeaver BW Accelerator, SAP BusinessObjects Explorer Accelerated, and SAP BusinessObjects Data Services is often referred to as the SAP BusinessObjects Accelerator or SAP BusinessObjects Explorer Accelerated Wave 2. Additional blades are added to the SAP NetWeaver BW Accelerator configuration to support the BusinessObjects Explorer Accelerated workload, enabling it to be delivered as part of the SAP NetWeaver BW Accelerator solution.

1.4 SAP HANA

SAP HANA is the next logical step in SAP in-memory computing. By combining earlier developed or acquired technologies, such as the SAP NetWeaver BW Accelerator (including TREX technology), SAP MaxDB with its in-memory capabilities originating in SAP liveCache, or P*Time (acquired by SAP in 2005), with recent research results from the Hasso Plattner Institute for Software Systems Engineering[3] (HPI), SAP created an in-memory database appliance for a wide range of applications.

[3] Founded in 1998 by Hasso Plattner, one of the founders of SAP AG, chairman of the board until 2003, and currently chairman of the supervisory board of SAP AG

Figure 1-1 shows the evolution of SAP in-memory computing.

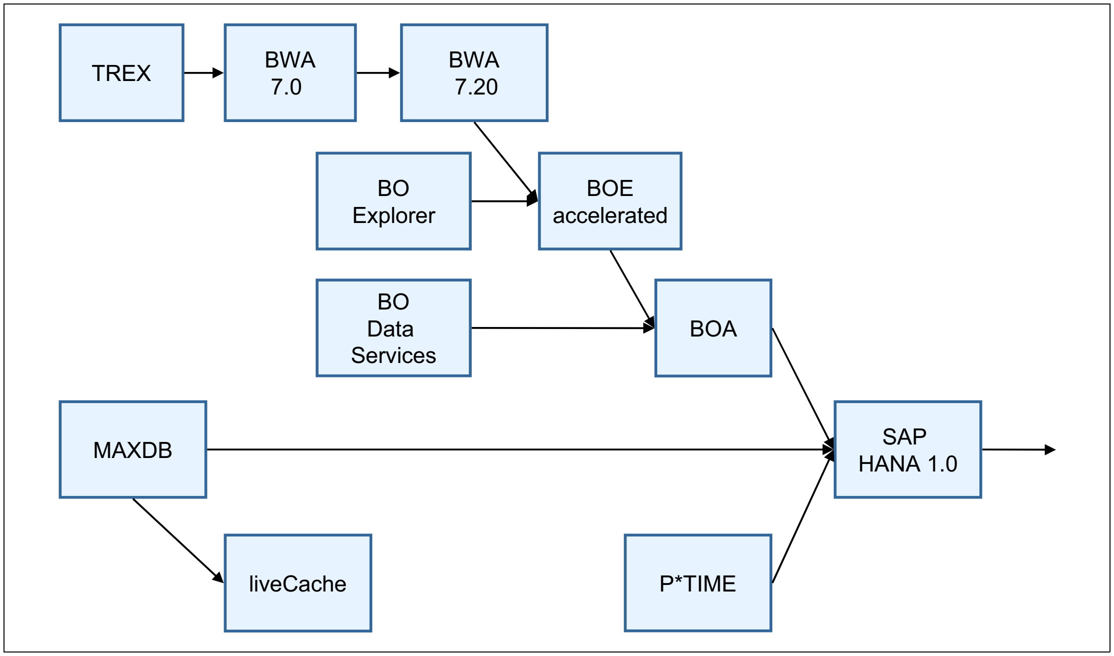

Figure 1-1 Evolution of SAP in-memory computing

Initially targeted at analytical workloads, Hasso Plattner presented (during the announcement of SAP HANA at SapphireNOW 2010) his vision of SAP HANA becoming a database suitable as a base for SAP's entire enterprise software portfolio. He confirmed this vision during his keynote at SapphireNOW 2012 by highlighting how SAP HANA is on the path to becoming the unified foundation for all types of enterprise workloads, not only online analytical processing (OLAP), but also online transaction processing (OLTP) and text.

Just as with SAP NetWeaver BW Accelerator, SAP decided to deploy SAP HANA in an appliance-like delivery model. IBM was one of the first hardware partners to work with SAP on an infrastructure solution for SAP HANA.

This IBM Redbooks publication focuses on SAP HANA and the IBM solution for SAP HANA.

2

Basic concepts

In-memory computing is a technology that allows the processing of massive quantities of data in main memory to provide immediate results from analysis and transaction. The data to be processed is ideally real-time data (that is, data that is available for processing or analysis immediately after it is created).

To achieve the desired performance, in-memory computing follows these basic concepts:

- Keep data in main memory to speed up data access.
- Minimize data movement by leveraging the columnar storage concept, compression, and performing calculations at the database level.
- Divide and conquer. Leverage the multi-core architecture of modern processors and multi-processor servers, or even scale out into a distributed landscape, to be able to grow beyond what can be supplied by a single server.

In this chapter, we describe those basic concepts with the help of a few examples. We do not describe the full set of technologies employed with in-memory databases, such as SAP HANA, but we do provide an overview of how in-memory computing is different from traditional concepts.

2.1 Keeping data in-memory

Today, a single enterprise class server can hold several terabytes of main memory. At the same time, prices for server main memory dramatically dropped over the last few decades. This increase in capacity and reduction in cost makes it a viable approach to keep huge amounts of business data in memory. This section discusses the benefits and challenges.

2.1.1 Using main memory as the data store

The most obvious reason to use main memory (RAM) as the data store for a database is because accessing data in main memory is much faster than accessing data on disk. Figure 2-1 compares the access times for data in several locations.

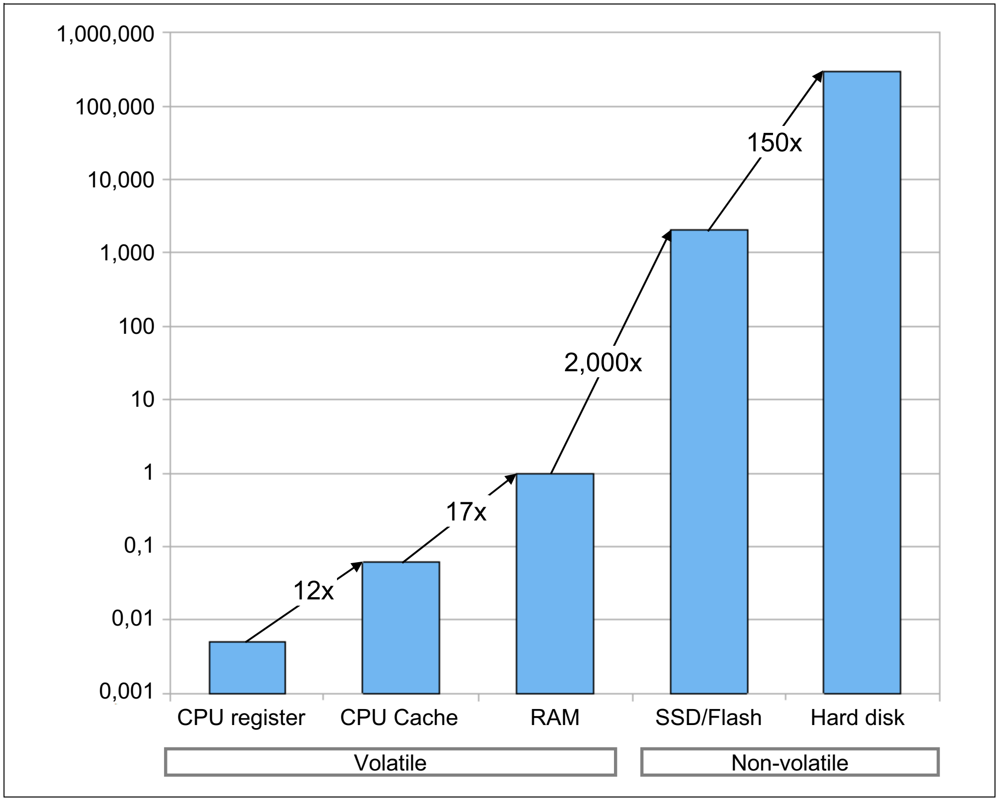

Figure 2-1 Data access times of various storage types, relative to RAM (logarithmic scale)

The main memory is the fastest storage type that can hold a significant amount of data. While CPU registers and CPU cache are faster to access, their usage is limited to the actual processing of data. Data in main memory can be accessed more than a hundred thousand times faster than data on a spinning hard disk, and even flash technology storage is about a thousand times slower than main memory. Main memory is connected directly to the processors through a high-speed bus, whereas hard disks are connected through a chain of buses (QPI, PCIe, SAN) and controllers (I/O hub, RAID controller or SAN adapter, and storage controller).

Compared with keeping data on disk, keeping the data in main memory can dramatically improve database performance just by the advantage in access time.

2.1.2 Data persistence

Keeping data in main memory brings up the question of what will happen in case of a loss of power.

In database technology, atomicity, consistency, isolation, and durability (ACID) is a set of requirements that guarantees that database transactions are processed reliably:

- A transaction must be atomic. That is, if part of a transaction fails, the entire transaction has to fail and leave the database state unchanged.
- The consistency of a database must be preserved by the transactions that it performs.
- Isolation ensures that no transaction interferes with another transaction.
- Durability means that after a transaction is committed, it will remain committed.

While the first three requirements are not affected by the in-memory concept, durability is a requirement that cannot be met by storing data in main memory alone. Main memory is volatile storage. That is, it looses its content when it is out of electrical power. To make data persistent, it must reside on non-volatile storage, such as hard drives, SSD, or Flash devices.

The storage used by a database to store data (in this case, main memory) is divided into pages. When a transaction changes data, the corresponding pages are marked and written to non-volatile storage in regular intervals. In addition, a database log captures all changes made by transactions. Each committed transaction generates a log entry that is written to non-volatile storage. This ensures that all transactions are permanent. Figure 2-2 on page 12 illustrates this using the example of SAP HANA. SAP HANA stores changed pages in savepoints, which are asynchronously written to persistent storage in regular intervals (by default every five minutes). The log is written synchronously. A transaction does not return before the corresponding log entry is written to persistent storage, to meet the durability requirement, as previously described.

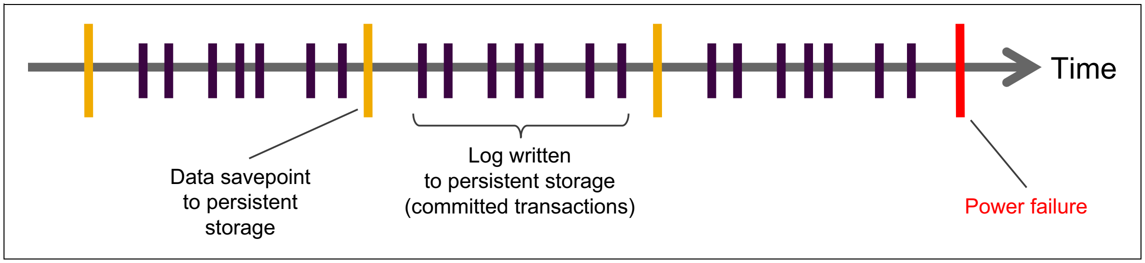

Figure 2-2 Savepoints and logs in SAP HANA

After a power failure, the database can be restarted like a disk-based database. The database pages are restored from the savepoints and then the database logs are applied (rolled forward) to restore the changes that were not captured in the savepoints. This ensures that the database can be restored in memory to exactly the same state as before the power failure.

2.2 Minimizing data movement

The second key to improving data processing performance is to minimize the movement of data within the database and between the database and the application. This section describes measures to achieve this.

2.2.1 Compression

Even though today's memory capacities allow keeping enormous amounts of data in-memory, compressing the data in-memory is still desirable. The goal is to compress data in a way that does not use up performance gained, while still minimizing data movement from RAM to the processor.

By working with dictionaries to be able to represent text as integer numbers, the database can compress data significantly and thus reduce data movement, while not imposing additional CPU load for decompression, but even adding to the performance[1]. Figure 2-3 on page 13 illustrates this with a simplified example.

[1] See the example in Figure 2-5 on page 16.

Row ID	Date/ Time	Material	Customer Name	Quantity
1	14:05	Radio	Dubois	1
2	14:11	Laptop	Di Dio	2
3	14:32	Stove	Miller	1
4	14:38	MP3 Player	Newman	2
5	14:48	Radio	Dubois	3
6	14:55	Refrigerator	Miller	1
7	15:01	Stove	Chevrier	1

⋮

#	Customers
1	Chevrier
2	Di Dio
3	Dubois
4	Miller
5	Newman

#	Material
1	MP3 Player
2	Radio
3	Refrigerator
4	Stove
5	Laptop

Row ID	Date/ Time	Material	Customer Name	Quantity
1	845	2	3	1
2	851	5	2	2
3	872	4	4	1
4	878	1	5	2
5	888	2	3	3
6	895	3	4	1
7	901	4	1	1

⋮

Figure 2-3 Illustration of dictionary compression

On the left side of Figure 2-3, the original table is shown containing text attributes (that is, material and customer name) in their original representation. The text attribute values are stored in a dictionary (upper right), assigning an integer value to each distinct attribute value. In the table, the text is replaced by the corresponding integer value, as defined in the dictionary. The date and time attribute was also converted to an integer representation. Using dictionaries for text attributes reduces the size of the table because each distinct attribute value has only to be stored once, in the dictionary; therefore, each additional occurrence in the table just needs to be referred to with the corresponding integer value.

The compression factor achieved by this method is highly dependent on data being compressed. Attributes with few distinct values compress well; whereas, attributes with many distinct values do not benefit as much.

While there are other, more effective compression methods that can be employed with in-memory computing, to be useful, they must have the correct balance between compression effectiveness. This gives you more data in your memory, or less data movement (that is, higher performance), resources needed for decompression, and data accessibility (that is, how much unrelated data has to be decompressed to get to the data that you need). As discussed here, dictionary compression combines good compression effectiveness with low decompression resources and high data access flexibility.

2.2.2 Columnar storage

Relational databases organize data in tables that contain the data records. The difference between row-based and columnar (or column-based) storage is the way in which the table is stored:

- Row-based storage stores a table in a sequence of rows.
- Column-based storage stores a table in a sequence of columns.

Figure 2-4 illustrates the row-based and column-based models.

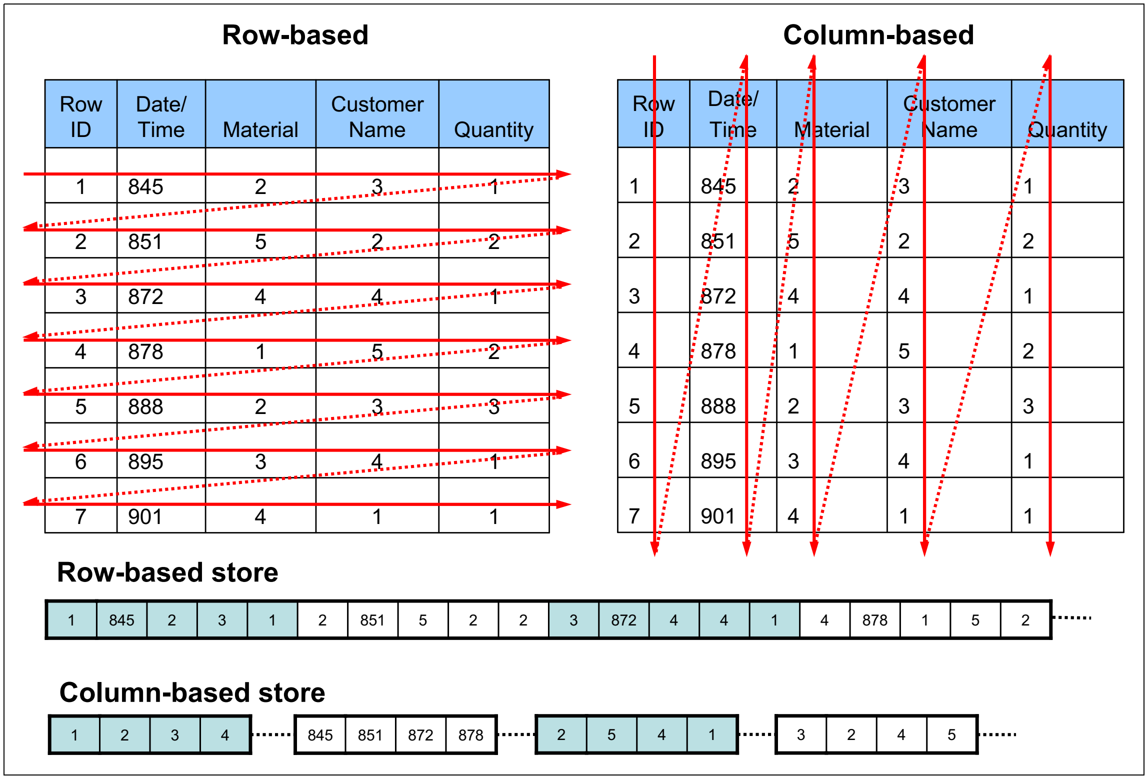

Figure 2-4 Row-based and column-based storage models

Both storage models have benefits and drawbacks, which are listed in Table 2-1.

Table 2-1 Benefits and drawbacks of row-based and column-based storage

	Row-based storage	**Column-based storage**
Benefits	► Record data is stored together. ► Easy to insert/update.	► Only affected colums have to be read during the selection process of a query. ► Efficient projections[a]. ► Any column can serve as an index.
Drawbacks	► All data must be read during selection, even if only a few columns are involved in the selection process.	► After selection, selected rows must be reconstructed from columns. ► No easy insert/update.

a. Projection: View on the table with a subset of columns

The drawbacks of column-based storage are not as grave as they seem. In most cases, not all attributes (that is, column values) of a row are needed for processing, especially in analytic queries. Also, inserts or updates to the data are less frequent in an analytical environment[2]. SAP HANA implements both a row-based storage and a column-based storage; however, its performance originates in the use of column-based storage in memory. The following sections describe how column-based storage is beneficial to query performance and how SAP HANA handles the drawbacks of column-based storage.

[2] An exception is bulk loads (for example, when replicating data in the in-memory database, which can be handled differently).

Efficient query execution

To show the benefits of dictionary compression combined with columnar storage, Figure 2-5 shows an example of how a query is executed. Figure 2-5 refers to the table shown in Figure 2-3 on page 13.

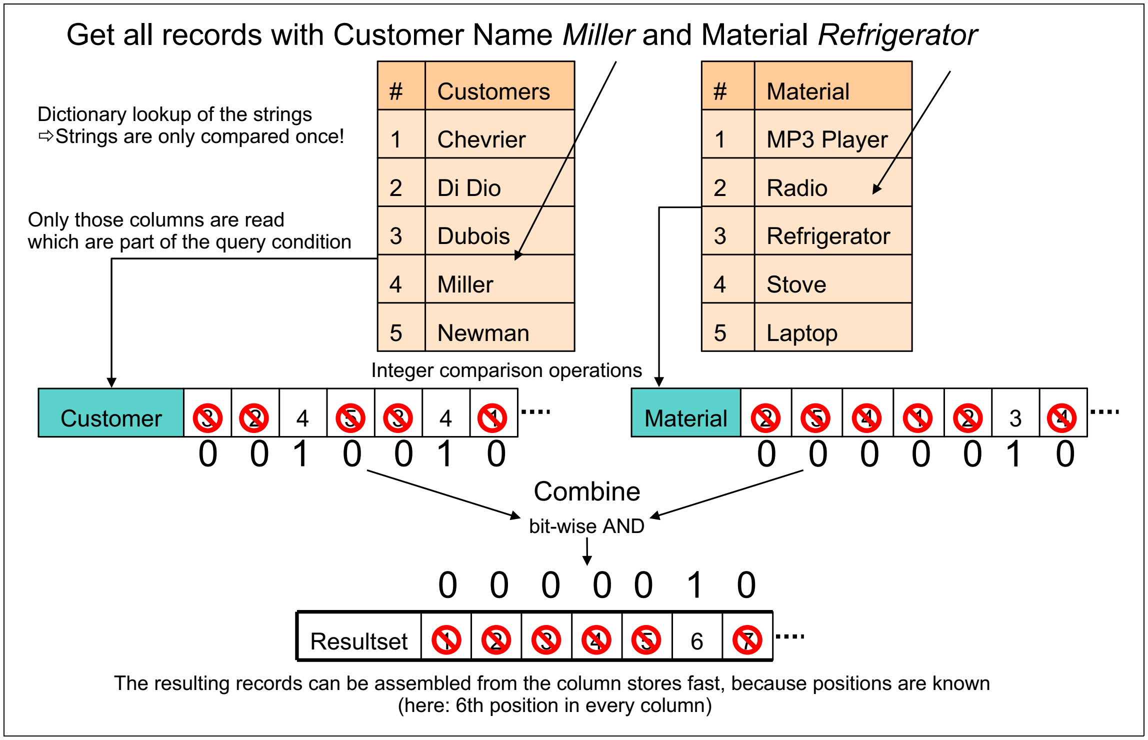

Figure 2-5 Example of a query executed on a table in columnar storage

The query asks to get all records with Miller as the customer name and Refrigerator as the material.

First, the strings in the query condition are looked up in the dictionary. Miller is represented as the number 4 in the customer name column. Refrigerator is represented as the number 3 in the material column. Note that this lookup has to be done only once. Subsequent comparison with the values in the table are based on integer comparisons, which are less resource intensive than string comparisons.

In a second step, the columns are read that are part of the query condition (that is, the Customer and Material columns). The other columns of the table are not needed for the selection process. The columns are then scanned for values matching the query condition. That is, in the Customer column all occurrences of

4 are marked as selected, and in the Material column all occurrences of 3 are marked.

These selection marks can be represented as bitmaps, a data structure that allows efficient boolean operations on them, which is used to combine the bitmaps of the individual columns to a bitmap representing the selection or records matching the entire query condition. In our example, the record number 6 is the only matching record. Depending on the columns selected for the result, now the additional columns must be read to compile the entire record to return. But because the position within the column is known (record number 6) only the parts of the columns have to be read that contain the data for this record.

This example shows how compression not only can limit the amount of data needed to be read for the selection process, but even simplify the selection itself, while the columnar storage model further reduces the amount of data needed for the selection process. Although the example is simplified, it illustrates the benefits of dictionary compression and columnar storage.

Delta-merge and bulk inserts

To overcome the drawback of inserts or updates having impact on performance of the column-based storage, SAP plans to implement a lifecycle management for database records[3].

[3] See "Efficient Transaction Processing in SAP HANA Database - The End of a Column Store Myth" by Sikka, Färber, Lehner, Cha, Peh, Bornhövd, available at
http://dl.acm.org/citation.cfm?id=2213946

Figure 2-6 illustrates the lifecycle management for database records in the column-store.

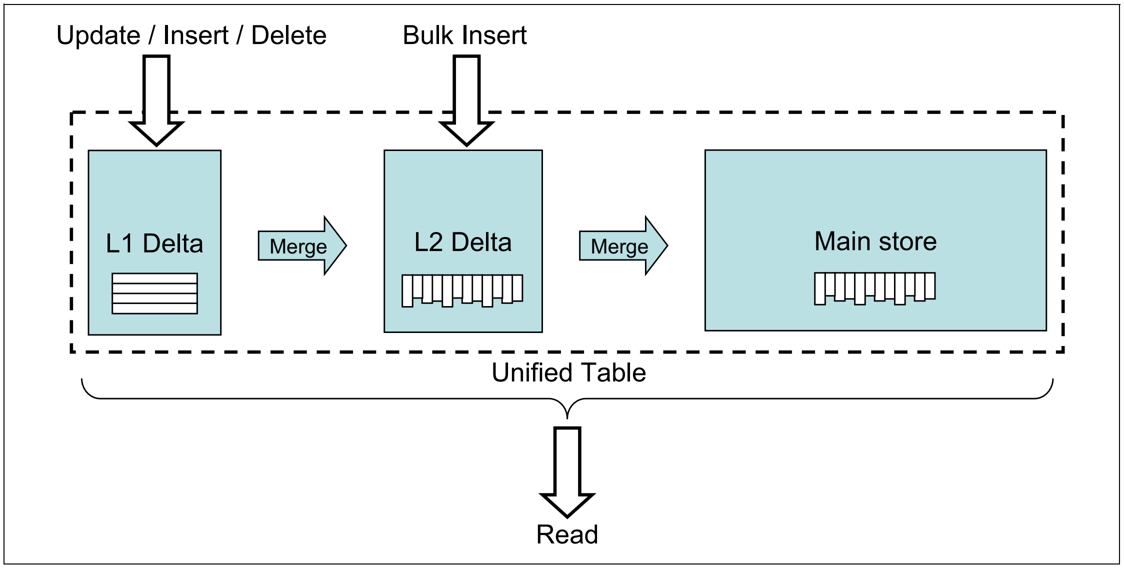

Figure 2-6 Lifetime management of a data record in the SAP HANA column-store

There are three different types of storage for a table:

- L1 Delta Storage is optimized for fast write operations. The update is performed by inserting a new entry into the delta storage. The data is stored in records, like in a traditional row-based approach. This ensures high performance for write, update, and delete operations on records stored in the L1 Delta Storage.
- L2 Delta Storage is an intermediate step. While organized in columns, the dictionary is not as much optimized as in the main storage and appends new dictionary entries to the end of the dictionary. This results in easier inserts, but has drawbacks with regards to search operations on the dictionary because it is not sorted.
- Main Storage contains the compressed data for fast read with a search optimized dictionary.

All write operations on a table work on the L1 Delta storage. Bulk inserts bypass L1 Delta storage and write directly into L2 Delta storage. Read operations on a table always reads from all storages for that table, merging the result set to provide a unified view on all data records in the table.

During the lifecycle of a record, it is moved from L1 Delta storage to L2 Delta storage and finally to the Main storage. The process of moving changes to a table from one storage to the next one is called *Delta Merge*, and is an asynchronous process. During the merge operations, the columnar table is still available for read and write operations.

Moving records from L1 Delta storage to L2 Delta storage involves reorganizing the record in a columnar fashion and compressing it, as illustrated in Figure 2-3 on page 13. If a value is not yet in the dictionary, a new entry is appended to the dictionary. Appending to the dictionary is faster than inserting, but results in an unsorted dictionary, which impacts the data retrieval performance.

Eventually, the data in the L2 Delta storage must be moved to the Main storage. To accomplish that, the L2 Delta storage must be locked, and a new L2 Delta storage must be opened to accept further additions. Then a new Main storage is created from the old Main storage and the locked L2 Delta storage. This is a resource intensive task and has to be scheduled carefully.

2.2.3 Pushing application logic to the database

Whereas the concepts described above speed up processing within the database, there is still one factor that can significantly slow down the processing of data. An application executing the application logic on the data has to get the data from the database, process it, and possibly send it back to the database to store the results. Sending data back and forth between the database and the application usually involves communication over a network, which introduces communication overhead and latency and is limited by the speed and throughput of the network between the database and the application itself.

To eliminate this factor and increase overall performance, it is beneficial to process the data where it is, at the database. If the database can perform calculations and apply application logic, less data needs to be sent back to the application and might even eliminate the need for the exchange of intermediate results between the database and the application. This minimizes the amount of data transfer, and the communication between database and application contributes a less significant amount of time to the overall processing time.

2.3 Divide and conquer

The phrase “divide and conquer” (derived from the Latin saying *divide et impera*) is typically used when a big problem is divided into a number of smaller, easier-to-solve problems. With regard to performance, processing huge amounts of data is a big problem that can be solved by splitting it up into smaller chunks of data, which can be processed in parallel.

2.3.1 Parallelization on multi-core systems

When chip manufactures reached the physical limits of semiconductor-based microelectronics with their single-core processor designs, they started to increase processor performance by increasing the number of cores, or processing units, within a single processor. This performance gain can only be leveraged through parallel processing because the performance of a single core remained unchanged.

The rows of a table in a relational database are independent of each other, which allows parallel processing. For example, when scanning a database table for attribute values matching a query condition, the table, or the set of attributes (columns) relevant to the query condition, can be divided into subsets and spread across the cores available to parallelize the processing of the query. Compared with processing the query on a single core, this basically reduces the time needed for processing by a factor equivalent to the number of cores working on the query (for example, on a 10-core processor the time needed is one-tenth of the time that a single core would need).

The same principle applies for multi-processor systems. A system with eight 10-core processors can be regarded as an 80-core system that can divide the processing into 80 subsets processed in parallel.

2.3.2 Data partitioning and scale-out

Even though servers available today can hold terabytes of data in memory and provide up to eight processors per server with up to 10 cores per processor, the amount of data to be stored in an in-memory database or the computing power needed to process such quantities of data might exceed the capacity of a single server. To accommodate the memory and computing power requirements that go beyond the limits of a single server, data can be divided into subsets and placed across a cluster of servers, forming a distributed database (scale-out approach).

The individual database tables can be placed on different servers within the cluster, or tables bigger than what a single server can hold can be split into several partitions, either horizontally (a group of rows per partition) or vertically (a group of columns per partition) with each partition residing on a separate server within the cluster.

3

SAP HANA overview

In this chapter, we describe the SAP HANA offering, its architecture and components, use cases, delivery model, and sizing and licensing aspects.

This chapter contains the following sections:

- SAP HANA overview
- SAP HANA delivery model
- Sizing SAP HANA
- SAP HANA software licensing

3.1 SAP HANA overview

This section gives an overview of SAP HANA. When talking about SAP HANA, these terms are used:

- SAP HANA database

  The SAP HANA database (also referred to as the SAP in-memory database) is a hybrid in-memory database that combines row-based, column-based, and object-based database technology, optimized to exploit the parallel processing capabilities of current hardware. It is the heart of SAP offerings, such as SAP HANA.

- SAP HANA Appliance (SAP HANA)

  SAP HANA is a flexible, data source agnostic appliance that allows you to analyze large volumes of data in real time without the need to materialize aggregations. It is a combination of hardware and software, and it is delivered as an optimized appliance in cooperation with SAP's hardware partners for SAP HANA.

For the sake of simplicity, we use the terms SAP HANA, SAP in-memory database, SAP HANA database, and SAP HANA appliance synonymously in this paper. We only cover the SAP in-memory database as part of the SAP HANA appliance. Where required, we make sure that the context makes it clear which part we are talking about.

3.1.1 SAP HANA architecture

Figure 3-1 shows the high-level architecture of the SAP HANA appliance. Section 4.1, “SAP HANA software components” on page 36 explains the most important software components around SAP HANA database.

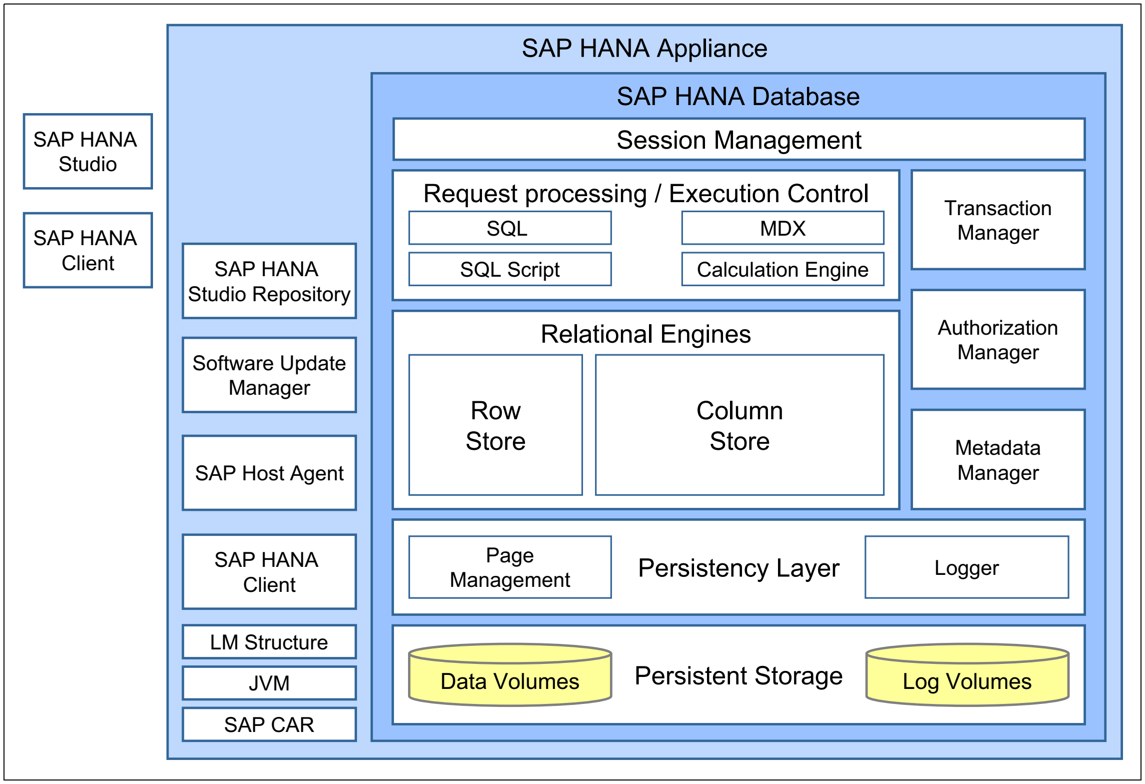

Figure 3-1 SAP HANA architecture

The SAP HANA database

The heart of the SAP HANA database is the relational database engines. There are two engines within the SAP HANA database:

- The column-based store: Stores relational data in columns, optimized holding tables with huge amounts of data, which can be aggregated in real-time and used in analytical operations.
- The row-based store: Stores relational data in rows, as traditional database systems do. This row store is more optimized for row operations, such as frequent inserts and updates. It has a lower compression rate, and query performance is much lower compared to the column-based store.

The engine used to store data can be selected on a per-table basis at the time of creation of a table. There is a possibility to convert an existing table from one type to another. Tables in the row-store are loaded at startup time; whereas, tables in the column-store can be either loaded at startup or on demand during normal operation of the SAP HANA database.

Both engines share a common persistency layer, which provides data persistency consistent across both engines. There is page management and logging, much like in traditional databases. Changes to in-memory database pages are persisted through savepoints written to the data volumes on persistent storage, which are usually hard drives. Every transaction committed in the SAP HANA database is persisted by the logger of the persistency layer in a log entry written to the log volumes on persistent storage. The log volumes use flash technology storage for high I/O performance and low latency.

The relational engines can be accessed through a variety of interfaces. The SAP HANA database supports SQL (JDBC/ODBC), MDX (ODBO), and BICS (SQL DBC). The calculation engine allows calculations to be performed in the database without moving the data into the application layer. It also includes a business functions library that can be called by applications to do business calculations close to the data. The SAP HANA-specific SQL Script language is an extension to SQL that can be used to push down data-intensive application logic into the SAP HANA database.

3.1.2 SAP HANA appliance

The SAP HANA appliance consists of the SAP HANA database and adds components needed to work with, administer, and operate the database. It contains the repository files for the SAP HANA studio, which is an Eclipse-based administration and data-modeling tool for SAP HANA, in addition to the SAP HANA client, which is a set of libraries required for applications to be able to connect to the SAP HANA database. Both the SAP HANA studio and the client libraries are usually installed on a client PC or server.

The Software Update Manager (SUM) for SAP HANA is the framework allowing the automatic download and installation of SAP HANA updates from the SAP Marketplace and other sources using a host agent. It also allows distribution of the Studio repository to the users.

The Lifecycle Management (LM) Structure for SAP HANA is a description of the current installation and is, for example, used by SUM to perform automatic updates.

More details about existing software components is in section 4.1, “SAP HANA software components” on page 36.

3.2 SAP HANA delivery model

SAP decided to deploy SAP HANA as an integrated solution combining software and hardware, frequently referred to as the SAP HANA appliance. As with SAP NetWeaver BW Accelerator, SAP partners with several hardware vendors to provide the infrastructure needed to run the SAP HANA software. IBM was among the first hardware vendors to partner with SAP to provide an integrated solution.

Infrastructure for SAP HANA must run through a certification process to ensure that certain performance requirements are met. Only certified configurations are supported by SAP and the respective hardware partner. These configurations must adhere to certain requirements and restrictions to provide a common platform across all hardware providers:

- Only certain Intel Xeon processors can be used. For the currently available Intel Xeon processor E7 family, the allowed processor models are E7-2870, E7-4870, and E7-8870. The previous CPU generation was limited to the Intel Xeon processor X7560.
- All configurations must provide a certain main memory per core ratio, which is defined by SAP to balance CPU processing power and the amount of data being processed.
- All configurations must meet minimum performance requirements for various load profiles. SAP tests for these requirements as part of the certification process.
- The capacity of the storage devices used in the configurations must meet the sizing rules (see 3.3, “Sizing SAP HANA” on page 25).
- The networking capabilities of the configurations must include 10 Gb Ethernet for the SAP HANA software.

By imposing these requirements, SAP can rely on the availability of certain features and ensure a well-performing hardware platform for their SAP HANA software. These requirements give the hardware partners enough room to develop an infrastructure architecture for SAP HANA, which adds differentiating features to the solution. The benefits of the IBM solution are described in Chapter 6, “The IBM Systems Solution for SAP HANA” on page 87.

3.3 Sizing SAP HANA

This section introduces the concept of T-shirt sizes for SAP HANA and gives a short overview of how to size for an SAP HANA system.

3.3.1 The concept of T-shirt sizes for SAP HANA

SAP defined so-called T-shirt sizes for SAP HANA to both simplify the sizing and to limit the number of hardware configurations to support, thus reducing complexity. The SAP hardware partners provide configurations for SAP HANA according to one or more of these T-shirt sizes. Table 3-1 lists the T-shirt sizes for SAP HANA.

