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SAP HANA System Replication Scale-Out - Performance-Optimized Scenario

with SAPHanaSR-angi

SUSE Linux Enterprise Server for SAP Applications 15

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SUSE

SAP HANA System Replication Scale-Out - Performance-Optimized Scenario

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SUSE® Linux Enterprise Server for SAP Applications is optimized in various ways for SAP* applications. This guide provides detailed information about installing and customizing _SUSE Linux Enterprise Server for SAP Applications_ for SAP HANA scale-out system replication in a multi-target architecture. It is based on SUSE Linux Enterprise Server for SAP Applications 15 SP6. The concept however can be used with SUSE Linux Enterprise Server for SAP Applications 15 SP4 or newer.

Contents

1 About this guide

1.1 Introduction

SUSE® Linux Enterprise Server for SAP Applications is optimized in various ways for SAP* applications. This guide provides detailed information about installing and customizing *SUSE Linux Enterprise Server for SAP Applications* for SAP HANA scale-out system replication in a multi-target architecture. The automation of system replication between SAP HANA first site to SAP HANA second site is managed by SUSE Linux Enterprise Server for SAP Applications while there is an additional system replication to a third site outside the scope of automation by SUSE Linux Enterprise Server for SAP Applications.

High availability is an important aspect of running your mission-critical SAP HANA servers.

The SAP HANA scale-out multi-target system replication is a replication of all data in SAP HANA to a second SAP HANA system in a SYNC replication. To a third SAP HANA system usually it is an ASYNC replication. The SAP HANA itself replicates all of its data to secondary SAP HANA instances. It is an out-of-the-box, standard feature.

The recovery time objective (RTO) is minimized through the data replication at regular intervals. SAP HANA supports asynchronous and synchronous modes. The document at hand describes the synchronous replication from memory into memory of the second system. This is the only method that allows the cluster to make a decision based on coded algorithms.

1.2 Abstract

This guide describes planning, setup, and basic testing of SUSE Linux Enterprise Server for SAP Applications 15 for an "SAP HANA Scale-Out Multi-Target System Replication - ERP style" scenario.

From the application perspective the following variants are covered:

- Plain system replication
- Multi-tier (chained) system replication
- Multi-target system replication
- Multi-tenant database containers for all above

- Active/active read enabled for all of the above
- HANA host auto-failover is not used, there is only one master name server configured and no candidates
- HANA host auto-failover is restricted and not explained in this guide

From the infrastructure perspective the following variants are covered:

- 3-site cluster with disk-based SBD fencing and a 4th non-cluster site (replication [A ⇒ B] → C)
- 1-site cluster with disk-based SBD fencing and a 2nd non-cluster site is possible, but not explained in this guide
- Other fencing is possible, but not explained here
- On-premises deployment on physical and virtual machines
- Public cloud deployment (usually needs additional documentation on cloud specific details)

Deployment automation simplifies roll-out. There are several options available, particularly on public cloud platfoms. Ask your public cloud provider or your SUSE contact for details.

Note

In this guide the software package SAPHanaSR-angi is used. This package replaces the two packages SAPHanaSR and SAPHanaSR-ScaleOut. Thus new deployment should be done with SAPHanaSR-angi only. For upgrading existing clusters to SAPHanaSR-angi, read the blog article https://www.suse.com/c/how-to-upgrade-to-saphanasr-angi/ .

1.3 Additional documentation and resources

Chapters in this manual contain links to additional documentation resources that are either available on the system or on the Internet.

For the latest SUSE product documentation updates, see https://documentation.suse.com .

Find white-papers, best-practices guides, and other resources at the

- SUSE Linux Enterprise Server for SAP Applications resource library: https://documentation.suse.com/sbp/sap/
- SUSE Best Practices Web page: https://documentation.suse.com/sbp/sap/
- Supported high availability solutions by SUSE Linux Enterprise Server for SAP Applications overview: https://documentation.suse.com/sles-sap/sap-ha-support/html/sap-ha-support/article-sap-ha-support.html

Lastly, there are manual pages shipped with the product.

1.4 Feedback

Several feedback channels are available:

Bugs and Enhancement Requests

For services and support options available for your product, refer to http://www.suse.com/support/.

To report bugs for a product component, go to https://scc.suse.com/support/ requests, log in, and select *Submit New SR* (Service Request).

Mail

For feedback on the documentation of this product, you can send a mail to doc-team@suse.com (mailto:doc-team@suse.com). Make sure to include the document title, the product version and the publication date of the documentation. To report errors or suggest enhancements, provide a concise description of the problem and refer to the respective section number and page (or URL).

2 Scope of this documentation

This document describes how to set up SAP HANA scale-out multi-target system replication with a cluster installed on two sites (and a third site which acts as majority maker) based on SUSE Linux Enterprise Server for SAP Applications 15 SP4. Furthermore, it describes how to add an additional non-cluster site for a multi-target architecture. This concept can also be used with SUSE Linux Enterprise Server for SAP Applications 15 SP4 or newer.

For a better understanding and overview, the installation and setup is subdivided into seven steps.

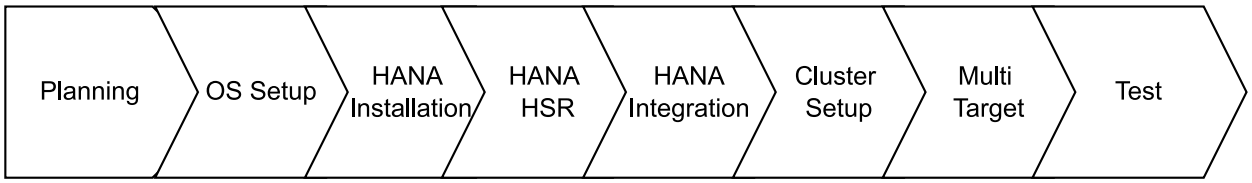

FIGURE 1: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP] [SAPHANAINST] [SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

- Planning (section *Section 3, "Planning the installation"* (page 9))
- OS setup (section *[OsSetup]*)
- SAP HANA installation (section *[SAPHanaInst]*)
- SAP HANA system replication configuration (section *[SAPHanaHsr]*)
- SAP HANA cluster integration (section *Section 7, "Integrating SAP HANA with the Linux cluster"* (page 37))
- SLES for SAP cluster configuration (section *Section 8, "Configuring the cluster and SAP HANA resources"* (page 43))
- Setup of third SAP HANA site in a multi-target architecture (section *Section 9, "Setting up a scale-out multi-target architecture"* (page 59))
- Testing (section *[Testing]*)

First, we will set up a SUSE Linux Enterprise Server for SAP Applications cluster controlling two sites of SAP HANA scale-out in a system replication configuration. Next, we will set up a third site which is outside the SUSE Linux Enterprise High Availability Extension cluster but acts as additional SAP HANA target, forming a multi-target architecture.

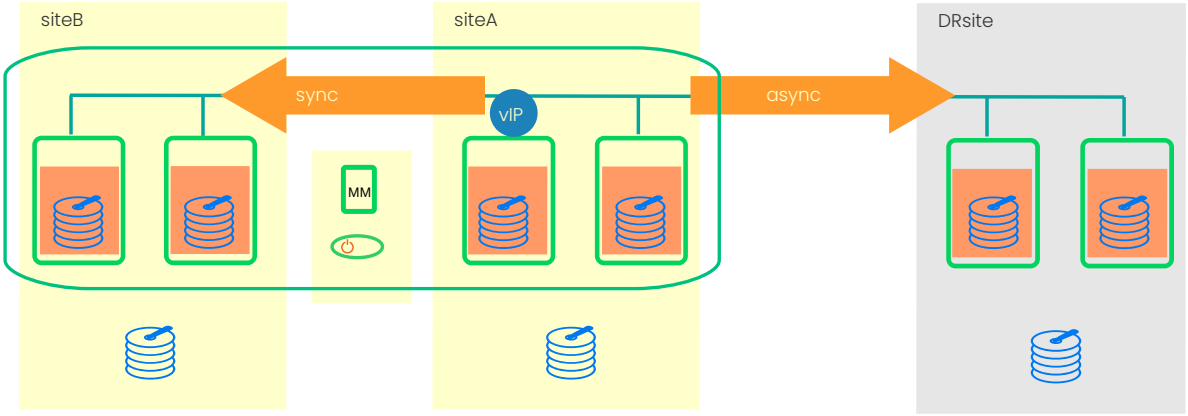

FIGURE 2: CLUSTER WITH SAP HANA MULTI-TARGET SR - PERFORMANCE OPTIMIZED

With SAPHanaSR-angi, various SAP HANA scale-out configurations are supported. Details on requirements and supported scenarios are given below.

In this guide we will cover a scale-out scenario without standby nodes, thus there is no host auto-failover. More details are explained at https://www.suse.com/c/sap-hana-scale-out-system-replication-for-large-erp-systems/ . The scenario where SAP HANA is configured for host auto-failover is explained at https://documentation.suse.com/sbp/sap-15/html/SLES4SAP-hana-scaleOut-PerfOpt-15/index.html.

Note

For upgrading an existing SAP HANA scale-out system replication cluster from classical SAPHanaSR-ScaleOut, consult manual page SAPHanaSR_upgrade_to_angi(8).

3 Planning the installation

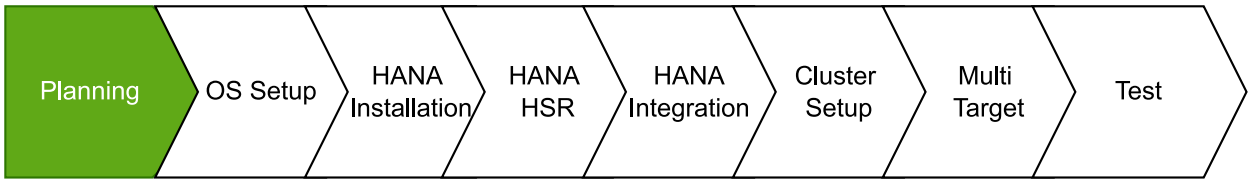

FIGURE 3: PLANNING *[OSSETUP] [SAPHANAINST] [SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

Planning the installation is essential for a successful SAP HANA cluster setup.

What you need before you start:

- Software from SUSE: SUSE Linux Enterprise Server for SAP Applications installation media and a valid subscription for getting updates
- Software from SAP: SAP HANA installation media
- Physical or virtual systems including disks and NFS storage pools (see below)
- Filled parameter sheet (see below)

3.1 Minimum lab requirements and prerequisites

This section defines some minimum requirements to install SAP HANA scale-out multi-target in ERP style.

From SAP HANA perspective we have three sites with two nodes each. Each site has one NFS service providing three shares to the two nodes. The NFS services must **not** be stretched across sites. The */hana/shared/* needs to be shared across the two nodes. The */hana/data/* and */hana/log/* are on NFS and provided to both nodes, for simplicity. However, instead this two shares could be placed on the nodes locally, both file systems at each node.

Note

Refer to SAP HANA TDI documentation for allowed storage configuration and file systems.

From Linux cluster perspective we have three sites. Two of the cluster sites are hosting the workload. The third cluster site is for the majority maker node. HANA file systems and NFS shares are not managed by the Linux cluster.

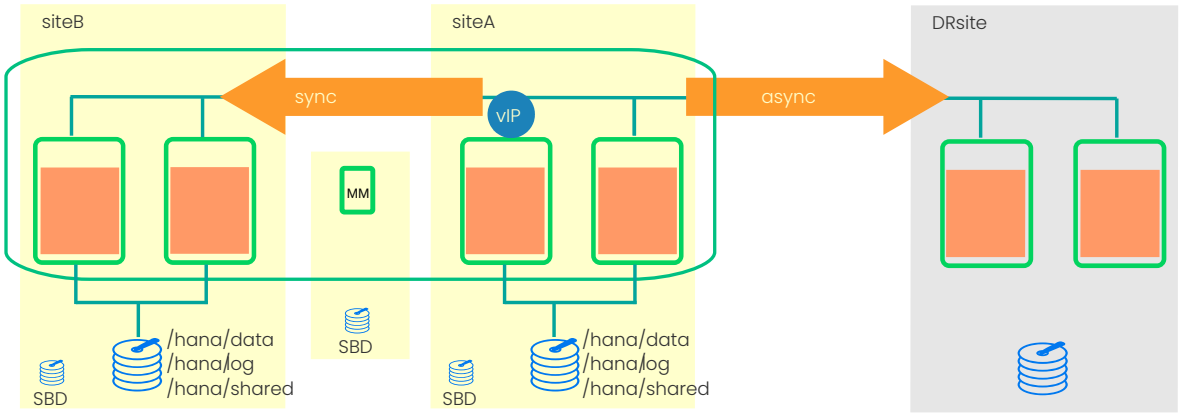

FIGURE 4: SIMPLIFIED NFS STRUCTURE OF AN SAP HANA MULTI-TARGET SYSTEM REPLICATION CLUSTER

The SBD based fencing needs up to three block devices. They are shared across the three cluster sites and accessed by all five cluster nodes. One block device for SBD might be an iSCSI target placed at the cluster third site. The SBD block devices are backed by storage outside the cluster.

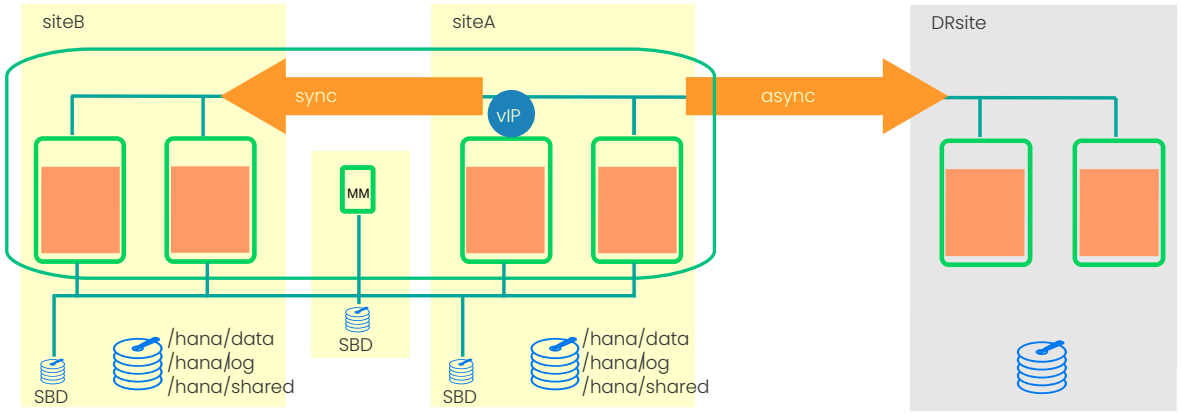

FIGURE 5: SIMPLIFIED SBD STRUCTURE OF AN SAP HANA MULTI-TARGET SYSTEM REPLICATION CLUSTER

Requirements with 2 SAP HANA instances per site (aka [2+0 ⇐ 2+0] → 2+0) plus the majority maker:

- 6 VMs with each 32 GB RAM, 50 GB disk space
- 1 VM with 2 GB RAM, 50 GB disk space
- 1 shared disk for SBD with 10 MB disk space
- 3 NFS pools (one per site) with a capacity of each 120 GB

- 1 additional IP address for takeover
- optional: 2nd additional IP address for active/read-enabled setup

Note

The minimum lab requirements mentioned here are no SAP sizing information. These data are provided only to rebuild the described cluster in a lab for test purposes. Even for such tests the requirements can increase depending on your test scenario. For productive systems ask your hardware vendor or use the official SAP sizing tools and services.

3.2 Parameter sheet

The multi-target architecture with a cluster organizing two SAP HANA sites and a third site is quite complex. The installation should be planned properly. You should have all needed parameters like SID, IP addresses and much more already in place. It is a good practice to first fill out the parameter sheet and then begin with the installation.

TABLE 1: PARAMETER SHEET TO PREPARE THE NFS BASED SETUP

Parameter	Value
Path to SLES for SAP media	
RMT server or SCC account	
NTP server(s)	
Path to SAP HANA media	
S-User for SAP marketplace	
Node 1 name site 1	
Node 2 name site 1	
Node 1 name site 2	
Node 2 name site 2	
Node 1 name site 3	

Parameter	Value
Node 2 name site 3	
Node name majority maker (site 3 or 4)	
IP addresses of all cluster nodes	
SID	
Instance number	
Service IP address	
Service IP address active/read-enabled	
HANA site name site 1	
HANA site name site 2	
HANA site name site 3	
NFS server site 1	
NFS share "shared" site 1	
NFS share "data" site 1	
NFS share "log" site 1	
NFS server site 2	
NFS share "shared" site 2	
NFS share "data" site 2	
NFS share "log" site 2	
NFS server site 3	

Parameter	Value
NFS share "shared" site 3	
NFS share "data" site 3	
NFS share "log" site 3	
SBD STONITH block device(s)	
Watchdog driver	

3.3 Scale-out scenario and HA resource agents

To automate the failover of SAP HANA database and virtual IP resource between the first two sites in a scale-out multi-target setup, SUSE Linux Enterprise High Availability which comes with *SUSE Linux Enterprise Server for SAP Applications* is used. Two resource agents have been created to handle the scenario.

The first is the **SAPHanaController** resource agent (RA), which checks and manages the SAP HANA database instances. This RA is configured as a multi-state resource.

The master assumes responsibility for the active master name server of the SAP HANA database running in primary mode. All other instances are represented by the unpromoted mode.

