



SAP HANA SR Performance Optimized Scenario

SUSE Linux Enterprise Server for SAP
Applications 11 SP4



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1 About This Guide

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 system replication in the performance optimized scenario.

1.1 Introduction

“SAP customers invest in SAP HANA” is the conclusion reached by a recent market study carried out by Pierre Audoin Consultants (PAC). In Germany alone, half of the companies expect SAP HANA to become the dominant database platform in the SAP environment. In many cases, the “SAP Business Suite* powered by SAP HANA*” scenario is already being discussed in concrete terms.

Naturally, SUSE is also accommodating this development by providing SUSE Linux Enterprise Server for SAP Applications – the recommended and supported operating system for SAP HANA. In close collaboration with SAP and hardware partners, therefore, SUSE provides two resource agents for customers to ensure the high availability of SAP HANA system replications.

1.1.1 Scale-Up vs. Scale-Out

The first set of scenarios include the architecture and development of *scale-up* solutions. For this scenarios SUSE developed the scale-up resource agent package [SAPHanaSR](#). System replication will help to replicate the database data from one computer to another computer in order to compensate for database failures (single-box replication).

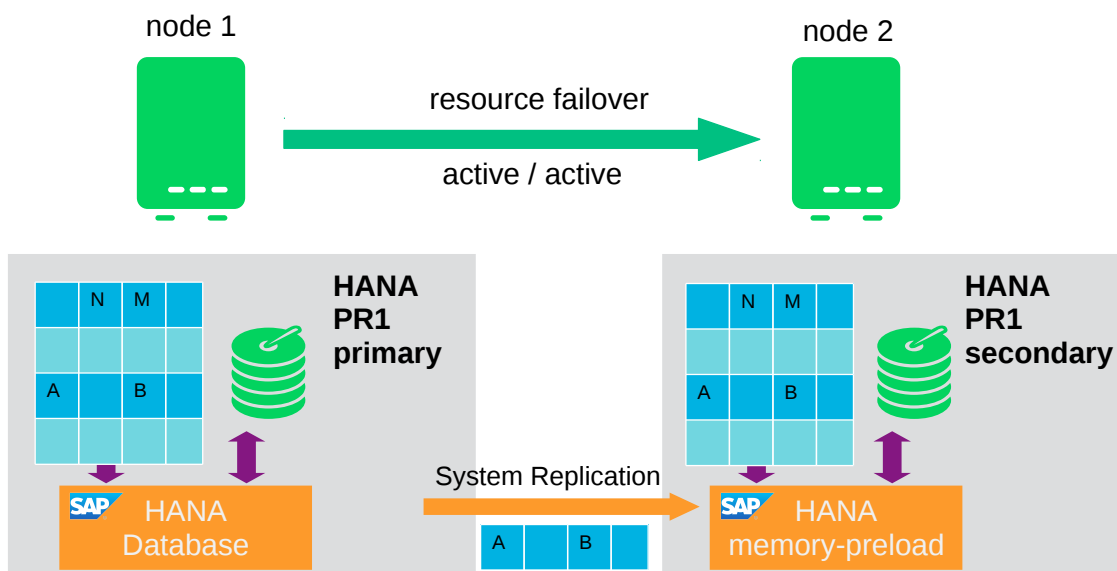


FIGURE 1.1: SAP HANA SYSTEM REPLICATION IN THE CLUSTER

The second set of scenarios include the architecture and development of *scale-out* solutions (multibox replication). For this scenarios SUSE developed the scale-out resource agent package SAPHanaSR-ScaleOut. With this mode of operation, internal SAP HANA high-availability (HA) mechanisms and the resource agent must work together or be coordinated with each other. SAP HANA system replication automation for scale-out will be described in an own document available in the resource library at <https://www.suse.com/products/sles-for-sap/resource-library/>.

1.1.2 Scale-Up scenarios and resource agents

SUSE has implemented the scale-up scenario with the SAPHana resource agent (RA), which performs the actual check of the SAP HANA database instances. This RA is configured as a master/slave resource. In the scale-up scenario, the master assumes responsibility for the SAP HANA databases running in primary mode, and the slave is responsible for instances that are operated in synchronous (secondary) status.

To make configuring the cluster as simple as possible, SUSE also developed it's SAPHanaTopology resource agent. This runs on all nodes of an SLE 11 HAE cluster and gathers information about the statuses and configurations of SAP HANA system replications. It is designed as a normal (stateless) clone.

SAP HANA System replication for Scale-Up is supported in the following scenarios or use cases:

- Performance optimized ($A = > B$). This scenario and setup is described in this document.

In the performance optimized scenario a HANA RDBMS A is synchronizing with a HANA RDBMS on a second node. As the HANA RDBMS on the second node is configured to preload the tables the takeover time is typically very short.

- Cost optimized ($A \Rightarrow B, Q$). This scenario and setup is described in an other document in the resource library (<https://www.suse.com/products/sles-for-sap/resource-library/>). In the cost optimized scenario the second node is also used for a non-productive HANA RDBMS system (like QAS or TST). Whenever a takeover is needed the non-productive system must be stopped first. As the productive secondary system on this node must be limited in using system resources, the table preload must be switched off and a possible takeover needs longer than in the performance optimized use case.
- Multi Tier ($A \Rightarrow B \rightarrow C$). This scenario and setup is described in an other document in the resource library (<https://www.suse.com/products/sles-for-sap/resource-library/>). A Multi Tier system replication has an additional target, which must be connected to the secondary (chain topology).
- Multi-tenancy or MDC.
Multi-tenancy is supported for all above scenarios and use cases. This scenario is supported since SAP HANA SPS09. The set-up and configuration from cluster point of view is the same for multi-tenancy and single container, so you can use the above documents for both kinds of scenarios. In our notation we mark a MDC like %A. This means MDC, performance optimized is abbreviated as $\%A \Rightarrow \%B$.

1.1.3 The concept of the Performance Optimized Scenario

In case of failure of the primary SAP HANA on node 1 (node or database instance) 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.

To achieve an automation of this resource handling process, we can utilize the SAP HANA resource agents included in SAPHanaSR. System replication of the productive database is automated with SAPHana and SAPHanaTopology.

You can setup 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.

Important

The solution is not designed to manually 'migrate' the primary or secondary instance using HAWK or any other cluster client commands. We plan to include a migration support with one of the next resource agent updates. In the admin section we describe how to 'migrate' the primary to the secondary site.

1.1.4 Customers Receive Complete Package

With both the SAPHana and SAPHanaTopology resource agents, customers will therefore be able to integrate SAP HANA system replications in their cluster. This has the advantage of enabling companies to use not only their business-critical SAP systems but also their SAP HANA databases without interruption while noticeably reducing needed budgets. SUSE provides the extended solution together with best practices documentation.

SAP and hardware partners who do not have their own SAP HANA high-availability solution will also benefit from this SUSE Linux development.

1.2 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 documentation updates, see <http://www.suse.com/documentation>.

You can also find numerous whitepapers, a best-practices guide, and other resources at the SUSE Linux Enterprise Server for SAP Applications resource library: <https://www.suse.com/products/sles-for-sap/resource-library/>.

1.3 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*.

User Comments

We want to hear your comments about and suggestions for this manual and the other documentation included with this product. Use the User Comments feature at the bottom of each page in the online documentation or go to <http://www.suse.com/doc/feedback.html> and enter your comments there.

Mail

For feedback on the documentation of this product, you can also send a mail to doc-team@suse.de. 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).

1.4 Documentation Conventions

The following typographical conventions are used in this manual:

- /etc/passwd: directory names and file names
- placeholder: replace placeholder with the actual value
- PATH: the environment variable PATH
- ls, --help: commands, options, and parameters
- user: users or groups
- Alt, Alt-F1: a key to press or a key combination; keys are shown in uppercase as on a keyboard
- *File*, *File > Save As*: menu items, buttons
- amd64, em64t, ipf This paragraph is only relevant for the architectures amd64, em64t, and ipf. The arrows mark the beginning and the end of the text block. ◀
- System z, ipseries This paragraph is only relevant for the architectures System z and ipseries. The arrows mark the beginning and the end of the text block. ◀
- *Dancing Penguins* (Chapter *Penguins*, ↑Another Manual): This is a reference to a chapter in another manual.

