SAP HANA SPS 09 - What's New?

SAP HANA Multitenant Database Containers

(Delta from SPS 08 to SPS 09)

SAP HANA Product Management

November, 2014

Agenda

Background

- Multitenancy, Deployment options (prior to SPS09)

Basics

- SAP HANA multitenant database containers - first glimpse

Positioning

- Scope

Technology

- SAP multitenant database containers - deeper insight

Details

Summary

Background

Multitenancy - Introduction

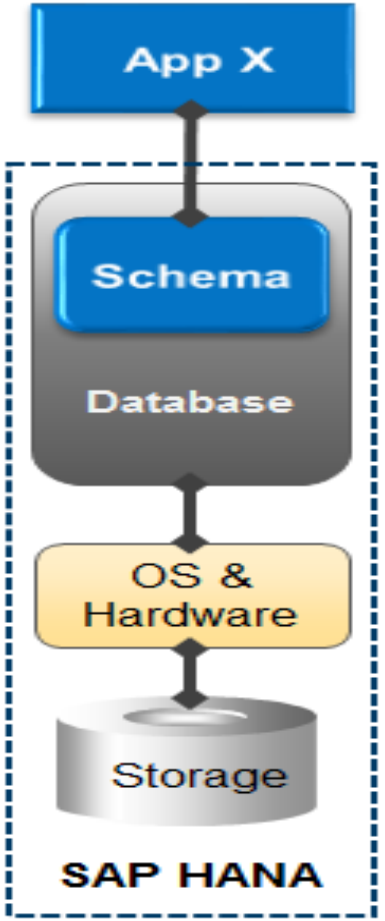
SAP HANA multitenant database containers establishes a foundation for providing *multitenancy* in SAP HANA

Multitenancy refers to a principle in software architecture where a single instance of the software runs on a server, serving multiple tenants. A tenant is a group of users sharing the same view on a software they use. With a multitenant architecture, a software application is designed to provide every tenant a dedicated share of the instance including its data, configuration, user management, tenant individual functionality and non-functional properties. Multitenancy contrasts with multi-instance architectures where separate software instances operate on behalf of different tenants. From http://en.wikipedia.org/wiki/Multitenancy

Standard SAP HANA Deployment Scenario

One SAP HANA DBMS, one database, one application, one schema

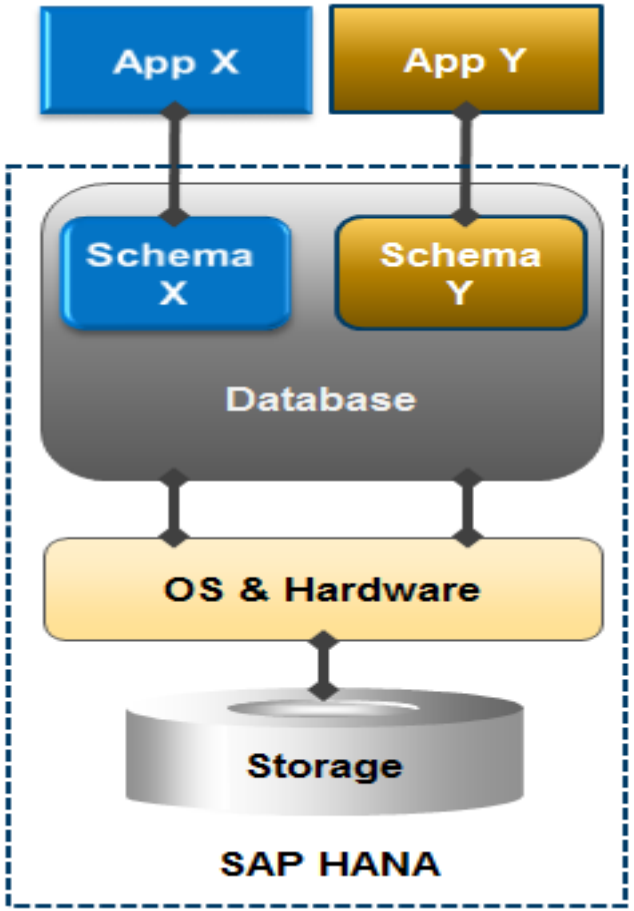
- Simple, straightforward scenario
- Key benefit: maximum resource allocation to single application/scenario with no resource contention with others
- Key tradeoff: TCO
- Supported with no restrictions



Multiple Applications on One SAP HANA system
Multiple Components One Database (MCOD)

One SAP HANA DBMS, one database, several applications, several schemas

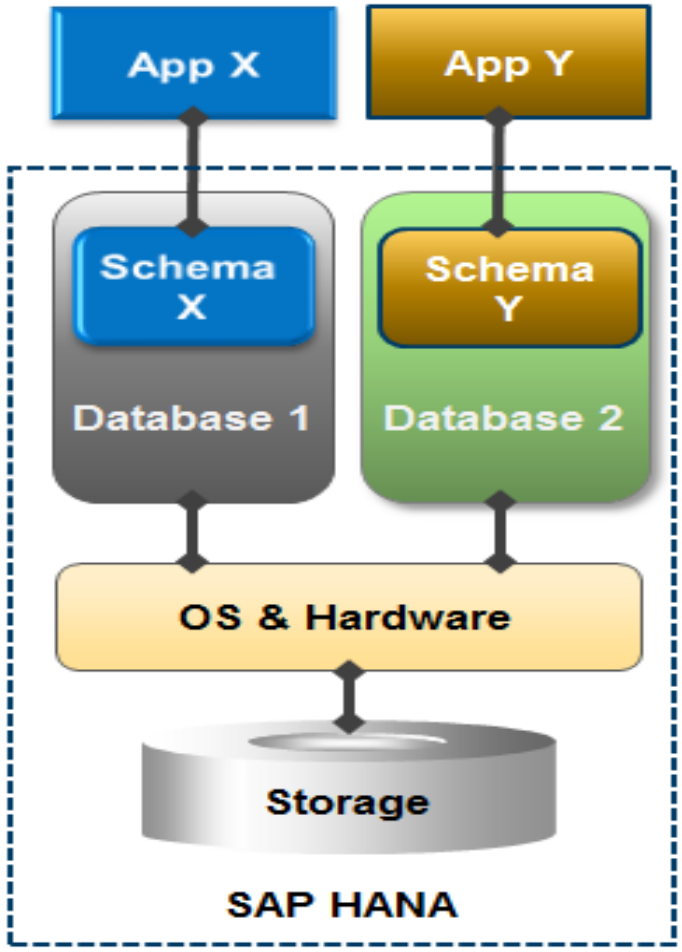
- Key benefit: May have TCO advantages
- Key tradeoffs:
  - Contention for resources may negatively impact performance
  - Additive sizing approach required
  - DB recovery available for entire DB (not available per schema)
- Supported for non-production with no restrictions
- Supported for production with restrictions: see note 1661202 (white list of applications / scenarios) and note 1826100 (white list relevant when running SAP Business Suite on SAP HANA)



Several Databases on One SAP HANA System
Multiple Components One System (MCOS)

More than one SAP HANA DBMS (with one DB in each), 1-n applications, 1-n schemas

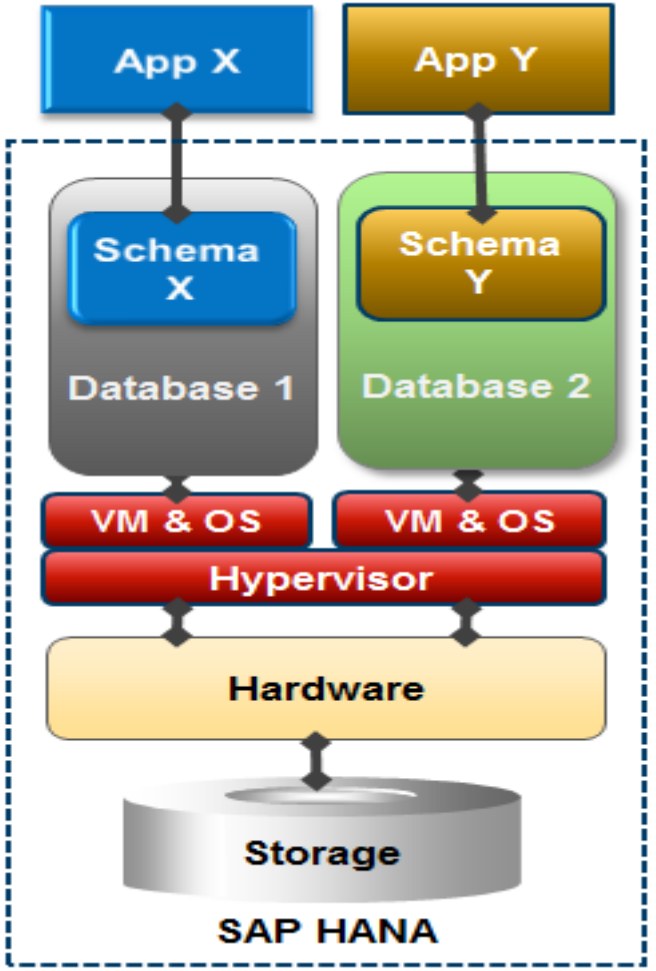
- Key benefit: May have TCO advantages
- Key tradeoffs:
  - Contention for resources may negatively impact performance
  - Additive sizing approach required
- Supported for non-production with restrictions
  - Performance issue can only be reported to SAP if they still occur when all other DBs stopped
- Not supported for production
- Current status outlined in SAP note 1681092



SAP HANA virtualized: Use Cases

Use Cases for virtualized SAP HANA deployments:

- For customers already standardizing on virtualization technology, SAP HANA offers the customer TCO reductions and additional options for planning and managing their systems landscapes.
  - Ease of HW replacement / Avoidance of re-certification of OS & SAP installations
  - Separation of IT Ownership (HW and SW layer)
  - OS independent monitoring
  - Low-cost HA capabilities in Dev & Test environments
- Private and Public Cloud offerings also lower entry barrier e.g. for startups by starting their business small and later scale along their needs in regards to user and data volume.
  - Positive impact on capital expenditures
- Current status on virtualization is outlined in SAP note 1995460