Table 3-1 SAP HANA T-shirt sizes

SAP T-shirt size	XS	S and S+	M and M+	L
Compressed data in memory	64 GB	128 GB	256 GB	512 GB
Server main memory	128 GB	256 GB	512 GB	1024 GB
Number of CPUs	2	2	4	8

In addition to the T-shirt sizes listed in Table 3-1, you might come across the T-shirt size XL, which denotes a scale-out configuration for SAP HANA.

The T-shirt sizes S+ and M+ denote upgradable versions of the S and M sizes:

- S+ delivers capacity equivalent to S, but the hardware is upgradable to an M size.
- M+ delivers capacity equivalent to M, but the hardware is upgradable to an L size.

These T-shirt sizes are used when relevant growth of the data size is expected.

For more information about T-shirt size mappings to IBM System Solution building blocks, refer to the section 6.3.2, “SAP HANA T-shirt sizes” on page 108.

3.3.2 Sizing approach

The sizing of SAP HANA depends on the scenario in which SAP HANA is used. We discuss these scenarios here:

- SAP HANA as a stand-alone database
- SAP HANA as the database for an SAP NetWeaver BW

The sizing methodology for SAP HANA is described in detail in the following SAP Notes[1] and attached presentations:

- Note 1514966 - SAP HANA 1.0: Sizing SAP In-Memory Database
- Note 1637145 - SAP NetWeaver BW on HANA: Sizing SAP In-Memory Database

The following sections provide a brief overview of sizing for SAP HANA.

SAP HANA as a stand-alone database

This section covers sizing of SAP HANA as a stand-alone database, used for example as technology platform, operational reporting, or accelerator use case scenarios, as described in Chapter 5, "SAP HANA use cases and integration scenarios" on page 59.

The sizing methodology for this scenario is described in detail in SAP Note 1514966 and the attached presentation.

Sizing the RAM needed

Sizing an SAP HANA system is mainly based on the amount of data to be loaded into the SAP HANA database because this determines the amount of main memory (or RAM) needed in an SAP HANA system. To size the RAM, perform the following steps:

1. Determine the volume of data that is expected to be transferred to the SAP HANA database. Note that typically customers only select a sub-set of data from their ERP or CRM databases, so this must be done at the table level.

   The information required for this step can be acquired with database tools. SAP Note 1514966 contains a script supporting this process for SAP NetWeaver based systems, for example, IBM DB2® LUW and Oracle. If data comes from non-SAP NetWeaver systems, use the manual SQL statement.

   The sizing methodology is based on uncompressed source data size, so in case that compression is used in the source database, this must be taken into account too. The script is automatically adjusting table sizes only for DB2 LUW database because information about compression ratio is available in the data dictionary.

   For other database systems, compression factor must be estimated. Note that real compression factors can differ because compression itself is dependent on actual data.

   In case that source database is non-unicode, multiply the volume of data by overhead for unicode conversion (assume 50% overhead).

[1] SAP Notes can be accessed at http://service.sap.com/notes. An SAP S-user ID is required.

The uncompressed total size of all the tables (without DB indexes) storing the required information in the source database is denoted as A.

2. Although the compression ratio achieved by SAP HANA can vary depending on the data distribution, a working assumption is that, in general, a compression factor of 7 can be achieved:

   ```
   B = ( A / 7 )
   ```

   B is the amount of RAM required to store the data in the SAP HANA database.

3. Use only 50% of the total RAM for the in-memory database. The other 50% is needed for temporary objects (for example, intermediate results), the operating system, and the application code:

   ```
   C = B * 2
   ```

   C is the total amount of RAM required.

Round the total amount of RAM up to the next T-shirt configuration size, as described in 3.3.1, “The concept of T-shirt sizes for SAP HANA” on page 26, to get the correct T-shirt size needed.

Sizing the disks

The capacity of the disks is based on the total amount of RAM.

As described in 2.1.2, “Data persistence” on page 11, there are two types of storage in SAP HANA:

- $Disk_{persistence}$

  The persistence layer writes snapshots of the database in HANA to disk in regular intervals. These are usually written to an array of SAS drives[2]. The capacity for this storage is calculated based on the total amount of RAM:

  $Disk_{persistence} = 4 * C$

  Note that backup data must not be permanently stored in this storage. After backup is finished, it needs to be moved to external storage media.

- $Disk_{log}$

  This contains the database logs, written to flash technology storage devices, that is, SSDs or PCIe Flash adapters. The capacity for this storage is calculated based on the total amount of RAM:

  $Disk_{log} = 1 * C$

[2] The SSD building block, as described in 6.3, “Custom server models for SAP HANA” on page 104, combines $Disk_{persistence}$ and $Disk_{log}$ on a single SSD array with sufficient capacity.

The certified hardware configurations already take these rules into account, so there is no need to perform this disk sizing. However, we still include it here for your understanding.

Sizing the CPUs

A CPU sizing can be performed in case that unusually high amount of concurrently active users executing complex queries is expected. Use the T-shirt configuration size that satisfies both the memory and CPU requirements.

The CPU sizing is user-based. The SAP HANA system must support 300 SAPS for each concurrently active user. The servers used for the IBM Systems Solution for SAP HANA support about 60 to 65 concurrently active users per CPU, depending on the server model.

SAP recommends that the CPU load not exceed 65%. Therefore size servers to support no more then 40 to 42 concurrently active users per CPU for standard workload.

SAP HANA as the database for an SAP NetWeaver BW

This section covers sizing of SAP HANA as the database for an SAP NetWeaver BW, as described in section 5.5.1, “SAP NetWeaver BW running on SAP HANA” on page 75.

The sizing methodology for this scenario is described in detail in SAP Note 1637145 and attached presentations.

Sizing the RAM needed

Similar to the previous scenario, it is important to estimate the volume of uncompressed data that will be stored in the SAP HANA database. The main difference is that the SAP NetWeaver BW system is using column based tables only for tables generated by BW. All other tables are stored as row-based tables.

The compression factor is different for each type of storage; therefore, the calculation formula is slightly different.

To size the RAM, perform the following steps:

1. The amount of data that will be stored in the SAP HANA database can be estimated using scripts attached to SAP Note 1637145. They determine the volume of row based and column based tables separately.

   Because the size of certain system tables can grow over time and because the row store compression factors are not as high as for the column store, it is recommended to clean up unnecessary data. In a cleansed SAP NetWeaver BW system, the volume of row-based data is around 60 GB.

Just as in the previous case, only the size of tables is relevant. All associated indexes can be ignored.

In case the data in the source system is compressed, the calculated volume needs to be adjusted by an estimated compression factor for the given database. Only for DB2 databases, which contain the actual compression rates in the data dictionary, the script calculates the required corrections automatically.

In case the source system is a non-unicode system, a unicode conversion will be part of the migration scenario. In this case, the volume of data needs to be adjusted, assuming a 10% overhead because the majority of data is expected to be numerical values.

Alternatively, an ABAP report can be used to estimate the table sizes. SAP Note 1736976 has a report attached that calculates the sizes based on the data present in an existing SAP NetWeaver BW system.

The uncompressed total size of all the column tables (without DB indexes) is denoted as A_{column}. The uncompressed total size of all the row tables (without DB indexes) is referred to as A_{row}.

2. The average compression factor is approximately 4 for column-based data and around 1.5 for row based data.

   Additionally, an SAP NetWeaver BW system requires about 40 GB of RAM for additional caches and about 10 GB of RAM for SAP HANA components.

   $B_{column} = (A_{column} / 4)$

   $B_{row} = (A_{row} / 1.5)$

   $B_{other} = 50$

   For a fully cleansed SAP NetWeaver BW system having 60 GB of row store data, we can therefore assume a requirement of about 40 GB of RAM for row-based data.

   $B_{row} = 40$

   B is the amount of RAM required to store the data in the SAP HANA database for a given type of data.

3. Additional RAM is required for objects that are populated with new data and for queries. This requirement is valid for column based tables.

   $C = B_{column} * 2 + B_{row} + B_{other}$

   For fully cleansed BW systems, this formula can be simplified:

   $C = B_{column} * 2 + 90$

   C is the total amount of RAM required.

The total amount of RAM must be rounded up to the next T-shirt configuration size, as described in 3.3.1, “The concept of T-shirt sizes for SAP HANA” on page 26, to get the correct T-shirt size needed.

Sizing the disks

The capacity of the disks is based on the total amount of RAM and follows the same rules as in the previous scenario. For more details, see “Sizing the disks” on page 28.

$$Disk_{persistence} = 4 * C$$
$$Disk_{log} = 1 * C$$

As in the previous case, disk sizing is not required because certified hardware configurations already takes these rules into account.

Special considerations for scale-out systems

If the memory requirements exceed the capacity of single node appliance, a scale-out configuration needs to be deployed.

In this case, it is important to understand how the data is distributed during the import operation. For optimal performance, different types of workload must be separated from each other.

The master node holds all row-based tables, which are mostly system tables, and is responsible for SAP NetWeaver-related workloads. Also, additional SAP HANA database components are hosted on the master node, such as a name server or statistics server.

All additional slave nodes hold all master data and transactional data. Transactional tables are partitioned and distributed across all existing slave nodes to reach optimal parallel processing.

This logic must be taken into account when planning scale-out configuration for SAP NetWeaver BW system. For more information, review the following SAP notes and attached presentations:

- Note 1637145 - SAP NetWeaver BW on SAP HANA: Sizing SAP In-Memory Database
- Note 1702409 - SAP HANA DB: Optimal number of scale out nodes for SAP NetWeaver BW on SAP HANA
- Note 1736976 - Sizing Report for BW on HANA

Selecting a T-shirt size

According to the sizing results, select an SAP HANA T-shirt size that satisfies the sizing requirements in terms of main memory, and possibly CPU capabilities. For example, a sizing result of 400 GB for the main memory (C) suggests a T-shirt size of M.

The sizing methodology previously described is valid at the time of writing this publication and only for use case scenarios previously mentioned. Other use cases might require another sizing methodology. Also, SAP HANA is constantly being optimized, which might affect the sizing methodology. Consult SAP documentation regarding other use cases and up-to-date sizing information.

> **Note:** The sizing approach described here is simplified and can only provide a rough idea of the sizing process for the actual sizing for SAP HANA. Consult the SAP sizing documentation for SAP HANA when performing an actual sizing. It is also a best practice to involve SAP for a detailed sizing because the result of the sizing does not only affect the hardware infrastructure, but it also affects the SAP HANA licensing.

In addition to the sizing methodologies described in SAP Notes, SAP provides sizing support for SAP HANA in the SAP Quick Sizer. The SAP Quick Sizer is an online sizing tool that supports most of the SAP solutions available. For SAP HANA, it supports sizing for:

- Stand-alone SAP HANA system, implementing the sizing algorithms described in SAP Note 1514966 (which we described above)
- SAP HANA as the database for an SAP NetWeaver BW system, implementing the sizing algorithms described in SAP Note 1637145
- Special sizing support for the SAP HANA rapid-deployment solutions

The SAP Quick Sizer is accessible online at:

`http://service.sap.com/quicksizer`[3]

[3] SAP S-user ID required

3.4 SAP HANA software licensing

As described in 3.2, “SAP HANA delivery model” on page 25, SAP HANA has an appliance-like delivery model. However, while the hardware partners deliver the infrastructure, including operating system and middleware, the license for the SAP HANA software must be obtained directly from SAP.

The SAP HANA software is available in these editions:

- SAP HANA platform edition

  This is the basic edition containing the software stack needed to use SAP HANA as a database, including the SAP HANA database, SAP HANA Studio for data modeling and administration, the SAP HANA clients, and software infrastructure components. The software stack comes with the hardware provided by the hardware partners; whereas, the license has to be obtained from SAP.

- SAP HANA enterprise edition

  The SAP HANA enterprise edition extends the SAP HANA platform edition with the software licenses needed for SAP Landscape Transformation replication, ETL-based replication using SAP BusinessObjects Data Services, and Extractor-based replication with Direct Extractor Connection.

- SAP HANA extended enterprise edition

  SAP HANA extended enterprise edition extends the SAP HANA platform edition with the software licenses needed for log-based replication with the Sybase Replication server.

- SAP HANA database edition for SAP NetWeaver BW

  This edition is restricted to be used as the primary database for an SAP NetWeaver BW system. Any access to the SAP HANA database must take place through the BW system.

Additional information about available replication technologies is in section 4.2, “Data replication methods for SAP HANA” on page 51.

The SAP HANA licenses are based on the amount of main memory for SAP HANA. The smallest licensable memory size is 64 GB, increasing in steps of 64 GB. The hardware might provide up to double the amount of main memory than licensed, as illustrated in Table 3-2.

Table 3-2 Licensable memory per T-shirt size

T-shirt size	Server main memory	Licensable memory[a]
XS	128 GB	64 - 128 GB

T-shirt size	Server main memory	Licensable memory[a]
S	256 GB	128 - 256 GB
M	512 GB	256 - 512 GB
L	1024 GB (= 1 TB)	512 - 1024 GB

a. In steps of 64 GB

As you can see from Table 3-2 on page 33, the licensing model allows you to have a matching T-shirt size for any licensable memory size between 64 GB and 1024 GB.

4

Software components and replication methods

This chapter explains the purpose of individual software components of SAP HANA solution and introduces available replication technologies.

This chapter contains the following sections:

4.1 SAP HANA software components

The SAP HANA solution is composed from the following main software components, which we describe in the following sections:

- 4.1.1, "SAP HANA database" on page 37
- 4.1.2, "SAP HANA client" on page 37
- 4.1.3, "SAP HANA studio" on page 38
- 4.1.4, "SAP HANA studio repository" on page 46
- 4.1.5, "SAP HANA landscape management structure" on page 47
- 4.1.6, "SAP host agent" on page 47
- 4.1.7, "Software Update Manager for SAP HANA" on page 48
- 4.1.8, "SAP HANA Unified Installer" on page 51

Figure 4-1 illustrates the possible locations of these components.

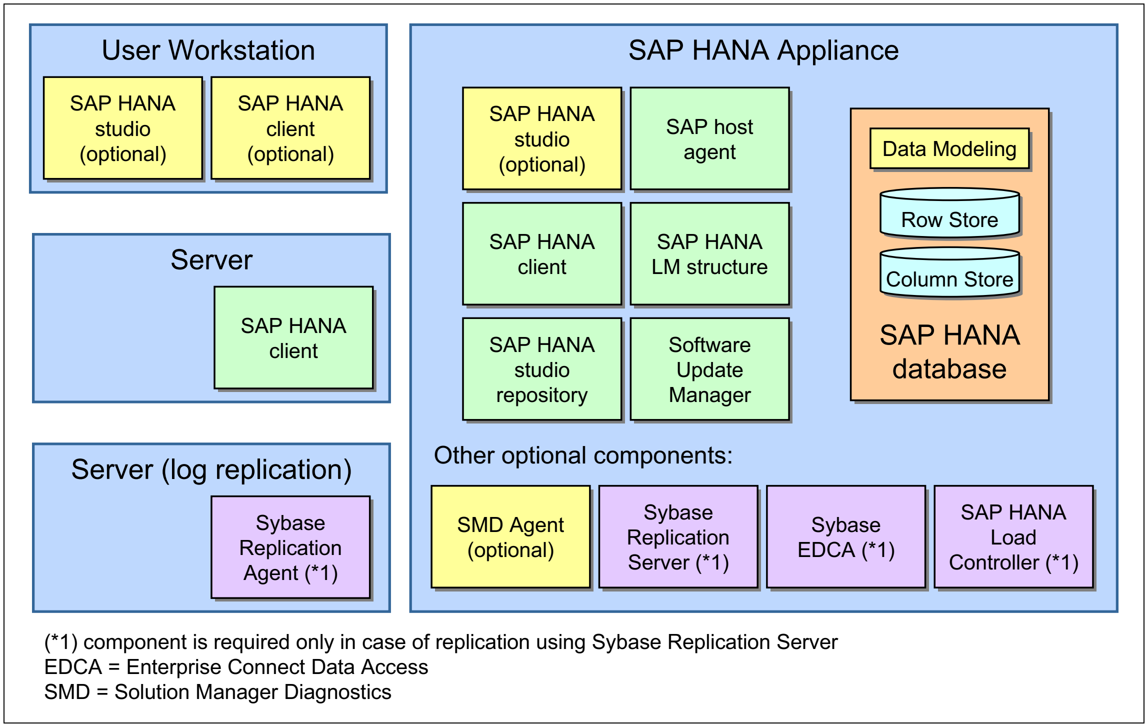

Figure 4-1 Distribution of software components related to SAP HANA

Components related to replication using Sybase Replication Server are not covered in this publication.

4.1.1 SAP HANA database

The SAP HANA database is the heart of the SAP HANA offering and the most important software component running on the SAP HANA appliance.

SAP HANA is an in-memory database that combines row-based and column-based database technology. All standard features available in other relational databases are supported (for example, tables, views, indexes, triggers, SQL interface, and so on)

On top of these standard functions, the SAP HANA database also offers modeling capabilities that allow you to define in-memory transformation of relational tables into analytic views. These views are not materialized; therefore, all queries are providing real-time results based on content of the underlying tables.

Another feature extending the capabilities of the SAP HANA database is the SQLscript programming language, which allows you to capture transformations that might not be easy to define using simple modeling.

The SAP HANA database can also be integrated with external applications, such as an SAP R/3 software environment. Using these possibilities customers can extend their models by implementing existing statistical and analytical functions developed in the SAP R/3 programming language.

The internal structures of the SAP HANA database are explained in detail in Chapter 3, “SAP HANA overview” on page 21.

4.1.2 SAP HANA client

The SAP HANA client is a set of libraries that are used by external applications to connect to the SAP HANA database.

The following interfaces are available after installing the SAP HANA client libraries:

- SQLDBC

  An SAP native database SDK that can be used to develop new custom applications working with the SAP HANA database.

- OLE DB for OLAP (ODBO) (available only on Windows)

  ODBO is a Microsoft driven industry standard for multi-dimensional data processing. The query language used in conjunction with ODBO is the Multidimensional Expressions (MDX) language.

- Open Database Connectivity (ODBC)

  ODBC interface is a standard for accessing database systems, which was originally developed by Microsoft.

- Java Database Connectivity (JDBC)

  JDBC is a Java-based interface for accessing database systems.

The SAP HANA client libraries are delivered in 32-bit and 64-bit editions. It is important to always use the correct edition based on the architecture of the application that will use this client. 32-bit applications cannot use 64-bit client libraries and vice versa.

To access the SAP HANA database from Microsoft Excel you can also use a special 32-bit edition of the SAP HANA client called `SAP HANA client package for Microsoft Excel`.

The SAP HANA client is backwards compatible, meaning that the revision of the client must be the same or higher than the revision of the SAP HANA database.

The SAP HANA client libraries must be installed on every machine where connectivity to the SAP HANA database is required. This includes not only all servers but also user workstations that are hosting applications that are directly connecting to the SAP HANA database (for example SAP BusinessObjects Client Tools or Microsoft Excel).

It is important to keep in mind that whenever the SAP HANA database is updated to a more recent revision, all clients associated with this database must also be upgraded.

For more information about how to install the SAP HANA client, see the official SAP guide *SAP HANA Database - Client Installation Guide*, which is available for download at:

http://help.sap.com/hana_appliance

4.1.3 SAP HANA studio

The SAP HANA studio is a graphical user interface that is required to work with local or remote SAP HANA database installations. It is a multipurpose tool that covers all of the main aspects of working with the SAP HANA database. Because of that, the user interface is slightly different for each function.

Note that the SAP HANA studio is not dependent on the SAP HANA client.

The following main function areas are provided by the SAP HANA studio (each function area is also illustrated by a corresponding figure of the user interface):

- ► Database administration

  The key functions are stopping and starting the SAP HANA databases, status overview, monitoring, performance analysis, parameter configuration, tracing, and log analysis.

  Figure 4-2 shows the SAP HANA studio user interface for database administration.

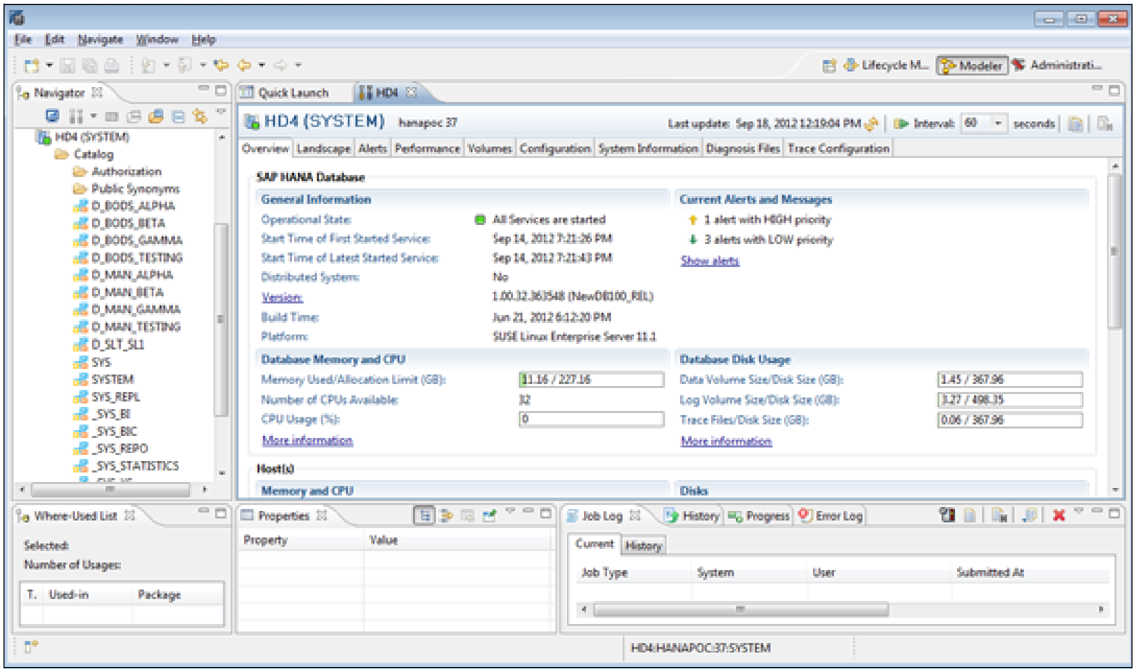

Figure 4-2 SAP HANA studio: Administration console (overview)

- Security management

  This provides tools that are required to create users, to define and assign roles, and to grant database privileges.

  Figure 4-3 shows an example of the user definition dialog.

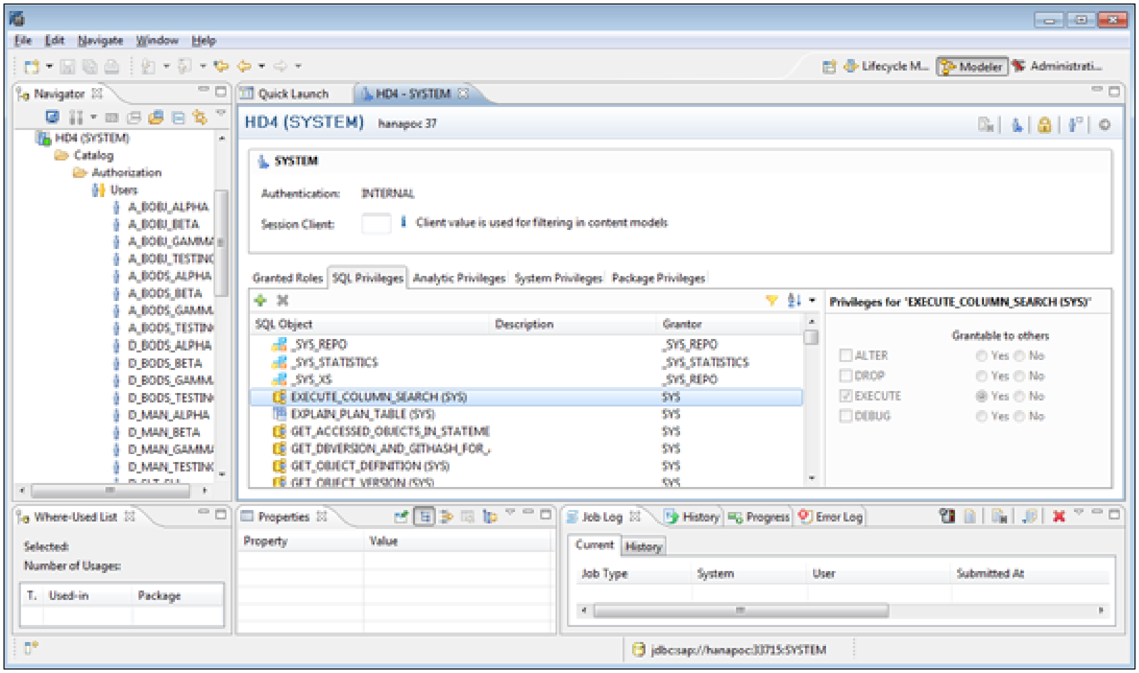

Figure 4-3 SAP HANA studio: User definition dialog

- Data management

  Functions to create, change or delete database objects (like tables, indexes, views), commands to manipulate data (for example insert, update, delete, bulk load, and so on)

  Figure 4-4 shows an example of the table definition dialog.

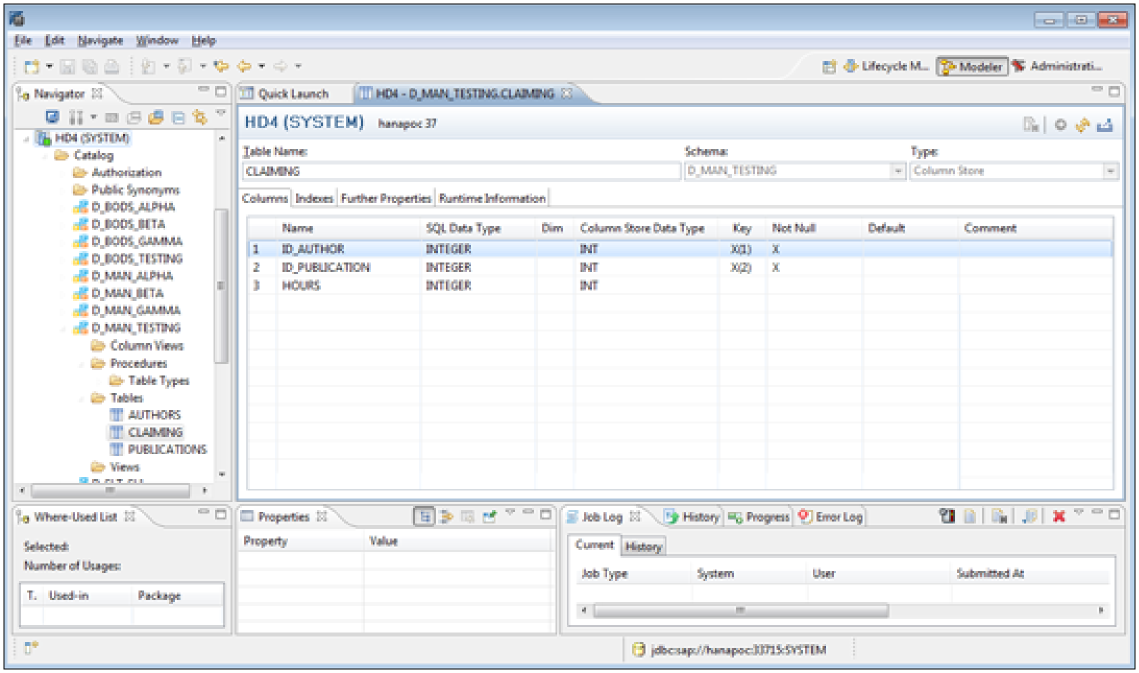

Figure 4-4 SAP HANA studio: Table definition dialog

- ► Modeling

  This is the user interface to work with models (metadata descriptions how source data is transformed in resulting views), including the possibility to define new custom models, and to adjust or delete existing models.

  Figure 4-5 shows a simple analytic model.

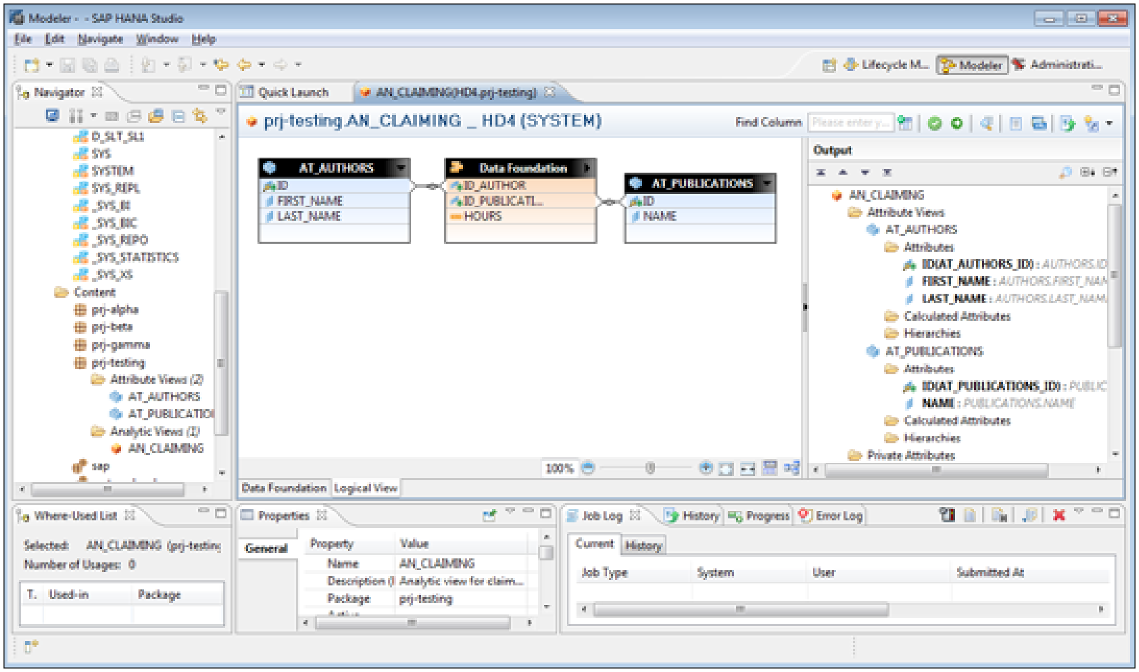

Figure 4-5 SAP HANA studio: Modeling interface (analytic view)

- Content management

  Functions offering the possibility to organize models in packages, to define delivery units for transport into a subsequent SAP HANA system, or to export and import individual models or whole packages.

  Content management functions are accessible from the main window in the modeler perspective, as shown in Figure 4-6.

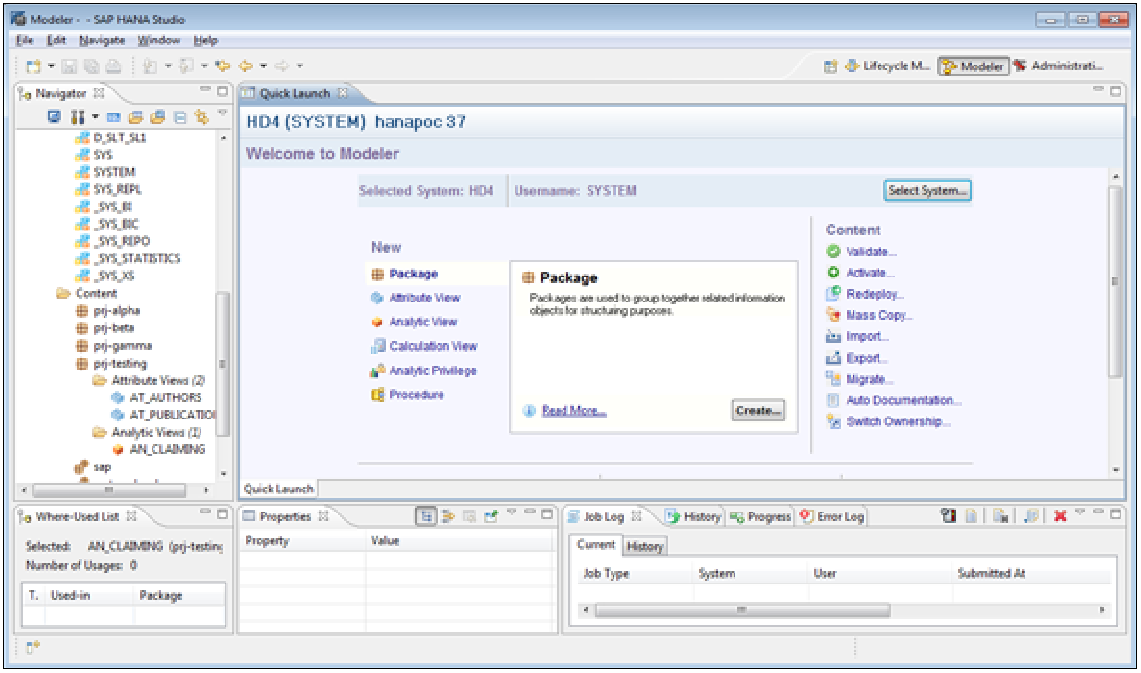

Figure 4-6 SAP HANA studio: Content functions on the main panel of modeler perspective

- Replication management

  Data replication into the SAP HANA database is controlled from the Data Provisioning dialog in the SAP HANA studio, where new tables can be scheduled for replication, suspended, or replication for a particular table can be interrupted.

  Figure 4-7 shows an example of a data provisioning dialog.

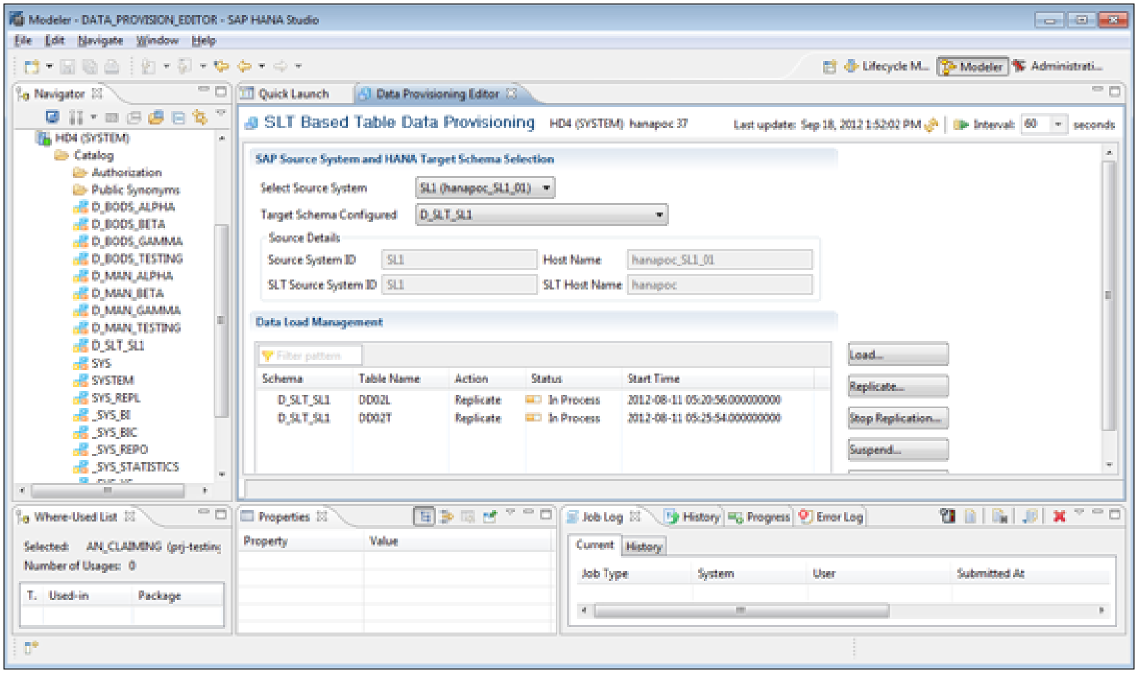

Figure 4-7 SAP HANA studio: Data provisioning dialog

- Software Lifecycle Management

  The SAP HANA solution offers the possibility to automatically download and install updates to SAP HANA software components. This function is controlled from the Software Lifecycle Management dialog in the SAP HANA studio. Figure 4-8 shows an example of such a dialog.

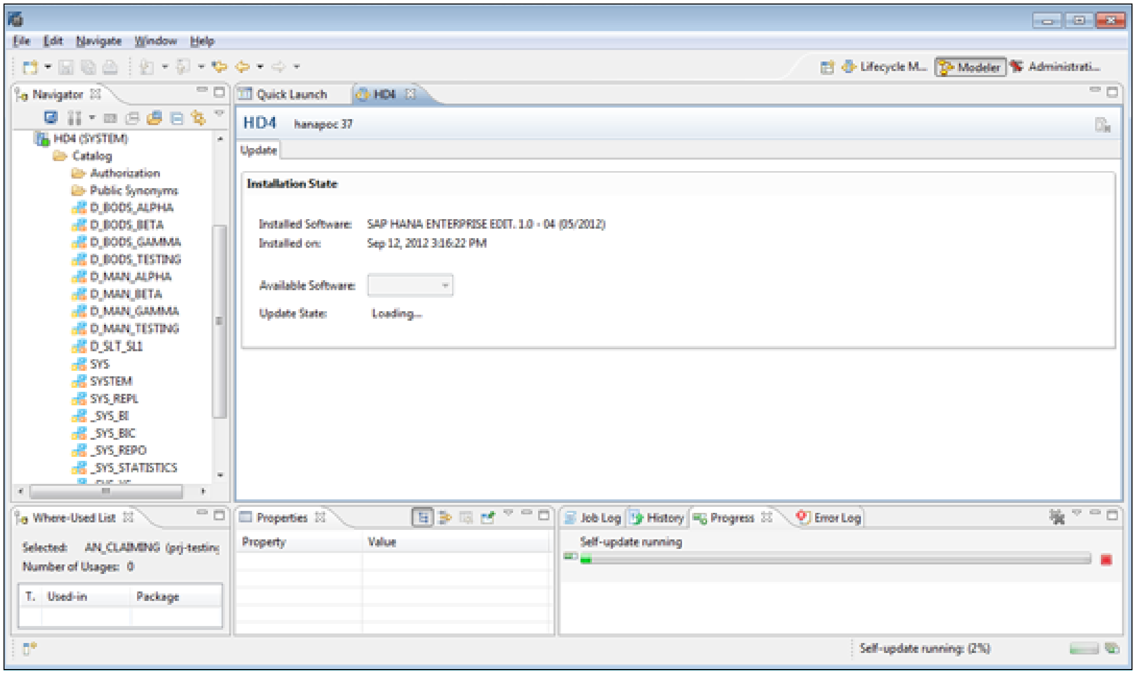

Figure 4-8 SAP HANA studio: Software lifecycle dialog

The SAP HANA database queries are consumed indirectly using front-end components, such as SAP BusinessObjects BI 4.0 clients. Therefore the SAP HANA studio is required only for administration or development and is not needed for end users.

