Setting up Pacemaker on Red Hat Enterprise Linux in Azure

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The article describes how to configure basic Pacemaker cluster on Red Hat Enterprise Server(RHEL). The instructions cover RHEL 7, RHEL 8 and RHEL 9.

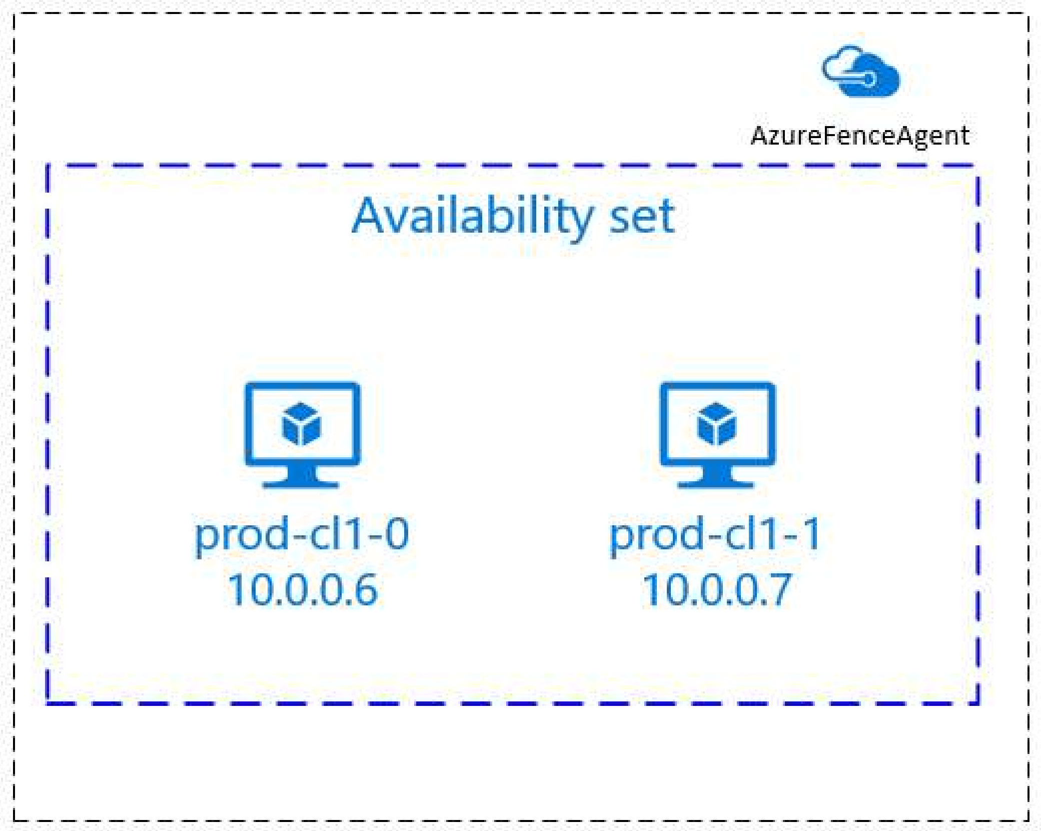
Prerequisites

Read the following SAP Notes and papers first:

- SAP Note 1928533 , which has:
  - The list of Azure VM sizes that are supported for the deployment of SAP software.
  - Important capacity information for Azure VM sizes.
  - The supported SAP software, and operating system (OS) and database combinations.
  - The required SAP kernel version for Windows and Linux on Microsoft Azure.
- SAP Note 2015553 lists prerequisites for SAP-supported SAP software deployments in Azure.
- SAP Note 2002167 recommends OS settings for Red Hat Enterprise Linux
- SAP Note 3108316 recommends OS settings for Red Hat Enterprise Linux 9.x
- SAP Note 2009879 has SAP HANA Guidelines for Red Hat Enterprise Linux
- SAP Note 3108302 has SAP HANA Guidelines for Red Hat Enterprise Linux 9.x
- SAP Note 2178632 has detailed information about all monitoring metrics reported for SAP in Azure.
- SAP Note 2191498 has the required SAP Host Agent version for Linux in Azure.
- SAP Note 2243692 has information about SAP licensing on Linux in Azure.
- SAP Note 1999351 has additional troubleshooting information for the Azure Enhanced Monitoring Extension for SAP.
- SAP Community WIKI has all required SAP Notes for Linux.
- Azure Virtual Machines planning and implementation for SAP on Linux
- Azure Virtual Machines deployment for SAP on Linux (this article)
- Azure Virtual Machines DBMS deployment for SAP on Linux
- SAP HANA system replication in pacemaker cluster
- General RHEL documentation
  - High Availability Add-On Overview