Basics

SAP HANA multitenant database containers

Concept and Terminology

A single database container is also called a *tenant database*

Run multiple tenant databases on one SAP HANA system

Run/support multiple applications/scenarios on one SAP HANA system in production

Strong Separation of data and users

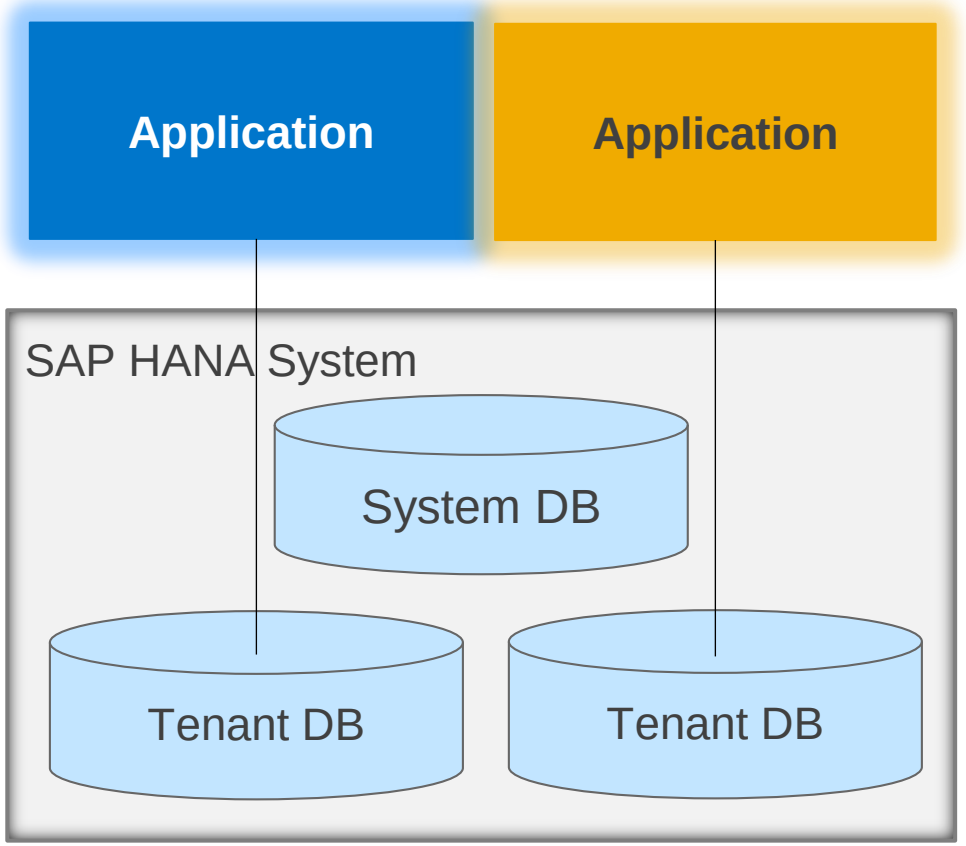
Backup and restore available by tenant DB

Resource management by tenant

- CPU, Memory

Move/copy tenant DBs/applications to different hosts/systems

Integration with existing data center operations procedures



SAP HANA multitenant database containers

New administration layer containing a System database

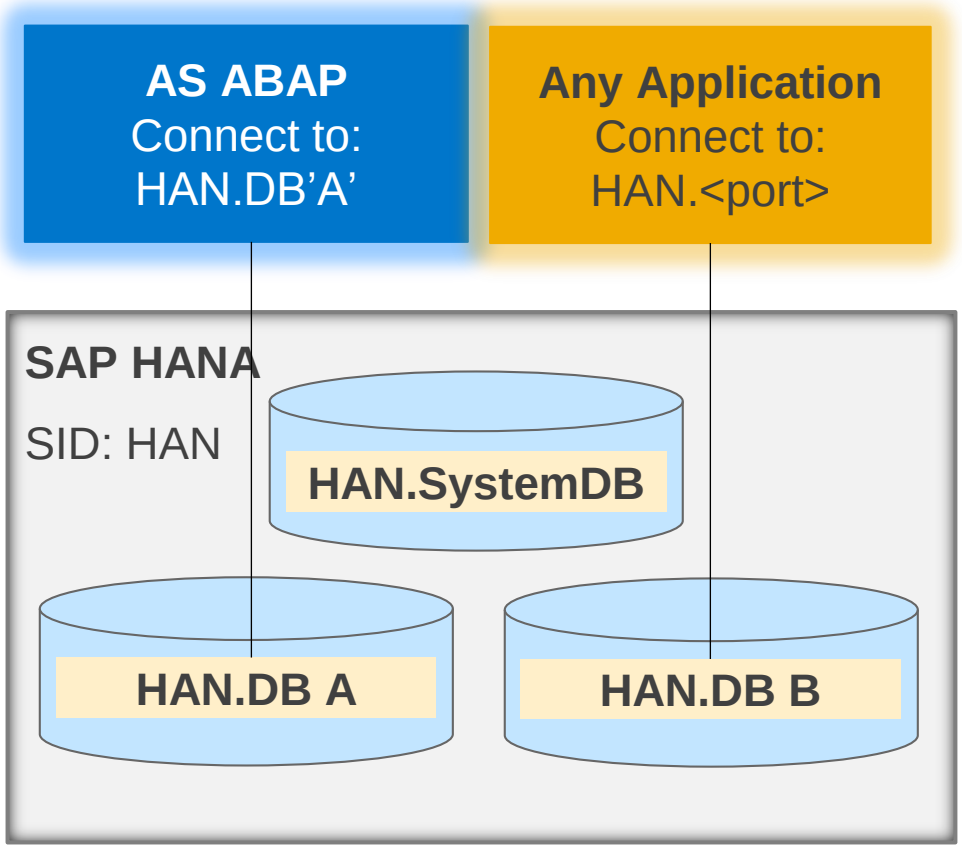
- Landscape topology information
- System-wide parameter settings
- Focal point for complete backup of all databases
- Resource management for all tenant DBs (CPU, memory, etc)

0 to n tenant databases identified by their names

- Tenant database related parameter settings
- Individual backup/restore of tenant database
- Clear separation of application data and user management

One database software version for a SAP HANA system (all tenant databases)

One HA/DR setting for a SAP HANA system: all tenants are included in a HA/DR scenario



Positioning

First focus with SAP HANA multitenant database containers

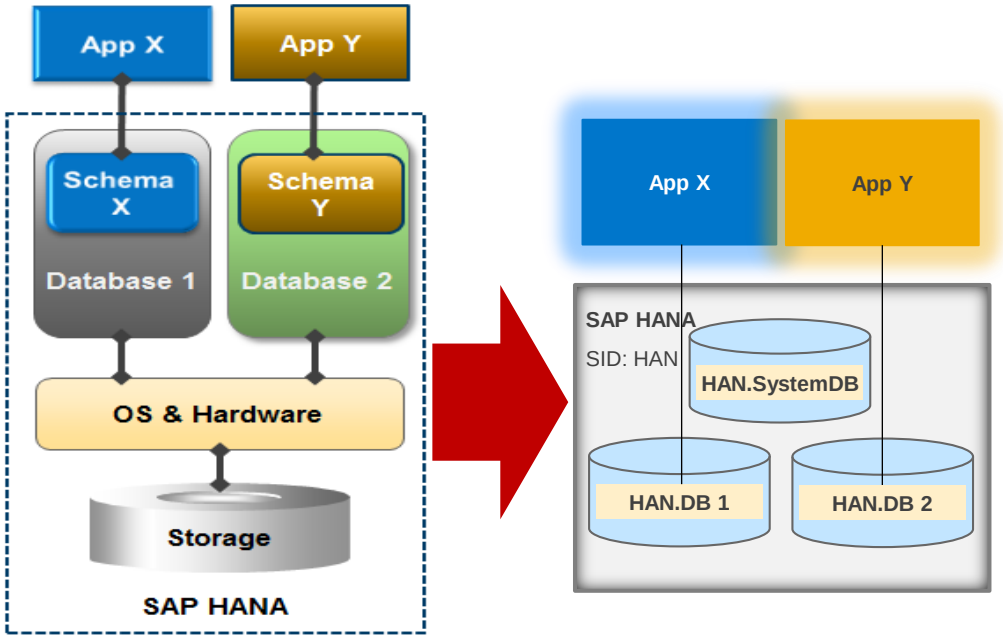
SPS09/10

Cloud Scenarios

- SAP HANA Cloud Platform
- SAP HANA Enterprise Cloud

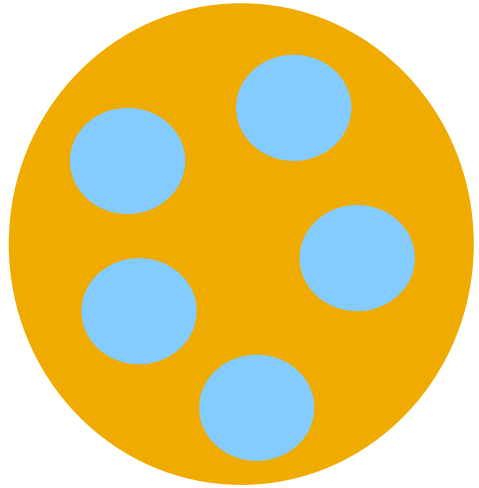
On-Premise Scenarios

- Replace most MCOS deployments (Multiple components one system)
- Featuring several tenant databases
- Address common MCOD scenarios (e.g. ERP-CRM-BW, QA/DEV, Data Marts)
- Cross scenario support: Fast federation between tenant databases (read only with SPS09)



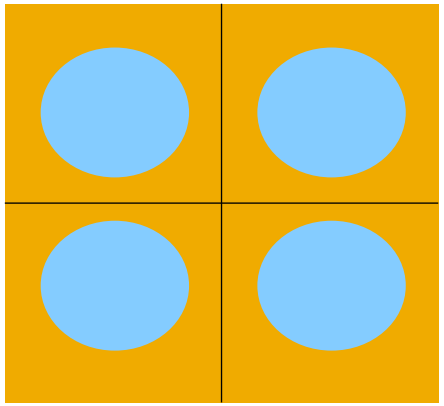
Positioning multitenant database containers II