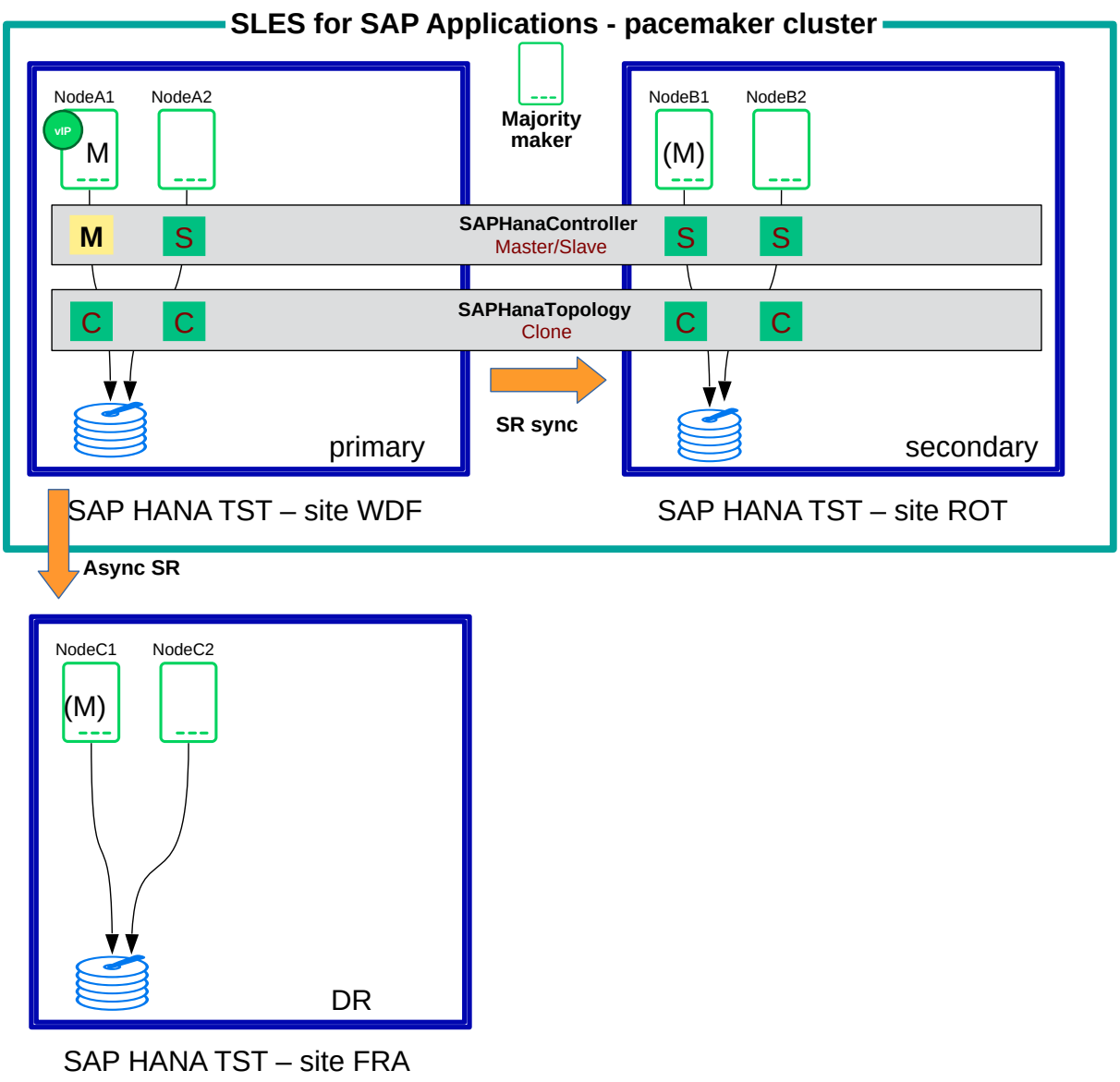

FIGURE 6: CLUSTER RESOURCE AGENTS AND MULTI-STATE STATUS MAPPING

The second resource agent is **SAPHanaTopology**. This RA has been created to make configuring the cluster as simple as possible. It runs on all nodes (except the majority maker) of a SUSE Linux Enterprise High Availability 15 cluster. It gathers information about the statuses and configurations of the SAP HANA system replication. It is designed as a normal (stateless) clone resource.

The third resource agent is **SAPHanaFilesystem**. This RA

With the current version of resource agents, SAP HANA system replication for scale-out is supported in the following scenarios or use cases:

Performance optimized, single container ([A => B])

In the performance optimized scenario an SAP HANA RDBMS on site "A" is synchronizing with an SAP HANA RDBMS on a second site "B". As the SAP HANA RDBMS on the second site is configured to preload the tables the takeover time is typically very short. See also the requirements section below for details.

Performance optimized, multi-tenancy also named MDC ([%A => %B])

Multi-tenancy is available for all of the supported scenarios and use cases in this document. This scenario is the default installation type for SAP HANA 2.0. The setup and configuration from a cluster point of view is the same for multi-tenancy and single containers. The one caveat is, that the tenants are managed all together by the Linux cluster. See also the requirements section below.

Multi-Tier Replication ([A => B] -> C)

A Multi-Tier system replication has an additional target, which must be connected to the secondary (chain topology). This is a special case of the Multi-Target replication. Because of the mandatory chain topology, the RA feature AUTOMATED_REGISTER = true is not possible with pure Multi-Tier replication. See also the requirements section below.

Multi-Target Replication ([A <= B] -> C)

This scenario and setup is described in this document. A Multi-Target system replication has an additional target, which is connected to either the secondary (chain topology) or to the primary (star topology). Multi-Target replication is possible since SAP HANA 2.0 SPS04. See also the requirements section below.

3.4 The concept of the multi-target scenario

A multi-target scenario consists of 3 sites. Site 1 and site 2 are in HA cluster while site 3 is outside the HA cluster.

In case of failure of the primary SAP HANA on site 1 the cluster first tries to start the takeover process. This allows to use the already loaded data at the secondary site. Typically the takeover is much faster than the local restart.

A site is noticed as "down" or "on error", if the **LandscapeHostConfiguration status** reflects this (return code 1). This happens when worker nodes are going down without any SAP HANA standby nodes left. ERP-style SAP HANA scale-out database will have no standby nodes by design. Find more details on concept and implementation in manual pages SAPHanaSR-angi(7) and SAPHanaSR-ScaleOut(7).

To achieve an automation of this resource handling process, use the SAP HANA resource agents included in the *SAPHanaSR-angi* RPM package delivered with SUSE Linux Enterprise Server for SAP Applications.

You can configure the level of automation by setting the parameter *AUTOMATED_REGISTER*. If automated registration is activated the cluster will also automatically register a former failed primary to get the new secondary. Find configuration details in manual page ocf_suse_SAPHana-Controller(7).

The resource agent for HANA in a Linux cluster does not trigger a takeover to the secondary site when a software failure causes one or more HANA processes to be restarted. The same is valid when a hardware error causes the index server to restart locally. Therefor the SAPHanaSR-angi package contains the HA/DR provider hook script susChkSrv.py. For details see manual page susChkSrv.py(7).

Site 3 is connected as an additional system replication target to either SAP HANA site inside the cluster. That two HANA sites need to be configured for automatically re-registering the 3rd site in case of takeover.

3.5 Important prerequisites

Read the SAP Notes and papers first.

The *SAPHanaSR-angi* resource agent software package supports scale-out (multiple-box to multiple-box) system replication with the following configurations and parameters:

- The cluster must include a valid STONITH method. SBD disk-based is the recommended STONITH method.
- Both clusters controlled SAP HANA sites are either in the same network segment (layer 2) to allow an easy takeover of an IP address, or you need a technique like overlay IP addresses in virtual private clouds.
- Technical users and groups, such as *<sid>adm*, are defined **locally** in the Linux system.

- Name resolution of the cluster nodes and the virtual IP address should be done **locally** on **all** cluster nodes to not depend on DNS services (as it can fail, too).
- Time synchronization is needed between the cluster nodes using reliable time services like NTP.
- All SAP HANA sites have the same SAP Identifier (SID) and instance number.
- The SAP HANA scale-out system must have only **one** active master name server per site. There are no configured master name servers.
- For SAP HANA databases without additional master name server candidate, the package SAPHanaSR-angi version 1.2 or newer is needed.
- The SAP HANA scale-out system must have only **one** failover group.
- There is maximum one additional SAP HANA system replication connected from outside the Linux cluster. Thus two sites are managed by the Linux cluster, one site outside is recognized. For SAP HANA multi-tier and multi-target system replication, the package SAPHanaSR-angi version 1.2 or newer is needed.
- Only one SAP HANA SID is installed. Thus the performance optimized setup is supported. The cost optimized and MCOS scenarios are currently not supported.
- The *saphostagent* must be running. *saphostagent* is needed to translate between the system node names and SAP host names used during the installation of SAP HANA.
    - For SystemV style, the `sapinit` script needs to be active.
    - For systemd style, the services saphostagent and SAP<SID>_<INO> can stay enabled. The systemd-enabled saphostagent and instance´s sapstartsrv is supported from SAPHanaSR-angi 1.2. Refer to the OS documentation for the systemd version. SAP HANA comes with native systemd integration as default starting with version 2.0 SPS07. Refer to SAP documentation for the SAP HANA version.
    - Combining systemd style hostagent with SystemV style instance is allowed. However, all nodes in one Linux cluster need to use the same style.
- All SAP HANA instances controlled by the cluster must not be activated via `sapinit` auto-start.
- Automated start of SAP HANA instances during system boot must be switched **off**.

- The replication mode should be either 'sync' or 'syncmem'. 'async' is supported outside the Linux cluster.
- SAP HANA 2.0 SPS05 rev.059.04 and later provides Python 3 and the HA/DR provider hook method srConnectionChanged() with needed parameters for *susHanaSR.py*.
- SAP HANA 2.0 SPS05 or later provides the HA/DR provider hook method srServiceStateChanged() with needed parameters for susChkSrv.py.
- SAP HANA 2.0 SPS06 or later provides the HA/DR provider hook method preTakeover() with multi-target aware parameters and separate return code for Linux HA clusters.
- No other HA/DR provider hook script should be configured for the above mentioned methods. Hook scripts for other methods, provided in SAPHanaSR-angi, can be used in parallel, if not documented contradictingly.
- The Linux cluster needs to be up and running to allow HA/DR provider events being written into CIB attributes. The current HANA SR status might differ from CIB srHook attribute after Linux cluster maintenance.
- The user <sid>adm needs execution permission as user root for the command `SAPHanaSR-hookHelper`.
- For optimal automation, *AUTOMATED_REGISTER="true"* is recommended.

Important

As good starting configuration for projects, it is recommended to **switch off** the automated registration of a failed primary, therefor `AUTOMATED_REGISTER="false"` is the **default**.

In this case, you need to register a failed primary after a takeover manually. Use SAP tools like SAP HANA Cockpit or **hdbnsutil**. Make sure to use always the exact site names as already known to the cluster.

The two SAP HANA sites inside the Linux cluster can be configured to re-register the outer SAP HANA in case of takeover. For this a configuration item 'register_secondaries_on_takeover=true' needs to be added in the system_replication block of the *global.ini* file. See also manual page susHanaSR.py(7).

- You need at least SAPHanaSR-angi version 1.2, SUSE Linux Enterprise Server for SAP Applications 15 SP4 and SAP HANA 2.0 SPS 05 rev.59.04 for all mentioned setups.
- The Linux cluster can be either freshly installed as described in this guide, or it can be upgraded as described in respective documentation. Not allowed is mixing old and new cluster attributes or hook scripts within one cluster.
- No manual actions must be performed on the SAP HANA database while it is controlled by the Linux cluster. All administrative actions need to be aligned with the cluster.

Find more details in the REQUIREMENTS section of manual pages SAPHanaSR-ScaleOut(7), ocf_suse_SAPHanaController(7), ocf_suse_SAPHanaFilesystem(7), susHanaSR.py(7), SAPHanaSR-manageAttr(8), susChkSrv.py(7), susTkOver.py(7) and SAPHanaSR-alert-fencing(8).

Important

You must implement a valid STONITH method. Without a valid STONITH method, the complete cluster is unsupported and will not work properly.

In this setup guide, NFS is used as storage for the SAP HANA database. This has been chosen for simplicity. However, any storage supported by SAP HANA and the SAP HANA storage API can be used. Refer to the SAP HANA TDI documentation for supported storage and follow the respective storage vendor's configuration instructions.

This setup guide focuses on the scale-out multi-target setup.

If you need to implement a different scenario, it is strongly recommended to define a Proof-of-Concept (PoC) with SUSE. This PoC will focus on testing the existing solution in your scenario. The limitation of most of the above items is mostly because of testing limits.

4 Setting up the operating system

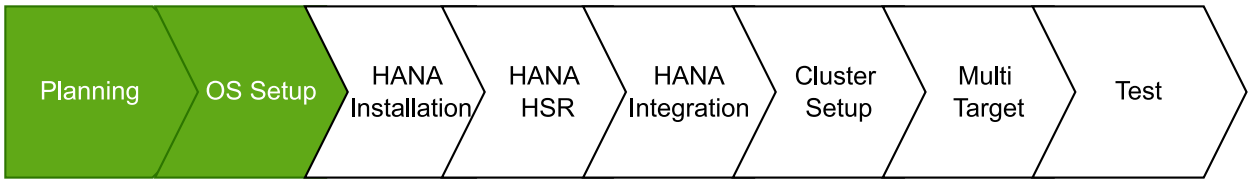

FIGURE 7: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) OSSETUP *[SAPHANAINST] [SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

This section includes information you should consider during the installation of the operating system.

In this document, first SUSE Linux Enterprise Server for SAP Applications is installed and configured. Then the SAP HANA database including the system replication is set up. Next, the automation with the cluster is set up and configured. Finally, the multi-target setup of the 3rd site is set up and configured.

4.1 Installing SUSE Linux Enterprise Server for SAP Applications

Multiple installation guides are already existing, with different reasons to set up the server in a certain way. Below it is outlined where this information can be found. In addition, you will find important details you should consider to get a system which is well prepared to deliver SAP HANA.

4.1.1 Installing the base operating system

Depending on your infrastructure and the hardware used, you need to adapt the installation. All supported installation methods and minimum requirement are described in the *Deployment Guide* (https://documentation.suse.com/sles/15-SP4/single-html/SLES-deployment/#book-deployment). In case of automated installations you can find further information in the *Au-*

toYaST Guide (https://documentation.suse.com/sles/15-SP4/single-html/SLES-autoyast/#book-autoyast). The major installation guide for SUSE Linux Enterprise Server for SAP Applications to fit all requirements for SAP HANA is described in the SAP notes:

- 2578899 SUSE Linux Enterprise Server 15: Installation Note and
- 2684254 SAP HANA DB: Recommended OS settings for SLES 15 / SLES for SAP Applications 15

4.1.2 Installing additional software

SUSE delivers with SUSE Linux Enterprise Server for SAP Applications special resource agents for SAP HANA. With the pattern *sap-hana* the resource agent for SAP HANA **ScaleUp** is installed. For the **ScaleOut** scenario you need a special resource agent. Follow the instructions below on each node if you have installed the systems based on SAP note 2684254. The pattern *High Availability* summarizes all tools recommended to be installed on **all** nodes, including the *majority maker*.

- remove package: patterns-sap-hana, SAPHanaSR, yast2-sap-ha
- install package: SAPHanaSR-angi, ClusterTools2, saptune
- install pattern: ha_sles

To do so, for example, use Zypper:

EXAMPLE 1: UNINSTALL THE SAPHANASR AGENT FOR SCALE-UP

> As Linux user *root* , type:
>
> ```
> # zypper remove SAPHanaSR
> ```
>
> If the package is installed, you will get an output like this:
>
> ```
> Loading repository data...
> Reading installed packages...
> Resolving package dependencies...
>
> The following 3 packages are going to be REMOVED:
>   patterns-sap-hana SAPHanaSR yast2-sap-ha
>
> The following pattern is going to be REMOVED:
>   sap-hana
> ```

```
3 packages to remove.
After the operation, 494.2 KiB will be freed.
Continue? [y/n/...? shows all options] (y): y
(1/3) Removing patterns-sap-hana-15.3-6.8.2.x86_64 ..........................
[done]
(2/3) Removing yast2-sap-ha-1.0.0-2.5.12.noarch ..............................
[done]
(3/3) Removing SAPHanaSR-0.161.21-1.1.noarch .................................
[done]
```

EXAMPLE 2: INSTALLATION OF THE SAPHANASR-ANGI AGENT FOR SCALE-OUT

As user root, type:

```
# zypper in SAPHanaSR-angi
```

If the package is not installed yet, you should get an output like the below:

```
Refreshing service 'Advanced_Systems_Management_Module_15_x86_64'.
Refreshing service
 'SUSE_Linux_Enterprise_Server_for_SAP_Applications_15_SP4_x86_64'.
Loading repository data...
Reading installed packages...
Resolving package dependencies...

The following 1 NEW packages are going to be installed:
  SAPHanaSR-angi

2 new packages to install.
Overall download size: 539.1 KiB. Already cached: 0 B. After the operation,
 additional 763.1 KiB will be used.
Continue? [y/n/...? shows all options] (y): y
Retrieving package SAPHanaSR-angi-1.2.5-150400-1.1.noarch                (1/1),
 48.7 KiB (211.8 KiB unpacked)
Retrieving: SAPHanaSR-
angi-1.2.5-150400-1.1.noarch.rpm ................................[done]
Checking for file
 conflicts: ..........................................................[done]
(1/1) Installing: SAPHanaSR-
angi-1.2.5-150400-1.1.noarch ................................[done]
```

Install the tools for High Availability on all nodes.

```
# zypper in --type pattern ha_sles
# zypper in ClusterTools2
```

4.1.3 Getting the latest updates

If you have installed the packages before, make sure to deploy the newest updates on all machines to have the latest versions of the resource agents and other packages. Also, make sure all systems have indentical package versions. A prerequisite is a valid subscription for SUSE Linux Enterprise Server for SAP Applications. There are multiple ways to get updates via SUSE Manager, the Repository Management Tool (RMT), or via a direct connection to the SUSE Customer Center (SCC).

