How To Perform System Replication for SAP HANA

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For additional information contact:
melchthild.bore-wuesthof@sap.com
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## Document History

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1. **Business Scenario**

Business Continuity requires that the operation of business critical systems remain highly available at all time, even in the presence of failures. High availability and disaster recovery are the building blocks to support this.

Among other features, SAP HANA provides the possibility to replicate your SAP HANA system within the same or over two data centers. This paper briefly describes SAP HANA System Replication in a step-by-step manner to support High Availability and Disaster Recovery and references the needed guides for details.

2. **Before you start**

It is recommended to have studied the following documents, which are frequently referred to in this document:


The first and second document will give a broad overview and basic knowledge to understand what this paper discusses.

Additionally there is a set of SAP HANA Academy videos available, which are worth watching:


You should also be aware of these SAP notes containing valuable information on SAP HANA system replication:

- **SAP Note 1999880 - FAQ: SAP HANA System Replication**
- **SAP Note 2165547 - FAQ: SAP HANA Database Backup & Recovery in an SAP HANA System Replication Landscape**
How To System Replication for SAP HANA

- SAP Note 1945676 - Correct usage of hdbnsutil -sr_unregister
- SAP Note 1917506 - HANA system replication backward compatibility
- SAP Note 1984882 – Using HANA system replication for Hardware Exchange with Minimum Downtime
- SAP Note 2063657 - HANA System Replication takeover decision guideline
- SAP Note 1913302 - Connectivity suspend of Appserver during takeover.

The following SCN blogs also discuss the topic; please check there and feel free to comment:

For information about SAP HANA in general, see: http://help.sap.com/hana_appliance

3. Background Information

3.1 High Availability

SAP HANA offers different kinds of high availability mechanisms, supporting a broad range of recovery scenarios from various faults.

There are three basic scenarios:

- Host Auto-Failover: One (or more) standby nodes are added to an SAP HANA system and configured to work in standby mode. (SAP HANA scale-out).
- Storage Replication: The storage itself replicates all data to another location (this solution is provided by hardware partners). Disks are mirrored without a control process from the SAP HANA system.
- System Replication: SAP HANA replicates all data to a secondary SAP HANA system (standard SAP HANA feature). Data is constantly pre-loaded on the secondary system to minimize the recovery time objective (RTO).

This paper focuses on supporting decision making on SAP HANA system replication including setting up, testing and maintaining such a system. Of course, a comprehensive high availability solution offers more design choices and requires the discussion of more details than can be covered in a short paper; thus, additional consultation may be required.
3.2 System Replication

SAP HANA system replication ships all data to a secondary system located at another site:

Once SAP HANA system replication is enabled, each server process on the secondary system establishes a connection with its primary counterpart and requests a snapshot of the data. Now all logged changes in the primary system are replicated continuously. Each persisted redo log in the primary system is sent to the secondary. A transaction in the primary system is not committed before the redo logs are replicated.

SAP HANA Multitenant Database Containers (introduced with SPS09) can also run in an SAP HANA system replication configuration. The system as a whole is replicated\(^1\), i.e. the System DB and all tenant DBs. Just like in the single container HANA database each service of the primary site replicates to its counterpart on the secondary site.

While the system replication is running, the secondary system, which is configured identically to the primary, will be on standby until a takeover takes place.

---

\(^1\) Note that SAP HANA system replication on tenant database level is not supported.
3.2.1 Replication modes
Depending on customer requirements, SAP HANA offers different modes for replication:

- **Synchronous**: Secondary system sends acknowledgement back to primary as soon as data are received and persisted to disk.
- **Synchronous in-memory**: Secondary system sends acknowledgement back to primary as soon as data is received (this might lead to performance increase depending on disk speed).
- **Asynchronous**: As per design of asynchronous replication, the primary does not wait until the secondary sends an acknowledgement.

Additionally (as of SPS08) the *synchronous* replication mode (SYNC) can run with “full sync” enabled. In *full sync* operation, transaction processing on the primary site blocks, when the secondary is currently not connected and newly created redo log buffers cannot be shipped to the secondary site. This behavior ensures that no transaction can be committed locally without shipping the redo log buffers to the secondary site.

3.2.2 Operation modes
Since SPS11 SAP HANA system replication can be run in two different operation modes:

- **delta_datashipping**: In addition to the continuous redo log shipping taking place the secondary system requests a delta data shipping from time to time (per default every 10 minutes). During takeover the redo log needs to be replayed up to the last arrived delta data shipment. (This is the “classical” operation mode of SAP HANA system replication.)
- **logreplay**: In this operation mode pure redo log shipping is done after the system replication was initially set up with one full data shipping. The redo log is replayed on the secondary immediately after arrival making this step superfluous during a takeover, which shortens the RTO by factors. Additionally the amount of data which needs to be transferred to the secondary site is reduced dramatically, because no delta data shipping is required anymore.

Using the operation mode *logreplay* makes your secondary site in the SAP HANA system replication a *HotStandby* system.
3.2.3 Data transferred to the secondary

The HANA database sends two resp. three types of data “packages” over the network to the secondary side (depending on the configured operation mode), when system replication is configured:

- **Full data shipping**: A full set of the data created as HANA in-place snapshot on the disk of the primary is initially sent when system replication is set up.

- **Delta data shipping**: Only in delta_datashipping operation mode the increment of the data (i.e. every data that has changed since the last full or the last delta data shipping), is transported from time to time (default every 10 minutes) from the data area of the primary to the data area of the secondary.

- **Redo Log shipping**: Every committing write transaction on the primary generates redo log buffers that are continuously sent to the secondary site.

The following picture visualizes this traffic on the transportation channel between primary and secondary for the delta_datashipping operation mode.

In logreplay operation mode the delta data shipping is not required.
3.3 Takeover

The takeover process is the name for the task of switching your active system from the current primary system onto the secondary system\(^2\). Once the takeover command runs, the former secondary system becomes the new primary system. The takeover automatically performs some tasks before the system is fully available:

- Until SPS08 the row store tables were loaded into memory during takeover; since SPS09 the row store is kept in shared memory and thus is “pre-loaded”.
- Until SPS09 the row store indexes were rebuilt during takeover; with SPS10 rebuilding the secondary indexes during reactivation of the row store is done in a decoupled way, so it does not influence the takeover performance.
- Until SPS10 the redo log buffers shipped to the secondary site since the last delta data transport could first be replayed during takeover; with SPS11 and in logreplay operation mode the log is continuously replayed on the secondary site, increasing the takeover performance.

\(^2\) Note that a takeover does not include stopping the previous primary, if it is still running!
• If preload is used, the main parts of the column tables are already loaded into memory, as they were loaded in the primary. The first access to a table that was previously used in the primary loads the delta part only. The delta part is typically much smaller than the main part and can be loaded within seconds in most cases.

4. Planning

Let us discuss some facts, which need to be considered or decided during the planning phase.

