High Availability Clustering with RHEL 7/8 and z/VM®

Advanced Setup

—

Solution Assurance

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RHEL HA - **Agenda**

- **Introduction**
- **Architecture and Requirements**
- **High Availability Concepts**
  - **Quorum**
  - **Planned/Unplanned Outage**
  - **Resources**

1. **First Steps – Cluster Setup**
2. **Live Guest Relocation (SSI)**
3. **Fencing/STONITH (SBD)**
4. **Cluster Timeouts**
5. **Resources**
   - **Shared Storage**
   - **Floating IP Address**
   - **Your Workload**
6. **Cluster Testing**

Guidance Notes

- Some of the operations must be run on all nodes and some only one one node.
- The "**Run on**" graphic on the right indicate on which of the nodes you must run the command.

- "**#**" at the beginning of the line indicate a privileged bash command.

- "**rhel7/8**" at the beginning of the line indicate that this command should run on RHEL 7.7+ and RHEL 8.3+.

```
rhel7/8# echo "Example command"
```

- The graphic on the right is used for illustration purposes.

Introduction

Introduction - References

Documentation:

Official Red Hat® **documentation**:
- RHEL7: LINK
- RHEL8: LINK

Official Red Hat® **support statements**:
- z/VM specific
- Components in General

Official Red Hat® **version changes**:
- RHEL7: LINK
- RHEL8 Release Notes: LINK

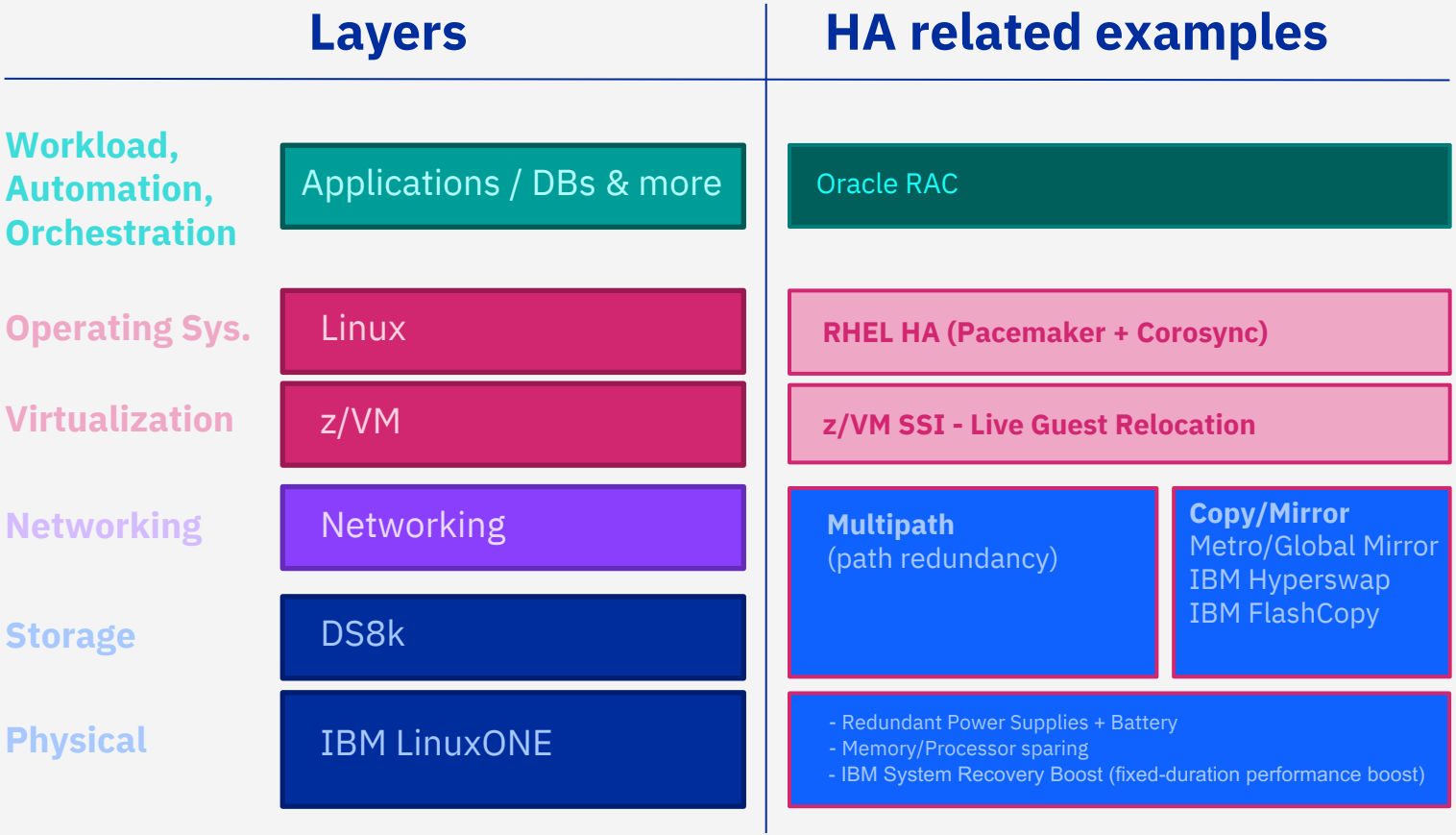
Redbooks® publication - HA on Linux
- HA services or applications **uptime** approaches 100%
- **HA withstands** failures that are caused by **planned or unplanned outages**

Pacemaker documentation

SIDE A

SIDE B

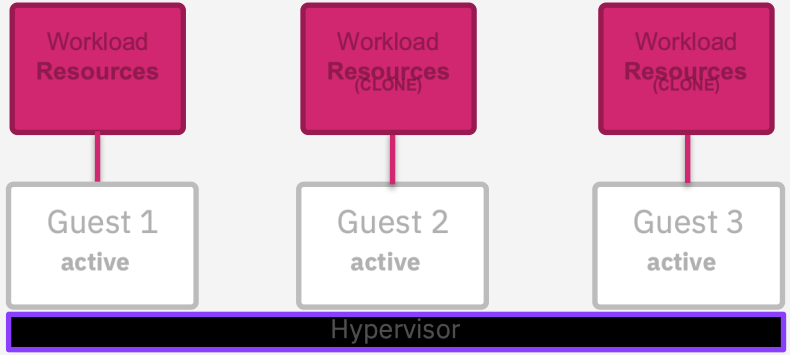
Introduction – High Availability Stack



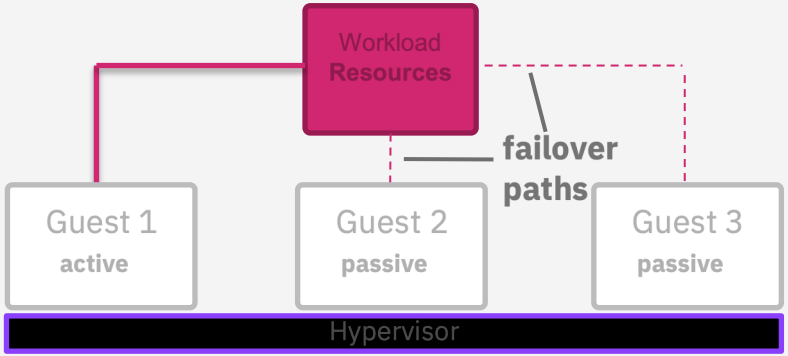
Introduction – HA Complexity

"No Red Hat High Availability"

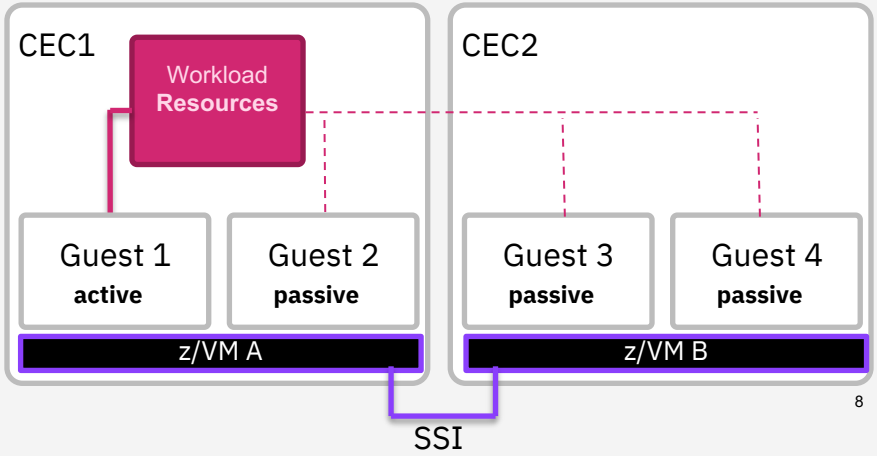
"Active/Active Cluster" often with load balancing



"Active / Passive Failover"



"Cluster spanning multiple sites with SSI"



Architecture and Requirements

Architecture and Details

Setup:

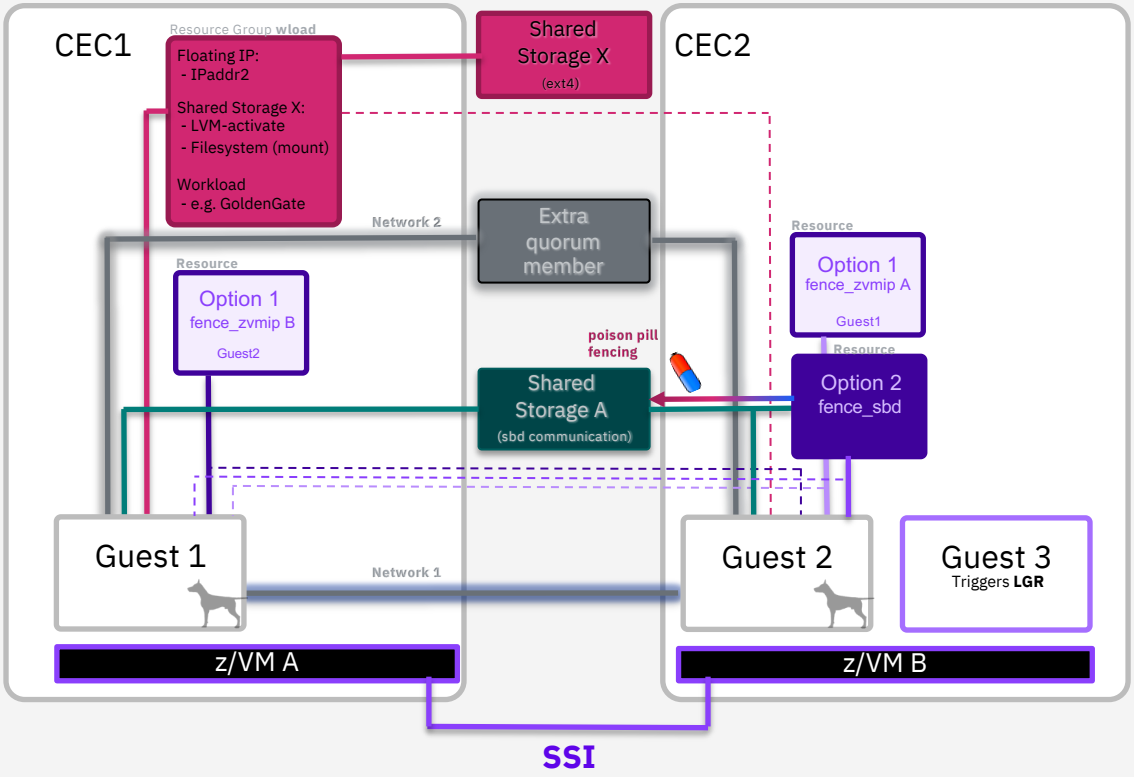
- z15™ and DS8000®
- 1 SSI Cluster (2 z/VMs and 2 guests)
- 1 guest on the third side
- 2+ ECKD DASD Fullpack Minidisk (shared storage)
- 3 ECKD DASD (z/VM guests OS)

z/VM guests:

- On z/VM 7.2
- Distro: RHEL 8.3+ (or 7.7+)

Legend:

- **Watchdog**
- **Poison Pill**
- **Failover Paths**



A more detailed graphic can be found in Appendix B

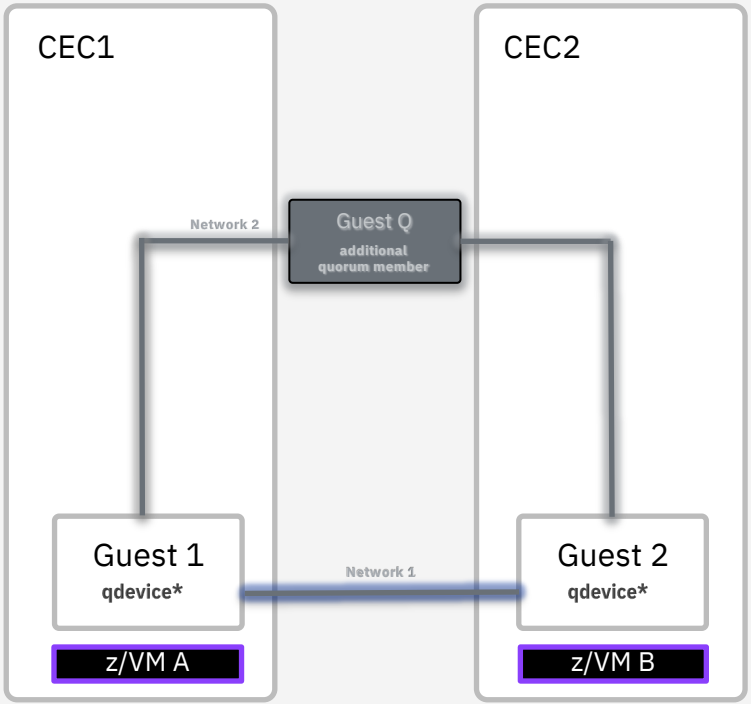
Quorum Concept

Quorum - Concepts

Corosync Votequorum

- Quantity of **votes are assigned to the systems**
- Only when a **majority of votes are present** the cluster **operations are allowed** to proceed.
- With 1 CEC an uneven amount of nodes ensures quorum when 1 node fails.
- With 2 CECs you either need:
  - A third cluster member on a neutral/third side
  - Or a quorum server on a neutral/third side which only votes but does not participate otherwise
- (See next slides for reasons on why a third side is needed)

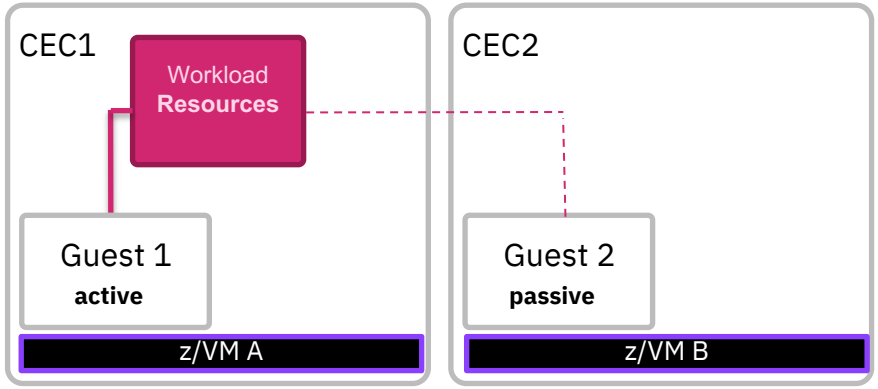
Example 2 CEC quorum setup:



Quorum – 2/3-Nodes Challenges

2-node cluster

split brain challenge

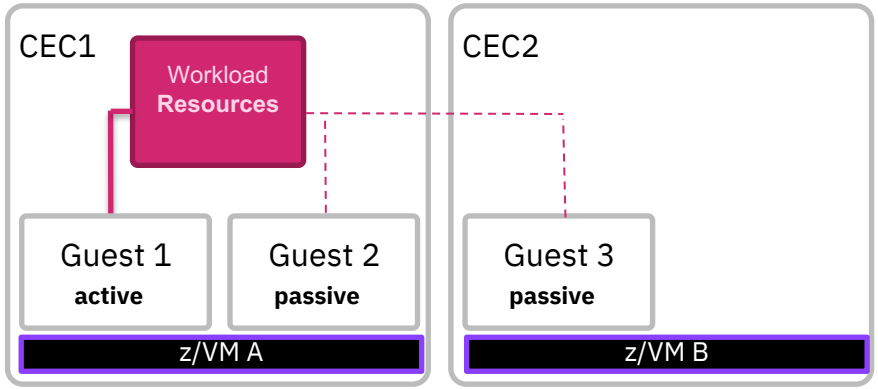


Does not work because in case of a network failure both CECs would be quorate or inquorate which results in running the workload twice or not at all. (**split brain**)

When you use a Tie-Breaker it **does not work** when the wrong CEC dies.

3-node cluster

quorum challenge

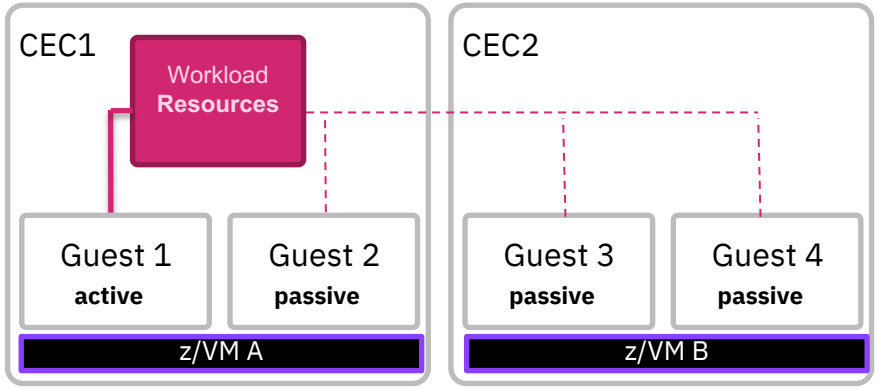


Does not work because in case of CEC1 failure CEC2 alone is not quorate!

Quorum – 4 Nodes Challenges and Solution

4-nodes cluster

split brain + quorum challenge

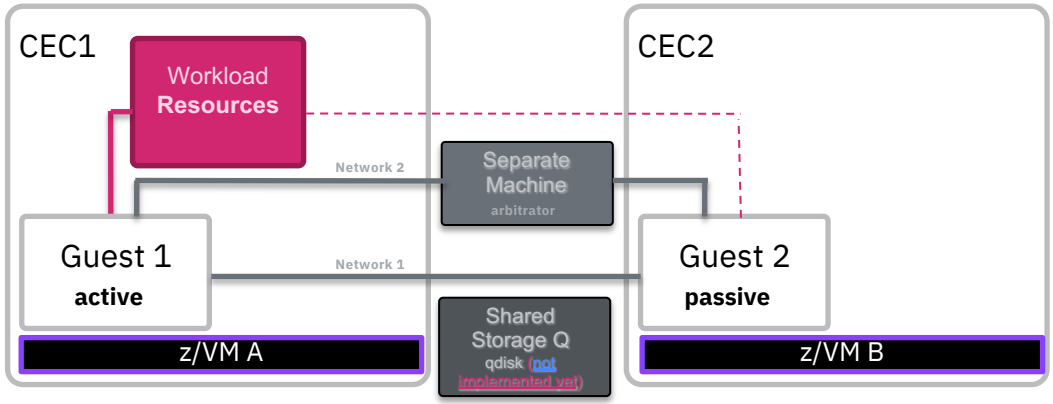


Does not work because in case of a network failure in between the CECs both CECs are not quorate.
A tiebreaker would only help one side.

Solution:

2 / 4 nodes + additional quorum member

solves challenges



A **separate machine** which participates as quorum member **prevents split brain** and other quorum challenges.

Planned / Unplanned Outage Concept

Planned / Unplanned Outage - Concepts

Planned Outage

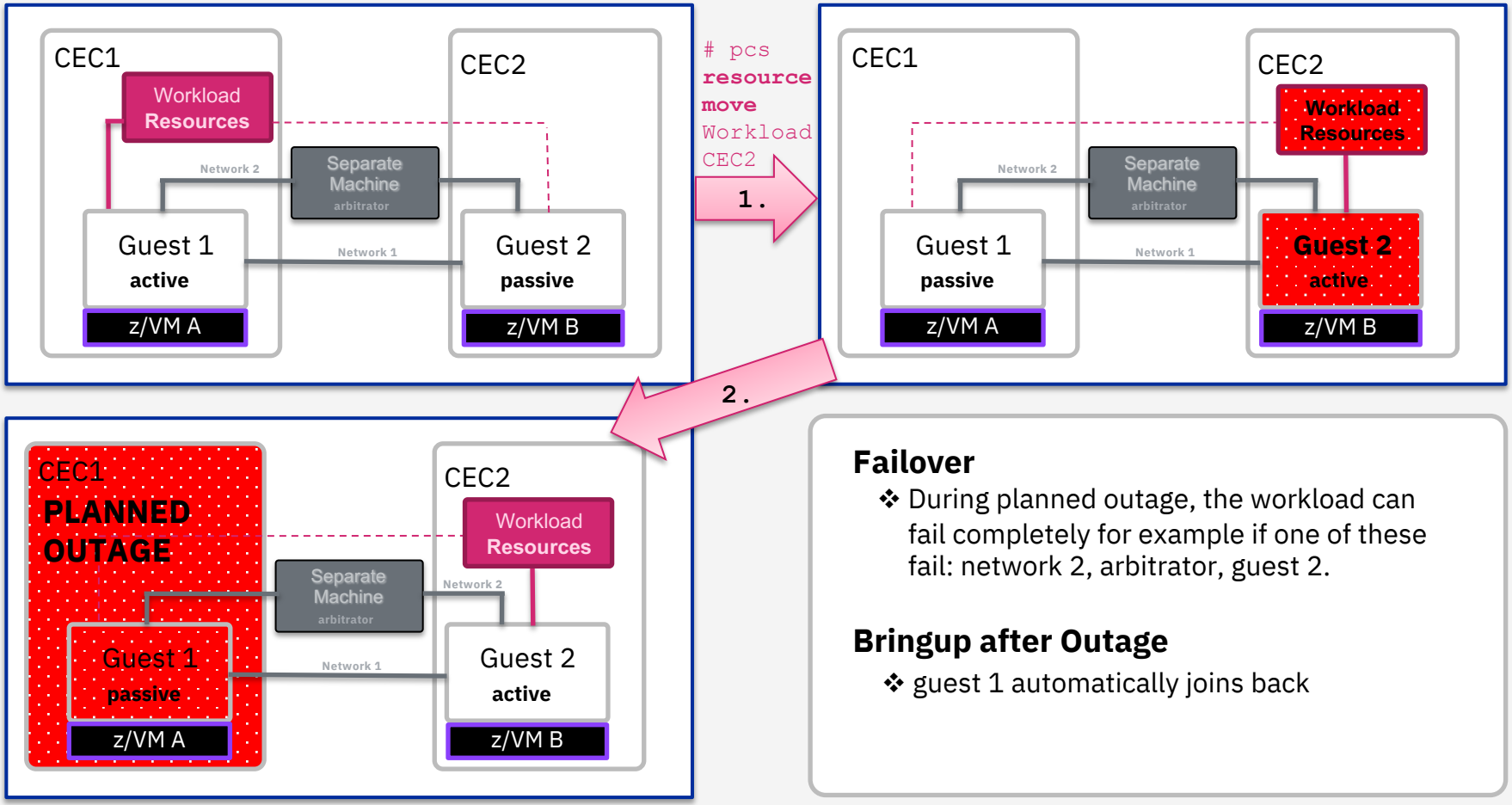
- Red Hat HA allows you to manually trigger the movement of workload to the other side
- When a SSI cluster is in use you can move the whole guest to the other side with Live Guest Relocation (LGR).
  - Note that only the LGR of passive guests might be supported (LINK) and therefore a movement of the workload in the cluster might be needed before moving.

Unplanned Outage

- Red Hat HA automatically fails over in case of failure.
- Additionally, the node might be killed/fenced to make sure the resources are released before the Resource is brought up on the other node.

➢ See following slides for graphic illustrations.