Depending on your company or customer rules, use `zypper update` or `zypper patch`.

EXAMPLE 3: SOFTWARE UPDATE MUST BE TRIGGERED FROM EACH NODE

> The command `zypper patch` will install all available needed patches. As user root, type:
>
> ```
> # zypper patch
> ```
>
> The command `zypper update` will update all or specified installed packages with newer versions, if possible. As user root, type:
>
> ```
> # zypper update
> ```

4.2 Configuring SUSE Linux Enterprise Server for SAP Applications to run SAP HANA

4.2.1 Tuning or modifying the operating system

Operating system tuning are described in SAP note 1275776 and 2684254. The SAP note 1275776 explains three ways to implementing the settings.

EXAMPLE 4: USING SAPTUNE (PREFERRED)

```
# saptune solution apply HANA
```

4.2.2 Enabling SSH access via public key (optional)

Public key authentication provides SSH users access to their servers without entering their passwords. SSH keys are also more secure than passwords, because the private key used to secure the connection is never shared. Private keys can also be encrypted. Their encrypted contents cannot easily be read. For the document at hand, a very simple but useful setup is used. This setup is based on only one SSH key pair which enables SSH access to all cluster nodes.

Note

Follow your company security policy to set up access to the systems.

EXAMPLE 5: SSH KEY CREATION AND EXCHANGE

As user root create an SSH key on one node.

```
# ssh-keygen -t rsa
```

The SSH key generation asks for missing parameters.

```
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:ip/8kdTbYZNuuEUAdsaYOAErkwnkAPBR7d2SQIpIZCU root@<host1>
The key's randomart image is:
+---[RSA 2048]----+
|XEooo+ooo+o      |
|=+.= o=.o+.      |
|..B o. + o.      |
|   (°<           |
|  /  )           |
|   --            |
|   B. . o o =    |
|     o . . +     |
|      +.. .      |
+----[SHA256]-----+
```

After the `ssh-keygen` is set up, you will have two new files under */root/.ssh/* .

```
# ls /root/.ssh/
id_rsa  id_rsa.pub
```

Collect the public host keys from all other node. For the document at hand, the `ssh-keyscan` command is used.

```
# ssh-keyscan
```

The SSH host key is automatically collected and stored in the file */root/.ssh/known_host* during the first SSH connection. To avoid to confirm the first login with "yes", which accepts the host key, collect and store them beforehand.

```
# ssh-keyscan -t ecdsa-sha2-nistp256 <host1>,<host1 ip> >>.ssh/known_hosts
# ssh-keyscan -t ecdsa-sha2-nistp256 <host2>,<host2 ip> >>.ssh/known_hosts
# ssh-keyscan -t ecdsa-sha2-nistp256 <host3>,<host3 ip> >>.ssh/known_hosts
...
```

After collecting all host keys store them in a file named *authorized_keys*. Push the entire directory */root/.ssh/* from the first node to all further cluster members.

```
# rsync -ay /root/.ssh/ <host2>:/root/.ssh/
# rsync -ay /root/.ssh/ <host3>:/root/.ssh/
# rsync -ay /root/.ssh/ <host4>:/root/.ssh/
...
```

4.2.3 Setting up disk layout for SAP HANA

An SAP certified storage system with a validated storage API is generally recommended. This is a prerequisite of a stable and reliable scale-out installation.

- /hana/shared/<SID>
- /hana/data/<SID>
- /hana/log/<SID>

Create the mount directories on all SAP HANA nodes.

```
# mkdir -p /hana/shared/<SID>
# mkdir -p /hana/data/<SID>
# mkdir -p /hana/log/<SID>
# mkdir -p /usr/sap
```

The SAP HANA installation needs a special storage setup. The NFS setup used for this guide must be reboot-persistent. You can achieve this with entries in the */etc/fstab* file.

Note

NFS version 4 is required in the setup at hand.

EXAMPLE 6: CREATE PERMANENT MOUNT ENTRIES FOR ALL NFS POOLS

Create */etc/fstab* entries for the three NFS pools.

```
<nfs>  /hana/shared/<SID>    nfs4  defaults  0 0
```

> In the sample environment those lines are as follows:
>
> ```
> /exports/TST_WDF1/shared  /hana/shared/TST      nfs4  defaults  0 0
> ```

Mount all NFS shares.

```
# mount -a
```

Create other directories (optional).

```
# mkdir -p /sapsoftware
```

File systems

/hana/shared/<SID>

The mount directory is used for shared files between all hosts in an SAP HANA system. Each HANA site has its own instance of this directory. It is accessible to the two nodes of that site. In our setup we use NFS.

/hana/log/<SID>

The default path to the log directory depends on the SAP System ID of the SAP HANA host. In our setup each HANA site has its own instance of this directory. It is accessible to the two nodes of that site. Each node has its own subdirectories. In our setup we use NFS. It would be possible be to use local disks instead.

/hana/data/<SID>

The default path to the data directory depends on the system ID of the SAP HANA host. In our setup each HANA site has its own instance of this directory. It is accessible to the two nodes of that site. Each node has its own subdirectories. In our setup we use NFS. It would be possible be to use local disks instead.

/usr/sap

This is the path to the local SAP system instance directories. It is possible to join this location with the Linux installation.

/sapsoftware

(optional) Space for copying the SAP install software media. This NFS pool is mounted on all HANA sites and contains the SAP HANA installation media and installation parameter files.

Set up host name resolution for all machines. You can either use a DNS server or modify the */etc/hosts* on **all** nodes.

With maintaining the */etc/hosts* file, you minimize the impact of a failing DNS service. Replace the IP address and the host name in the following commands.

```
# vi /etc/hosts
```

Insert the following lines to */etc/hosts*. Change the IP address and host name to match your environment.

```
192.168.201.151 hanaso0
192.168.201.152 hanaso2
...
```

Enable NTP service on all nodes.

Simply enable an **ntp service** on all node in the cluster to have proper time synchronization.

```
# yast2 ntp-client
```

5 Installing the SAP HANA databases on both sites

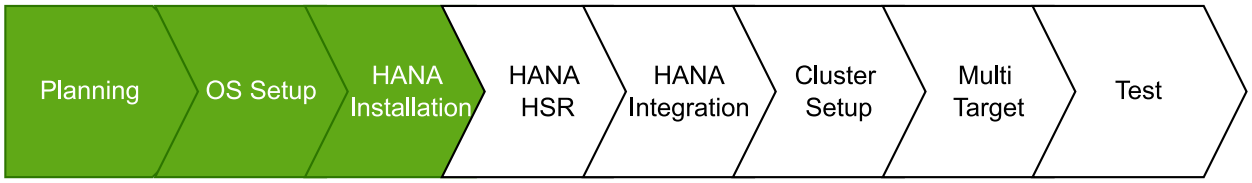

FIGURE 8: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP]* SAPHANAINST *[SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

The infrastructure is set up. Now install the SAP HANA database at both sites. This chapter summarizes the test environment. In a cluster a machine is also called a *node*. Always use the official documentation from SAP to install SAP HANA and to set up the system replication.

This guide shows SAP HANA and saphostagent with native systemd integration. An example for legacy SystemV is outlined in the appendix *Section 11.3, "Example for checking legacy SystemV integration"*.

PROCEDURE

1. Install the SAP HANA database on all SAP HANA nodes.
2. Check if the SAP hostagent is installed on all SAP HANA nodes.
3. Verify that both databases are up and running.

In the example at hand, to make it easier to follow the documentation, the machines (or nodes) are named *hanaso0*, … *hanasoX*. The nodes (hanaso0, hanaso1) will be part of site "A" (WDF1), the nodes (hanaso2, hanaso3) will be part of site "B" (ROT1), and the nodes (hanaso4, hanaso5) will be part of site "C" (FRA1).

The following users are automatically created during the SAP HANA installation:

<sid>adm
: The user <sid>adm is the operating system user required for administrative tasks, such as starting and stopping the system.

sapadm
: The SAP Host Agent administrator.

SYSTEM
: The SAP HANA database superuser.

5.1 Installing the SAP HANA database

- Read the SAP Installation and Setup Manuals available at the SAP Marketplace.
- Download the SAP HANA Software from SAP Marketplace.
- Mount the file systems to install SAP HANA database software and database content (data and log).
- Start the installtion.

1. Mount /hana/shared from the nfs server.

```
# for system in hanaso{0,1,2,3,4,5}; do
    ssh $system mount -a
done
```

2. Install the SAP HANA Database as described in the SAP HANA Server Installation Guide on **all** machines (three sites) except the majority maker. All three databases need to have same SID and instance number. You can use either the graphical user interface or the command line installer `hdblcm`. The command line installer can be used in an interactive or batch mode.

EXAMPLE 7: USING HDBLCM IN INTERACTIVE MODE

```
# <path_to_sap_media>/hdblcm
```

Alternatively you can also use the batch mode of `hdblcm`. This can either be done by specifying all needed parameters via the command line or by using a parameter file.
In the example at hand the command line parameters are used. In the batch mode you need to provide an XML password file (here *<path>/hana_passwords*). A template of this password file can be created with the following command:

EXAMPLE 8: CREATING A PASSWORD FILE

```
# <path_to_sap_media>/hdblcm --dump_configfile_template=templateFile
```

This command creates two files:

- *templateFile* is the template for a parameter file.
- *templateFile.xml* is the XML template used to provide several hana_passwords to the hdblcm installer.

The XML password file looks as follows:

EXAMPLE 9: THE XML PASSWORD TEMPLATE

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- Replace the 3 asterisks with the password -->
<Passwords>
    <root_password><![CDATA[***]]></root_password>
    <sapadm_password><![CDATA[***]]></sapadm_password>
    <master_password><![CDATA[***]]></master_password>
    <sapadm_password><![CDATA[***]]></sapadm_password>
    <password><![CDATA[***]]></password>
    <system_user_password><![CDATA[***]]></system_user_password>
    <streaming_cluster_manager_password><![CDATA[***]]></
streaming_cluster_manager_password>
    <ase_user_password><![CDATA[***]]></ase_user_password>
    <org_manager_password><![CDATA[***]]></org_manager_password>
</Passwords>
```

After having created the XML password file, you can immediately start the SAP HANA installation in batch mode by providing all needed parameters via the command line.

EXAMPLE 10: USING HDBLCM IN BATCH MODE

In the example below the password file is used to provide the password during the installation dialog. All installation parameters are named directly as one command.

```
# cat <path>/hana_passwords | \
<path_to_sap_media>/hdblcm \
  --batch \
  --sid=<SID>\
  --number=<instanceNumber> \
  --action=install \
  --hostname=<node1> \
  --addhosts=<node2>:role=worker  \
  --certificates_hostmap=<node1>=<node1> \
  --certificates_hostmap=<node2>=<node2> \
  --install_hostagent \
  --system_usage=test \
  --checkmnt=/hana/shared/<SID> \
  --sapmnt=/hana/shared \
  --datapath=<datapath> \
  --logpath=<logpath> \
  --root_user=root  \
  --workergroup=default \
  --home=/usr/sap/<SID>/home \
  --userid=<uid> \
  --shell=/bin/bash \
  --groupid=<gid> \
  --read_password_from_stdin=xml
```

The second example use the modified template file as answering file.

```
# cat <path>/hana_passwords | \
<path_to_sap_media>/hdblcm \
 -b \
 --configfile=<path_to_templateFile>/<mod_templateFile> \
 --read_password_from_stdin=xml
```

5.2 Checking if the SAP hostagent is installed on all SAP HANA nodes

Check if the native systemd enabled SAP hostagent and instance sapstartsrv are installed on all SAP HANA nodes. If not, install and enable it now.

As Linux user *root* run the command `systemctl` on all SAP HANA nodes to check the SAP hostagent and instance services:

```
# systemctl list-unit-files | grep sap
saphostagent.service enabled
sapinit.service generated
saprouter.service disabled
saptune.service enabled
```

The mandatory `saphostagent` service is enabled. This is the installation default. Some more SAP related services might be enabled, for example the recommended `saptune`.

The instance service SAP<SID>_<NR>.service needs to be enabled as well.

```
# systemctl list-unit-files | grep SAP
SAPTST_00.service enabled
```

The instance service is indeed enabled, as required.

5.3 Verifying both databases are up and running

Verify that both databases are up and running on all SAP HANA nodes. As Linux user *root* run the command `systemd-cgls` all SAP HANA nodes to check both databases:

```
# systemd-cgls -u SAP.slice
Unit SAP.slice (/SAP.slice):
├─saphostagent.service
│ ├─2630 /usr/sap/hostctrl/exe/saphostexec pf=/usr/sap/hostctrl/exe/host_profile -systemd
│ ├─2671 /usr/sap/hostctrl/exe/sapstartsrv pf=/usr/sap/hostctrl/exe/host_profile -D
│ └─3591 /usr/sap/hostctrl/exe/saposcol -l -w60 pf=/usr/sap/hostctrl/exe/host_profile
└─SAPTST_00.service
  ├─ 1257 hdbcompileserver
  ├─ 1274 hdbpreprocessor
  ├─ 1353 hdbindexserver -port 31003
  ├─ 1356 hdbxsengine -port 31007
  ├─ 2077 hdbwebdispatcher
  ├─ 2300 hdbrsutil --start --port 31003 --volume 3 --volumesuffix mnt00001/
hdb00003.00003 --identifier 1644426276
  ├─28462 /usr/sap/TST/HDB00/exe/sapstartsrv pf=/usr/sap/TST/SYS/profile/
TST_HDB00_hanaso0
  ├─31314 sapstart pf=/usr/sap/TST/SYS/profile/TST_HDB00_hanaso0
  ├─31372 /usr/sap/TST/HDB00/hanaso0/trace/hdb.sapTST_HDB00 -d -nw -f /usr/sap/TST/HDB00/
suse21/daemon.ini pf=/usr/sap/TST/SYS/profile/TST_HDB00_hanaso1
  ├─31479 hdbnameserver
```

```
  └─32201 hdbrsutil --start --port 31001 --volume 1 --volumesuffix mnt00001/hdb00001 --
identifier 1644426203
```

The SAP hostagent **saphostagent.service** and the instance´s `sapstartsrv` **SAPTST_00.service** are running in the **SAP.slice**. See also manual pages systemctl(8) and systemd-cgls(8) for details.

Use the python script *landscapeHostConfiguration.py* to show the status of an entire SAP HANA site. The landscape host configuration is shown with a line per SAP HANA host. Query the host roles (as user <sid>adm):

```
~> HDBSettings.sh landscapeHostConfiguration.py

| Host   | Host   |... NameServer  | NameServer  | IndexServer | IndexServer
|        | Active |... Config Role | Actual Role | Config Role | Actual Role
| ------ | ------ |... ----------- | ----------- | ----------- | -----------
| hanaso0 | yes    |... master 1    | master      | worker      | master
| hanaso1 | yes    |... master 2    | slave       | worker      | slave

overall host status: ok
```

Get an overview of instances of that site (as user <sid>adm) You should get a list of SAP HANA instances belonging to that site.