2 Supported Scenarios and Prerequisites

With the SAPHanaSR resource agent software package, we limit the support to Scale-Up (single-box to single-box) system replication with the following configurations and parameters:

- Two-node clusters.
- The cluster must include a valid STONITH method.
 - Any STONITH mechanism supported by SLE 11 HAE (like SDB, IPMI) is supported with SAPHanaSR.
 - This guide is focusing on the sbd fencing method as this is hardware independent.
 - If you use sbd as the fencing mechanism, you need one or more shared drives. For productive environments, we recommend more than one sbd device.
- Both nodes are in the same network segment (layer 2).
- 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 must be done locally on all cluster nodes.
- Time synchronization between the cluster nodes using NTP.
- Both SAP HANA instances have the same SAP Identifier (SID) and instance number.
- If the cluster nodes are installed in different data centers or data center areas, the environment must match the requirements of the SLE HAE cluster product. Of particular concern are the network latencies and recommended maximum distance between the nodes. Please review our product documentation for SLE HAE about those recommendations.
- Automated registration of a failed primary after takeover.
 - As a good starting configuration for projects, we recommend to switch off the automated registration of a failed primary. The setup AUTOMATED_REGISTER="false" is the default. In this case, you need to register a failed primary after a takeover manually. Use SAP tools like hanastudio or hdbnsutil.
 - For optimal automation, we recommend AUTOMATED_REGISTER="true".
- Automated start of SAP HANA instances during system boot must be switched off.

You need at least SAPHanaSR version 0.151, SUSE Linux Enterprise Server for SAP Applications 11 SP4 and SAP HANA SPS09 (095) for all mentioned setups.

Important: Valid STONITH Method

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

This setup-guide focuses on the performance optimized setup. No other SAP HANA system (like QAS or TST) on the replicating node which needs to be stopped during takeover is considered in this scenario.

- Cost optimized setups with a non-productive SAP HANA (like QAS or TST) on the secondary node are supported. SUSE has published a setup-guide for cost optimized scenarios too (↑ SAP HANA SR Cost Optimized Scenario). We already have a SCN article for this kind of setups: <http://scn.sap.com/docs/DOC-65899>. You need to configure the SAP HANA database resources at the secondary side to run them side by side (see SAP documentation for cost optimized setups).
- Multi-tier setups (A => B -> C) are supported. You need to disable automated re-registration (AUTOMATED_REGISTER="false"), because SAP currently does not allow two targets to be connected to one primary (↑ SAP HANA SR Multi Tier Scenario).
- Multi-tenancy (MDC) databases are supported.
 - Multi-tenancy databases could be used in combination with any other setup (performance based, cost optimized and multi-tier).
 - In MDC configurations the SAP HANA RDBMS is treated as a single system including all database containers. Therefore cluster takeover decisions are based on the complete RDBMS status independent of the status of individual containers.
 - You need SAP HANA version >= SPS10 rev3 or SPS11+, if you need to stop tenants during production and like the cluster to be able to takeover. Older SAP HANA versions are marking the system replication as failed, if you stop a tenant.

If you need to implement a different scenario, we strongly recommend to define a 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 due to testing limits.

Besides SAP HANA, you need SAP Host Agent to be installed on your system.

3 Scope of this Documentation

This document describes how to setup the cluster to control SAP HANA in System Replication Scenarios. The document focuses on the steps to integrate an already installed and working SAP HANA with System Replication.

This setup builds a SAP HANA HA cluster in two data-centers in Walldorf (WDF) and in Rot (ROT), installed on two SLES for SAP 11 SP4 systems.

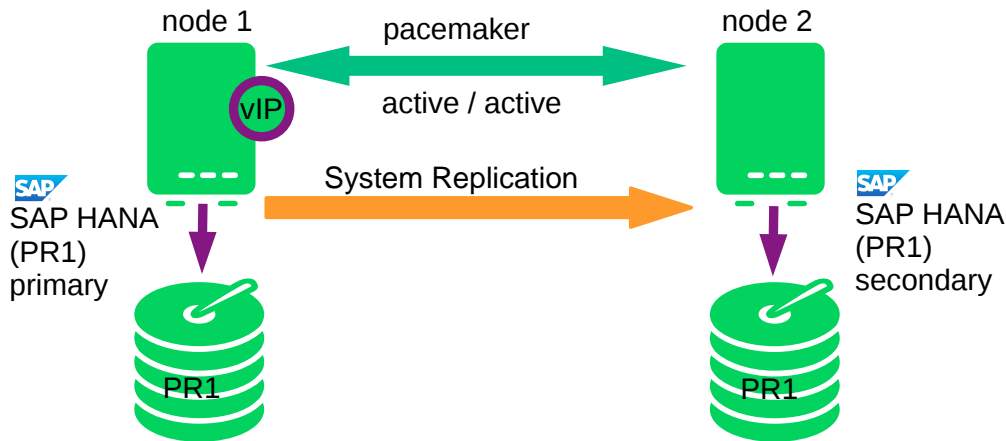


FIGURE 3.1: CLUSTER WITH SAP HANA SR - PERFORMANCE OPTIMIZED

TABLE 3.1: PARAMETERS USED IN THIS DOCUMENT

Parameter	Value	Role
Cluster node 1	<u>suse01</u> , <u>192.168.1.11</u>	Cluster node name and IP address.
Cluster node 2	<u>suse02</u> , <u>192.168.1.12</u>	Cluster node name and IP address.
SID	<u>HA1</u>	SAP Identifier
Instance number	<u>10</u>	Number of the SAP HANA database. For system replication also Instance Number + 1 is blocked.
Network mask	<u>255.255.255.0</u>	

Parameter	Value	Role
Virtual IP address	<u>192.168.1.20</u>	
Storage		Storage for HDB data and log files is connected “locally” (per node; not shared)
SBD	<u>/dev/disk/by-id/SBDA</u>	STONITH device (two for production)
HAWK Port	<u>7630</u>	
NTP Server		Address or name of your time server

4 Installing the SAP HANA Databases on both cluster nodes

Even though this document focuses on the integration of an already installed SAP HANA with already set up system replication into the pacemaker cluster, this chapter summarizes the test environment. Please always use the official documentation from SAP to install SAP HANA and to setup the system replication.

4.1 SAP HANA Installation

Preparation

- Read the SAP Installation and Setup Manuals available at the SAP Marketplace.
- Download the SAP HANA Software from SAP Marketplace.

PROCEDURE 4.1: INSTALLATION AND CHECKS

1. Install the SAP HANA Database as described in the SAP HANA Server Installation Guide.
2. Check if the SAP Host Agent is installed on all cluster nodes. If this SAP service is not installed, please install it now.
3. Verify that both databases are up and all processes of these databases are running correctly.

As Linux user `<sid>adm` use the command line tool **HDB** to get an overview of running HANA processes. The output of **HDB info** should show something like shown in the following screenshot:

```
suse02:~> HDB info
USER          PID ... COMMAND
haladm        6561 ... -csh
haladm        6635 ... \_ /bin/sh /usr/sap/HA1/HDB10/HDB info
haladm        6658 ... \_ ps fx -U hal -o user,pid,ppid,pcpu,vsz,rss,args
haladm        5442 ... sapstart pf=/hana/shared/HA1/profile/HA1_HDB10_suse02
haladm        5456 ... \_ /usr/sap/HA1/HDB10/suse02/trace/hdb.sapHA1_HDB10 -d
-nw -f /usr/sap/HA1/HDB10/suse
haladm        5482 ... \_ hdbnameserver
haladm        5551 ... \_ hdbpreprocessor
haladm        5554 ... \_ hdbcompileserver
```

```
haladm      5583 ...      \_ hdbindexserver
haladm      5586 ...      \_ hdbstatisticsserver
haladm      5589 ...      \_ hdbxsengine
haladm      5944 ...      \_ sapwebdisp_hdb
pf=/usr/sap/HA1/HDB10/suse02/wdisp/sapwebdisp.pfl -f /usr/sap/SL
haladm      5363 ... /usr/sap/HA1/HDB10/exe/sapstartsrv
pf=/hana/shared/HA1/profile/HA1_HDB10_suse02 -D -u s
```

4.2 Postinstallation configuration

4.2.1 Back Up the Primary Database

Back up the primary database as described in the SAP HANA Administration Guide, Section *SAP HANA Database Backup and Recovery*. We provide an example with SQL Commands:

```
suse01:~ # hdbsql -u system -i 10 "BACKUP DATA USING FILE ('backup')"
```

If you have (for example) created a backup database user and a user key *hanabackup*, you can create an initial backup using the following command:

```
suse01:~ # hdbsql -U hanabackup "BACKUP DATA USING FILE ('backup')"
```

If the user key *hanabackup* has not been defined, please use an instance/user/password combination for login.

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

4.2.2 HDB System Replication

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

PROCEDURE 4.2: SET UP SYSTEM REPLICATION ON PRIMARY AND SECONDARY SYSTEMS

1. Enable system replication on the primary system (`hdbnsutil -sr_enable`)
2. Register the secondary system with the primary system (`hdbnsutil -sr_register`)
3. Start the secondary system.