Planned Outage - RHEL HA



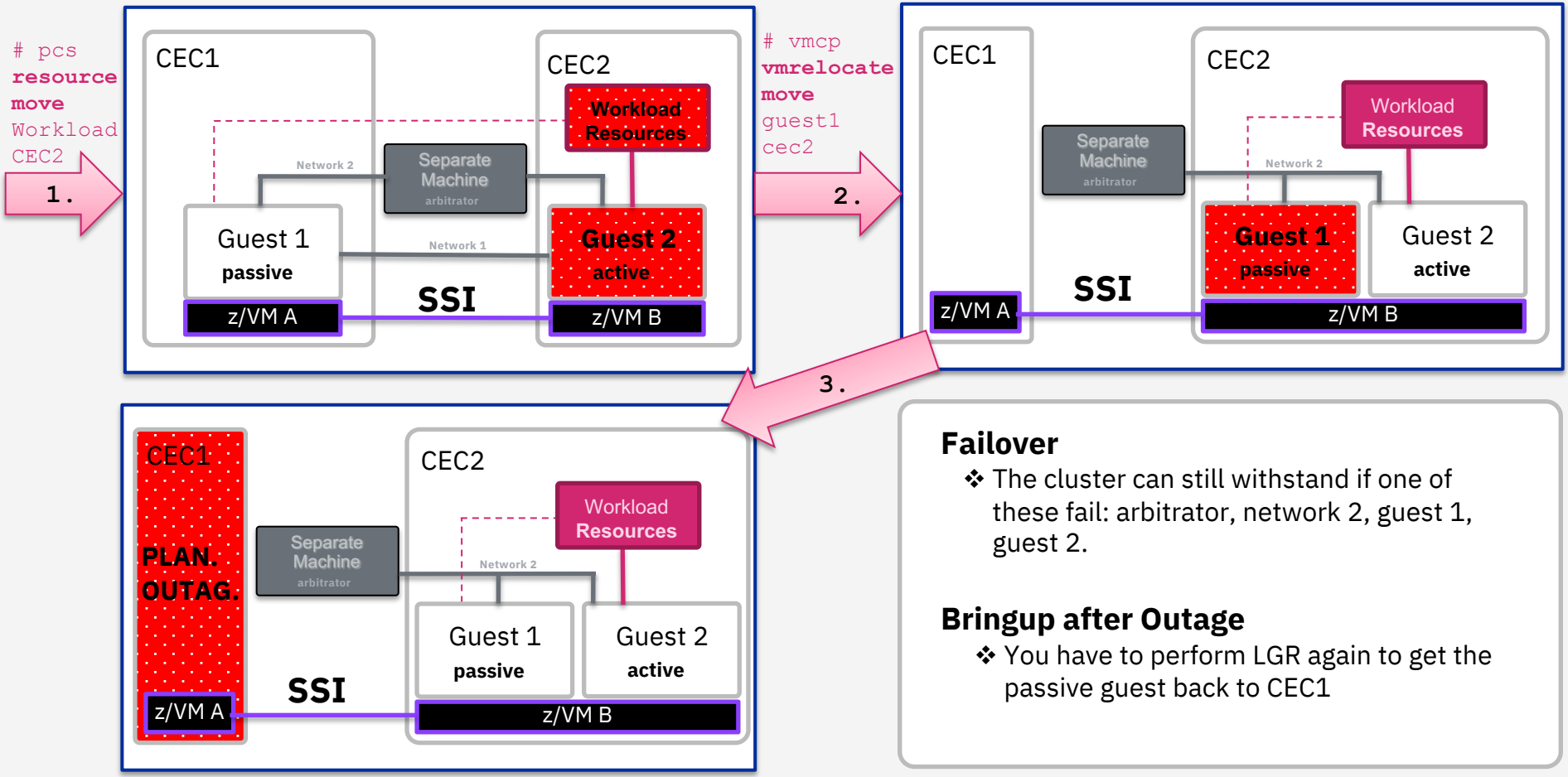
Failover

- During planned outage, the workload can fail completely for example if one of these fail: network 2, arbitrator, guest 2.

Bringup after Outage

- guest 1 automatically joins back

Planned Outage - RHEL HA + SSI



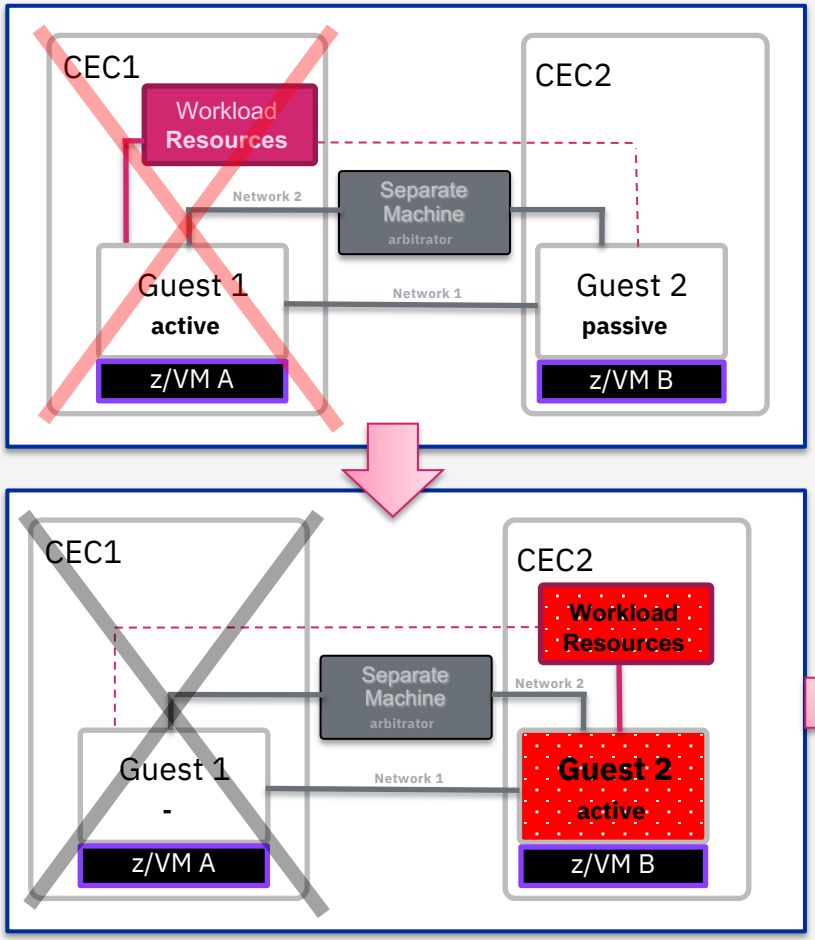
Failover

- The cluster can still withstand if one of these fail: arbitrator, network 2, guest 1, guest 2.

Bringup after Outage

- You have to perform LGR again to get the passive guest back to CEC1

UN-Planned Outage - RHEL HA



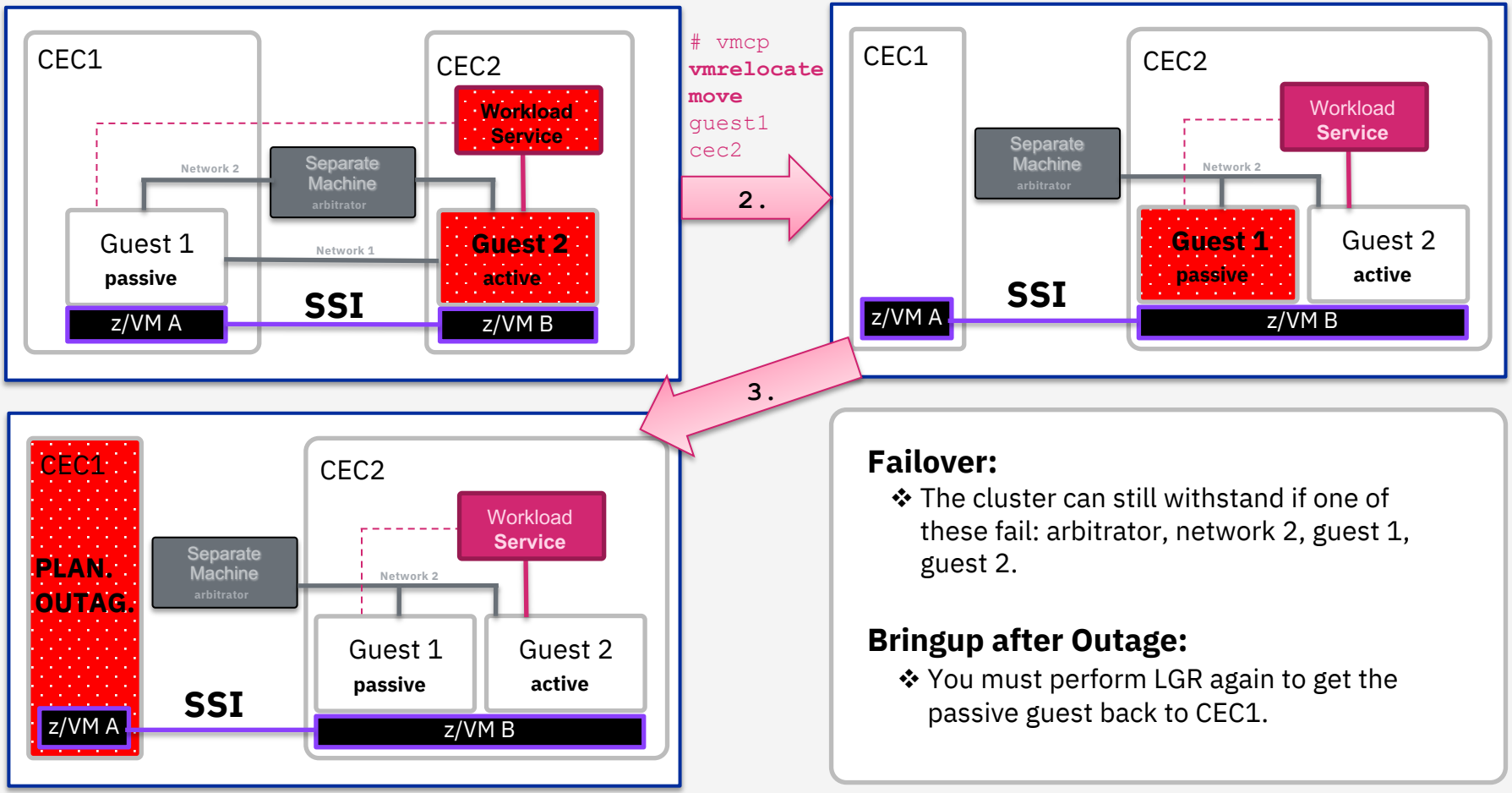
Failover

- Workload is automatically moved to guest 2 on CEC2
- Fencing of guest 1 fail
- **No big differences to non-SSI Cluster**

Bringup after Outage:

- Guest 1 automatically joins back

UN-Planned Outage - RHEL HA + SSI



Failover:

- The cluster can still withstand if one of these fail: arbitrator, network 2, guest 1, guest 2.

Bringup after Outage:

- You must perform LGR again to get the passive guest back to CEC1.