```
~> sapcontrol -nr <instanceNumber> -function GetSystemInstanceList
06.01.2024 17:25:16
GetSystemInstanceList
OK
hostname, instanceNr, httpPort, httpsPort, startPriority, features, dispstatus
hanaso0, 00, 50013, 50014, 0.3, HDB|HDB_WORKER, GREEN
hanaso1, 00, 50013, 50014, 0.3, HDB|HDB_WORKER, GREEN
```

6 Setting up SAP HANA system replication

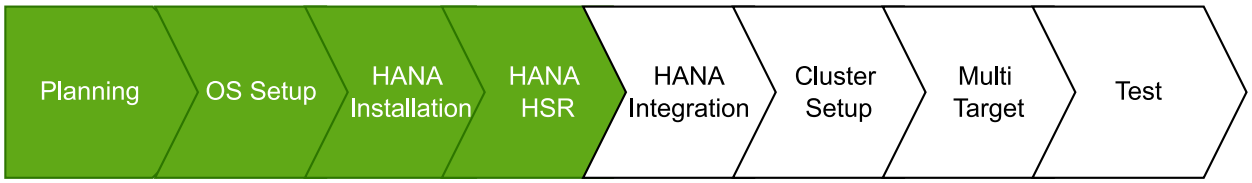

FIGURE 9: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP] [SAPHANAINST]* SAPHANAHSR *SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

This section describes the setup of the system replication (HSR) after SAP HANA has been installed properly.

PROCEDURE

1. Back up the primary database
2. Enable the primary database
3. Register the secondary database
4. Verify the system replication

For more information read the Section *Setting Up System Replication* of the SAP HANA Administration Guide.

6.1 Backing up the primary database

First back up the primary database as described in the *SAP HANA Administration Guide, Section SAP HANA Database Backup and Recovery*.

Below find examples to back up SAP HANA with SQL Commands:

EXAMPLE 11: SIMPLE BACKUP FOR THE SYSTEM DATABASE AND ALL TENANTS WITH ONE SINGE BACKUP CALL

> As user <sid>adm enter the following command:
>
> ```
> ~> hdbsql -i {refInst} -u SYSTEM -d SYSTEMDB \
>    "BACKUP DATA FOR FULL SYSTEM USING FILE ('backup')"
> ```
>
> You get the following command output (or similar):
>
> ```
> 0 rows affected (overall time 15.352069 sec; server time 15.347745 sec)
> ```

EXAMPLE 12: SIMPLE BACKUP FOR A SINGLE CONTAINER (NON-MDC) DATABASE

> Enter the following command as user <sid>adm:
>
> ```
> ~> hdbsql -i <instanceNumber> -u <dbuser> \
>    "BACKUP DATA USING FILE ('backup')"
> ```

Important

Without a valid backup, you **cannot** bring SAP HANA into a system replication configuration.

6.2 Enabling the primary database

As Linux user *<sid>adm* enable the system replication at the primary node. You need to define a site name (like *WDF1*) which must be unique for all SAP HANA databases which are connected via system replication. This means the secondary must have a different site name.

EXAMPLE 13: ENABLE THE SYSTEM REPLICATION ON THE PRIMARY SITE

> As user <sid>adm enable the primary:
>
> ```
> ~> hdbnsutil -sr_enable --name=WDF1
> ```
>
> Check if the command output is similar to:
>
> ```
> nameserver is active, proceeding ...
> successfully enabled system as system replication source site
> done.
> ```

The command line tool `hdbnsutil` can be used to check the system replication mode and site name.

EXAMPLE 14: CHECK THE SYSTEM REPLICATION CONFIGURATION STATUS AS USER <SID>ADM ON THE PRIMARY

> ```
> ~> hdbnsutil -sr_stateConfiguration
> ```
>
> If the system replication enablement was successful at the primary, the output should be as follows:
>
> ```
> checking for active or inactive nameserver ...
> System Replication State
> ~~~~~~~~~~~~~~~~~~~~~~~~
>
> mode: primary
> site id: 1
> site name: WDF1
> done.
> ```

The mode has changed from “none” to “primary” and the site now has a site name and a site ID.

6.3 Registering the secondary database

The SAP HANA database instance on the secondary side must be stopped before the system can be registered for the system replication. You can use your preferred method to stop the instance (like *HDB* or *sapcontrol*). After the database instance has been stopped successfully, you can register the instance using *hdbnsutil*.

EXAMPLE 15: STOP THE SECONDARY AS LINUX USER *<SID>ADM*:

```
~> sapcontrol -nr <instanceNumber> -function StopSystem
```

EXAMPLE 16: COPY THE KEY AND KEY-DATA FILE FROM THE PRIMARY TO THE SECONDARY SITE

> The copy of key and key-data should only be done on the master name server. As the files are in the global file space, you do not need to run the command on all cluster nodes.
>
> ```
> cd /usr/sap/<SID>/SYS/global/security/rsecssfs
> rsync -va {,<node1-siteB>:}$PWD/data/SSFS_<SID>.DAT
> rsync -va {,<node1-siteB>:}$PWD/key/SSFS_<SID>.KEY
> ```

EXAMPLE 17: REGISTER THE SECONDARY AS LINUX USER *<SID>ADM*:

```
~> hdbnsutil -sr_register --name=<site2> \
     --remoteHost=<node1-siteA> --remoteInstance=<instanceNumber> \
     --replicationMode=sync --operationMode=logreplay
```

```
adding site ...
checking for inactive nameserver ...
nameserver hanaso2:30001 not responding.
collecting information ...
updating local ini files ...
done.
```

The *remoteHost* is the primary node in our case, the *remoteInstance* is the database instance number (here 00).

Now start the database instance again and verify the system replication status. On the secondary site, the mode should be one of „SYNC“, „SYNCMEM“ or „ASYNC“. The mode depends on the **sync** option defined during the registration of the secondary.

EXAMPLE 18: START THE SYSTEM ON THE SECONDARY SITE AS USER <SID>ADM

> ```
> ~> sapcontrol -nr <instanceNumber> -function StartSystem
> ```
>
> Wait until the SAP HANA database is started completely.

EXAMPLE 19: CHECK THE SYSTEM REPLICATION CONFIGURATION AS LINUX USER <SID>ADM

> ```
> ~> hdbnsutil -sr_stateConfiguration
> ```

The output should look like the following:

```
System Replication State
~~~~~~~~~~~~~~~~~~~~~~~~
mode: sync
site id: 2
site name: ROT1
active primary site: 1

primary masters: hanaso0 hanaso1
done.
```

6.4 Verifying the system replication

To view the replication state of the whole SAP HANA cluster, use the following command as *<sid>adm* user on the primary site.

EXAMPLE 20: CHECK THE SYSTEM REPLICATION STATUS AT THE PRIMARY SITE (AS <SID>ADM)

```
~> HDBSettings.sh systemReplicationStatus.py
```

This script prints a human-readable table of the system replication channels and their status. The most interesting column is the **Replication Status**, which should be **ACTIVE**.

```
| Database | Host   | .. Site Name | Secondary | .. Secondary | .. Replication
|          |        | ..           | Host      | .. Site Name | .. Status
| -------- | ------ | .. --------- | --------- | .. --------- | .. ------
| SYSTEMDB | hanaso0 | .. WDF1      | hanaso2  | .. ROT1      | .. ACTIVE
| TST      | hanaso0 | .. WDF1      | hanaso2  | .. ROT1      | .. ACTIVE
| TST      | hanaso0 | .. WDF1      | hanaso2  | .. ROT1      | .. ACTIVE
| TST      | hanaso1 | .. WDF1      | hanaso3  | .. ROT1      | .. ACTIVE

status system replication site "2": ACTIVE
overall system replication status: ACTIVE

Local System Replication State
~~~~~~~~~~

mode: PRIMARY
site id: 1
site name: WDF1
```

7 Integrating SAP HANA with the Linux cluster

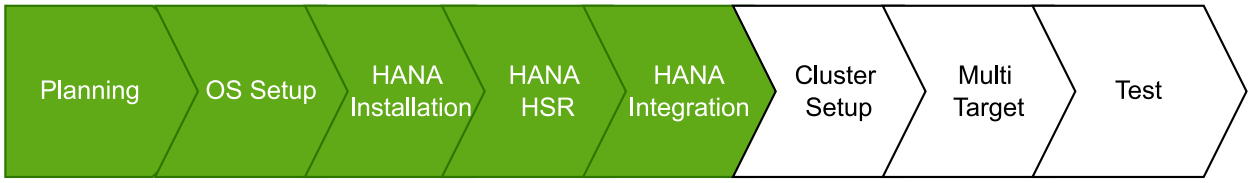

FIGURE 10: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP] [SAPHANAINST] [SAPHANAHSR]* INTEGRATION *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

This chapter describes what to change on the SAP HANA configuration for the ERP style scale-out multi-target scenario.

PROCEDURE

1. Stop SAP HANA
2. Configure system replication operation mode
3. Adapt SAP HANA *nameserver* configuration
4. Implement susHanaSR.py for srConnectionChanged
5. Implement susChkSrv.py for srServiceStateChanged
6. Implement susTkOver.py for preTakeover
7. Allow <sid>adm to access the cluster
8. Start SAP HANA
9. Test the HA/DR provider hook script integration

Note

All hook scripts should be used directly from the SAPHanaSR-angi package. If the scripts are moved or copied, regular SUSE package updates will not work.

7.1 Stopping SAP HANA

The SAP HANA needs to be stopped at both sites that will be part of the Linux cluster. At each site do the following:

```
# su - <sid>adm
```

```
~> sapcontrol -nr <instanceNumber> -function StopSystem
~> sapcontrol -nr <instanceNumber> -function WaitforStopped 300 20
~> sapcontrol -nr <instanceNumber> -function GetSystemInstanceList
```

7.2 Configuring the system replication operation mode

When your system is connected as an SAPHanaSR target, you can find an entry in the *global.ini* file which defines the operation mode. Up to now there are three modes available:

- *delta_datashipping*
- *logreplay*
- *logreplay_readaccess*

Until performing a takeover and re-registration in the opposite direction, the entry for the operation mode is missing on your primary site. The default and preferred mode for HA is *logreplay*. Using the operation mode *logreplay* makes your secondary site in the SAP HANA system replication a hot standby system. For more details regarding replication modes, check the available SAP documentation such as the guide "How To Perform System Replication for SAP HANA" (https://www.sap.com/documents/2017/07/606a676e-c97c-0010-82c7-eda71af511fa.html).

For a multi-target setup, site 3 should follow the primary SAP HANA after takeover. For this a configuration 'register_secondaries_on_takeover = true' needs to be added in the system_replication block of the *global.ini* file. This configuration needs to be added on the two SAP HANA sites in the Linux cluster.

Check both *global.ini* files and add the operation mode, if needed. Also add the 'register_secondaries_on_takeover = true' for multi-target setups.

Path for the *global.ini*: /hana/shared/<SID>/global/hdb/custom/config/global.ini

```
[system_replication]
operation_mode = logreplay
register_secondaries_on_takeover = true
```

7.3 Adapting SAP HANA name server configuration

We need change the *nameserver.ini* for the two sites controlled by the Linux cluster. This change ensures that there is no second master name server candidate as this is an ERP style setup. By default during the SAP HANA installation the second node at each site will be configured as the master name server candidate. We need to remove the second node from the line starting with 'master =''. The below example is given for instance number '00'.

Before configuration change:

```
[landscape]
...
master = hanaso0:30001 hanaso1:30001
worker = hanaso0 hanaso1
active_master = hanaso0:30001
```

After configuration change:

```
[landscape]
...
master = hanaso0:30001
worker = hanaso0 hanaso1
active_master = hanaso0:30001
```

Refer to SAP HANA documentation for details.

7.4 Implementing susHanaSR.py for srConnectionChanged

This step must be done on both sites that will be part of the cluster. Use the SAP HANA tools for changing global.ini and integrating the hook script. In global.ini, the section `[ha_dr_provider_sushanasr]` needs to be created. The section `[trace]` might be adapted. The ready-to-use HA/DR hook script is shipped with the SAPHanaSR-angi package in directory /usr/share/SAPHanaSR-angi/. The hook script must be available on all cluster nodes, including the majority maker. Find more details in manual pages susHanaSR.py(7) and SAPHanaSR-manageProvider(8).

EXAMPLE 21: ADDING SUSHANASR.PY VIA GLOBAL.INI

```
[ha_dr_provider_sushanasr]
provider = susHanaSR
path = /usr/share/SAPHanaSR-angi/
```

```
execution_order = 1

[trace]
ha_dr_sushanasr = info
```

7.5 Implementing susChkSrv.py for srServiceStateChanged

This step must be done on both sites that will be part of the cluster. Use the SAP HANA tools for changing global.ini and integrating the hook script. In global.ini, the section `[ha_dr_provider_suschksrv]` needs to be created. The section `[trace]` might be adapted. The ready-to-use HA/DR hook script is shipped with the SAPHanaSR-angi package in directory /usr/share/SAPHanaSR-angi/. The hook script must be available on all cluster nodes, including the majority maker. Find more details in manual pages susChkSrv.py(7), SAPHanaSR-manageProvider(8) and SAPHanaSR-alert-fencing(8).

EXAMPLE 22: ADDING SUSCHKSRV.PY VIA GLOBAL.INI

```
[ha_dr_provider_suschksrv]
provider = susChkSrv
path = /usr/share/SAPHanaSR-angi/
execution_order = 3
action_on_lost = stop

[trace]
ha_dr_suschksrv = info
```

It is again reminded that the srHook script "susChkSrv.py" is not available in the installation ISO media. It is only available in update channels of SUSE Linux Enterprise Server for SAP Applications 15 SP4. So, for a correctly working setup a full system patching is mandatory after registering the system to SCC, RMT or SUSE Manager. From SUSE Linux Enterprise Server for SAP Applications 15 SP5 onwards the "susChkSrv.py" will be included in the ISO.

7.6 Implementing susTkOver.py for preTakeover

This step must be done on both sites that will be part of the cluster. Use the SAP HANA tools for changing global.ini and integrating the hook script. In global.ini, the section `[ha_dr_provider_sustkover]` needs to be created. The section `[trace]` might be adapted. The ready-to-use HA/DR hook script is shipped with the SAPHanaSR-angi package in directory /

usr/share/SAPHanaSR-angi/. The hook script must be available on all cluster nodes, including the majority maker. Find more details in manual pages susTkOver.py(7) and SAPHanaSR-manageProvider(8).

EXAMPLE 23: ADDING SUSTKOVER.PY VIA GLOBAL.INI

```
[ha_dr_provider_sustkover]
provider = susTkOver
path = /usr/share/SAPHanaSR-angi/
execution_order = 2
sustkover_timeout = 30

[trace]
ha_dr_sustkover = info
```

It is again reminded that the srHook script "susTkOver.py" is not available in the installation ISO media. It is only available in update channels of SUSE Linux Enterprise Server for SAP Applications 15 SP4. So, for a correctly working setup a full system patching is mandatory after registering the system to SCC, RMT or SUSE Manager. From SUSE Linux Enterprise Server for SAP Applications 15 SP5 onwards the "susTkOver.py" will be included in the ISO.

7.7 Allowing <sid>adm to access the cluster

The current version of the susHanaSR.py python hook uses the command `sudo` to allow the <sid>adm user to access the cluster attributes. In Linux you can use `visudo` to start the vi editor for the Linux system */etc/sudoers*. We recommend to use a specific file */etc/sudoers.d/SAPHanaSR* instead. That file can be edited by plain `vi`, or handled by any configuration management.

The user <sid>adm must be able to set the cluster attributes **hana_<sid>_site_srHook_*** and **hana_<sid>_gsh**. The SAP HANA system replication hook needs password free access. The following example limits the sudo access to exactly setting the needed attribute. See manual pages sudoers(5), susHanaSR.py(7) and susChkSrv.py(7) for details.

EXAMPLE 24: ENTRY IN SUDO PERMISSIONS */ETC/SUDOERS.D/SAPHANASR* FILE

> Example for basic options to allow <sid>adm to use the hook scripts. Replace the <sid> by the lowercase SAP system ID. Replace the <SID> by the uppercase SAP system ID.
>
> ```
> # SAPHanaSR-angi needs for HA/DR hook scripts
> <sid>adm ALL=(ALL) NOPASSWD: /usr/sbin/crm_attribute -n hana_<sid>_*
> ```

```
<sid>adm ALL=(ALL) NOPASSWD: /usr/bin/SAPHanaSR-hookHelper --sid=<SID> *
```

Example for looking up the sudo permissions for the hook scripts.

```
# sudo -U <sid>adm -l | grep "NOPASSWD"
```

7.8 Starting SAP HANA

After having completed the SAP HANA configuration and having configured the communication between SAP HANA and the Linux cluster, you can start the SAP HANA database on both sites.

EXAMPLE 25: STARTING A COMPLETE SAP HANA SITE AS USER <SID>ADM

```
~> sapcontrol -nr <instanceNumber> -function StartSystem
```

The *sapcontrol* service commits the request with OK.

```
12.06.2024 11:11:01
StartSystem
OK
```

Check if SAP HANA has finished starting.

```
~> sapcontrol -nr <instanceNumber> -function WaitforStarted 300 20
~> sapcontrol -nr <instanceNumber> -function GetSystemInstanceList
```

7.9 Testing the HA/DR provider hook script integration

When the SAP HANA database has been restarted after the changes, check if the hook scripts have been loaded correctly. A useful verification is to check the SAP HANA trace files as <sid>adm. More complete checks wil be done later, when the Linux cluster is up and running.

7.9.1 Checking for *susHanaSR.py*

Check if SAP HANA has initialized the *susHanaSR.py* hook script for the **srConnectionChanged** events. Check the HANA name server trace files and the specific hook script trace file. Do this on both sites' master name server. See also manual page susHanaSR.py(7).

```
~> cdtrace
~> grep HADR.*load.*susHanaSR nameserver_*.trc | tail -3
```

```
~> grep susHanaSR.*init nameserver_*.trc | tail -3
```

7.9.2 Checking for susChkSrv.py

Check if SAP HANA has initialized the *susChkSrv.py* hook script for the **srServiceStateChanged** events. Check the HANA name server trace files and the specific hook script trace file. Do this on all nodes. See also manual page susChkSrv.py(7).

```
~> cdtrace
~> grep HADR.*load.*susChkSrv nameserver_*.trc | tail -3
~> grep susChkSrv.init nameserver_*.trc | tail -3
```

7.9.3 Checking for susTkOver.py

Check if SAP HANA has initialized the *susTkOver.py* hook script for the **preTakeover** events. Check the HANA name server trace. Do this on all nodes. See also manual page susTkOver.py(7).