4.2.2.1 Enable Primary Node

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

```
suse01:~> hdbnsutil -sr_enable --name=WDF
checking local nameserver:
checking for active nameserver ...
nameserver is running, proceeding ...
configuring ini files ...
successfully enabled system as primary site ...
done.
```

4.2.2.2 Verify the state of system replication

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

```
suse01:~> hdbnsutil -sr_state
checking for active or inactive nameserver ...
System Replication State
~~~~~
mode: primary
site id: 1
site name: WDF
Host Mappings:
~~~~~
done.
```

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

4.2.2.3 Enable the Secondary Node

The SAP HANA database instance on the secondary side must be stopped before the instance 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`. Again, use Linux user `<sid>adm`:

```
suse02:~> HDB stop
...
suse02:~> hdbnsutil -sr_register --name=ROT \
```

```

--remoteHost=suse01 --remoteInstance=10 \
--replicationMode=sync --operationMode=logreplay
adding site ...
checking for inactive nameserver ...
nameserver suse02:30001 not responding.
collecting information ...
updating local ini files ...
done.

```

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

```

suse02:~> HDB start
...
suse02:~> hdbnsutil -sr_state
...
System Replication State
~~~~~

mode: sync
site id: 2
site name: ROT
active primary site: 1
...

```

The remoteHost is the primary node in our case, the remoteInstance is the database instance number (here 10).

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

```

suse01:~> HDBSettings.sh systemReplicationStatus.py
...

```

4.2.3 Manual re-establish SAP HANA SR to original state

1. Bring the systems back to the original state:
2. takeover SLE to node 1
3. wait till sync state is active
4. stop SLE on node 2

5. re-register node 2 as secondary
6. reconfigure global.ini
7. start SLE on node2

Please note that while you are switching back to original system replication direction you must also re-change the global.ini as the srTakeover hook should have deleted the parameters for memory limitation and table preload.

5 Configuration of the Cluster and SAP HANA Database Integration

This chapter describes the configuration of the cluster software SUSE Linux Enterprise High Availability Extension, which is part of the SUSE Linux Enterprise Server for SAP Applications, and SAP HANA Database Integration.

PROCEDURE 5.1: INSTALL AND CONFIGURE THE CLUSTER

1. Install the High Availability pattern and the SAPHanaSR Resource Agents.
2. Basic Cluster Configuration.
3. Configure Cluster Properties and Resources.

5.1 Installation

If have not already done, install the pattern High Availability on both nodes. To do so, for example, use **zypper**:

```
suse01:~> zypper in -t pattern ha_sles
```

Now the Resource Agents for controlling the SAP HANA system replication needs to be installed at both cluster nodes.

```
suse01:~> zypper in SAPHanaSR SAPHanaSR-doc
```

For more information, see *Installation and Basic Setup*, ↑SUSE Linux Enterprise High Availability Extension.

5.2 Basic Cluster Configuration

The first step is to set up the basic cluster framework. For convenience, use YaST2 or the sle-ha-init script. It is strongly recommended to add a second corosync ring, change to UCAST communication and adjust the timeout values to your environment.

5.2.1 Initial cluster setup using `sleha-init`

For more information, see *Automatic Cluster Setup*, ↑SUSE Linux Enterprise High Availability Extension.

Create an initial setup, using `sleha-init` command and follow the dialogs. This is only to be done on the first cluster node.

```
suse01:~> sleha-init
```

This command 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



Important: Change the password of the user `hacluster`

As requested by `sleha-init`, change the password of the user `hacluster`.

5.2.2 Adapting the Corosync and `sb`d Configuration

It is recommended to add a second `corosync` ring and to change to UCAST communication as described in 3.2.1 of *Best Practices for SAP on SUSE Linux Enterprise*.

Stop the already running cluster by using `rcopenais stop`. After setup of the `corosync` config and `sb`d parameters, start the cluster again.

5.2.2.1 Corosync Configuration

Adjust the following blocks in the file `/etc/corosync/corosync.conf`, see also the example at the end of this document.

```
totem {  
    ...  
    interface {
```

```

    #Network Address to bind for this interface setting
    bindnetaddr: 192.168.1.0
    member {
        memberaddr: 192.168.1.11
    }
    member {
        memberaddr: 192.168.1.12
    }
    #The multicast port to be used
    mcastport: 5405
    #The ringnumber assigned to this interface setting
    ringnumber: 0
}
...
#
transport: udpu
#How many token retransmits should be attempted before forming
# a new configuration.
token_retransmits_before_loss_const: 10
#To make sure the auto-generated nodeid is positive
clear_node_high_bit: new
...
}

```

5.2.2.2 Configure a watchdog

It is highly recommended that you configure your Linux system to load a watchdog driver with hardware assistance (as is available on most modern systems), such as `hpwdt`, `iTCO_wdt`, or others. As a fall-back, you can use the `softdog` module.

No other software must access the watchdog timer; it can only be accessed by one process at any given time. Some hardware vendors ship systems management software that use the watchdog for system resets (f.e. HP ASR daemon). Such software has to be disabled if the watchdog is to be used by SBD.

5.2.2.3 Adapting `sbd config`

You can skip this section, if you do not have any `sbd` devices, but be sure to implement an other supported fencing mechanism. If you use the newest updates of the `pacemaker` packages from the SUSE maintenance channels, you can also use the `-P` option (*Check Pacemaker quorum and node health*), which enables the cluster nodes not to self-fence if SBDs are lost, but `pacemaker` communication is still available.

Please see the `sbd` man page for further details of the parameters `-S <n>`, `-P`, `-W`.

TABLE 5.1: SBD OPTIONS

Parameter	Description
<code>-W</code>	Use watchdog. It is mandatory to use a watchdog. SBD does not work reliable without watchdog. Please refer to the SLES manual and SUSE TIDs 7016880 for setting up a watchdog.
<code>-S 1</code>	Start mode. If set to one, <code>sbd</code> will only start if the node was previously shutdown cleanly or if the slot is empty.
<code>-P</code>	Check Pacemaker quorum and node health.

In the following, replace `/dev/disk/by-id/SBDA` and `/dev/disk/by-id/SBDB` by your real `sbd` device names.

```
# /etc/sysconfig/sbd
SBD_DEVICE="/dev/disk/by-id/SBDA;/dev/disk/by-id/SBDB"
SBD_OPTS="-W -P -S 1"
```

5.2.2.4 Verify the `sbd` device

You can skip this section if you do not have any `sbd` devices, but make sure to implement a supported fencing mechanism.

It's a good practice to check, if the `sbd` device can be accessed from both nodes and does contain valid records. Check this for all devices configured in `/etc/sysconfig/sbd`.

```
suse01:~ # sbd -d /dev/disk/by-id/SBDA dump
==Dumping header on disk /dev/disk/by-id/SBDA
Header version      : 2.1
UUID                : 0f4ea13e-fab8-4147-b9b2-3cdcfff07f86
Number of slots     : 255
Sector size         : 512
Timeout (watchdog)  : 20
Timeout (allocate)  : 2
Timeout (loop)      : 1
```

```
Timeout (msgwait) : 40
==Header on disk /dev/disk/by-id/SBDA is dumped
```

The timeout values in our sample are only start values, which need to be tuned to your environment.

To check the current sbd entries for the various cluster nodes, you can use `sbd list`. If all entries are `clear`, no fencing task is marked in the sbd device.

```
suse01:~ # sbd -d /dev/disk/by-id/SBDA list
0      suse01      clear
1      suse02      clear
```

For more information on SBD configuration parameters, please read section *Storage-based Fencing*, ↑SUSE Linux Enterprise High Availability Extension and TIDs 7016880 and 7008216.

Now it's time to restart the cluster at the first node again (`rcopenais start`).

5.2.3 Cluster configuration on the second node

The second node of the two nodes cluster could be integrated by starting the command `sleha-join`. This command just asks for the IP address or name of the first cluster node. Then all needed configuration files are copied over. As a result the cluster is started on both nodes.

```
# sleha-join
```

5.2.4 Check the Cluster for the first Time

Now it's time to check and optionally start the cluster for the first time on both nodes.

```
suse01:~ # rcopenais status
suse02:~ # rcopenais status
suse01:~ # rcopenais start
suse02:~ # rcopenais start
```

Check the cluster status with `crm_mon`. We 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 following screen output. The most interesting information for now is that there are two nodes in the status "online" and the message "partition with quorum".


```
Last updated: Fri Apr 25 09:44:59 2014
Last change: Fri Apr 25 08:30:58 2014 by root via cibadmin on suse01
Stack: classic openais (with plugin)
Current DC: suse01 - partition with quorum
Version: 1.1.9-2db99f1
2 Nodes configured, 2 expected votes
6 Resources configured.
Online: [ suse01 suse02]
Full list of resources:
stonith-sbd      (stonith:external/sbd): Started suse01
```

5.3 Configure Cluster Properties and Resources

This section describes how to configure constraints, resources, bootstrap and STONITH using the `crm configure shell` command as described in section *Configuring and Managing Cluster Resources (Command Line)*, ↑SUSE Linux Enterprise High Availability Extension.

Use the command `crm` to add the objects to CRM. Copy the following examples to a local file, edit the file and then load the configuration to the CIB:

```
suse01:~ # vi crm-fileXX
suse01:~ # crm configure load update crm-fileXX
```

5.3.1 Cluster bootstrap and more

The first example defines the cluster bootstrap options, the resource and operation defaults. The `stonith-timeout` should be greater than 1.2 times the SBD `msgwait` timeout.