Multitenant Database Containers vs Virtualization



Multitenant Database Containers

- Lower TCO, single software stack
- Central configuration & administration (database level)
- Direct database resource management
- Optimized federation (performance benefits)
- Performance advantages (no virtualization overhead)
- Licensed via SAP HANA



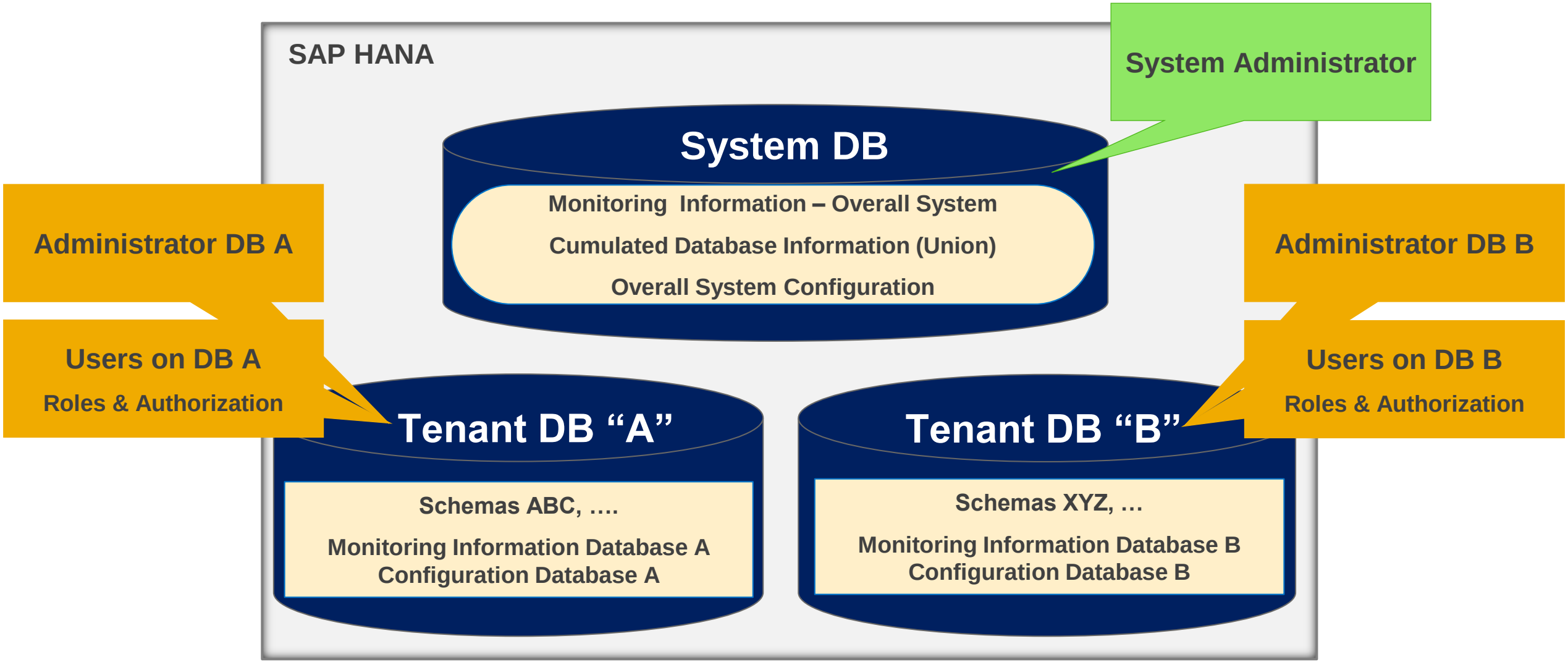
Virtualization

- Strong isolation
- Separate SAP HANA revisions option
- Standard federation (SDA)
- Additional virtualization license (e.g. VMWARE)

Technology

SAP HANA multitenant database containers

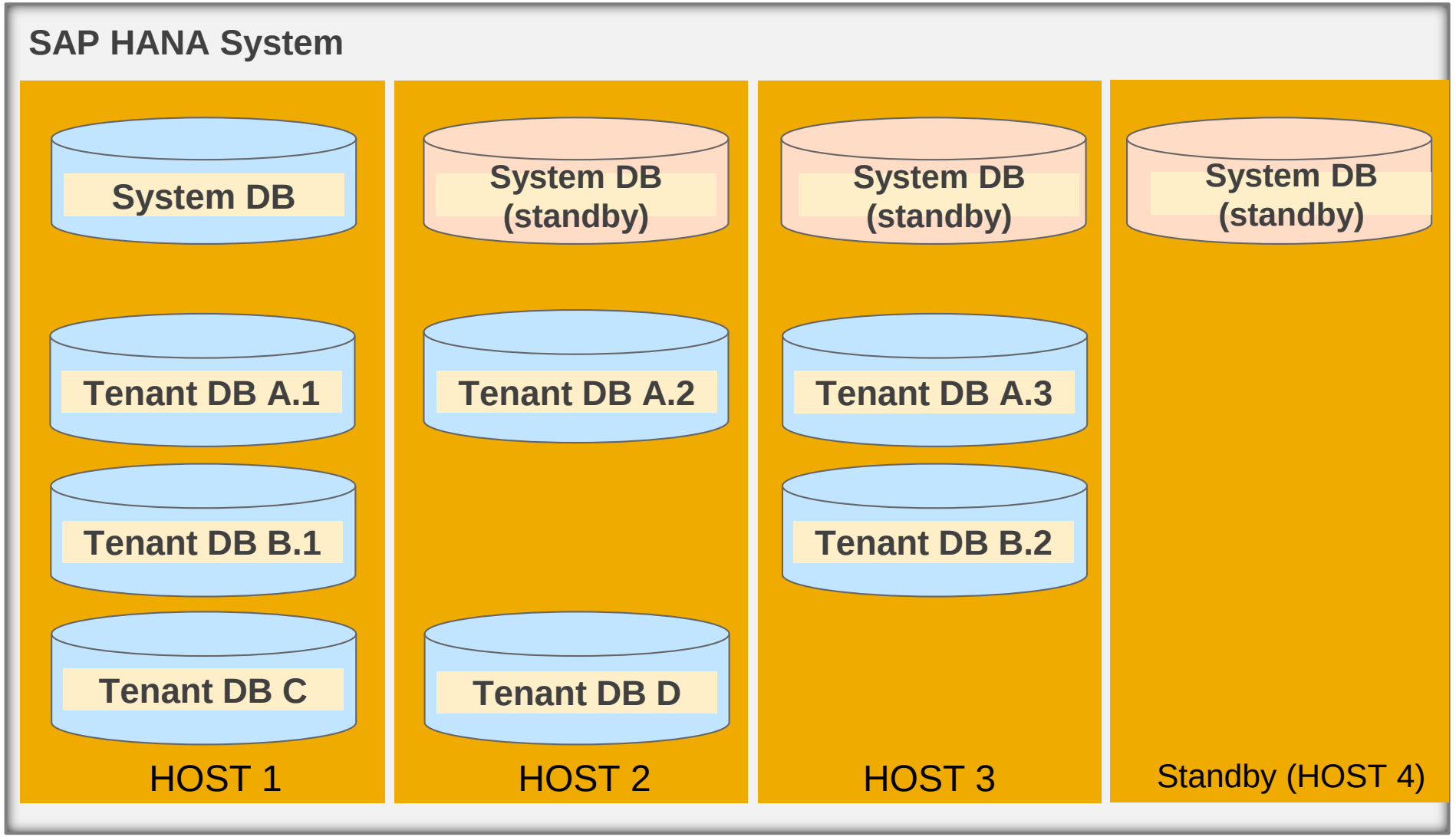
User and Administration Layers



Scale-out scenario with multitenant database containers

Tenant databases can spread over multiple nodes (hosts) in scale-out systems

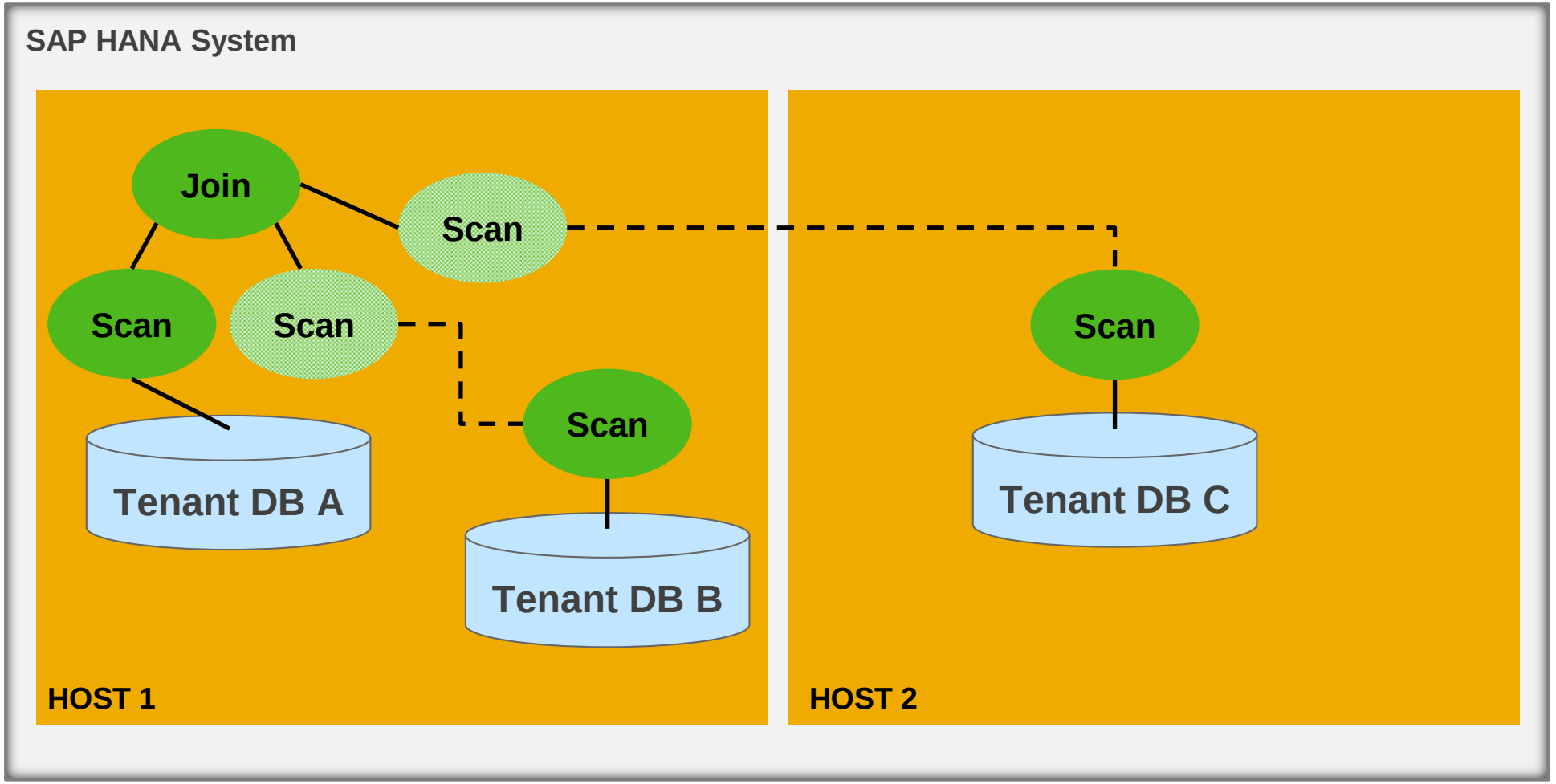
Example:
If host 2 goes down, the standby host becomes active. The tenant DBs normally running on host 2 will become active on the standby host