```
~> cdtrace
~> grep HADR.*load.*susTkOver nameserver_*.trc | tail -3
~> grep susTkOver.init nameserver_*.trc | tail -3
```

8 Configuring the cluster and SAP HANA resources

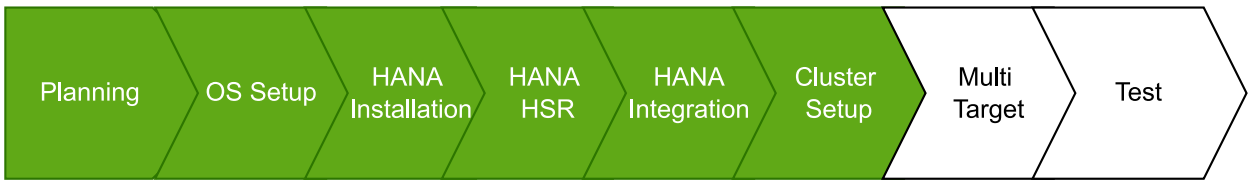

FIGURE 11: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP] [SAPHANAINST] [SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) CLUSTER *SECTION 9, "SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE"* (PAGE 59) *[TESTING]*

This chapter describes the configuration of the SUSE Linux Enterprise High Availability Extension cluster. The SUSE Linux Enterprise High Availability Extension is part of SUSE Linux Enterprise Server for SAP Applications. Further, the integration of SAP HANA System Replication with the SUSE Linux Enterprise High Availability Extension cluster is explained. The integration is done by using the SAPHanaSR-angi package which is also part of SUSE Linux Enterprise Server for SAP Applications.

PROCEDURE

1. Install the cluster packages
2. Basic cluster configuration
3. Configure cluster properties, resources and alerts
4. Final steps

8.1 Installing the cluster packages

If not already done, install the pattern **High Availability** on **all** nodes.

To do so, use Zypper.

```
# zypper in -t pattern ha_sles
```

Now the resource agents for controlling the SAP HANA system replication need to be installed at **all** cluster nodes, including the majority maker.

```
# zypper in SAPHanaSR-angi
```

If you have the packages installed before, make sure to get the newest updates on **all** nodes

```
# zypper patch
```

8.2 Configuring the basic cluster

After having installed the cluster packages, the next step is to set up the basic cluster framework. For convenience, use YaST or the *ha-cluster-init* script.

Important

It is strongly recommended to add a second corosync ring, implement unicast (UCAST) communication and adjust the timeout values to your environment.

Prerequisites

- Name resolution
- Time synchronization

- Redundant network for cluster communication
- STONITH method

8.2.1 Setting up watchdog for "Storage-based Fencing"

It is recommended to use SBD as central STONITH device, as done in the example at hand. Each node constantly monitors connectivity to the storage device, and terminates itself in case the partition becomes unreachable. Whenever SBD is used, a correctly working watchdog is crucial. Modern systems support a hardware watchdog that needs to be "tickled" by a software component. The software component (usually a daemon) regularly writes a service pulse to the watchdog. If the daemon stops "tickling" the watchdog, the hardware will enforce a system restart. This protects against failures of the SBD process itself, such as dying, or getting stuck on an I/O error.

EXAMPLE 26: SET UP FOR WATCHDOG

> **Important**
>
> Access to the Watchdog Timer: No other software must access the watchdog timer. Some hardware vendors ship systems management software that uses the watchdog for system resets (for example HP ASR daemon). Disable such software, if watchdog is used by SBD.

Determine the right watchdog module. Alternatively, you can find a list of installed drivers with your kernel version.

```
# ls -l /lib/modules/$(uname -r)/kernel/drivers/watchdog
```

Check if any watchdog module is already loaded.

```
# lsmod | egrep "(wd|dog|i6|iT|ibm)"
```

If you get a result, the system has already a loaded watchdog. If the watchdog does not match your watchdog device, you need to unload the module.

To safely unload the module, check first if an application is using the watchdog device.

```
# lsof /dev/watchdog
# rmmod <wrong_module>
```

Enable your watchdog module and make it persistent. For the example below, *softdog* has been used which has some restrictions and should not be used as first option.

```
# echo softdog > /etc/modules-load.d/watchdog.conf
# systemctl restart systemd-modules-load
```

Check if the watchdog module is loaded correctly.

```
# lsmod | grep dog
```

Testing the watchdog can be done with a simple action. Ensure to switch of your SAP HANA first because watchdog will force an unclean reset/shutdown of your system.

In case of a hardware watchdog a desired action is predefined after the timeout of the watchdog has reached. If your watchdog module is loaded and not controlled by any other application, do the following:

Important

Triggering the watchdog without continuously updating the watchdog resets/switches off the system. This is the intended mechanism. The following commands will force your system to be reset/switched off.

```
# touch /dev/watchdog
```

In case the softdog module is used the following action can be performed:

```
# echo 1 > /dev/watchdog
```

After your test was successful you can implement the watchdog on all cluster members. The example below applies to the softdog module. Replace <**wrong_module**> by the module name queried before.

```
# for i in hana{so0,so1,so2,so3,mm}; do
    ssh -T $i <<EOSSH
        hostname
        rmmod <wrong_module>
        echo softdog > /etc/modules-load.d/watchdog.conf
        systemctl restart systemd-modules-load
        lsmod |grep -e dog
EOSSH
done
```

8.2.2 Basic cluster configuration using *ha-cluster-init*

For more detailed information about ha-cluster-* tools, see section *Overview of the Bootstrap Scripts* of the Installation and Setup Quick Start Guide for SUSE Linux Enterprise High Availability at https://documentation.suse.com/sle-ha/15-SP4/html/SLE-HA-all/article-installation.html#sec-ha-inst-quick-bootstrap.

Create an initial setup by using the `ha-cluster-init` command. Follow the dialog steps.

Note

This is **only** to be done on the **first** cluster node. If you are using SBD as STONITH mechanism, you need to first load the watchdog kernel module matching your setup. In the example at hand, the *softdog* kernel module is used.

The command `ha_cluster-init` configures the basic cluster framework including:

- SSH keys
- csync2 to transfer configuration files
- SBD (at least one device)
- corosync (at least one ring)
- HAWK Web interface

```
# ha-cluster-init -u -s <sbd-device>
```

As requested by *ha-cluster-init*, change the password of the user *hacluster* on all cluster nodes.

Note

Do not forget to change the password of the user *hacluster*.

8.2.3 Cluster configuration for all other cluster nodes

The other nodes of the cluster could be integrated by starting the command `ha-cluster-join`. This command asks for the IP address or name of the **first** cluster node. Than all needed configuration files are copied over. As a result the cluster is started on **all** nodes. Do not forget the majority maker.

If you are using SBD as STONITH method, you need to activate the *softdog* kernel module matching your systems. In the example at hand the *softdog* kernel module is used.

```
# ha-cluster-join -c <host1>
```

8.2.4 Checking the cluster for the first time

Now it is time to check and optionally start the cluster for the first time on all nodes.

```
# crm cluster run "crm cluster start"
```

Note

All nodes should be started in parallel. Otherwise unseen nodes might get fenced.

Check whether all cluster nodes have registered at the SBD device(s). See manual page cs_show_sbd_devices(8) for details.

```
# cs_show_sbd_devices
```

Check the cluster status with `crm_mon`. Use the option `-r` to also see resources which are configured but stopped.

```
# crm_mon -r
```

The command will show the empty cluster and will print something like the screen output below. The most interesting information in this output is that there are two nodes in the status "online" and the message "partition with quorum".

```
Stack: corosync
Current DC: hanamm (version 1.1.16-4.8-77ea74d) - partition with quorum
Last updated: Tue Jan 25 16:55:04 2024
Last change: Tue Jan 25 16:53:58 2024 by root via crm_attribute on hanaso2

5 nodes configured
1 resource configured

Online: [ hanamm hanaso0 hanaso1 hanaso2 hanaso3 ]

Full list of resources:
```

```
stonith-sbd     (stonith:external/sbd): Started hanamm
```

8.3 Configuring cluster properties and resources

This section describes how to configure bootstrap, STONITH, resources and constraints using the `crm` configure shell command as described in section *Managing cluster resources* of the SUSE Linux Enterprise High Availability Extension Administration Guide (see https://documentation.suse.com/sle-ha/15-SP4/html/SLE-HA-all/cha-ha-manage-resources.html).

Use the command `crm` to add the objects to the Cluster Resource Management (CRM). Copy the following examples to a local file and then load the configuration to the Cluster Information Base (CIB). The benefit is that you have a scripted setup and a backup of your configuration.

Perform all `crm` commands only on **one** node, for example on machine hanaso0.

First write a text file with the configuration, which you load into your cluster in a second step. This step is as follows:

```
# vi crm-file<XX>
# crm configure load update crm-file<XX>
```

8.3.1 Cluster bootstrap and more

The first example defines the cluster bootstrap options including the resource and operation defaults.

The `stonith-timeout` should be greater than 1.2 times the SBD `msgwait` timeout. Find more details and examples in manual page SAPHanaSR-ScaleOut_basic_cluster(7).

```
# vi crm-bs.txt
```

Enter the following to *crm-bs.txt*:

```
property cib-bootstrap-options: \
    have-watchdog=true \
    cluster-infrastructure=corosync \
    cluster-name=hacluster \
    placement-strategy=balanced \
    no-quorum-policy=freeze \
    stonith-enabled=true \
    concurrent-fencing=true \
    stonith-action=reboot \
```

```
    stonith-timeout=150
rsc_defaults rsc-options: \
    resource-stickiness=1000 \
    migration-threshold=50
op_defaults op-options: \
    timeout=600 \
    record-pending=true
```

Now add the configuration to the cluster.

```
# crm configure load update crm-bs.txt
```

8.3.2 STONITH

As already explained in the requirements, STONITH is crucial for a supported cluster setup. Without a valid fencing mechanism your cluster is unsupported.

A standard STONITH mechanism implements SBD based fencing. The SBD STONITH method is very stable and reliable and has proved very good road capability.

You can use other fencing methods available for example from your public cloud provider. However, it is crucial to intensively test the server fencing.

For SBD based fencing you can use one up to three SBD devices. The cluster will react differently when an SBD device is lost. The differences and SBD fencing are explained very well in the SUSE product documentation of the SUSE Linux Enterprise High Availability Extension available at https://documentation.suse.com/.

You need to adapt the SBD resource for the SAP HANA scale-out cluster.

As user <sid>adm create a file named for *crm-fencing.txt*.

EXAMPLE 27: CONFIGURE FENCING

```
# vi crm-fencing.txt
```

Enter the following to *crm-fencing.txt*:

```
primitive stonith-sbd stonith:external/sbd \
 params pcmk_action_limit=-1 pcmk_delay_max=1
```

Now load the configuration from the file to the cluster.

```
# crm configure load update crm-fencing.txt
```

8.3.3 Cluster in maintenance mode

Load the configuration for the resources and the constraints step-by-step to the cluster to explain the different parts. The best way to avoid unexpected cluster reactions is to

- first set the complete cluster to maintenance mode,
- then do all needed changes and,
- as last step, end the cluster maintenance mode.

```
# crm maintenance on
```

8.3.4 SAPHanaTopology

SAPHanaTopology is the resource agent (RA) that analyzes the SAP HANA topology and writes its findings into the CIB. Prepare the RA configuration in a text file, for example *crm-saphanatop.txt*, and load these with the `crm` command.

If necessary, change the **SID** and **instance number** (bold) to appropriate values for your setup.

EXAMPLE 28: CONFIGURE SAPHANATOPOLOGY

```
hanaso0:~ # vi crm-saphanatop.txt
```

Enter the following to *crm-saphanatop.txt*:

```
primitive rsc_SAPHanaTop_<SID>_HDB<instanceNumber> ocf:suse:SAPHanaTopology \
    op monitor interval="50" timeout="600" \
    op start interval="0" timeout="600" \
    op stop interval="0" timeout="300" \
    params SID="<SID>" InstanceNumber="<instanceNumber>"

clone cln_SAPHanaTop_<SID>_HDB<instanceNumber>
 rsc_SAPHanaTop_<SID>_HDB<instanceNumber> \
    meta clone-node-max="1" interleave="true"
```

```
primitive rsc_SAPHanaTop_TST_HDB00 ocf:suse:SAPHanaTopology \
    op monitor interval="50" timeout="600" \
    op start interval="0" timeout="600" \
    op stop interval="0" timeout="300" \
    params SID="TST" InstanceNumber="00"

clone cln_SAPHanaTop_TST_HDB00 rsc_SAPHanaTop_TST_HDB00 \
    meta clone-node-max="1" interleave="true"
```

For additional information about all parameters, use the command `man ocf_suse_SAPHanaTopology`.

Again, add the configuration to the cluster.

```
# crm configure load update crm-saphanatop.txt
```

The most important parameters here are `SID` (TST) and `InstanceNumber` (00), which are self explaining in an SAP context. Beside these parameters, the timeout values or the operations (start, monitor, stop) are typical values to be adjusted for your environment. Additional information about all parameters can be found in manual page ocf_suse_SAPHanaTopology(7).

8.3.5 SAPHanaFilesystem

This step is to define the resources to monitor the file system used by HANA, for example */hana/shared/<SID>*. The RA monitors the file system but does not mount nor umount it. Mounting and umounting is done by the OS through */etc/fstab*.

If necessary, change the **SID** and **instance number** (bold) to the appropriate values for your setup.

EXAMPLE 29: CONFIGURE SAPHANAFILESYSTEM

```
hanaso0:~ # vi crm-saphanafil.txt
```

Enter the following to *crm-saphanafil.txt*:

```
primitive rsc_SAPHanaFil_<SID>_HDB<instanceNumber> ocf:suse:SAPHanaFilesystem \
    op monitor interval="120" timeout="120" \
    op start interval="0" timeout="10" \
    op stop interval="0" timeout="20" \
    params SID="<SID>" InstanceNumber="<instanceNumber>" ON_FAIL_ACTION="fence"

clone cln_SAPHanaFil_<SID>_HDB<instanceNumber>
 rsc_SAPHanaFil_<SID>_HDB<instanceNumber> \
    meta clone-node-max="1" interleave="true"
```

```
primitive rsc_SAPHanaFil_TST_HDB00 ocf:suse:SAPHanaFilesystem \
    op monitor interval="120" timeout="120" \
    op start interval="0" timeout="10" \
    op stop interval="0" timeout="20" \
    params SID="TST" InstanceNumber="00" ON_FAIL_ACTION="fence"
```

```
clone cln_SAPHanaFil_TST_HDB00 rsc_SAPHanaFil_TST_HDB00 \
    meta clone-node-max="1" interleave="true"
```

Additional information about all parameters can be found in manual page ocf_suse_SAPHanaFilesystem(7).

Again, add the configuration to the cluster.

```
# crm configure load update crm-saphanafil.txt
```

The most important parameters here are *SID* (TST) and *InstanceNumber* (00), which are self explaining in an SAP context. ON_FAIL_ACTION defines how the RA should react on monitor failures. See also manual page SAPHanaSR-alert-fencing(8). Beside these parameters, the time-out values or the operations (start, monitor, stop) are typical values to be adjusted for your environment.

8.3.6 SAPHanaController

SAPHanaController is the resource agent (RA) that controls the HANA database. Prepare the RA configuration in a text file, for example *crm-saphanatop.txt*, and load these with the `crm` command.

EXAMPLE 30: CONFIGURE SAPHANACONTROLLER

Enter the following to *crm-saphanacon.txt*:

```
# vi crm-saphanacon.txt
```

Enter the following to *crm-saphanacon.txt*:

```
primitive rsc_SAPHanaCon_<SID>_HDB<instanceNumber> ocf:suse:SAPHanaController \
    op start interval="0" timeout="3600" \
    op stop interval="0" timeout="3600" \
    op promote interval="0" timeout="900" \
    op demote interval="0" timeout="320" \
    op monitor interval="60" role="Promoted" timeout="700" \
    op monitor interval="61" role="Unpromoted" timeout="700" \
    params SID="<SID>" InstanceNumber="<instanceNumber>" \
        PREFER_SITE_TAKEOVER="true" \
        DUPLICATE_PRIMARY_TIMEOUT="7200" AUTOMATED_REGISTER="false" \
        HANA_CALL_TIMEOUT="120"

clone mst_SAPHanaCon_<SID>_HDB<instanceNumber> \
    rsc_SAPHanaCon_<SID>_HDB<instanceNumber> \
```

```
    meta clone-node-max="1" promotable="true" interleave="true" \
    maintenance="true"
```

The most important parameters here are <SID> (TST) and <instanceNumber> (00), which are in the SAP context quite self explaining. Beside these parameters, the timeout values or the operations (start, monitor, stop) are typical tuneables. Find more details in manual page ocf_suse_SAPHanaController(7).

```
primitive rsc_SAPHanaCon_TST_HDB00 ocf:suse:SAPHanaController \
    op start interval="0" timeout="3600" \
    op stop interval="0" timeout="3600" \
    op promote interval="0" timeout="900" \
    op demote interval="0" timeout="320" \
    op monitor interval="60" role="Promoted" timeout="700" \
    op monitor interval="61" role="Unpromoted" timeout="700" \
    params SID="TST" InstanceNumber="00" PREFER_SITE_TAKEOVER="true" \
        DUPLICATE_PRIMARY_TIMEOUT="7200" AUTOMATED_REGISTER="false" \
        HANA_CALL_TIMEOUT="120"

clone msl_SAPHanaCon_TST_HDB00 rsc_SAPHanaCon_TST_HDB00 \
    meta clone-node-max="1" promotable="true" interleave="true" \
    maintenance="true"
```

Add the configuration to the cluster.