  - High Availability Add-On Administration
  - High Availability Add-On Reference
  - Support Policies for RHEL High Availability Clusters - sbd and fence_sbd
- Azure-specific RHEL documentation:
  - Support Policies for RHEL High Availability Clusters - Microsoft Azure Virtual Machines as Cluster Members
  - Installing and Configuring a Red Hat Enterprise Linux 7.4 (and later) High-Availability Cluster on Microsoft Azure
  - Considerations in adopting RHEL 8 - High availability and clusters
  - Configure SAP S/4HANA ASCS/ERS with Standalone Enqueue Server 2 (ENSA2) in Pacemaker on RHEL 7.6
  - RHEL for SAP Offerings on Azure

Cluster installation



ⓘ **Note**

Red Hat doesn't support software-emulated watchdog. Red Hat doesn't support SBD on cloud platforms. For details see **Support Policies for RHEL High Availability**

Clusters - sbd and fence_sbd . The only supported fencing mechanism for Pacemaker Red Hat Enterprise Linux clusters on Azure, is Azure fence agent.

The following items are prefixed with either **[A]** - applicable to all nodes, **[1]** - only applicable to node 1 or **[2]** - only applicable to node 2. Differences in the commands or the configuration between RHEL 7 and RHEL 8/RHEL 9 are marked in the document.

1. **[A]** Register - optional step. This step isn't required, if using RHEL SAP HA-enabled images.

   For example, if deploying on RHEL 7, register your virtual machine and attach it to a pool that contains repositories for RHEL 7.

   ```
   sudo subscription-manager register
   # List the available pools
   sudo subscription-manager list --available --matches '*SAP*'
   sudo subscription-manager attach --pool=<pool id>
   ```

   By attaching a pool to an Azure Marketplace PAYG RHEL image, you will be effectively double-billed for your RHEL usage: once for the PAYG image, and once for the RHEL entitlement in the pool you attach. To mitigate this situation, Azure now provides BYOS RHEL images. For more information, see Red Hat Enterprise Linux bring-your-own-subscription Azure images.

2. **[A]** Enable RHEL for SAP repos - optional step. This step isn't required, if using RHEL SAP HA-enabled images.

   In order to install the required packages on RHEL 7, enable the following repositories.

   ```
   sudo subscription-manager repos --disable "*"
   sudo subscription-manager repos --enable=rhel-7-server-rpms
   sudo subscription-manager repos --enable=rhel-ha-for-rhel-7-server-rpms
   sudo subscription-manager repos --enable=rhel-sap-for-rhel-7-server-rpms
   sudo subscription-manager repos --enable=rhel-ha-for-rhel-7-server-eus-
   rpms
   ```

3. **[A]** Install RHEL HA Add-On

Bash

```
sudo yum install -y pcs pacemaker fence-agents-azure-arm nmap-ncat
```

Important

We recommend the following versions of Azure Fence agent (or later) for customers to benefit from a faster failover time, if a resource stop fails or the cluster nodes cannot communicate which each other anymore:
RHEL 7.7 or higher use the latest available version of fence-agents package
RHEL 7.6: fence-agents-4.2.1-11.el7_6.8
RHEL 7.5: fence-agents-4.0.11-86.el7_5.8
RHEL 7.4: fence-agents-4.0.11-66.el7_4.12
For more information, see **Azure VM running as a RHEL High Availability cluster member take a very long time to be fenced, or fencing fails / times-out before the VM shuts down** .