4.1 Prerequisites

Before you start setting up SAP HANA system replication, you need to fulfill the following prerequisites:

• The primary and secondary systems are both installed and configured. You have verified that both are independently up and running.
• The number of nodes in the secondary system has to be equal to the number of active nodes in the primary system. (As of SPS06 the secondary system does not need to have standby nodes.)
• All configuration steps have to be executed on the master name server node; for SAP HANA Multitenant Database Containers this means on the System DB (and not on the tenant DBs).
• The SAP HANA software version of the secondary has to be equal to or newer than the one on the primary.
• The secondary system must have the same SAP system ID, <SID>, and instance number as the primary system. The primary replicates all relevant license information to the secondary.
• System replication between two systems on the same host is not supported.
• Changes to the ini file configuration parameters made on one system should be manually duplicated on the other system.

As of SPS06 the configuration parameter checker reports differences between primary and secondary parameter settings (generating alerts in the SAP HANA studio).

• The required ports must be available. The same <instance number> is used for primary and secondary systems. The <instance number>+1 must be free on both systems, because this port range is used for system replication communication.
• An initial data backup or snapshot must be performed on the primary before the system replication can be activated. In SAP HANA Multitenant Database
Containers all databases must have been backed up, i.e. the system DB as well as all tenant DBs³.

4.2 Distance between data centers
System replication offers synchronous and asynchronous replication modes to accommodate network latency.
If the distance between your sites is less than 100 km you can use a synchronous replication mode: *SYNC* or *SYNCMEM*.
For all data centers that are more than 100 km apart, the asynchronous replication mode *ASYNC* is recommended.

**Note**
Depending on latency, data volume, volume of changed data records, this could lead to loss of changes because of missing redo logs. Please also consider monitoring requirements for asynchronous mode.

4.3 Use secondary site for DEV/QA system
It is possible to make use of the secondary site for running DEV/QA systems while the primary system is in production.
The following prerequisites must be taken into account:

- Additional independent disk volume is needed for DEV/QA systems
- The SIDs and instance numbers have to be different for DEV/QA. The `<instance number>+1` of the productive system must not be used but must be free on both sites, because this port range is used for system replication communication.
- Preload of tables must be switched off on the Secondary:
  ```ini
global.ini/[system_replication]-> preload_column_tables=false
  ```
- The takeover process will take longer as no data is preloaded to memory on the secondary site (could still meet SLAs for disaster recovery)
- DEV/QA systems need to be shut down in case of a takeover.
- Additionally, the global allocation limit on the secondary must be set in a way that the available memory covers the memory needed by the secondary system as well as the DEV/QA systems:
  ```ini
global.ini/[memorymanager]-> global_allocation_limit
  ```

As of SPS11 the configured operation mode influences the memory size required on the secondary:

<table>
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<th>operation mode</th>
<th>memory needed on secondary</th>
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³In an already running SAP HANA system replication for a Multitenant Database Container HANA, every newly created tenant DB has to be backed up for the replication to start.
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<table>
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<th>delta_datashipping</th>
<th>minimum 64 GB or row store size⁴ + 20 GB (if this sum is higher)⁵</th>
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<td>logreplay</td>
<td>size of loaded column tables (in-memory)⁶ + row store size⁴ + 50 GB</td>
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If the row store size grows during operation of the primary, it might become necessary to increase the `global_allocation_limit` on the secondary site. As of SPS07 it is possible to change the `global.ini` on the secondary accordingly and then activate the change with “hdbnsutil –reconfig” (because no SQL is possible in this state).

### 4.4 License Validity

The primary system automatically replicates relevant license information to the secondary. In the current active/passive system replication implementation – where no SQL is possible on the secondary system – no additional license needs to be installed, since the primary and secondary have the same SID and the secondary cannot be accessed by applications.

Further information on licensing in SAP HANA system replication can be found in SAP note 2211663.

### 5. Configuration steps

This section describes the following steps:

- Perform an initial data backup or a storage snapshot using native HANA options. An initial data backup or snapshot is mandatory but an up-to-date backup is highly recommended anyway
- Enable the primary system for system replication
- Establish a connection between secondary and primary system
- Initiate a full data replication by configuring system replication on the secondary and starting it – thereafter incremental data replication (only in delta_datashipping operation mode) and continuous redo log replication occurs (automatic process)
- Disable system replication on secondary system

---

⁴ The row store size can be determined with this SQL statement:
```sql
select host, round(sum(page_size*USED_BLOCK_COUNT)/1024/1024/1024,2) as "RowStore Size GB"
from m_data_volume_page_statistics where page_sizeclass = '16k-RowStore' group by host;
```

⁵ If this limit is not set, the HANA database on the secondary site uses as much memory as it can get and possibly takes it away from the DEV/QA systems, which could run into out-of-memory.

⁶ The size of loaded column tables (in-memory) can be found with this SQL statement:
```sql
select round(sum(memory_size_in_total)/1024/1024/1024) size_GB from m_cs_tables;
```
• Disable system replication on primary system
• Monitor status of system replication to ensure that both systems are active and in sync

System replication can be set up on the console via command line or using the SAP HANA studio. The primary system stays online during this procedure.

For testing purposes SAP HANA studio provides an easy way to set up and maintain system replication, whereas during run time the command line will probably be used, because it can be a part of a script, which executes further steps beyond system replication.

5.1 Configure system replication

5.1.1 Using SAP HANA studio

Use the SAP HANA studio to set up system replication between two identically configured systems:

Create a data backup of the primary system. Right mouse-click on dedicated primary → Backup and Recovery → Back Up System.

7 In SAP HANA Multitenant Database Containers, the System DB as well as all tenant DBs have to be backed up.
Alternatively you could create a storage snapshot. Right mouse-click on dedicated primary → Backup and Recovery → Manage Storage Snapshot:

Prepare:

Confirm:

A data backup can also be created using the SAP HANA Cockpit “Data Backup” application accessed via the corresponding tile. (For details please read the corresponding section in the SAP HANA Admin guide.)

In SAP HANA Multitenant Database Containers, the data backups must be created for the System DB as well as for all tenant DBs. However, the setup steps described in the following sections have to be executed on the System DB only.
Right mouse-click on Primary System → *Configuration and Monitoring* → *Configure System Replication*\(^8\) ... Check the radio button to enable system replication:

Give the primary a logical name, for example SITEA:

Stop the secondary system with right mouse-click on Secondary System → *Configuration and Monitoring* → *Stop System*

Register the secondary: Right mouse-click on Secondary System → *Configuration and Monitoring* → *Configure System Replication* ... Check radio button “Register secondary system”:

Type a logical name for the secondary, choose a replication mode, an operation mode, and enter the primary site’s host name:

---

\(^8\) Only the actions that are possible in the current system state will be offered to you. In this case only the “enable” is possible.
Once the secondary system is automatically started, the replication process will also start automatically.

### 5.1.2 Using command line tool hdbnsutil

Alternatively use the command line tool hdbnsutil as `<sid>adm` on OS level.

Create a data backup of the primary system (see the section Backup and Recovery in the SAP HANA Administration Guide):

```
hdbsql BACKUP DATA USING FILE ('<path><prefix>')
```

In **SAP HANA Multitenant Database Containers** all databases must be backed up using the "hdbsql" tool via the database name option:

- for the system DB `"-d SystemDB"` resp.
- for the tenant DBs `"-d <tenantDBName>"`.