```
suse01:~ # vi crm-bs.txt
# enter the following to crm-bs.txt
property $id="cib-bootstrap-options" \
    no-quorum-policy="ignore" \
    stonith-enabled="true" \
    stonith-action="reboot" \
    stonith-timeout="150s"
rsc_defaults $id="rsc-options" \
    resource-stickiness="1000" \
    migration-threshold="5000"
op_defaults $id="op-options" \
    timeout="600"
```

Now we add the configuration to the cluster.

```
suse01:~ # crm configure load update crm-bs.txt
```

5.3.2 STONITH device

The next configuration part defines a SBD disk STONITH resource.

```
# vi crm-sbd.txt
# enter the following to crm-sbd.txt
primitive stonith-sbd stonith:external/sbd \
    params pcmk_delay_max="15" \
    op monitor interval="15" timeout="15"
```

Again we add the configuration to the cluster.

```
suse01:~ # crm configure load update crm-sbd.txt
```

For alternative IPMI/ILO setup see our cluster product documentation. An example for an IPMI STONITH resource can be found in the appendix (section 7.5) of this document.

5.3.3 Using IPMI as fencing mechanism

For alternative IPMI/ILO setup see our cluster product documentation. An example for an IPMI STONITH resource can be found in the appendix (section 7.5) of this document.

To use IPMI the remote management boards must be compatible with the IPMI standard.

For the IPMI based fencing you need to configure a primitive per cluster node. Each resource is responsible to fence exactly one cluster node. You need to adapt the IP addresses and login user / password of the remote management boards to the STONITH resource agent. We recommend to create a special STONITH user instead of providing root access to the management board. Location rules must guarantee that a host should never run its own STONITH resource.

5.3.4 Using other fencing mechanisms

We recommend to use SBD (best practice) or IPMI (second choice) as STONITH mechanism. The SUSE Linux Enterprise High Availability product also supports additional fencing mechanism not covered here.

For further information about fencing, see SUSE Linux Enterprise High Availability Guide.

5.3.5 SAPHanaTopology

Next we define the group of resources needed, before the HANA instances can be started. Prepare the changes in a text file, for example `crm-saphanatop.txt`, and load these with the command:

`crm configure load update crm-saphanatop.txt`

```
# vi crm-saphanatop.txt
# enter the following to crm-saphanatop.txt
primitive rsc_SAPHanaTopology_HA1_HDB10 ocf:suse:SAPHanaTopology \
    operations $id="rsc_sap2_HA1_HDB10-operations" \
    op monitor interval="10" timeout="600" \
    op start interval="0" timeout="600" \
    op stop interval="0" timeout="300" \
    params SID="HA1" InstanceNumber="10"
clone cln_SAPHanaTopology_HA1_HDB10 rsc_SAPHanaTopology_HA1_HDB10 \
    meta clone-node-max="1" interleave="true"
```

Additional information about all parameters could be found with the command **`man ocf_suse_SAPHanaTopology`**

Again we add the configuration to the cluster.

```
suse01:~ # crm configure load update crm-saphanatop.txt
```

The most important parameters here are `SID` and `InstanceNumber`, which are in the SAP context quite self explaining. Beside these parameters, the timeout values or the operations (start, monitor, stop) are typical tuneables.

5.3.6 SAPHana

Next we define the group of resources needed, before the HANA instances can be started. Edit the changes in a text file, for example `crm-saphana.txt` and load these with the command: **`crm configure load update crm-saphana.txt`**

TABLE 5.2: TYPICAL RESOURCE AGENT PARAMETER SETTINGS FOR DIFFERENT SCENARIOS

Parameter	Performance Optimized	Cost Optimized	Multi-Tier
PREFER_SITE_TAKEOVER	true	false	false / true
AUTOMATED_REGISTER	false / true	false / true	false

Parameter	Performance Optimized	Cost Optimized	Multi-Tier
DUPLICATE_PRIMARY_TIMEOUT	7200	7200	7200

TABLE 5.3: DESCRIPTION OF IMPORTANT RESOURCE AGENT PARAMETERS

Parameter	Description
PREFER_SITE_TAKEOVER	Defines whether RA should prefer to takeover to the secondary instance instead of restarting the failed primary locally.
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 <code>false</code> the former primary must be manually registered. The cluster will not start this SAP HANA RDBMS till it is registered to avoid double primary up situations.
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, than the cluster hold one or both instances in a "WAITING" status. This is to give a admin 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 could be found with the command `man ocf_suse_SAPHana`

```
# vi crm-saphana.txt
```

```
# enter the following to crm-saphana.txt
primitive rsc_SAPHana_HA1_HDB10 ocf:suse:SAPHana \
    operations $id="rsc_sap_HA1_HDB10-operations" \
    op start interval="0" timeout="3600" \
    op stop interval="0" timeout="3600" \
    op promote interval="0" timeout="3600" \
    op monitor interval="60" role="Master" timeout="700" \
    op monitor interval="61" role="Slave" timeout="700" \
    params SID="HA1" InstanceNumber="10" PREFER_SITE_TAKEOVER="true" \
    DUPLICATE_PRIMARY_TIMEOUT="7200" AUTOMATED_REGISTER="false"
ms msl_SAPHana_HA1_HDB10 rsc_SAPHana_HA1_HDB10 \
    meta clone-max="2" clone-node-max="1" interleave="true"
```

We add the configuration to the cluster.

```
suse01:~ # crm configure load update crm-saphana.txt
```

The most important parameters here are again SID and InstanceNumber. Beside these parameters the timeout values for the operations (start, promote, monitors, stop) are typical tuneables.

5.3.7 The virtual IP address

The last resource to be added to the cluster is covering the virtual IP address.

```
# vi crm-vip.txt
# enter the following to crm-vip.txt

primitive rsc_ip_HA1_HDB10 ocf:heartbeat:IPaddr2 \
    operations $id="rsc_ip_HA1_HDB10-operations" \
    op monitor interval="10s" timeout="20s" \
    params ip="192.168.1.20"
```

We load the file to the cluster.

```
suse01:~ # 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.

5.3.8 Constraints

Two 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 SAPHana and SAPHanaTopology.

```
# vi crm-cs.txt
# enter the following to crm-cs.txt

colocation col_saphana_ip_HA1_HDB10 2000: rsc_ip_HA1_HDB10:Started \
    msl_SAPHana_HA1_HDB10:Master
order ord_SAPHana_HA1_HDB10 Optional: cln_SAPHanaTopology_HA1_HDB10 \
    msl_SAPHana_HA1_HDB10
```

We load the file to the cluster.

```
suse01:~ # crm configure load update crm-cs.txt
```

6 Testing the Cluster

The lists of tests will be improved in the next update of this document.

As with any cluster testing is crucial. Please make sure that all test cases derived from customer expectations are implemented and passed fully. Else the project is likely to fail in production use

The test prerequisite, if not described differently, is always that both nodes are booted, normal members of the cluster and the HANA RDBMS is running. The system replication is in sync (SOK).

6.1 Test cases for semi automation

In the following test descriptions we assume PREFER_SITE_TAKEOVER="true" and AUTOMATED_REGISTER="false".

NOTE: The following tests are designed to be run in sequence and depend on the exit state of the preceding tests.

TEST 1: STOP PRIMARY DATABASE ON NODE 1

Component:

Primary Database

Description:

The primary HANA database is stopped during normal cluster operation.

PROCEDURE 6.1: TEST PROCEDURE

- Stop the primary HANA database gracefully as <sid> adm.

```
suse01# HDB stop
```

PROCEDURE 6.2: RECOVERY PROCEDURE

- Manually register the old primary (on node 1) with the new primary after takeover (on node 2) as <sid> adm.

```
suse01# hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --  
replicationMode=sync --name=WDF
```

Restart the HANA database (now secondary) on node 1 as root.

```
suse01# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse01
```

Expected:

1. The cluster detects the stopped primary HANA database (on node 1) and marks the resource failed.
2. The cluster promotes the secondary HANA database (on node 2) to take over as primary.
3. The cluster migrates the IP address to the new primary (on node 2).
4. After some time the cluster shows the sync_state of the stopped primary (on node 1) as SFAIL.
5. Because AUTOMATED_REGISTER="false" the cluster does not restart the failed HANA database or register it against the new primary.
6. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
7. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 2: STOP PRIMARY DATABASE ON NODE 2

Component:

Primary Database

Description:

The primary HANA database is stopped during normal cluster operation.