```
# crm configure load update crm-saphanacon.txt
```

TABLE 2: TABLE DESCRIPTION OF IMPORTANT RESOURCE AGENT PARAMETER

Name	Description
PREFER_SITE_TAKEOVER	Defines whether RA should prefer to takeover to the secondary instance instead of restarting the failed primary locally. Set to **true** for SAPHanaSR-angi.
AUTOMATED_REGISTER	Defines whether a former primary should be automatically registered to be secondary of the new primary. With this parameter you can adapt the level of system replication automation. If set to **false**, the former primary must be manually registered. The cluster will not start this SAP HANA RDBMS until it is registered to avoid double primary up situations.

Name	Description
DUPLICATE_PRIMARY_TIMEOUT	Time difference needed between two primary time stamps if a dual-primary situation occurs. If the time difference is less than the time gap, the cluster holds one or both sites in a "WAITING" status. This is to give an administrator the chance to react on a failover. If the complete node of the former primary crashed, the former primary will be registered after the time difference is passed. If "only" the SAP HANA RDBMS has crashed, then the former primary will be registered immediately. After this registration to the new primary, all data will be overwritten by the system replication.

Additional information about all parameters can be found in manual page ocf_suse_SAPHana_Controller(7).

8.3.7 Virtual IP address of the HANA primary

The last mandatory resource to be added to the cluster is covering the virtual IP address for the HANA primary master name server. Replace the bold string with your instance number, SAP HANA system ID and the virtual IP address.

EXAMPLE 31: CONFIGURE THE VIRTUAL IP ADDRESS OF THE PRIMARY

```
# vi crm-vip.txt
```

Enter the following to *crm-vip.txt*:

```
primitive rsc_ip_<SID>_HDB<instanceNumber> ocf:heartbeat:IPaddr2 \
    op monitor interval="10s" timeout="20s" \
    params ip="<IP>"
```

EXAMPLE 32: REPLACE <SID> BY TST, <INSTANCENUMBER> BY 00, <IP> BY 192.7.7.20

```
primitive rsc_ip_TST_HDB00 ocf:heartbeat:IPaddr2 \
    op monitor interval="10s" timeout="20s" \
    params ip="192.7.7.20"
```

Load the file to the cluster.

```
# crm configure load update crm-vip.txt
```

In most installations, only the parameter **ip** needs to be set to the virtual IP address to be presented to the client systems. See manual page ocf_heartbeat_IPaddr2(7) for details on additional parameters.

8.3.8 Constraints

The constraints are organizing the correct placement of the virtual IP address for the client database access and the start order between the two resource agents SAPHanaController and SAPHanaTopology.

EXAMPLE 33: CONFIGURE NEEDED CONSTRAINTS

```
# vi crm-cs.txt
```

Enter the following to *crm-cs.txt*:

```
colocation col_saphana_ip_<SID>_HDB<instanceNumber> 2000:
 rsc_ip_<SID>_HDB<instanceNumber>:Started \
    mst_SAPHanaCon_<SID>_HDB<instanceNumber>:Promoted

order ord_SAPHana_<SID>_HDB<instanceNumber> Optional:
 cln_SAPHanaTop_<SID>_HDB<instanceNumber> \
    mst_SAPHanaCon_<SID>_HDB<instanceNumber>

location SAPHanaCon_not_on_majority_maker mst_SAPHanaCon_<SID>_HDB<instanceNumber> \
    -inf: <majority maker>
location SAPHanaTop_not_on_majority_maker cln_SAPHanaTop_<SID>_HDB<instanceNumber> \
    -inf: <majority maker>
location SAPHanaFil_not_on_majority_maker cln_SAPHanaFil_<SID>_HDB<instanceNumber> \
    -inf: <majority maker>
```

EXAMPLE 34: REPLACE <SID> BY TST, <INSTANCENUMBER> BY 00

```
colocation col_saphana_ip_TST_HDB00 2000: rsc_ip_TST_HDB00:Started \
    mst_SAPHanaCon_TST_HDB00:Master

order ord_SAPHana_TST_HDB00 Optional: cln_SAPHanaTop_TST_HDB00 \
    mst_SAPHanaCon_TST_HDB00

location SAPHanaCon_not_on_majority_maker msl_SAPHanaCon_TST_HDB00 -inf: hanamm
```

```
location SAPHanaTop_not_on_majority_maker cln_SAPHanaTop_TST_HDB00 -inf: hanamm
location SAPHanaFil_not_on_majority_maker cln_SAPHanaFil_TST\_HDB00 -inf: hanamm
```

Load the file to the cluster.

```
# crm configure load update crm-cs.txt
```

8.3.9 Configuring virtual IP address of the HANA read-enabled secondary

This optional resource is covering the virtual IP address for the read-enabled HANA secondary master name server. It is useful if SAP HANA is configured with the active/read-enabled feature. Replace the bold string with your instance number, SAP HANA system ID and the virtual IP address.

Note

In scale-out this works only for an SAP HANA topology with exactly one master name server and exactly one worker node.

EXAMPLE 35: CONFIGURE THE VIRTUAL IP ADDRESS OF THE READ-ENABLED SECONDARY

```
# vi crm-vip-ro.txt
```

Enter the following to *crm-vip-ro.txt*:

```
primitive rsc_ip_ro_<SID>_HDB<instanceNumber> ocf:heartbeat:IPaddr2 \
    op monitor interval="10s" timeout="20s" \
    params ip="<IP-ro>"
colocation col_ip_ro_with_secondary_<SID>_HDB<instanceNumber> \
    2000: rsc_ip_ro_<SID>_HDB<instanceNumber>:Started \
    mst_SAPHanaCon_<SID>_HDB<instanceNumber>:Unpromoted
location loc_ip_ro_not_master_<SID>_HDB<instanceNumber> \
    rsc_ip_ro_<SID>_HDB<instanceNumber> \
    rule -inf: hana_<sid>_roles ne master1:master:worker:master
```

EXAMPLE 36: REPLACE <SID> BY TST, <INSTANCENUMBER> BY 00, <IP-RO> BY 192.168.201.161

```
primitive rsc_ip_ro_TST_HDB00 ocf:heartbeat:IPaddr2 \
    op monitor interval="10s" timeout="20s" \
    params ip="192.168.201.161"
colocation col_ip_ro_with_secondary_TST_HDB00 \
    2000: rsc_ip_ro_TST_HDB00:Started \
```

```
    mst_SAPHanaCon_TST_HDB00:Unpromoted
location loc_ip_ro_not_master_TST_HDB00 \
    rsc_ip_ro_TST_HDB00 \
    rule -inf: hana_tst_roles ne master1:master:worker:master
```

Load the file to the cluster.

```
# crm configure load update crm-vip-ro.txt
```

In most installations, only the parameter **ip** needs to be set to the virtual IP address to be presented to the client systems. Use the command `man ocf_heartbeat_IPaddr2` for details on additional parameters. See also manual page SAPHanaSR-ScaleOut_basic_cluster(7).

8.4 Final steps

8.4.1 Verifying the communication between the hook and the cluster

In this case the HA/DR provider sets the attribute to SFAIL to inform the cluster about a broken system replication.

8.4.2 Using special virtual host names or FQHN during the installation of SAP HANA

If you have used special virtual host names or the fully qualified host name (FQHN) instead of the short node name, the resource agents need to map these names. To be able to match the short node name with the used SAP 'virtual host name', the saphostagent needs to report the list of installed instances correctly:

EXAMPLE 37: IN THE SETUP AT HAND THE VIRTUAL HOST NAME MATCHES THE NODE NAME

```
hanaso0:tstadm> /usr/sap/hostctrl/exe/saphostctrl -function ListInstances
 Inst Info : HA1 - 00 - hanaso0 - 749, patch 418, changelist 1816226
```

8.4.3 Ending the cluster maintenance mode

After all changes are applied, as final steps, end the cluster maintenance mode, let the cluster detect the SAP HANA status and set the SAPHanaController resource out of maintenance.

EXAMPLE 38: ENDING THE CLUSTER MAINTENANCE

```
# crm maintenance off
# cs_wait_for_idle -s 5
# crm resource refresh mst_SAPHanaCon_TST_HDB00
# cs_wait_for_idle -s 5
# crm resource maintenance mst_SAPHanaCon_TST_HDB00 off
```

The command `cs_wait_for_idle` is part of the package `ClusterTools2`. For more details, see manual pages cs_wait_for_idle(8), crm(8), SAPHanaSR_maintenance_examples(7).

9 Setting up a scale-out multi-target architecture

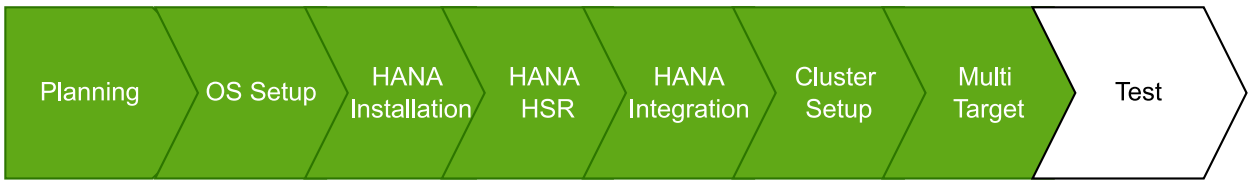

FIGURE 12: *SECTION 3, "PLANNING THE INSTALLATION"* (PAGE 9) *[OSSETUP] [SAPHANAINST] [SAPHANAHSR] SECTION 7, "INTEGRATING SAP HANA WITH THE LINUX CLUSTER"* (PAGE 37) *SECTION 8, "CONFIGURING THE CLUSTER AND SAP HANA RESOURCES"* (PAGE 43) MULTITARGET *[TESTING]*

This chapter is optional, depending on your needs. IIt covers configuring the third site in a multi-target setup after reinstalling the entire landscape using the procedures mentioned so far in the document.

9.1 Setting up third SAP HANA site in a multi-target architecture

This section applies only if you plan to attach a 3rd replication site to the existing multi-targe aware cluster. This is a general approach. Neverteless, a 3rd site could have been prepared already.

When the existing or newly created part of the scale-out performance optimized cluster is ready, complete the following steps to configure the third SAP HANA site into multi-target.

9.1.1 Installing SAP HANA at the third site

Follow the same steps as described in chapter *[SAPHanaInst]* for the secondary site. Make sure to use the identifiers for the third site, as defined in the parameter sheet.

9.1.2 Registering the third site

Register the master node on the third site with the source of the SAP HANA system replication. In our case the source is the primary site with its respective primary master name server. Use the third site´s site name as noted in the parameter sheet.

```
~> hdbnsutil -sr_register --name=FRA1 --remoteHost=hanaso0 --remoteInstance=00 --
replicationMode=async --operationMode=logreplay
```

9.1.3 Checking SAPHanaSR attributes for the third site

SAPHanaSR-showAttr shows the status of the third site which should be as below:

```
hanaso0:~ # SAPHanaSR-showAttr
Global cib-time                 maintenance prim sec  sid topology
-------------------------------------------------------------------
global Tue Jan 06 00:44:25 2024 false       WDF1 ROT1 TST ScaleOut

Resource              maintenance
---------------------------------
mst_SAPHana_TST_HDB00 false

Sites lpt       lss mns     opMode    srHook srMode srPoll srr
-----------------------------------------------------------
FRA1                                  SOK
ROT1 30         4   hanaso2 logreplay SOK    sync   SOK    S
WDF1 1657838665 4   hanaso0 logreplay PRIM   sync   PRIM   P