Resources Concept

(Managed) Resources

A cluster contains one or multiple resources. Each resource has following properties:

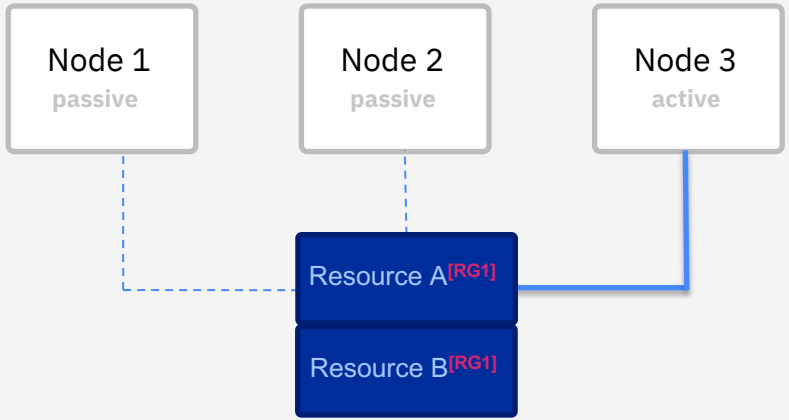
- type (e.g., apache) and resource identifier (e.g., Website)

Resource:

- Implemented as Resource Agent (RA)
- executable/service conforming to a standard (usually ocf **or systemd**)
- handles all **operations: (start, stop, monitor)**
- **attributes** for configuration (e.g., configfile=a.conf)
- **constraints** (**location, order, colocation**)

Resource Groups [RG1]:

- Resources in a resource group **start and stop in order**
- When one of the resources moves in the group, the other resources in that group move with it



Predefined Ressources:

- List all predefined Resources

```
# pcs resource list
```

- Look into the Resource docu

```
# pcs resource describe x
```

- Add Resources to cluster

```
# pcs resource create ...
```

Define your own Ressource

- Article from Red Hat ®: LINK
- OCF compliant RA: LINK
  - XML definition file
  - Operations implemented in any programming language
  - Exit codes standardized
- Add to pacemaker search location: `/usr/lib/ocf`

First Steps – Cluster Setup

Qnetd Server and Network Setup

Separate Machine Informations:

- Use a guest which is running on a **third side**
  - **Avoid a single point of failure** by having a **separate physical network** connecting both guests with the **third side** Guest Q

Separate Network Setup

- Example commands to create a second/new network interface (if-2)

Guest 1
Guest 2
qnetd

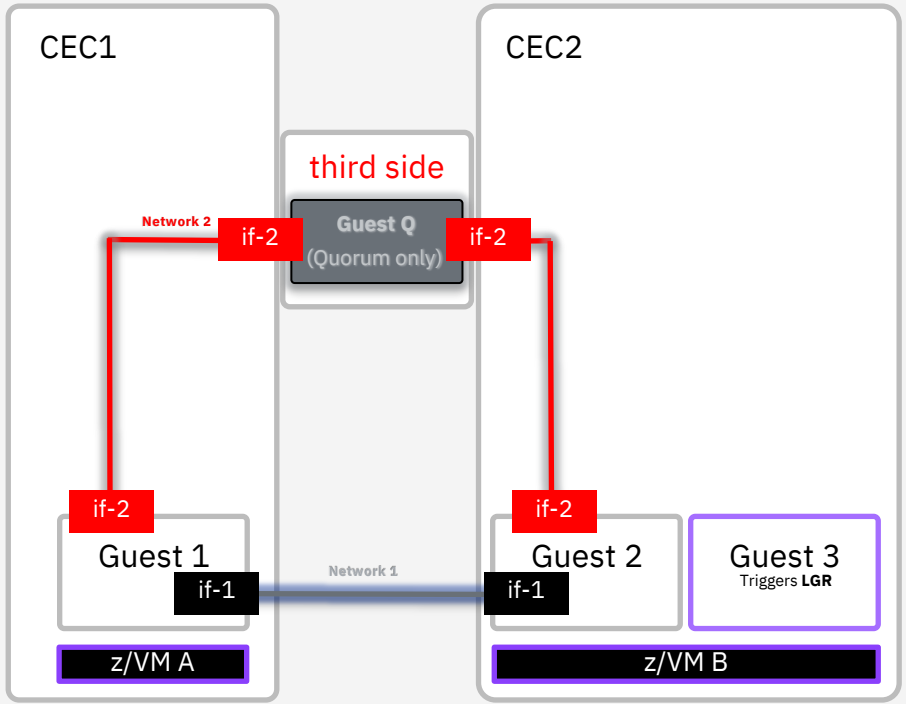
```
rhel7/8# cio_ignore -r 0.0.b100-0.0.b102
rhel7  # vim /etc/zipl.conf
rhel8  # vim /boot/loader/entries/*.conf
```

add to parmline:

```
rd.znet=qeth,0.0.b100,0.0.b101,0.0.b102
rhel7/8# zipl -V
rhel7/8# reboot
rhel7/8# cd /etc/sysconfig/network-scripts
rhel7/8# cp ifcfg-encbdf0 ifcfg-enccw0.0.b100
rhel7/8# vim ifcfg-enccw0.0.b100
```

do setup for second network interface

```
rhel7/8# reboot
```



RHEL HA Installation and Firewall Configuration

Step 1.0 – RHEL HA Installation

Run on: Guest 1, Guest 2, qnetd

```
rhel7/8# subscription-manager register --auto-attach

rhel8  # dnf config-manager --set-enabled \
           rhel-8-for-s390x-highavailability-rpms
rhel7  # yum install -y yum-utils
rhel7  # yum-config-manager --enable \
           rhel-ha-for-rhel-7-for-system-z-rpms

rhel7/8# yum update -y
rhel7/8# yum install -y pcs
```

Run on: Guest 1, Guest 2

```
rhel7/8# yum install -y pacemaker \
                        fence-agents-all \
                        corosync-qdevice
```

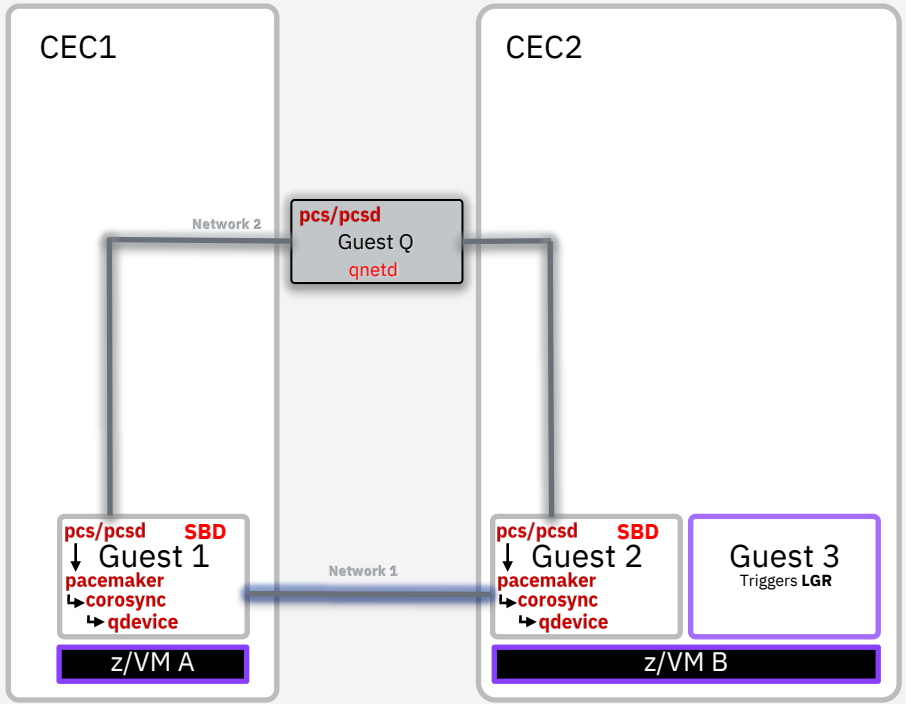
Run on: qnetd

```
rhel7/8# yum install -y corosync-qnetd
```

Step 1.1 – Firewall Configuration

Run on: Guest 1, Guest 2, qnetd

```
rhel7/8# firewall-cmd --permanent \
           --add-service=high-availability
rhel7/8# firewall-cmd --reload
```



RHEL HA Cluster Setup

Step 1.2 – Prepare Cluster

Run on: Guest 1, Guest 2, qnetd

❖ Create a linux® user used by the cluster

```
rhel7/8# passwd hacluster
```

Note:
- Same password for each node recommended.

❖ Enable the cluster controlling and configuration daemon

```
rhel7/8# systemctl enable pcsd.service --now
```

Step 1.3 – Auth Nodes

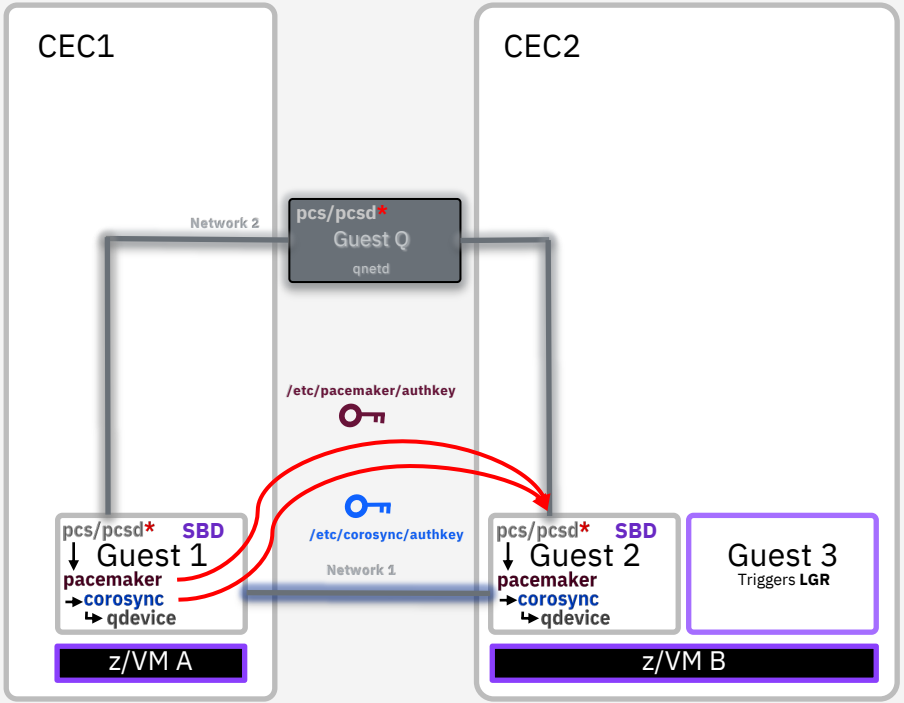
Run on: Guest 1

```
rhel7# pcs cluster auth guest1 guest2 qnetd
rhel8# pcs host auth guest1 guest2 qnetd
Username: hacluster
Password: …
```

Step 1.4 – Setup Cluster

Run on: Guest 1

```
rhel7# pcs cluster setup --name \
  my_cluster guest1 guest2
rhel8# pcs cluster setup \
  my_cluster guest1 guest2
```



Startup of the Cluster and Status

Step 1.5 – Start and Enable Services

Run on: Guest 1

```
rhel7/8# pcs cluster start --all
rhel7/8# pcs cluster enable --all
```

Step 1.6 – Status and CLI Tools

Run on: Guest 1

- The pcs CLI tool allows you to configure the cluster (pacemaker + corosync) and view the status
  - Full cluster status:

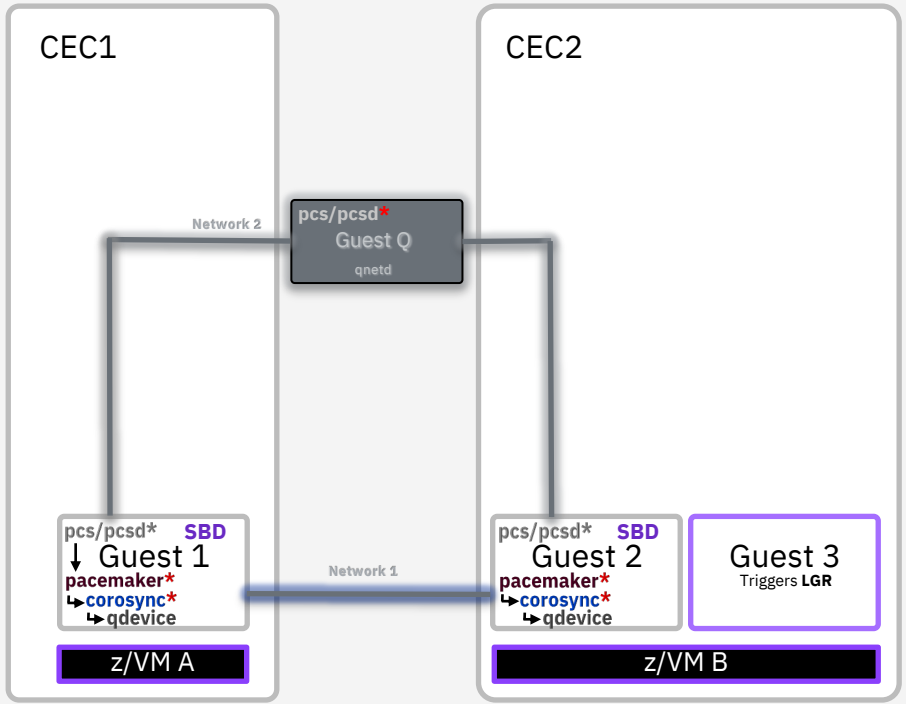
    ```
    rhel7/8# pcs status --full
    ```
  - Pacemaker configuration