Important

We recommend the following versions of Azure Fence agent (or later) for customers wishing to use Managed Identities for Azure resources instead of service principal names for the fence agent.
RHEL 8.4: fence-agents-4.2.1-54.el8
RHEL 8.2: fence-agents-4.2.1-41.el8_2.4
RHEL 8.1: fence-agents-4.2.1-30.el8_1.4
RHEL 7.9: fence-agents-4.2.1-41.el7_9.4.

Important

On RHEL 9, we recommend the following package versions (or later) to avoid issues with Azure Fence agent: fence-agents-4.10.0-20.el9_0.7
fence-agents-common-4.10.0-20.el9_0.6
ha-cloud-support-4.10.0-20.el9_0.6.x86_64.rpm

Check the version of the Azure fence agent. If necessary, update it to the minimum required version or later.

```
# Check the version of the Azure Fence Agent
 sudo yum info fence-agents-azure-arm
```

> ⓘ **Important**
>
> If you need to update the Azure Fence agent, and if using custom role, make sure to update the custom role to include action **powerOff**. For details see Create a custom role for the fence agent.

4. If deploying on RHEL 9, install also the resource agents for cloud deployment:

Bash

```
sudo yum install -y resource-agents-cloud
```

5. **[A]** Setup host name resolution

You can either use a DNS server or modify the /etc/hosts on all nodes. This example shows how to use the /etc/hosts file. Replace the IP address and the hostname in the following commands.

> ⓘ **Important**
>
> If using host names in the cluster configuration, it's vital to have reliable host name resolution. The cluster communication will fail, if the names are not available and that can lead to cluster failover delays. The benefit of using /etc/hosts is that your cluster becomes independent of DNS, which could be a single point of failures too.

```
sudo vi /etc/hosts
```

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

```
# IP address of the first cluster node
10.0.0.6 prod-cl1-0
# IP address of the second cluster node
10.0.0.7 prod-cl1-1
```

6. **[A]** Change hacluster password to the same password

```
sudo passwd hacluster
```

7. **[A]** Add firewall rules for pacemaker

   Add the following firewall rules to all cluster communication between the cluster nodes.

```
sudo firewall-cmd --add-service=high-availability --permanent
sudo firewall-cmd --add-service=high-availability
```

8. **[A]** Enable basic cluster services

   Run the following commands to enable the Pacemaker service and start it.

```
sudo systemctl start pcsd.service
sudo systemctl enable pcsd.service
```

9. **[1]** Create Pacemaker cluster

   Run the following commands to authenticate the nodes and create the cluster. Set the token to 30000 to allow Memory preserving maintenance. For more information, see this article for Linux.

   If building a cluster on **RHEL 7.x**, use the following commands:

```
sudo pcs cluster auth prod-cl1-0 prod-cl1-1 -u hacluster
sudo pcs cluster setup --name nw1-azr prod-cl1-0 prod-cl1-1 --token 30000
sudo pcs cluster start --all
```

If building a cluster on **RHEL 8.x/RHEL 9.x**, use the following commands:

```
sudo pcs host auth prod-cl1-0 prod-cl1-1 -u hacluster
sudo pcs cluster setup nw1-azr prod-cl1-0 prod-cl1-1 totem token=30000
sudo pcs cluster start --all
```

Verify the cluster status, by executing the following command:

```
 # Run the following command until the status of both nodes is online
sudo pcs status
# Cluster name: nw1-azr
# WARNING: no stonith devices and stonith-enabled is not false
# Stack: corosync
# Current DC: prod-cl1-1 (version 1.1.18-11.el7_5.3-2b07d5c5a9) - partition with quorum
# Last updated: Fri Aug 17 09:18:24 2018
# Last change: Fri Aug 17 09:17:46 2018 by hacluster via crmd on prod-cl1-1
#
# 2 nodes configured
# 0 resources configured
#
# Online: [ prod-cl1-0 prod-cl1-1 ]
#
# No resources
#
# Daemon Status:
#   corosync: active/disabled
#   pacemaker: active/disabled
#   pcsd: active/enabled
```