PROCEDURE 6.3: TEST PROCEDURE

- Stop the database gracefully as <sid> adm.

```
suse02# HDB stop
```

PROCEDURE 6.4: RECOVERY PROCEDURE

- Manually register the old primary (on node 2) with the new primary after takeover (on node 1) as <sid> adm.

```
suse02# hdbnsutil -sr_register --remoteHost=suse01 --remoteInstance=10 --  
replicationMode=sync --name=ROT
```

Restart the HANA database (now secondary) on node 1 as root.

```
suse02# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse02
```


Expected:

1. The cluster detects the stopped primary HANA database (on node 2) and marks the resource failed.
2. The cluster promotes the secondary HANA database (on node 1) to take over as primary.
3. The cluster migrates the IP address to the new primary (on node 1).
4. After some time the cluster shows the sync_state of the stopped primary (on node 2) as SFAIL.
5. Because AUTOMATED_REGISTER="false" the cluster does not restart the failed HANA database or register it against the new primary.
6. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
7. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 3: CRASH PRIMARY DATABASE ON NODE 1

Component:

Primary Database

Description:

Simulate a complete break-down of the primary database system.

PROCEDURE 6.5: TEST PROCEDURE

- Kill the primary database system using signals as <sid> adm.

```
suse01# HDB kill-9
```

PROCEDURE 6.6: RECOVERY PROCEDURE

- Manually register the old primary (on node 1) with the new primary after takeover (on node 2) as <sid> adm.

```
suse01# hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --  
replicationMode=sync --name=WDF
```

Restart the HANA database (now secondary) on node 1 as root.

```
suse01# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse01
```

Expected:

1. The cluster detects the stopped primary HANA database (on node 1) and marks the resource failed.
2. The cluster promotes the secondary HANA database (on node 2) to take over as primary.
3. The cluster migrates the IP address to the new primary (on node 2).
4. After some time the cluster shows the sync_state of the stopped primary (on node 1) as SFAIL.
5. Because AUTOMATED_REGISTER="false" the cluster does not restart the failed HANA database or register it against the new primary.
6. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
7. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 4: CRASH PRIMARY DATABASE ON NODE 2

Component:

Primary Database

Description:

Simulate a complete break-down of the primary database system.

PROCEDURE 6.7: TEST PROCEDURE

- Kill the primary database system using signals as <sid> adm.

```
suse02# HDB kill-9
```

PROCEDURE 6.8: RECOVERY PROCEDURE

- Manually register the old primary (on node 2) with the new primary after takeover (on node 1) as <sid> adm.

```
suse02# hdbnsutil -sr_register --remoteHost=suse01 --remoteInstance=10 --  
replicationMode=sync --name=ROT
```

Restart the HANA database (now secondary) on node 1 as root.

```
suse02# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse02
```

Expected:

1. The cluster detects the stopped primary HANA database (on node 2) and marks the resource failed.
2. The cluster promotes the secondary HANA database (on node 1) to take over as primary.
3. The cluster migrates the IP address to the new primary (on node 1).
4. After some time the cluster shows the sync_state of the stopped primary (on node 2) as SFAIL.
5. Because AUTOMATED_REGISTER="false" the cluster does not restart the failed HANA database or register it against the new primary.
6. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
7. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 5: CRASH PRIMARY SITE NODE (NODE 1)

Component:

Cluster node of primary site

Description:

Simulate a crash of the primary site node running the primary HANA database.

PROCEDURE 6.9: TEST PROCEDURE

- Crash the primary node by sending a 'fast-reboot' system request.

```
suse01# echo 'b' > /proc/sysrq-trigger
```

PROCEDURE 6.10: RECOVERY PROCEDURE

1. If SBD fencing is used then pacemaker will not automatically restart after being fenced, in this case clear the fencing flag on all SBD devices and subsequently start pacemaker.

```
suse01# sbd -d /dev//dev/disk/by-id/SBDA message suse01 clear
```

```
suse01# rcpopenais start
```

2. Manually register the old primary (on node 1) with the new primary after takeover (on node 2) as `<sid> adm`.

```
suse01# hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --  
replicationMode=sync --name=WDF
```

Restart the HANA database (now secondary) on node 1 as root.

```
suse01# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse01
```

Expected:

1. The cluster detects the failed node (node 1) and declares it UNCLEAN and sets the secondary node (node 2) to status "partition WITHOUT quorum".
2. The cluster fences the failed node (node 1).
3. The cluster declares the failed node (node 1) OFFLINE.
4. The cluster promotes the secondary HANA database (on node 2) to take over as primary.
5. The cluster migrates the IP address to the new primary (on node 2).
6. After some time the cluster shows the sync_state of the stopped primary (on node 2) as SFAIL.
7. If SBD fencing is used then the manual recovery procedure will be used to clear the fencing flag and restart pacemaker on the node.
8. Because `AUTOMATED_REGISTER="false"` the cluster does not restart the failed HANA database or register it against the new primary.
9. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
10. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 6: CRASH SECONDARY SITE NODE (NODE 2)

Component:

Cluster node of secondary site

Description:

Simulate a crash of the secondary site node running the primary HANA database.

PROCEDURE 6.11: TEST PROCEDURE

- Crash the secondary node by sending a 'fast-reboot' system request.

```
suse02# echo 'b' > /proc/sysrq-trigger
```

PROCEDURE 6.12: RECOVERY PROCEDURE

1. If SBD fencing is used then pacemaker will not automatically restart after being fenced, in this case clear the fencing flag on all SBD devices and subsequently start pacemaker.

```
suse02# sbd -d /dev//dev/disk/by-id/SBDA message suse02 clear
```

```
suse02# rcpopenais start
```

2. Manually register the old primary (on node 2) with the new primary after takeover (on node 1) as `<sid> adm`.

```
suse02# hdbnsutil -sr_register --remoteHost=suse01 --remoteInstance=10 --  
replicationMode=sync --name=ROT
```

Restart the HANA database (now secondary) on node 2 as root.

```
suse02# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse02
```

Expected:

1. The cluster detects the failed secondary node (node 2) and declares it UNCLEAN and sets the primary node (node 1) to status "partition WITHOUT quorum".
2. The cluster fences the failed secondary node (node 2).
3. The cluster declares the failed secondary node (node 2) OFFLINE.
4. The cluster promotes the secondary HANA database (on node 1) to take over as primary.
5. The cluster migrates the IP address to the new primary (on node 1).
6. After some time the cluster shows the sync_state of the stopped secondary (on node 2) as SFAIL.

7. If SBD fencing is used then the manual recovery procedure will be used to clear the fencing flag and restart pacemaker on the node.
8. Because `AUTOMATED_REGISTER="false"` the cluster does not restart the failed HANA database or register it against the new primary.
9. After the manual register and resource cleanup the system replication pair is marked as in sync (SOK).
10. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 7: STOP THE SECONDARY DATABASE ON NODE 2

Component:

Secondary HANA database

Description:

The secondary HANA database is stopped during normal cluster operation.

PROCEDURE 6.13: TEST PROCEDURE

- Stop the secondary HANA database gracefully as `<sid> adm`.

```
suse02# HDB stop
```

PROCEDURE 6.14: RECOVERY PROCEDURE

- Cleanup the failed resource status of the secondary HANA database (on node 2) as root.

```
suse02# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse02
```

Expected:

1. The cluster detects the stopped secondary database (on node 2) and marks the resource failed.
2. The cluster detects the broken system replication and marks it as failed (SFAIL).
3. The cluster restarts the secondary HANA database on the same node (node 2).
4. The cluster detects that the system replication is in sync again and marks it as ok (SOK).
5. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 8: CRASH THE SECONDARY DATABASE ON NODE 2

Component:

Secondary HANA database

Description:

Simulate a complete break-down of the secondary database system.

PROCEDURE 6.15: TEST PROCEDURE

- Kill the secondary database system using signals as `<sid> adm`.

```
suse02# HDB kill-9
```

PROCEDURE 6.16: RECOVERY PROCEDURE

- Cleanup the failed resource status of the secondary HANA database (on node 2) as root.

```
suse02# crm resource cleanup rsc_SAPHana_HA1_HDB10 suse02
```

Expected:

1. The cluster detects the stopped secondary database (on node 2) and marks the resource failed.
2. The cluster detects the broken system replication and marks it as failed (SFAIL).
3. The cluster restarts the secondary HANA database on the same node (node 2).
4. The cluster detects that the system replication is in sync again and marks it as ok (SOK).
5. The cluster "failed actions" are cleaned up after following the recovery procedure.

TEST 9: CRASH SECONDARY SITE NODE (NODE 2) RUNNING SECONDARY HANA DATABASE

Component:

Cluster node of secondary site

Description:

Simulate a crash of the secondary site node running the secondary HANA database.