The SAP HANA studio runs on the Eclipse platform; therefore, every user must have Java Runtime Environment (JRE) 1.6 or 1.7 installed, having the same architecture (64-bit SAP HANA studio has 64-bit JRE as prerequisite).

Currently supported platforms are Windows 32-bit, Windows 64-bit, and Linux 64-bit.

Just like the SAP HANA client, the SAP HANA studio is also backwards compatible, meaning that the revision level of the SAP HANA studio must be the same or higher revision level than the revision level of the SAP HANA database.

However, based on practical experience, the best approach is to keep SAP HANA studio on same revision level as the SAP HANA database whenever possible. Installation and parallel use of multiple revisions of SAP HANA studio on one workstation is possible. When using one SAP HANA studio instance for multiple SAP HANA databases, the revision level of the SAP HANA studio must be the same or higher revision level than the highest revision level of the SAP HANA databases being connected to.

SAP HANA studio must be updated to a more recent version on all workstations whenever the SAP HANA database is updated. This can be automated using Software Update Manager (SUM) for SAP HANA. We provide more details about this in 4.1.4, “SAP HANA studio repository” on page 46 and 4.1.7, “Software Update Manager for SAP HANA” on page 48.

For more information about how to install the SAP HANA studio, see the official SAP guide, *SAP HANA Database - Studio Installation Guide*, which is available for download at:

http://help.sap.com/hana_appliance

4.1.4 SAP HANA studio repository

Because SAP HANA studio is an Eclipse based product it can benefit from all standard features offered by this platform. One of these features is the ability to automatically update the product from a central repository located on the SAP HANA server.

The SAP HANA studio repository is initially installed by the SAP HANA Unified Installer and must be manually updated at the same time that the SAP HANA database is updated (more details about version compatibility are in section 4.1.3, “SAP HANA studio” on page 38). This repository can then be used by all SAP HANA studio installations to automatically download and install new versions of code.

Using this feature is probably the most reliable way to keep all installations of SAP HANA studio in sync with the SAP HANA database. However note that a one time configuration effort is required on each workstation (for more details see 4.1.7, “Software Update Manager for SAP HANA” on page 48).

For more information about how to install the SAP HANA studio repository, see the official SAP guide, *SAP HANA Database - Studio Installation Guide*, which is available for download at:

http://help.sap.com/hana_appliance

4.1.5 SAP HANA landscape management structure

The SAP HANA landscape management (LM) structure (lm_structure) is an XML file that describes the software components installed on a server. The information in this file contains:

- SID of SAP HANA system and host name
- Stack description including the edition (depending on the license schema)
- Information about the SAP HANA database, including installation directory
- Information about the SAP HANA studio repository, including location
- Information about the SAP HANA client, including location
- In the case of the SAP HANA enterprise extended edition: information about SAP HANA load controller (which is part of the Sybase Replication Server based replication)
- Information about host controller

The LM structure description also contains revisions of individual components and therefore needs to be upgraded when the SAP HANA database is upgraded.

Information contained in this file is used by the System Landscape Directory (SLD) data suppliers and by the Software Update Manager (SUM) for SAP HANA.

More information about how to configure the SLD connection is provided in the official SAP guide, *SAP HANA Installation Guide with Unified Installer*, which is available for download at:

`http://help.sap.com/hana_appliance`

4.1.6 SAP host agent

The SAP host agent is a standard part of every SAP installation. In an SAP HANA environment, it is important in the following situations:

- Automatic update using Software Update Manager (SUM) for SAP HANA (more information is in documents *SAP HANA Automated Update Guide* and *SAP HANA Installation Guide with Unified Installer*)
- Replication using the Sybase Replication Server where the host agent is handling login authentication between source and target servers (explained in the document *SAP HANA Installation and Configuration Guide - Log-Based Replication*)

4.1.7 Software Update Manager for SAP HANA

The Software Update Manager (SUM) for SAP HANA is a tool that belongs to the SAP Software Logistics (SL) Toolset. This tool offers two main functions:

- Automated update of the SAP HANA server components to the latest revision, downloaded from SAP Service Marketplace
- Enablement of automated update of remote SAP HANA studio installations against the studio repository installed on SAP HANA server

Both functions are discussed in the subsequent sections.

Automated update of SAP HANA server components

The SAP Software Update Manager is a separate software component that must be started on the SAP HANA server. A good practice is to install this component as a service.

Tip:

The Software Update Manager can be configured as a Linux service by running the following commands:

```
export JAVA_HOME=/usr/sap/<SID>/SUM/jvm/jre

/usr/sap/<SID>/SUM/daemon.sh install
```

The service can be started using the following command:

```
/etc/init.d/sum_daemon start
```

The SAP Software Update Manager does not have a user interface. It is controlled remotely from the SAP HANA studio.

Figure 4-9 illustrates the interaction of SUM with other components.

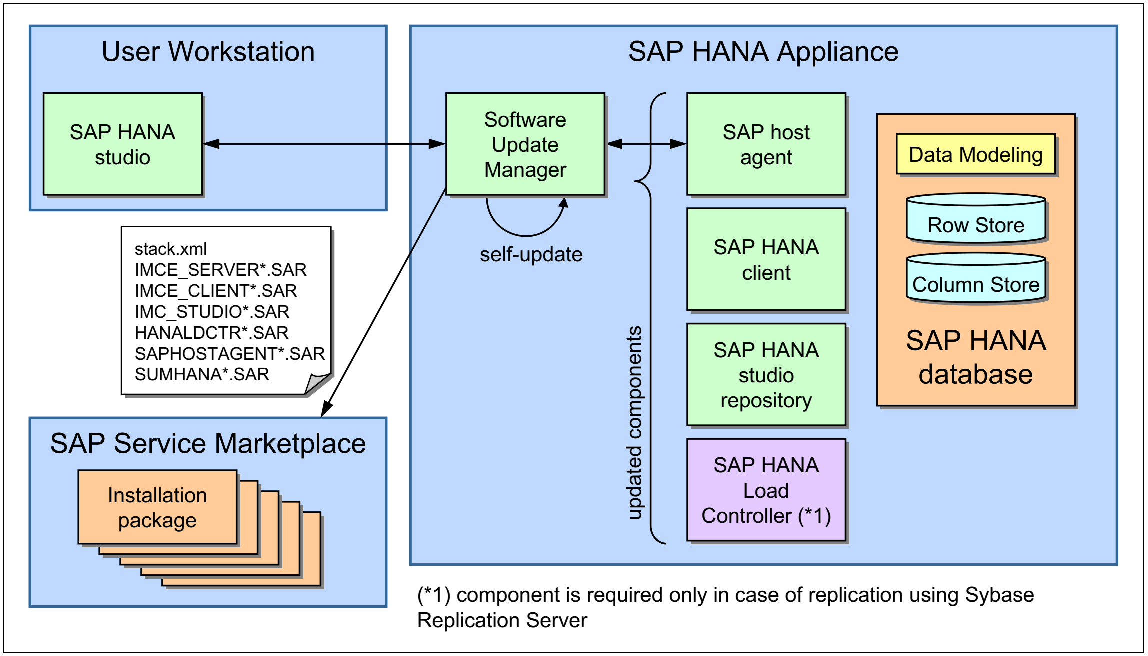

Figure 4-9 Interaction of Software Update Manager (SUM) for SAP HANA with other software components

The Software Update Manager can download support package stack information and other required files directly from the SAP Service Marketplace (SMP).

If a direct connection from the server to the SAP Service Marketplace is not available, the support package stack definition and installation packages must be downloaded manually and then uploaded to the SAP HANA server. In this case, the stack generator at the SAP Service Marketplace can be used to identify required packages and to generate the stack.xml definition file (a link to the stack generator is located in the download section, subsection “Support packages” in the SAP HANA area).

The SUM update file (SUMHANA*.SAR archive) is not part of the stack definition and needs to be downloaded separately.

The Software Update Manager will first perform a self-update as soon as the Lifecycle Management perspective is opened in the SAP HANA studio.

After the update is started, all SAP HANA software components are updated to their target revisions, as defined by the support package stack definition file. This operation needs downtime; therefore, a maintenance window is required, and the database must be backed up before this operation.

This scenario is preconfigured during installation using the Unified Installer (see the document *SAP HANA Installation Guide with Unified Installer* - section SUM for SAP HANA Default Configuration for more details). If both the SAP HANA studio and the Software Update Manager for SAP HANA are running on SPS04, no further steps are required.

Otherwise a last configuration step, installing the server certificate inside the Java keystore, needs to be performed on a remote workstation where the SAP HANA studio is located.

For more information about installation, configuration, and troubleshooting of SUM updates, see the guides:

- *SAP HANA Installation Guide with Unified Installer*
- *SAP HANA Automated Update Guide*

The most common problem during configuration of automatic updates using SUM is a host name mismatch between server installation (fully-qualified host name that was used during installation of SAP HANA using Unified Installer) and the host-name used in the SAP HANA studio. For more details, see the troubleshooting section in *SAP HANA Automated Update Guide*.

Automated update of SAP HANA studio

The second function of the Software Update Manager for SAP HANA is to act as an update server for remote SAP HANA studio installations.

Figure 4-10 illustrates the interaction of SUM with other components for this scenario.

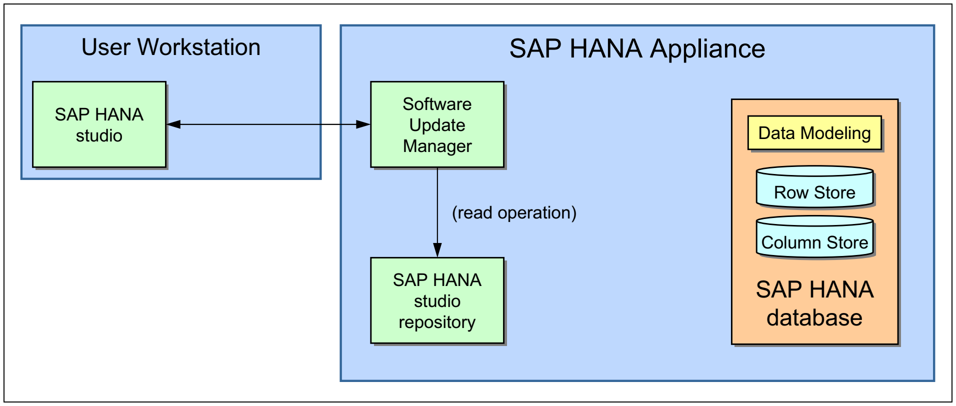

Figure 4-10 Interaction of the Software Update Manager (SUM) for SAP HANA with other software components during update of remote SAP HANA studio

If the Unified Installer was used to install SAP HANA software components, no actions need to be performed on the server.

The only configuration step needed is to adjust the SAP HANA studio preferences to enable updates and to define the location of the update server.

4.1.8 SAP HANA Unified Installer

The SAP HANA Unified Installer is tool targeted to be used by SAP HANA hardware partners. It installs all required software components on the SAP HANA appliance according to SAP requirements and specifications.

Installation parameters, such as system ID, system number, and locations of required directories, are provided through the configuration file.

The tool then automatically deploys all required software components in predefined locations and performs all mandatory steps to configure the Software Update Manager (SUM) for SAP HANA.

See the *SAP HANA Installation Guide with Unified Installer* for more details.

4.2 Data replication methods for SAP HANA

Data can be written to the SAP HANA database either directly by a source application, or it can be replicated using replication technologies.

The following replication methods are available for use with the SAP HANA database:

- Trigger-based replication

  This method is based on database triggers created in the source system to record all changes to monitored tables. These changes are then replicated to the SAP HANA database using the SAP Landscape Transformation system.

- ETL-based replication

  This method employs an Extract, Transform, and Load (ETL) process to extract data from the data source, transform it to meet the business or technical needs, and load it into the SAP HANA database. The SAP BusinessObject Data Services application is used as part of this replication scenario.

- Extractor-based replication

  This approach uses the embedded SAP NetWeaver BW that is available on every SAP NetWeaver-based system to start an extraction process using available extractors and then redirecting the write operation to the SAP HANA database instead of the local Persistent staging Area (PSA).

- Log-based replication

  This method is based on reading the transaction logs from the source database and re-applying them to the SAP HANA database.

Figure 4-11 illustrates these replication methods.

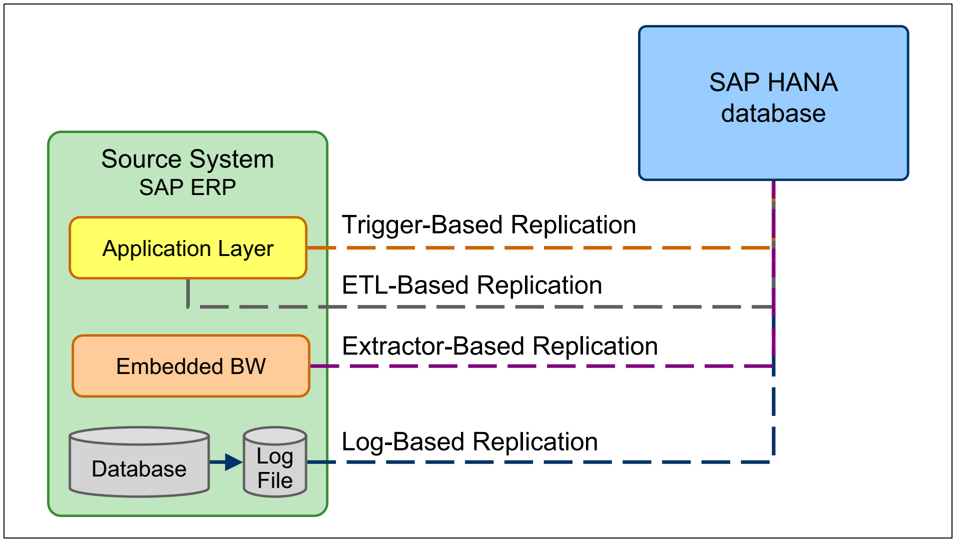

Figure 4-11 Available replication methods for SAP HANA

The following sections discuss these replication methods for SAP HANA in more detail.

4.2.1 Trigger-based replication with SAP Landscape Transformation

SAP Landscape Transformation replication is based on tracking database changes using database triggers. All modifications are stored in logging tables in the source database, which ensures that every change is captured even when the SAP Landscape Transformation system is not available.

The SAP Landscape Transformation system reads changes from source systems and updates the SAP HANA database accordingly. The replication process can be configured as real-time (continuous replication) or scheduled replication in predefined intervals.

The SAP Landscape Transformation operates on the application level; therefore, the trigger-based replication method benefits from the database abstraction provided by the SAP software stack, which makes it database independent. It also has extended source system release coverage, where supported releases start from SAP R/3 4.6C up to the newest SAP Business Suite releases.

The SAP Landscape Transformation also supports direct replication from database systems supported by the SAP NetWeaver platform. In this case, the database must be connected to the SAP Landscape Transformation system directly (as an additional database) and the SAP Landscape Transformation is playing the role of the source system.

The replication process can be customized by creating ABAP routines and configuring their execution during replication process. This feature allows the SAP Landscape Transformation system to replicate additional calculated columns and to scramble existing data or filter-replicated data based on defined criteria.

The SAP Landscape Transformation replication leverages proven System Landscape Optimization (SLO) technologies (such as Near Zero Downtime, Test Data Migration Server (TDMS), and SAP Landscape Transformation) and can handle both unicode and non-unicode source databases. The SAP Landscape Transformation replication provides a flexible and reliable replication process, fully integrates with SAP HANA Studio, and is simple and fast to set up.

The SAP Landscape Transformation Replication Server does not have to be a separate SAP system. It can run on any SAP system with the SAP NetWeaver 7.02 ABAP stack (Kernel 7.20EXT). However, it is recommended to install the SAP Landscape Transformation Replication Server on a separate system to avoid high replication load causing performance impact on base system.

The SAP Landscape Transformation Replication Server is the ideal solution for all SAP HANA customers who need real-time (or scheduled) data replication from SAP NetWeaver-based systems or databases supported with SAP NetWeaver.

4.2.2 ETL-based replication with SAP BusinessObjects Data Services

An ETL-based replication for SAP HANA can be set up using SAP BusinessObjects Data Services, which is a full-featured ETL tool that gives customers maximum flexibility with regard to the source database system:

- Customers can specify and load the relevant business data in defined periods of time from an SAP ERP system into the SAP HANA database.

- SAP ERP application logic can be reused by reading extractors or utilizing SAP function modules.
- It offers options for the integration of third-party data providers and supports replication from virtually any data source.

Data transfers are done in batch mode, which limits the real-time capabilities of this replication method.

SAP BusinessObjects Data Services provides several kinds of data quality and data transformation functionality. Due to the rich feature set available, implementation time for the ETL-based replication is longer than for the other replication methods. SAP BusinessObjects Data Services offers integration with SAP HANA. SAP HANA is a available as a predefined data target for the load process.

The ETL-based replication server is the ideal solution for all SAP HANA customers who need data replication from non-SAP data sources.

4.2.3 Extractor-based replication with Direct Extractor Connection

Extractor-based replication for SAP HANA is based on already existing application logic available in every SAP NetWeaver system. The SAP NetWeaver BW package that is a standard part of the SAP NetWeaver platform can be used to run an extraction process and store the extracted data in the SAP HANA database.

This functionality requires some corrections and configuration changes to both the SAP HANA database (import of delivery unit and parametrization) and on the SAP NetWeaver BW system as part of the SAP NetWeaver platform (implementing corrections using SAP note or installing a support package and parametrization). Corrections in the SAP NetWeaver BW system ensures that extracted data is not stored in local Persistent staging Area (PSA) but diverted to the external SAP HANA database.

Use of native extractors instead of replication of underlying tables can bring certain benefits. Extractors offer the same transformations that are used by SAP NetWeaver BW systems.This can significantly decrease the complexity of modeling tasks in the SAP HANA database.

This type of replication is not real-time and only available features and transformation capabilities provided by a given extractor can be used.

Replication using Direct Extractor Connection (DXC) can be realized in the following basic scenarios:

- Using the embedded SAP NetWeaver BW functionality in the source system

  SAP NetWeaver BW functions in the source system are usually not used. After implementation of the required corrections, the source system calls its own extractors and pushes data into the external SAP HANA database.

  The source system must be based on SAP NetWeaver 7.0 or higher. Since the function of a given extractor is diverted into SAP HANA database, this extractor must not be in use by the embedded SAP NetWeaver BW component for any other purpose.

- Using an existing SAP NetWeaver BW to drive replication

  An existing SAP NetWeaver BW can be used to extract data from the source system and to write the result to the SAP HANA system.

  The release of the SAP NetWeaver BW system that is used must be at least SAP NetWeaver 7.0, and the given extractor must not be in use for this particular source system.

- Using a dedicated SAP NetWeaver BW to drive replication

  The last option is to install a dedicated SAP NetWeaver system to extract data from the source system and store the result in the SAP HANA database. This option has minimal impact on existing functionality because no existing system is changed in any way. However a new system is required for this purpose.

The current implementation of this replication technology is only allowing for one database schema in the SAP HANA database. Using one system for controlling replication of multiple source systems can lead to collisions because all source systems use the same database schema in the SAP HANA database.

4.2.4 Log-based replication with Sybase Replication Server

The log-based replication for SAP HANA is realized with the Sybase Replication Server. It captures table changes from low-level database log files and transforms them into SQL statements that are in turn executed on the SAP HANA database. This is similar to what is known as *log shipping* between two database instances.

Replication with the Sybase Replication Server is fast and consumes little processing power due to its closeness to the database system. However, this mode of operation makes this replication method highly database dependent, and the source database system coverage is limited[1]. It also limits the conversion capabilities; therefore, replication with the Sybase Replication Server only supports Unicode source databases. The Sybase Replication Server cannot convert between code pages, and because SAP HANA works with unicode encoding internally, the source database has to use unicode encoding as well. Also, certain table types used in SAP systems are unsupported.

To set up replication with the Sybase Replication Server, the definition and content of tables chosen to be replicated must initially be copied from the source database to the SAP HANA database. This initial load is done with the R3Load program, which is also used for database imports and exports. Changes in tables during initial copy operation are captured by the Sybase Replication Server; therefore, no system downtime is required.

This replication method is only recommended for SAP customers who were invited to use it during the ramp up of SAP HANA 1.0.

SAP recommends to instead use trigger-based data replication using the SAP Landscape Transformation Replicator, which is described in the previous section.

4.2.5 Comparing the replication methods

Each of the described data replication methods for SAP HANA has its benefits and weaknesses:

- The trigger-based replication method with the SAP Landscape Transformation system provides real-time replication while supporting a wide range of source database systems. It can handle both unicode and non-unicode databases and makes use of proven data migration technology. It leverages the SAP application layer, which limits it to SAP source systems. Compared to the log-based replication method, it offers a broader support of source systems, while providing almost similar real-time capabilities, and for that reason it is recommended for replication from SAP source systems.
- The ETL-based replication method is the most flexible of all, paying the price for flexibility with only near real-time capabilities. With its variety of possible data sources, advanced transformation, and data quality functionality, it is the ideal choice for replication from non-SAP data sources.
- The extractor-based replication method offers reuse of existing transformation capabilities that are available in every SAP NetWeaver based system. This can significantly decrease the required implementation effort. However this type of replication is not real time and is limited to capabilities provided by the available extractors in the source system.
- The log-based replication method with the Sybase Replication Server provides the fastest replication from the source database to SAP HANA.

[1] Only certain versions of IBM DB2 on AIX, Linux, and HP-UX are supported with this replication method.

However, it is limited to unicode-encoded source databases, and it does not support all table types used in SAP applications. It provides no transformation functionality, and the source database system support is limited.

Figure 4-12 shows these replication methods in comparison.

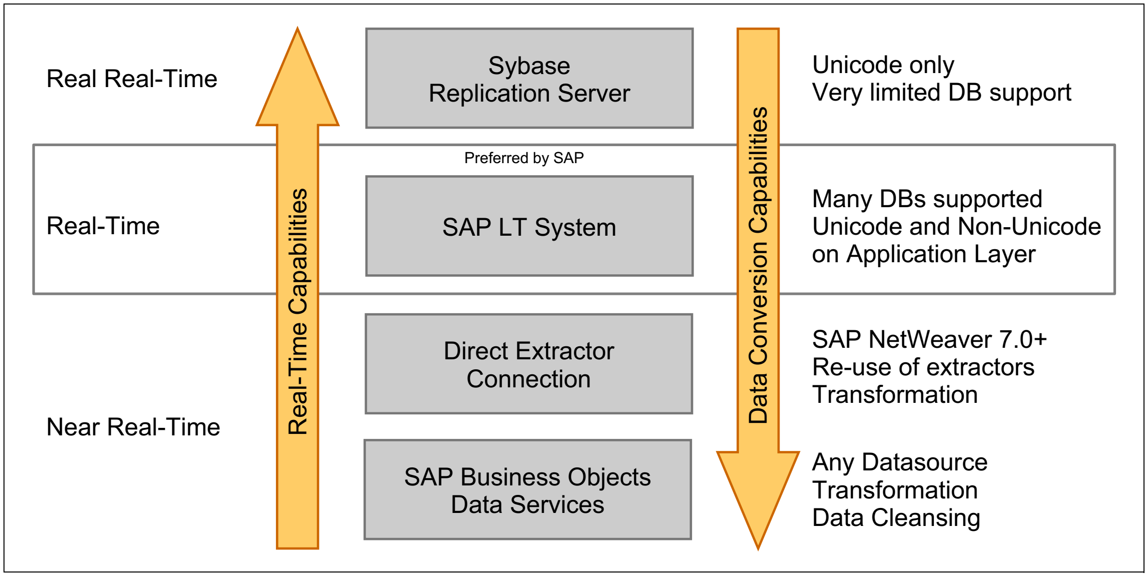

Figure 4-12 Comparison of the replication methods for SAP HANA

The replication method that you choose depends on the requirements. When real-lime replication is needed to provide benefit to the business, and the replication source is an SAP system, then the trigger-based replication is the best choice. Extractor based replication might keep project cost down by reusing existing transformations. ETL-based replication provides the most flexibility regarding data source, data transformation, and data cleansing options, but does not provide real-time replication.

5

SAP HANA use cases and integration scenarios

In this chapter, we outline the different ways that SAP HANA can be implemented in existing customer landscapes and highlight various aspects of such an integration. Whenever possible, we mention real-world examples and related offerings.

This chapter is divided in several sections based on the role of SAP HANA and the way it interacts with other software components:

5.1 Basic use case scenarios

The following classification of use cases was presented during the SAP TechEd 2011 event in session *EIM205 Applications powered by SAP HANA*. SAP defined the following five use case scenarios:

- Technology platform
- Operational reporting
- Accelerator
- In-Memory products
- Next generation applications

Figure 5-1 illustrates these use case scenarios.

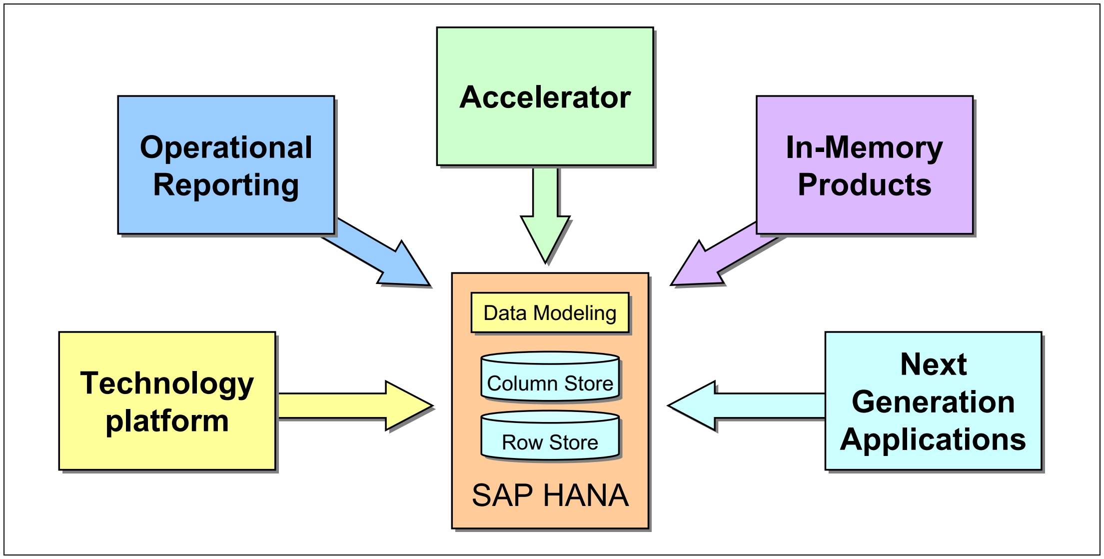

Figure 5-1 Basic use case scenarios defined by SAP in session EIM205

These five basic use case scenarios describe the elementary ways SAP HANA can be integrated. We cover each of these use case scenarios in a dedicated section within this chapter.

SAP maintains a "SAP HANA Use Case Repository" with specific examples for how SAP HANA can be integrated. This repository is online at the following web address:

http://www.experiencesaphana.com/community/resources/use-cases

The use cases in this repository are divided into categories based on their relevance to a specific industry sector. It is a good idea to review this repository to find inspiration about how SAP HANA can be leveraged in various scenarios.

5.2 SAP HANA as a technology platform

SAP HANA can be used even in non-SAP environments. The customer can use structured and un-structured data that is derived from non-SAP application systems to be able to take advantage of SAP HANA power. SAP HANA can be used to accelerate existing functionality or to provide new functionality that was, until now, not realistic.

Figure 5-2 presents SAP HANA as a technology platform.

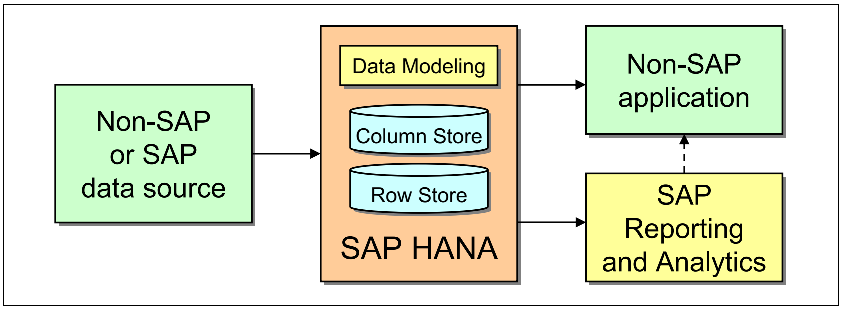

Figure 5-2 SAP HANA as technology platform

SAP HANA is not technologically dependent on other SAP products and can be used independently as the only one SAP component in the customer's Information Technology (IT) landscape. On the other hand, SAP HANA can be easily integrated with other SAP products, such as SAP BusinessObjects BI platform for reporting or SAP BusinessObjects Data Services for ETL replication, which gives customers the possibility to use only the components that are needed.

There are many ways that SAP HANA can be integrated into a customer landscape, and it is not possible to describe all combinations. Software components around the SAP HANA offering can be seen as building blocks, and every solution must be assembled from the blocks that are needed in a particular situation.

This approach is extremely versatile and the amount of possible combinations is growing because SAP constantly keeps adding new components in their SAP HANA-related portfolio.

IBM offers consulting services that help customers to choose the correct solution for their business needs. For more information, see section 8.4.1, “A trusted service partner” on page 154.

5.2.1 SAP HANA data acquisition

There are multiple ways that data can flow into SAP HANA. In this section, we describe the various options that are available. Figure 5-3 gives an overview.

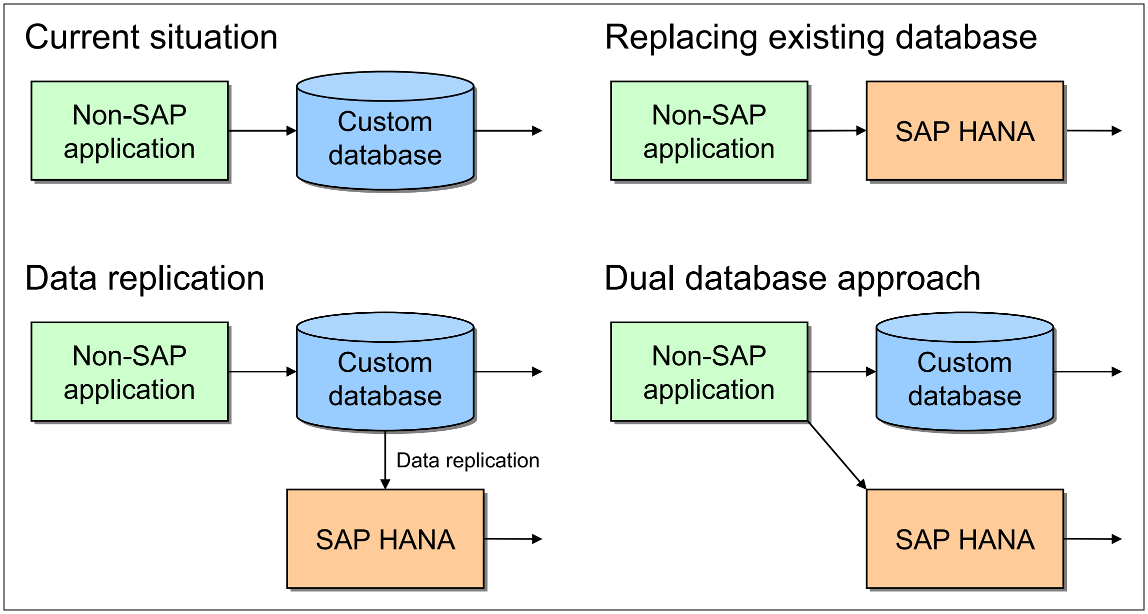

Figure 5-3 Examples of SAP HANA deployment options in regards to data acquisition

The initial situation is schematically displayed in the upper-left corner of Figure 5-3. In this example, a customer specific non-SAP application writes data to a custom database that is slow and not meeting customer needs.

The other three examples in Figure 5-3 show that SAP HANA can be deployed in such a scenario. These show that there is no single solution that is best for every customer but that each situation must be considered independently.

Each of these three solutions have both advantages and disadvantages, which we highlight, to show aspects of a given solution that might need more detailed consideration:

- Replacing the existing database with SAP HANA

  The advantage of this solution is that the overall architecture is not going to be significantly changed. The solution will remain simple without the need to include additional components. Customers might also save on license costs for the original database.

  A disadvantage to this solution is that the custom application must be adjusted to work with the SAP HANA database. If ODBC or JDBS is used for database access, this is not a big problem. Also the whole setup must be tested properly. Because the original database is being replaced, a certain amount of downtime is inevitable.

  Customers considering this approach must be familiar with the features and characteristics of SAP HANA, especially when certain requirements must be met by the database that is used (for example in case of special purpose databases).

- Populating SAP HANA with data replicated from the existing database

  The second option is to integrate SAP HANA as a “side-car” database to the primary database and to replicate required data using one of the available replication techniques.

  An advantage of this approach is that the original solution is not touched and therefore no downtime is required. Also only the required subset of data has to be replicated from the source database, which might allow customers to minimize acquisition costs because SAP HANA acquisition costs are directly linked to the volume of stored data.

  The need for implementing replication technology can be seen as the only disadvantage of this solution. Because data is only delivered into SAP HANA through replication, this component is a vital part of the whole solution. Customers considering this approach must be familiar with various replication technologies, including their advantages and disadvantages, as outlined in section 4.2, “Data replication methods for SAP HANA” on page 51.

  Customers must also be aware that replication might cause additional load on the existing database because modified records must be extracted and then transported to the SAP HANA database. This aspect is highly dependent on the specific situation and can be addressed by choosing the proper replication technology.

- Adding SAP HANA as a second database in parallel to the existing one

  This third option keeps the existing database in place while adding SAP HANA as a secondary database. The custom application then stores data in both the original database and in the SAP HANA database.

  This option balances advantages and disadvantages of the previous two options. A main prerequisite is the ability of the source application to work with multiple databases and the ability to control where data is stored. This can be easily achieved if the source application was developed by the customer and can be changed, or if the source application is going to be developed as part of this solution. If this prerequisite cannot be met, this option is not viable.

  An advantage of this approach is that no replication is required because data is directly stored in SAP HANA as required. Customers can also decide to store some of the records in both databases.

  If data stored in the original database is not going to be changed and SAP HANA data will be stored in both databases simultaneously, customers might achieve only minimal disruption to the existing solution.

  A main disadvantage is the prerequisite that the application must be able to work with multiple databases and that it must be able to store data according to the customers expectations.

  Customers considering this option must be aware about the abilities provided by the application delivering data into the existing database. Also, disaster recovery plans must be carefully adjusted, especially when consistency between both databases is seen as a critical requirement.

These examples must not be seen as an exhaustive list of integration options for an SAP HANA implementation, but rather as a demonstration of how to develop a solution that matches customer needs.

It is of course possible to populate the SAP HANA database with data coming from multiple different sources, such as SAP or non-SAP applications, custom databases, and so on.

These sources can feed data into SAP HANA independently, each using a different approach or in a synchronized manner using the SAP BusinessObjects Data Services, which can replicate data from several different sources simultaneously.

5.2.2 SAP HANA as a source for other applications

The second part of integrating SAP HANA is to connect existing or new applications to run queries against the SAP HANA database. Figure 5-4 illustrates an example of such an integration.

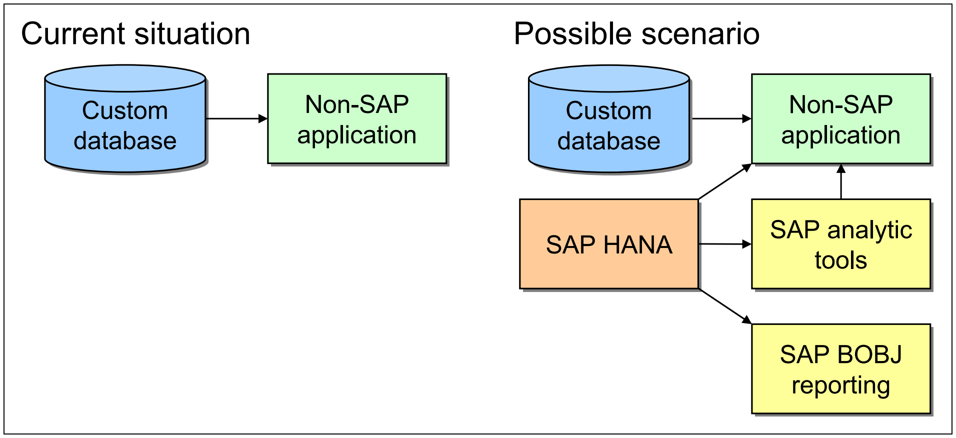

Figure 5-4 An example of SAP HANA as a source for other applications

The initial situation is schematically visualized in the left part of Figure 5-4. A customer-specific application runs queries against a custom database that is a functionality that we must preserve.