Cross-database queries between multitenant database containers

Cross-database queries (federation) are supported in SQL engine and Calculation engine.

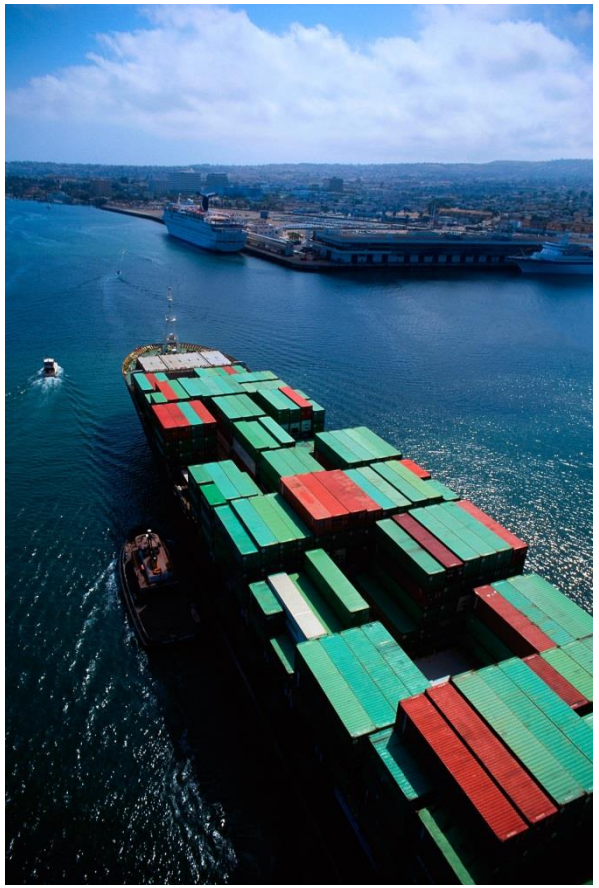
SPS09: Read-only



Migration of a single database to a multitenant database system

SAP HANA single database system can be migrated to a multitenant database system. This step is irrevocable.

- System database will be generated
- Single DB will be converted into a tenant DB automatically
- No changes to application/customer data
- Migration does not occur automatically with SPS09 upgrade
  - Must be explicitly triggered
  - Single DB is SPS09 default, MDC is optional



SAP HANA multitenant database containers Status – 1

Installation, Set-Up

- Installation as a multitenant database container system
- Migration to a multitenant database container system

Initiate database

- Create/Drop database
- Start/Stop database
- Connect to a tenant database by name

Parameters

- Modify parameters on a tenant database
- Modify parameters of a tenant database through the system database

SAP HANA multitenant database containers Status – 2

Server/XS engine

- One statistics server per tenant database
- XS server embedded in index server by default
- Web dispatcher configuration fully integrated into SAP HANA configuration

Authorization/Security

- Isolated users per tenant database
- Isolated trace and dump files per tenant database
- New privilege DATABASE ADMIN
- Data encryption per tenant database (central store, keys per tenant DB)
- Auditing in local tables per tenant database

SAP HANA multitenant database containers Status – 3

Backup/Recovery

- Local tenant database backup by local database administrator
- Single tenant database backup by system administrator
- All tenant database backup by system administrator
- Single tenant database recovery by system administrator
- All tenant database recovery by system administrator

Landscape management

- HA/DR: System replication set-up for the whole system (all tenant databases)
  - (note # for restrictions)
- Scale-out option per tenant database (each tenant database can be distributed)
- Add/remove host by system database
- Expensive (performance) statements tracing per tenant database

Details

Administration & Monitoring, Backup & Recovery

Improved Monitoring and Supportability
Multitenant Database Containers: Administration

Specific properties of SAP HANA multitenant database containers regarding administration/monitoring

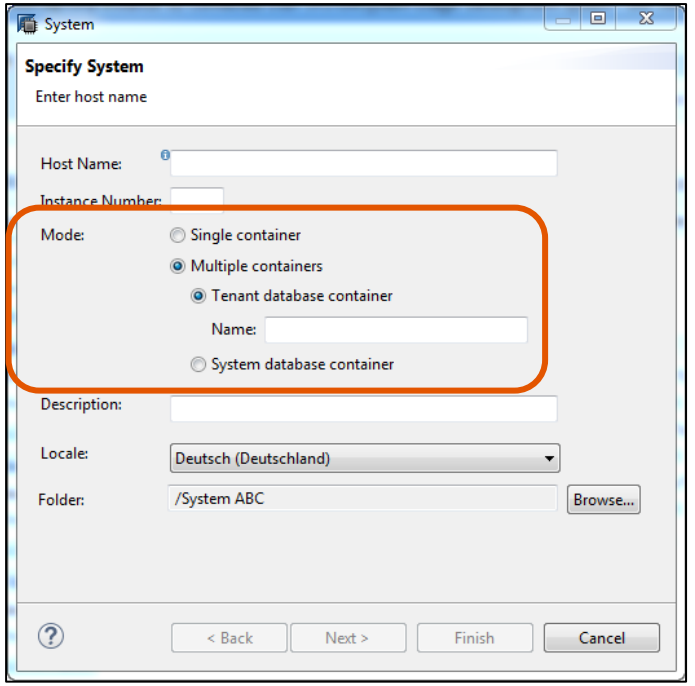
- The *system database* plays a central role:
  - Responsible for overall system and resource monitoring
  - Can restart the system database itself and can restart individual tenant databases
  - Can initiate backups of the system database itself and of individual tenant databases.
  - Recoveries are always initiated by the system database
  - Tenant databases - always created/dropped by the system database
  - Resource limits for tenant databases: configured from the system database
- Tenant databases are monitored individually
- Alert, trace, parameter and user configuration is done for each tenant database individually

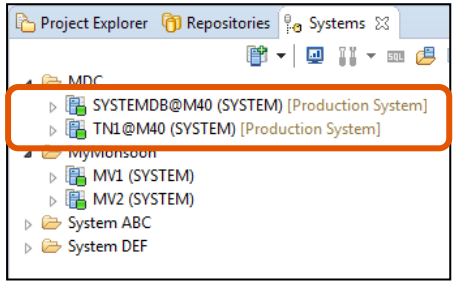
Improved Monitoring and Supportability

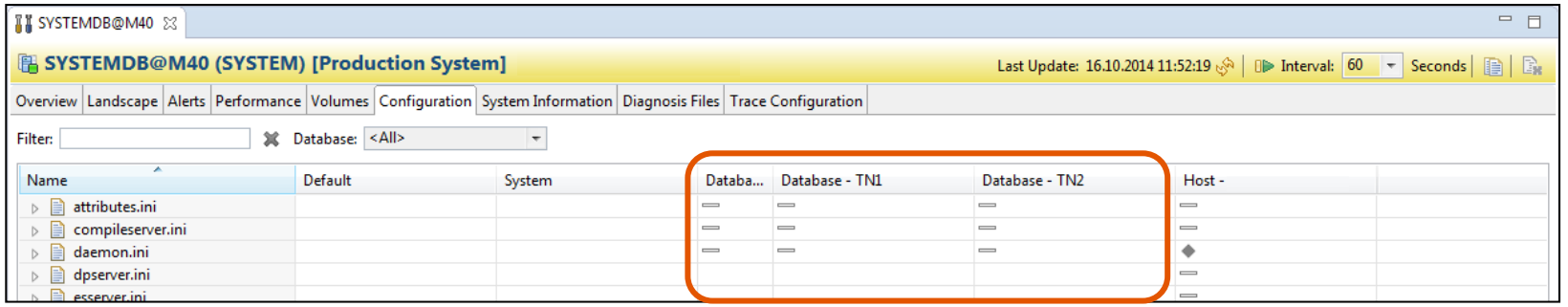
SAP HANA Multitenant Database Containers: Administration Tools

Administration Tools

- SAP HANA studio has been adapted to be able to
  - Connect to the system database and any tenant database
  - Display the database type in the systems view
  - Monitor the system database & any tenant DB using the Administration perspective
  - Change database specific parameters
- SAP HANA cockpit can be used to monitor the system database and any tenant DB
- DBA Cockpit can be used to monitor the system database and any tenant database







Backup/Recovery Concept

Multitenant database containers follow the usual SAP HANA backup/recovery principles