10. **[A]** Set Expected Votes.

```
# Check the quorum votes
 pcs quorum status
 # If the quorum votes are not set to 2, execute the next command
 sudo pcs quorum expected-votes 2
```

> **Tip**
>
> If building multi-node cluster, that is cluster with more than two nodes, don't set the votes to 2.

11. **[1]** Allow concurrent fence actions

```
sudo pcs property set concurrent-fencing=true
```

Create fencing device

The fencing device uses either a managed identity for Azure resource or service principal to authorize against Microsoft Azure.

Using Managed Identity

To create a managed identity (MSI), create a system-assigned managed identity for each VM in the cluster. Should a system-assigned managed identity already exist, it will be used. User assigned managed identities should not be used with Pacemaker at this time. Fence device, based on managed identity is supported on RHEL 7.9 and RHEL 8.x/RHEL 9.x.

Using Service Principal

Follow these steps to create a service principal, if not using managed identity.

1. Go to the Azure portal .
2. Open the Azure Active Directory blade
   Go to Properties and make a note of the Directory ID. This is the **tenant ID**.
3. Click App registrations
4. Click New Registration
5. Enter a Name, select "Accounts in this organization directory only"
6. Select Application Type "Web", enter a sign-on URL (for example http://localhost) and click Add
   The sign-on URL isn't used and can be any valid URL
7. Select Certificates and Secrets, then click New client secret

8. Enter a description for a new key, select "Never expires" and click Add
9. Make a node the Value. It is used as the **password** for the service principal
10. Select Overview. Make a note the Application ID. It's used as the username (**login ID** in the steps below) of the service principal

[1] Create a custom role for the fence agent

Neither managed identity nor service principal has permissions to access your Azure resources by default. You need to give the managed identity or service principal permissions to start and stop (power-off) all virtual machines of the cluster. If you didn't already create the custom role, you can create it using PowerShell or Azure CLI

Use the following content for the input file. You need to adapt the content to your subscriptions that is, replace *xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx* and *yyyyyyyy-yyyy-yyyy-yyyy-yyyyyyyyyyyy* with the Ids of your subscription. If you only have one subscription, remove the second entry in AssignableScopes.

JSON

```json
{
      "Name": "Linux Fence Agent Role",
      "description": "Allows to power-off and start virtual machines",
      "assignableScopes": [
              "/subscriptions/xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx",
              "/subscriptions/yyyyyyyy-yyyy-yyyy-yyyy-yyyyyyyyyyyy"
      ],
      "actions": [
              "Microsoft.Compute/*/read",
              "Microsoft.Compute/virtualMachines/powerOff/action",
              "Microsoft.Compute/virtualMachines/start/action"
      ],
      "notActions": [],
      "dataActions": [],
      "notDataActions": []
}
```

[A] Assign the custom role

Using Managed Identity

Assign the custom role "Linux Fence Agent Role" that was created in the last chapter to each managed identity of the cluster VMs. Each VM system-assigned managed identity needs the role assigned for every cluster VM's resource. For detailed steps, see Assign a managed identity access to a resource by using the Azure portal. Verify each VM's managed identity role assignment contains all cluster VMs.

> **Important**
>
> Be aware assignment and removal of authorization with managed identities **can be delayed** until effective.

Using Service Principal

Assign the custom role "Linux Fence Agent Role" that was created in the last chapter to the service principal. Don't use the Owner role anymore! For detailed steps, see Assign Azure roles using the Azure portal.
Make sure to assign the role for both cluster nodes.