A potential solution is in the right part of Figure 5-4. A customer-specific application runs problematic queries against the SAP HANA database. If the existing database is still part of the solution, specific queries that do not need acceleration can still be executed against the original database.

Specialized analytic tools, such as the SAP BusinessObjects Predictive Analysis, can be used to run statistical analysis on data that is stored in the SAP HANA database. This tool can run analysis directly inside the SAP HANA database, which helps to avoid expensive transfers of massive volumes of data between the application and the database. The result of this analysis can be stored in SAP HANA, and the custom application can use these results for further processing, for example, to facilitate decision making.

SAP HANA can be easily integrated with products from the SAP BusinessObjects family; therefore, these products can be part of the solution, responsible for reporting, monitoring critical KPIs using dashboards, or for data analysis.

These tools can also be used without SAP HANA however SAP HANA is enabling these tools to process much bigger volumes of data and still provide results in reasonable time.

5.3 SAP HANA for operational reporting

Operational reporting is playing more and more of an important role. In today's economic environment, companies must understand how various events in our globally integrated world impact their business to be able to make proper adjustments to counter the effects of these events. Therefore the pressure to minimize the delay in reporting is becoming higher and higher. An ideal situation is to have the ability to have a real-time snapshot of current situations just within seconds from requesting.

At the same time, the amount of data that is being captured grows every year. Additional information is collected and stored at more detailed levels. All of this makes operational reporting more challenging because huge amounts of data need to be processed quickly to produce the desired result.

SAP HANA is a perfect fit for this task. Required information can be replicated from existing transactional systems into the SAP HANA database and then processed significantly faster than directly on the source systems.

The following use case is often referred to as a data mart or *side-car approach* because SAP HANA sits by the operational system and receives the operational data (usually only an excerpt) from this system by means of replication.

In a typical SAP-based application landscape today, you will find a number of systems, such as SAP ERP, SAP CRM, SAP SCM, and other, possibly non-SAP, applications. All of these systems contain loads of operational data, which can be used to improve business decision making using business intelligence technology. Data used for business intelligence purposes can be gathered either on a business unit level using data marts or on an enterprise level with an enterprise data warehouse, such as the SAP NetWeaver Business Warehouse (SAP NetWeaver BW). ETL processes feed the data from the operational systems into the data marts and the enterprise data warehouse.

Figure 5-5 illustrates such a typical landscape.

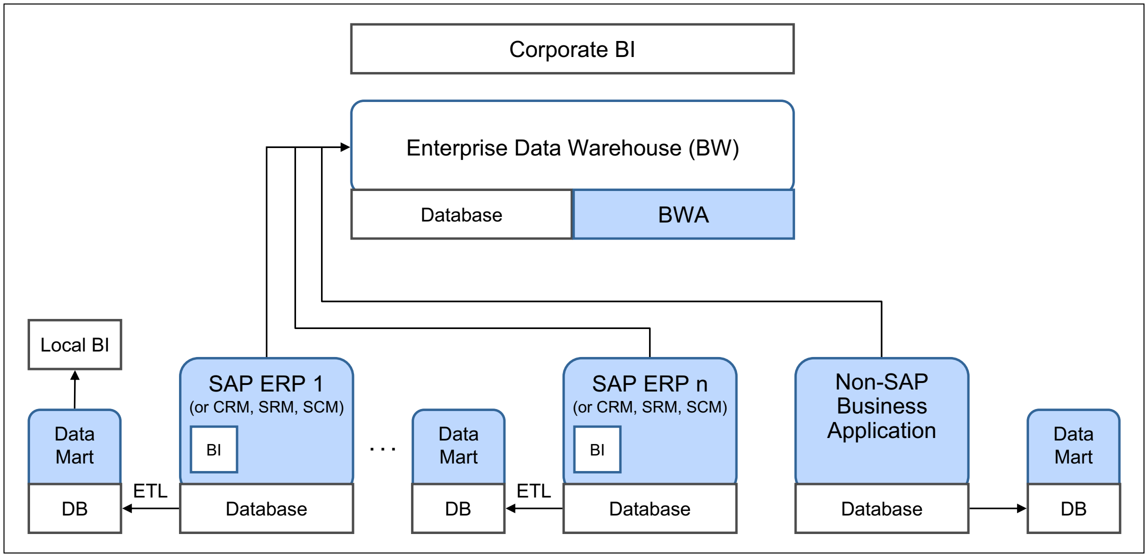

Figure 5-5 Typical view of an SAP-based application landscape today

With the huge amounts of data collected in an enterprise data warehouse, response times of queries for reports or navigation through data can become an issue, generating new requirements to the performance of such an environment. To address these requirements, SAP introduced the SAP NetWeaver Business Warehouse Accelerator, which is built for this use case by speeding up queries and reports in the SAP NetWeaver BW by leveraging in-memory technology. While being a perfect fit for an enterprise data warehouse holding huge amounts of data, the combination of SAP NetWeaver BW and SAP NetWeaver BW Accelerator is not always a viable solution for the relatively small data marts.

With the introduction of SAP HANA 1.0, SAP provided an in-memory technology aiming to support business intelligence at a business unit level. SAP HANA combined with business intelligence tools, such as the SAP BusinessObjects tools and data replication mechanisms feeding data from the operational system into SAP HANA in real-time, brought in-memory computing to the business unit level. Figure 5-6 shows such a landscape with the local data marts replaced by SAP HANA.

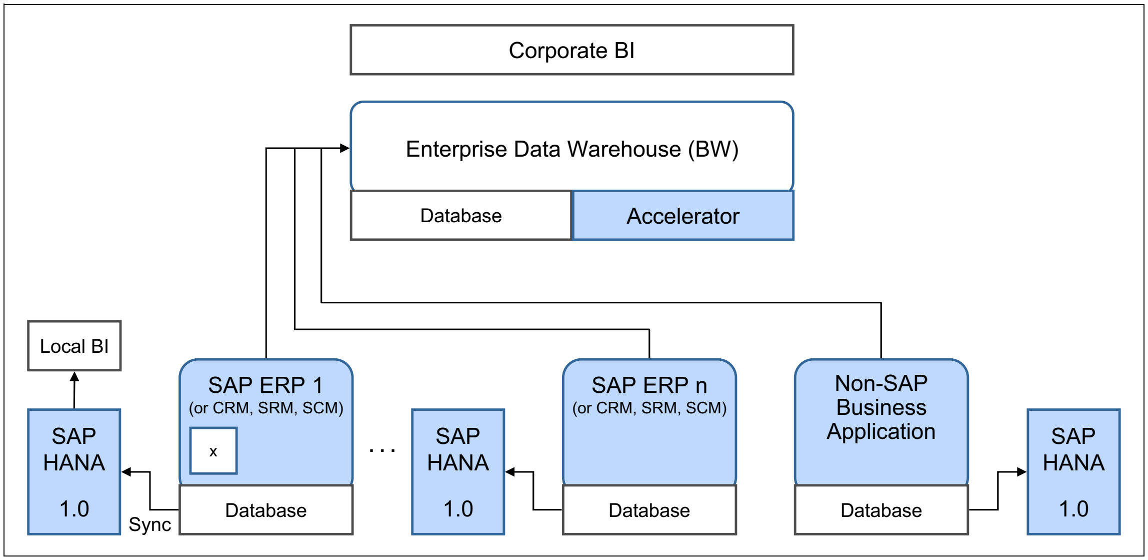

Figure 5-6 SAP vision after the introduction of SAP HANA 1.0

Business intelligence functionality is provided by an SAP BusinessObjects BI tool, such as the SAP BusinessObjects Explorer, communicating with the SAP HANA database through the BI Consumer Services (BICS) interface.

This use case scenario is oriented mainly on existing products from the SAP Business Suite where SAP HANA acts as a foundation for reporting on big volumes of data.

Figure 5-7 illustrates the role of SAP HANA in an operational reporting use case scenario.

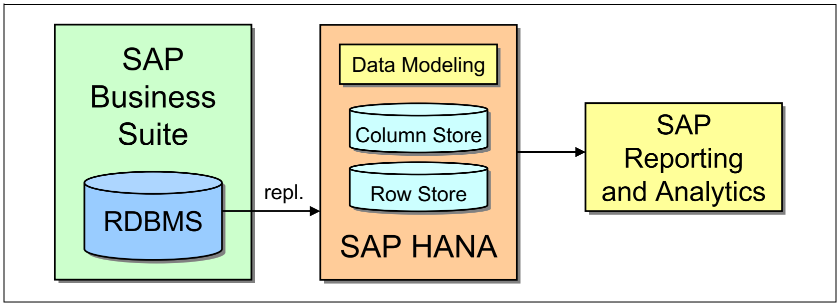

Figure 5-7 SAP HANA for operational reporting

Usually the first step is the replication of data into the SAP HANA database, which is usually originating from the SAP Business Suite. However some solution packages are also built for non-SAP data sources.

Sometimes source systems need to be adjusted by implementing modifications or by performing specific configuration changes.

Data is typically replicated using the SAP Landscape Transformation replication; however, other options, such as replication using SAP BusinessObjects Data Services or SAP HANA Direct Extractor Connection (DXC), are also possible. The replication technology is usually chosen as part of the package design and cannot be changed easily during implementation.

A list of tables to replicate (for SAP Landscape Transformation replication) or transformation models (for replication using Data Services) are part of the package.

SAP HANA is loaded with models (views) that are either static (designed by SAP and packaged) or automatically generated based on customized criteria. These models describe the transformation of source data into the resulting column views. These views are then consumed by SAP BusinessObjects BI 4.0 reports or dashboards that are either delivered as final products or pre-made templates that can be finished as part of implementation process.

Some solution packages are based on additional components (for example, SAP BusinessObjects Event Insight). If required, additional content that is specific to these components can also be part of the solution package.

Individual use cases, required software components, prerequisites, configuration changes, including overall implementation processes, are properly documented and attached as part of the delivery.

Solution packages can contain:

- SAP BusinessObjects Data Services Content (data transformation models)
- SAP HANA Content (exported models - attribute views, analytic views)
- SAP BusinessObjects BI Content (prepared reports, dashboards)
- Transports, ABAP reports (adjusted code to be implemented in source system)
- Content for other software components, such as SAP BusinessObjects Event Insight, Sybase Unwired Platform, and so on.
- Documentation

Packaged solutions like these are being delivered by SAP under the name “SAP Rapid Deployment Solutions (RDS) for SAP HANA” or by other system integrators, such as IBM.

Available offerings contain everything that customers need to implement the requested function. Associated services, including implementation, can also be part of delivery.

While SAP HANA as a technology platform can be seen as an open field where every customer can build their own solution using available building blocks, the SAP HANA for operational reporting scenarios are well prepared packaged scenarios that can easily and quickly be deployed on existing landscapes.

A list of SAP Rapid Deployment Solution (RDS) offerings are at the following web address:

http://www.sap.com/solutions/rapid-deployment/solutions-by-business.epx?Filter1=SOLA000069

Alternatively, you can use the following quick link and then open **Technology** → **SAP HANA**:

http://service.sap.com/solutionpackages

There are SAP notes containing Quick Guide documents that are critical for understanding how a given solution is designed. These documents contain information about required software components that might have to be obtained, about version requirements for existing components, and about implementation sequences.

The currently available Rapid Deployment Solutions, SAP Notes with more information, and links to related web content (where available) are:

- SAP Bank Analyzer Rapid-Deployment Solution for Financial Reporting with SAP HANA (see SAP Note 1626729)

  http://service.sap.com/rds-hana-finrep

- SAP CRM rapid-deployment solution for analytics with SAP HANA (see SAP Note 1680801)

  http://service.sap.com/rds-crm-bwhana

- SAP Customer Usage Analysis rapid deployment solution (see SAP Note 1729467)

  http://service.sap.com/rds-haha-cua

- SAP rapid-deployment solution for implementation of data services, BI platform, and rapid marts to SAP HANA (see SAP Note 1678910)

  http://service.sap.com/rds-eim

- SAP Grid Infrastructure Analytics rapid-deployment solution (see SAP Note 1703517)

  http://service.sap.com/rds-grid-ana

- SAP rapid-deployment solution for sales pipeline analysis with SAP HANA (see SAP Note 1637113)

  http://service.sap.com/rds-crm-pipeline

- SAP ERP rapid-deployment solution for profitability analysis with SAP HANA (see SAP Note 1632506)

  http://service.sap.com/rds-hana-copa

- SAP ERP rapid-deployment solution for accelerated finance and controlling with SAP HANA (see SAP Note 1656499)

  http://service.sap.com/rds-hana-fin

- SAP ERP rapid-deployment solution for operational reporting with SAP HANA (see SAP Note 1647614 for SAP HANA SP03, or SAP Note 1739432 for SAP HANA SP04)

  http://service.sap.com/rds-hana-erp

- SAP Global Trade Services rapid-deployment solution for sanctioned-party list screening with SAP HANA (see SAP Note 1689708)

  http://service.sap.com/rds-gts

- SAP Situational Awareness rapid-deployment solution for public sector with SAP HANA (see SAP Note 1681090)

  http://service.sap.com/rds-saps

- Program Performance Analysis rapid-deployment solution for Aerospace and Defense (see SAP Note 1696052)

  `http://service.sap.com/rds-aad`

- SAP rapid-deployment solution for Sentiment Intelligence with SAP HANA (see SAP Note 1710619)

  `http://service.sap.com/rds-sent-int`

- SAP rapid-deployment solution for Shopper Insight (see SAP Note 1735653)

  `http://service.sap.com/rds-shop`

- SAP Deposits Management rapid-deployment solution for transaction history analysis with SAP HANA (see SAP Note 1626730)

  `http://service.sap.com/rds-hana-transhis`

5.4 SAP HANA as an accelerator

SAP HANA in a side-car approach as an accelerator is similar to a side-car approach for reporting purposes. The difference is that the consumer of the data replicated to SAP HANA is not a business intelligence tool but the source system itself. The source system can use the in-memory capabilities of the SAP HANA database to run analytical queries on the replicated data. This helps applications performing queries on huge amounts of data to run simulations, pattern recognition, planning runs, and so on.

SAP HANA can also be used to accelerate existing processes in SAP Business Suite systems, even for those systems that are not yet released to be directly running on the SAP HANA database.

Some SAP systems are processing big amounts of records that need to be filtered or aggregated based on specific criteria. Results are then used as inputs for all dependent activities in a given system.

In case of really big data volumes, execution time can be unacceptable (in amount of hours). Such workloads can easily run several hours, which can cause unnecessary delays. Currently these tasks are typically being processed overnight as batch jobs.

SAP HANA as an accelerator can help to significantly decrease this execution time.

Figure 5-8 illustrates this use case scenario.

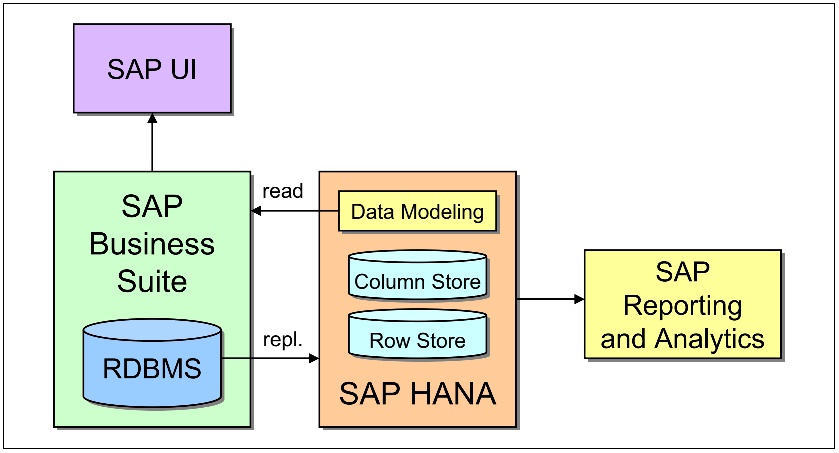

Figure 5-8 SAP HANA as an accelerator

The accelerated SAP system must meet specific prerequisites. Before this solution can be implemented, installation of specific support packages or implementation of SAP Notes might be required. This introduces the necessary code changes in the source system.

The SAP HANA client must be installed on a given server, and the SAP kernel must be adjusted to support direct connectivity to the SAP HANA database.

As a next step, replication of data from the source system is configured. Each specific use case has a defined replication method and a list of tables that must be replicated. Most common is the SAP Landscape Transformation replication; however, some solutions offer alternatives, for example, for the SAP CO-PA Accelerator, replication can also be performed by an SAP CO-PA Accelerator specific ABAP report in source system.

The source system is configured to have direct connectivity into SAP HANA as the secondary database. The required scenario is configured according to the specifications and then activated. During activation the source system automatically deploys the required column views into SAP HANA and activates new ABAP code that was installed in the source system as the solution prerequisite. This new code can run time, consuming queries against the SAP HANA database, which leads to significantly shorter execution times.

Because SAP HANA is populated with valuable data, it is easy to extend the accelerator use case by adding operational reporting functions. Additional (usually optional) content is delivered for SAP HANA and for SAP BusinessObjects BI 4.0 client tools, such as reports or dashboards.

SAP HANA as the accelerator and SAP HANA for operational reporting use case scenarios can be nicely combined in a single package. Here is a list of SAP Rapid Deployment Solutions (RDS) implementing SAP HANA as accelerator:

- SAP Bank Analyzer Rapid-Deployment Solution for Financial Reporting with SAP HANA (see SAP Note 1626729)

  http://service.sap.com/rds-hana-finrep

- SAP rapid-deployment solution for customer segmentation with SAP HANA (see SAP Note 1637115)

  http://service.sap.com/rds-cust-seg

- SAP ERP rapid-deployment solution for profitability analysis with SAP HANA (see SAP Note 1632506)

  http://service.sap.com/rds-hana-copa

- SAP ERP rapid-deployment solution for accelerated finance and controlling with SAP HANA (see SAP Note 1656499)

  http://service.sap.com/rds-hana-fin

- SAP Global Trade Services rapid-deployment solution for sanctioned-party list screening with SAP HANA (see SAP Note 1689708)

  http://service.sap.com/rds-gts

5.5 SAP products running on SAP HANA

Another way that SAP HANA can be deployed is to use SAP HANA as the primary database for selected products.

SAP NetWeaver Business Warehouse (BW) running on SAP HANA is generally available since April 2012. The SAP ERP Central Component (SAP ECC) running on HANA was announced to be available by the end of 2012 and other products from the SAP Business Suite family are expected to follow.

One big advantage of running existing products to use SAP HANA as the primary database is the minimal disruption to the existing system. Almost all functions, customizations, and with SAP NetWeaver BW, also customer specific modeling, are preserved because application logic written in ABAP is not changed. From a technical perspective, the SAP HANA conversion is similar to any other database migration.

Figure 5-9 illustrates SAP NetWeaver BW running on SAP HANA.

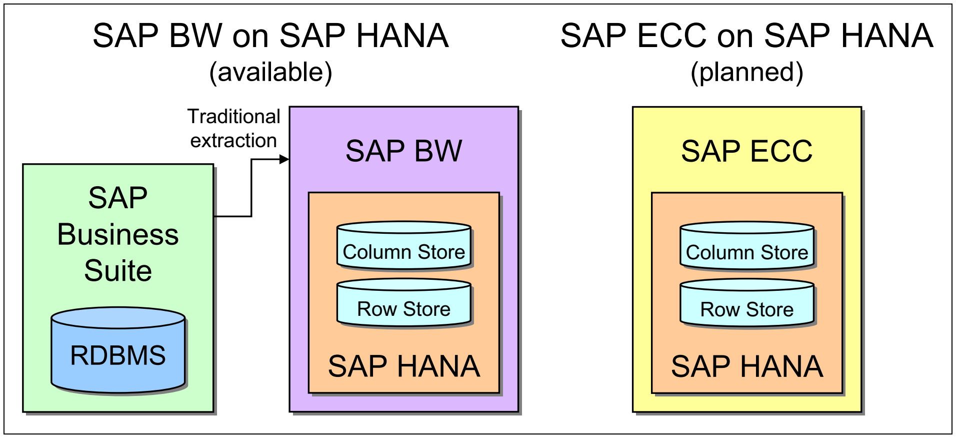

Figure 5-9 SAP products running on SAP HANA: SAP Business Warehouse (SAP NetWeaver BW) and SAP ERP Central Component (SAP ECC)

5.5.1 SAP NetWeaver BW running on SAP HANA

SAP HANA can be used as the database for an SAP NetWeaver Business Warehouse (SAP NetWeaver BW) installation. In this scenario, SAP HANA replaces the traditional database server of an SAP NetWeaver BW installation. The application servers stay the same.

The in-memory performance of SAP HANA dramatically improves query performance and eliminates the need for manual optimizations by materialized aggregates in SAP NetWeaver BW. Figure 5-10 shows SAP HANA as the database for the SAP NetWeaver Business Warehouse.

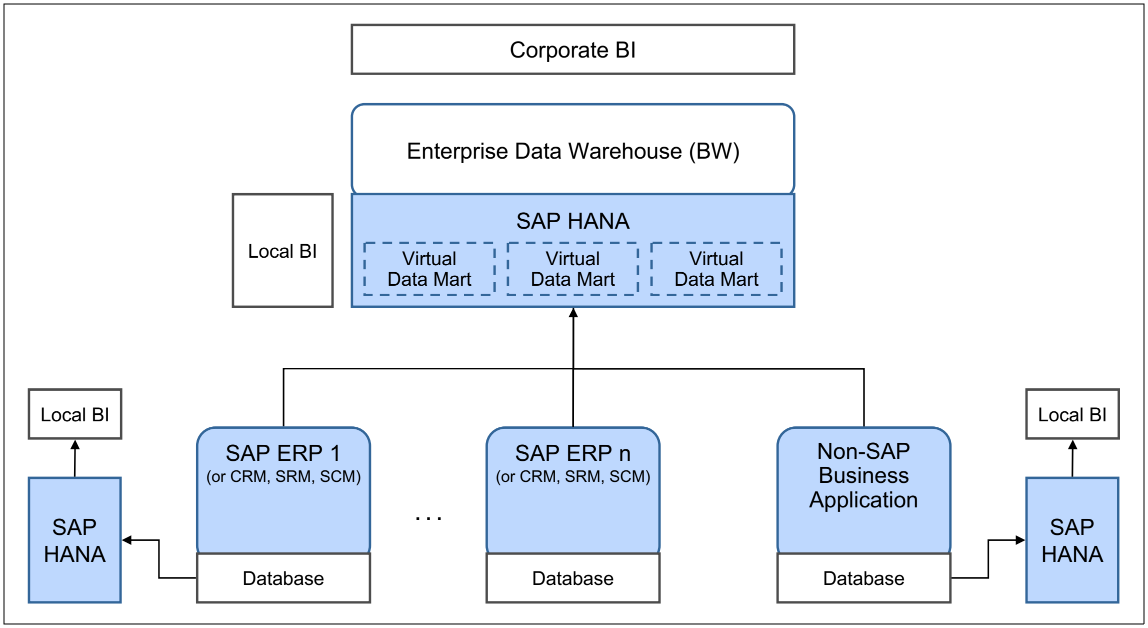

Figure 5-10 SAP HANA as the database for SAP NetWeaver Business Warehouse

In contrast to an SAP NetWeaver BW system accelerated by the in-memory capabilities of SAP NetWeaver BW Accelerator, an SAP NetWeaver BW system with SAP HANA as the database keeps *all* data in-memory. With SAP NetWeaver BW Accelerator, the customer chooses the data to be accelerated, which is then copied to the SAP NetWeaver BW Accelerator. Here the traditional database server (for example, IBM DB2 or Oracle) still acts as the primary datastore.

SAP NetWeaver BW on SAP HANA is probably the most popular SAP HANA use case, which achieves big performance improvements with relatively small efforts.

The underlying database is replaced by the SAP HANA database, which significantly improves both data loading times and query execution times. Because the application logic written in ABAP is not impacted by this change, all investments in developing BW models are preserved. The transition to SAP HANA is a transparent process that requires minimal effort to adjust existing modeling.

In-memory optimized InfoCubes

InfoCubes in SAP NetWeaver BW running on traditional database are using the so called *Enhanced Star Schema*. This schema was designed to optimize different performance aspects of working with multidimensional models on existing database systems.

Figure 5-11 illustrates the Enhanced Star Schema in BW with an example.

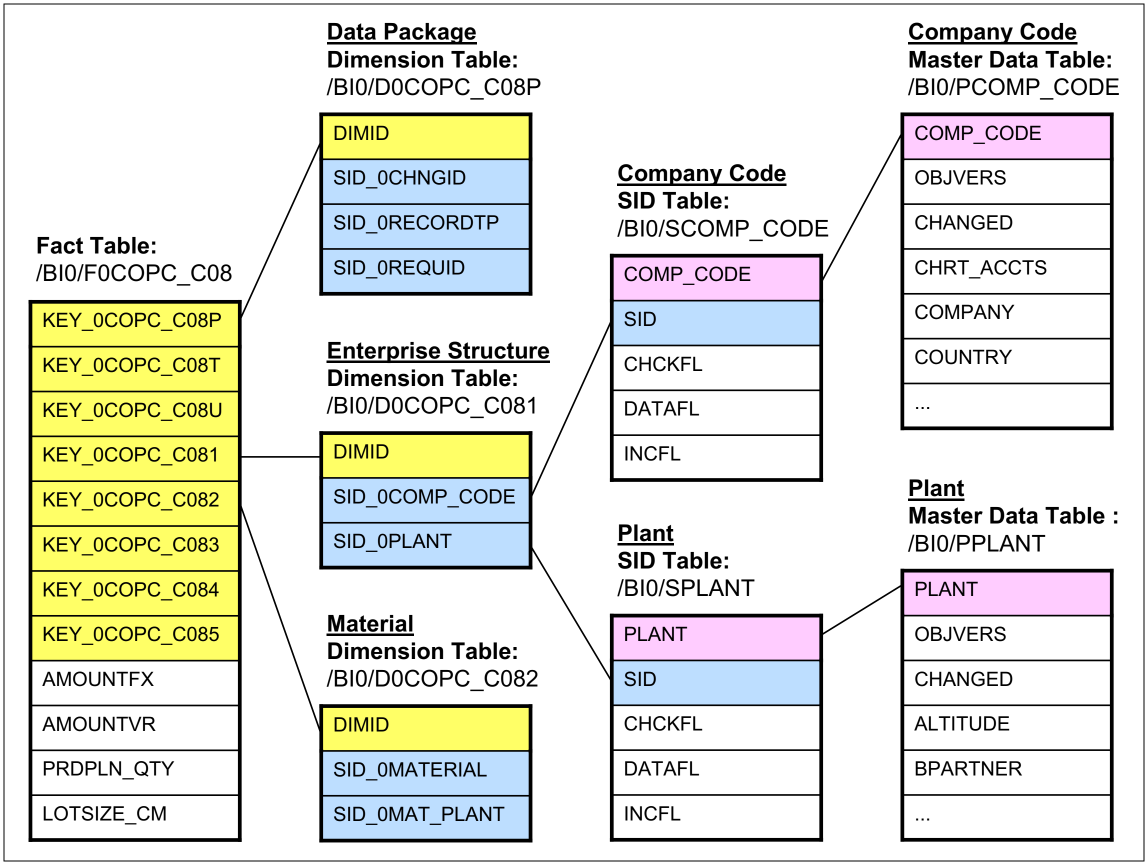

Figure 5-11 Enhanced Star Schema in SAP NetWeaver Business Warehouse

The core part of every InfoCube is the fact table. This table contains dimension identifiers (IDs) and corresponding key figures (measures). This table is surrounded by dimension tables that are linked to fact tables using the dimension IDs.

Dimension tables are usually small tables that group *logically connected* combinations of characteristics, usually representing master data. Logically connected means that the characteristics are highly related to each other, for example, company code and plant. Combining unrelated characteristics leads to a big amount of possible combinations, which can have a negative impact on the performance.

Because master data records are located in separate tables outside of the InfoCube, an additional table is required to connect these master data records to dimensions. These additional tables contain a mapping of auto-generated Surrogate IDs (SIDs) to the real master data.

This complex structure is required on classical databases; however, with SAP HANA this requirement is obsolete. SAP therefore introduced the SAP HANA Optimized Star Schema, illustrated in Figure 5-12.

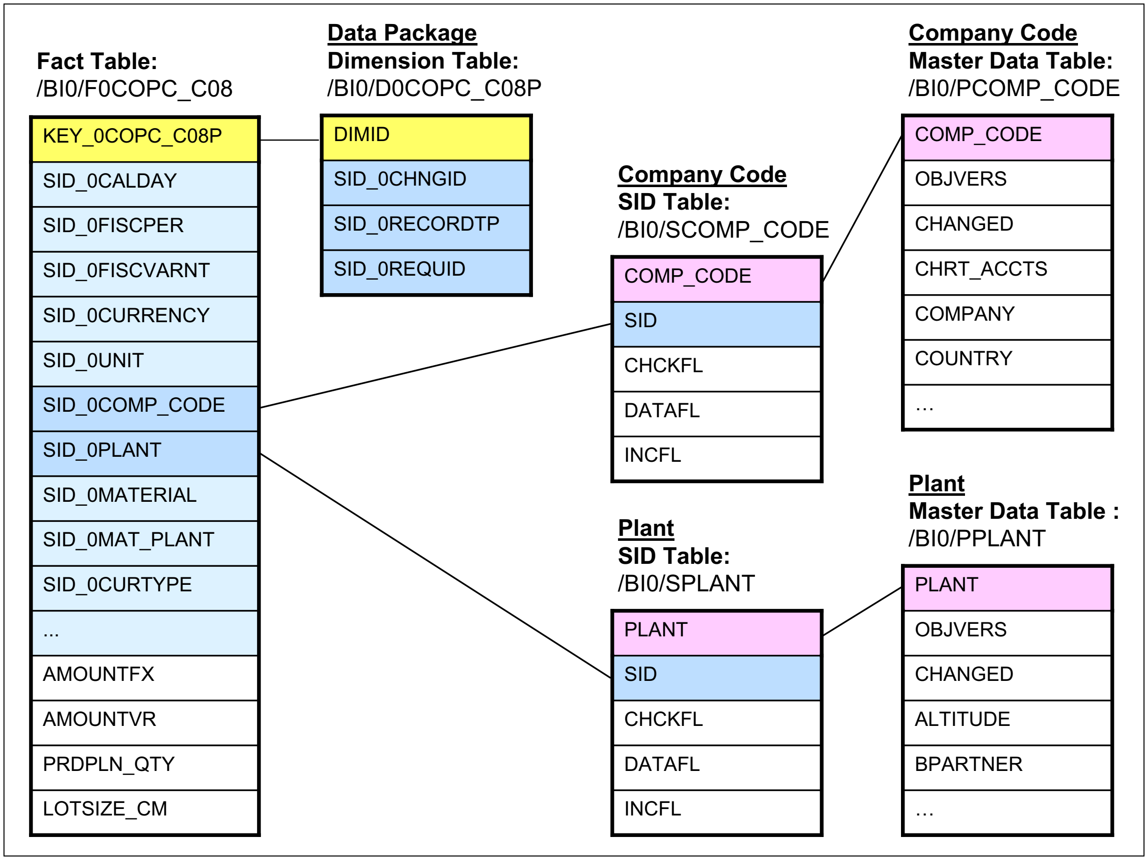

Figure 5-12 SAP HANA Optimized Star Schema in SAP NetWeaver BW system

The content of all dimensions (except for the Data Package dimension) is incorporated into the fact table. This modification brings several advantages:

- Simplified modeling

  Poorly designed dimensions (wrong combinations of characteristics) cannot affect performance anymore. Moving characteristics from one dimension to another is not a physical operation anymore; instead, it is just a metadata update.

- Faster loading

  Because dimension tables do not exist, all overhead workload related to identification of existing combinations or creating new combinations in the dimension tables is not required anymore. Instead, the required SID values are directly inserted into the fact table.

The SAP HANA Optimized Star Schema is automatically used for all newly created InfoCubes on the SAP NetWeaver BW system running on the SAP HANA database.

Existing InfoCubes are not automatically converted to this new schema during the SAP HANA conversion of the SAP NetWeaver BW system. The conversion of standard InfoCubes to in-memory optimized InfoCubes must be done manually as a follow-up task after the database migration.

SAP HANA acceleration areas

The SAP HANA database can bring significant performance benefits; however, it is important to set the expectations correctly. SAP HANA can improve loading and query times, but there are certain limits that cannot be overcome.

Migration of SAP NetWeaver BW to run on SAP HANA will certainly not improve extraction processes because extraction happens in the source system. Therefore it is important to understand how much of the overall load time is taken by extraction from the source system. This information is needed to properly estimate the potential performance improvement for the load process.

Other parts of the load process are improved. The new star schema removes unnecessary activities from the loading process.

Some of the calculations and application logic can be pushed to the SAP HANA database. This ensures that data intensive activities are being done on the SAP HANA database level instead of on the application level. This increases the performance because the amount and volume of data exchanged between the database and the application are significantly reduced.

SAP HANA can calculate all aggregations in real-time. Therefore aggregates are no longer required, and roll-up activity related to aggregate updates is obsolete. This also reduces overall execution time of update operations.

If SAP NetWeaver BW Accelerator was used, the update of its indexes is also no longer needed. Because SAP HANA is based on similar technology as an SAP NetWeaver BW Accelerator, all queries are accelerated. Query performance with SAP HANA can be compared to situations when all cubes are indexed by the SAP NetWeaver BW Accelerator. In reality, query performance can be even faster than with SAP NetWeaver BW Accelerator because additional features are available for SAP NetWeaver BW running on SAP HANA, for example, the possibility to remove an InfoCube and instead run reports against in-memory optimized DataStore Objects (DSOs).

5.5.2 Migrating SAP NetWeaver BW to SAP HANA

There are multiple ways that an existing SAP NetWeaver Business Warehouse system can be moved to an SAP HANA database. It is important to distinguish between a building proof of concept (POC) demo system and a productive migration.

The available options are divided into two main groups:

- "SAP NetWeaver BW database migration" on page 80
- "Transporting the content to the SAP NetWeaver BW system" on page 83

These two groups are just main driving ideas behind the move from a traditional database to SAP HANA. Within each group there are still many possibilities of how a project plan can be orchestrated.

In the following sections, we explain these two approaches in more detail.

SAP NetWeaver BW database migration

The following software levels are prerequisites for SAP NetWeaver BW running on SAP HANA[1]:

- SAP NetWeaver BW 7.30 SP5[2] or SAP NetWeaver BW 7.31 SP4
- SAP HANA 1.0 SPS03 (the latest available revision is recommended)

[1] see SAP Note 1600929 for latest information
[2] As per SAP Note 1600929, SP07 or higher must be imported for your SAP NetWeaver BW Installation (ABAP) before migration and after installation.

It is important to be aware that not all SAP NetWeaver BW add-ons are supported to run on the SAP HANA based system. For the latest information, see following SAP Notes:

- Note 1600929 - SAP NetWeaver BW powered by SAP HANA DB: Information
- Note 1532805 - Add-On Compatibility of SAP NetWeaver 7.3
- Note 1652738 - Add-on compatibility for SAP NetWeaver EHP 1 for NW 7.30

Unless your system already meets the minimal release requirements, the first step before converting SAP NetWeaver BW is to upgrade the system to the latest available release and to the latest available support package level.

A database upgrade might be required as part of the release upgrade or as a prerequisite before database migration to SAP HANA. For a list of supported databases, see SAP note 1600929.

Table 5-1 lists the databases that were approved as source databases for the migration to SAP HANA at the time of writing.

Table 5-1 Supported source databases for a migration to the SAP HANA database

Database	SAP NetWeaver BW 7.30	SAP NetWeaver BW 7.31
Oracle	11.2	11.2
MaxDB	7.8	7.9
MS SQL server	2008	2008
IBM DB2 LUW	9.7	9.7
IBM DB2 for i	6.1, 7.1	6.1, 7.1
IBM DB2 for z/OS®	V9, V10	V9, V10
SybaseASE	n/a	15.7

SAP HANA is currently not a supported database for any SAP NetWeaver Java stack; therefore, dual-stack installations (ABAP+Java) must be separated into two individual stacks using the Dual-Stack Split Tool from SAP.

Because some existing installations are still non-Unicode installations, another important prerequisite step might be a conversion of the database to unicode encoding. This unicode conversion can be done as a separate step or as part of the conversion to the SAP HANA database.

All InfoCubes with data persistency in the SAP NetWeaver Business Warehouse Accelerator are set as inactive during conversion, and their content in SAP NetWeaver BW Accelerator is deleted. These InfoCubes must be reloaded again from the original primary persistence; therefore, required steps must be incorporated into the project plan.

A migration to the SAP HANA database follows the exact same process as any other database migration. All activity in the SAP NetWeaver BW system is suspended after all preparation activities are finished. A special report is executed to generate database-specific statements for the target database that is used during import. Next, the content of the SAP system is exported to a platform-independent format and stored in files on disk.

These files are then transported to the primary application server of the SAP NetWeaver BW system. Note that application part of SAP NetWeaver BW is not allowed to run on the SAP HANA appliance. Therefore a minimal installation needs to have two servers:

- SAP HANA appliance hosting the SAP HANA database

  The SAP HANA appliance is delivered by IBM with the SAP HANA database preloaded. However, the database will be empty.