Enable the primary system and give the primary a logical name, for example SITEA:

```
hdbnsutil -sr_enable --name=SITEA
```

Stop the secondary system:

```
sapcontrol –nr <instance_number> -function StopSystem HDB
```

Register the secondary system, provide a logical name (for example SITEB), and choose a replication mode and the operation mode:

```
hdbnsutil -sr_register --remoteHost=<primary hostname>
   --remoteInstance=<instance number>
   --replicationMode=<sync|syncmem|async>
   --operationMode=<delta_datashipping|logreplay> --name=SITEB
```
Start the secondary system to start replication:
```
sapcontrol -nr <instance_number> -function StartSystem HDB
```

Once the secondary system is started, the replication process will start automatically.

### 5.1.3 Creating a tenant DB in a running system replication

After a new tenant DB was created in a SAP HANA Multitenant Database Containers system running with SAP HANA system replication, a backup of this new tenant DB is necessary. Otherwise the replication will not start.

### 5.2 Disable system replication

#### 5.2.1 Using SAP HANA studio

Stop the secondary system with right mouse-click on Secondary System → Configuration and Monitoring → Stop System

On secondary system: Unregister system replication for the secondary system with right mouse-click on Secondary System → Configuration and Monitoring → Configure System Replication ... :

On primary system: Disable system replication on the primary system with right mouse-click on Primary System → Configuration and Monitoring → Configure System Replication ...:
5.2.2 Using command line tool **hdbnsutil**

Stop the secondary system:
```
sapcontrol -nr <instance_number> -function StopSystem HDB
```

On secondary system unregister the secondary system:
```
hdbnsutil -sr_unregister
```

On primary system disable system replication:
```
hdbnsutil -sr_disable
```

5.3 Setting up Multitier System Replication

As of SPS07 with the Multitier System Replication, a synchronous system replication can be used as the source for asynchronous replication in a chained setup of primary site, tier-2 secondary site and tier-3 secondary site.

The primary site **synchronously** replicates to the tier-2 secondary site and the tier-2 secondary site **asynchronously** replicates to the tier-3 secondary site.

---

9 Currently only asynchronous replication is supported for the connection between the tier 2 and the tier 3 secondary site.
Given a synchronously running 2-tier system replication (as described above) the following steps are to be executed to add the tier-3 secondary; this third site must fulfill the same prerequisites as described in 4.1.

5.3.1 Using SAP HANA studio

Use the SAP HANA studio to add a tier-3 secondary to a system replication landscape:

- Right mouse-click on the tier-2 secondary → **Configuration and Monitoring** → **Configure System Replication** ...

Check the radio button to enable system replication – site name is already known from topology:

Stop the tier-3 secondary system with right mouse-click → **Configuration and Monitoring** → **Stop System**.

Register the tier-3 secondary: Right mouse-click on tier-3 secondary system → **Configuration and Monitoring** → **Configure System Replication**...
Type a logical name for the tier-3 secondary, choose replication mode **ASYNC**, the **same operation mode** as for the primary and tier-2 secondary (in this example: `logreplay`) and enter the tier-2 secondary site’s host name:

![Register the system as the secondary system of the primary system or tier 2 secondary system (source system).](image)

Once the secondary system is automatically started the replication process to the tier-3 secondary will also start automatically.

⚠️ In **Multitier System Replication** the **operation mode** must be the same for all sites.

### 5.3.2 Using command line tool `hdbnsutil`

1. Tier-2 secondary: `hdbnsutil -sr_enable`
2. Tier-3 secondary: `sapcontrol -nr <instance_number> -function StopSystem HDB`
3. Tier-3 secondary:
   
   ```
   hdbnsutil -sr_register --remoteHost=<tier_2_host> 
   --remoteInstance=<instance_number> --replicationMode=async 
   --operationMode=<delta_datashipping|logreplay> --name=SITEC
   ```
4. Tier-3 secondary: `sapcontrol -nr <instance_number> -function StartSystem HDB`
5.4 Enabling full sync replication

As of SPS08 to reach a true RPO=0 for synchronous system replication, the full sync option can be enabled for SYNC replication (i.e. not for SYNCMEM). With the activated full sync option, transaction processing on the primary blocks when the secondary is currently not connected and newly created log buffers cannot be shipped to the secondary site. This behavior ensures that no transaction can be locally committed without shipping the log buffers to the secondary site.

The full sync option can be switched on and off using the command

   hdbnsutil -sr_fullsync --enable|--disable

It changes the setting of the global.ini file accordingly:

   global.ini/[system_replication]/enable_full_sync

However, in a running system, full sync might not become active immediately. This is done to prevent the system from blocking transactions immediately when setting the parameter to true. Instead, in a first step, full sync has to be enabled by the administrator. In a second step it is internally activated, when the secondary is connected and becomes ACTIVE.

In the M_SERVICE_REPLICATION system view the setting of the full sync option can be viewed in the column “FULL_SYNC”. It can have the following values:

- **DISABLED**: full sync is not configured at all
  
  global.ini/[system_replication]/enable_full_sync = false

- **ENABLED**: full sync is configured, but it is not yet active, so transactions do not block in this state. To become active the secondary has to connect and REPlication_STATUS has to be ACTIVE.

- **ACTIVE**: full sync mode is configured and active. If a connection of a connected secondary is getting closed, transactions on the primary side will block in this state.

If full sync is enabled when an active secondary is currently connected, the FULL_SYNC will be immediately set to ACTIVE.

⚠️ Resolving a blocking situation of the primary caused by the enabled full sync option must be done with the hdbnsutil command, since also a configuration changing command could block in this state.

6. Takeover

6.1 Perform Takeover

The following steps are performed:
• Trigger a takeover to the secondary system in the event of a disaster.
• Register the former primary system as new secondary when it becomes available again.

The takeover can be triggered from the command line or from the SAP HANA Studio.

Depending on the scenario a second takeover back to the primary site can be performed once the two systems are in sync.

6.1.1 Using SAP HANA studio

On secondary system: Perform a takeover with right mouse-click on Secondary System → Configuration and Monitoring → Configure System Replication ...

When the former primary is available again it can be registered as secondary.

Stop original (former) primary system.

On original (former) primary system: Register system as secondary with right mouse-click on former Primary System → Configuration and Monitoring → Configure System Replication ...

You will be informed that this system used to be the primary system before.
6.1.2 Using command line tool hdbnsutil

1. Perform a takeover on the secondary:
   hdbnsutil -sr_takeover

2. When the former primary is available again it can be registered as the new secondary:
   hdbnsutil -sr_register --remoteHost=<new primary hostname>
   --remoteInstance=<instance number>
   --replicationMode=<sync/syncmem/async>
   --operationMode=<delta_datashipping|logreplay> --name=SITEA

6.2 Client connection recovery

To perform the takeover only on the SAP HANA system will, in most cases, not be enough. Somehow the client or application server needs to be able to continuously reach the SAP HANA system, no matter which site is currently the primary. There are several methods:

- IP redirection: A virtual IP address is assigned to the virtual host name. In case of a takeover, the virtual IP will unbind from the network adapter of the primary system and bind to the adapter on the secondary system.
- DNS redirection: In this scenario the IP for the host name in the DNS will be changed from the address of the primary to the address of the secondary system.