PROCEDURE 6.17: TEST PROCEDURE

- Crash the secondary node by sending a 'fast-reboot' system request.

```
suse02# echo 'b' > /proc/sysrq-trigger
```

PROCEDURE 6.18: RECOVERY PROCEDURE

- If SBD fencing is used then pacemaker will not automatically restart after being fenced, in this case clear the fencing flag on all SBD devices and subsequently start pacemaker.

```
suse02# sbd -d /dev//dev/disk/by-id/SBDA message suse02 clear
```

```
suse02# rcpopenais start
```

Expected:

1. The cluster detects the failed secondary node (node 2) and declares it UNCLEAN and sets the primary node (node 1) to status "partition WITHOUT quorum".
2. The cluster fences the failed secondary node (node 2).
3. The cluster declares the failed secondary node (node 2) OFFLINE.
4. After some time the cluster shows the sync_state of the stopped secondary (on node 2) as SFAIL.
5. If SBD fencing is used then the manual recovery procedure will be used to clear the fencing flag and restart pacemaker on the node.
6. Once the fenced node (node 2) rejoins the cluster the former secondary HANA database is started automatically.
7. The cluster detects that the system replication is in sync again and marks it as ok (SOK).

TEST 10: TEST FAILURE OF REPLICATION LAN

Component:

Replication LAN

Description:

Loss of replication LAN connectivity between the primary and secondary node.

PROCEDURE 6.19: TEST PROCEDURE

- Break the connection between the cluster nodes on the replication LAN.

PROCEDURE 6.20: RECOVERY PROCEDURE

- Re-establish the connection between the cluster nodes on the replication LAN.

Expected:

1. After some time the cluster shows the sync_state of the secondary (on node 2) as SFAIL.
2. The primary HANA database (node 1) "HDBSettings.sh systemReplicationStatus.py" shows "CONNECTION TIMEOUT" and the secondary HANA database (node 2) is not able to reach the primary database (node 1).
3. The primary HANA database continues to operate as “normal”, but no system replication takes place and is therefore no longer a valid take over destination.
4. Once the LAN connection is re-established, HDB automatically detects connectivity between the HANA databases and restarts the system replication process
5. The cluster detects that the system replication is in sync again and marks it as ok (SOK).

7 Administration

7.1 Do and Don't

In your project, you should:

- Define STONITH before adding other resources to the cluster
- Do intensive testing.
- Tune the timeouts of operations of SAPHana and SAPHanaTopology.
- Start with `PREFER_SITE_TAKEOVER = "true"`, `AUTOMATED_REGISTER = "false"` and `DUPLICATE_PRIMARY_TIMEOUT = "7200"`.

In your project, avoid:

- Rapidly changing/changing back cluster configuration, such as: Setting nodes to standby and online again or stopping/starting the master/slave resource.
- Creating a cluster without proper time synchronization or unstable name resolutions for hosts, users and groups
- Adding location rules for the clone, master/slave or IP resource. Only location rules mentioned in this setup guide are allowed.
- As "migrating" or "moving" resources in `crm-shell`, HAWK or other tools would add client-prefer location rules this activities are completely forbidden.

7.2 Monitoring and Tools

You can use the High Availability Web Console (HAWK), SAP HANA Studio and different command line tools for cluster status requests.

7.2.1 HAWK – Cluster Status and more

You can use an internet browser to check the cluster status.

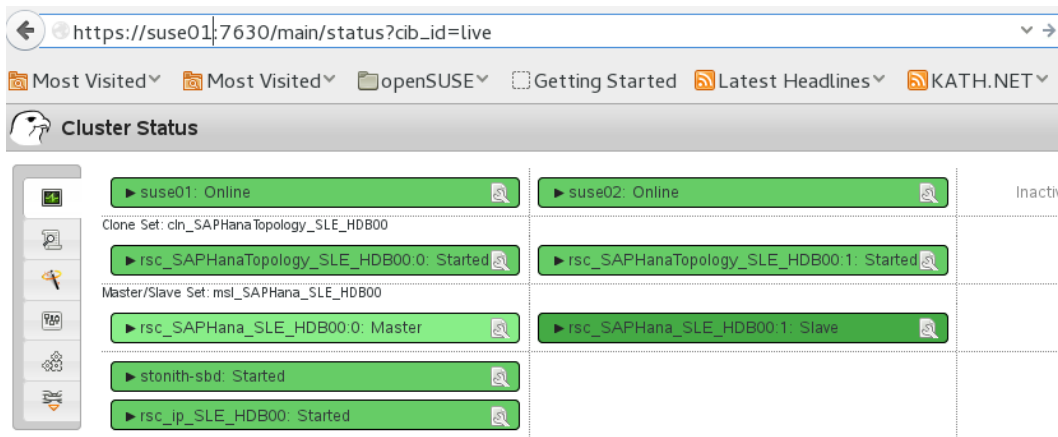


FIGURE 7.1: CLUSTER STATUS IN HAWK

If you set up the cluster using sleha-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, doing administrative tasks or even configure resources and cluster bootstrap parameters. Read our product manuals for a complete documentation of this powerful user interface.

7.2.2 SAP HANA Studio

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

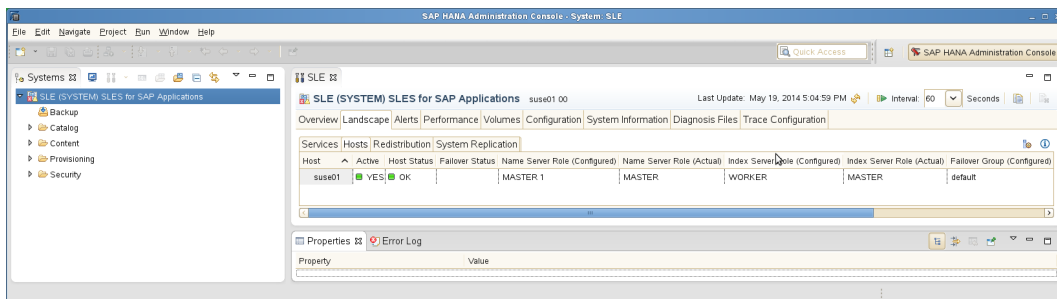


FIGURE 7.2: SAP HANA STUDIO – LANDSCAPE

7.2.3 Cluster Command-Line Tools

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

```

suse01:~ # crm_mon -r1
Last updated: Fri May 16 17:18:56 2014
Last change: Fri May 16 17:17:45 2014 by root via crm_attribute on suse01
Stack: classic openais (with plugin)
Current DC: suse01 - partition with quorum
Version: 1.1.10-f3eeaf4
2 Nodes configured, 2 expected votes
6 Resources configured

Online: [ suse01 suse02 ]

Full list of resources:

stonith-sbd (stonith:external/sbd): Started suse01
Clone Set: cln_SAPHanaTopology_HA1_HDB10 [rsc_SAPHanaTopology_HA1_HDB10]
  Started: [ suse01 suse02 ]
Master/Slave Set: ms1_SAPHana_HA1_HDB10 [rsc_SAPHana_HA1_HDB10]
  Masters: [ suse01 ]
  Slaves: [ suse02 ]

```

See the manual page `crm_mon(8)` for details.

To show some of the SAPHana, SAPHanaTopology resource agent internal values, you can call the program `SAPHanaSR-showAttr`. The internal values, storage place and their parameter names may change in the next versions. The command `SAPHanaSR-showAttr` will always fetch the values from the correct storage place.

Do not use cluster commands like `crm_attribute` to fetch the values directly from the cluster, because in such cases your methods will be broken, when we need to move an attribute to a different storage place or even out of the cluster. For first `SAPHanaSR-showAttr` is a test program only and should not be used for automated system monitoring.

```

suse01:~ # SAPHanaSR-showAttr
Host \ Attr clone_state remoteHost roles      ... site  srmode sync_state ...
-----
suse01    PROMOTED   suse02    4:P:master1:... WDF      sync  PRIM      ...
suse02    DEMOTED   suse01    4:S:master1:... ROT      sync  SOK       ...

```

7.2.4 SAP HANA LandscapeHostConfiguration

To check the status of a SAPHana database and to figure out if the cluster should react, you can use the script `landscapeHostConfiguration` to be called as Linux user `<sid>adm`.

```
suse01:~> HDBSettings.sh landscapeHostConfiguration.py
| Host | Host | ... NameServer | NameServer | IndexServer | IndexServer |
|      | Active | ... Config Role | Actual Role | Config Role | Actual Role |
| ----- | ----- | ... ----- | ----- | ----- | ----- |
| suse01 | yes | ... master 1 | master | worker | master |

overall host status: ok
```

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

TABLE 7.1: INTERPRETATION OF RETURN CODES

Return Code	Interpretation
4	SAP HANA database is up and OK. The cluster does interpret this as a 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.
1	SAP HANA database is down. If the database should be up and is not down by intention, this could trigger a takeover.
0	Internal Script Error – to be ignored.

7.3 Maintenance

It is highly recommended to register your systems to either a local SUSE Manager or SMT or remote with SUSE Customer Center to be able to receive updates to the OS or HAE.