- Primary application server hosting ABAP instance of SAP NetWeaver BW

  There are minimal restrictions with regard to the operating system of the primary application server. See the Product Availability Matrix (PAM) for available combinations (search for SAP NetWeaver 7.3 and download overview presentation):

  http://service.sap.com/pam

At the time of writing this book, the following operating systems (see Table 5-2) were available to host ABAP part of SAP NetWeaver BW system:

Table 5-2 Supported operating systems for primary application server

	Windows Server 2008 x86_64 (64-bit) (including R2)	AIX 6.1, 7.1 Power (64-bit)	HP-UX 11.31 IA64 (64-bit)	Solaris 10 SPARC (64-bit)	Solaris 10 x86_64 (64-bit)	Linux SLES 11 SP1 x86_64 (64-bit)	Linux RHEL 5 x86_64 (64-bit)	Linux RHEL 6 x86_64 (64-bit)	IBM i 7.1 Power (64-bit)
SAP NetWeaver BW 7.30	yes	yes	yes	yes	yes	yes	yes	yes	no
SAP NetWeaver BW 7.31	yes	yes	yes	yes	yes	yes	no	yes	yes

The next step is the database import. It contains the installation of the SAP NetWeaver BW on the primary application server and the import of data into the SAP HANA database. The import occurs remotely from the primary application server as part of the installation process.

Parallel export/import using socket connection and FTP and NFS exchange modes are not supported. Currently only the asynchronous file-based export/import method is available.

After mandatory post-activities, conversion of InfoCubes and DataStore objects to their in-memory optimized form must be initiated to take all benefits that the SAP HANA database can offer. This can be done either manually for each object or as a mass operation using a special report.

Customers must plan a sufficient amount of time to perform this conversion. This step can be time consuming because the content of all InfoCubes must be copied into temporary tables that have the new structure.

After all post activities are finished, the system is ready to be tested.

Transporting the content to the SAP NetWeaver BW system

Unlike with a database migration, this approach is based on performing transports of activated objects (Business Content) from the existing SAP

NetWeaver BW system into a newly installed SAP NetWeaver BW system with SAP HANA as a primary database.

The advantage of this approach is that content can be transported across releases, as explained in following SAP Notes:

- Note 1090842 - Composite note: Transports across several releases
- Note 454321 - Transports between Basis Release 6.* and 7.0
- Note 1273566 - Transports between Basis Release 700/701 and 702/73*
- Note 323323 - Transport of all activated objects of a system

The possibility to transport content across different releases can significantly reduce the amount of effort that is required to build a proof of concept (POC) system because most of the prerequisite activities, such as the release upgrade, database upgrade, dual-stack split, and so on, are not needed.

After transporting the available objects (metadata definitions), their content must also be transported from the source to the target system. The SAP NetWeaver BW consultant must asses which available options are most suitable for this purpose.

Note that this approach is not recommended for production migration where a conventional database migration is used. Therefore additional effort invested in building a POC system in the same way as the production system will be treated, is a valuable test. This kind of test can help customers to create a realistic effort estimation for the project, estimate required runtimes, and define detailed planning of all actions that are required. All involved project team members become familiar with the system and can solve and document all specific problems.

Parallel approach to SAP HANA conversion

The recommended approach to convert an SAP NetWeaver BW system to use the SAP HANA database is a parallel approach, meaning that the new SAP NetWeaver BW system is created as a clone of the original system. The standard homogeneous system copy method can be used for this purpose.

This clone is then reconfigured in a way that both the original and the cloned BW system is functional and both systems can extract data from the same sources.

Detailed instructions about how to perform this cloning operation are explained in SAP Note 886102, scenario B2.

Here is some important information that is relevant to the cloned system. Refer to the content in SAP Note 886102 to understand the full procedure that must be applied on the target BW system. The SAP Note states:

Caution: This step deletes all transfer rules and PSA tables of these source systems, and the data is lost. A message is generated stating that the source system cannot be accessed (since you deleted the host of the RFC connection). Choose "Ignore".

It is important to understand the consequences of this action and to plan the required steps to reconfigure the target BW system so that it can again read data from the source systems.

Persistent Staging Area (PSA) tables can be regenerated by the replication of DataSources from the source systems, and transfer rules can be transported from the original BW system. However the content of these PSA tables is lost and needs to be reloaded from source systems.

This step might potentially cause problems where DataStore objects are used and PSA tables contain the complete history of data.

An advantage of creating a cloned SAP NetWeaver BW system is that the original system is not impacted and can still be used for productive tasks. The cloned system can be tested and results compared with the original system immediately after the clone is created and after every important project milestone, such as a release upgrade or the conversion to SAP HANA itself.

Both systems are fully synchronized because both systems periodically extract data from the same source systems. Therefore, after an entire project is finished, and the new SAP NetWeaver BW system running on SAP HANA meets the customer's expectations, the new system can fully replace the original system.

A disadvantage of this approach is the additional load imposed on the source systems, which is caused by both SAP NetWeaver BW systems performing extraction from the same source system, and certain limitations mentioned in the following SAP notes:

- Note 775568 - Two and more BW systems against one OLTP system
- Note 844222 - Two OR more BW systems against one OLTP system

5.6 Programming techniques using SAP HANA

The last use case scenario is based on recent developments from SAP where applications can be built directly against the SAP HANA database leveraging all its features, such as the embedded application server (XS Engine) or stored procedures, which allows logic to be directly processed inside the SAP HANA database.

A new software component can be integrated with SAP HANA either directly or it can be built on top of the SAP NetWeaver stack, which is can work with the SAP HANA database using client libraries.

Because of its breadth and depth, this use case scenario is not discussed in detail as part of this publication.

6

The IBM Systems Solution for SAP HANA

This chapter discusses the IBM Systems Solution for SAP HANA. We describe the hardware and software components, scale-up and scale-out approaches, workload-optimized models, interoperability with other platforms, and support processes. We also highlight IBM Systems solution with SAP Discovery System.

The following topics are covered:

6.1 IBM eX5 Systems

IBM decided to base their offering for SAP HANA on their high-performance, scalable IBM eX5 family of servers. These servers represent the IBM high-end Intel-based enterprise servers. IBM eX5 systems, all based on the eX5 Architecture, are the HX5 blade server, the x3690 X5, the x3850 X5, and the x3950 X5. They have a common set of technical specifications and features:

- The IBM System x3850 X5 is a 4U highly rack-optimized server. The x3850 X5 also forms the basis of the x3950 X5, the new flagship server of the IBM x86 server family. These systems are designed for maximum utilization, reliability, and performance for compute-intensive and memory-intensive workloads, such as SAP HANA.
- The IBM System x3690 X5 is a 2U rack-optimized server. This machine brings the eX5 features and performance to the mid tier. It is an ideal match for the smaller, two-CPU configurations for SAP HANA.
- The IBM BladeCenter HX5 is a single wide (30 mm) blade server that follows the same design as all previous IBM blades. The HX5 brings unprecedented levels of capacity to high-density environments.

When compared with other machines in the System x portfolio, these systems represent the upper end of the spectrum and are suited for the most demanding x86 tasks.

For SAP HANA, the x3690 X5 and the x3950 X5 are used, which is why we feature only these systems in this paper.

> **Note:** For the latest information about the eX5 portfolio, see the IBM Redpaper™ publication *IBM eX5 Portfolio Overview: IBM System x3850 X5, x3950 X5, x3690 X5, and BladeCenter HX5*, REDP-4650, for further eX5 family members and capabilities. This paper is available at the following web page:
>
> http://www.redbooks.ibm.com/abstracts/redp4650.html

6.1.1 IBM System x3850 X5 and x3950 X5

The IBM System x3850 X5 (Figure 6-1 on page 89) offers improved performance and enhanced features, including MAX5 memory expansion and workload-optimized x3950 X models to maximize memory, minimize costs, and simplify deployment.

Figure 6-1 IBM System x3850 X5 and x3950 X5

The x3850 X5 and the workload-optimized x3950 X5 are the logical successors to the x3850 M2 and x3950 M2, featuring the IBM eX4 chipset. Compared with previous generation servers, the x3850 X5 offers:

- High memory capacity

  Up to 64 DIMMS standard and 96 DIMMs with the MAX5 memory expansion per 4-socket server
- Intel Xeon processor E7 family

  Exceptional scalable performance with advanced reliability for your most data-demanding applications
- Extended SAS capacity with eight HDDs and 900 GB 2.5" SAS drives or 1.6 TB of hot-swappable RAID 5 with eXFlash technology
- Standard dual-port Emulex 10 GB Virtual Fabric adapter
- Ten-core, 8-core, and 6-core processor options with up to 2.4 GHz (10-core), 2.13 GHz (8-core), and 1.86 GHz (6-core) speeds with up to 30 MB L3 cache
- Scalable to a two-node system with eight processor sockets and 128 DIMM sockets
- Seven PCIe x8 high-performance I/O expansion slots to support hot-swap capabilities
- Optional embedded hypervisor

The x3850 X5 and x3950 X5 both scale to four processors and 2 Terabytes (TB) of RAM. With the MAX5 attached, the system can scale to four processors and 3 TB of RAM. Two x3850 X5 servers can be connected together for a single system image with eight processors and 4 TB of RAM.

With their massive memory capacity and computing power, the IBM System x3850 X5 and x3950 X5 rack-mount servers are the ideal platform for high-memory demanding, high-workload applications, such as SAP HANA.

6.1.2 IBM System x3690 X5

The IBM System x3690 X5 (Figure 6-2) is a 2U rack-optimized server that brings new features and performance to the mid tier.

Figure 6-2 IBM System x3690 X5

This machine is a two-socket, scalable system that offers up to four times the memory capacity of current two-socket servers. It supports the following specifications:

- Up to 2 sockets for Intel Xeon E7 processors. Depending on the processor model, processors have six, eight, or ten cores.
- Scalable from 32 to 64 DIMMs sockets with the addition of a MAX5 memory expansion unit.
- Advanced networking capabilities with a Broadcom 5709 dual Gb Ethernet controller standard in all models and an Emulex 10 Gb dual-port Ethernet adapter standard on some models, optional on all others.
- Up to 16 hot-swap 2.5-inch SAS HDDs, up to 16 TB of maximum internal storage with RAID 0, 1, or 10 to maximize throughput and ease installation. RAID 5 is optional. The system comes standard with one HDD backplane that can hold four drives. A second and third backplane are optional for an additional 12 drives.
- New eXFlash high-IOPS solid-state storage technology.
- Five PCIe 2.0 slots.
- Integrated Management Module (IMM) for enhanced systems management capabilities.

The x3690 X5 features the IBM eXFlash internal storage using solid state drives to maximize the number of I/O operations per second (IOPS). All configurations for SAP HANA based on x3690 X5 use eXFlash internal storage for high IOPS log storage or for both data and log storage.

The x3690 X5 is an excellent choice for a memory-demanding and performance-demanding business application, such as SAP HANA. It provides maximum performance and memory in a dense 2U package.

6.1.3 Intel Xeon processor E7 family

The IBM eX5 portfolio of servers uses CPUs from the Intel Xeon processor E7 family to maximize performance. These processors are the latest in a long line of high-performance processors.

The Intel Xeon processor E7 family CPUs are the latest Intel scalable processors and can be used to scale up to four or more processors. When used in the IBM System x3850 X5 or x3950 X5, these servers can scale up to eight processors.

The Intel Xeon E7 processors have a lot of features that are relevant for the SAP HANA workload. We cover some of these features in the following sections. For more in-depth information about the benefits of the Intel Xeon processor E7 family for SAP HANA, see the Intel white paper “Analyzing Business as it Happens,” April 2011, available for download at:

http://www.Intel.com/en_us/ssets/pdf/whitepaper/mc_sap_wp.pdf

Instruction set extensions

SAP HANA makes use of several instruction set extensions of the Intel Xeon E7 processors. For example, these extensions allow you to process multiple data items with one instruction. SAP HANA uses these instructions to speed up compression and decompression of in-memory data and to improve search performance.

Intel Hyper-Threading Technology

Intel Hyper-Threading Technology enables a single physical processor to execute two separate code streams (threads) concurrently on a single processor core. To the operating system, a processor core with Hyper-Threading appears as two logical processors, each of which has its own architectural state. Hyper-Threading Technology is designed to improve server performance by exploiting the multi-threading capability of operating systems and server applications. SAP HANA makes extensive use of Hyper-Threading to parallelize processing.

For more information about Hyper-Threading Technology, see the following web page:

http://www.intel.com/technology/platform-technology/hyper-threading/

Intel Turbo Boost Technology 2.0

Intel Turbo Boost Technology dynamically turns off unused processor cores and increases the clock speed of the cores in use. For example, with six cores active, a 2.4 GHz 10-core processor can run the cores at 2.67 GHz. With only four cores active, the same processor can run those cores at 2.8 GHz. When the cores are needed again, they are dynamically turned back on and the processor frequency is adjusted accordingly. When temperature, power, or current exceed factory-configured limits and the processor is running higher than the base operating frequency, the processor automatically reduces the core frequency to reduce temperature, power, and current.

Turbo Boost Technology is available on a per-processor number basis for the eX5 systems. For ACPI-aware operating systems, no changes are required to take advantage of it. Turbo Boost Technology can be engaged with any number of cores enabled and active, resulting in increased performance of both multi-threaded and single-threaded workloads.

For more information about Turbo Boost Technology, see the following web page:

http://www.intel.com/technology/turboboost/

Quick Path Interconnect (QPI)

Earlier versions of the Intel Xeon processor were connected by a parallel bus to a core chipset, which functions as both a memory and I/O controller. The new Intel Xeon E7 processors implemented in IBM eX5 servers include a separate memory controller to each processor. Processor-to-processor communication is carried over shared-clock or coherent quick path interconnect (QPI) links, and I/O is transported over non-coherent QPI links through I/O hubs (Figure 6-3).

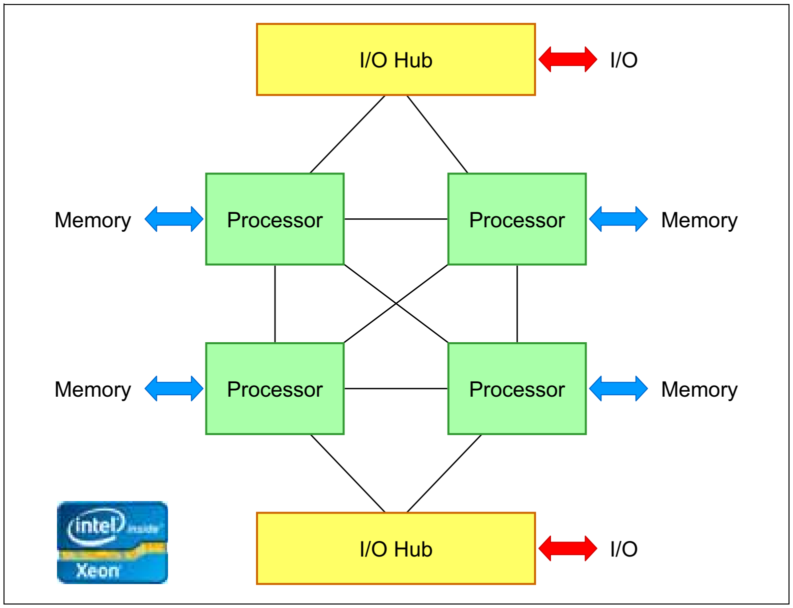

Figure 6-3 Quick path interconnect, as in the eX5 portfolio

In previous designs, the entire range of memory was accessible through the core chipset by each processor, which is called a *shared memory* architecture. This new design creates a *non-uniform memory access (NUMA)* system in which a portion of the memory is directly connected to the processor where a given thread is running, and the rest must be accessed over a QPI link through another processor. Similarly, I/O can be local to a processor or remote through another processor.

For more information about QPI, see the following web page:

http://www.intel.com/technology/quickpath/

Reliability, availability, and serviceability

Most system errors are handled in hardware by the use of technologies, such as error checking and correcting (ECC) memory. The E7 processors have additional reliability, availability, and serviceability (RAS) features due to their architecture:

- Cyclic redundancy checking (CRC) on the QPI links

  The data on the QPI link is checked for errors.

- QPI packet retry

  If a data packet on the QPI link has errors or cannot be read, the receiving processor can request that the sending processor retry sending the packet.

- QPI clock failover

  In the event of a clock failure on a coherent QPI link, the processor on the other end of the link can take over providing the clock. This is not required on the QPI links from processors to I/O hubs because these links are asynchronous.

- SMI packet retry

  If a memory packet has errors or cannot be read, the processor can request that the packet be resent from the memory buffer.

- Scalable memory interconnect (SMI) retry

  If there is an error on an SMI link, or a memory transfer fails, the command can be retried.

- SMI lane failover

  When an SMI link exceeds the preset error threshold, it is disabled, and memory transfers are routed through the other SMI link to the memory buffer.

All these features help prevent data from being corrupted or lost in memory. This is especially important with an application, such as SAP HANA, because any failure in the area of memory or inter-CPU communication leads to an outage of the application or even of the complete system. With huge amounts of data loaded into main memory, even a restart of only the application means considerable time required to return to operation.

Machine Check Architecture

The Intel Xeon processor E7 family also features the machine check architecture (MCA), which is a RAS feature that enables the handling of system errors that otherwise require the operating system to be halted. For example, if a dead or corrupt memory location is discovered, but it cannot be recovered at the memory subsystem level, and provided that it is not in use by the system or an application, an error can be logged but the operation of the server can continue.

If it is in use by a process, the application to which the process belongs can be aborted or informed about the situation.

Implementation of the MCA requires hardware support, firmware support (such as that found in the unified extensible firmware interface (UEFI)), and operating system support. Microsoft, SUSE, Red Hat, and other operating system vendors included support for the Intel MCA on the Intel Xeon processors in their latest operating system versions.

SAP HANA is the first application that leverages the MCA to handle system errors to prevent the application from being terminated in case of a system error. Figure 6-4 shows how SAP HANA leverages the Machine Check Architecture.

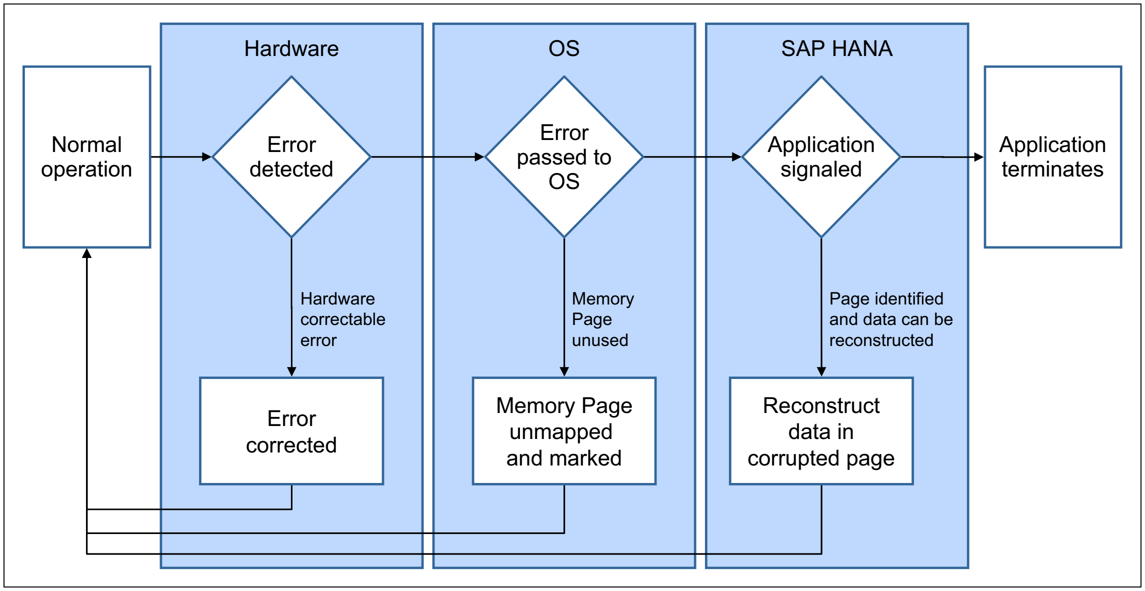

Figure 6-4 Intel Machine Check Architecture (MCA) with SAP HANA

If a memory error is encountered that cannot be corrected by the hardware, the processor sends an MCA recovery signal to the operating system. An operating system supporting MCA, such as SUSE Linux Enterprise Server used in the SAP HANA appliance, now determines whether the affected memory page is in use by an application. If unused, it unmaps the memory page and marks it as bad. If the page is used by an application, traditionally the OS has to hold that application, or in the worst case stop all processing and halt the system. With SAP HANA being MCA-aware, the operating system can signal the error situation to SAP HANA, giving it the chance to try to repair the effects of the memory error.

Using the knowledge of its internal data structures, SAP HANA can decide what course of action to take. If the corrupted memory space is occupied by one of the SAP in-memory tables, SAP HANA reloads the associated tables. In addition, it analyzes the failure and checks whether it affects other stored or committed data, in which case it uses savepoints and database logs to reconstruct the committed data in a new, unaffected memory location.

With the support of MCA, SAP HANA can take appropriate action at the level of its own data structures to ensure a smooth return to normal operation and avoid a time-consuming restart or loss of information.

I/O hubs

The connection to I/O devices (such as keyboard, mouse, and USB) and to I/O adapters (such as hard disk drive controllers, Ethernet network interfaces, and Fibre Channel host bus adapters) is handled by I/O hubs, which then connect to the processors through QPI links. Figure 6-3 on page 93 shows the I/O Hub connectivity. Connections to the I/O devices are fault tolerant because data can be routed over either of the two QPI links to each I/O hub.

For optimal system performance in the four processor systems (with two I/O hubs), balance high-throughput adapters across the I/O hubs. The configurations used for SAP HANA contain several components that require high throughput I/O:

- Dual-port 10 Gb Ethernet adapters
- ServeRAID controllers to connect the SAS drives
- High IOPS PCIe Adapters

To ensure optimal performance, the placement of these components in the PCIe slots was optimized according to the I/O architecture outlined above.

6.1.4 Memory

For an in-memory appliance, such as SAP HANA, a system's main memory, its capacity, and its performance play an important role. The Intel Xeon processor E7 family, Figure 6-5 on page 97, has a memory architecture that is well suited to the requirements of such an appliance.

The E7 processors have two SMIs. Therefore, memory needs to be installed in matched pairs. For better performance, or for systems connected together, memory must be installed in sets of four. The memory used in the eX5 systems is DDR3 SDRAM registered DIMMs. All of the memory runs at 1066 MHz or less, depending on the processor.

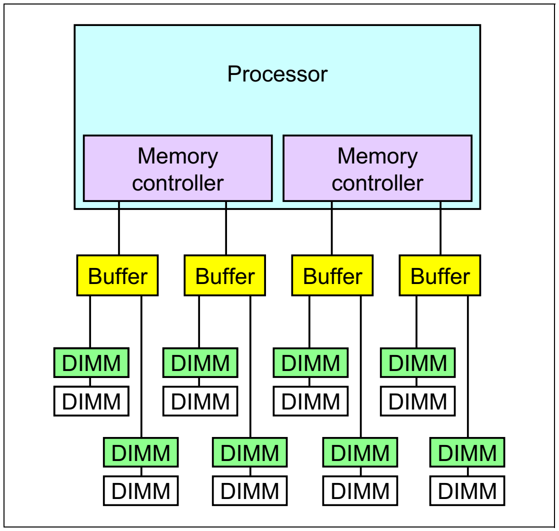

Figure 6-5 Memory architecture with Intel Xeon processor E7 family

Memory DIMM placement

The eX5 servers support a variety of ways to install memory DIMMs. It is important to understand that because of the layout of the SMI links, memory buffers, and memory channels, you must install the DIMMs in the correct locations to maximize performance.

Figure 6-6 on page 98 shows eight possible memory configurations for the two memory cards and 16 DIMMs connected to each processor socket in an x3850 X5. Similar configurations apply to the x3690 X5 and HX5. Each configuration has a relative performance score. The following key information from this chart is important:

- The best performance is achieved by populating all memory DIMMs in the server (configuration 1 in Figure 6-6 on page 98).
- Populating only one memory card per socket can result in approximately a 50% performance degradation. (Compare configuration 1 with 5.)
- Memory performance is better if you install DIMMs on all memory channels than if you leave any memory channels empty. (Compare configuration 2 with 3.)
- Two DIMMs per channel result in better performance than one DIMM per channel. (Compare configuration 1 with 2, and compare 5 with 6.)

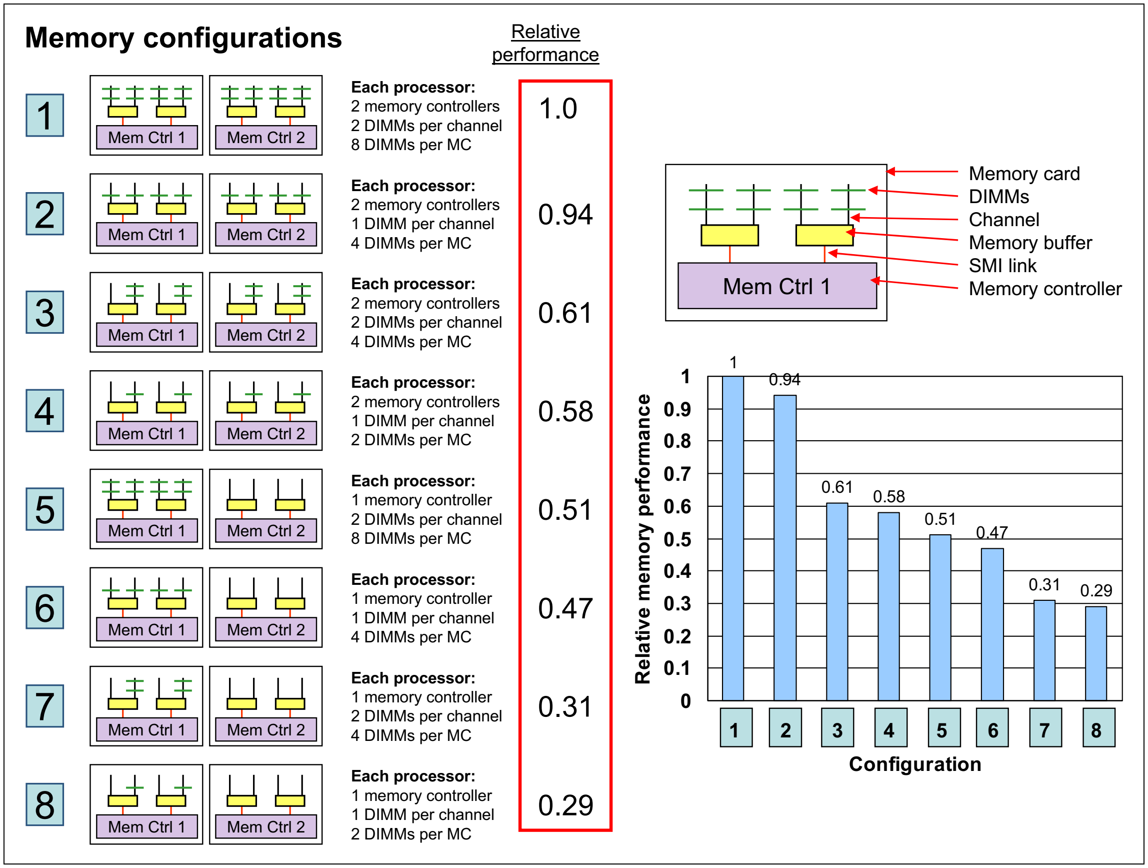

Figure 6-6 Relative memory performance based on DIMM placement (one processor and two memory cards shown)

Nonuniform memory architecture

Nonuniform memory architecture (NUMA) is an important consideration when configuring memory because a processor can access its own local memory faster than non-local memory. The configurations used for SAP HANA do not use all available DIMM sockets. For configurations like these, another principle to consider when configuring memory is that of *balance*. A balanced configuration has all of the memory cards configured with the same *amount* of memory. This principle helps to keep remote memory access to a minimum.

A server with a NUMA, such as the servers in the eX5 family, has local and remote memory. For a given thread running in a processor core, *local memory* refers to the DIMMs that are directly connected to that particular processor. *Remote memory* refers to the DIMMs that are not connected to the processor where the thread is running currently. Remote memory is attached to another processor in the system and must be accessed through a QPI link (Figure 6-3 on page 93). However, using remote memory adds latency. The more such latencies add up in a server, the more performance can degrade. Starting with a memory configuration where each CPU has the same local RAM capacity is a logical step toward keeping remote memory accesses to a minimum.

In a NUMA system, each processor has fast, direct access to its own memory modules, reducing the latency that arises due to bus-bandwidth contention. SAP HANA is NUMA-aware, and thus benefits from this direct connection.

Hemisphere mode

Hemisphere mode is an important performance optimization of the Intel Xeon processor E7, 6500, and 7500 product families. Hemisphere mode is automatically enabled by the system if the memory configuration allows it. This mode interleaves memory requests between the two memory controllers within each processor, enabling reduced latency and increased throughput. It also allows the processor to optimize its internal buffers to maximize memory throughput.

Hemisphere mode is enabled only when the memory configuration behind each memory controller on a processor is identical. In addition, because eight DIMMs per processor are required for using all memory channels, eight DIMMs per processor must be installed at a time for optimized memory performance.

6.1.5 Flash technology storage

As discussed in 2.1.2, “Data persistence” on page 11, storage technology providing high IOPS capabilities with low latency is a key component of the infrastructure for SAP HANA. The IBM eX5 systems used for the IBM Systems Solution for SAP HANA feature two kinds of flash technology storage devices:

- eXFlash, as used in the IBM System x3690 X5-based configuration
- High IOPS adapters, as used in the IBM System x3950 X5-based configurations

The following sections provide more information about these options.

eXFlash

IBM eXFlash is the name given to the eight 1.8-inch solid state drives (SSDs), the backplanes, SSD hot swap carriers, and indicator lights that are available for the x3850 X5/x3950 X5 and x3690 X5. Each eXFlash can be put in place of four SAS or SATA disks. The eXFlash units connect to the same types of ServeRAID disk controllers as the SAS/SATA disks. Figure 6-7 shows an eXFlash unit, with the status light assembly on the left side.

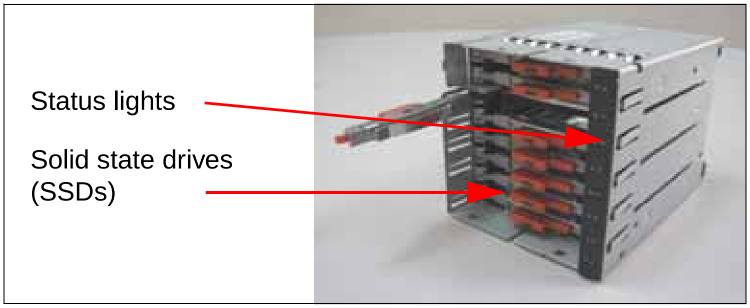

Figure 6-7 IBM eXFlash unit

In addition to using less power than rotating magnetic media, the SSDs are more reliable and can service many more I/O operations per second (IOPS). These attributes make them suited to I/O-intensive applications, such as transaction processing, logging, backup and recovery, and business intelligence. Built on enterprise-grade MLC NAND flash memory, the SSD drives used in eXFlash deliver up to 30,000 IOPS per single drive. Combined into an eXFlash unit, these drives can deliver up to 240,000 IOPS and up to 2 GBps of sustained read throughput per eXFlash unit.

In addition to its superior performance, eXFlash offers superior uptime with three times the reliability of mechanical disk drives. SSDs have no moving parts to fail. Each drive has its own backup power circuitry, error correction, data protection, and thermal monitoring circuitry. They use Enterprise Wear-Leveling to extend their use even longer.

A single eXFlash unit accommodates up to eight hot-swap SSDs and can be connected to up to 2 performance-optimized controllers. The x3690 X5-based models for SAP HANA enable RAID protection for the SSD drives by using two ServeRAID M5015 controllers with the ServeRAID M5000 Performance Accelerator Key for the eXFlash units.

High IOPS adapter

The IBM High IOPS SSD PCIe Adapters provide a new generation of ultra-high-performance storage based on solid state device technology for

System x and BladeCenter. These adapters are alternatives to disk drives and are available in several sizes, from 160 GB to 1.2 TB. Designed for high-performance servers and computing appliances, these adapters deliver throughput of up to 900,000 I/O operations per second (IOPS), while providing the added benefits of lower power, cooling, and management overhead and a smaller storage footprint. Based on standard PCIe architecture coupled with silicon-based NAND clustering storage technology, the High IOPS adapters are optimized for System x rack-mount systems and can be deployed in blades through the PCIe expansion units. They are available in storage capacities up to 2.4 TB.

These adapters use NAND flash memory as the basic building block of solid-state storage and contain no moving parts. Thus, they are less sensitive to issues associated with vibration, noise, and mechanical failure. They function as a PCIe storage and controller device, and after the appropriate drivers are loaded, the host operating system sees them as block devices. Therefore, these adapters cannot be used as bootable devices.

The IBM High IOPS PCIe Adapters combine high IOPS performance with low latency. As an example, with 512 KB block random reads, the IBM 1.2TB High IOPS MLC Mono Adapter can deliver 143,000 IOPS, compared with 420 IOPS for a 15 K RPM 146 GB disk drive. The read access latency is about 68 microseconds, which is one hundredth of the latency of a 15 K RPM 146 GB disk drive (about 5 ms or 5000 microseconds). The write access latency is even less, with about 15 microseconds.

Reliability features include the use of Enterprise-grade MLC (eMLC), advanced wear-leveling, ECC protection, and Adaptive Flashback redundancy for RAID-like chip protection with self-healing capabilities, providing unparalleled reliability and efficiency. Advanced bad-block management algorithms enable taking blocks out of service when their failure rate becomes unacceptable. These reliability features provide a predictable lifetime and up to 25 years of data retention.

The x3950 X5-based models of the IBM Systems Solution for SAP HANA come with IBM High IOPS adapters, either with 320 GB (7143-H1x), 640 GB (7143-H2x, -H3x), or 1.2 TB storage capacity (7143-HAx, -HBx, -HCx).

Figure 6-8 shows the IBM 1.2TB High IOPS MLC Mono adapter, which comes with the x3950 based 2012 models (7143-HAx, -HBx, -HCx).

Figure 6-8 IBM 1.2 TB High IOPS MLC Mono adapter

6.2 IBM General Parallel File System

The IBM General Parallel File System (GPFS) is a key component of the IBM Systems Solution for SAP HANA. It is a high-performance shared-disk file management solution that can provide faster, more reliable access to a common set of file data. It enables a view of distributed data with a single global namespace.

GPFS leverages its cluster architecture to provide quicker access to your file data. File data is automatically spread across multiple storage devices, providing optimal use of your available storage to deliver high performance.

GPFS is designed for high-performance parallel workloads. Data and metadata flow from all the nodes to all the disks in parallel under control of a distributed lock manager. It has a flexible cluster architecture that enables the design of a data storage solution that not only meets current needs but that can also quickly be adapted to new requirements or technologies. GPFS configurations include direct-attached storage, network block input and output (I/O), or a combination of the two, and multi-site operations with synchronous data mirroring.

GPFS can intelligently prefetch data into its buffer pool, issuing I/O requests in parallel to as many disks as necessary to achieve the peak bandwidth of the underlying storage-hardware infrastructure. GPFS recognizes multiple I/O patterns, including sequential, reverse sequential, and various forms of striped access patterns. In addition, for high-bandwidth environments, GPFS can read or write large blocks of data in a single operation, minimizing the overhead of I/O operations.

Expanding beyond a storage area network (SAN) or locally attached storage, a single GPFS file system can be accessed by nodes using a TCP/IP or InfiniBand connection. Using this block-based network data access, GPFS can outperform network-based sharing technologies, such as NFS and even local file systems such as the EXT3 journaling file system for Linux or Journaled File System. Network block I/O (also called network shared disk (NSD)) is a software layer that transparently forwards block I/O requests from a GPFS client application node to an NSD server node to perform the disk I/O operation and then passes the data back to the client. Using a network block I/O, configuration can be more cost effective than a full-access SAN.

Storage pools enable you to transparently manage multiple tiers of storage based on performance or reliability. You can use storage pools to transparently provide the appropriate type of storage to multiple applications or different portions of a single application within the same directory. For example, GPFS can be configured to use low-latency disks for index operations and high-capacity disks for data operations of a relational database. You can make these configurations even if all database files are created in the same directory.

For optimal reliability, GPFS can be configured to eliminate single points of failure. The file system can be configured to remain available automatically in the event of a disk or server failure. A GPFS file is designed to transparently fail over token (lock) operations and other GPFS cluster services, which can be distributed throughout the entire cluster to eliminate the need for dedicated metadata servers. GPFS can be configured to automatically recover from node, storage, and other infrastructure failures.

GPFS provides this functionality by supporting these:

- Data replication to increase availability in the event of a storage media failure
- Multiple paths to the data in the event of a communications or server failure
- File system activity logging, enabling consistent fast recovery after system failures

In addition, GPFS supports snapshots to provide a space-efficient image of a file system at a specified time, which allows online backup and can help protect against user error.

GPFS offers time-tested reliability and was installed on thousands of nodes across industries, from weather research to multimedia, retail, financial industry analytics, and web service providers. GPFS also is the basis of many cloud storage offerings.

The IBM Systems solution for SAP HANA benefits in several ways from the features of GPFS:

- GPFS provides a stable, industry-proven, cluster-capable file system for SAP HANA.
- GPFS adds extra performance to the storage devices by striping data across devices.
- GPFS enables the IBM Systems solution for SAP HANA to grow beyond the capabilities of a single system, into a scale-out solution, without introducing the need for external storage.
- GPFS adds high-availability and disaster recovery features to the solution.

This makes GPFS the ideal file system for the IBM Systems solution for SAP HANA.