    ```
    rhel7/8# pcs cluster cib
    ```
- Pacemaker and corosync have their own cli tools:
  - Pacemaker configuration

    ```
    rhel7/8# cibadmin -Q
    ```
  - Show corosync object database

    ```
    rhel7/8# corosync-cmapctl
    ```
  - Dump live corosync flight data

    ```
    rhel7/8# corosync-blackbox
    ```



Start Qnetd Service and Qdevice Daemon

Step 1.7 – Start Qnetd Service

Run on: qnetd

```
rhel7/8# pcs qdevice setup model net --enable –start
rhel7/8# systemctl status corosync-qnetd
```

Step 1.8 – Setup Qdevice Daemon

Run on: Guest 1

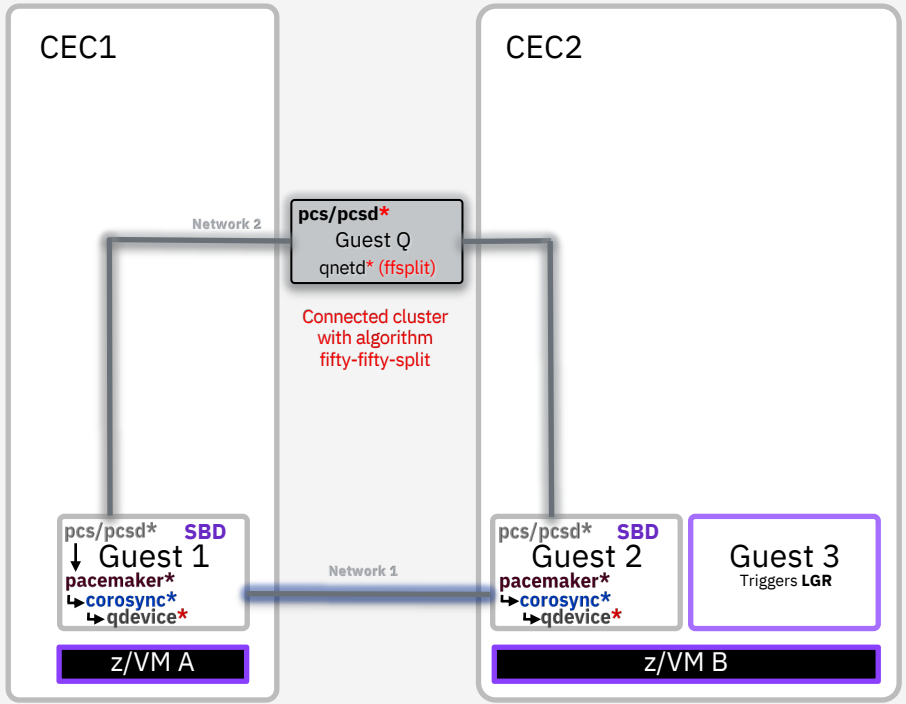
- Add qdevice daemon to cluster (connected to qnetd)

```
rhel7/8# pcs quorum device add model net \
          host=xxx.xxx.xxx.xxx algorithm=ffsplit
```

- Check status of qdevice daemon

```
rhel7/8# /usr/sbin/corosync-qdevice-tool -s -v
```

Note:
- You can connect multiple clusters to Guest Q.



Live Guest Relocation (SSI)

Live Guest Relocation

Step 2.0 – Live Guest Relocation

Run on: Guest 3

- Check on which side a guest is running

```
# vmcp q guestX extend at all | cut -d" " -f1
```

- Test Live Guest Relocation (**from same side**)

```
# vmcp vmrelocate test guest2 ZVM_A
```

- Test Live Guest Relocation (**from other side**)

```
# vmcp at ZVM_A cmd vmrelocate test guest1 ZVM_B
```

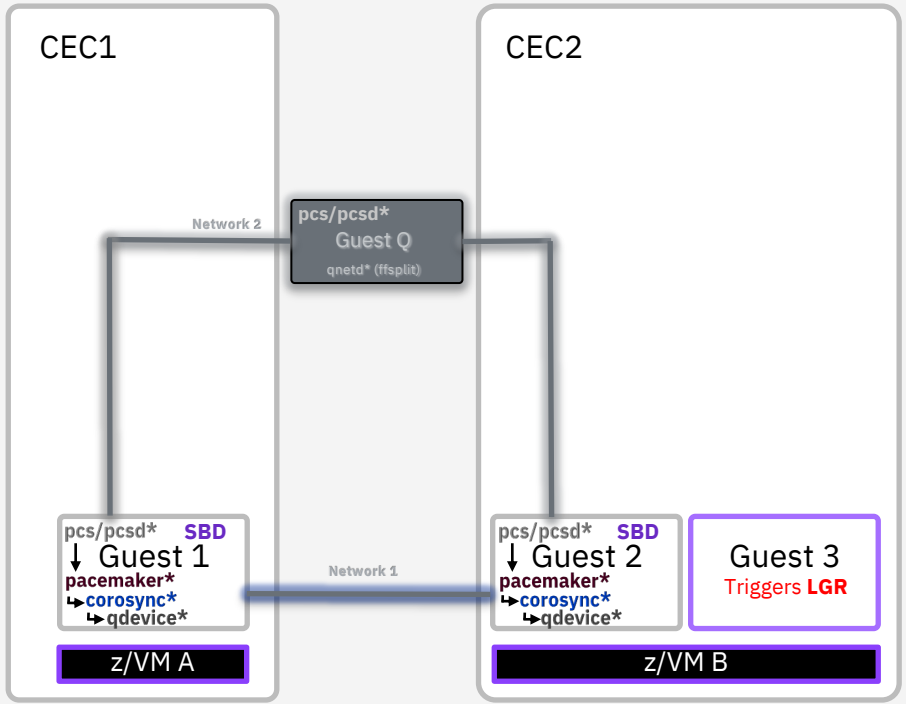
Note: You might have to detach certain z/VM disks for live guest relocation to work e.g.:

```
# vmcp 'DET 0190'
# vmcp 'DET 019D'
# vmcp 'DET 019E'
# vmcp 'DET 0592'
```

- Perform Live Guest Relocation (from same side)

```
# vmcp vmrelocate move guest2 ZVM_A
```

Note:
- Make sure the z/VM userid for guest3 has enough permissions to trigger LGR.



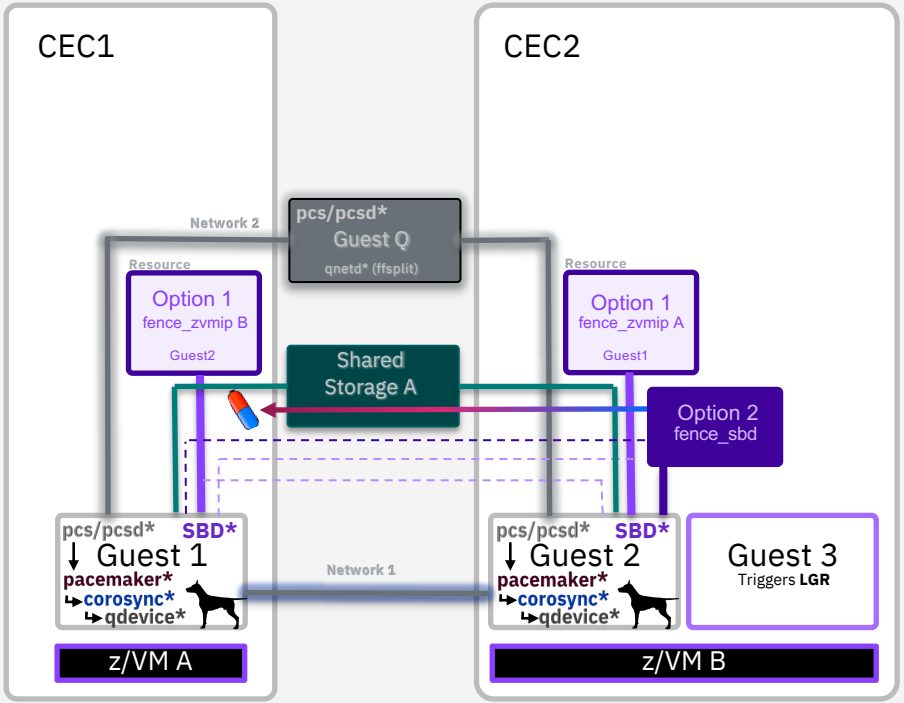
Fencing / STONITH (SBD)

Fencing / STONITH concept

Concept of Fencing/STONITH

- Ensures that it is not possible for a guest to run resources if the guest is not intended to do so
- Different fencing methods are available
  - **via z/VM SMAPI**: (option 1) In a 2 CEC setup you have to use 2 fence-agents specifying the other side. This fence agent is not SSI aware which means you would have to change both fence-agents every time you do LGR. (Instructions)
  - **via SBD**: (option 2) SBD watches the cluster health locally and triggers self fencing if needed. Additionally, SBD watches a shared disk where the fence-agent can write a poison pill to which also triggers fencing.

➢ SBD is set up in the following slides as this method works with 2 CECs and SSI



self-fencing / watchdog-timeout fencing

Watchdogs must be fed otherwise they kill the guest.

AND

poison pill fencing

Watchdogs fed with a poison pill kills the guest!

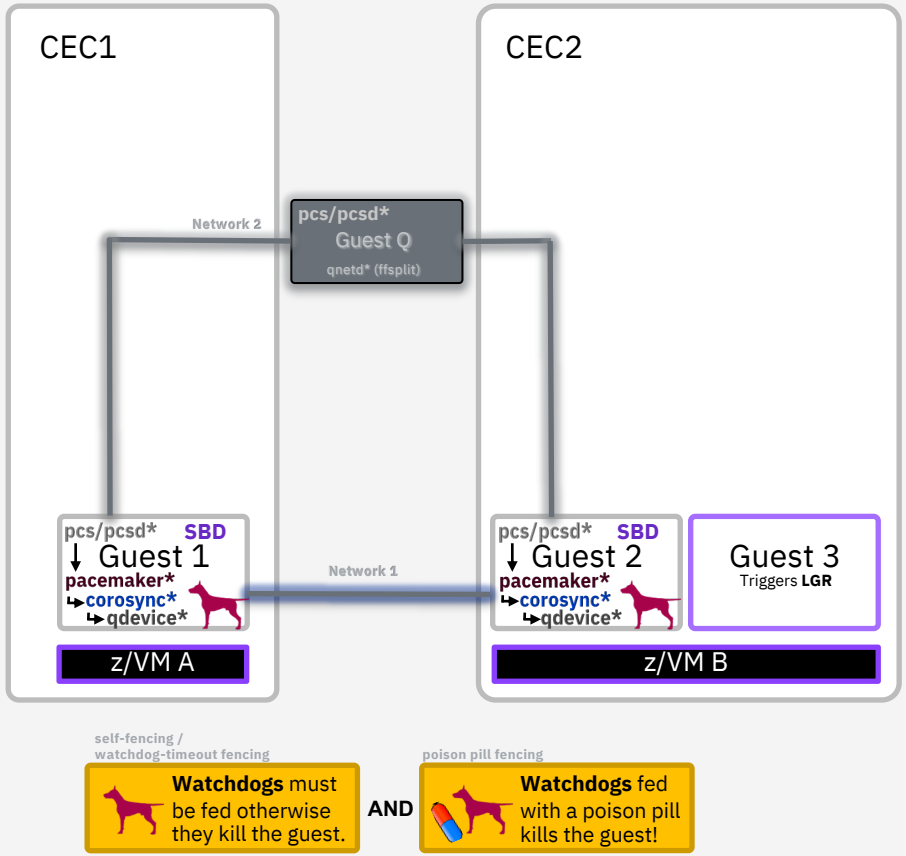
Setup SBD Fencing - Watchdog

Step 3.0 – Setup Watchdog

Run on:
- Guest 1
- Guest 2

- Enable watchdog kernel module
```
# modprobe diag288_wdt
```
- Show watchdog
```
# wdctl
```
- Test if watchdog works (should halt after 30s)
```
# timeout=30; echo; echo; echo "Opening watchdog device to start countdown from $timeout"; echo start > /dev/watchdog; echo "Counting down. The system should halt near 0 if the watchdog is functional."; while true; do if [ $timeout -le 0 ]; then echo "Timeout expired.  System should be halting."; else echo "$timeout..."; fi; timeout=$((timeout-1)); sleep 1; done;
```
- Check z/VM command executed on timeout
```
# cat /sys/module/diag288_wdt/parameters/cmd
```
- Make watchdog loading persistent
```
# echo "diag288_wdt" > /etc/modules-load.d/watchdog.conf
```