- Data backups: initiated manually or scheduled via scripts/tools (e.g. DBA Cockpit, etc)
- Log backups: automatic log mode set to NORMAL (recommended for production)
- Backup information: stored backup catalog
- Backup destinations supported: file system, backups to 3rd party backup tools
- Database copies using backup/recovery: supported for individual tenant databases
- Recovery options: point-in-time recovery, recovery to a specific data backup
- Tool support: SAP HANA Studio, DBA Cockpit, command line (SQL statements)

Specific properties of multitenant database container backup/recovery

- System database: central for backup/recovery; can initiate backups of the system database itself and individual tenant DBs. Recoveries always initiated by system database.
- Tenant DBs: local admin can carry out backup of her tenant DB (unless prohibited in the system configuration)
- Backup catalogs: System database and tenant databases have their own backup catalogs
- Snapshots: not available with SPS09

Backing up the System Database

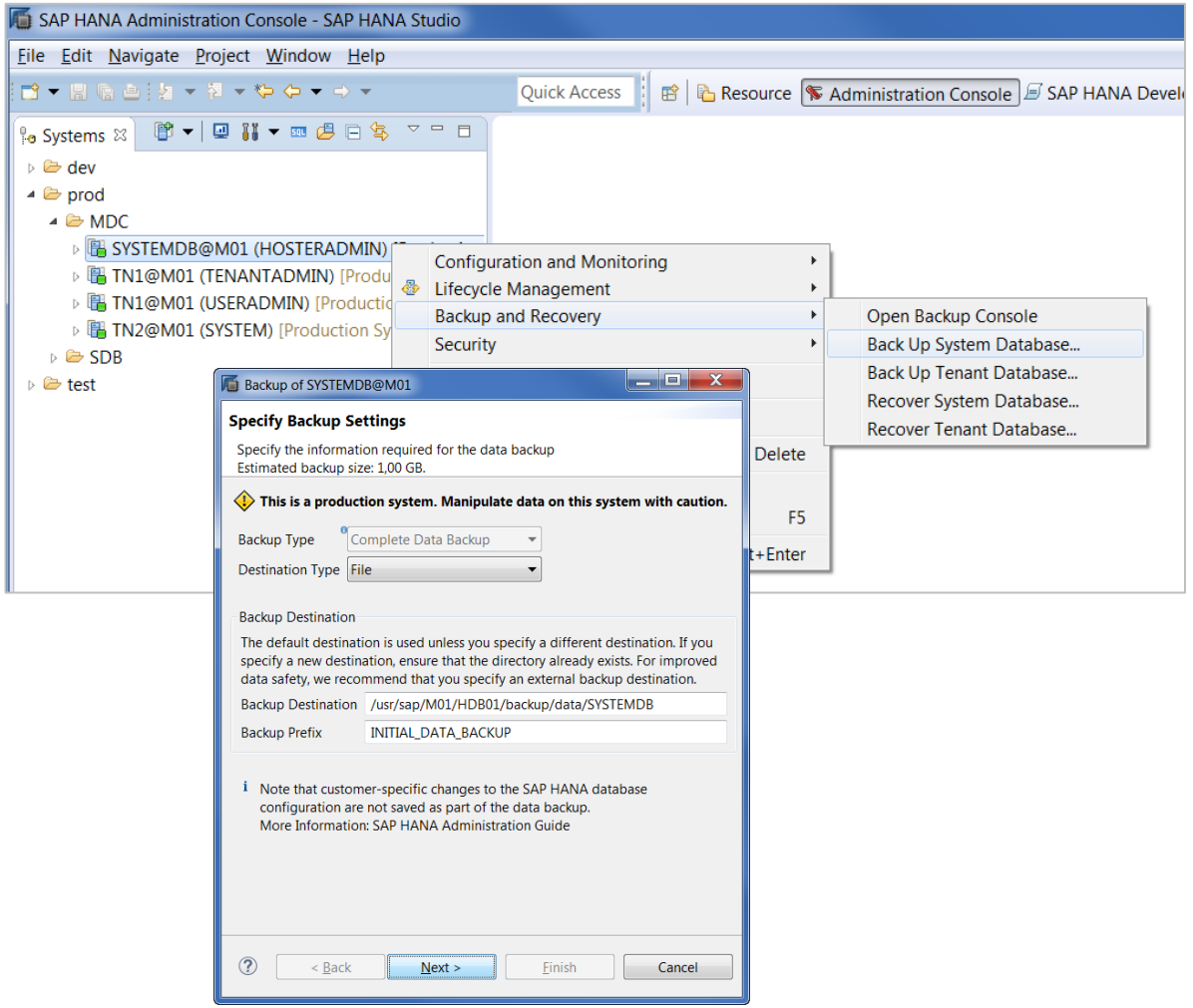
Important – regularly backup the system database

The system database contains information about the system as a whole and all tenant databases and is used for central system administration.

Creating a data backup of the system database

- Prerequisites: User in the system database with BACKUP ADMIN or BACKUP OPERATOR and CATALOG READ system privileges

1. In the *Systems* view in SAP HANA studio, right-click on the system database and choose *Backup and Recovery* → *Backup Up System Database...*
2. Specify your backup settings and start the backup



Backing up a Tenant Database

Important – regularly backup the tenant databases

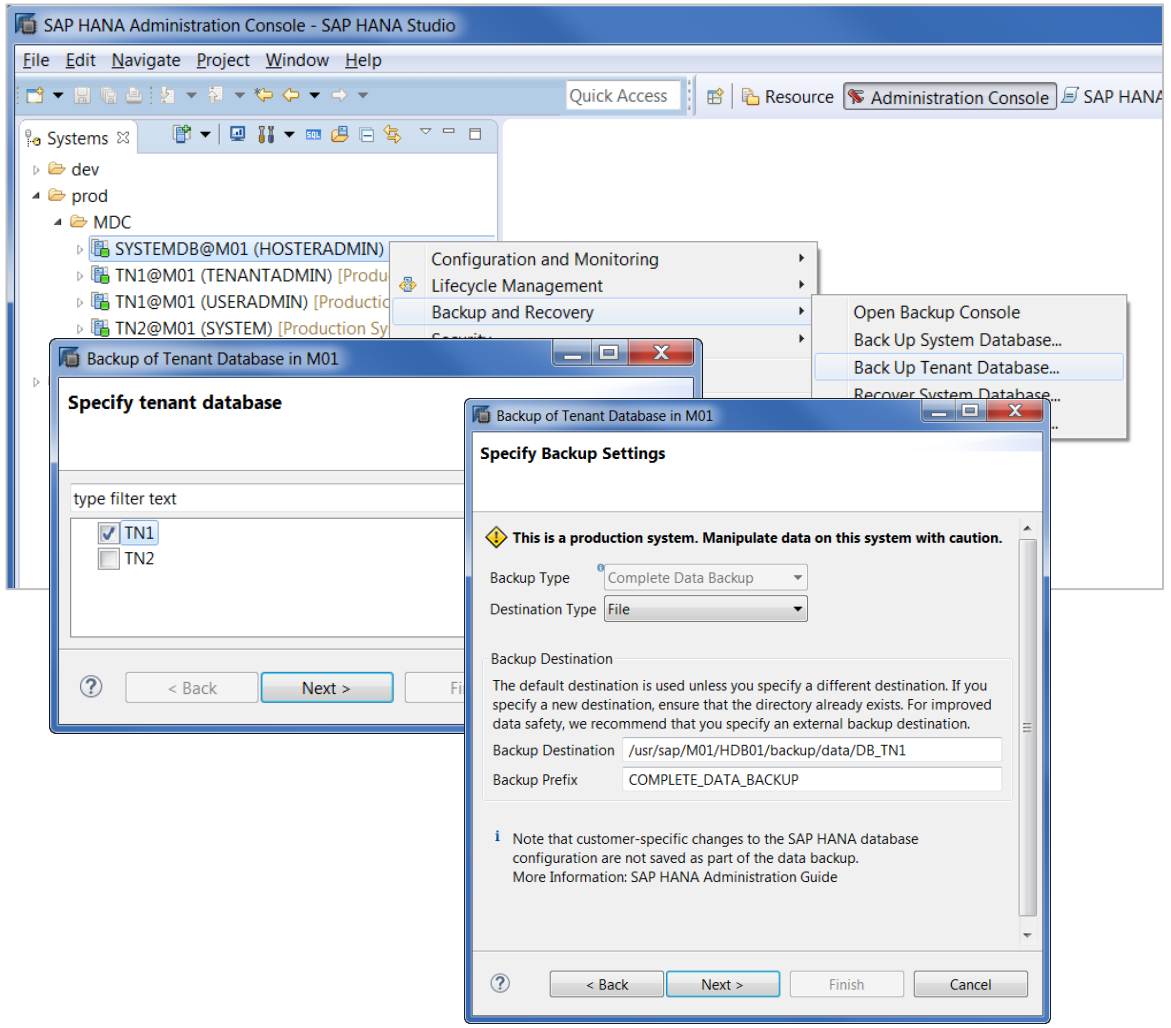
The tenant databases contain the organization's data. They have their own index servers.