6.3 Custom server models for SAP HANA

Following the appliance-like delivery model for SAP HANA, IBM created several custom server models for SAP HANA. These workload-optimized models are designed to match and exceed the performance requirements and the functional requirements as specified by SAP. With a small set of IBM System x workload-optimized models for SAP HANA, all sizes of SAP HANA solutions can be built, from the smallest to large installations.

6.3.1 IBM System x workload-optimized models for SAP HANA

In the first half of 2011, IBM announced a full range of IBM System x workload-optimized models for SAP HANA, covering all SAP HANA T-shirt sizes with the newest generation technology. Because there is no direct relationship between the workload-optimized models and the SAP HANA T-shirt sizes, we refer to these models as building blocks. In some cases, there are several building blocks available for one T-shirt size. In some, two-building blocks have to be combined to build a specific T-shirt size. Table 6-1 shows all building blocks announced in 2011 and their features.

Table 6-1 IBM System x workload-optimized models for SAP HANA, 2011 models

Building block	Server (MTM)	CPUs	Main memory	Log storage	Data storage	Preload
XS	x3690 X5 (7147-H1x[a])	2x Intel Xeon E7-2870	128 GB DDR3 (8x 16 GB)	8x 50 GB 1.8” MLC SSD	8x 300 GB 10 K SAS HDD	Yes
S	x3690 X5 (7147-H2x)	2x Intel Xeon E7-2870	256 GB DDR3 (16x 16 GB)	8x 50 GB 1.8” MLC SSD	8x 300 GB 10 K SAS HDD	Yes
SSD	x3690 X5 (7147-H3x)	2x Intel Xeon E7-2870	256 GB DDR3 (16x 16 GB)	10x 200 GB 1.8” MLC SSD (combined log and data)		Yes
S+	x3950 X5 (7143-H1x)	2x Intel Xeon E7-8870	256 GB DDR3 (16x 16 GB)	320 GB High IOPS adapter	8x 600 GB 10 K SAS HDD	Yes
M	x3950 X5 (7143-H2x)	4x Intel Xeon E7-8870	512 GB DDR3 (32x 16 GB)	640 GB High IOPS adapter	8x 600 GB 10 K SAS HDD	Yes
L Option	x3950 X5 (7143-H3x)	4x Intel Xeon E7-8870	512 GB DDR3 (32x 16 GB)	640 GB High IOPS adapter	8x 600 GB 10 K SAS HDD	No

a. x = Country-specific letter (for example, EMEA MTM is 7147-H1G, and the US MTM is 7147-H1U). Contact your IBM representative for regional part numbers.

In addition to the models listed in Table 6-1, there are models specific to a geographic region:

- Models 7147-H7x, -H8x, and -H9x are for Canada only and are the same configurations as H1x, H2x, and H3x, respectively.
- Models 7143-H4x and -H5x are for Canada only and are the same configuration as H1x and H2x, respectively.

In October of 2012, IBM announced a new set of IBM System x workload-optimized models for SAP HANA, updating some of the components with newer generation versions. Table 6-2 shows all building blocks announced in 2012 and their features.

Table 6-2 IBM System x workload-optimized models for SAP HANA, 2012 models

Building block	Server (MTM)	CPUs	Main memory	Log storage	Data storage	Preload
XS	x3690 X5 (7147-HAx[a])	2x Intel Xeon E7-2870	128 GB DDR3 (8x 16 GB)	10x 200 GB 1.8” MLC SSD (combined log and data)		Yes
S	x3690 X5 (7147-HBx)	2x Intel Xeon E7-2870	256 GB DDR3 (16x 16 GB)	10x 200 GB 1.8” MLC SSD (combined log and data)		Yes
S+	x3950 X5 (7143-HAx)	2x Intel Xeon E7-8870	256 GB DDR3 (16x 16 GB)	1.2 TB High IOPS adapter	8x 900 GB 10 K SAS HDD	Yes
M	x3950 X5 (7143-HBx)	4x Intel Xeon E7-8870	512 GB DDR3 (32x 16 GB)	1.2 TB High IOPS adapter	8x 900 GB 10 K SAS HDD	Yes
L Option	x3950 X5 (7143-HCx)	4x Intel Xeon E7-8870	512 GB DDR3 (32x 16 GB)	1.2 TB High IOPS adapter	8x 900 GB 10 K SAS HDD	No

a. x = Country-specific letter (for example, EMEA MTM is 7147-HAG, and the US MTM is 7147-HAU). Contact your IBM representative for regional part numbers.

All models (except for 7143-H3x and 7143-HCx) come with a preload comprising SUSE Linux Enterprise Server for SAP Applications (SLES for SAP) 11 SP1, IBM GPFS, and the SAP HANA software stack. Licenses and maintenance fees (for three years) for SLES for SAP and GPFS are included. Section “GPFS license information” on page 160 has an overview about which type of GPFS license comes with a specific model, and the amount of Processor Value Units (PVU) included.The licenses for the SAP software components have to be acquired separately from SAP.

The L-Option building blocks (7143-H3x or 7143-HCx) are intended as an extension to an M building block (7143-H2x or 7143-HBx). When building an L-Size SAP HANA system, one M building block has to be combined with an L-Option building block, leveraging eX5 scalability. Both systems then act as one single eight-socket, 1 TB server. Therefore, the L-Option building blocks do not require a software preload, it comes however with the required additional software licenses for GPFS and SLES for SAP.

The building blocks are configured to match the SAP HANA sizing requirements. The main memory sizes match the number of CPUs, to give the correct balance between processing power and data volume. Also, the storage devices in the systems provide the storage capacity required to match the amount of main memory.

All systems come with storage for both the data volume and the log volume (Figure 6-9). Savepoints are stored on a RAID protected array of 10 K SAS hard drives, optimized for data throughput. The SAP HANA database logs are stored on flash technology storage devices:

- RAID-protected, hot swap eXFlash SSD drives on the models based on IBM System x3690 X5
- Flash-based High IOPS PCIe adapters for the models based on IBM System x3950 X5

These flash technology storage devices are optimized for high IOPS performance and low latency to provide the SAP HANA database with a log storage that allows the highest possible performance. Because a transaction in the SAP HANA database can only return after the corresponding log entry is written to the log storage, high IOPS performance and low latency are key to database performance.

The building blocks based on the IBM System x3690 X5 (except for the older 7147-H1x and 7147-H2x), come with combined data and log storage on an array of RAID-protected, hot-swap eXFlash SSD drives. Optimized for throughput, high IOPS performance, and low latency, these building blocks give extra flexibility when dealing with large amounts of log data, savepoint data, or backup data.

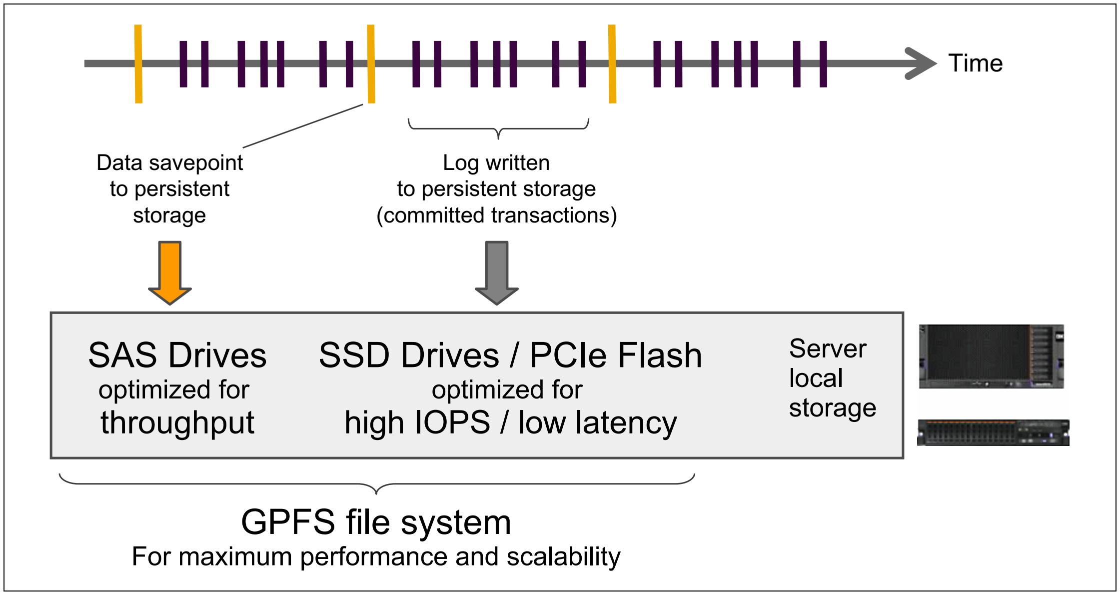

Figure 6-9 SAP HANA data persistency with the internal storage of the workload-optimized systems

6.3.2 SAP HANA T-shirt sizes

This section provides information about how the SAP HANA T-shirt sizes, as described in 3.3.1, “The concept of T-shirt sizes for SAP HANA” on page 26, can be realized using the IBM System x workload-optimized models for SAP HANA[1]:

- For a T-shirt size XS 128 GB SAP HANA system, building block XS (7147-H1x or 7147-HAx) is the correct choice. These x3690 X5-based building blocks are the entry-level models of the line of IBM System x workload-optimized systems for SAP HANA.
- A T-shirt size S 256 GB can either be realized with the newer S building block (7147-HBx) or the older SSD building block (7147-H3x) with combined data and log storage on eXFlash SSD drives. The older S building block (7147-H2x) is suitable too, equipped with separate storage for data (SAS drives) and logs (SSD drives), but has limitations with regards to the scale-out solution. All three are based on IBM System x3690 X5.
- For a T-shirt size S 256 GB with upgradability to M (that is, a T-shirt size S+), the S+ building block (7143-H1x or 7143-HAx) is the perfect choice. Unlike the S and SSD building blocks, it is based on the IBM System x3950 X5 4-socket system to ensure upgradability.
- A T-shirt size M 512 GB can be realized with the M building block (7143-H2x or 7143-HBx). As it can be upgraded to a T-shirt size L using the L-Option building block, it is also the perfect fit if a T-shirt size M+ is required.
- For a T-shirt size L 1 TB, one M building block (7143-H2x or 7143-HBx) must be combined with an L-Option building block (7143-H3x or 7143-HCx), connected together to form a single server using eX5 scaling technology.

[1] The model numbers given might have be to replaced by a region-specific equivalent by changing the *x* to a region-specific letter identifier. See 6.3.1, “IBM System x workload-optimized models for SAP HANA” on page 104.

Table 6-3 gives an overview of the SAP HANA T-Shirt sizes and their relation to the IBM custom models for SAP HANA.

Table 6-3 SAP HANA T-shirt sizes and their relation to the IBM custom models

SAP T-shirt size	XS	S	S+	M and M+	L
Compressed data in memory	64 GB	128 GB	128 GB	256 GB	512 GB
Server main memory	128 GB	256 GB	256 GB	512 GB	1024 GB
Number of CPUs	2	2	2	4	8
Mapping to building blocks[a]	7147-HAx or 7147-H1x	7147-HBx or 7147-H3x or 7147-H2x	7143-HAx or 7143-H1x	7143-HBx or 7143-H2x	Combine 7143-HBx or 7143-H2x with 7143-HCx or 7143-H3x)

a. For a region-specific equivalent, see 6.3.1, “IBM System x workload-optimized models for SAP HANA” on page 104.

6.3.3 Scale-up

This section talks about upgradability, or scale-up, and shows how IBM custom models for SAP HANA can be upgraded to accommodate the need to grow into bigger T-shirt sizes.

To accommodate growth, the IBM Systems Solution for SAP HANA can be scaled in these ways:

- Scale-up approach: Increase the capabilities of a single system by adding more components.
- Scale-out approach: Increase the capabilities of the solution by using multiple systems working together in a cluster.

We discuss the scale-out approach in 6.4, “Scale-out solution for SAP HANA” on page 110.

The building blocks of the IBM Systems Solution for SAP HANA, as described previously, were designed with extensibility in mind. The following upgrade options exist:

- An XS building block can be upgraded to be an S-size SAP HANA system by adding 128 GB of main memory to the system.
- An S+ building block can be upgraded to be an M-Size SAP HANA system by adding two more CPUs, which is another 256 GB of main memory. For the 7143-H1x, another 320 GB High IOPS adapter needs to be added to the system, the newer 7143-HAx has the required flash capacity already included.
- An M building block (7143-H2x or 7143-HBx) can be extended with the L option (7143-H3x or 7143-HCx) to resemble an L-Size SAP HANA System. The 2011 models can be combined with the 2012 models, for example, the older 7143-H2x can be extended with the new 7143-HCx.
- With the option to upgrade S+ to M, and M to L, IBM can provide an unmatched upgrade path from a T-shirt size S up to a T-shirt size L, without the need to retire a single piece of hardware.

Of course, upgrading server hardware requires system downtime. However, due to GPFS’s capability to add storage capacity to an existing GPFS file system by just adding devices, data residing on the system remains intact. We nevertheless recommend that you do a backup of the data before changing the system’s configuration.

6.4 Scale-out solution for SAP HANA

Up to now we talked about single-server solutions. Although the scale-up approach gives flexibility to expand the capabilities of an SAP HANA installation, there might be cases where the required data volumes exceed the capabilities of a single server. To meet such requirements, the IBM Systems Solution for SAP HANA supports a scale-out approach (that is, combining a number of systems into a clustered solution, which represents a single SAP HANA instance). A SAP HANA system can span multiple servers, partitioning the data, to be able to hold and process larger amounts of data than a single server can accommodate.

To illustrate this scale-out solution, the following figures show a schematic depiction of such an installation. Figure 6-10 shows a single-node SAP HANA system.

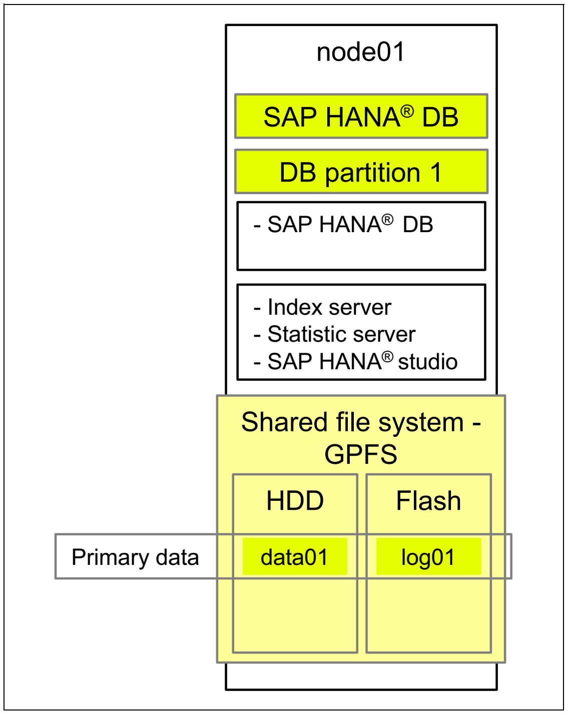

Figure 6-10 Single-node SAP HANA system

This single-node solution has these components:

- The SAP HANA software (SAP HANA database with index server and statistic server)
- The shared file system (GPFS) on the two types of storage:
  - The data storage (on SAS disks), here referred to as *HDD*, which holds the savepoints
  - The log storage (on SSD drives or PCIe Flash devices), here referred to as *Flash*, which holds the database logs

This single node represents one single SAP HANA database consisting of one single database partition. Both the savepoints (data01) and the logs (log01) are stored once (that is, they are not replicated), denoted as being *primary data* in Figure 6-10.

6.4.1 Scale-out solution without high-availability capabilities

The first step towards a scale-out solution was to introduce a clustered solution without failover or high-availability (HA) capabilities. IBM was the first hardware partner to validate a scale-out solution for SAP HANA. SAP validated this solution for clusters of up to four nodes, using S or M building blocks in a homogeneous cluster (that is, no mixing of S and M building blocks).

This scale-out solution differs from a single server solution in a number of ways:

- The solution consists of a homogeneous cluster of building blocks, interconnected with two separate 10 Gb Ethernet networks (not shown in Figure 6-11 on page 113), one for the SAP HANA application and one for the GPFS file system communication.
- The SAP HANA database is split into partitions, forming a single instance of the SAP HANA database.
- Each node of the cluster holds its own savepoints and database logs on the local storage devices of the server.
- The GPFS file system spans all nodes of the cluster, making the data of each node available to all other nodes of the cluster.

Figure 6-11 on page 113 illustrates this solution, showing a 3-node configuration as an example.

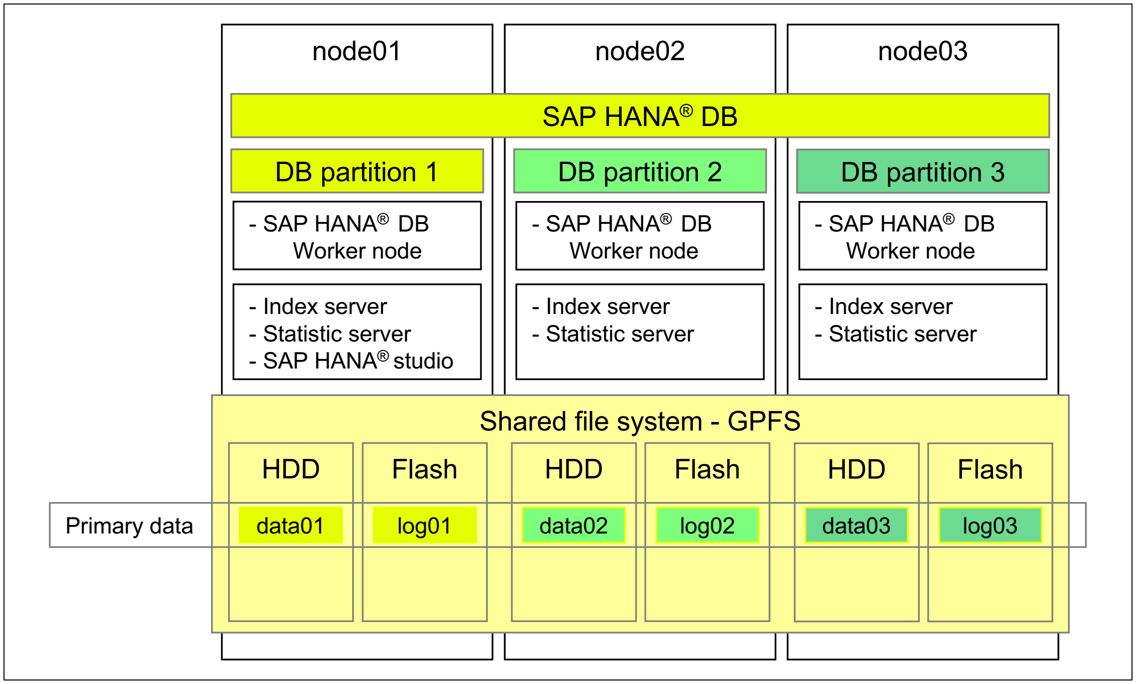

Figure 6-11 A 3-node clustered solution without failover capabilities

To an outside application connecting to the SAP HANA database, this looks like a single instance of SAP HANA. The SAP HANA software distributes the requests internally across the cluster to the individual worker nodes, which process the data and exchange intermediate results, which are then combined and sent back to the requestor. Each node maintains its own set of data, persisting it with savepoints and logging data changes to the database log.

GPFS combines the storage devices of the individual nodes into one big file system, making sure that the SAP HANA software has access to all data regardless of its location in the cluster, while making sure that savepoints and database logs of an individual database partition are stored on the appropriate storage device of the node on which the partition is located. While GPFS provides the SAP HANA software with the functionality of a shared storage system, it ensures maximum performance and minimum latency by using locally attached disks and flash devices. In addition, because server-local storage devices are used, the total capacity and performance of the storage within the cluster automatically increases with the addition of nodes, maintaining the same per-node performance characteristics regardless of the size of the cluster. This kind of scalability is not achievable with external storage systems.

The absence of fail-over capabilities represents a major disadvantage of this solution. The cluster acts as a single-node configuration. In case one node becomes unavailable for any reason, the database partition on that node becomes unavailable, and with it the entire SAP HANA database. Loss of the storage of a node means data loss (as with a single-server solution), and the data has to be recovered from a backup. For this reason, this scale-out solution without failover capabilities is an intermediate solution that will go away after all of the SAP hardware partners can provide a solution featuring high-availability capabilities. The IBM version of such a solution is described in the next section.

6.4.2 Scale-out solution with high-availability capabilities

The scale-out solution for SAP HANA with high-availability capabilities enhances the exemplary four-node scale-out solution described in the previous section in two major fields:

- Making the SAP HANA application highly available by introducing standby nodes, which can take over from a failed node within the cluster
- Making the data provided through GPFS highly available to the SAP HANA application, even in the event of the loss of one node, including its data on the local storage devices

SAP HANA allows the addition of nodes in the role of a standby node. These nodes run the SAP HANA application, but do not hold any data or take an active part in the processing. In case one of the active nodes fails, a standby node takes over the role of the failed node, including the data (that is, the database partition) of the failed node. This mechanism allows the clustered SAP HANA database to continue operation.

Figure 6-12 illustrates a four-node cluster with the fourth node being a standby node.

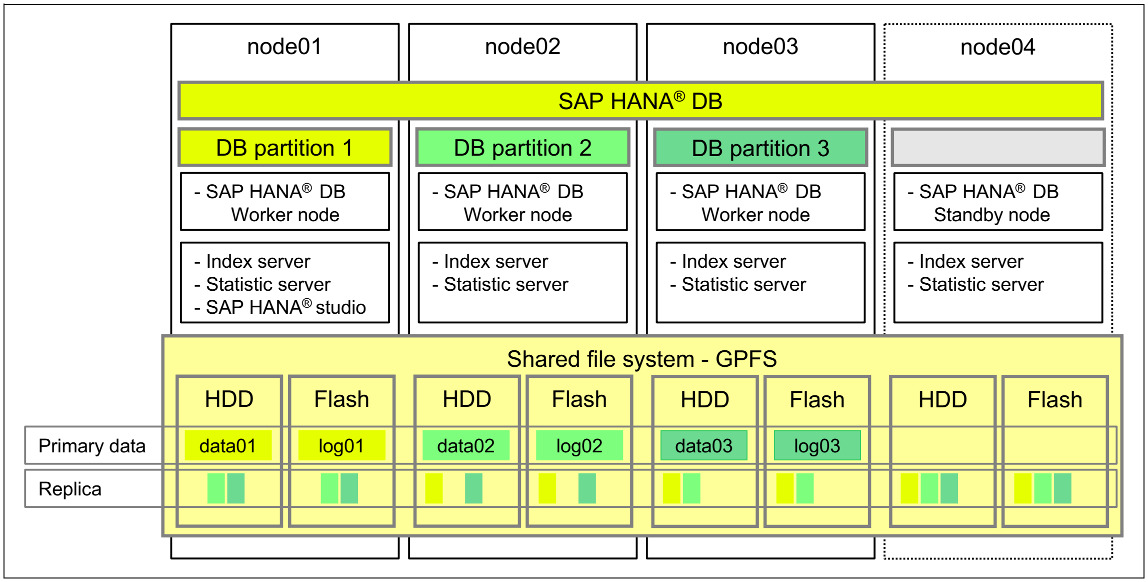

Figure 6-12 A 4-node clustered solution with failover capabilities

To be able to take over the database partition from the failed node, the standby node has to load the savepoints and database logs of the failed node to recover the database partition and resume operation in place of the failed node. This is possible because GPFS provides a global file system across the entire cluster, giving each individual node access to all the data stored on the storage devices managed by GPFS.

In case a node has an unrecoverable hardware error, the storage devices holding the node's data might become unavailable or even destroyed. In contrast to the solution without high-availability capabilities, here the GPFS file system replicates the data of each node to the other nodes, to prevent data loss in case one of the nodes goes down. Replication is done in a striping fashion. That is, every node has a piece of data of all other nodes. In the example illustrated in Figure 6-12, the contents of the data storage (that is, the savepoints, here data01) and the log storage (that is, the database logs, here log01) of node01 are replicated to node02, node03, and node04, each holding a part of the data on the matching device (that is, data on HDD, log on flash). The same is true for all nodes carrying data, so that all information is available twice within the GPFS file system, which makes it tolerant to the loss of a single node. The replication occurs synchronously. That is, the write operation only finishes when the data is both written locally and replicated. This ensures consistency of the data at any point in time. Although GPFS replication is done over the network and in a synchronous fashion. This solution still over achieves the performance requirements for validation by SAP.

Using replication, GPFS provides the SAP HANA software with the functionality and fault tolerance of a shared storage system while maintaining its performance characteristics. Again, due to the fact that server-local storage devices are used, the total capacity and performance of the storage within the cluster automatically increases with the addition of nodes, maintaining the same per-node performance characteristics regardless of the size of the cluster. This kind of scalability is not achievable with external storage systems.

Example of a node takeover

To further illustrate the capabilities of this solution, this section provides a node takeover example. In this example, we have a 4-node setup, initially configured as illustrated in Figure 6-12 on page 115, with three active nodes and one standby node.

First, node03 experiences a problem and fails unrecoverably. The master node (node01) recognizes this and directs the standby node, node04, to take over from the failed node. Remember that the standby node is running the SAP HANA application and is part of the cluster, but in an inactive role.

To recreate database partition 3 in memory to be able to take over the role of node03 within the cluster, node04 reads the savepoints and database logs of node03 from the GPFS file system, reconstructs the savepoint data in memory, and re-applies the logs so that the partition data in memory is exactly like it was before node03 failed. Node04 is in operation, and the database cluster has recovered.

Figure 6-13 illustrates this scenario.

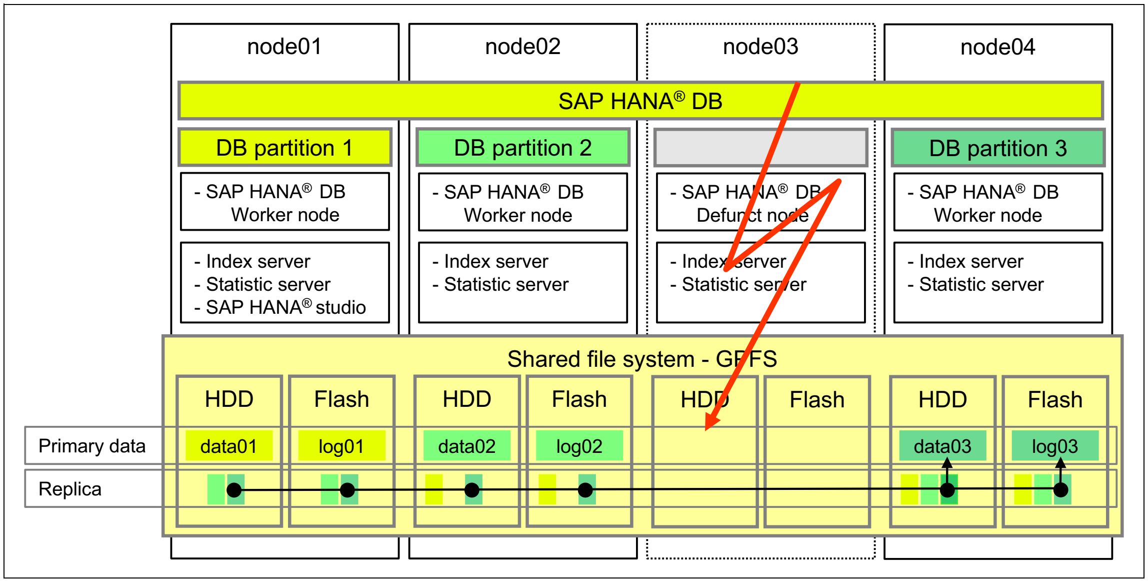

Figure 6-13 Standby node 4 takes over from failed node 3

The data that node04 was reading was the data of node03, which failed, including the local storage devices. For that reason GPFS had to deliver the data to node04 from the replica spread across the cluster using the network. Now when node04 starts writing savepoints and database logs again during the normal course of operations, these are not written over the network, but to the local drives, again with a replica striped across the cluster.

After fixing the cause for the failure of node03, it can be reintegrated into the cluster as the new standby system (Figure 6-14 on page 118).

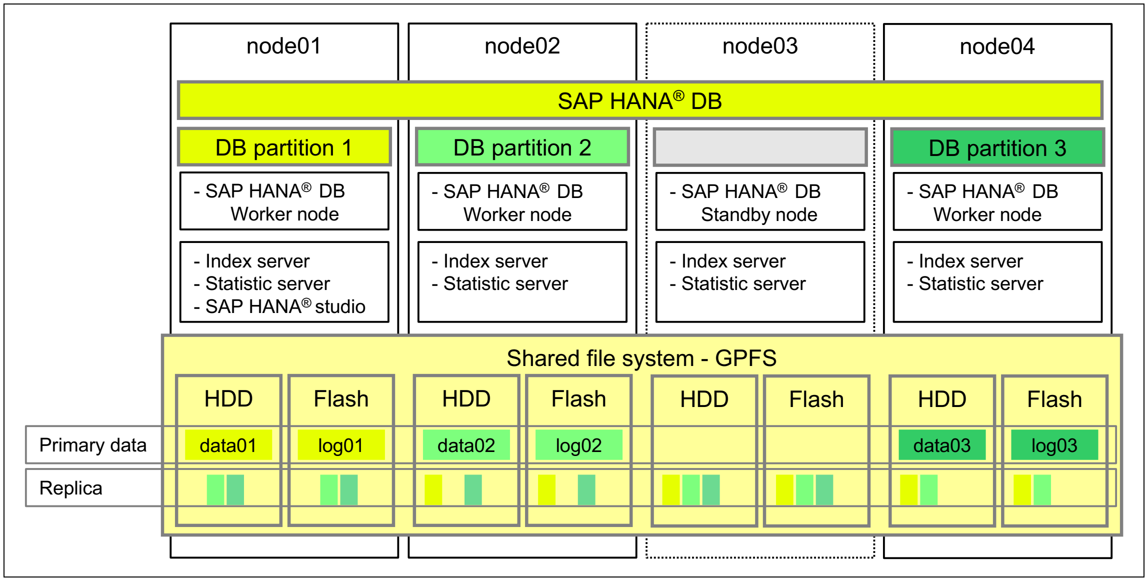

Figure 6-14 Node 3 is reintegrated into the cluster as a standby node

This example illustrates how IBM combines two independently operating high-availability measures (that is, the concept of standby nodes on the SAP HANA application level and the reliability features of GPFS on the infrastructure level), resulting in a highly available and scalable solution.

At the time of writing, clusters of up to 16 nodes using S building blocks (7143-HBx only), SSD building blocks, M building blocks or L configurations (M building block extended by L option) are validated by SAP. This means that the cluster has a total main memory of up to 16 TB or up to 8TB of compressed data. Depending on compression factor, this accommodates up to 56 TB of source data[2].

Note: SAP validated this scale-out solution (with HA), which is documented in the SAP product availability matrix, with up to 16 nodes in a cluster. However, the building block approach of IBM makes the solution scalable without any known limitation. For those customers who need a scaleout configuration beyond the 16 TB offered today, IBM offers a joint validation at the customer site working closely with SAP.

[2] Uncompressed source data, compression factor of 7:1

6.4.3 Networking architecture for the scale-out solution

Networking plays an integral role in the scale-out solution. The standard building blocks are used for scale-out, interconnected by 10 Gb Ethernet, in a redundant fashion. There are two redundant 10 Gb Ethernet networks for the communication within the solution:

- A fully redundant 10 Gb Ethernet network for cluster-internal communication of the SAP HANA software
- A fully redundant 10 Gb Ethernet network for cluster-internal communication of GPFS, including replication

These networks are internal to the scale-out solution and have no connection to the customer network. The networking switches for these networks are part of the appliance and cannot be substituted with other than the validated switch models.

Figure 6-15 illustrates the networking architecture for the scale-out solution and shows the SAP HANA scale-out solution connected to an SAP NetWeaver BW system as an example.

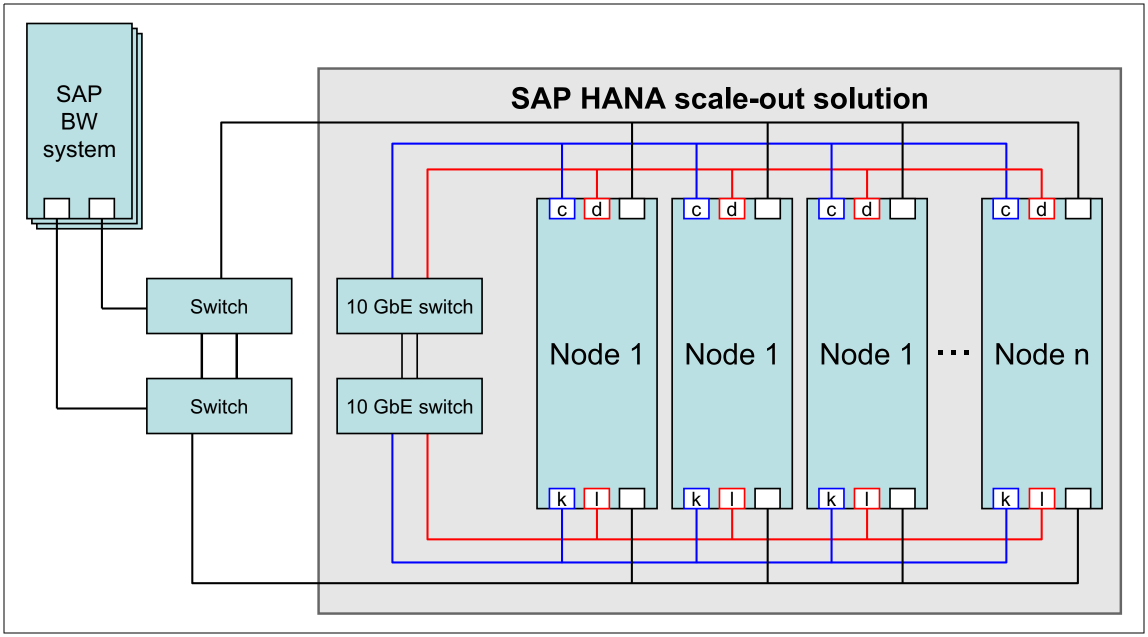

Figure 6-15 Networking architecture for the scale-out solution

All network connections within the scale-out solution are fully redundant. Both the internal GPFS network and the internal SAP HANA network are connected to two 10 Gb Ethernet switches, interconnected for full redundancy. The switch model used here is the IBM System Networking RackSwitch™ G8264. It delivers exceptional performance, being both lossless and low latency. With 1.2 Tbps throughput, the G8264 provides massive scalability and low latency that is ideal for latency-sensitive applications, such as SAP HANA. The scale-out solution for SAP HANA makes intensive use of the advanced capabilities of this switch, such as virtual link aggregation groups (vLAG).

Figure 6-16 shows the back of an M building block (here: 7143-H2x) with the network interfaces available. The letters denoting the interfaces correspond to the letters used in Figure 6-15 on page 119.

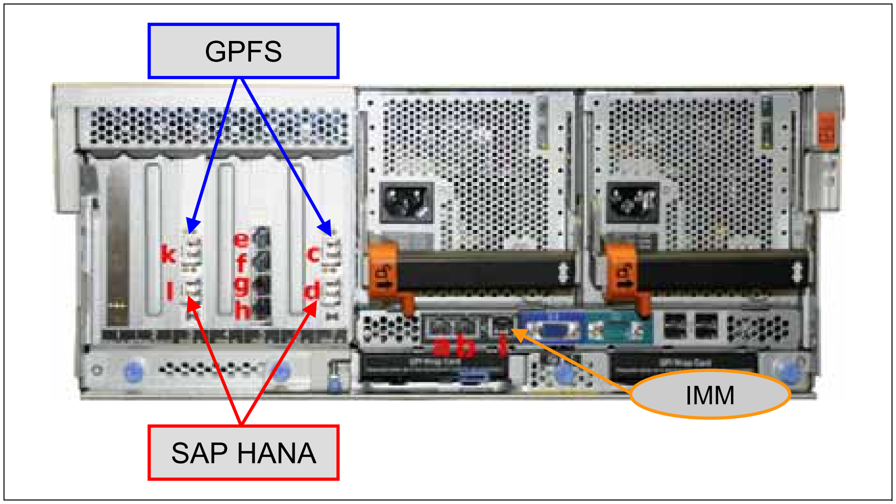

Figure 6-16 The back of an M building block with the network interfaces available

Each building block comes with one (2011 models) or two (2012 models) dual-port 10 Gb Ethernet interface cards (NIC). To provide enough ports for a fully redundant network connection to the 10 Gb Ethernet switches, an additional dual-port 10 Gb Ethernet NIC can be added to the system (see also section 6.4.4, “Hardware and software additions required for scale-out” on page 121).

An exception to this is an L configuration, where each of the two chassis (the M building block and the L option) hold one or two dual-port 10 Gb Ethernet NICs. Therefore an L configuration does not need an additional 10 Gb Ethernet NIC for the internal networks, even for the 2011 models.

The six available 1 Gb Ethernet interfaces available (a.b.e.f.g.h) on the system can be used to connect the systems to other networks or systems, for example, for client access, application management, systems management, data management, and so on. The interface denoted with the letter i is used to connect the integrated management module (IMM) of the server to the management network.

6.4.4 Hardware and software additions required for scale-out

The scale-out solution for the IBM Systems Solution for SAP HANA builds upon the same building blocks as they are used in a single-server installation. There are however additional hardware and software components needed, to complement the basic building blocks when implementing a scale-out solution.