[1] Create the fencing devices

After you edited the permissions for the virtual machines, you can configure the fencing devices in the cluster.

```
sudo pcs property set stonith-timeout=900
```

> **Note**
>
> Option 'pcmk_host_map' is ONLY required in the command, if the RHEL host names and the Azure VM names are NOT identical. Specify the mapping in the format **hostname:vm-name**. Refer to the bold section in the command. For more information, see **What format should I use to specify node mappings to fencing devices in pcmk_host_map**

Managed Identity

For RHEL **7.x**, use the following command to configure the fence device:

```
sudo pcs stonith create rsc_st_azure fence_azure_arm msi=true
resourceGroup="resource group" \
subscriptionId="subscription id" pcmk_host_map="prod-cl1-0:prod-cl1-0-vm-
name;prod-cl1-1:prod-cl1-1-vm-name" \
power_timeout=240 pcmk_reboot_timeout=900 pcmk_monitor_timeout=120
pcmk_monitor_retries=4 pcmk_action_limit=3 pcmk_delay_max=15 \
op monitor interval=3600
```

For RHEL **8.x/9.x**, use the following command to configure the fence device:

```
sudo pcs stonith create rsc_st_azure fence_azure_arm msi=true
resourceGroup="resource group" \
subscriptionId="subscription id" pcmk_host_map="prod-cl1-0:prod-cl1-0-vm-
name;prod-cl1-1:prod-cl1-1-vm-name" \
power_timeout=240 pcmk_reboot_timeout=900 pcmk_monitor_timeout=120
pcmk_monitor_retries=4 pcmk_action_limit=3 pcmk_delay_max=15 \
op monitor interval=3600
```

If you're using fencing device, based on service principal configuration, read Change from SPN to MSI for Pacemaker clusters using Azure fencing and learn how to convert to managed identity configuration.

Tip

Only configure the `pcmk_delay_max` attribute in two node Pacemaker clusters. For more information on preventing fence races in a two node Pacemaker cluster, see **Delaying fencing in a two node cluster to prevent fence races of "fence death" scenarios** .

Important

The monitoring and fencing operations are deserialized. As a result, if there is a longer running monitoring operation and simultaneous fencing event, there is no delay to the cluster failover, due to the already running monitoring operation.

[1] Enable the use of a fencing device

```
sudo pcs property set stonith-enabled=true
```

Tip

Azure Fence Agent requires outbound connectivity to public end points as documented, along with possible solutions, in **Public endpoint connectivity for VMs using standard ILB**.

Optional fencing configuration

Tip

This section is only applicable, if it is desired to configure special fencing device `fence_kdump`.

If there is a need to collect diagnostic information within the VM, it may be useful to configure additional fencing device, based on fence agent `fence_kdump`. The `fence_kdump` agent can detect that a node entered kdump crash recovery and can allow the crash recovery service to complete, before other fencing methods are invoked. Note that `fence_kdump` isn't a replacement for traditional fence mechanisms, like Azure Fence Agent when using Azure VMs.

Important

Be aware that when `fence_kdump` is configured as a first level fencing device, it will introduce delays in the fencing operations and respectively delays in the application resources failover.

> If a crash dump is successfully detected, the fencing will be delayed until the crash recovery service completes. If the failed node is unreachable or if it doesn't respond, the fencing will be delayed by time determined by the configured number of iterations and the `fence_kdump` timeout. For more details, see **How do I configure fence_kdump in a Red Hat Pacemaker cluster** .
> The proposed fence_kdump timeout may need to be adapted to the specific environment.
>
> We recommend to configure `fence_kdump` fencing only when necessary to collect diagnostics within the VM and always in combination with traditional fence method as Azure Fence Agent.

The following Red Hat KBs contain important information about configuring `fence_kdump` fencing:

- How do I configure fence_kdump in a Red Hat Pacemaker cluster
- How to configure/manage fencing levels in RHEL cluster with Pacemaker
- fence_kdump fails with "timeout after X seconds" in a RHEL 6 or 7 HA cluster with kexec-tools older than 2.0.14
- For information how to change the default timeout see How do I configure kdump for use with the RHEL 6,7,8 HA Add-On
- For information on how to reduce failover delay, when using `fence_kdump` see Can I reduce the expected delay of failover when adding fence_kdump configuration

Execute the following optional steps to add `fence_kdump` as a first level fencing configuration, in addition to the Azure Fence Agent configuration.