Both methods have their advantages but it will be mostly decided by the IT policies and existing configuration. If there are no existing constraints, IP redirection has the clear benefit of being faster to process in a script rather than synchronizing changes of DNS entries over a global network.
Since SPS09 SAP HANA offers the so-called **HA/DR providers** which are capable of informing external entities about activities inside SAP HANA scale-out (such as Host Auto-Failover) and SAP HANA system replication setups. In a Python script actions can be defined which should be executed before or after certain HANA activities (like startup, shutdown, failover, takeover, connectionChanged, ...). One example for these so-called hooks is moving virtual IP addresses after takeover in SAP HANA system replication. Additionally external cluster management software can be used to perform the client reconnect after takeover.

# 7. Resync optimization

Whenever the primary and the secondary sites are disconnected (e.g. due to network problems, a temporarily stopped primary or secondary, or after a takeover and prior to a failback where the former primary is registered as new secondary), the replication is out of sync. To get in sync again after reconnect the SAP HANA system replication tries to achieve this by initiating a delta shipping of the missing data (instead of a full data shipping).

For the "**delta_datashipping**" and "**logreplay**" operation modes (introduced with SPS11) two different attempts are in place to achieve this: **Data Retention** and **Log Retention**.

## 7.1 Data Retention

In the SAP HANA system replication operation mode "**delta_datashipping**" the primary sends the incremental data to resync after a disconnect or for a failback, if the last snapshot, that was successfully sent to the secondary, is still available. How long it is kept depends on the value of the parameter `datashipping_snapshot_max_retention_time` (default: 120 minutes). If it is not available anymore, a full set of data is necessary to get in sync again.

## 7.2 Log Retention

In the SAP HANA system replication operation mode "**logreplay**" the secondary site only uses the log of the online log area of the primary for re-syncing. After the reconnect or a failback the primary sends the incremental log. Thus, the log must be retained for a longer time (than in **delta_datashipping** operation mode); log segments will not be freed, while the secondary is disconnected.

### 7.2.1 Log Retention for Secondary Disconnect (on primary)

The **primary** will not reuse log segments in the online log area that are required to sync the secondary via **delta log shipping**.

If the secondary is disconnected – but still registered...
• The log segments are retained on the primary and marked as RetainedFree until secondary has successfully synced again
• The log volume will grow on the primary site, until it has filled up with log segment

In HANA studio this can be monitored on the primary system form the tab Volumes by selecting the corresponding log volume

Once the secondary system reconnects and has synced the missing log, these log segments are set to Free and can be reused\(^{10}\) after that.

Depending on the setting of the parameter logshipping_max_retention_size a full log volume can be prevented at the price of a possibly necessary full data shipping when the system reconnects.

This behavior is automatically turned on, if a secondary system with operation mode logreplay is registered.

\(^{10}\) Log segments marked as “Free” can be reclaimed to free the disk space of these currently unused log segments using this console command: \texttt{hdbcons -e <service> “log release”}. 
Caution
If a secondary site is shut down and not used for a longer period of time unregister (hdbnsutil -sr_unregister) to prevent log volumes from filling up on the primary site!

7.2.2 Log Retention for Failback (on secondary)

On the secondary site, log retention is required to do a failback with optimized data synchronization. The primary periodically creates persistence snapshots during replication (every 20 min resp. 5 GB) and provides the log position information to the secondary. After takeover, when the old primary is started as secondary, the most recent snapshot is opened on the old primary and the missing log – up to this snapshot – is requested from the new primary.

Log retention can occur in two situations:

- **While replication is active**
  - The secondary keeps all log starting from the last snapshot position provided by the primary site
  - The old log is automatically released after a new snapshot has been created on the primary site
  - This is active by default and ensures that during replication only a few RetainedFree segments are kept online needed to fill the gap between the primary snapshot and the current potential takeover log position

- **After a takeover**
  - The new primary has to keep the log until a new secondary site is registered and has synced the missing log
  - Because syncing can take some time this behavior has to be explicitly turned on by setting this parameter on the new primary global.ini/[system_replication]/enable_log_retention = on

Caution
If the old primary will not be reused as new secondary (failback), it should be disabled after the takeover (hdbnsutil -sr_disable) to prevent log volumes from filling up on the new primary site.

11 Please check SAP Note 1945676 - Correct usage of hdbnsutil -sr_unregister
If you have a setup in which there will be frequent failbacks between two sites, we recommend that you set the following parameter on both sites to simplify configuration:

```
global.ini/[system_replication]/enable_log_retention = on
```

### 7.2.3 Log Retention Parameters

There are two ini parameters to be mentioned in the context of log retention with operation mode logreplay in global.ini/[system_replication] section:

- `enable_log_retention = auto|on|off`
  - auto
    - Enable log retention on primary for re-connect
  - On
    - Enable log retention always
      → required after takeover for failback with delta log shipping
- `logshipping_max_retention_size = 1048576 (MB), default: 1 TB`
  - Specifies how the system behaves when many log segments of type RetainedFree are created
  - Maximum amount of log that will be kept on primary side for syncing a system replication secondary system:
    - **Soft limit** if set <> 0
      → If the limit is reached, segment in state RetainedFree are reused in disk full; then a full data shipping is required, i.e. the secondary needs to be newly registered (sr_register)
    - **Hard limit** if set to 0
      → Primary standstill, in case disk on primary runs full

### 8. Testing

The test phase is a very important phase to verify if KPIs are met and the landscape performs the way it was configured. Therefore, a few test cases are suggested below as guideline, which should be enhanced by your specific requirements. The tests should be performed with realistic data load and size.

<table>
<thead>
<tr>
<th>Test case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Replication</td>
<td>Measure how long the initial synchronization takes, from when replication is started until primary and secondary are in sync.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Lost Connection</th>
<th>Measure how long it takes until primary and secondary are back in sync after the connection is re-established.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takeover</td>
<td>Measure how long it takes for the secondary system to be fully available after a takeover command.</td>
</tr>
<tr>
<td>Data Consistency</td>
<td>Create or change data, then perform a takeover and check if the data is still available.</td>
</tr>
<tr>
<td>Client Reconnect</td>
<td>Test client access after a take-over, to check if the DNS/Virtual IP switch worked.</td>
</tr>
<tr>
<td>Primary becomes secondary</td>
<td>Measure how long it takes until both systems are in sync, when the former primary becomes the secondary after a takeover.</td>
</tr>
</tbody>
</table>

9. Operation / Maintenance

There are multiple ways to monitor SAP HANA, which are described in the SAP HANA Administration Guide and SAP Solution Manager\(^\text{12}\).

And there are various ways to verify if the primary and secondary systems are in sync and are running correctly.