Depending on the building blocks used, additional GPFS licenses might be needed for the scale-out solution. The GPFS on x86 Single Server for Integrated Offerings, V3 provides file system capabilities for *single-node* integrated offerings. This kind of GPFS license does not cover the use in *multi-node* environments, such as the scale-out solution discussed here. To use building blocks that come with the GPFS on x86 Single Server for Integrated Offerings licenses, for a scale-out solution, GPFS on x86 Server licenses have to be obtained for these building blocks. Section “GPFS license information” on page 160 has an overview about which type of license comes with a specific model, and the amount of Processor Value Units (PVU) needed. Alternatively, GPFS File Placement Optimizer licenses can be used in conjunction with GPFS on x86 Server licenses. In a scale-out configuration, a minimum of three nodes have to use GPFS on x86 Server licenses, and the remaining nodes can use GPFS File Placement Optimizer licenses. Other set ups, such as the disaster recovery solution described in section 7.2, “Disaster Recovery for SAP HANA” on page 137, might require more nodes using GPFS on x86 Server licenses, depending on the role of the nodes in the actual setup. Section “GPFS license information” on page 160 has an overview on the GPFS license types, which type of license comes with a specific model, and the amount of Processor Value Units (PVU) needed.

As we discussed in section 6.4.3, “Networking architecture for the scale-out solution” on page 119, additional 10 Gb Ethernet network interface cards have to be added to the building blocks in some configurations, to provide redundant network connectivity for the internal networks, and possibly also for the connection to the customer network, in case a 10 Gb Ethernet connection to the other systems (for example, replication server, SAP application servers) is required. Information about supported network interface cards for this purpose is provided in the Quick Start Guide.

For a scale-out solution built upon the SSD-only building blocks based on x3690 X5, additional 200 GB 1.8 MLC SSD drives are required to be able to accommodate the additional storage capacity required for GPFS replication. The total number of SSD drives required is documented in the SAP Product Availability Matrix (PAM) for SAP HANA available online at (search for “HANA”):

http://service.sap.com/pam

6.5 Installation services

The IBM Systems Solution for SAP HANA comes with the complete software stack, including the operating system, GPFS, and the SAP HANA software. Due to the nature of the software stack, and dependencies on how the IBM Systems solution for SAP HANA is used at the customer location, the software stack cannot be preloaded completely at manufacturing. Therefore installation services are required. Installation services for the IBM Systems Solution for SAP HANA typically include:

- Performing an inventory and validating of the delivered system configuration
- Verifying / updating the hardware to the latest level of BIOS, firmware, device drivers, OS patches as required
- Verifying / configuring the RAID configuration
- Finishing the software preload according to the customer environment
- Configuring / verifying network settings and operation
- Performing system validation
- Providing onsite skills transfer (when required) on the solution and best practices and delivering post install documentation

To ensure the correct operation of the appliance, installation services for the IBM Systems Solution for SAP HANA have to be performed by specifically trained personnel, available from IBM STG Lab Services, IBM Global Technology Services, or IBM business partners, depending on the geography.

6.6 Interoperability with other platforms

To access the SAP HANA database from a system (SAP or non-SAP), the SAP HANA database client has to be available for the platform the system is running on. Platform availability of the SAP HANA database client is documented in the product availability matrix (PAM) for SAP HANA, which is available online at (search for “HANA”):

http://service.sap.com/pam

At the time of writing, the SAP HANA database client is available on all major platforms, including but not limited to:

- Microsoft Windows Server 2008 ´
- Microsoft Windows XP (32 bit), Windows Vista, Windows 7 (both 32 bit and 64 bit)
- SUSE Linux Enterprise Server 11 on 32 and 64 bit x86 platforms, IBM System z®,
- RedHat Enterprise Linux on 64 bit x86 platforms
- IBM AIX 5.2, 5.3, 6.1 and 7.1 on the IBM POWER® platform
- IBM i V7R1 on the IBM POWER platform
- HP-UX 11.31 on Itanium
- Oracle Solaris on x86 and SPARC

For up-to-date and detailed availability information, refer to the PAM.

If there is no SAP HANA database client available for a certain platform, SAP HANA can still be used in a scenario with replication, by using a dedicated SAP Landscape Transformation server (for SAP Business Suite sources) or an SAP BusinessObjects Data Services server running on a platform for which the SAP HANA database client is available. This way data can be replicated into SAP HANA, which then can be used for reporting or analytic purposes, using a front end supporting SAP HANA as a data source.

6.7 Support process

The deployment of SAP HANA as an integrated solution, combining software and hardware from both IBM and SAP, also reflects in the support process for the IBM Systems Solution for SAP HANA.

All SAP HANA models offered by IBM include SLES for SAP Applications with SUSE 3-year priority support and IBM GPFS with 3-year support. The hardware comes with a 3-year limited warranty[3], including customer replaceable unit (CRU) and on-site support[4].

6.7.1 IBM SAP integrated support

SAP integrates the support process with SUSE and IBM as part of the HANA appliance solution-level support. If you encounter software problems on your

[3] For information about the IBM Statement of Limited Warranty, see http://www.ibm.com/servers/support/machine_warranties/

[4] IBM sends a technician after attempting to diagnose and resolve the problem remotely.

SAP HANA system, access the SAP Online Service System (SAP OSS) website at:

https://service.sap.com

When you reach the website, create a service request ticket using a subcomponent of BC-HAN or BC-DB-HDB as the problem component. IBM support works closely with SAP and SUSE and is dedicated to supporting SAP HANA software and hardware issues.

Send all questions and requests for support to SAP using their OSS messaging system. A dedicated IBM representative is available at SAP to work on this solution. Even if it is clearly a hardware problem, an SAP OSS message should be opened to provide the best direct support for the IBM Systems solution for SAP HANA.

When opening an SAP support message, we recommend using the text template provided in the Quick Start Guide, when it is obvious that you have a hardware problem. This procedure expedites all hardware-related problems within the SAP support organization. Otherwise, the SAP Support Teams will gladly help you with the questions regarding the SAP HANA appliance in general.

Before you contact support, make sure that you have taken these steps to try to solve the problem yourself:

- Check all cables to make sure that they are connected.
- Check the power switches to make sure that the system and any optional devices are turned on.
- Use the troubleshooting information in your system documentation, and use the diagnostic tools that come with your system. Information about diagnostic tools is available in the *Problem Determination and Service Guide* on the IBM Documentation CD that comes with your system.
- Go to the following IBM support website to check for technical information, hints, tips, and new device drivers or to submit a request for information:

  http://www.ibm.com/supportportal/
- For SAP HANA software-related issues you can search the SAP Online Service System (OSS) website for problem resolutions. The OSS website has a knowledge database of known issues and can be accessed here:

  https://service.sap.com/notes

The main SAP HANA information source is available here:

https://help.sap.com/hana_appliance

If you have a specific operating system question or issue, contact SUSE regarding SUSE Linux Enterprise Server for SAP Applications. Go to the SUSE website:

http://www.suse.com/products/prioritysupportsap/

Media is available for download here:

http://download.novell.com/index.jsp?search=Search&families=2658&keywords=SAP

> **Note:** Registration is required before you can download software packages from the SUSE website.

6.7.2 The IBM SAP International Competence Center InfoService

The IBM SAP International Competence Center (ISICC) InfoService is the key support function of the IBM and SAP Alliance. It serves as a single point of entry for all SAP-related questions for customers using IBM Systems and Solutions with SAP applications. As a managed question and answer service it has access to a worldwide network of experts on technology topics about IBM products in SAP environments. You can contact the ISICC InfoService using email at infoservice@de.ibm.com.

> **Note:** The ISICC InfoService does not provide product support. If you need product support for the IBM Systems solution for SAP HANA, refer to section 6.7.1, “IBM SAP integrated support” on page 123. If you need support for other IBM products, consult the product documentation on how to get product support.

6.8 IBM Systems Solution with SAP Discovery System

The SAP Discovery system is a preconfigured hardware and software landscape that can be used to test drive SAP technologies. It is an evaluation tool that provides an opportunity to realize the joint value of the SAP business process platform and SAP BusinessObjects tools running on a single system. It provides a complete, fully documented system with standard SAP software components for developing and delivering service-based applications, including all the interfaces, functionality, data, and guidance necessary to run a complete, end-to-end business scenario.

The SAP Discovery system allows you to interact with SAP’s most current technologies: Mobility (Sybase Unwired Platform, Afaria), SAP HANA, SAP

CRM, SAP ERP EhP5, SAP NetWeaver 7.3, SAP BusinessObjects and more along with the IBM robust DB2 database. The SAP business process platform, which is a part of the SAP Discovery system, helps organizations discover ways to accelerate business innovation and respond to changing business needs by designing reusable process components that make use of enterprise services. The SAP BusinessObjects portfolio of tools and applications on the SAP Discovery system were designed to help optimize information discovery and delivery, information management and query, reporting, and analysis. For business users, the SAP Discovery system helps bridge the gap between business and IT and serves as a platform for future upgrade planning and functional trial and gap analysis.

The SAP Discovery system includes sample business scenarios and demonstrations that are preconfigured and ready to run. It is a preconfigured environment with prepared demos and populated with Best Practices data. A list of detailed components, exercises, and SAP Best Practices configuration is available online at:

http://www.sdn.sap.com/irj/sdn/discoverysystem

The IBM Systems Solution with SAP Discovery system uses the IBM System x3650 M4 server to provide a robust, compact and cost-effective hardware platform for the SAP Discovery System, using VMware ESXi software with Microsoft Windows and SUSE Linux operating systems. IBM System x3650 M4 servers offer an energy-smart, affordable, and easy-to-use rack solution for data center environments looking to significantly lower operational and solution costs. Figure 6-17 shows the IBM Systems solution with SAP Discovery system.

Figure 6-17 The IBM Systems solution with SAP Discovery System

With an embedded VMware hypervisor, x3650 M4 provides a virtualized environment for the SAP software, consolidating a wealth of applications onto a single 2U server. The IBM Systems solution with SAP Discovery system is also configured with eight hard drives (including one recovery drive) to create a compact, integrated system.

The combination of the IBM Systems solution for SAP HANA and the IBM Systems solution with SAP Discovery System is the ideal platform to explore, develop, test, and demonstrate the capabilities of an SAP landscape including SAP HANA. Figure 6-18 illustrates this.

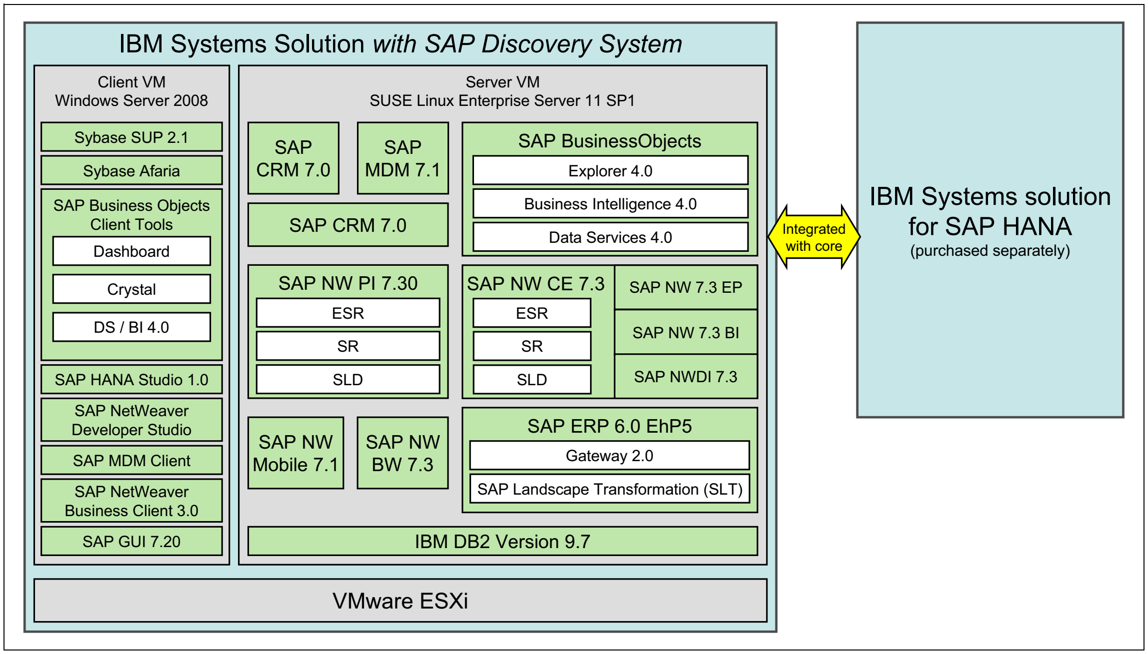

Figure 6-18 IBM Systems solution with SAP Discovery System combined with SAP HANA

Whether you plan to integrate new SAP products into your infrastructure or are preparing for an upgrade, the IBM Systems solution with SAP Discovery system can help you thoroughly evaluate SAP applications and validate their benefits. You gain hands-on experience, the opportunity to develop a proof of concept, and the perfect tool for training your personnel in advance of deploying a production system. The combination of the IBM Systems solution with SAP Discovery system with one of the SAP HANA models based on IBM System x3690 X5 gives you a complete SAP environment including SAP HANA in a compact 4U package.

More information about the IBM Systems solution with SAP Discovery System is available online at:

http://www.ibm.com/sap/discoverysystem

7

SAP HANA operations

This chapter discusses the operational aspects of running an SAP HANA system.

The following topics are covered:

7.1 Backing up and restoring data for SAP HANA

Because SAP HANA usually plays a critical role in the overall landscape, it is critical to back up the data in the SAP HANA database and be able to restore it. This section gives a short overview about the basics of backup and recovery for SAP HANA and the integration of SAP HANA and IBM Tivoli® Storage Manager for ERP.

7.1.1 Basic Backup and Recovery

Simply saving away the savepoints and the database logs is technically impossible in a consistent way, and thus does not constitute a consistent backup that can be recovered from. Therefore a simple file-based backup of the persistency layer of SAP HANA is not sufficient.

Backing up

A backup of the SAP HANA database has to be triggered through the SAP HANA Studio or alternatively through the SAP HANA SQL interface. SAP HANA will then create a consistent backup, consisting of one file per cluster node. Simply saving away the savepoints and the database logs does not constitute a consistent backup that can be recovered from. SAP HANA always performs a full backup. Incremental backups are currently not supported by SAP HANA.

SAP HANA internally maintains transaction numbers, which are unique within a database instance, also and especially in a scale-out configuration. To be able to create a consistent backup across a scale-out configuration, SAP HANA chooses a specific transaction number, and all nodes of the database instance write their own backup files including all transactions up to this transaction number.

The backup files are saved to a defined staging area that might be on the internal disks, an external disk on an NFS share, or a directly attached SAN subsystem. In addition to the data backup files, the configuration files and backup catalog files have to be saved to be recovered. For point in time recovery, the log area also has to be backed up.

With the IBM Systems solution for SAP HANA, one of the 1 Gbit network interfaces of the server can be used for NFS connectivity, alternatively an additional 10Gbit Network interface (if PCI slot available). It is also supported to add a fibre channel HBA for SAN connectivity. The Quick Start Guide for the IBM Systems solution for SAP HANA lists supported hardware additions to provide additional connectivity.

Restoring a backup

It might be necessary to recover the SAP HANA database from a backup in the following situations:

- The data area is damaged

  If the data area is unusable, the SAP HANA database can be recovered up to the latest committed transaction, if all the data changes after the last complete data backup are still available in the log backups and log area. After the data and log backups have been restored, the SAP HANA databases uses the data and log backups and the log entries in the log area to restore the data and replay the logs, to recover. It is also possible to recover the database using an older data backup and log backups, as long as all relevant log backups made after the data backup are available[1]. More information: SAP Note 1705945 (Determining the files needed for a recovery)

- The log area is damaged.

  If the log area is unusable, the only possibility to recover is to replay the log backups. In consequence, any transactions committed after the most recent log backup are lost, and all transactions that were open during the log backup are rolled back.

  After restoring the data and log backups, the log entries from the log backups are automatically replayed in order to recover. It is also possible to recover the database to a specific point in time, as long as it is within the existing log backups.

- The database needs to be reset to an earlier point in time because of a logical error.

  To reset the database to a specific point in time, a data backup from before the point in time to recover to and the subsequent log backups must be restored. During recovery the log area might be used as well, depending on the point in time the database is reset to. All changes made after the recovery time are (intentionally) lost.

- You want to create a copy of the database.

  It can be desirable to create a copy of the database for various purposes, such as creating a test system.

A database recovery is initiated from the SAP HANA studio.

A backup can only be restored to an identical SAP HANA system, with regard to the number of nodes, node memory size, host names and SID. Changing of host names and SID during recovery is however enabled since SAP HANA 1.0 SPS04.

[1] See SAP Note 1705945 for help with determining the files needed for a recovery.

When restoring a backup image from a single node configuration into a scale-out configuration, SAP HANA does not repartition the data automatically. The correct way to bring a backup of a single-node SAP HANA installation to a scale-out solution is as follows:

1. Backup the data from the stand-alone node.
2. Install SAP HANA on the master node.
3. Restore the backup into the master node.
4. Install SAP HANA on the slave and standby nodes as appropriate, and add these nodes to the SAP HANA cluster.
5. Repartition the data across all worker nodes.

More detailed information about the backup and recovery processes for the SAP HANA database is provided in the SAP HANA Backup and Recovery Guide, available online at:

http://help.sap.com/hana_appliance

Backup tool integration

There is currently no backup tool integration with SAP HANA. In the future, SAP will provide an interface that can be used by manufacturers of external backup tools to back up the data and redo logs of an SAP HANA system[2].

There is however a possibility to integrate a backup tool with SAP HANA, by allowing it to trigger an application level backup using SQL and then save away the backup files. Section 7.1.2, "IBM Tivoli Storage Manager for ERP" on page 132 describes such an integration of IBM Tivoli Storage Manager for ERP with SAP HANA.

7.1.2 IBM Tivoli Storage Manager for ERP

IBM Tivoli Storage Manager for ERP is a simple, scalable data protection solution for SAP HANA and SAP ERP. Tivoli Storage Manager (TSM) for ERP V6.4 includes a one-step command that automates SAP HANA backup and TSM data protection.

TSM customers running SAP HANA appliances can backup their instances using their existing TSM backup environment. Until a standardized backup interface is available for SAP HANA, TSM customers running SAP HANA appliances need a solution to move their file-based backups to TSM. TSM for ERP – Data Protection for SAP HANA v6.4 provides such backup and restore functionality for SAP HANA.

[2] See SAP Note 1730932 - "Using backup tools with Backint" for more details.

Setting up Data Protection for SAP HANA

The Data Protection for SAP HANA comes with a “setup.sh” command, which is a configuration tool to prepare the TSM for ERP configuration file, create the SAP HANA backup user and set all necessary environment variables for the SAP HANA administration user. The “setup.sh” command guides through the configuration process. Data Protection for SAP HANA stores a backup user and its password in the SAP HANA keystore called 'hdbuserstore', to enable unattended operation of a backup.

Backing up the SAP HANA database with TSM

SAP HANA writes its backup (logs and data) to files at pre-configured directories. The Data Protection for SAP HANA command “backup.sh” reads the configuration files to retrieve these directories (if not default configuration). On backup execution the files created in these directories are moved to the running TSM instance and are deleted afterwards from these directories (except for the HANA configuration files).

Figure 7-1 illustrates this backup process.

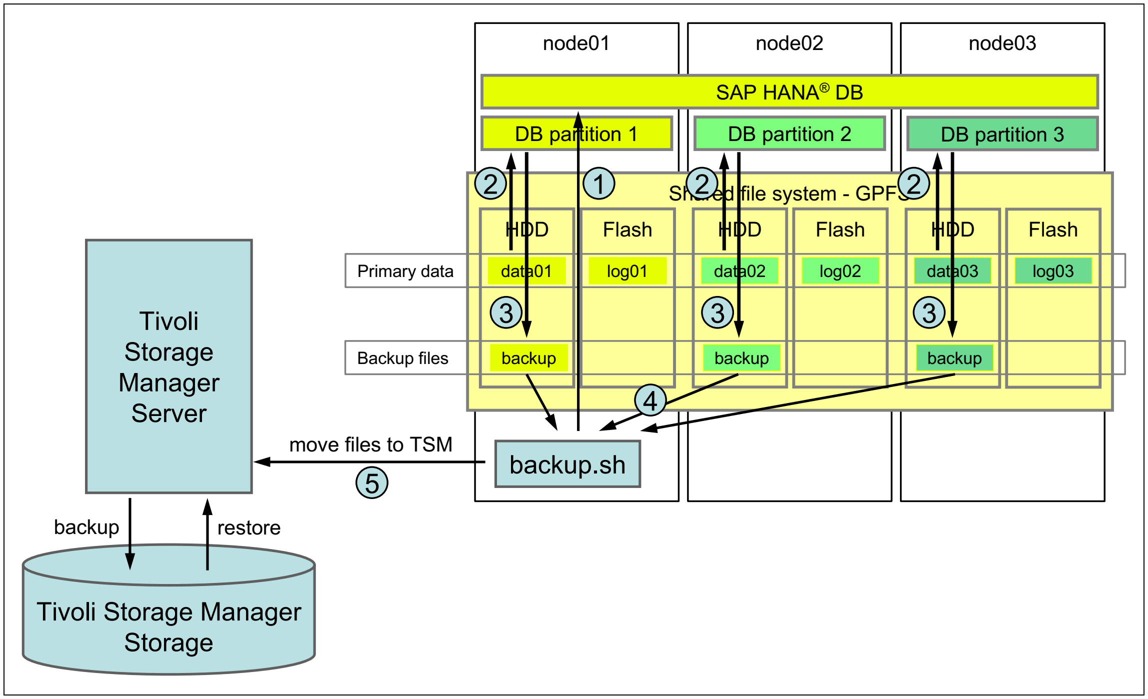

Figure 7-1 Backup process with Data Protection for SAP HANA, using local storage for backup files

The backup process follows these steps:

1. The backup.sh command triggers a log or data backup of the SAP HANA database.
2. The SAP HANA database performs a synchronized backup on all nodes.
3. The SAP HANA database writes a backup file on each node.
4. The backup.sh command collects the filenames of the backup files.
5. The backup files are moved to TSM (and deleted on the nodes).

Instead of having the backup files of the individual nodes written to the local storage of the nodes, and external storage system can be used to provide space to store the backup files. All nodes need to be able to access this storage, for example, using NFS. Figure 7-2 illustrates this.

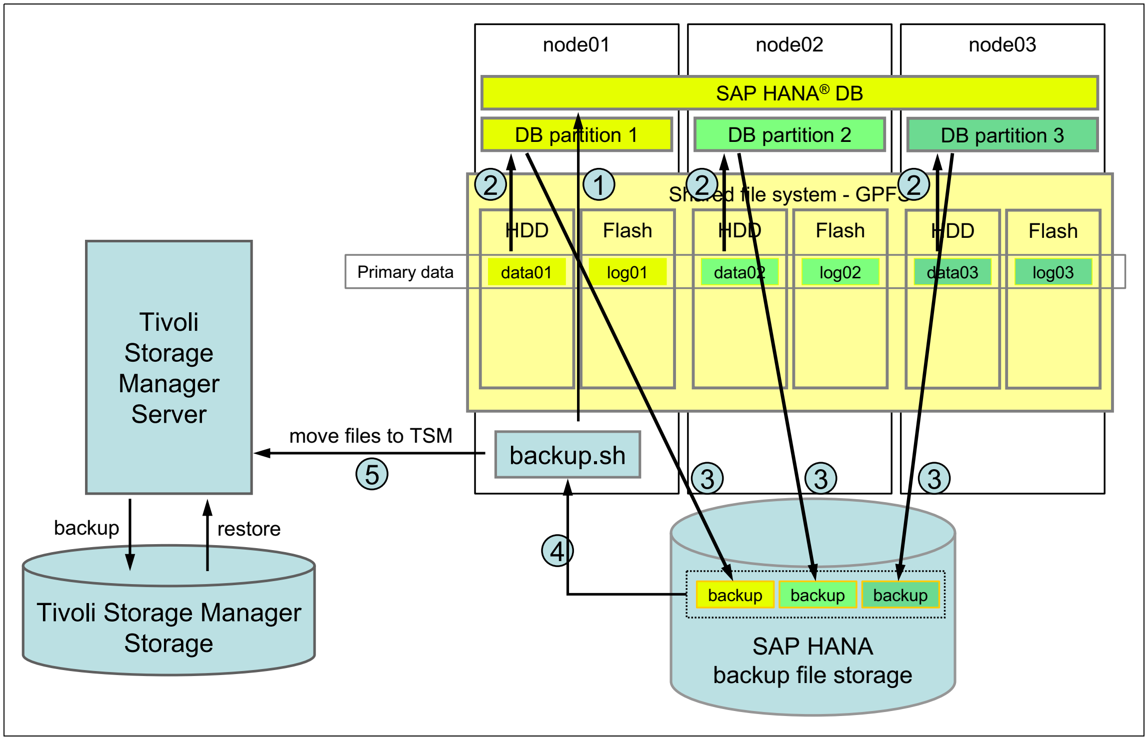

Figure 7-2 Backup process with Data Protection for SAP HANA, using external storage for backup files

Running log and data backups requires the DP for SAP HANA “backup.sh” command to be executed as the SAP HANA administration user (“<sid>adm”).

The “backup.sh” command provides two basic functions:

1. Complete the data-backup (including HANA instance and landscape configuration files).
2. Complete log-backup and remove successfully saved redo log files from disk.

The functions can be selected using command line arguments to be able to schedule the backup script with a given parameter:

`backup.sh --data` Performs complete data and configuration file backup

`backup.sh --logs` Performs complete log backup followed by a “LOG RECLAIM”

By using this command, a backup of the SAP HANA database into TSM can be fully automated.

Restoring the SAP HANA database from TSM

The SAP HANA database requires the backup files to be restored to start a recovery process using the SAP HANA studio. For SAP HANA database revisions 30 and higher, Data Protection for SAP HANA provides a “restore.sh” command that moves all required files back to file system location automatically, so that the user is not required to search these files manually. For earlier revisions of the SAP HANA database, this has to be done manually using the TSM BACKUP-Filemanager. The SAP HANA database expects the backup files to be restored to same directory as they were written during backup. The recovery itself can then be triggered using the SAP HANA Studio.

To restore data backups, including SAP HANA configuration files and logfile backups, TSM's BACKUP-Filemanager is used. Figure 7-3 shows a sample panel of the BACKUP-Filemanager.

```
                    BACKUP-Filemanager V6.4.0.0, Copyright IBM 2001-2012
.------------------+-------------------------------------------------------------.
|   Backup ID's    | Files stored under TSM___A0H7K1C4QI                          |
|------------------+-------------------------------------------------------------|
| TSM___A0H7KM0XF4 | */hana/log_backup/log_backup_2_0_1083027170688_1083043933760 |
| TSM___A0H7KLYP3Z | */hana/log_backup/log_backup_2_0_1083043933760_1083060697664 |
| TSM___A0H7KHNLU6 | */hana/log_backup/log_backup_2_0_1083060697664_1083077461376 |
| TSM___A0H7KE6V19 | */hana/log_backup/log_backup_2_0_1083077461376_1083094223936 |
| TSM___A0H7K9KR7F | */hana/log_backup/log_backup_2_0_1083094223936_1083110986880 |
| TSM___A0H7K7L73W | */hana/log_backup/log_backup_2_0_1083110986880_1083127750848 |
| TSM___A0H7K720A4 | */hana/log_backup/log_backup_2_0_1083127750848_1083144513792 |
| TSM___A0H7K4BDXV | */hana/log_backup/log_backup_2_0_1083144513792_1083161277760 |
| TSM___A0H7K472YC | */hana/log_backup/log_backup_2_0_1083161277760_1083178040064 |
| TSM___A0H7K466HK | */hana/log_backup/log_backup_2_0_1083178040064_1083194806336 |
| TSM___A0H7K1C4QI | */hana/log_backup/log_backup_2_0_1083194806336_1083211570688 |
| TSM___A0H7JX1S77 | */hana/log_backup/log_backup_2_0_1083211570688_1083228345728 |
| TSM___A0H7JSRG2B | */hana/log_backup/log_backup_2_0_1083228345728_1083245109824 |
| TSM___A0H7JOH1ZP | */hana/log_backup/log_backup_2_0_1083245109824_1083261872960 |
| TSM___A0H7JK6ONC | */hana/log_backup/log_backup_2_0_1083261872960_1083278636608 |
| TSM___A0H7JJWUI8 | */hana/log_backup/log_backup_2_0_1083278636608_1083295400384 |
| TSM___A0H7JJU5YN | */hana/log_backup/log_backup_2_0_1083295400384_1083312166016 |
| TSM___A0H7JFWAV4 | */hana/log_backup/log_backup_2_0_1083312166016_1083328934016 |
| TSM___A0H7JBG625 | */hana/log_backup/log_backup_2_0_1083328934016_1083345705856 |
| TSM___A0H7JBAASN | */hana/log_backup/log_backup_2_0_1083345705856_1083362476352 |
| TSM___A0H7J7BLDK | */hana/log_backup/log_backup_2_0_1083362476352_1083379244416 |
| TSM___A0H7J5U8S7 | */hana/log_backup/log_backup_2_0_1083379244416_1083396008064 |
| TSM___A0H7J5T92O | */hana/log_backup/log_backup_2_0_1083396008064_1083412772928 |
| TSM___A0H7J4TWPG | */hana/log_backup/log_backup_2_0_1083412772928_1083429538688 |
|                  | */hana/log_backup/log_backup_2_0_1083429538688_1083446303424 |
|                  | */hana/log_backup/log_backup_2_0_1083446303424_1083463079488 |
|                  | */hana/log_backup/log_backup_2_0_1083463079488_1083479846528  V
|------------------+-------------------------------------------------------------|
|  24 BID's        | 190 File(s) - 190 marked                                     |
`------------------+-------------------------------------------------------------'
TAB change windows   F2 Restore   F3 Mark all       F4 Unmark allF5 reFresh
F6 fileInfo          F7 redireCt  F8 Delete         F10 eXit     ENTER mark file
```

Figure 7-3 The BACKUP-Filemanager interface

Desired data and log backups can be selected and then restored to the desired location. If no directory is specified for the restore, the BACKUP-Filemanager restores the backups to the original location from which the backup was done.

After the backup files have been restored, the recovery process has to be started using SAP HANA Studio. More information about this process and the various options for a recovery is contained in the SAP HANA Backup and Recovery Guide, available online at:

http://help.sap.com/hana_appliance

After completing the recovery process successfully and the backup files are no longer needed, they must be removed from disk manually.

7.2 Disaster Recovery for SAP HANA

When talking about Disaster Recovery it is important to understand the difference between Disaster Recovery and High Availability. High Availability is covering a hardware failure (e.g. one node becomes unavailable due to a faulty CPU, memory DIMM, storage or network failure) in a scale out configuration. This has been covered in section 6.4.2, "Scale-out solution with high-availability capabilities" on page 114.

Disaster Recovery (DR) covers the event, when multiple nodes in a scale-out configuration fail, or a whole data center goes down due to a fire, flood, or other disaster, and a secondary site needs to take over the SAP HANA system. The ability to recover from a disaster, or to "tolerate" a disaster without major impact, is sometimes also referred to as Disaster Tolerance (DT).

When running an SAP HANA side-car scenario (e.g. SAP CO-PA Accelerator, sales planning, smart metering) the data will still be available in the source SAP Business Suite system. Planning or analytical tasks will run significantly slower without the SAP HANA system being available, but no data is lost. More important is the situation if SAP HANA is the primary database, like when using Business Warehouse with SAP HANA as the database. In this case the productive data is solely available within the SAP HANA database, and according to the business service level agreements, prevention for a failure is absolutely necessary.

A disaster recovery solution for SAP HANA can be based on two different levels:

- On the application level, by shipping database logs from the primary site to the secondary site. At the time of writing this feature is not supported by the SAP HANA database.
- On the infrastructure level:
  - Using backups replicated or otherwise shipped from the primary site to the secondary site, and used for a restore in case of a disaster.

– By replicating the data written to disks by SAP HANA's persistency layer, either synchronously or asynchronously, allowing to restart and recovering the SAP HANA database on the secondary site in the event the primary site becomes unavailable.

Which kind of disaster recovery solution to implement depends on the Recovery Time Objective (RTO) and the Recovery Point Objective (RPO). The RTO describes how quickly the SAP HANA database has to be back available after a disaster. The RPO describes the point in time to which data has to be restored after a disaster, for example, how old the most recent backup is.

7.2.1 Using backup and restore as a disaster recovery solution

Using backup and restore as a disaster recovery solution is a basic way of providing disaster recovery. Depending on the RPO it might however be a viable way to achieve disaster recovery. The basic concept is to backup the data on the primary site regularly (at least daily) to a defined staging area that might be an external disk on an NFS share or a directly attached SAN subsystem (does not need to be dedicated to SAP HANA). After the backup is done, it has to be transferred to the secondary site, for example, by a simple file transfer (can be automated) or by using replication functionality of the storage system used to hold the backup files.

As described in "Restoring a backup" on page 131, a backup can only be restored to an identical SAP HANA system, therefore an SAP HANA system has to exist on the secondary side which is identical to the one on the primary site, at minimum with regard to the number of nodes and node memory size. During normal operations this system can run other non-productive SAP HANA instances, for example a Quality Assurance (QA), Development (DEV), Test, or other second tier systems. In case the primary site goes down, the system needs to be cleared from these second tier HANA systems (a fresh install of the SAP HANA software is recommended) and the backup can be restored. Upon configuring the application systems to use the secondary site instead of the primary one, operation can be resumed. The SAP HANA database will recover from the latest backup in case of a disaster.

Figure 7-4 illustrates the concept of using backup and restore as a basic disaster recovery solution.

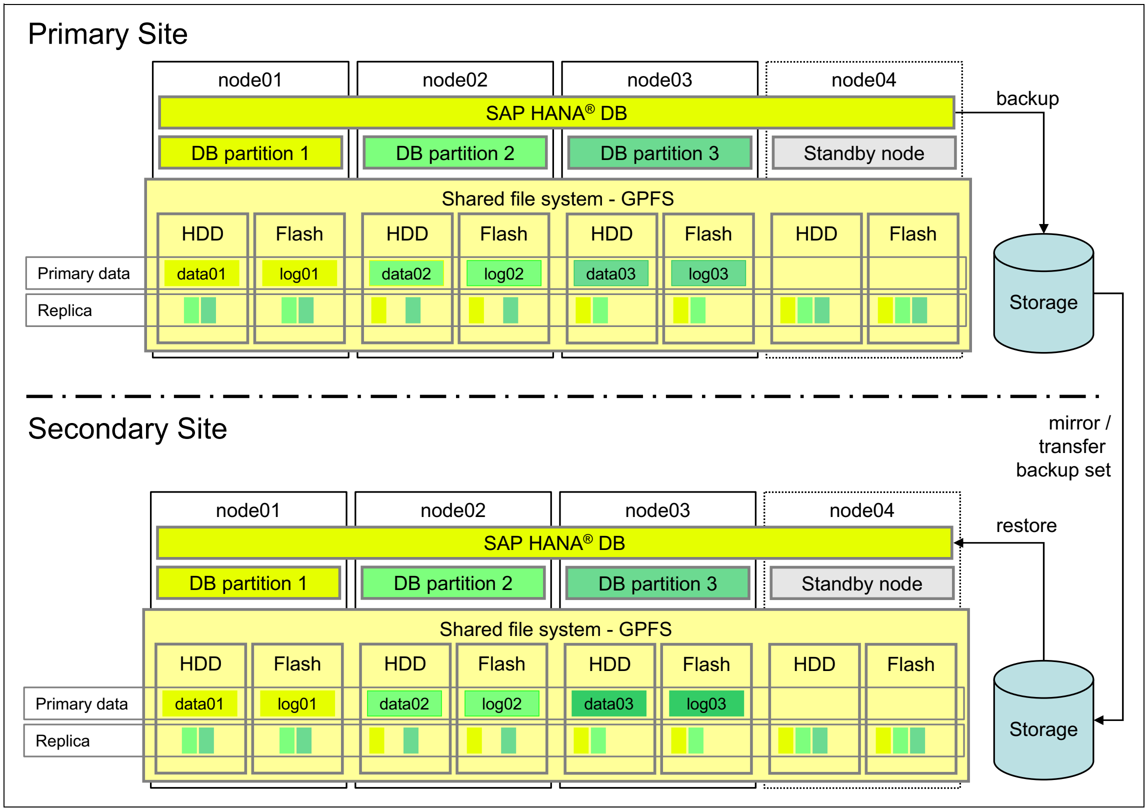

Figure 7-4 Using backup and restore as a basic disaster recovery solution

7.2.2 Disaster recovery by using replication

The replication based disaster recovery solution for the IBM Systems solution for SAP HANA is based on the same architecture as the scale-out solution. Using GPFS functionality a secondary (and tertiary) site is added to the solution to achieve disaster recovery. Maintaining the same setup and administration concept as with a single-site configuration, a migration from a single-site setup to a multiple site setup is seamless. The following sections give an overview on a multi-site disaster recovery solution leveraging GPFS replication.

Overview

For a Disaster Recovery setup it is necessary to have identical scale-out configurations on both the primary and the secondary site. In addition there needs to be a third site which has the sole responsibility to act as a quorum site. In the configuration described here, the distance between the primary and secondary data centers has to be within a range to allow for synchronous replication with limited impact to the overall application performance (also referred to as metro-mirror distance).

The major difference between a single site (as described in 6.4.2, “Scale-out solution with high-availability capabilities” on page 114) and a multi-site solution is the placement of the replicas within GPFS. Whereas in a single-site configuration there is only one replica[3] of each data block in one cluster, a multi-site solution will hold an additional replica in the remote or secondary site. This ensures that, when the primary site fails, a complete copy of the data is available in the second site and operation can be resumed on this site.