Note: Depending on the system configuration, it may also be possible to initiate a data backup directly from a tenant database

Creating a data backup of a tenant database

- Prerequisites: User in the system database with DATABASE ADMIN system privilege

1. In the *Systems* view in SAP HANA studio, right-click on the system database and choose *Backup and Recovery* → *Backup Up Tenant Database...*
2. Select the tenant database to be backed up
3. Specify your backup settings and start the backup



Viewing Backup Information

Backup information is contained in the backup catalog

Viewing information for all databases

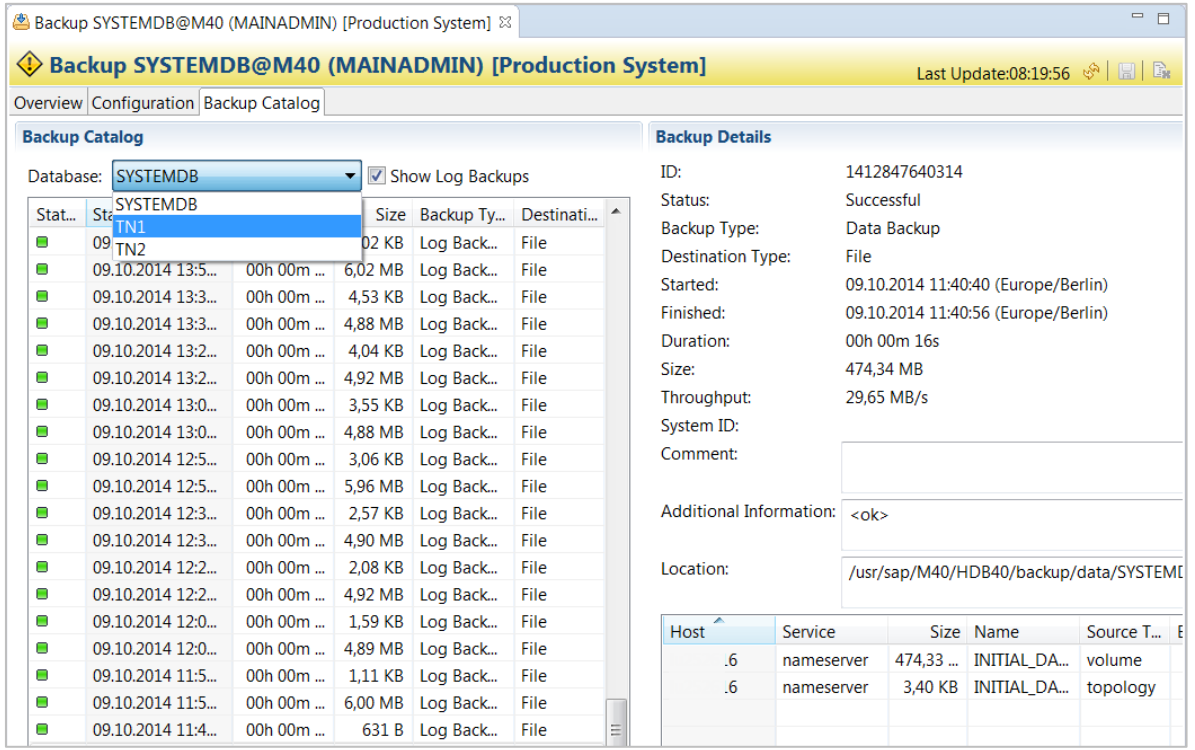
- Prerequisites: User in the system database with DATABASE ADMIN privilege; tenant database running

1. In the *Systems* view in SAP HANA studio, expand the system database and double-click on *Backup*
2. Open the *Backup Catalog* tab and select the database for which you want to view the information

Viewing information for a tenant database

- Prerequisites: User in the tenant database with BACKUP ADMIN and CATALOG READ privileges

1. In the *Systems* view in SAP HANA studio, expand the tenant database and double-click on *Backup*
2. Open the *Backup Catalog* tab



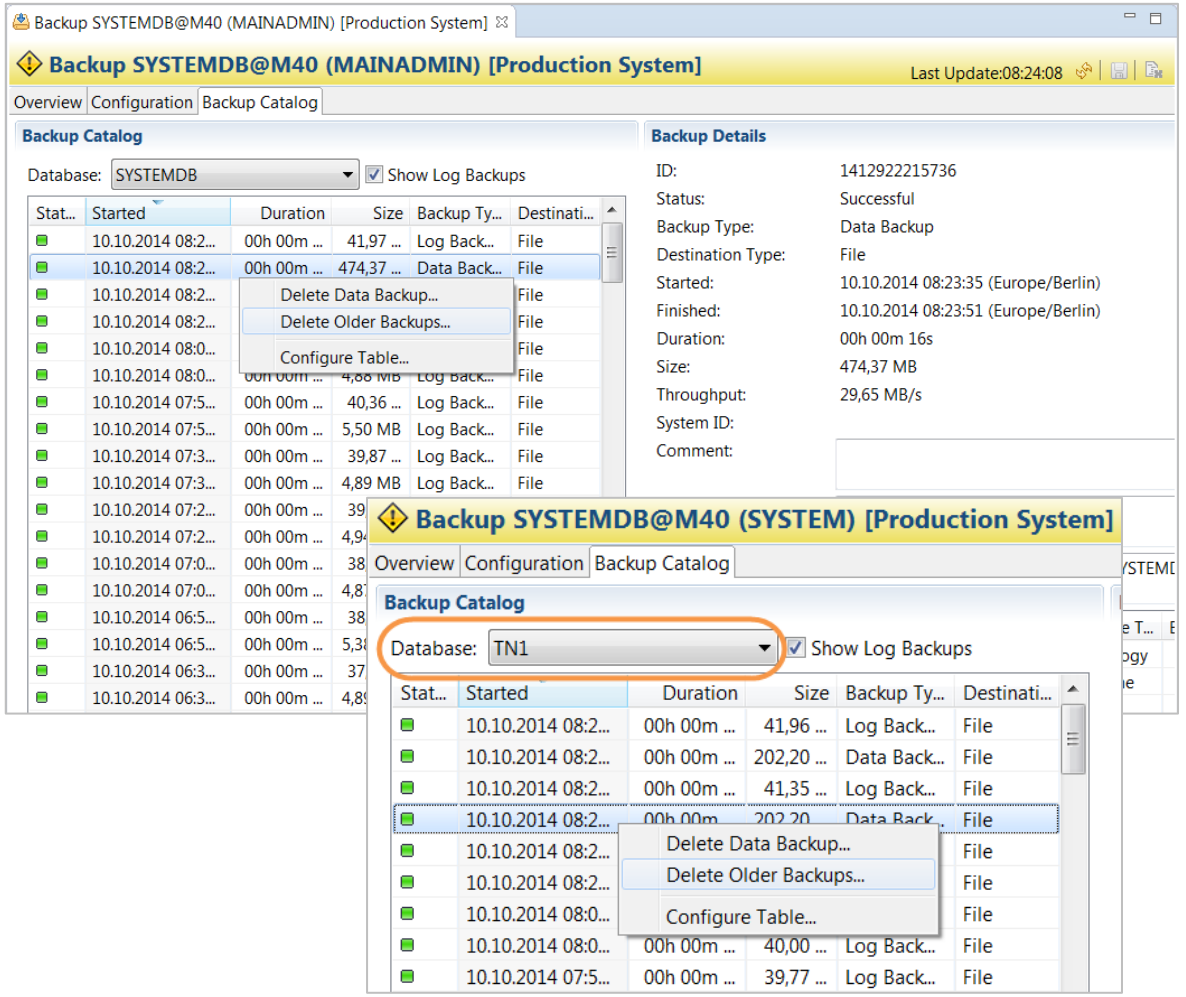
Backup Management

You can delete obsolete backups

Deleting old backups

- Prerequisites: User in the system database with DATABASE ADMIN system privilege

1. In the *Systems* view in SAP HANA studio, expand the system database and double-click on *Backup*
2. Open the *Backup Catalog* tab and select the database for which you want to delete backups
3. From the context menu, choose which backups you want to delete
4. Choose whether the backups should only be deleted from the backup catalog, or both from the catalog and from the file system/3rd party backup tool