Hosts   clone_state node_state roles                       score  site srah
-------------------------------------------------------------------------
hanamm              online
hanaso0 PROMOTED    online     master1:master:worker:master 150    WDF1 -
hanaso1 DEMOTED     online     slave:slave:worker:slave     -10000 WDF1
hanaso2 DEMOTED     online     master1:master:worker:master 100    ROT1 -
hanaso3 DEMOTED     online     slave:slave:worker:slave     -12200 ROT1
```

Important items in above output that may seem different from earlier hook output are:

- The "Global" section shows the "sid" SID, "prim" primary and "sec" secondary site name, and the "topology" (ScaleUp or ScaleOut). Optionally, the cluster resource maintenance status is shown.
- The "Resource" section shows up if a cluster resource maintenance status has been changed.

- The "Sites" section shows the "srHook" attribute that reflects the SAP HANA system replication status as reported by the HA/DR provider script. The attribute changes whenever SAP HANA raises an srConnectionChanged() event (and the Linux cluster is functional). This information helps to decide whether an SAP HANA takeover can be initiated in case the primary site fails. Only if the “srHook” attribute is “SOK”, the cluster will initiate a takeover. The “srPoll” attribute reflects the SAP HANA system replication status as reported by the SAPHanaController RA monitor. The RA sets this attribute whenever processing a monitor or probe action. The call is SAP HANA’s systemReplicationStatus.py. This happens on regular base, defined by the monitor interval, and on start/stop/promote/demote operations. The “lss” column shows SAP HANA’s overall landscape status per site. The SAPHanaTopology RA monitor calls SAP HANA’s landscapeHostConfiguration.py script and updates this attribute accordingly. As long as SAP HANA does not report “lss” as “1”, no takeover will happen. A value of “0” indicates a fatal internal communication error that made it impossible to detect the current landscape status. The attribute “srr” indicates the detected system replication role. “P” is the abbreviation for “primary” and “S” for “secondary”. The SAPHanaTopology resource agent sets these values to allow operation in maintenance windows of SAP HANA. The attribute “mns” indicates the current identified active master names server of the site.
- In the “Hosts” section the “roles” column shows **actual** and **configured** roles for HANA on each node. Since we do not have standby nodes, **actual** and **configured** is always the same for a given host once SAP HANA is running. This output reflects the entries we made in HANA’s *nameserver.ini* file. The SAPHanaTopology RA updates these attributes during each monitor run. The majority maker has no SAP HANA roles. The “score” column shows what scores SAPHanaController uses for placing the roles, such as primary SAP HANA master name server, primary worker and more on the right hosts.

10 Testing the cluster

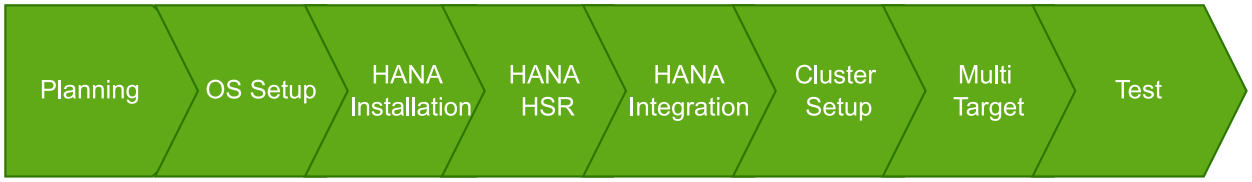

FIGURE 13: *SECTION 3, “PLANNING THE INSTALLATION”* (PAGE 9) *[OSSETUP] [SAPHANAINST] [SAPHANAHSR] SECTION 7, “INTEGRATING SAP HANA WITH THE LINUX CLUSTER”* (PAGE 37) *SECTION 8, “CONFIGURING THE CLUSTER AND SAP HANA RESOURCES”* (PAGE 43) *SECTION 9, “SETTING UP A SCALE-OUT MULTI-TARGET ARCHITECTURE”* (PAGE 59) TESTING

Testing is one of the most important project tasks for implementing clusters. Proper testing is crucial. Make sure that all test cases derived from project or customer expectations are defined and passed completely. **Without testing the project is likely to fail in production use**.

The test prerequisite, if not described differently, is always that all cluster nodes are booted, are already normal members of the cluster and the SAP HANA RDBMS is running. The system replication is in state **SYNC** represented by 'srHook SOK' for the secondary site. The cluster is idle, no actions are pending, no migration constraints left over, no failcounts left over.

The expected results are given for SAPHanaController parameter AUTOMATED_REGISTER = "false" and SBD parameter SBD_START_MODE = "always". These are installation defaults. Further susChkSrv.py parameter action_on_lost = "stop" is used.

10.1 Generic cluster tests

The cluster tests described in this section cover the cluster reaction during operations. This includes starting and stopping the complete cluster or simulating SBD failures and much more.

- Parallel start of all cluster nodes (`crm cluster start` should be done in a short time frame).
- Stop of the complete cluster.
- Isolate ONE of the two SAP HANA sites.
- Power-off the majority maker.
- Isolate the SBD.
- Simulate a maintenance procedure with cluster continuously running.
- Simulate a maintenance procedure with cluster restart.
- Kill the corosync process of one of the cluster nodes.

10.2 Tests on the primary site

The tests described in this section are checking the reaction on several failures of the primary site. Of course, primary site always is where the SAP HANA primary is running. That site will change after most of this tests.

10.2.1 Tests regarding cluster nodes of the primary site

The tests listed here will check the SAP HANA and cluster reaction if one or more nodes of the primary site are failing.

- Power-off master name server of the primary.

Expected Observation: The cluster initiates a takeover. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Power-off the worker node but not the master name server of the primary.

Expected Observation: The cluster will fail to stop the remaining HANA instance and thus fence the primary master node. Then the cluster initiates a takeover. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

10.2.2 Tests regarding the complete primary site

This test category is simulating a complete site failure.

- Power off all nodes of the primary site in parallel.

Expected observation: The cluster initiates a takeover. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Manually registering a failed primary site as new secondary.

Prerequistes: A failed former primary sites has been manually registered. The exact site name has been used as already known to the cluster, see parameter sheet.

Expected observation: The cluster accepts the registered site as secondary. The HANA resources are looking fine. After a while, system replication for the new secondary site gets okay (srHook SOK).

10.2.3 Tests regarding the SAP HANA instances of the primary site

The tests listed here are checks about the SAP HANA and cluster reactions triggered by application failures such as a crashed SAP HANA instance.

- Kill the SAP HANA instance of the master name server of the primary.

Expected observation: Cluster notices the failure of monitor operation of the HANA resource and initiates a takeover to the secondary site. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Kill the SAP HANA instance of the worker node but not the master name server of the primary.

Expected observation: Cluster notices the failure of monitor operation of the HANA resource and initiates a takeover to the secondary site. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Kill **sapstartsrv** of any SAP HANA instance of the primary.

Expected observation: Cluster notices the failure of monitor operation of the HANA resource and initiates a takeover to the secondary site. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Kill **hdbindexserver** processs on the worker node of the primary.

Expected observation: SAP HANA HA/DR provider stops HANA instance. Cluster notices the failure of monitor operation of the HANA resource and initiates a takeover to the secondary site. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

- Kill **hdbindexserver** processs on the master name server node of the primary.

Expected observation: SAP HANA HA/DR provider stops HANA instance. Cluster notices the failure of monitor operation of the HANA resource and initiates a takeover to the secondary site. The master name server at secondary site gets promoted. The source of system replication to the DR site changes to the new primary site. The former primary site stays unregistered.

10.3 Tests on the secondary site

The tests described in this section are checking the reaction on several failures of the secondary site. Of course, secondary site always is where the SAP HANA secondary is running.

10.3.1 Tests regarding cluster nodes of the secondary site

The tests listed here will check the SAP HANA and cluster reaction if one or more nodes of the secondary site are failing.

- Power off master name server of the secondary.

Expected Observation: Cluster notices the power down of the master name server on secondary. System replication gets broken between primary and secondary.

- Power off the worker node but not the master name server of the secondary.

Expected observation: Cluster notices the power down of the worker node on secondary site. The remaining master name server will be stopped. System replication gets broken between primary and secondary.

- Rejoin of a previously powered-off worker node.

Expected observation: Cluster notices rejoining of previously powered-off node. The HANA instance gets started. System replication gets back to okay (srHook SOK).

- Kill **hdbindexserver** processs on the worker node of the secondary.

Expected observation: SAP HANA HA/DR provider stops HANA instance. Cluster notices the failure of monitor operation of the HANA resource and initiates a local restart of the secondary.

- Kill **hdbindexserver** processs on the master name server node of the secondary.

Expected observation: SAP HANA HA/DR provider stops HANA instance. Cluster notices the failure of monitor operation of the HANA resource and initiates a local restart of the secondary site.

10.3.2 Tests regarding the complete secondary site

This test category is simulating a complete site failure.

- Power off all nodes of the secondary site in parallel.

Expected observation: Cluster notices the nodes that are down. System replication gets broken (srHook SFAIL).

- Rebuild the secondary site.

Expected observation: Cluster notices the nodes that are back. HANA instance gets started. After a while, system replication for secondary site gets okay (srHook SOK).

10.3.3 Tests regarding the SAP HANA instances of the secondary site

The tests listed here are checks about the SAP HANA and cluster reactions triggered by application failures such as a crashed SAP HANA instance.

- Kill the SAP HANA instance of the master name server of the secondary.

Expected observation: Monitor operation on HANA resource on the master candidate at secondary gets failed. Cluster then restarts the HANA resource on the affected nodes.

- Kill the SAP HANA instance of the worker node but not the master name server of the secondary.

Expected observation: Monitor operation on HANA resource on the master candidate at secondary gets failed. Cluster then restarts the HANA resource on the affected nodes.

- Kill **sapstartsrv** of any SAP HANA instance of the secondary.

Expected observation: Monitor operation on HANA resource on the master name server at secondary gets failed. Cluster then restarts the HANA resource on the affected nodes.

10.4 Tests on the third site

The third site is not controlled by the Linux cluster. No failure on third site should trigger any cluster action. Only effect might be third site´s srHook attribute changing from SOK to SFAIL, or vice versa.

10.4.1 Tests regarding the complete third site

This test category is simulating a complete site failure.

- Power off all nodes of the third site in parallel.

Expected observation: System replication for third site gets broken (srHook SFAIL).

- Rebuild the third site.

Expected observation: After a while, system replication for third site gets okay (srHook SOK).

11 Administration

11.1 Dos and don’ts

In your project, you should **do** the following:

- Define (and test) STONITH **before** adding other resources to the cluster.
- Do **intensive** testing.
- **Tune** the timeouts of operations of SAPHanaController, SAPHanaTopology, SAPHanaFilesystem.
- Start with SAPHanaController parameters **PREFER_SITE_TAKEOVER = true** , **AUTOMATED_REGISTER = false** and **DUPLICATE_PRIMARY_TIMEOUT = 7200**.
- Start with susChkSrv.py parameter **action_on_lost = stop**.
- Always make sure that the cluster configuration does not contain any left-over client-location constraints or failcounts.
- Before testing or beginning maintenance procedures, check if the cluster is in idle state.

In your project, **avoid** the following:

- Rapidly changing/changing back cluster configuration, such as: Setting nodes to standby and online again or stopping/starting the multi-state resource.
- Creating a cluster without proper time synchronization or unstable name resolutions for hosts, users, and groups.
- Adding location rules for the clone, multi-state or IP resource. Only location rules mentioned in this setup guide are allowed.

- Using SAP tools for attempting start/stop/takeover actions on a database while the cluster is in charge of managing that database. Same for unregistering/disabling system replication.
- As "migrating" or "moving" resources in *crm-shell*, HAWK or other tools would add client-location rules, these activities are completely forbidden!

11.2 Monitoring and tools

You can use the High Availability Web Konsole (HAWK), SAP HANA Cockpit and different command line tools for cluster status requests. See manual pages crm_mon(8), cs_wait_for_idle(8), SAPHanaSR-ScaleOut_maintenance_examples(7), SAPHanaSR-showAttr(8), susHanaSR.py(7) and susChkSrv.py(7).

11.2.1 HAWK – cluster status and more

You can use an Internet browser to check the cluster status. Use the following URL: https://<node>:7630

The login credentials are provided during the installation dialog of *ha-cluster-init*. Keep in mind to change the default password of the Linux user *hacluster* .

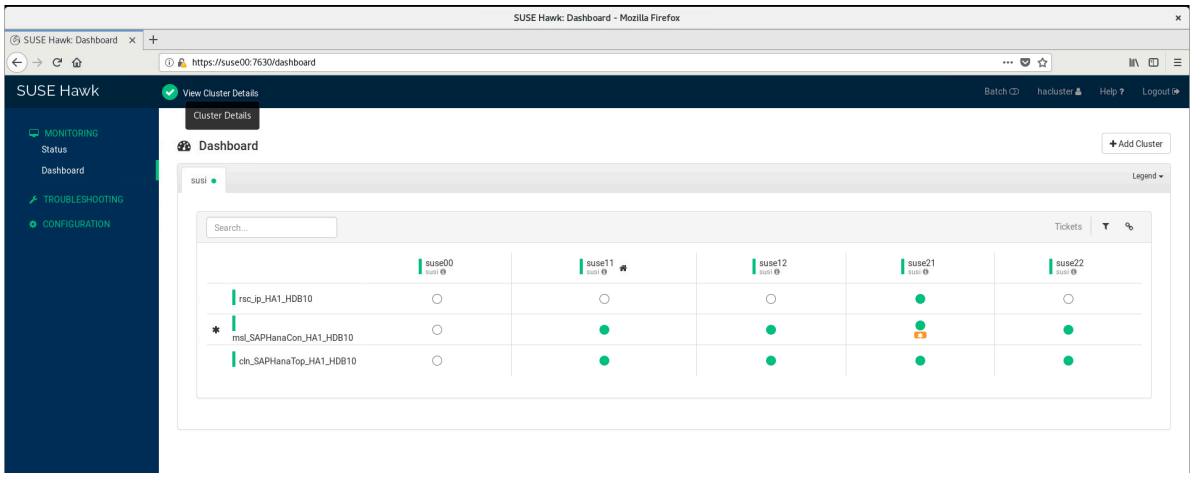

FIGURE 14: CLUSTER STATUS IN HAWK

If you set up the cluster using *ha-cluster-init* and you have installed all packages as described above, your system will provide a very useful Web interface. You can use this graphical Web interface to get an overview of the complete cluster status, perform administrative tasks or even configure resources and cluster bootstrap parameters.

Read the product manuals for a complete documentation of this powerful user interface.

11.2.2 SAP HANA Cockpit

Database-specific administration and checks can be done with SAP HANA Cockpit.

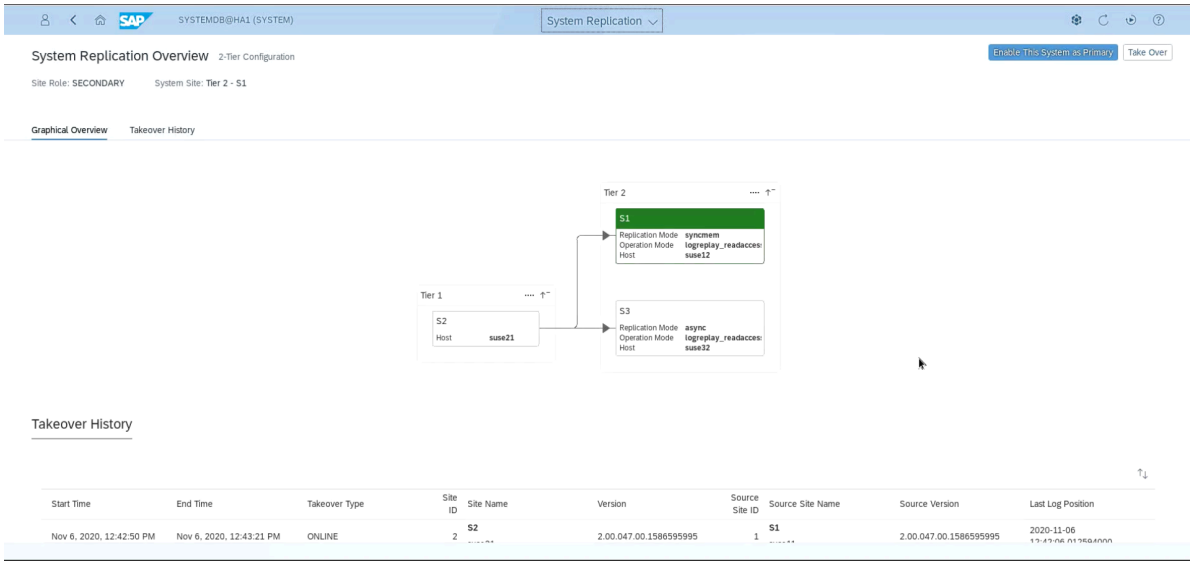

FIGURE 15: SAP HANA COCKPIT – SYSTEM REPLICATION OVERVIEW

Note

Be extremely careful with changing any parameter or the topology of the system replication. This might cause an interference with the cluster resource management.

A positive example is to register a former primary as new secondary and you have set *AUTOMATED_REGISTER = false*.

A negative example is to un-register a secondary, disable the system replication on the primary, and similar actions.

For all actions that change the system replication it is recommended to first check for the maintenance procedure. See manual page SAPHanaSR_maintenance_examples(7) and blog article https://www.suse.com/c/sap-hana-maintenance-suse-clusters/ .

11.2.3 Cluster command line tools

crm_mon

A simple overview can be obtained by calling `crm_mon`. Using the option `-r` shows also stopped but already configured resources. Option `-1` tells `crm_mon` to output the status once instead of periodically.

```
Cluster Summary:
  * Stack: corosync
  * Current DC: hanaso1 (version
 2.0.5+20201202.ba59be712-150300.4.21.1-2.0.5+20201202.ba59be712) - partition with quorum
  * Last updated: Tue Jan  6 00:12:46 2024
  * Last change:  Tue Jan  6 00:11:40 2024 by root via crm_attribute on hanaso0
  * 5 nodes configured
  * 12 resource instances configured

Node List:
  * Online: [ hanamm hanaso0 hanaso1 hanaso2 hanaso3 ]

Active Resources:
  * stonith-sbd (stonith:external/sbd):  Started hanamm
  * Clone Set: cln_SAPHanaTop_TST_HDB00 [rsc_SAPHanaTop_TST_HDB00]:
    * Started: [ hanaso0 hanaso1 hanaso2 hanaso3 ]
  * Clone Set: cln_SAPHanaFil_TST_HDB00 [rsc_SAPHanaFil_TST_HDB00]:
    * Started: [ hanaso0 hanaso1 hanaso2 hanaso3 ]
  * Clone Set: mst_SAPHanaCon_TST_HDB00 [rsc_SAPHanaCon_TST_HDB00] (promotable):
    * Masters: [ hanaso0 ]
    * Slaves: [ hanaso1 hanaso2 hanaso3 ]
  * rsc_ip_TST_HDB00    (ocf::heartbeat:IPaddr2):        Started hanaso0
```

See manual page crm_mon(8) for details.

SAPHanaSR-showAttr

To show some SAPHanaController and SAPHanaTopology resource agent internal values, you can call the program `SAPHanaSR-showAttr`. The internal values, storage location and their parameter names may change in the next versions. The command `SAPHanaSR-showAttr` will always fetch the values from the correct attribute location. Find more details and examples in manual page SAPHanaSR-showAttr(8).

Important

Do **not** use cluster commands like `crm_attribute` to fetch the values directly from the cluster. Your methods will be broken, when you need to move an attribute to a different location. `SAPHanaSR-showAttr` is firstly a test program only and should not be used for automated system monitoring.

EXAMPLE 39: CHECK SAPHANASR-SHOWATTR AS USER ROOT

```
suse-mm:~ # SAPHanaSR-showAttr --sid=<SID>
```

The tool displays all interesting cluster attributes in three areas.

- The **global** section shows information about SAP HANA SID, cib time stamp and a fall-back for the status of the system replication.
- The **sites** section shows the attributes per site. It shows the system replication status as reported by SAP HANA HADR provider. Further it shows which site the primary and the return code of the *landscapeHostConfiguration.py* script. In addition the active master name server is shown.
- The **hosts** section shows the node status, the roles of the host inside the SAP HANA database, the calculated score to get the primary master name server and the site the host belongs to.

```
hanaso0:~ # SAPHanaSR-showAttr
Global cib-time                 maintenance prim sec  sid topology
-------------------------------------------------------------------
global Tue Jan 06 00:44:25 2024 false       WDF1 ROT1 TST ScaleOut

Resource              maintenance
---------------------------------
mst_SAPHana_TST_HDB00 false

Sites lpt        lss mns     opMode    srHook srMode srPoll srr
-----------------------------------------------------------------
FRA1                        SOK
ROT1  30         4   hanaso2 logreplay SOK    sync   SOK    S
WDF1  1657838665 4   hanaso0 logreplay PRIM   sync   PRIM   P

Hosts   clone_state node_state roles                       score  site srah
--------------------------------------------------------------------------
hanamm              online
```

```
hanaso0 PROMOTED    online     master1:master:worker:master 150    WDF1 -
hanaso1 DEMOTED     online     slave:slave:worker:slave     -10000 WDF1
hanaso2 DEMOTED     online     master1:master:worker:master 100    ROT1 -
hanaso3 DEMOTED     online     slave:slave:worker:slave     -12200 ROT1
```

The majority maker *hanamm* does not run an SAP HANA instance and therefor neither has a role attribute nor a score or site value. The third HANA site FRA1 is not controlled by the Linux cluster. Therefor it doesnot have any attribute except the srHook status.

11.2.4 SAP HANA LandscapeHostConfiguration

To check the status of an SAP HANA database and to figure out if the cluster should react, you can use the script `landscapeHostConfiguration.py`.

EXAMPLE 40: CHECK THE LANDSCAPE STATUS AS USER <SID>ADM

```
~> HDBSettings.sh landscapeHostConfiguration.py
```

The landscape host configuration is shown with a line per SAP HANA host.