A two-site solution implements the concept of a synchronous data replication on file system level between both sites, leveraging the replication capabilities of GPFS. Synchronous data replication means that any write request issued by the application is only committed to the application after it has been successfully written on both sides. In order to maintain the application performance within reasonable limits the network latency (and therefore the distance) between the sites has to be limited to metro-mirror distances. The maximum achievable distance depends on the performance requirements of the SAP HANA system and of the network configuration in the customer environment.

Basic setup

During normal operation there is an active SAP HANA instance running. The SAP HANA instance on the secondary site is not active. The implementation on each site is identical to a standard scale-out cluster with high availability as described in section 6.4.2, “Scale-out solution with high-availability capabilities”

[3] In addition to the primary data. In GPFS terminology, these are already two replicas, that is the primary data and the first copy. To avoid confusion, we do not count the primary data as a replica.

on page 114. It therefore has to include standby servers for high availability. A server failure is being handled completely within on site and does not enforce a site failover. Figure 7-5 illustrates this setup.

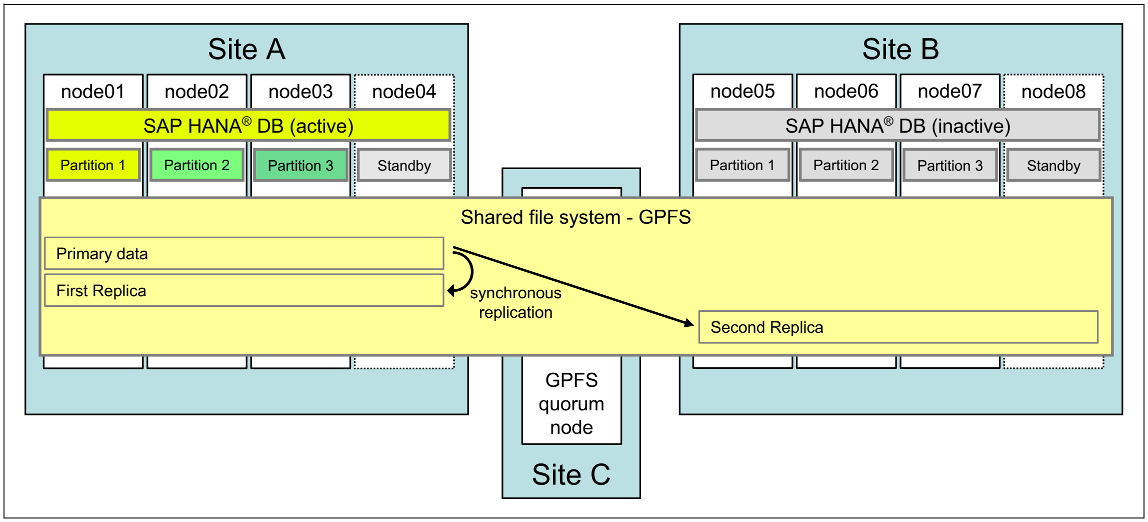

Figure 7-5 Basic setup of the disaster recovery solution using GPFS synchronous replication

The connection between the two main sites A and B depends on the customers network infrastructure. It is recommended to have a dual link dark fibre connection to allow for redundancy also in the network switch side on each site. For full redundancy an additional link pair is required for cross connection the switches. Within each site the 10 Gb Ethernet network connections for both the internal SAP HANA and the internal GPFS network are implemented in a redundant layout.

As with a standard scale-out implementation, the disaster recovery configuration relies on GPFS functionality to enable the synchronous data replication between sites. A single site solution holds one replica of each data block. This is being enhanced with a second replica in the dual site disaster recovery implementation. A stretched GPFS cluster is being implemented between the two sites. Figure 7-5 illustrates that there is a combined cluster on GPFS level between both sites, whereas the SAP HANA installations are independent of each other. GPFS file placement policies ensure that there is one replica on the primary site and a second replica on the secondary site. In case of a site failure the file system can therefore stay active with a complete data replica in the secondary site. The SAP HANA database can then be made operational through a manually procedure based on the persistency and log files available in the file system.

Site failover

During normal operation there is a running SAP HANA instance active on the primary site. The secondary site has an installed SAP HANA instance that is inactive. A failover to the remote SAP HANA installation has to be initiated manually. Depending on the reason for the site failover it can be decided if the secondary site becomes the production site or both sites stay offline until the reason for the failover is removed and the primary site becomes active again.

During normal operation the GPFS file system is not mounted on the secondary site, ensuring that there is not read nor write access to the file system. In case of a failover, first ensure that a second replica of data is available on the secondary site before the file system is mounted. This replication process is initiated manually, and as soon as it completes correctly, the file system is mounted. From there on the SAP HANA instance can be started and the data loaded into memory. The SAP HANA database is restored to the latest savepoint and the available logs are recovered.

Any switch from one site to the other incorporates a down time of SAP HANA operations, because the two independent instances on either site must not run at the same time, due to the sharing of the persistency and log files on the filesystem.

Summary

The disaster recovery solution for the IBM Systems solution for SAP HANA exploits the advanced replication features of GPFS, creating a cross-site cluster that ensures availability and consistency of data across two sites. It does not impose the need for additional storage systems, but completely builds upon the scale-out solution for SAP HANA. This simple architecture reduces the complexity in maintaining such a solution.

7.3 Monitoring SAP HANA

In a productive environment, administration and monitoring of an SAP HANA appliance play an important role.

7.3.1 Monitoring with SAP HANA Studio

The SAP tool for administration of and monitoring the SAP HANA appliance is the SAP HANA Studio. It allows you to monitor the overall system state:

- General system information (such as software versions).

- A warning section shows the latest warnings generated by the statistics server. Detailed information about these warnings is available as a tooltip.
- Bar views provide an overview of important system resources. The amount of available memory, CPUs, and storage space is displayed, in addition to the used amount of these resources.

In a distributed landscape the amount of available resources is aggregated over all servers.

> **Note:** More information about administration and monitoring of SAP HANA is available in the SAP HANA administration guide, accessible online:
>
> http://help.sap.com/hana_appliance

7.3.2 Monitoring SAP HANA with Tivoli

Most of the monitoring data visible in SAP HANA Studio is collected by the statistics server, which is a monitoring tool for the SAP HANA database. It collects statistical and performance information from the database using SQL statements.

Monitoring data provided by the statistics sever can be used by other monitoring tools also. Figure 7-6 shows an image of this data integrated into IBM Tivoli monitoring.

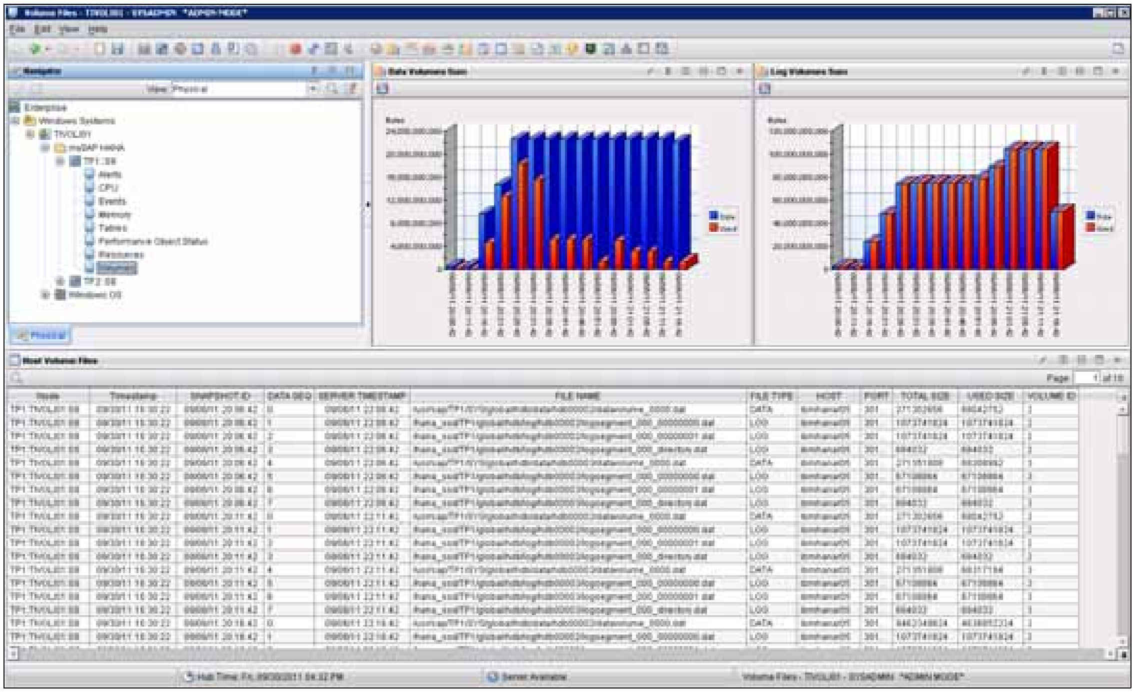

Figure 7-6 Monitoring the SAP HANA database with Tivoli

Tivoli monitoring also provides agents to monitor the operating system of the SAP HANA appliance. Hardware monitoring of the SAP HANA appliance servers can be achieved with IBM Systems Director, which also can be integrated into a Tivoli monitoring landscape.

By integrating the monitoring data collected by the statistics server, the Tivoli Monitoring agent for the operating system, and hardware information provided by IBM director, Tivoli Monitoring can provide a holistic view of the SAP HANA appliance.

7.4 Sharing an SAP HANA system

SAP HANA is a high performance appliance, prohibiting the use of any kind of virtualization concept. This can lead to many, many SAP HANA appliances in the datacenter, for example, production, disaster recovery, quality assurance (QA), test and sandbox systems, possibly for multiple application scenarios, regions or lines of business. Therefore the consolidation of SAP HANA instances, at least for non-production systems, seems desirable. There are however major drawbacks when consolidating multiple SAP HANA instances on one system[4]. Due to this it is generally not supported for production systems. For non-production systems the support status depends on the scenario:

Multiple Components on One System (MCOS)

Having multiple SAP HANA instances on one system, also referred to as MCOS (Multiple Components on One System) is not recommended because this poses conflicts between different SAP HANA databases on a single server, for example, common data and log volumes, possible performance degradations, interference of the systems against each other, and so on. SAP and IBM support this under certain conditions (see SAP Note 1681092), however, if issues arise, as part of the troubleshooting process, SAP or IBM may ask you to stop all but one of the instances to see if the issue persists.

Multiple Components on One Cluster ("MCOC")

Running multiple SAP HANA Instances on one scale-out cluster (for the sake of similarity to the other abbreviations we call this "MCOC") is supported as long as each node of the cluster runs only one SAP HANA instance. A development and a QA instance can run on one cluster, but with dedicated nodes for each of the two SAP HANA instances, for example, each of the nodes runs either the development instance, or the QA instance, but not both. Only the GPFS file system is shared across the cluster.

Multiple Components in One Database (MCOD)

Having one SAP HANA Instance containing multiple components, schemas or application scenarios - also referred to as Multiple Components in One Database (MCOD) - is supported. This means however to have all data within a single database which is also maintained as a single database, which can lead to limitations in operations, database maintenance, backup and recovery, and so on. For example, bringing down the SAP HANA database affects all of the scenarios. It is impossible to bring it down for only one scenario. SAP Note 1661202 documents the implications.

Things to consider when consolidating SAP HANA instances on one system are:

- An instance filling up the log volume causes all other instances on the system to stop working properly. This can be addressed by monitoring the system closely.

[4] One SAP HANA system, as referred to in this section, can consist of one single server or multiple servers in a clustered configuration.

- Installation of an additional instance might fail, when there are already other instances installed and active on the system. The installation procedures check the available space on the storage, and refuse to install when there is less free space than expected. This might also happen when trying to re-install an already installed instance.
- Installing a new SAP HANA revision for one instance might affect other instances already installed on the system. For example new library versions coming with the new install might break the already installed instances.
- The performance of the SAP HANA system becomes unpredictable because the individual instances on the system sharing resources like memory and CPU.

When asking for support for such a system, you might be asked to remove the additional instances and to recreate the issue on a single instance system.

7.5 Installing additional agents

Many organizations have processes and supporting software in place, to monitor, back up, or otherwise interact with their servers. As SAP HANA is delivered in an appliance-like model, there are restrictions with regards to additional software, for example, monitoring agents, to be installed onto the appliance.

Only the software installed by the hardware partner is recommended on the SAP HANA appliance. For the IBM Systems solution for SAP HANA, IBM defined three categories of agents:

Supported IBM provides a solution covering the respective area, no validation by SAP is required.

Tolerated Solutions provided by a third party that are allowed to be used on the IBM Workload Optimized Solution for SAP HANA. It is customers' responsibility to obtain support for such solutions. Such solutions are not validated by IBM and SAP. If issues with such solutions occur and cannot be resolved, the use of such solutions might be prohibited in the future.

Prohibited Solutions that must not be used on the IBM Systems solution for SAP HANA, using these solutions might compromise the performance, stability or data integrity of the SAP HANA appliance.

Do not install additional software on the SAP HANA appliance which is classified as prohibited for use on the SAP HANA appliance. As an example, initial tests show that some agents can decrease performance or even possibly corrupt the SAP HANA database (for example, virus scanners).

In general, all additionally installed software must be configured not to interfere with the functionality or performance of the SAP HANA appliance. If any issue of the SAP HANA appliance occurs, you might be asked by SAP to remove all additional software and to reproduce the issue.

The list of agents that are supported, tolerated, or prohibited for use on the SAP HANA appliance are published in the Quick Start Guide for the IBM Systems Solution for SAP HANA appliance, available online at:

http://www-947.ibm.com/support/entry/myportal/docdisplay?lndocid=MIGR-5087035

7.6 Software and firmware levels

The IBM Systems solution for SAP HANA appliance contains several different components that might at times be required to be upgraded (or downgraded) depending on different support organizations recommendations. These components can be split up into four general categories:

- Firmware
- Operating system
- Hardware drivers
- Software

The IBM System x SAP HANA support team, after informed, reserves the right to perform basic system tests on these levels when it is deemed to have a direct impact on the SAP HANA appliance. In general, IBM does not give specific recommendations to which levels are allowed for the SAP HANA appliance.

The IBM System x SAP HANA Development team provides at regular intervals new images for the SAP HANA appliance. Since these images have dependencies regarding hardware, operating system, and drivers use the latest image for maintenance and installation of SAP HANA systems. These images can be obtained through IBM support. Part number information is contained in the Quick Start Guide.

If the firmware level recommendations for the IBM components of the SAP HANA appliance are given through the individual IBM System x Support teams that fix known code bugs, it is the customer's responsibility to up-/downgrade to the recommended levels as instructed by IBM Support.

If the operating system recommendations for the SUSE Linux components of the SAP HANA appliance are given through the SAP, SUSE, or IBM Support teams that fix known code bugs, it is the customer's responsibility to up- or downgrade to the recommended levels, as instructed by SAP through an explicit SAP Note or allowed through a Customer OSS Message. SAP describes their operational concept, including updating of the operating system components in SAP Note 1599888 - SAP HANA: Operational Concept. If the Linux kernel is updated, take extra care to recompile the IBM High IOPS drivers and IBM GPFS software as well.

If an IBM High IOPS driver or IBM GPFS recommendation to update the software is given through the individual IBM Support teams (System x, Linux, GPFS) that fix known code bugs, it is *not* recommend to update these drivers without first asking the IBM System x SAP HANA support team through an SAP OSS Customer Message.

If the other hardware or software recommendations for IBM components of the SAP HANA appliance are given through the individual IBM Support teams that fix known code bugs, it is the customer's responsibility to up-/downgrade to the recommended levels as instructed by IBM Support.

8

Summary

This chapter summarizes the benefits of in-memory computing and the advantages of IBM infrastructure for running the SAP HANA solution. We discuss the following topics:

8.1 Benefits of in-memory computing

In today's data-driven culture, tools for business analysis are quickly evolving. Organizations need new ways to take advantage of critical data dynamically to not only accelerate decision making, but also to gain insights into key trends. The ability to instantly explore, augment, and analyze all data in near real time can deliver the competitive edge that your organization needs to make better decisions faster and to leverage favorable market conditions, customer trends, price fluctuations, and other factors that directly influence the bottom line.

Made possible through recent technology advances that combine large, scalable memory, multi-core processing, fast solid-state storage, and data management, in-memory computing leverages these technology innovations to establish a continuous real-time link between insight, foresight, and action to deliver significantly accelerated business performance.

8.2 SAP HANA: An innovative analytic appliance

To support today's information-critical business environment, SAP HANA gives companies the ability to process huge amounts of data faster than ever before. The appliance lets business users instantly access, model, and analyze all of a company's transactional and analytical data from virtually any data source in real time, in a single environment, without impacting existing applications or systems.

The result is accelerated business intelligence (BI), reporting, and analysis capabilities with direct access to the in-memory data models residing in SAP in-memory database software. Advanced analytical workflows and planning functionality directly access operational data from SAP ERP or other sources. SAP HANA provides a high-speed data warehouse environment, with an SAP in-memory database serving as a next-generation, in-memory acceleration engine.

SAP HANA efficiently processes and analyzes massive amounts of data by packaging SAP's use of in-memory technology, columnar database design, data compression, and massive parallel processing together with essential tools and functionality such as data replication and analytic modeling.

Delivered as an optimized hardware appliance based on IBM eX5 enterprise servers, the SAP HANA software includes:

- High-performance SAP in-memory database and a powerful data calculation engine
- Real-time replication service to access and replicate data from SAP ERP

- Data repository to persist views of business information
- Highly tuned integration with SAP BusinessObjects BI solutions for insight and analytics
- SQL and MDX interfaces for third-party application access
- Unified information-modeling design environment
- SAP BusinessObjects Data services to provide access to virtually any SAP and non-SAP data source

To explore, model, and analyze data in real time without impacting existing applications or systems, SAP HANA can be leveraged as a high-performance "side-by-side" data mart to an existing data warehouse. It can also replace the database server for SAP NetWeaver Business Warehouse, adding in-memory acceleration features.

These components create an excellent environment for business analysis, letting organizations merge large volumes of SAP transactional and analytical information from across the enterprise, and instantly explore, augment, and analyze it in near-real time.

8.3 IBM Systems Solution for SAP HANA

The IBM Systems Solution for SAP HANA based on IBM eX5 enterprise servers provides the performance and scalability to run SAP HANA, enabling customers to drive near real-time business decisions and helping organizations stay competitive. IBM eX5 enterprise servers provide a proven, scalable platform for SAP HANA that enables better operational planning, simulation, and forecasting, in addition to optimized storage, search, and ad hoc analysis of today's information. SAP HANA running on powerful IBM eX5 enterprise servers combines the speed and efficiency of in-memory processing with the ability of IBM eX5 enterprise servers to analyze massive amounts of business data.

Based on scalable IBM eX5 technology included in IBM System x3690 X5 and System x3950 X5 servers, SAP HANA running on eX5 enterprise servers offers a solution that can help meet the need to analyze growing amounts of transactional data, delivering significant gains in both performance and scalability in a single, flexible appliance.

8.3.1 Workload Optimized Solution

IBM offers several Workload Optimized Solution models for SAP HANA. These models, based on the 2-socket x3690 X5 and 4-socket x3950 X5, are optimally designed and certified by SAP. They are delivered preconfigured with key software components preinstalled to help speed delivery and deployment of the solution. The x3690 X5-based configurations offer 128 - 256 GB of memory and the choice of only solid-state disk or a combination of spinning disk and solid-state disk. The x3950 X5-based configurations leverage the scalability of eX5 and offer the capability to pay as you grow, starting with a 2-processor, 256 GB configuration and growing to an 8-processor, 1 TB configuration. The x3950 X5-based configurations integrate High IOPS SSD PCIe adapters. The 8-socket configuration uses a scalability kit that combines the 7143-H2x or 7143-HBx with the 7143-H3x or 7143-HCx to create a single 8-socket, 1 TB system.

IBM offers the *appliance in a box* with no need for external storage. With the x3690 X5-based SSD only models, IBM has a unique offering with no spinning hard drives, providing greater reliability and performance.

8.3.2 Leading performance

IBM eX5 enterprise servers offer extreme memory and performance scalability. With improved hardware economics and new technology offerings, IBM is helping SAP realize a real-time enterprise with in-memory business applications. IBM eX5 enterprise servers deliver a long history of leading SAP benchmark performance.

IBM eX5 enterprise servers come equipped with the Intel Xeon processor E7 series. These processors deliver performance that is ideal for your most data-demanding SAP HANA workloads and offer improved scalability along with increased memory and I/O capacity, which is critical for SAP HANA. Advanced reliability and security features work to maintain data integrity, accelerate encrypted transactions, and maximize the availability of SAP HANA applications. In addition, Machine Check Architecture Recovery, a reliability, availability, and serviceability (RAS) feature built into the Intel Xeon processor E7 series, enables the hardware platform to generate machine check exceptions. In many cases, these notifications enable the system to take corrective action that allows the SAP HANA to keep running when an outage would otherwise occur.

IBM eX5 features, such as eXFlash solid-state disk technology, can yield significant performance improvements in storage access, helping deliver an optimized system solution for SAP HANA. Standard features in the solution, such as the High IOPS Adapters for IBM System x, can also provide fast access to storage.

8.3.3 IBM GPFS enhancing performance, scalability, and reliability

Explosions of data, transactions, and digitally aware devices are straining IT infrastructure and operations, while storage costs and user expectations are increasing. The IBM General Parallel File System (GPFS), with its high-performance enterprise file management, can help you move beyond simply adding storage to optimizing data management for SAP HANA. High-performance enterprise file management using GPFS gives SAP HANA applications these:

- Performance to satisfy the most demanding SAP HANA applications
- Seamless capacity expansion to handle the explosive growth of SAP HANA information
- Scalability to enable support for the largest SAP HANA database requirements
- High reliability and availability to help eliminate production outages and provide disruption-free maintenance and capacity upgrades

Seamless capacity and performance scaling, along with the proven reliability features and flexible architecture of GPFS, help your company foster innovation by simplifying your environment and streamlining data workflows for increased efficiency.

8.3.4 Scalability

IBM offers configurations allowing customers to start with a 2 CPU/256 GB RAM model (S+), which can scale up to a 4 CPU/512 GB RAM model (M), and then to an 8 CPU/1024 GB configuration (L). With the option to upgrade S+ to M, and M+ to L, IBM can provide an unmatched upgrade path from a T-shirt size S up to a T-shirt size L, without the need to retire a single piece of hardware.

If you have large database requirements, you can scale the workload-optimized solutions to multi-server configurations. IBM and SAP have validated configurations of up to sixteen nodes with high availability, each node holding either 256 GB, 512 GB or 1 TB of main memory. This scale-out support enables support for databases as large 16 TB, able to hold the equivalent of about 56 TB of uncompressed data. While the IBM solution is certified for up to 16 nodes, its architecture is designed for extreme scalability and can even grow beyond that. The IBM solution does not require external storage for the stand-alone or for the scale-out solution. The solution is easy to grow by the simple addition of nodes to the network. There is no need to reconfigure a storage area network for failover. That is all covered by GPFS under the hood.

IBM uses the same base building blocks from stand-alone servers to scale out, providing investment protection for customers who want to grow their SAP HANA solution beyond a single server.

IBM or IBM Business Partners can provide these scale-out configurations preassembled in a rack, helping to speed installation and setup of the SAP HANA appliance.

8.3.5 Services to speed deployment

To help speed deployment and simplify maintenance of your x3690 X5 and x3950 X5, the Workload Optimized Solution for SAP HANA, IBM Lab Services, and IBM Global Technology Services offer quick-start services to help set up and configure the appliance and health-check services to ensure that it continues to run optimally. In addition, IBM also offers skills and enablement services for administration and management of IBM eX5 enterprise servers.

8.4 Going beyond infrastructure

Many clients require more than software and hardware products. IBM as a globally integrated enterprise can provide clients real end-to-end offering ranging across hardware, software, infrastructure, and consulting services - all of them provided by single company and integrated together.

8.4.1 A trusted service partner

Clients need a partner to help them assess their current capabilities, identify areas for improvement, and develop a strategy for moving forward. This is where IBM Global Business Services provides immeasurable value with thousands of SAP consultants in 80 countries organized by industry sectors.

IBM Global Business Services worked together with IBM Research teams, IBM Software group and IBM Hardware teams to prepare an integrated offering focused on business analytical space and mobility. Among others this offering also covers all services around the SAP HANA appliance.

Through this offering IBM can help you to take full advantage of SAP HANA running on IBM eX5 enterprise servers.

Defining the strategy for business analytics

An important step before implementing the SAP HANA solution is the formulation of an overall strategy how this new technology can be leveraged to deliver business value and how it will be implemented in the existing customer landscape.

Customers are typically facing the following challenges where IBM Global Business Services offering can help:

- Mapping of existing paint-points to available offerings
- Designing a customer specific use case where no existing offering is available
- Creation of a business case for implementing SAP HANA technology
- Understanding long term technology trends and their influence on individual decisions
- Underestimating importance of high availability, disaster recovery and operational aspects of the SAP in-memory solution
- Avoiding delays caused by poor integration between hardware and implementation partners
- Alignment of already running projects to a newly developed in-memory strategy

IBM experts conduct a series of workshops with all important stakeholders including decision makers, key functional and technical leads and architects. As a result of these workshops, an SAP HANA implementation roadmap is defined.

The implementation roadmap is based on the existing customer landscape and on defined functional, technical, and business-related needs and requirements. It will reflect current analytic capabilities and current status of existing systems.

An SAP HANA implementation roadmap contains individual use cases about how SAP HANA can be best integrated into the customer landscape to deliver the desired functionality. Other technologies that can bring additional value are identified and the required architectural changes are documented.

For certain situations, a proof of concept might be recommended to validate that desired key performance indicators (KPIs) can be met including:

- Data compression rates
- Data load performance
- Data replication rates
- Backup/restore speed
- Front-end performance

After the SAP HANA implementation roadmap is accepted by the customer, IBM expert teams work with the customer to implement the roadmap.

Used implementation methods

Existing use case scenarios can be divided in two groups based on how SAP HANA is deployed:

- SAP HANA as a stand-alone component

  The technology platform, operational reporting and accelerator use case scenarios are describing the SAP HANA database as stand-alone component.

  IBM Global Business Services is offering services to implement the SAP HANA database using a combination of the IBM Lean implementation approach, ASAP 7.2 Business Add-on for SAP HANA methodology and agile development methodologies that are important for this type of projects.

  Used methodologies are keeping strict control upon following solution components:

  - Use case (overall approach how SAP HANA will be implemented)
  - Sources of data (source tables containing required information)
  - Data replication (replication methods for transferring data into SAP HANA)
  - Data models (transformation of source data into required format)
  - Reporting (front-end components like reports and dashboards)

  This approach has following implementation phases:

  - Project preparation
  - Project kick-off
  - Blueprint
  - Realization
  - Testing
  - Go-live preparation
  - Go-live

  This methodology is focused to help both IBM and customer to keep the defined and agreed scope under control and to help with issue classification and resolution management. It is also giving the required visibility about the current progress of development or testing to all involved stakeholders.

- SAP HANA as the underlying database for SAP Business Suite products

  A SAP NetWeaver BW system running on SAP HANA is currently the only released solution from this category. Offerings for other products are announced after they are released to run on SAP HANA database.

  IBM Global Business Services is using a facility called “IBM SAP HANA migration factory” designed specially for this purpose. Local experts who are directly working with the clients are cooperating with remote teams performing the required activities based on a defined conversion methodology agreed with SAP. This facility is having the required amount of trained experts covering all key positions needed for a smooth transition from a traditional database to SAP HANA.

The migration service related to conversion of existing SAP NetWeaver BW system to run on SAP HANA database has following phases:

- Initial assessment

  Local teams perform an initial assessment of the existing systems, their relations and technical status. Required steps are identified, and an implementation roadmap is developed and presented to the customer.

- Conversion preparation

  IBM remote teams perform all required preparations for the conversion. BW experts clean BW systems to remove unnecessary objects. If required, the system is cloned and upgraded to the required level.

- Migration to SAP HANA database

  In this phase, IBM remote teams perform the conversion to the SAP HANA database including all related activities. Existing InfoCubes and DataStore objects are converted to an in-memory optimized format. After successful testing the system is released back for customer usage.

8.4.2 IBM and SAP team for long-term business innovation

With a unique combination of expertise, experience, and proven methodologies — and a history of shared innovation — IBM can help strengthen and optimize your information infrastructure to support your SAP applications.

IBM and SAP have worked together for nearly 40 years to deliver innovation to their shared customers. Since 2006, IBM has been the market leader for implementing SAP's original in-memory appliance, the SAP NetWeaver Business Warehouse Accelerator. Hundreds of SAP NetWeaver BW Accelerator deployments have been successfully completed in multiple industries. These SAP NetWeaver BW Accelerator appliances have been successfully deployed on many of SAP's largest business warehouse implementations, which are based on IBM hardware and DB2, optimized for SAP.

IBM and SAP offer solutions that move business forward and anticipate organizational change by strengthening your business analytics information infrastructure for greater operational efficiency and offering a way to make smarter decisions faster.

A

Appendix

This appendix provides information about the GPFS license.

GPFS license information

The models of the IBM Systems Solution for SAP HANA come with GPFS licenses, including three years of Software Subscription and Support. Software Subscription and Support contracts, including Subscription and Support renewals, are managed through IBM Passport Advantage® or Passport Advantage Express.

There are currently four different types of GPFS licenses:

- The GPFS on x86 Single Server for Integrated Offerings provides file system capabilities for single-node integrated offerings. This kind of GPFS license does not cover the use in multi-node environments like the scale-out solution discussed here. In order to use building blocks that come with the GPFS on x86 Single Server for Integrated Offerings licenses, for a scale-out solution, GPFS on x86 Server licenses or GPFS File Placement Optimizer licenses have to be obtained for these building blocks.
- The GPFS Server license permits the licensed node to perform GPFS management functions such as cluster configuration manager, quorum node, manager node, and network shared disk (NSD) server. In addition, the GPFS Server license permits the licensed node to share GPFS data directly through any application, service, protocol or method, such as NFS (Network File System), CIFS (Common Internet File System), FTP (File Transfer Protocol), or HTTP (Hypertext Transfer Protocol).
- The GPFS File Placement Optimizer license permits the licensed node to perform NSD server functions for sharing GPFS data with other nodes that have a GPFS File Placement Optimizer or GPFS Server license. This license cannot be used to share data with nodes that have a GPFS Client license or non-GPFS nodes.
- The GPFS Client license permits exchange of data between nodes that locally mount the same file system (i.e. via a shared storage). No other export of the data is permitted. The GPFS Client may not be used for nodes to share GPFS data directly through any application, service, protocol or method, such as NFS, CIFS, FTP, or HTTP. For these functions, a GPFS Server license would be required. Due to the architecture of the IBM Systems solution for SAP HANA (not having a shared storage system) this type of license cannot be used for the IBM solution.

Table A-1 on page 161 lists the types of GPFS license and the processor value units (PVUs) included for each of the models.

Table A-1 GPFS licenses included in the custom models for SAP HANA

MTM	Type of GPFS license included	PVUs included
7147-H1x	GPFS on x86 Server	1400
7147-H2x	GPFS on x86 Server	1400
7147-H3x	GPFS on x86 Server	1400
7147-H7x	GPFS on x86 Server	1400
7147-H8x	GPFS on x86 Server	1400
7147-H9x	GPFS on x86 Server	1400
7147-HAx	GPFS on x86 Single Server for Integrated Offerings	1400
7147-HBx	GPFS on x86 Single Server for Integrated Offerings	1400
7143-H1x	GPFS on x86 Server	1400
7143-H2x	GPFS on x86 Server	4000
7143-H3x	GPFS on x86 Server	5600
7143-H4x	GPFS on x86 Server	1400
7143-H5x	GPFS on x86 Server	4000
7143-HAx	GPFS on x86 Single Server for Integrated Offerings	4000
7143-HBx	GPFS on x86 Single Server for Integrated Offerings	4000
7143-HCx	GPFS on x86 Single Server for Integrated Offerings	5600

Licenses for IBM GPFS on x86 Single Server for Integrated Offerings, V3 (referred to as “Integrated” in the table) cannot be ordered independent of the select hardware for which it is included. This type of license provides file system capabilities for single-node integrated offerings. Therefore the model 7143-HAx includes 4000 PVUs of GPFS on x86 Single Server for Integrated Offerings, V3 licenses, so that an upgrade to the 7143-HBx model does not require additional licenses. The PVU rating for the 7143-HAx model to consider when purchasing other GPFS license types is 1400 PVUs.

Clients with highly available, multi-node clustered scale-out configurations must purchase the GPFS on x86 Server and GPFS File Placement Optimizer product, as described in 6.4.4, “Hardware and software additions required for scale-out” on page 121.

Abbreviations and acronyms

ABAP	Advanced Business Application Programming
ACID	Atomicity, Consistency, Isolation, Durability
APO	Advanced Planner and Optimizer
BI	Business Intelligence
BICS	BI Consumer Services
BM	bridge module
BW	Business Warehouse
CD	compact disc
CPU	central processing unit
CRC	cyclic redundancy checking
CRM	Customer Relationship Management
CRU	customer replaceable unit
DB	database
DEV	development
DIMM	dual inline memory module
DSOs	DataStore Objects
DR	Disaster Recovery
DXC	Direct Extractor Connection
ECC	ERP Central Component
ECC	error checking and correcting
ERP	enterprise resource planning
ETL	Extract, Transform, and Load
FTSS	Field Technical Sales Support
GB	gigabyte
GBS	Global Business Services
GPFS	General Parallel File System
GTS	Global Technology Services
HA	high availability
HDD	hard disk drive
HPI	Hasso Plattner Institute
I/O	input/output
IBM	International Business Machines
ID	Identifier
IDs	identifiers
IMM	Integrated Management Module
IOPS	I/O operations per second
ISICC	IBM SAP International Competence Center
ITSO	International Technical Support Organization
JDBC	Java Database Connectivity
JRE	Java Runtime Environment
KPIs	key performance indicators
LM	landscape management
LUW	logical unit of work
MB	megabyte
MCA	Machine Check Architecture
MCOD	Multiple Components in One Database
MCOS	Multiple Components on One System
MDX	Multidimensional Expressions
NOS	Notes object services
NSD	network shared disk
NUMA	non-uniform memory access
ODBC	Open Database Connectivity
ODBO	OLE DB for OLAP
OLAP	online analytical processing
OLTP	online transaction processing
OS	operating system

OSS	Online Service System
PAM	Product Availability Matrix
PC	personal computer
PCI	Peripheral Component Interconnect
POC	proof of concept
PSA	Persistent Staging Area
PVU	processor value unit
PVUs	processor value units
QA	quality assurance
QPI	QuickPath Interconnect
RAID	Redundant Array of Independent Disks
RAM	random access memory
RAS	reliability, availability, and serviceability
RDS	Rapid Deployment Solution
RPM	revolutions per minute
RPO	Recovery Point Objective
RTO	Recovery Time Objective
SAN	storage area network
SAPS	SAP Application Benchmark Performance Standard
SAS	Serial Attached SCSI
SATA	Serial ATA
SCM	Supply Chain Management
SCM	software configuration management
SD	Sales and Distribution
SDRAM	synchronous dynamic random access memory
SLD	System Landscape Directory
SLES	SUSE Linux Enterprise Server
SLO	System Landscape Optimization
SMI	scalable memory interconnect
SQL	Structured Query Language
SSD	solid state drive
SSDs	solid state drives
STG	Systems & Technology Group
SUM	Software Update Manager
TB	terabyte
TCO	total cost of ownership
TCP/IP	Transmission Control Protocol/Internet Protocol
TDMS	Test Data Migration Server
TREX	Text Retrieval and Information Extraction
TSM	Tivoli Storage Manager
UEFI	Unified Extensible Firmware Interface

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

- *The Benefits of Running SAP Solutions on IBM eX5 Systems*, REDP-4234
- *IBM eX5 Portfolio Overview: IBM System x3850 X5, x3950 X5, x3690 X5, and BladeCenter HX5*, REDP-4650
- *Implementing the IBM General Parallel File System (GPFS) in a Cross Platform Environment*, SG24-7844

You can search for, view, download, or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

This publication is also relevant as a further information source:

- Prof. Hasso Plattner, Dr. Alexander Zeier, "In-Memory Data Management," Springer, 2011

Online resources

These websites are also relevant as further information sources:

- IBM Systems Solution for SAP HANA

  http://www.ibm.com/systems/x/solutions/sap/hana/
- IBM Systems and Services for SAP HANA

http://www.ibm-sap.com/hana

- IBM and SAP: Business Warehouse Accelerator

  http://www.ibm-sap.com/bwa

- SAP In-Memory Computing - SAP Help Portal

  http://help.sap.com/hana

Help from IBM

IBM Support and downloads

ibm.com/support

IBM Global Services

ibm.com/services

IBM Redbooks

In-memory Computing with SAP HANA on IBM eX5 Systems

(0.2"spine)
0.17"<->0.473"
90<->249 pages

In-memory Computing with SAP HANA on IBM eX5 Systems

IBM Systems Solution for SAP HANA

SAP HANA overview and use cases

Basic in-memory computing principles

This IBM Redbooks publication describes in-memory computing appliances from IBM and SAP that are based on IBM eX5 flagship systems and SAP HANA. We first discuss the history and basic principles of in-memory computing, then we describe the SAP HANA offering, its architecture, sizing methodology, licensing policy, and software components. We also review IBM eX5 hardware offerings from IBM. Then we describe the architecture and components of IBM Systems solution for SAP HANA and its delivery, operational, and support aspects. Finally, we discuss the advantages of using IBM infrastructure platforms for running the SAP HANA solution.

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