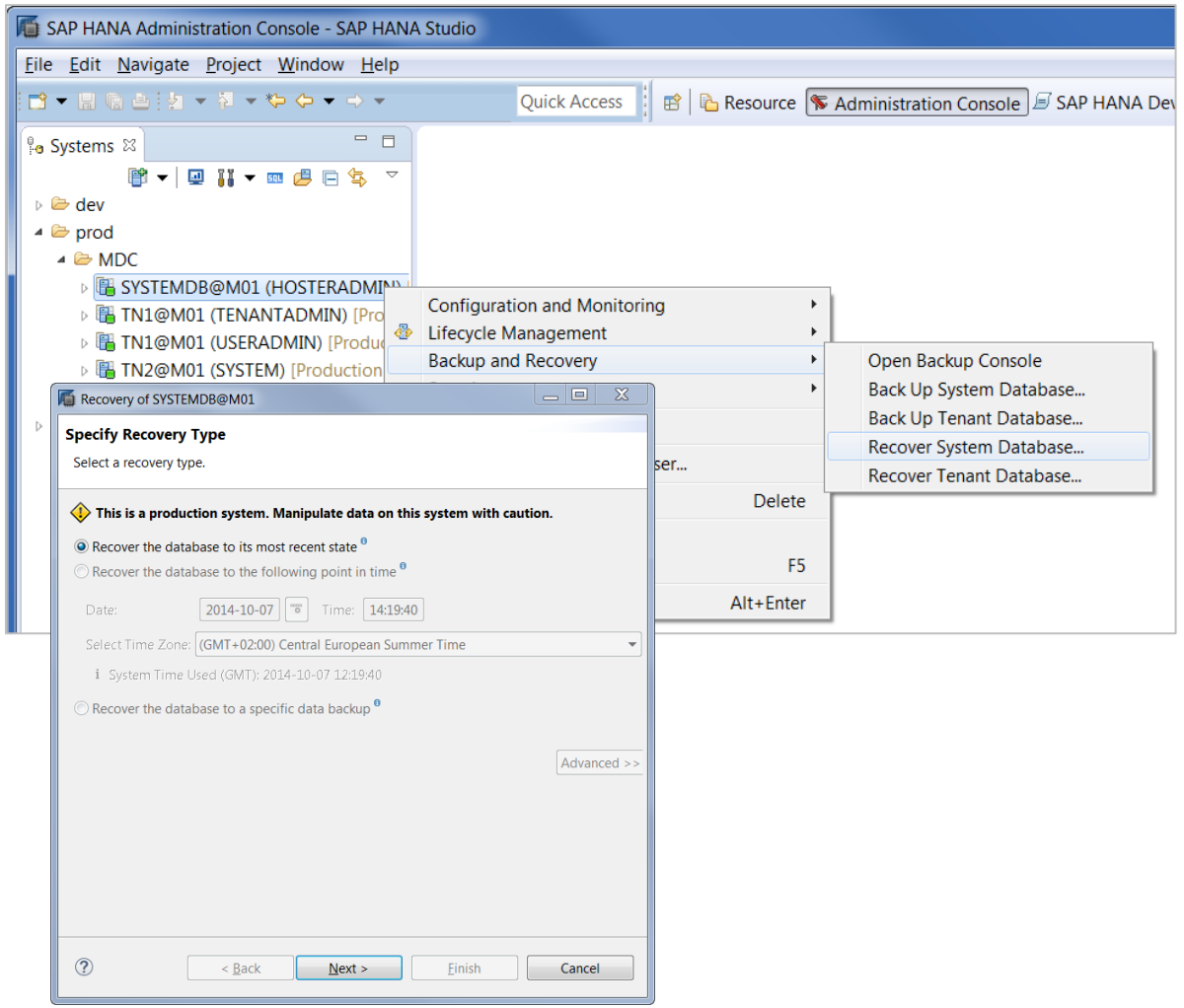
Recovering the System Database

The system database can be recovered should rare circumstances warrant it

Recovering the system database

- Prerequisites: <sid>adm OS user credentials

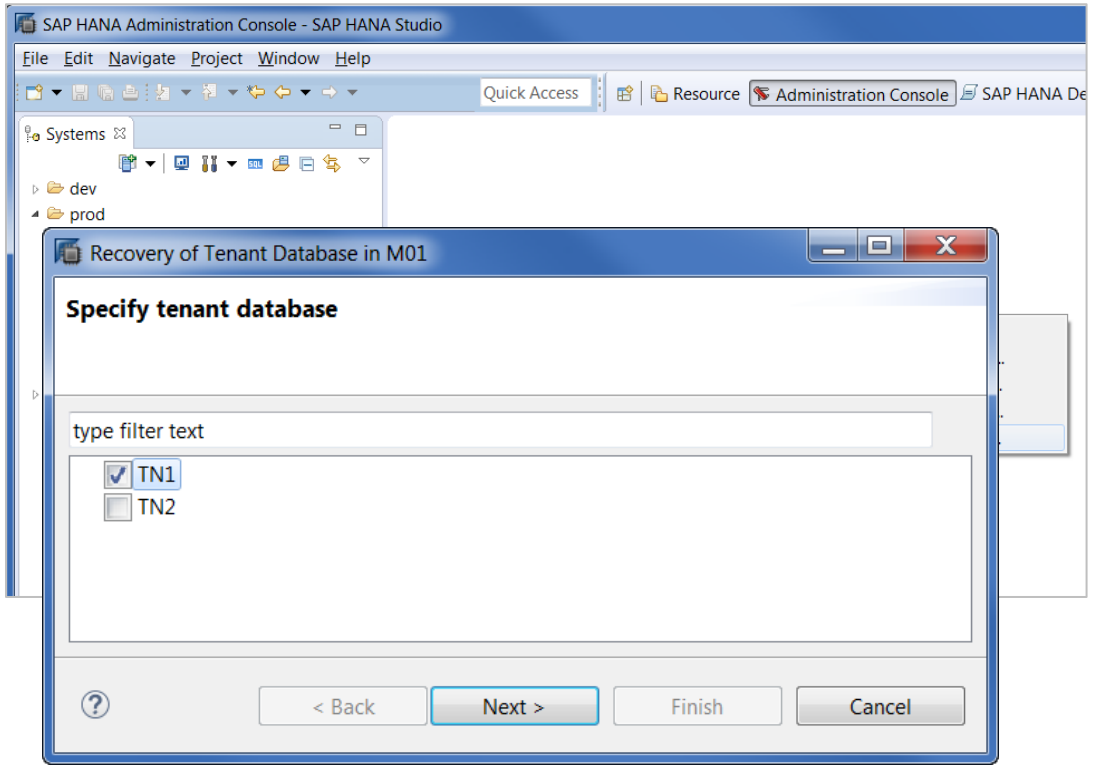
1. In the *Systems* view in SAP HANA studio, right-click on the system database and choose *Backup and Recovery* → *Recover System Database...*
2. Enter the <sid>adm credentials. The whole system will be shut down, including all tenant databases.
3. Specify your recovery type and further recovery settings and start the recovery. The system database will be recovered and restarted.
4. Restart the tenant databases. The tenant databases' content is not affected by the system database recovery.



Recovering a Tenant Database

The system database can be recovered if necessary

Recovery of tenant databases can only be initiated from the system database. The system database and other tenant databases are not affected. Recovery to last backup and point-in-time recovery are supported.



Recovering a tenant database

- Prerequisites: User in the system database with DATABASE ADMIN system privilege

1. In the *Systems* view in SAP HANA studio, right-click on the system database and choose *Backup and Recovery* → *Recover Tenant Database...*
2. Select the tenant database to be recovered
3. Specify your recovery type and further recovery settings and start the recovery.

Details

Migrating a single database to a multitenant database

Migration to a Tenant Database

Preparation

SAP HANA version providing the MDC features (>=SPS09).

Remove or migrate the statistics server according to documentation

Shutdown the system: `HDB stop`

Conversion

command: `hdbnsutil –convertToMultiDB` results in:

- Setting the "multidb mode" flag in configurations
- Creating the System DB
- Converting the original single DB to a tenant DB with name <SID>
- Updates the Secure Store

With initial `HDB start`, only the SystemDB will start up.

Connect to the SystemDB
either with `hdbsql -d SystemDB` (recommended)
or via SQL Port 3xx13

Start the new tenant database:

```
ALTER SYSTEM START DATABASE <SID>
```

Traces and configurations for any tenant DB are now stored in a respective subfolder DB_<dbname>.

Details

Connecting to tenant databases

Connecting to Tenant Databases

A client (i.e. application) can connect to a tenant database by directly specifying its SQL port number

A client can also connect to a tenant DB by using the specific tenant database name

Login redirection

In a MDC system, tenant databases are isolated

SYSTEMDB carries the hosts information for all tenant databases

Login redirection process:

- Client sends message to SYSTEMDB during login; looks for the ***host:port*** for the specified tenant database
- Receive response message from SYSTEMDB; client disconnects from SYSTEMDB & reconnects to the redirected database
- 'DATABASENAME' keyword has been introduced for this purpose

Connecting to Tenant Databases – Port Coverage

Single DB system: port 3xx15 connects to the master index server SQL port, where 'xx' is the instance number

Example how port coverage may appear in an **MDC system**:

Port 3xx13 connects to the SYSTEMDB SQL port

Port 3xx40 connects to the 1st tenant database TrexNet port
Port 3xx41 connects to the 1st tenant database SQL port
Port 3xx42 connects to the 1st tenant database HTTP port

Port 3xx43 connects to the 2nd tenant database TrexNet port
Port 3xx44 connects to the 2nd tenant database SQL port
Port 3xx45 connects to the 2nd tenant database HTTP port

When a Single DB is converted to an MDC system: port 3xx15 is kept for the converted tenant DB

Create Tenant Databases

Examples:

Create a database DB0 with SYSTEM user password Manager1:

```
CREATE DATABASE DB0 SYSTEM USER PASSWORD Manager1
```

Create a database DB0 with SYSTEM user password Manager1
on host A, and an additional worker indexserver on host B:

```
CREATE DATABASE DB0 AT LOCATION 'A' ADD 'indexserver' AT 'B' SYSTEM USER PASSWORD Manager1
```

Start and Stop Tenant Databases; Drop Tenant DBs

Examples:

Start/Stop Tenant Database

```
ALTER SYSTEM START DATABASE <name>

ALTER SYSTEM STOP DATABASE <name>
```

Drop a Tenant Database:

```
DROP DATABASE <DATABASE_NAME>
```

Details

Parameters and Resource Management

Setting Parameters

- Certain parameters can be defined per tenant database
- System DB admin can prohibit some parameters from being changed by local users of a tenant DB
- This parameter *blacklist* is maintained in the new configuration file multidb.ini

```
###############################################################################
# configuration blacklist
###############################################################################
# .short_desc
# Read-only blacklist for configuration parameters in a TenantDB
# .full_desc
# This blacklist ensures that TenantDB users are not allowed to change certain parameters.
# The parameters will be read-only for any (or the explicitely specified) inifile in DATABASE layer.
# Note: The configuration via SystemDB is still allowed. Only TenantDB configuration is blocked.
# Simple Format:               <section to be blocked> = <list of keys to be blocked>
# Complex Format: <ini file name>/<section to be blocked> = <list of keys to be blocked>
# Patterns: * matches anything.
# .change online
[readonly_parameters]
multidb.ini/readonly_parameters = *
memorymanager = allocationlimit,minallocationlimit,global_allocation_limit,async_free_threshold,async_free_target
execution = max_concurrency
session = maximum_connections,maximum_external_connections
sql = sql_executors
```

Resource Management - Memory

Parameter **memorymanager.allocationlimit –** in file indexserver.ini of each tenant DB

This parameter limits the maximum amount of memory that can be allocated to all processes of a given tenant DB

The current allocation limit can be viewed by selecting ALLOCATION_LIMIT from M_SERVICE_MEMORY

Example (From within the SYSTEMDB):

ALTER SYSTEM ALTER CONFIGURATION ('indexserver.ini', 'DATABASE', 'MYDB') SET ('memorymanager', 'allocationlimit') = '8192' WITH RECONFIGURE

Note: Stop and start is not required if ‘WITH RECONFIGURE’ is included

Resource Management – Influencing CPU Cores Utilization

Parameter **execution.max_concurrency -** in file indexserver.ini of each tenant DB

Directly influences the maximum number of CPU cores that can be utilized per tenant DB

Limits the number of concurrently running threads used by the SAP HANA job executer

View the current runtime value: select ' MAX_CONCURRENCY' from the 'M_JOBEXECUTORS' view

Example (From within the SYSTEMDB):

ALTER SYSTEM ALTER CONFIGURATION ('indexserver.ini', 'DATABASE', 'MYDB') SET ('execution', 'max_concurrency') = '4' WITH RECONFIGURE

Note: Stop and start is not required if ‘WITH RECONFIGURE’ is included

Details

Encryption

Encryption

Secure Sockets Layer (SSL) and Transport Layer Security (TLS):

- Can be configured separately for the external and internal communication channels of individual tenant DBs
- Separate key store and trust stores must be available and configured for each tenant DB

Data volume encryption:

- Can be enabled individually for each tenant database
- Each tenant DB has its own root encryption keys
  - stored securely in the secure storage on the file system (SSFS)

For more information, see SAP Security Guide and ‘Data Volume Encryption in Multitenant Database Containers’ in the SAP HANA Administration Guide.