9.1.1 Alerts

With SPS09 system replication specific alerts were introduced (they are no longer hidden behind “Internal Events”):

- System Replication Connection Closed (Alert ID 78)
- System Replication Configuration Parameter Mismatch (Alert ID 79)

These alerts are only visible with the Embedded Statistics Server (ESS)\(^\text{13}\), however, old style alerts are still generated in order not to invalidate any reporting infrastructure after migration.

Old alerting can be disabled by setting the following configuration parameter in `global.ini`:

```ini
[system_replication]
keep_old_style_alert = false (default=true)
```

To receive e-mail notification of alerts, you can configure check 78 and 79 as described in the SAP HANA Admin guide (see *Configure E-Mail Notifications for Alerts*).

---

\(^{12}\) For SAP Solution Manager please consider [Note 1747682 - SolMan 7.1: Managed System Setup for HANA](https://support.sap.com/notes/1747682).

\(^{13}\) Migration of the classic statistics server to the Embedded Statistics Server is described in SAP note [1917938](https://support.sap.com/notes/1917938).
9.2 Verification

9.2.1 Using SAP HANA cockpit

Since SPS10 the SAP HANA cockpit\textsuperscript{14} offers a system replication monitoring application. You can access it from a browser by using this address: 
<hostname>:80<sid>/sap/hana/admin/cockpit

If system replication is configured, the corresponding tile appears on the main screen providing information about the type of landscape (2-tier or multitier), the replication mode between the primary and the tier-2 secondary as well as an overall replication status:

![SAP HANA cockpit with system replication tile](image)

The System Replication tile\textsuperscript{15} displays the following states at a glance:

- Not configured (meaning system replication is not configured)
- All services are active and in sync (green square)
- All services are active but not yet in sync (yellow triangle)
- Errors in Replication (red circle)

To check the status of replication in detail, click on the System Replication tile. The application lists details about the system replication configuration and status. On

---


\textsuperscript{15} If the tile does not show up, you have to grant the system replication role to the corresponding user, e. g. in the HANA studio right mouse-click on the corresponding user in the landscape overview under Security \rightarrow on the "Granted Roles tab" click on "+" \rightarrow filter for "sysrep" and select corresponding role.
top, the “chain” of systems with their replication modes is shown containing further information about the sites and the network connections between them.

When a “site” view is activated, like in the picture below the “Primary”, an excerpt of the M_SERVICE_REPLICATION is shown. The displayed table shows at a glance per site and service the replication state per service.

If you click on one row, you can see the details for the corresponding service grouped thematically (see below):
If a “network” view is activated, like in the picture below the network connection used for **SYNC** replication, the “**Avg. Write Wait Time ms**” is given on top. It describes how long it took on average to send redo log buffers of “**Avg. Log Buffer Size**” to the secondary site based on measurements of the last 24 hours.  

A graph appears comparing the **local write wait time** (i.e. writing redo log buffer into the local log volume) with the **remote write wait time** (i.e. shipping the redo log and receiving the acknowledgement) monitored over the last 24 hours. At a glance, one can see if peak times occurred and how the network connection reacted.

If the **ASYNC** replication mode is configured between two sites, like in this example between tier-2 and tier-3, you also receive information about the network performance by clicking on the corresponding field as shown below:

---

16 For synchronous replication, this is the round trip time for sending the redo log buffer and receiving the acknowledgement; for asynchronous replication it refers to the time it takes, until the log buffer was sent after its creation.
Here the “Avg. Write Wait Time ms” describes the time it took from the creation of the redo log buffer (i.e. committing a write transaction) until the redo log buffer in fact was sent out to the network. This value is an indicator for peak load phases and could point to network or I/O problems\(^{17}\) on the secondary site, which can influence the primary’s performance as well.

When activating the “alerts” link on top, the system replication specific alerts (closed connection, parameter differences on the involved sites) that occurred recently, are shown. It jumps directly into the alert application provided by the HANA Cockpit.

\(^{17}\) If the receiving OS buffer on the secondary cannot write down the incoming redo log buffers to disk due to I/O problems, this buffer can run full and is not able to accept newly shipped buffer fast enough.
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9.2.2 Using SAP HANA studio

Check the overall status on the primary’s Overview tab. This should state “All services are active and in sync”:

To check the status of the replication in detail: Select Landscape tab → system replication (shows information from system view M_SERVICE_REPLICATION with a lot of columns):
For all services, the `REPLICATION_STATUS` should be "ACTIVE". Detailed information about shipped sizes and shipping times are available.

### 9.2.3 Check via SQL query

Or directly get system replication specific information from the system view `M_SERVICE_REPLICATION`. On the primary execute:

```sql
select * from "SYS"."M_SERVICE_REPLICATION";
```

Since SPS09 the contents of the view `M_SERVICE_REPLICATION` are collected by the statistics server every hour. Thus, the history of data and log replication can be viewed in the table. On the primary execute the following command to view the data replicated by the indexservers (volume 4 in this example) from the primary to the tier-2 secondary:

```sql
select * from "SYS_STATISTICS"."HOST_SERVICE_REPLICATION"
where volume_id=4 and site_id=1;
```

### 9.2.4 Using command line tool `hdbnsutil`

To view the system replication topology configuration status on both systems, execute `hdbnsutil -sr_state` on the primary and the secondary:

```
tedadm@ld2131:/usr/sap/TED/HDB07> hdbnsutil -sr_state
checking for active or inactive nameserver ...
System Replication State
~~~~~~~~~~~~~~~~~~~~~~~~
mode: primary
site id: 1
site name: SITEA
Host Mappings:
```

---

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For a Multitier System Replication the mappings of all three sites are displayed:

```
ld2131 -> [SITEA] ld2131
ld2131 -> [SITEB] ld2132
done.
```

```
For a Multitier System Replication the mappings of all three sites are displayed:
```

```
utiladm@ld2131:/usr/sap/UT1/HDB01> hdbnsutil -sr_state
checking for active or inactive nameserver ...
System Replication State
~~~~~~~~~~~~~~
mode: primary
site id: 1
site name: SITEA
Host Mappings:
~~~~~~~~~~~~~~
ld2131 -> [SITEA] ld2131
ld2131 -> [SITEC] ld2133
ld2131 -> [SITEB] ld2132
done.
```

When using the additional option `--sapcontrol=1` the key-value-pair output can be parsed by a script line by line.

Here is the output where the `-sr_state` command was executed on a primary site of a Multitier System Replication:

```
utiladm@ld2131:/usr/sap/UT1/HDB01> hdbnsutil -sr_state --sapcontrol=1
cHECKING FOR ACTIVE OR INACTIVE NAMESERVER ...
SAPCONTROL-OK: <begin>
mode=primary
site id=1
site name=SITEA
mapping/ld2131=SITEA/ld2131
mapping/ld2131=SITEC/ld2133
mapping/ld2131=SITEB/ld2132
SAPCONTROL-OK: <end>
done.
```

Here is the output where the `-sr_state` command was executed on a tier-2 secondary site of a Multitier System Replication:

```
utiladm@ld2132:/usr/sap/UT1/HDB01> hdbnsutil -sr_state --sapcontrol=1
cHECKING FOR ACTIVE OR INACTIVE NAMESERVER ...
SAPCONTROL-OK: <begin>
mode=sync
site id=2
site name=SITEB
active primary site=1
mapping/ld2132=SITEA/ld2131
mapping/ld2132=SITEC/ld2133
mapping/ld2132=SITEB/ld2132
primary masters=ld2131
SAPCONTROL-OK: <end>
done.
```
Further explanation of the output:

- **mode** – can have the values `primary`, `sync`, `async`, and `syncmem` to represent the mode relevant on the site where the command is executed (e.g. in a Multitier System Replication on the primary the mode would be `primary`, on the tier-2 secondary it could be either `sync` or `syncmem`, and on the tier-3 secondary it is `async`).
- **site id** – is a unique identifier of a site which is incremented for each site attached to a SAP HANA system replication. It is first removed, when the system replication is disabled.
- **site name** – is the name you give your sites during the `enable` and `register` steps of system replication configuration.
- **mapping/<currentHost>** – shows which hosts are involved in this SAP HANA system replication together with their `site name`; if the HANA database is offline, this host mapping cannot be shown on the secondaries.
- **active primary site** – shows the `site id` of the currently active site.
- **primary masters** – shows the hostname(s) of the currently active master candidates of the primary.

### 9.3 System Replication status checks

There are some ways to gather information about the overall status of the sites and of the system replication.

#### 9.3.1 Using `landscapeHostConfiguration.py`

Check the overall status of the primary system using as `<sid>adm` OS user the script `landscapeHostConfiguration.py` (located in `$DIR_INSTANCE/exe/python_support`).

```
<sid>adm$ python $DIR_INSTANCE/exe/python_support/landscapeHostConfiguration.py

<table>
<thead>
<tr>
<th>Host</th>
<th>Host</th>
<th>Host</th>
<th>...</th>
<th>NameServer</th>
<th>NameServer</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------------</td>
<td>------------</td>
<td>------</td>
</tr>
<tr>
<td>host1</td>
<td>yes</td>
<td>ok</td>
<td>...</td>
<td>master 1</td>
<td>master</td>
<td>...</td>
</tr>
<tr>
<td>host2</td>
<td>yes</td>
<td>ok</td>
<td>...</td>
<td>master 2</td>
<td>slave</td>
<td>...</td>
</tr>
</tbody>
</table>

overall host status: ok
```

The following host states are possible:

- **OK**: System is OK.
- **WARNING**: A host auto-failover to a standby host is taking place.

---

18 **IMPORTANT**: In a Multitier System Replication on tier-3 the given “primary” is the tier-2 secondary – which from this perspective is the primary for this tier-3.
• INFORMATION: The landscape is completely functional, but the current (actual) role of the host differs from the configured role.
• ERROR: There are not enough active hosts.

9.3.2 Using systemReplicationStatus.py

Check the overall status of the system replication using as `<sid>adm` OS user the script `systemReplicationStatus.py` (located in `$DIR_INSTANCE/exe/python_support`).

```
<sid>adm># python $DIR_INSTANCE/exe/python_support/systemReplicationStatus.py
| Host   | Service Name     | Site Name | Secondary |  ...  | Replication |...
| ------ | ---------------- | --------- |  --------- | ----- | ----------- |---
| ------ | ---------------- | --------- |  --------- | ----- | ----------- |---
| ld7805 | indexserver      | WALLDORF  | ld8475     |  ...  | ACTIVE      |
| ld8513 | statisticsserver | WALLDORF  | ld8476     |       | ACTIVE      |
| ld8513 | xsengine         | WALLDORF  | ld8476     |       | ACTIVE      |
| ld8513 | nameserver       | WALLDORF  | ld8476     |       | ACTIVE      |
| ld8513 | indexserver      | WALLDORF  | ld8476     |       | ACTIVE      |
| ld8559 | indexserver      | WALLDORF  | NOT MAPPED |       |             |
overall system replication status: ACTIVE
```

The script provides the following return codes.

• 10: No System Replication
• 11: Error
• 12: Unknown
• 13: Initializing
• 14: Syncing
• 15: Active

9.3.3 Using console

To check the replication status on all hosts and for all services the HDB console can be used. Especially in case of ASYNC replication this will provide some additional information currently not shown by the system view, because in this mode no acknowledgement is shipped and documented in the system view.

In this case an option is to check the current log position on the secondary using `hdbcons` on the secondary side – where currently no SQL is possible – on each node and for each persistency relevant service:

```
<sid>adm># hdbcons -e hdbindexserver "replication info"
SAP HANA DB Management Client Console (type '?' to get help for client commands)
Try to open connection to server process 'hdbindexserver' on system 'M19', instance '19'
SAP HANA DB Management Server Console (type 'help' to get help for server commands)
Executable: hdbindexserver (PID: 66110)
[OK]
--
listing default statistics for volume 3
```
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System Replication Secondary Information

System Replication Secondary Configuration