Note:
- Watchdog timeout cannot be lower than 15s! (link)



Setup SBD Fencing - Shared Storage

Step 3.1 – Setup SBD Shared Storage

- Shared Storage is already assumed to be setup. **(see appendix A for a cheat sheet)**

Run on: Guest 1

- Create SBD header on disk partition

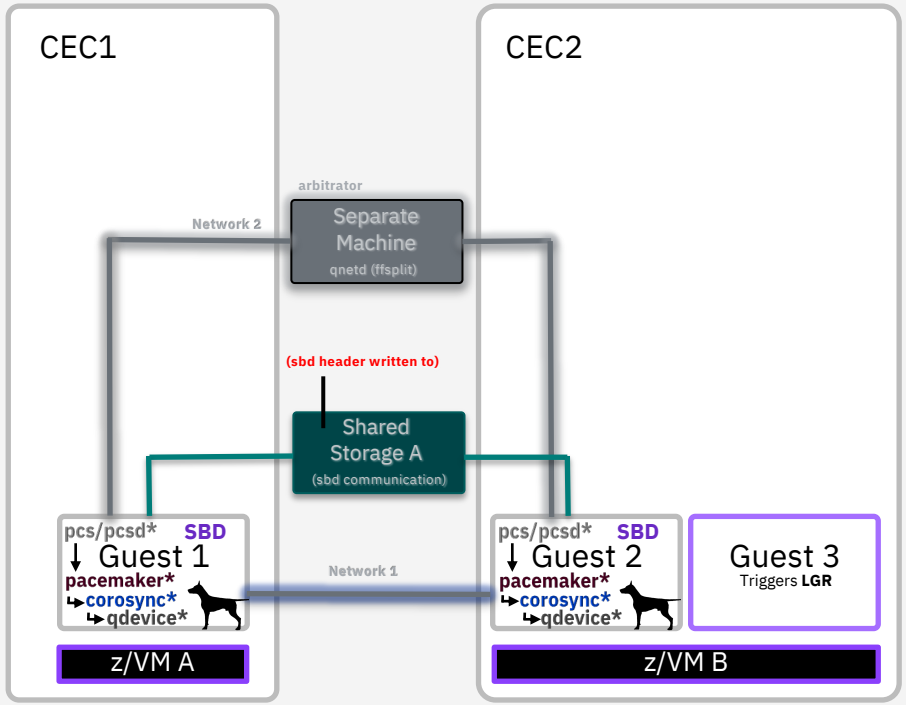
```
rhel7/8# pcs stonith sbd device setup \
    --device=/dev/disk/by-path/ccw-0.0.0200-part1 \
    watchdog-timeout=15 \
    msgwait-timeout=30
```

- Alternative command to create SBD header

```
# sbd -v \
      -d /dev/disk/by-path/ccw-0.0.0200-part1 \
      create
```

- Show SBD header

```
rhel7/8# pcs stonith sbd status --full
```



self-fencing / watchdog-timeout fencing

Watchdogs must be fed otherwise they kill the guest.

AND

poison pill fencing

Watchdogs fed with a poison pill kills the guest!

Setup SBD Fencing - Daemon

Step 3.2 – Setup SBD

Run on: Guest 1

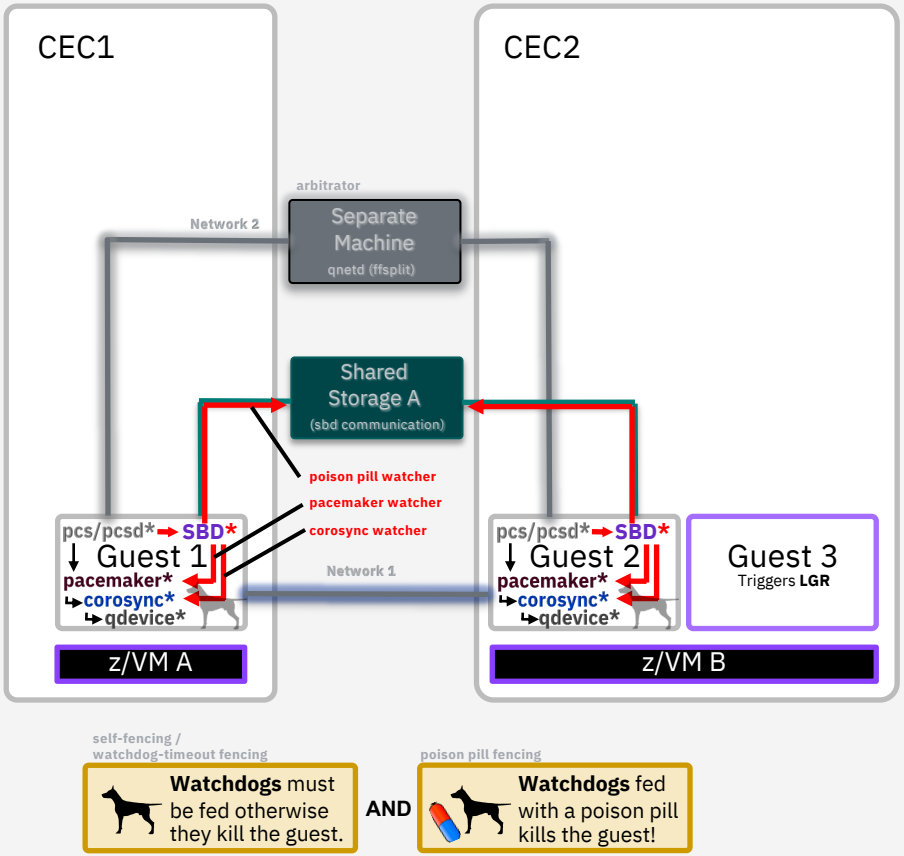
❖ Enable SBD systemd daemon in cluster

```
rhel7# pcs stonith sbd enable \
       --watchdog=/dev/watchdog \
       --device=/dev/disk/by-path/ccw-0.0.0200-part1 \
       SBD_DELAY_START=yes SBD_WATCHDOG_TIMEOUT=15
rhel8# pcs stonith sbd enable \
       watchdog=/dev/watchdog \
       device=/dev/disk/by-path/ccw-0.0.0200-part1 \
       SBD_DELAY_START=60 SBD_WATCHDOG_TIMEOUT=15
```

Note:
- SBD_* are environment variables for the SBD systemd service.
- SBD_WATCHDOG_TIMEOUT **only applies** when SBD runs in diskless mode.
-> when disks are defined the watchdog timer written to the disk header is used.
- **The diag288 watchdog minimum timeout is 15 seconds. (LINK)**
- SBD_DELAY_START postpones the start of the pacemaker systemd daemon
- SBD_DELAY_START should be longer then: corosync token timeout (5) + consensus timeout (6) + pcmk_delay_max (0) + msgwait (30) = 41 seconds. Otherwise, you might run into the issue that pacemaker starts with exit code 100.

❖ Restart cluster

```
rhel7/8# pcs cluster stop --all
rhel7/8# pcs cluster start --all
```



Setup SBD Fencing - Fence Agent

Step 3.4 – Setup SBD Fence Agent

Run on: Guest 1

❖ Show default power_timeout which indicates how long the fencing process waits before pacemaker must be up again after fencing

```
rhel7/8# fence_sbd -o metadata|grep -A 2 power_timeout
```

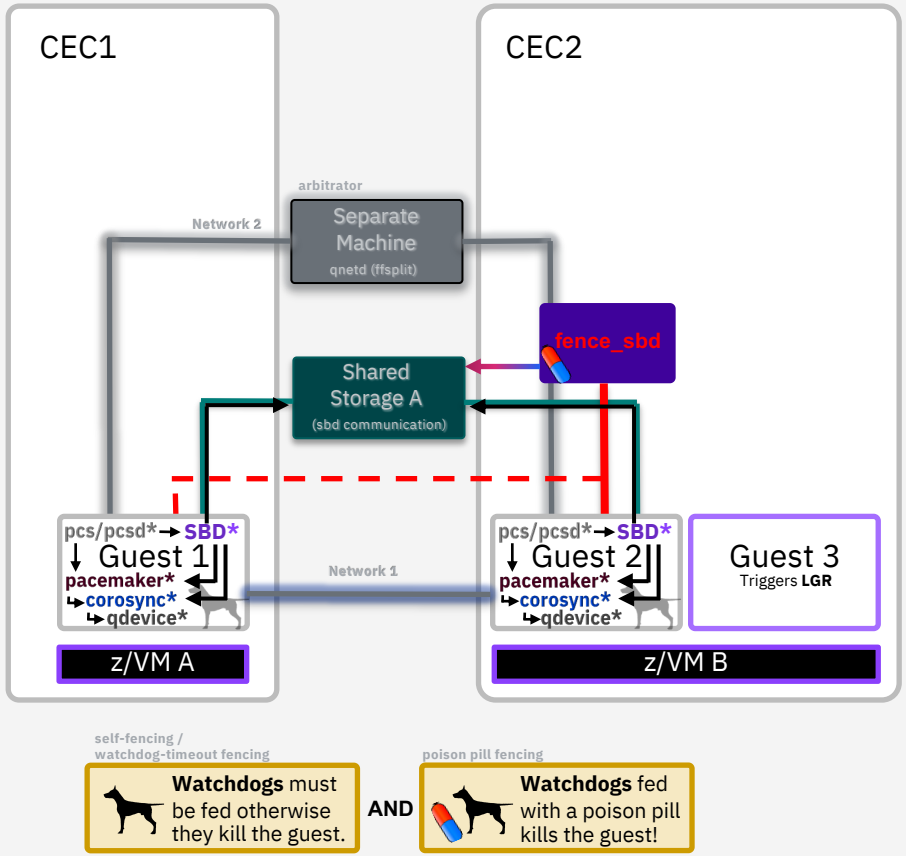
❖ Create SBD fence agent and set power_timeout

```
rhel7/8# pcs stonith create sbd fence_sbd \
     devices="/dev/disk/by-path/ccw-0.0.0200-part1" \
     power_timeout=45
```

Note:
- power_timeout should be bigger then msgwait timeout

❖ Show settings of SBD fence agent

```
rhel7  # pcs stonith show sbd
rhel8  # pcs stonith config
```



Setup SBD Fencing - Testing

Step 3.5 – Test SBD fencing

Run on: Guest 2

❖ Test sending of messages through A

```
rhel7/8# sbd -d /dev/disk/by-path/ccw-0.0.0200-part1 \
      message guest1 test
```

Run on: Guest 1

❖ Look at the Log of the SBD systemd service

```
rhel7/8# journalctl -u sbd -f
```