```
| Host   | Host   | ... NameServer  | NameServer  | IndexServer | IndexServer |
|        | Active | ... Config Role | Actual Role | Config Role | Actual Role |
| ------ | ------ | ... ----------- | ----------- | ----------- | ----------- |
| hanaso0 | yes    | ... master 1    | master      | worker      | master      |
| hanaso1 | yes    | ... slave    | slave       | worker      | slave       |

overall host status: ok
```

Following the SAP HA guideline, the *SAPHana* resource agent interprets the return codes in the following way:

TABLE 3: TABLE INTERPRETATION OF RETURN CODES

Return Code	Description
4	SAP HANA database is up and OK. The cluster does interpret this as correctly running database.
3	SAP HANA database is up and in status INFO. The cluster does interpret this as a correctly running database.
2	SAP HANA database is up and in status warning. The cluster does interpret this as a correctly running database.

Return Code	Description
1	SAP HANA database is down. If the database should be up and is not own by intention, this could trigger a takeover.
0	Internal Script Error – to be ignored.

11.3 Example for checking legacy SystemV integration

Check if the SAP hostagent is installed on all cluster nodes. As Linux user *root*, use the commands `systemctl` and `saphostctrl` to check the SAP hostagent:

```
# systemctl status sapinit
* sapinit.service - LSB: Start the sapstartsrv
   Loaded: loaded (/etc/init.d/sapinit; generated; vendor preset: disabled)
   Active: active (exited) since Wed 2022-02-09 17:25:36 CET; 3 weeks 0 days ago
     Docs: man:systemd-sysv-generator(8)
    Tasks: 0
   CGroup: /system.slice/sapinit.service
# /usr/sap/hostctrl/exe/saphostctrl -function ListInstances
Inst Info : TST - 00 - hanaso0 - 753, patch 819, changelist 2069355
```

The SystemV style sapinit is running and the hostagent recognises the installed database.

As Linux user *<sid>adm*, use the command line tool `HDB` to get an overview of running SAP HANA processes. The output of `HDB info` should be similar to the output shown below:

```
hanaso0:tstadm> HDB info
USER          PID     PPID  ... COMMAND
tstadm      13017    ... -sh
tstadm      13072    ...  \_ /bin/sh /usr/sap/TST/HDB00/HDB info
tstadm      13103    ...      \_ ps fx -U tstadm -o
 user:8,pid:8,ppid:8,pcpu:5,vsz:10,rss:10,args
tstadm       9268    ... hdbrsutil  --start --port 30003 --volume 2 --volumesuffix
 mnt00001/hdb00002.00003 --identifier 1580897137
tstadm       8911    ... hdbrsutil  --start --port 30001 --volume 1 --volumesuffix
 mnt00001/hdb00001 --identifier 1580897100
tstadm       8729    ... sapstart pf=/hana/shared/TST/profile/TST_HDB00_hanaso0
tstadm       8738    ...  \_ /usr/sap/TST/HDB00/hanaso0/trace/hdb.sapTST_HDB00 -d -nw -
f /usr/sap/TST/HDB00/hanaso0/daemon.ini pf=/usr/sap/TST/SYS/profile/TST_HDB00_hanaso0
tstadm       8756    ...      \_ hdbnameserver
tstadm       9031    ...      \_ hdbcompileserver
tstadm       9034    ...      \_ hdbpreprocessor
tstadm       9081    ...      \_ hdbindexserver -port 30003
```

```
tstadm       9084    ...      \_ hdbxsengine -port 30007
tstadm       9531    ...      \_ hdbwebdispatcher
tstadm       8574    ... /usr/sap/TST/HDB00/exe/sapstartsrv pf=/hana/shared/TST/profile/
TST_HDB00_hanaso0 -D -u tstadm
```

12 References

For more detailed information, have a look at the documents listed below.

12.1 SUSE Product Documentation

Best Practices for SAP on SUSE Linux Enterprise

https://documentation.suse.com/sbp/sap/

SUSE product manuals and documentation

https://documentation.suse.com/

Release notes

https://www.suse.com/releasenotes/

Online documentation of SLES for SAP

https://documentation.suse.com/sles-sap/15-SP4/

Online documentation of SUSE Linux Enterprise High Availability Extension

https://documentation.suse.com/sle-ha/15-SP4/single-html/SLE-HA-administration/#book-administration

Deployment guide for SUSE Linux Enterprise Server

https://documentation.suse.com/sles/15-SP4/single-html/SLES-deployment/#book-deployment

Tuning guide for SUSE Linux Enterprise Server

https://documentation.suse.com/sles/15-SP4/single-html/SLES-tuning/#book-tuning

Storage administration guide for SUSE Linux Enterprise Server

https://documentation.suse.com/sles/15-SP4/single-html/SLES-storage/

SUSE Linux Enterprise Server Persistent Memory Guide

https://documentation.suse.com/sles/15-SP4/html/SLES-all/cha-nvdimm.html

SUSE Linux Enterprise kernel specs

https://www.suse.com/releasenotes/x86_64/SUSE-SLES/15-SP4/index.html#kernel-limits

SUSE Linux Enterprise file system specs

https://www.suse.com/releasenotes/x86_64/SUSE-SLES/15-SP4/index.html#file-system-comparison

XFS file system

https://www.suse.com/c/xfs-the-file-system-of-choice/

SUSE YES certified hardware database

https://www.suse.com/yessearch/

SUSE Manager Product Page

https://www.suse.com/products/suse-manager/

SUSE Manager Documentation

https://documentation.suse.com/external-tree/en-us/suma/4.1/suse-manager/index.html

RMT = Repository Mirroring Tool documentation

https://documentation.suse.com/sles/15-SP4/html/SLES-all/book-rmt.html

SUSE Customer Center Fequently Asked Questions

https://scc.suse.com/docs/help

12.2 Related Manual Pages

- chronyc(8)
- corosync.conf(8)
- corosync_overview(8)
- crm(8)
- crm_mon(8)
- crm_simulate(8)
- cs_clusterstate(8)
- cs_man2pdf(8)
- cs_show_hana_info(8)
- cs_show_sbd_devices(8)
- cs_wait_for_idle(8)
- ha_related_sap_notes(7)
- ha_related_suse_tids(7)

- ocf_heartbeat_IPaddr2(7)
- ocf_heartbeat_SAPInstance(7)
- ocf_suse_SAPHanaController(7)
- ocf_suse_SAPHanaFilesystem(7)
- ocf_suse_SAPHanaTopology(7)
- ocf_suse_SAPHanaFilesystem(7)
- SAPHanaSR(7)
- SAPHanaSR-alert-fencing(8)
- SAPHanaSR-angi(7)
- SAPHanaSR_basic_cluster(7)
- SAPHanaSR-hookHelper(8)
- SAPHanaSR_maintenance_examples(7)
- SAPHanaSR-manageAttr(8)
- SAPHanaSR-manageProvider(8)
- SAPHanaSR-monitor(8)
- SAPHanaSR-replay-archive(8)
- SAPHanaSR-ScaleOut(7)
- SAPHanaSR-ScaleOut_basic_cluster(7)
- SAPHanaSR-showAttr(8)
- SAPHanaSR-show-hadr-runtimes(8)
- saptune(8)
- sbd(8)
- stonith_sbd(7)
- sudo(8)
- sudoers(5)

- supportconfig(8)
- susChkSrv.py(7)
- susCostOpt.py(7)
- susHanaSR.py(7)
- susTkOver.py(7)
- systemctl(8)
- systemd-cgls(8)
- votequorum(5)
- zypper(8)

12.3 Related SUSE TIDs

SAP HANA SR Performance Optimized Scenario - Setup Guide - Errata

https://www.suse.com/support/kb/doc/?id=7023882

Estimate correct multipath timeout

https://www.suse.com/support/kb/doc/?id=7016305

Can't open watchdog device: /dev/watchdog: Device or resource busy

https://www.suse.com/support/kb/doc/?id=7008216

Systemd-udev-settle timing out

https://www.suse.com/support/kb/doc/?id=7022681

Configuring Persistent Memory Devices (PMEM) results in booting to the recovery shell

https://www.suse.com/support/kb/doc/?id=000019517

Slow boot boot initialization on machines with Intel Optane DC Memory causing auto-mount to fail

https://www.suse.com/support/kb/doc/?id=000019462

How to load the correct watchdog kernel module

https://www.suse.com/support/kb/doc/?id=7016880

TID XFS metadata corruption and invalid checksum on SAP Hana servers

https://www.suse.com/support/kb/doc/?id=7022921

Overcommit Memory in SLES

https://www.suse.com/support/kb/doc/?id=7002775

Recommended SUSE SLES 4 SAP Settings

https://www.suse.com/support/kb/doc/?id=7024082

SAPHanaController running in timeout when starting SAP Hana

https://www.suse.com/support/kb/doc/?id=000019899

Troubleshooting the SAPHanaSR python hook

https://www.suse.com/support/kb/doc/?id=000019865

Entry "CALLING CRM: ... rc=256" in HANA trace after upgrading SAPHanaSR-ScaleOut

https://www.suse.com/support/kb/doc/?id=000020599

SAP HANA monitors timed out after 5 seconds

https://www.suse.com/support/kb/doc/?id=000020626

HA cluster takeover takes too long on HANA indexserver failure

https://www.suse.com/support/kb/doc/?id=000020845

Cluster node fence as SAPHanaTopology fails with error code 1 (OCF_ERR_GENERIC) during a normal cluster stop

https://www.suse.com/support/kb/doc/?id=000020964

SUSE HA for HANA cluster node fenced at shutdown, despite of systemd integration

https://www.suse.com/support/kb/doc/?id=000021046

SAP HANA scale-out - pacemaker.service: "Cannot find sapstartsrv and sapcontrol executable, please set DIR_EXECUTABLE parameter!"

https://www.suse.com/support/kb/doc/?id=000021062

SAPHanaSR-showAttr fails with error "Error: NIECONN_REFUSED ..."

https://www.suse.com/support/kb/doc/?id=000020548

Protect HANA against manually caused dual-primary situation in SUSE HA cluster

https://www.suse.com/support/kb/doc/?id=000021044

Address space monitoring and HANA DB performance

https://www.suse.com/support/kb/doc/?id=000020746

HANA DB resource failed to start

https://www.suse.com/support/kb/doc/?id=000020948

SAPHanaController monitor timeout leads to database restart

https://www.suse.com/support/kb/doc/?id=000021249

HANA Database Planning Engine crashes in __strncmp_avx2_rtm+0x1b3

https://www.suse.com/support/kb/doc/?id=000021026

Basic health check for two-node SAP HANA performance based model

https://www.suse.com/support/kb/doc/?id=7022984

How to re-enable replication in a two-node SAP performance based model

https://www.suse.com/support/kb/doc/?id=7023127

Showing SOK Status in Cluster Monitoring Tools Workaround

https://www.suse.com/support/kb/doc/?id=7023526

HANA SystemReplication doesn’t provide SiteName to Corosync Cluster

https://www.suse.com/support/kb/doc/?id=000019754

SUSE Cluster Support for SAP HANA System Replication Active / Active Read Enabled Feature

https://www.suse.com/support/kb/doc/?id=7023884

SAP Generating 'Database host operating system is not supported' alerts

https://www.suse.com/support/kb/doc/?id=7023744

sapstartsrv does not respawn after a forceful kill of the master nameserver

https://www.suse.com/support/kb/doc/?id=7024291

SAPHanaSR HANA system replication automation without layer 2 network

https://www.suse.com/support/kb/doc/?id=000020333

The vIP cluster resource does not follow the SAP HANA master ...

https://www.suse.com/support/kb/doc/?id=000019769

Handling failed NFS share in SUSE HA cluster for HANA system replication

https://www.suse.com/support/kb/doc/?id=000019904

SAP Instances failed stop on shutdown (PACEMAKER, SYSTEMD, SAP)

https://www.suse.com/support/kb/doc/?id=7022671

SAP on SLES shows Error: NIECONN_REFUSED in the logs

https://www.suse.com/support/kb/doc/?id=7023236

Indepth HANA Cluster Debug Data Collection (PACEMAKER, SAP)

https://www.suse.com/support/kb/doc/?id=7022702

How to prevent certain values in limits.conf from being changed by saptune

https://www.suse.com/support/kb/doc/?id=7023104

Disabling fstrim - under which conditions?

https://www.suse.com/support/kb/doc/?id=7023805

saptune: WARNING saptune.io.go:66: 'noop' is not a valid scheduler for device

https://www.suse.com/support/kb/doc/?id=000019572

How to patch a SAP Application Pacemaker Cluster

https://www.suse.com/support/kb/doc/?id=000020268

12.4 Related SUSE blogs

How to upgrade to SAPHanaSR-angi

https://www.suse.com/c/how-to-upgrade-to-saphanasr-angi/

Emergency Braking for SAP HANA Dying Indexserver

https://www.suse.com/c/emergency-braking-for-sap-hana-dying-indexserver/

SAP HANA Cockpit with SUSE HA integration greatly improves data integrity

https://www.suse.com/c/sap-hana-cockpit-with-suse-ha-integration-greatly-improves-data-integrity/

Handover for the Next Round – SAP on SUSE Cluster and systemd Native Integration

https://www.suse.com/c/handover-for-the-next-round-sap-on-suse-cluster-and-systemd-native-integration/

SAPHanaSR-ScaleOut for Multi-Target Architecture and Principles

https://www.suse.com/c/saphanasr-scaleout-multi-target/

SAP HANA Scale-Out System Replication for large ERP Systems

https://www.suse.com/c/sap-hana-scale-out-system-replication-for-large-erp-systems/

SAP HANA Cost-optimized – An alternative Route is available

https://www.suse.com/c/sap-hana-cost-optimized-an-alternative-route-is-available/

Let's flip the flags! Is my SAP HANA database in sync or not?

https://www.suse.com/c/lets-flip-the-flags-is-my-sap-hana-database-in-sync-or-not/

Entry to blog series #towardsZeroDowntime

https://www.suse.com/c/tag/towardszerodowntime/

Fail-Safe Operation of SAP HANA: SUSE Extends Its High-Availability Solution

http://scn.sap.com/community/hana-in-memory/blog/2014/04/04/fail-safe-operation-of-sap-hana-suse-extends-its-high-availability-solution

12.5 Related SAP Documentation

SAP Product Availability Matrix

https://support.sap.com/en/release-upgrade-maintenance.html#section_1969201630

SAP HANA Installation and Update Guide

https://help.sap.com/doc/e9702d76c3284623b02de196c0e79e49/2.0.05/en-US/SAP_HANA_Server_Installation_Guide_en.pdf

SAP HANA Administration Guide

https://help.sap.com/doc/eb75509ab0fd1014a2c6ba9b6d252832/2.0.05/en-US/SAP_HANA_Administration_Guide_en.pdf

SAP HANA Documentation Entry Page

https://help.sap.com/viewer/product/SAP_HANA_PLATFORM/2.0.05/en-US

SAP HANA Tailored Data Center Integration - FAQ

https://www.sap.com/documents/2016/05/e8705aae-717c-0010-82c7-eda71af511fa.html

SAP HANA and Persistent Memory

https://blogs.sap.com/2020/01/30/sap-hana-and-persistent-memory/

SAP HANA HA/DR Provider Hook Methods

https://help.sap.com/viewer/6b94445c94ae495c83a19646e7c3fd56/2.0.05/en-US/5df2e766549a405e95de4c5d7f2efc2d.html

12.6 Related SAP Notes

611361 - Hostnames of SAP servers

https://launchpad.support.sap.com/#/notes/611361

768727 - Automatic restart functions in sapstart for processes

https://launchpad.support.sap.com/#/notes/768727

927637 - Web service authentication in sapstartsrv as of Release 7.00

https://launchpad.support.sap.com/#/notes/927637

1092448 - IBM XL C/C++ runtime environment for Linux on system p

https://launchpad.support.sap.com/#/notes/1092448

1514967 - SAP HANA: Central Note

https://launchpad.support.sap.com/#/notes/1514967

1552925 - Linux: High Availability Cluster Solutions

https://launchpad.support.sap.com/#/notes/1552925

1763512 - Support details for SUSE Linux Enterprise for SAP Applications

https://launchpad.support.sap.com/#/notes/1763512

1846872 - "No space left on device" error reported from HANA

https://launchpad.support.sap.com/#/notes/1846872

1876398 - Network configuration for System Replication in HANA SP6

https://launchpad.support.sap.com/#/notes/1876398

1888072 - SAP HANA DB: Indexserver crash in strcmp sse42

https://launchpad.support.sap.com/#/notes/1888072

2021789 - SAP HANA Revison and Maintenance Strategy

https://launchpad.support.sap.com/#/notes/2021789

2196941 - SAP HANA Software Replication Takeover Hook Changes

https://launchpad.support.sap.com/#/notes/2196941

2235581 - SAP HANA: Supported Operating Systems

https://launchpad.support.sap.com/#/notes/2235581

2369981 - Required configuration steps for authentication with HANA System Replication

https://launchpad.support.sap.com/#/notes/2369981

2369910 - SAP Software on Linux: General information

https://launchpad.support.sap.com/#/notes/2369910

2380229 - SAP HANA Platform 2.0 - Central Note

https://launchpad.support.sap.com/#/notes/2380229

2434562 - System Replication Hanging in Status "SYNCING" or "ERROR" With Status Detail "Missing Log" or "Invalid backup size"

https://launchpad.support.sap.com/#/notes/2434562

2578899 - SUSE Linux Enterprise Server 15: Installation Note

https://launchpad.support.sap.com/#/notes/2578899

2647673 - HANA Installation Failure

https://launchpad.support.sap.com/#/notes/2647673

2684254 - SAP HANA DB: Recommended OS settings for SLES 15 / SLES for SAP Applications 15

https://launchpad.support.sap.com/#/notes/2684254

2733483 - Host Auto-Failover Not Occur when Indexserver Crash on Worker Node

https://launchpad.support.sap.com/#/notes/2733483

2750199 - Incorrect Alert Regarding Unsupported Operating System Version

https://launchpad.support.sap.com/#/notes/2750199

2844322 - SAP HANA Platform 2.0 SPS 05 Release Note

https://launchpad.support.sap.com/#/notes/2844322

2945239 - SAP HANA Platform 2.0 SPS 06 Release Note

https://launchpad.support.sap.com/#/notes/2945239

3007062 - FAQ: SAP HANA & Third Party Cluster Solutions

https://launchpad.support.sap.com/#/notes/3007062

3014176 - Applying System Size Dependent Resource Limits During Installation or Upgrade

https://launchpad.support.sap.com/#/notes/3014176

3043459 - SAP HANA 2 SPS05 Revision 056.00

https://launchpad.support.sap.com/#/notes/3043459

3072590 - Python 3 Support for Non-Productive SAP HANA Systems

https://launchpad.support.sap.com/#/notes/3072590

3070359 - Python 3 Migration Guide For SAP HANA

https://launchpad.support.sap.com/#/notes/3070359

3084229 - SAP HANA Python Support Scripts Fail due to Incompatibility With Python 3

https://launchpad.support.sap.com/#/notes/3084229

3091152 - sapstartsrv - improved deregistration for UNIX/Linux

https://launchpad.support.sap.com/#/notes/3091152

3093542 - Transition to Python 3 of the Python Distribution Delivered With SAP HANA 2.0 Server

https://launchpad.support.sap.com/#/notes/3093542

3139184 - Linux: systemd integration for sapstartsrv and SAP Hostagent

https://launchpad.support.sap.com/#/notes/3139184

3145200 - SAP Host Agent 7.22 PL57

https://launchpad.support.sap.com/#/notes/3145200

12.7 Pacemaker

Pacemaker Project Documentation

https://clusterlabs.org/pacemaker/doc/

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