7.3.1 Updating the OS and Cluster

Update of SUSE Linux Enterprise Server for SAP Applications packages including cluster software you should follow the rolling update procedure defined in the product documentation of SUSE Linux Enterprise High Availability *Upgrading Your Cluster and Updating Software Packages*, ↑ High Availability Administration Guide.

7.3.2 Updating SAP HANA

For updating SAP HANA database systems in system replication you need to follow the defined SAP processes. This section describes the steps to be done before and after the update procedure to get the system replication automated again.

PROCEDURE 7.1: TOP LEVEL STEPS TO UPDATING SAP HANA IN THE CLUSTER

1. Prepare the cluster not to react on the maintenance work to be done on the SAP HANA database systems. Set the master/slave resource to be unmanaged and the cluster nodes in maintenance mode.
For the master/slave resource set the unmanage status: `crm resource unmanage master-slave-resource`
For all cluster nodes set the ready status: `crm node maintenance node`.
2. Complete the SAP Update process for both SAP HANA database systems. This process is described by SAP.
3. After the SAP HANA update is complete on both sites, tell the cluster about the end of the maintenance process.
For all cluster nodes set the ready status: `crm node ready node`.
4. As we expect the primary/secondary roles to be exchanged after the maintenance, tell the cluster to forget about this states and to reprobe the updated SAP HANA database systems.
`crm resource cleanup master-slave-resource`.
5. In the last step we tell the cluster to manage the SAP HANA database systems again.
`crm resource manage master-slave-resource`.

7.3.3 Migrating a HANA primary

In the following procedures we assume the primary to be running on node1 and the secondary on node2. The goal is to "exchange" the roles of the nodes, so finally the primary should run on node2 and the secondary should run on node1.

There are different methods to get the exchange of the roles done, the following procedure shows how to tell the cluster to "accept" a role change done with native HANA commands.

PROCEDURE 7.2: MIGRATING A HANA PRIMARY WITH UNMANAGED MASTER/SLAVE RESOURCE

1. Set the master/slave resource to be unmanaged. This could be done on any cluster node.
crm resource unmanage master-slave-resource-name
2. Stop the primary SAP HANA database system. Enter the command in our example on node1 as user <sid> adm.
HDB stop
3. Start the takeover process on the secondary SAP HANA database system. Enter the command in our example on node2 as user <sid> adm.
hdbnsutil -sr_takeover
4. Register the former primary to become the new secondary. Enter the command in our example on node1 as user <sid> adm.
hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --replicationMode=sync --name=WDF --operationMode=logreplay
5. Start the new secondary SAP HANA database system. Enter the command in our example on node1 as user <sid> adm.
HDB start
Wait some time till SAPHanaSR-showAttr shows both SAP HANA database systems to be up again (field roles must start with the digit 4).
6. Tell the cluster to forget about the former master/slave roles and to re-monitor the failed master. The command could be submitted on any cluster node as user root.
crm resource cleanup master-slave-resource-name
7. Set the master/slave resource to the status managed again. The command could be submitted on any cluster node as user root.
crm resource manage master-slave-resource-name

Now we explain how to use the cluster to partially automatize the migration.

PROCEDURE 7.3: MIGRATING A HANA PRIMARY USING CLUSTER MIGRATION COMMANDS

1. Create a migrate away rule from this node rule.

```
crm resource migrate sapHanaResource force
```

Because of we used the migrate away rule the cluster will stop the current primary and run a promote on the secondary site, if the system replication was in sync before. You should not migrate the primary, if the status of the system replication is not in sync (SFAIL).

Wait till the secondary has completely taken over to be the new primary.

2. If you have setup `AUTOMATED_REGISTER="true"` you can skip this step. In other cases you now need to register the old primary. Enter the command in our example on node1 as user `<sid> adm`.

```
hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --replicationMode=sync --name=WDF --operationMode=logreplay
```

3. Unmigrate the resource to allow the cluster to start the new secondary.

```
crm resource unmigrate sapHanaResource
```

PROCEDURE 7.4: MIGRATING A HANA PRIMARY USING CLUSTER NODE STATUS STANDBY

1. Set the primary node to be standby.

```
crm node standby suse01
```

The cluster will stop the primary SAP HANA database and if the system replication was in sync process the takeover on the secondary site

Wait till the former secondary has completely taken over to be the new primary.

2. If you have setup `AUTOMATED_REGISTER="true"` you can skip this step. In other cases you now need to register the old primary. Enter the command in our example on node1 as user `<sid> adm`.

```
hdbnsutil -sr_register --remoteHost=suse02 --remoteInstance=10 --replicationMode=sync --name=WDF --operationMode=logreplay
```

3. Set the standby node to be online again.

```
crm node online suse01
```


A Useful Links, Manuals, and SAP Notes

A.1 SUSE Best Practices and More

- Best Practices for SAP on SUSE Linux Enterprise: <https://www.suse.com/products/sles-for-sap/resource-library/sap-best-practices.html> ↗
- 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> ↗
- HOW TO SET UP SAPHanaSR IN THE COST OPTIMIZED SAP HANA SR SCENARIO <http://scn.sap.com/docs/DOC-65899> ↗

A.2 SUSE Product Documentation

The SUSE product manuals and documentation can be downloaded at www.suse.com/documentation.

- Current online documentation of SLES for SAP https://www.suse.com/documentation/sles_for_sap/ ↗
- Current online documentation of SUSE Linux Enterprise High Availability Extension https://www.suse.com/documentation/sle_ha/ ↗
- Tuning guide for SUSE Linux Enterprise Server https://www.suse.com/documentation/sles11/book_sle_tuning/data/book_sle_tuning.html ↗
- Storage admin guide for SUSE Linux Enterprise Server https://www.suse.com/documentation/sles11/stor_admin/data/bookinfo.html ↗
- Release notes <https://www.suse.com/releasenotes/> ↗
- TID Estimate correct multipath timeout <http://www.suse.com/support/kb/doc.php?id=7008216> ↗
- TID How to load the correct watchdog kernel module <http://www.suse.com/support/kb/doc.php?id=7016880> ↗

- TID Performance issues after upgrade from SLES11 SP1 to SP2 or SP3 <http://www.suse.com/support/kb/doc.php?id=7011982> ↗
- TID Addressing file system performance issues on NUMA machines <http://www.suse.com/support/kb/doc.php?id=7008919> ↗
- TID Low write performance on SLES 11 servers with large RAM <https://www.suse.com/support/kb/doc.php?id=7010287> ↗
- TID Overcommit Memory in SLES <https://www.suse.com/support/kb/doc.php?id=7002775> ↗
- SLES technical information <https://www.suse.com/products/server/technical-information/> ↗
- XFS file system <https://www.suse.com/communities/conversations/xfs-the-file-system-of-choice/> ↗

A.3 SAP Product Documentation

- SAP HANA Installation and Update Guide http://help.sap.com/hana/SAP_HANA_Server_Installation_Guide_en.pdf ↗
- SAP HANA Administration Guide http://help.sap.com/hana/SAP_HANA_Administration_Guide_en.pdf ↗

A.4 SAP Notes

- 1310037 (<http://service.sap.com/sap/support/notes/1310037>) ↗ SUSE LINUX Enterprise Server 11: Installation notes
- 1824819 (<http://service.sap.com/sap/support/notes/2240716>) ↗ SAP HANA DB: Recommended OS settings for SLES 11 / SLES for SAP Applications 11 SP4
- 1876398 (<http://service.sap.com/sap/support/notes/1876398>) ↗ Network configuration for System Replication in HANA SP6
- 611361 (<http://service.sap.com/sap/support/notes/611361>) ↗ Hostnames of SAP servers
- 1275776 (<http://service.sap.com/sap/support/notes/1275776>) ↗ Preparing SLES for Sap Environments

- [1514967 \(http://service.sap.com/sap/support/notes/1514967\)](http://service.sap.com/sap/support/notes/1514967) ↗ SAP HANA: Central Note
- [1523337 \(http://service.sap.com/sap/support/notes/1523337\)](http://service.sap.com/sap/support/notes/1523337) ↗ SAP In-Memory Database 1.0: Central Note
- [1501701 \(http://service.sap.com/sap/support/notes/1501701\)](http://service.sap.com/sap/support/notes/1501701) ↗ Single Computing Unit Performance and Sizing
- [1944799 \(http://service.sap.com/sap/support/notes/1944799\)](http://service.sap.com/sap/support/notes/1944799) ↗ SAP HANA Guidelines for SLES Operating System Installation
- [1954788 \(http://service.sap.com/sap/support/notes/1954788\)](http://service.sap.com/sap/support/notes/1954788) ↗ SAP HANA DB: Recommended OS settings for SLES 11 / SLES for SAP Applications 11 SP3
- [1855805 \(http://service.sap.com/sap/support/notes/1855805\)](http://service.sap.com/sap/support/notes/1855805) ↗ Recommended SLES 11 packages for HANA support on OS level
- [1890444 \(http://service.sap.com/sap/support/notes/1890444\)](http://service.sap.com/sap/support/notes/1890444) ↗ Slow HANA system due to CPU power save mode
- [1867783 \(http://service.sap.com/sap/support/notes/1867783\)](http://service.sap.com/sap/support/notes/1867783) ↗ XFS Data Inconsistency Bug with SLES 11 SP2
- [1888072 \(http://service.sap.com/sap/support/notes/1888072\)](http://service.sap.com/sap/support/notes/1888072) ↗ SAP HANA DB: Indexserver crash in strcmp sse42
- [1846872 \(http://service.sap.com/sap/support/notes/1846872\)](http://service.sap.com/sap/support/notes/1846872) ↗ "No space left on device" error reported from HANA