Run on: Guest 2

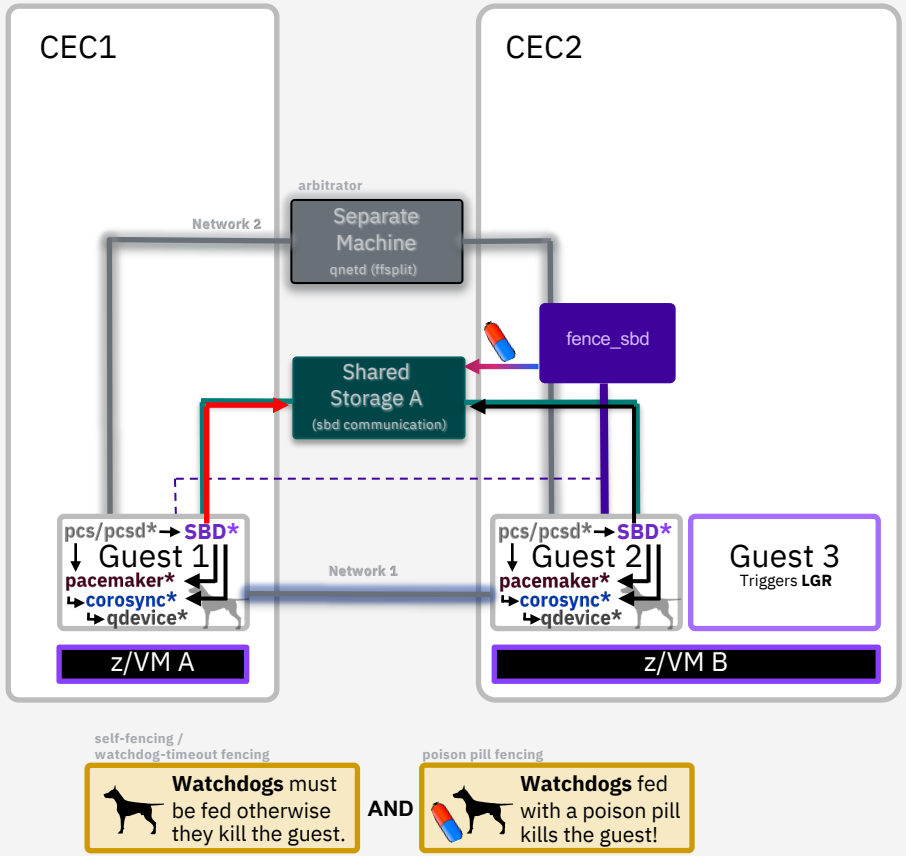
❖ Send poison pill from guest2 to guest1

```
rhel7/8# time pcs stonith fence guest1
```

Note:
- other system should reboot and the pacemaker systemd service should be delayed by the SBD systemd service by msgwait-timeout seconds.

❖ Helpful debugging options
- ❖ Increase SBD verbosity: add "-v" to SBD_OPTS in /etc/sysconfig/sbd
- ❖ Look at systemd startup

```
rhel7/8# systemd-analyze critical-chain
```



Cluster Timeouts

Setup Timeouts - Totem

Step 4.0 – Setup Totem Timeout

Run on: Guest 1

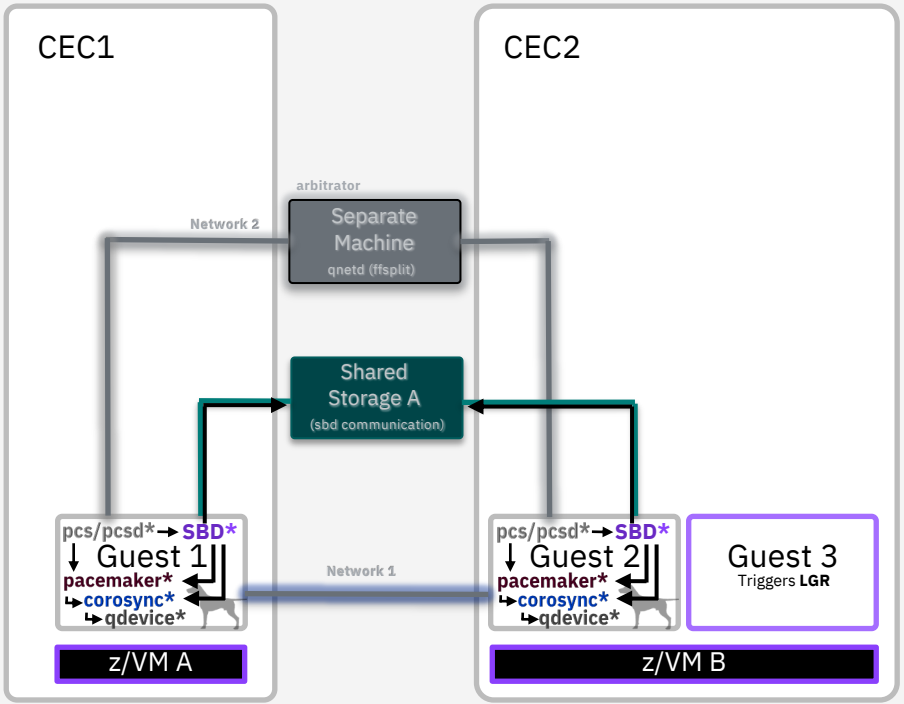
- "totem token timeout" specifies in milliseconds until a token loss is declared

```
rhel7# vim /etc/corosync/corosync.conf
-> add `token: 5000` in totem section
rhel7# pcs cluster sync
rhel7# pcs cluster reload corosync
rhel7/8# pcs cluster config update \
            totem token=5000
```

Note:
- For totem token limits check out the corosync support policies

- Check totem token timeout

```
rhel7/8# corosync-cmapctl | \
         grep "runtime.*totem.token "
```



Shared Storage

Shared Storage – Create Resources

Step 5.1 – Add LVM Resource to Cluster

Run on: Guest 1

- Shared Storage is already assumed to be setup **(see appendix A for a cheat sheet)**

- Change LVM option in /etc/lvm/lvm.conf to

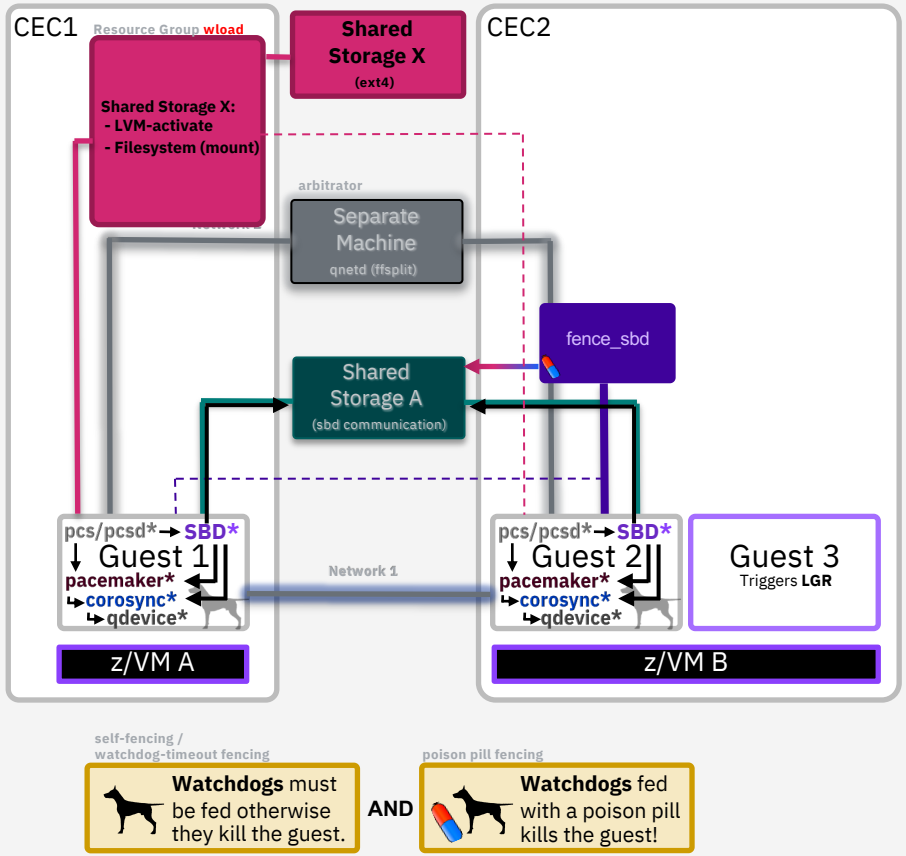
```
system_id_source = "uname"
```

- Create logical volume

```
rhel7/8# pvcreate \
           /dev/disk/by-path/ccw-0.0.0200-part1
rhel7/8# vgcreate my_vg \
           /dev/disk/by-path/ccw-0.0.0200-part1
rhel7/8# lvcreate -n my_lv -l 100%FREE my_vg
rhel7/8# mkfs.ext4 /dev/my_vg/my_lv
```

- Add required Resources to cluster

```
rhel7/8# pcs resource create my_lvm LVM-activate \
           vgname=my_vg \
           vg_access_mode=system_id \
           --group wload
rhel7/8# pcs resource create my_fs Filesystem \
           device="/dev/my_vg/my_lv" \
           directory="/var/www" fstype="ext4" \
           --group wload --after my_lvm
```



Floating IP Address

Floating IP Address – Create Resource

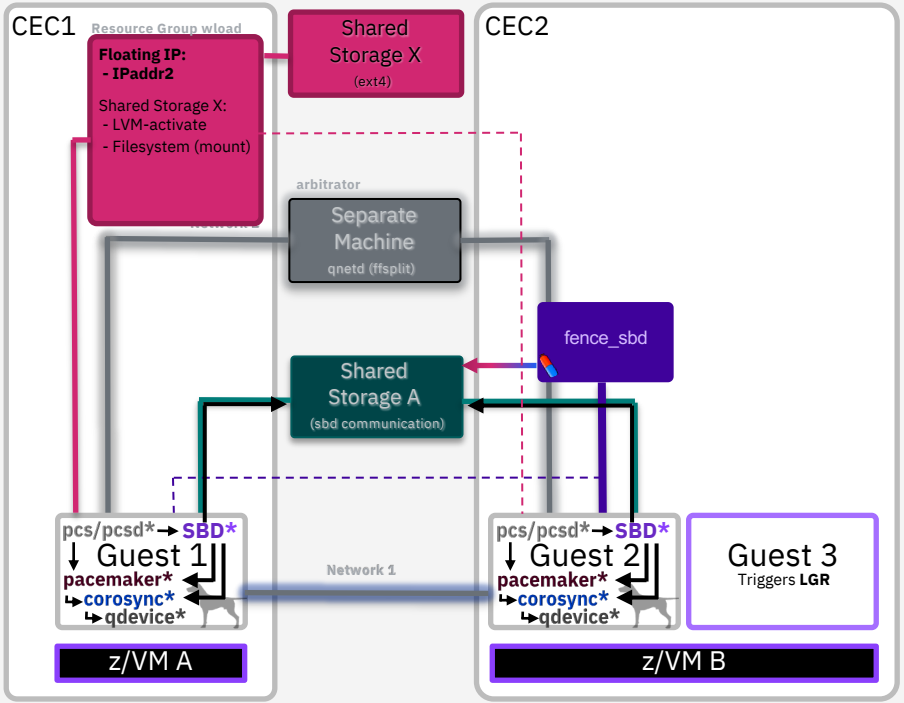
Step 5.2 – Setup Floating IP Address

Run on: Guest 1

❖ Add floating IP resource to cluster

```
rhel7/8# pcs resource create ClusterIP \
         ocf:heartbeat:IPaddr2 \
         ip="${FLOATING_IP_ADDRESS}" \
         --group wload \
         --before my_lvm
```

Note:
- Floating IP addresses is like a static IP address in the network.
- `${FLOATING_IP_ADDRESS}` is a placeholder.



self-fencing / watchdog-timeout fencing

Watchdogs must be fed otherwise they kill the guest.

AND

poison pill fencing

Watchdogs fed with a poison pill kills the guest!