1. **[A]** Verify that kdump is active and configured.

```
systemctl is-active kdump
# Expected result
# active
```

2. **[A]** Install the `fence_kdump` fence agent.

```
yum install fence-agents-kdump
```

3. **[1]** Create `fence_kdump` fencing device in the cluster.

```
 pcs stonith create rsc_st_kdump fence_kdump pcmk_reboot_action="off"
pcmk_host_list="prod-cl1-0 prod-cl1-1" timeout=30
```

4. **[1]** Configure fencing levels, so that `fence_kdump` fencing mechanism is engaged first.

```
 pcs stonith create rsc_st_kdump fence_kdump pcmk_reboot_action="off"
pcmk_host_list="prod-cl1-0 prod-cl1-1"
 pcs stonith level add 1 prod-cl1-0 rsc_st_kdump
 pcs stonith level add 1 prod-cl1-1 rsc_st_kdump
 pcs stonith level add 2 prod-cl1-0 rsc_st_azure
 pcs stonith level add 2 prod-cl1-1 rsc_st_azure
 # Check the fencing level configuration
 pcs stonith level
 # Example output
 # Target: prod-cl1-0
 # Level 1 - rsc_st_kdump
 # Level 2 - rsc_st_azure
 # Target: prod-cl1-1
 # Level 1 - rsc_st_kdump
 # Level 2 - rsc_st_azure
```

5. **[A]** Allow the required ports for `fence_kdump` through the firewall

```
firewall-cmd --add-port=7410/udp
firewall-cmd --add-port=7410/udp --permanent
```

6. **[A]** Ensure that `initramfs` image file contains `fence_kdump` and `hosts` files. For details see How do I configure fence_kdump in a Red Hat Pacemaker cluster .

```
lsinitrd /boot/initramfs-$(uname -r)kdump.img | egrep "fence|hosts"
# Example output
# -rw-r--r--   1 root     root          208 Jun  7 21:42 etc/hosts
# -rwxr-xr-x   1 root     root        15560 Jun 17 14:59 
usr/libexec/fence_kdump_send
```

7. **[A]** Perform the `fence_kdump_nodes` configuration in `/etc/kdump.conf` to avoid `fence_kdump` failing with a timeout for some `kexec-tools` versions. For details see fence_kdump times out when fence_kdump_nodes is not specified with kexec-tools version 2.0.15 or later and fence_kdump fails with "timeout after X seconds" in a RHEL 6 or 7 High Availability cluster with kexec-tools versions older than 2.0.14 . The example configuration for a two node cluster is presented below. After making a change in `/etc/kdump.conf`, the kdump image must be regenerated. That can be achieved by restarting the `kdump` service.

```
vi /etc/kdump.conf
# On node prod-cl1-0 make sure the following line is added
fence_kdump_nodes  prod-cl1-1
# On node prod-cl1-1 make sure the following line is added
fence_kdump_nodes  prod-cl1-0

# Restart the service on each node
systemctl restart kdump
```

8. Test the configuration by crashing a node. For details see How do I configure fence_kdump in a Red Hat Pacemaker cluster .

> ⓘ **Important**
>
> If the cluster is already in productive use, plan the test accordingly as crashing a node will have an impact on the application.

```
echo c > /proc/sysrq-trigger
```

Next steps

- Azure Virtual Machines planning and implementation for SAP
- Azure Virtual Machines deployment for SAP
- Azure Virtual Machines DBMS deployment for SAP
- To learn how to establish high availability and plan for disaster recovery of SAP HANA on Azure VMs, see High Availability of SAP HANA on Azure Virtual Machines (VMs)