```
[system_replication] site_id = 2
[system_replication] site_name = SiteA
[system_replication] mode = sync
[system_replication] operation_mode = logreplay
[system_replication] datashipping_min_logsize_threshold = 5368709120
[system_replication] datashipping_min_time_interval = 600
[system_replication] reconnect_time_interval = 30
[system_replication] enable_log_compression = false
[system_replication] preload_column_tables = true
[system_replication] ensure_backup_history = true
[system_replication] keep_old_style_alert = false
[system_replication] enable_log_retention = 1
[system_replication] logshipping_max_retention_size = 1048576
```

Last Primary Host: ld2133
Last Primary Port: 32003

Log Connection
- ptr : 0x00007fd58931a400
- channel : NetworkChannel FD 25 [0x00007fd5ad064a98] (refCnt=3, idx=2) 10.96.4.20/65117_tcp->10.96.4.22/32003_tcp Connected,[r---]
- mode : ReplicationMode_Synchronous
- logSinceLastBackup : 663552 bytes
- timeSinceLastBackup : 67431655 microseconds

Data Connection
- ptr : 0x00007fd589315000
- channel : NetworkChannel FD 31 [0x00007fd5ad064c58] (refCnt=2, idx=3) 10.96.4.20/65118_tcp->10.96.4.22/32003_tcp Connected,[----]

Secondary Statistics
- Creation Timestamp : 08.12.2015-14.25.27 (1449584727282603)
- Last Reset Timestamp : 08.12.2015-14.25.27 (1449584727282603)
- ReplicationMode : sync
- OperationMode : logreplay
- ReplicationStatus : ReplicationStatus_Active
- ReplicationStatusDetails :
- ReplicationFullSync : DISABLED
- shippedLogPos : 0x641cbb00
- shippedLogPosTimestamp : 08.12.2015-14.59.17 (1449586757965706)
- sentLogPos : 0x0
- sentLogPosTimestamp : 01.01.1970-00.00.00 (0)
- shippedLogBuffersCount : 11241
- shippedLogBuffersSize : 833585280 bytes
- shippedLogBuffersSizeUsed : 8309875456 bytes (99.69%)
- shippedLogBuffersSizeNet : 8309875456 bytes (99.69%)
- shippedLogBufferDuration : 0 microseconds
- shippedLogBufferDurationMin : 0 microseconds
- shippedLogBufferDurationMax : 0 microseconds
- shippedLogBufferDurationSend : 0 microseconds
- shippedLogBufferDurationComp : 0 microseconds
- shippedLogBufferThroughput : 0.00 bytes/s
- replayFinishLogPos : 0x641cbb00
- replayFinishLogPosTimestamp : 08.12.2015-14.59.17 (1449586757965706)
- replayStartLogPos : 0x641cbb00
- replayPushLogPos : 0x641cbb00
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- replayRetentionLogPos : 0x62a66fcb
- replayStepCount : 61709
- replayLogSize : 833581056 bytes
- replayDuration : 111608005 microseconds

- shippedSavepointVersion : 2252
- shippedSavepointLogPos : 0x5c595f82
- shippedSavepointTimestamp : 08.12.2015-14.25.28 (1449584728678668)

- shippedFullBackupCount : 1
- shippedFullBackupSize : 17884512256 bytes
- shippedFullBackupSizeNet : 17884512256 bytes (100.00%)
- shippedFullBackupDuration : 81098893 microseconds
- shippedFullBackupDurationComp : 0 microseconds
- shippedFullBackupThroughput : 220527205.67 bytes/s

- shippedLastFullBackupSize : 17884512256 bytes
- shippedLastFullBackupSizeNet : 17884512256 bytes (100.00%)
- shippedLastFullBackupStart : 08.12.2015-14.25.28 (1449584728678668)
- shippedLastFullBackupEnd : 08.12.2015-14.26.49 (1449584809777561)
- shippedLastFullBackupDuration : 81098893 microseconds

- shippedDeltaBackupCount : 0
- shippedDeltaBackupSize : 0 bytes
- shippedDeltaBackupSizeNet : 0 bytes (-nan%)
- shippedDeltaBackupDuration : 0 microseconds
- shippedDeltaBackupThroughput : 0.00 bytes/s

- shippedLastDeltaBackupSize : 0 bytes
- shippedLastDeltaBackupSizeNet : 0 bytes (-nan%)
- shippedLastDeltaBackupStart : not set
- shippedLastDeltaBackupEnd : not set
- shippedLastDeltaBackupDuration : 0 microseconds

- Secondary sync'ed via Log Count : 0
- syncLogCount : 0
- syncLogSize : 0 bytes
- Secondary Backup History : complete
- shippedMissingLogCount : 0
- shippedMissingLogSize : 0 bytes
- backlogSize : 0 bytes
- backlogTime : 0 microseconds
- backlogSizeMax : 0 bytes
- backlogTimeMax : 0 microseconds

- Secondary Log Connect time : 08.12.2015-14.25.27 (1449584727296916)
- Secondary Data Connect time : 08.12.2015-14.25.27 (1449584727491743)
- Secondary Log Close time : not set
- Secondary Data Close time : not set
- Secondary Log Reconnect Count : 0
- Secondary Log Failover Count : 0
- Secondary Data Reconnect Count : 0
- Secondary Data Failover Count : 0

[OK]
--
[EXIT]
--
[BYE]

Here you get information about the used replication and operation modes (mode, operation_mode). You see which IP address is used for data and log transfer (Log connection and Data connection) and – since this system replication
example is running with operation mode logreplay – you can see how far the log replay is on this secondary (the delta between shippedLogPos and replayFinishLogPos). For all services the ReplicationStatus should be ReplicationStatus_Active.

9.3.4 Using imported SQL statement

Attached to this SAP note https://service.sap.com/sap/support/notes/1969700 is a set of complex SQL statements – including some system replication relevant statements. These statements can be imported to and executed in the SAP HANA studio as follows:

For the primary system go to the System Information tab and right-click on the “Name” column \rightarrow Import SQL Statements.

Select the “SQL Statements.zip” you downloaded from the SAP note:

A folder with the SQL statements will be imported. Right-click on the statements under Replication \rightarrow Overview and Executed a statement – for example the Overview:

You will receive a lot of information about the system replication landscape and the per service replication state:
Of interest are for example the “Local log buffer write throughput (MB/s)” compared to the “Log buffer shipping throughput (MB/s)” in synchronous replication. For synchronous replication this could for example be an indication for network problems or a problem with the I/O on the secondary side (for SYNC), if these two values differ too much.

9.4 Monitoring ini file parameter changes

ini file parameters basically should be the same on the primary and secondary system and are checked automatically. The Configuration parameter checker reports differences between primary and secondary if parameters differ.

In the first version, those checks:

- Are done every hour by default
- Generate alerts (visible in SAP HANA studio as internal event and the system view M_EVENTS)

19 How you can setup an e-mail notification is described in the SAP HANA Admin guide in section: Configure E-Mail Notifications for Alerts.
In the `global.ini` an exclusion list can be maintained to exclude parameters to be checked:

```
[global.ini/[inifile_checker]]
enable = true|false
interval = 3600
exclusion_global.ini/SYSTEM = storage/*, persistence/*path*,
*hostname_resolution*, system_replication/*
exclusion_nameserver.ini/SYSTEM = landscape/*
exclusion_daemon.ini/HOST = */instances
exclusion_* = traceprofile_*
```

If you used your secondary system for DEV/QA systems and set the global allocation limit to its minimal value (as described above), you may exclude this parameter `global_allocation_limit` from these checks.

### 9.5 Monitoring the secondary site

Since SPS11 there is a possibility to monitor the secondary site using so-called proxy views. They provide remote SQL access on the primary – through *proxy schemas and views* – allowing for monitoring and reporting of secondary site statistics (for any replication mode). During registration of a secondary system, the new proxy schema on the primary site is created for each registered secondary site. The schema follows the naming convention `_SYS_SR_SITE_<siteName>` and contains a selected subset of monitoring views, which proxies the statistics from the secondary site. Proxy views have the same column definitions as the equivalently named public synonyms already available for the primary. When a secondary site is unregistered the corresponding schema will be dropped.

In the HANA studio in the landscape overview just open the `Catalog` and the corresponding schema:
There are some limitations of proxy views which need to be considered:

- Monitoring view access is only possible if primary and secondary sites run with exactly the same software version.
- When such a proxy view is queried against and the secondary site is not started, no results are shown without the report of an SQL error.
- Querying against SAP HANA multitenant database containers landscapes is limited to single tenant databases or the system database, meaning there are no views unifying all tenants on the system database similar to the SYS_DATABASES schema.

### 9.6 System replication connection

The replication in a configured system replication uses either a public or a separate network between the involved data centers.\(^{20}\)

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\(^{20}\) Please also check the HowTo guides on system replication networks: [https://scn.sap.com/docs/DOC-56044](https://scn.sap.com/docs/DOC-56044) and [https://scn.sap.com/docs/DOC-88553](https://scn.sap.com/docs/DOC-88553)
9.6.1 Secure configuration of the connection

By default the primary and secondary systems establish communication using the internal host names\(^{21}\).

With an IP address—virtual hostname mapping on the involved sites the system replication hostname resolution can be set up configuring a separate network for system replication data traffic between primary and secondary\(^{22}\).

This is done in the section `[system_replication_hostname_resolution]` in `global.ini`, where all hosts of the primary and the secondary sites have to be defined on each host:

```
global.ini/[system_replication_hostname_resolution]
<ip-address_same_site>=<internal_host_same_site>
<ip-address_other_site>=<internal_host_other_site>
```

This also holds valid for a multitier system replication consisting of three sites (primary, tier-2 secondary and tier-3 secondary) because roles can switch in after takeovers and failbacks.

⚠️ The parameters in the `global.ini` file must be set prior to registering the secondary system, because the `-sr_register` command uses this mapping. Registration is one step in the process of configuring the secondary system.

The entries in the `[system_replication_hostname_resolution]` section are used in combination with the `listeninterface` parameter in the `[system_replication_communication]` section. The following combinations are possible:

<table>
<thead>
<tr>
<th>[system_replicationcommunication]</th>
<th>[system_replication_hostname_resolution]</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>listeninterface</code></td>
<td></td>
<td><strong>.global</strong></td>
</tr>
<tr>
<td></td>
<td>No mappings specified</td>
<td>Default if nothing is specified. The default network route is used for system replication communication. This is normally the public network.</td>
</tr>
<tr>
<td></td>
<td><strong>Caution</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If you use a public network instead of a separate network, you must secure this connection with additional measures such as a firewall or a virtual private network and/or SSL.</td>
<td></td>
</tr>
<tr>
<td>.global</td>
<td></td>
<td><strong>.global</strong></td>
</tr>
<tr>
<td></td>
<td>Entries for the primary and secondary</td>
<td>A separate network is used for system replication communication.</td>
</tr>
</tbody>
</table>

\(^{21}\) All SAP HANA system views containing a HOST column show these internal host names, e.g. `M_DATABASE`.

\(^{22}\) As mentioned, in Multitier System Replication the tier 2 secondary serves as primary for the asynchronous replication to the tier 3 secondary.
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<table>
<thead>
<tr>
<th>hosts (for all hosts in multitier setups)</th>
<th>Entries for the primary and secondary hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>.internal</td>
<td>A separate network is used for system replication communication. The primary hosts listen on the dedicated ports of the separate network only and incoming requests on the public interfaces are rejected.</td>
</tr>
</tbody>
</table>

⚠️ Caution
In SAP HANA SPS 11, network communication for system replication with listeninterface=.internal is supported for two-tier replication but not for three-tier setups!

Here is an example of the settings for a 2-tier system replication (3 node system) using a separate internal network per site and a separate connection for the system replication.

Multi-node SAP HANA System Replication over separate network
9.6.2 Allowed senders for the connection

If for some reason no separate network channel was configured for the SAP HANA system replication communication between the involved sites, the parameter allowed_sender could be used to restrict communication between primary and secondary to certain hosts. For this, the following settings can be configured in the global.ini file on the primary site:

```
global.ini/[system_replication_communication]
Parameter: allowed_sender
Value: <list of IP-addresses of secondary or CIDR-netmasks>
Example: 10.0.1.0/30
```

The default is no restriction.

9.6.3 Encryption of the connection

SAP HANA System Replication supports secure network communication (SSL) for Data and Log shipping to the secondary site. The following settings can be configured in the global.ini file:

```
global.ini/[system_replication_communication]
Parameter: enable_ssl
Values:
  off: ssl is disabled for source and target replication channels (default)
  on:   ssl is enabled for source and target replication channels
  source: ssl is enabled for source replication channels only
  target: ssl is enabled for target replication channels only
```

The encrypted communication requires a certificate available in the internal store. The keystore (key.pem) and truststore (trust.pem) are located in /usr/sap/<SID>/HDB<nr>/<host>/ssl

Differentiating between source and target is especially helpful for 3-tier configurations. The topology transfer uses the encryption as supported with the secure HANA internal host communication.

9.6.4 Data and Log compression for transfer

Since SPS09 compression can be used to reduce the amount of traffic between sites especially over long distances. It will be used for the initial full data shipping, the sub sequential delta data shipping as well as for the continuous log shipping.

Configuration is done in global.ini on the secondary site.

```
[system_replication]
enable_log_compression = true (default = false)
enable_data_compression = true (default = false)
```
By default content compression is turned off; log buffer tail compression (default = true) and log buffer content compression can be combined.

### 9.6.5 Monitoring the connection

The connection between the primary and the secondary system should be available for replication. If this is not the case for a certain time, an internal event is generated which is visible as an internal event alert in the SAP HANA studio and in the system view M_EVENTS (if the old statistics server is used). With SPS09 system replication a specific alert was introduced:

- System Replication Connection Closed (Alert ID 78)

Additionally the replication connection can be checked using the HDB console:

```
  hdbcons -e hdbindexserver "replication info"
```

The output delivers “Log Connection” information for the connection used by the provided service. It also shows errors if the connection cannot be resolved properly:

```
...  
  Log Connection  
  - ptr : 0x000007fdb6e8e3410  
  - channel : NetworkChannel FD 158  
  0x00007fdb6f1bbc90 {refCnt=3, idx=1} 10.68.91.226/3  
  0103_tcp->10.68.92.13/49537_tcp Connected,[r---]  
...  
```

With the OS command

```
  lsof –n –p <indexserver-pid>
```

can be checked, if the configured connection is actually used. The output delivers “Log Connection” information for the connection used by the provided service.

### 9.7 Near Zero Downtime Upgrade and Maintenance

The fact that the version of the secondary system must be higher or the same as the one running on the primary system can be used for near zero downtime upgrades of the SAP HANA database.

The process, which is described in detail in the SAP HANA Administration Guide looks like this:

- Set user store entry for automatic repository import at takeover time on primary and secondary
  
  ```
  hdbuserstore SET SRTAKEOVER <public hostname>:<sqlport> system <passwd>
  ```

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- Upgrade secondary system
  
  `./hdblcm --action=update`

- Wait until secondary is in sync as shown in the `M_SERVICE_REPLICATION` view

- Stop primary system and perform takeover to the secondary (new primary)

- Upgrade the previous primary system without starting the system
  
  `./hdblcm --action=update --hdbupd_server_nostart`

- Register the previous primary as secondary
  
  `./hdbnsutil -sr_register ...

- Start the previous primary as secondary

To achieve a real zero downtime upgrade from the application server perspective, please have a look at this SAP Note 1913302 (Connectivity suspend of Appserver during takeover).

Additionally, as described in SAP Note 1984882 (Using HANA system replication for Hardware Exchange with Minimum Downtime) hardware can be exchanged with a minimal downtime using SAP HANA system replication.

### 9.8 Change replication mode

The replication mode can be changed without having to go through a full data shipping from the primary to the secondary afterwards.

Command on online or offline Secondary:

```
  hdbnsutil -sr_changemode --mode=sync|syncmem|async
```

If the mode was changed correctly can be checked in the `M_SERVICE_REPLICATION` view or with this command:

```
  hdbnsutil -sr_state --sapcontrol=1
```