Your Workload

Add your Cluster Workload

Step 5.3 – Add Workload to Cluster

Run on: Guest 1

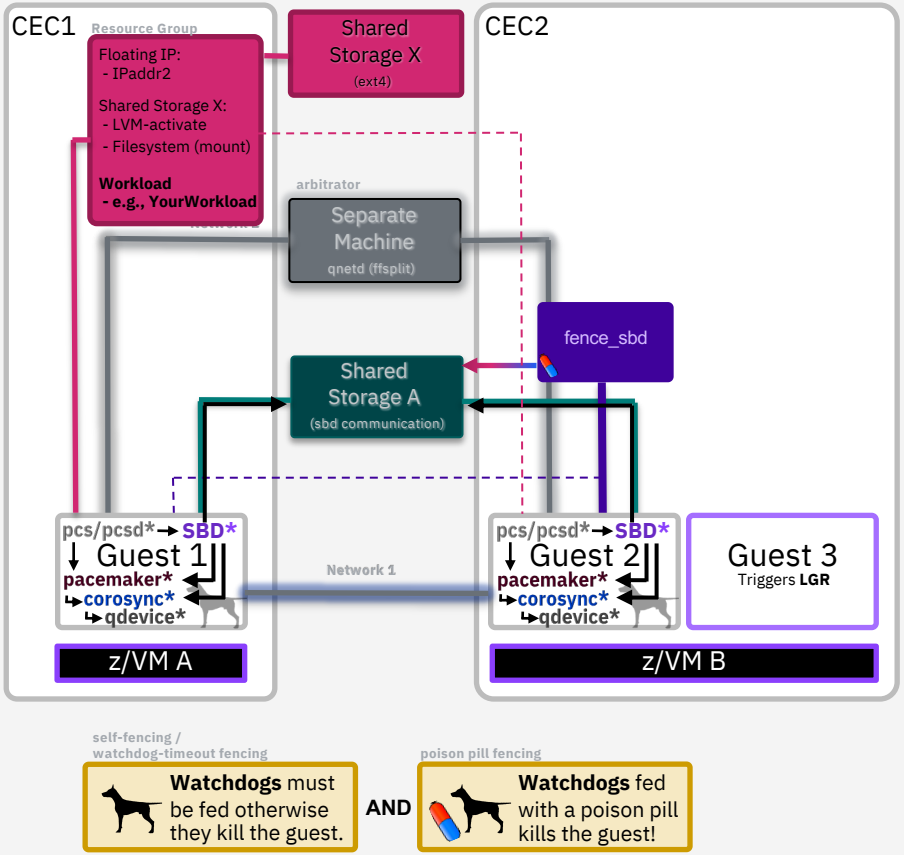
- Check if a Resource Agent (RA) exist for your workload. E.g. For the apache webserver a RA exists

```
rhel7/8# pcs resource list
```

Note:
- If no RA exists for your workload you might have to create a RA yourself. Checkout the previous slide about resources and Resource Agents.

- Add workload resource after filesystem mount

```
rhel7/8# pcs resource create YourWorkload \
            your-workload-ra \
            --group wload \
            --after my_fs
```



Cluster Testing

Cluster Testing

Step 6.0 – Test Workload Failover

❖ Watch the cluster status (live)

```
# watch -n1 pcs cluster status
```

Run on: Guest 2

❖ Trigger a kernel panic

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

Run on: Guest 1

❖ Or trigger a logoff via the z/VM hypervisor

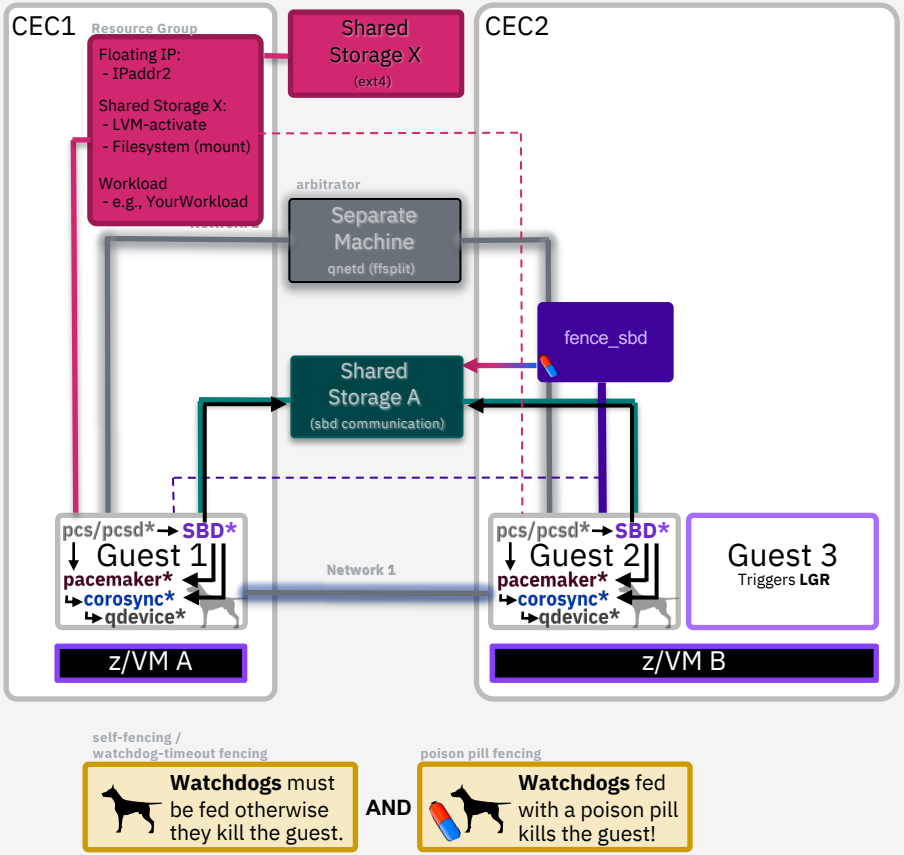
- ❖ Log into the z/VM guest user id and type

```
# cp logoff
```

Run on: z/VM A

❖ Check systemd logs (errors, warnings...)

```
# journalctl -u corosync
# journalctl -u pacemaker
# journalctl -u sbd
```



Appendix

Appendix A - Shared Storage – z/VM Shared Storage

Create Fullpack Minidisk in z/VM

This might be required to be executed multiple times when setting up shared storage in z/VM.

Run on: z/VM

❖ Create new user LINSHARE

```
USER LINSHARE NOLOG
MDISK 0200 3390 DEVNO 1111 MWV
```

❖ Link Minidisks

```
# vmcp 'link * 0200 0200 rw'
```

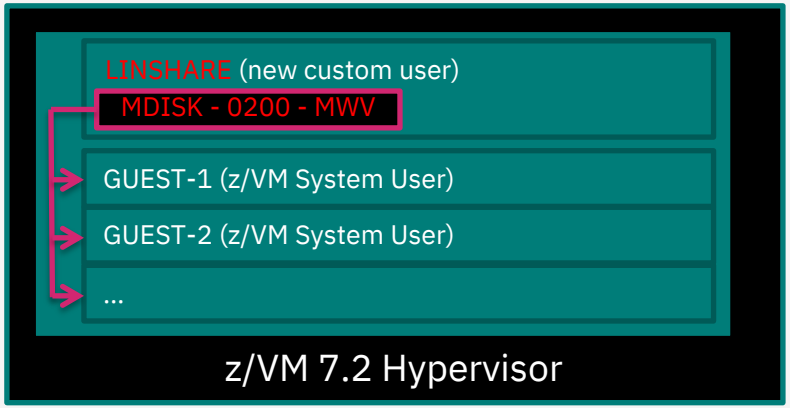
Run on: every guest in cluster

❖ De-ignore, enable and make DASD persistent:

```
# chzdev -e dasd 0.0.0200
# echo 0.0.0200 >> /etc/dasd.conf
```

❖ Format dasd and create partition over whole dasd

```
# dasdfmt -b 4096 -d cdl \
          -p /dev/disk/by-path/ccw-0.0.0200
# fdasd -a /dev/disk/by-path/ccw-0.0.0200
```



Appendix B – Detailed Architecture

Cluster Resources

(can be grouped, ordered, ..)

Cluster operations:
start, stop, monitor

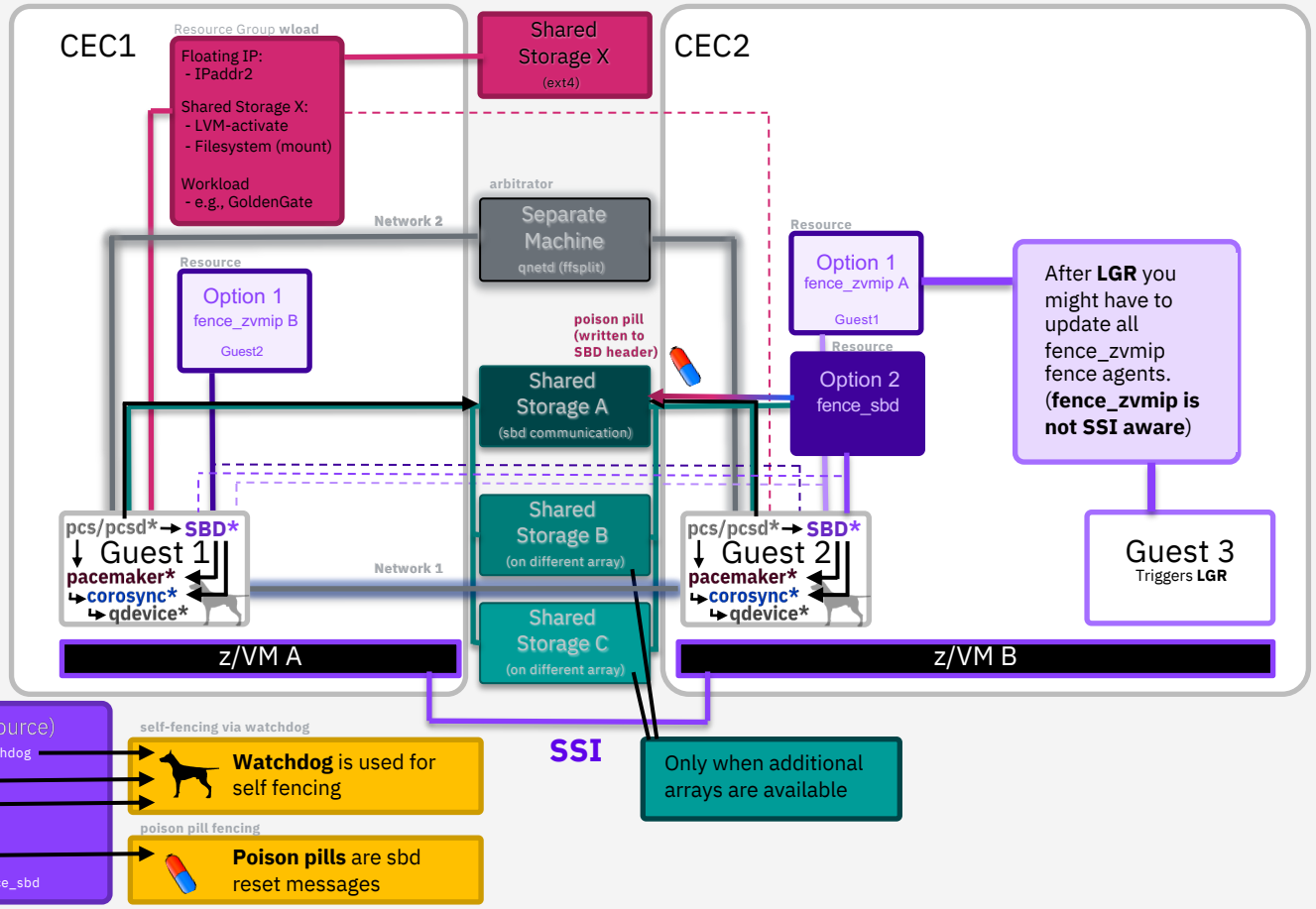
Cluster Quorum

Cluster operations:
start, stop, monitor
↳ needs quorum

avoids split-brain

Daemon

abbreviated with * in this graphic



sustain more node failures then standard quorum rules allow

qdevice* = systemd:qdevice

model: net — arbitrator only option. qdisk in future?

algorithm: fifty-fifty-split — ? decides One vote. Score decides.

Heuristics (optional) scripts (pings etc.) which all must pass; result send to qnetd (before Tiebreaker)

Tiebreaker in case all values are the same

sbd daemon (watch mode)

SBD* = systemd:sbd (Resource)
- inquisitor — inits /dev/watchdog
- corosync watcher
- pacemaker watcher
- disk watcher

Creates or uses sbd slot on /dev/by-path/ccw-0.0.0200-part1 and waits for instructions from fence_sbd

self-fencing via watchdog

Watchdog is used for self fencing

poison pill fencing

Poison pills are sbd reset messages