Details

Cross-tenant database access

Cross-Tenant Database Access

There are use cases where queries should run across tenant databases.

Database objects such as tables and views can be local to one tenant DB, but be read by users from other databases in the same system

Example:

SELECT * FROM schema1.table1 AS tab1, **db2.schema2.table2** as tab2
WHERE tab2.column2 = ‘excelsior'

Cross-Tenant Database Access - Accessing remote objects

SELECT statements can reference the following objects on a remote database:

- Schemas
  Tables (row and column)
  Views (row and column)

The following local objects can access remote database objects:

- SQL views
  Calculations views
  Procedures

Cross-Tenant Database Access – Unsupported Functionality – 1-

These objects cannot reference remote tenant database objects (in other tenant DBs):

- Hierarchy views
  Analytic views
  Attribute views
  Synonyms

Attribute views and analytic views need to be converted to calculation views in order to use remote tenant database objects

Cross-database DDL statements are not supported

DML statements other than SELECT are not supported

Cross-Tenant Database Access - Unsupported Functionality – 2-

These remote tenant database objects cannot be accessed in a SELECT query:

- Virtual tables
  Sequences
  Synonyms
  Monitoring views
  Triggers
  Indexes

Cross-Tenant Database Access - Setup

By default cross database access between tenants is inactive. To be able to run queries spanning multiple tenant databases the global cross database access switch has to be turned on. And a whitelist of databases that are allowed to communicate with each other has to be set up.

Turn on cross-tenant database communication (run this from SYSTEM database only)

```
ALTER SYSTEM ALTER CONFIGURATION
('global.ini', 'SYSTEM') SET ('cross_database_access', 'enabled') = 'true' WITH RECONFIGURE
```

Whitelisting a cross-tenant database communication channel (from SYSTEM database only)

```
ALTER SYSTEM ALTER CONFIGURATION
('global.ini', 'SYSTEM') SET ('cross_database_access', 'targets_for_DB1') = 'DB2' WITH RECONFIGURE
```

Attention: Communication channels are uni-directional by default (i.e. “one way street”). They can be made bi-directional by explicitly defining the configuration in reverse.

Cross-Tenant Database Access - Authorization

For the purpose of cross database query execution, a user mapping is needed in the remote tenant database

Example use case:

Use Two tenant databases DB1 and DB2. USER2 on DB2 owns table SCHEMA2.TABLE2. USER1 on DB1 should have access to TABLE2 in DB2.

Within DB2, a user administrator has to add a remote identity. This will be used the purpose of cross-tenant database query execution for USER1 from database DB1:

On DB2:

```
ALTER USER USER2 ADD REMOTE IDENTITY USER1 AT DATABASE DB1
```

Details

Monitoring multitenant database container system

Sizing

System Monitoring - Views

Every tenant database has its own SYS and _SYS_STATISTICS schema containing information about that database only. For system-level monitoring, additional views are available in the system database:

M_DATABASES

- Belongs to the SYS schema of the system database
- Overview of all tenant databases in the system
- Restricted to users with the system privilege DATABASE ADMIN

SYS_DATABASES schema

- Taken from a sub-set of the views available in the SYS schema
- Views in SYS_DATABASES schema provide aggregated information about all tenant databases in the system
- In these union views, identify each tenant database using the column DATABASE_NAME
- System views in the SYS_DATABASES schema - accessible only from the system database
- Access requires object privilege SELECT on the SYS_DATABASES schema

Sizing SAP multitenant database containers

As MDC is initially introduced with SAP HANA SPS09, a pragmatic approach for sizing MDC systems is advised

- Additive sizing: Perform a sizing estimation for each tenant database, as if it were a single database. Next, add the individual sizing estimates together and avoid underestimating.

- MCOD white lists the restrictions of notes 1661202 (white list of applications / scenarios) and 1826100 (white list relevant when running SAP Business Suite on SAP HANA) have a different meaning when MDC is utilized:
  - These white lists refer to the applications and scenarios that are supported to run together on the same tenant DB

- Implementation considerations: as MDC is new technology, a conservative approach to implementing MDC may be advisable:
  - customers may consider following the general approach of the whitelist at first (i.e. when determining which applications to deploy on the same SAP HANA production hardware)
  - A phased implementation approach could be beneficial: deploy a few applications on the same hardware in different tenants, and monitor/analyze resource utilization and performance; allow observations to guide next steps

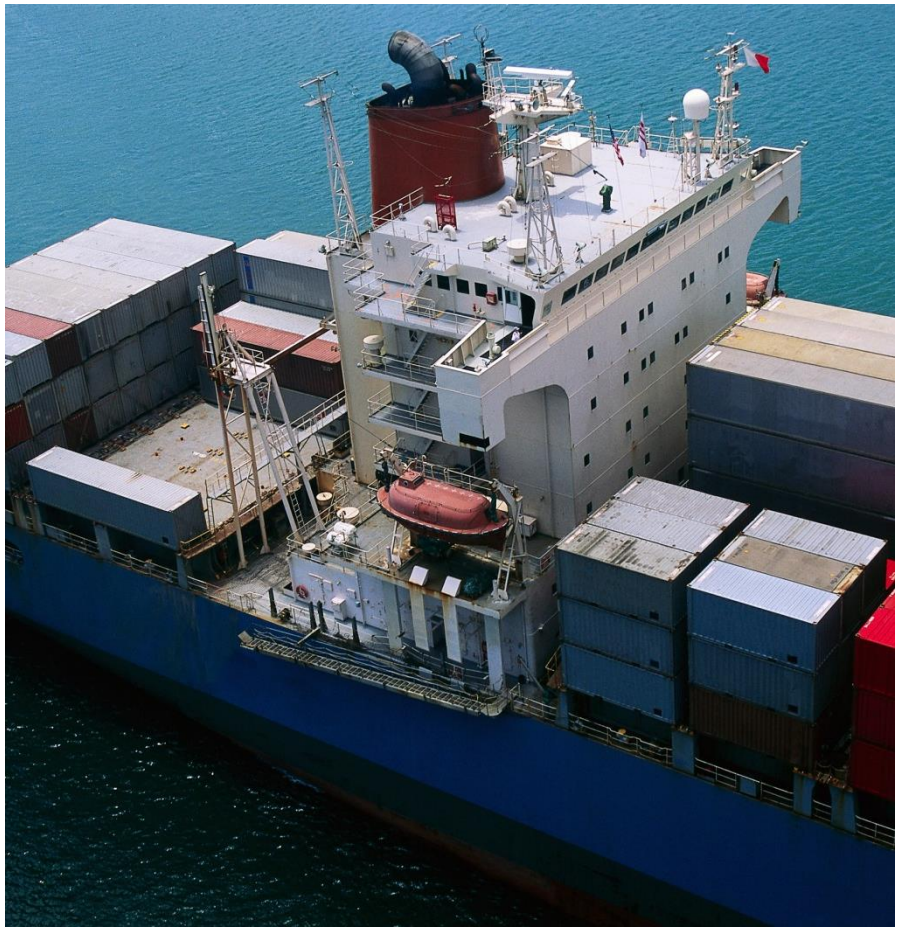
Summary

Summary

SAP HANA multitenant database containers

A new option for the SAP HANA platform

- Reduces TCO
- Enables tenant operation on database level
- Offers integrated administration, monitoring
- Offers powerful resource management
- Offers strong isolation
- Offers optimized cross-database operation within the system
- Supports flexible landscape management
- Supports cloud scenarios
- Supports on-premise scenarios

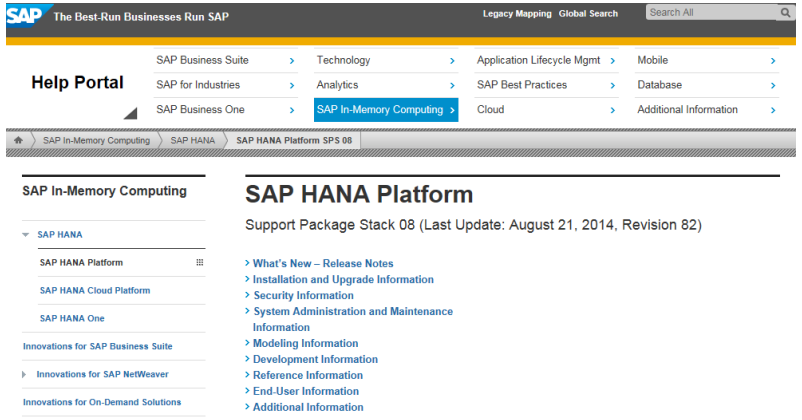


How to find SAP HANA documentation on this topic?

- In addition to this learning material, you can find SAP HANA platform documentation on SAP Help Portal knowledge center at http://help.sap.com/hana_platform.
- The knowledge centers are structured according to the product lifecycle: installation, security, administration, development:

SAP HANA Platform SPS

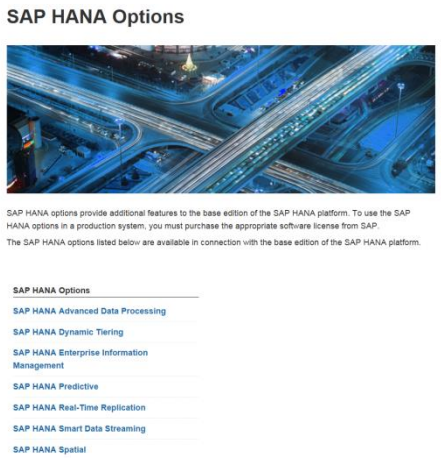
- What's New – Release Notes
- Installation
- Administration
- Development
- References



- Documentation sets for SAP HANA options can be found at http://help.sap.com/hana_options:

SAP HANA Options

- SAP HANA Advanced Data Processing
- SAP HANA Dynamic Tiering
- SAP HANA Enterprise Information Management
- SAP HANA Predictive
- SAP HANA Real-Time Replication
- SAP HANA Smart Data Streaming
- SAP HANA Spatial



Thank you

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