B Examples

B.1 Example sleha-init Configuration

```
suse01:~ # sleha-init
ntp on
Enabling sshd service
Generating ssh key
Configuring csync2
csync2 is already configured - overwrite? [y/N] y
Generating csync2 shared key (this may take a while)...done
Enabling csync2 service
Enabling xinetd service
csync2 checking files
Enabling sshd service
Generating ssh key
Configuring csync2
csync2 is already configured - overwrite? [y/N] y
Generating csync2 shared key (this may take a while)...done
Enabling csync2 service
Enabling xinetd service
csync2 checking files
Configure Corosync:
This will configure the cluster messaging layer. You will need
to specify a network address over which to communicate (default
is eth0's network, but you can use the network address of any
active interface), a multicast address and multicast port.
/etc/corosync/corosync.conf already exists - overwrite? [y/N] y
Network address to bind to (e.g.: 192.168.1.0) [192.168.1.0]
Multicast address (e.g.: 239.x.x.x) [239.107.222.58] 238.50.0.1
Multicast port [5404]
Configure SBD:
If you have shared storage, for example a SAN or iSCSI target,
you can use it avoid split-brain scenarios by configuring SBD.
This requires a 1 MB partition, accessible to all nodes in the
cluster. The device path must be persistent and consistent
across all nodes in the cluster, so /dev/disk/by-id/* devices
are a good choice. Note that all data on the partition you
specify here will be destroyed.
Do you wish to use SBD? [y/N] y
Path to storage device (e.g. /dev/disk/by-id/...) [] /dev/disk/by-id/SBDA
All data on /dev/disk/by-id/SBDA will be destroyed
Are you sure you wish to use this device [y/N] y
Initializing SBD.....done
```

```

Enabling hawk service
HA Web Konsole is now running, to see cluster status go to:
https://192.168.1.11:7630/
Log in with username 'hacluster', password 'linux'
WARNING: You should change the hacluster password to something more secure!
Enabling openais service
Waiting for cluster.....done
Loading initial configuration
Done (log saved to /var/log/sleha-bootstrap.log)
Change the hacluster password

```

B.2 Example Cluster Configuration

The following complete crm configuration is for a two-node cluster (suse01, suse02) and a SAP HANA database with SID HA1 and instance number 10. The virtual IP address in the example is 192.168.1.20

```

node suse01
node suse02

primitive rsc_SAPHanaTopology_HA1_HDB10 ocf:suse:SAPHanaTopology \
    operations $id="rsc_sap2_HA1_HDB10-operations" \
    op monitor interval="10" timeout="300" \
    op start interval="0" timeout="300" \
    op stop interval="0" timeout="300" \
    params SID="HA1" InstanceNumber="10"
primitive rsc_SAPHana_HA1_HDB10 ocf:suse:SAPHana \
    operations $id="rsc_sap_HA1_HDB10-operations" \
    op monitor interval="61" role="Slave" timeout="700" \
    op start interval="0" timeout="3600" \
    op stop interval="0" timeout="3600" \
    op promote interval="0" timeout="3600" \
    op monitor interval="60" role="Master" timeout="700" \
    params SID="HA1" InstanceNumber="10" PREFER_SITE_TAKEOVER="true"
DUPLICATE_PRIMARY_TIMEOUT="7200" AUTOMATED_REGISTER="false"
primitive rsc_ip_HA1_HDB10 ocf:heartbeat:IPaddr2 \
    operations $id="rsc_ip_HA1_HDB10-operations" \
    op monitor interval="10s" timeout="20s" \
    params ip="192.168.1.20"
primitive stonith-sbd stonith:external/sbd \
    params pcmk_delay_max="15" \
    op monitor interval="15" timeout="15"
ms msl_SAPHana_HA1_HDB10 rsc_SAPHana_HA1_HDB10 \
    meta clone-max="2" clone-node-max="1" interleave="true"

```

```

clone cln_SAPHanaTopology_HA1_HDB10 rsc_SAPHanaTopology_HA1_HDB10 \
    meta clone-node-max="1" interleave="true"
colocation col_saphana_ip_HA1_HDB10 2000: \
    rsc_ip_HA1_HDB10:Started msl_SAPHana_HA1_HDB10:Master
order ord_SAPHana_HA1_HDB10 2000: \
    cln_SAPHanaTopology_HA1_HDB10 msl_SAPHana_HA1_HDB10
property $id="cib-bootstrap-options" \
    dc-version="1.1.10-f3eeaf4" \
    cluster-infrastructure="classic openais (with plugin)" \
    expected-quorum-votes="2" \
    no-quorum-policy="ignore" \
    stonith-enabled="true" \
    stonith-action="reboot" \
    stonith-timeout="150s" \
    last-lrm-refresh="1398346620"
rsc_defaults $id="rsc_default-options" \
    resource-stickiness="1000" \
    migration-threshold="5000"
op_defaults $id="op_defaults-options" \
    timeout="600"

```

B.3 Example for /etc/corosync/corosync.conf

The following file shows a typical corosync configuration with one ring. Please view SUSE product documentation about details and about additional rings.

```

aisexec {
    #Group to run aisexec as. Needs to be root for Pacemaker
    group: root
    #User to run aisexec as. Needs to be root for Pacemaker
    user: root
}
service {
    #Default to start mgmtd with pacemaker
    use_mgmtd:    yes
    #Use logd for pacemaker
    use_logd:     yes
    ver:          0
    name:         pacemaker
}
totem {
    #The mode for redundant ring. None is used when only 1 interface
    #specified, otherwise, only active or passive may be chosen
    rrp_mode:     none
    #How long to wait for join messages in membership protocol. in ms

```

```

join: 60
#The maximum number of messages that may be sent by one processor
#on receipt of the token.
max_messages: 20
#The virtual synchrony filter type used to indentify a primary
#component. Change with care.
vsftype: none
#Timeout for a token lost. in ms
token: 5000
#How long to wait for consensus to be achieved before starting a
#new round of membership configuration.
consensus: 6000
interface {
    #Network Address to be bind for this interface setting
    bindnetaddr: 192.168.1.0
    member {
        memberaddr: 192.168.1.11
    }
    member {
        memberaddr: 192.168.1.12
    }
    #The multicast port to be used
    mcastport: 5405
    #The ringnumber assigned to this interface setting
    ringnumber: 0
}
#HMAC/SHA1 should be used to authenticate all message
secauth: on
#The only valid version is 2
version: 2
#How many threads should be used to encrypt and sending message.
#Only have meanings when secauth is turned on
threads: 4
#
transport: udpu
#How many token retransmits should be attempted before forming a
#new configuration.
token_retransmits_before_loss_const: 28
#To make sure the auto-generated nodeid is positive
clear_node_high_bit: new
}
logging {
    #Log to a specified file
    to_logfile: no
    #Log to syslog
    to_syslog: yes
    #Whether or not turning on the debug information in the log

```

```

debug: off
#Log timestamp as well
timestamp: off
#Log to the standard error output
to_stderr: no
#Logging file line in the source code as well
fileline: off
#Facility in syslog
syslog_facility: daemon
}
amf {
#Enable or disable AMF
mode: disable
}

```

B.4 Example for the IPMI STONITH Method

```

primitive rsc_suse01_stonith stonith:external/ipmi \
params hostname="suse01" ipaddr="192.168.1.101" userid="stonith" \
passwd="k1llm3" interface="lanplus" \
op monitor interval="1800" timeout="30"
...
primitive rsc_suse02_stonith stonith:external/ipmi \
params hostname="suse02" ipaddr="192.168.1.102" userid="stonith" \
passwd="k1llm3" interface="lanplus" \
op monitor interval="1800" timeout="30"
...
location loc_suse01_stonith rsc_suse01_stonith -inf: suse01
location loc_suse02_stonith rsc_suse02_stonith -inf: suse02

```


C Documentation Updates

This section will contain information about documentation content changes made to the *SAP HANA SR Performance Optimized Scenario Set-Up Guide*.