Red Hat Clustering:

Best Practices & Pitfalls

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Red Hat Clustering: Best Practices & Pitfalls

- Why Cluster?
- I/O Fencing and Your Cluster
- 2-Node Clusters and Why they are Special
- Quorum Disks
- Service Structure
- Multipath Considerations in a clustered environment
- GFS2 – Cluster File System

Why Cluster?

- Application/Service Failover
  - Reduce MTTR
  - Meet business needs and SLAs
  - Protect against software and hardware faults
  - Virtual machine management
  - Allow for planned maintenance with minimal downtime
- Load Balancing
  - Scale out workloads
  - Improve application response times

Why *not* Cluster?

- Often requires additional hardware
- Increases total system complexity
  - More possible parts that can fail
    - More failure scenarios to evaluate
  - Harder to configure
  - Harder to debug problems

Component Overview

- corosync – Totem SRP/RRP-based membership, VS messaging, closed process groups
- cman – quorum, voting, quorum disk
- fenced – handles I/O fencing for joined members
  - Fencing agents – carry out fencing operations
- DLM – distributed lock manager (kernel)
- clvmd – cluster logical volume manager
- gfs2 – cluster file system
- rgmanager – cold failover for applications
- Pacemaker (TP) – Next-generation CRM

Failure Recovery Overview

- corosync - Totem token is lost; Totem forms a new ring
- fenced enters recovery state – quorate partition initiates fencing of dead node(s)
- DLM enters recovery state – locks on dead node(s) are dropped
- clvmd, gfs2 enter recovery state – recover / replay journals
- rgmanager initiates cold failover of user applications

I/O Fencing

- An active countermeasure taken by a functioning host to isolate a misbehaving or presumed dead host from shared data
- Most critical part of a cluster utilizing SAN or other shared storage technology
  - Despite this, not everyone uses it
  - How much is your data worth?
- Required by gfs2, clvmd, and cold failover software shipped by Red Hat
- Utilized by RHEV, too – Fencing is *not* a cluster-specific technology

I/O Fencing

- Protects data in the event of planned or unplanned system downtime
  - Kernel panic
  - System freeze
  - Live hang / recovery
- Enables nodes to safely assume control of shared resources when booted in a network partition situation

I/O Fencing

- SAN fabric and SCSI fencing are not *fully recoverable*
  - Node must typically be rebooted manually
  - Enables an autopsy of the node
  - Sometimes does not require additional hardware
- Power fencing is usually *fully recoverable*
  - Your system can reboot and rejoin the cluster - thereby restoring capacity - without administrator intervention
  - This is a reduction in MTTR

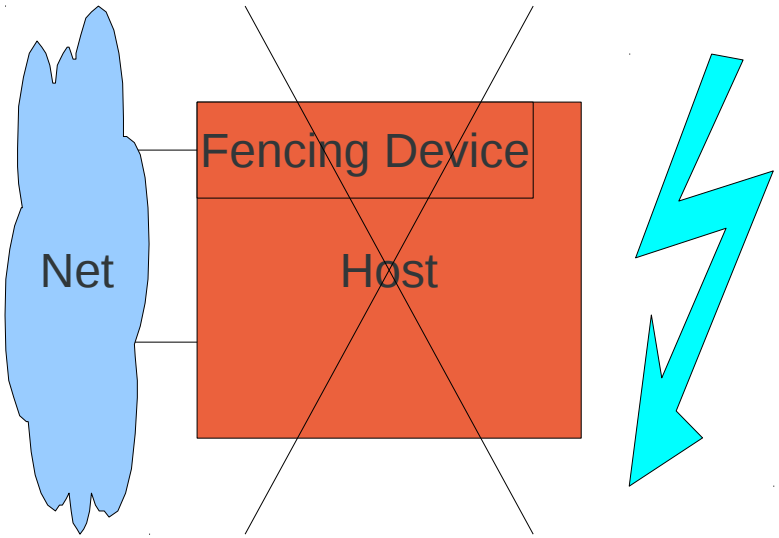
I/O Fencing – Drawbacks

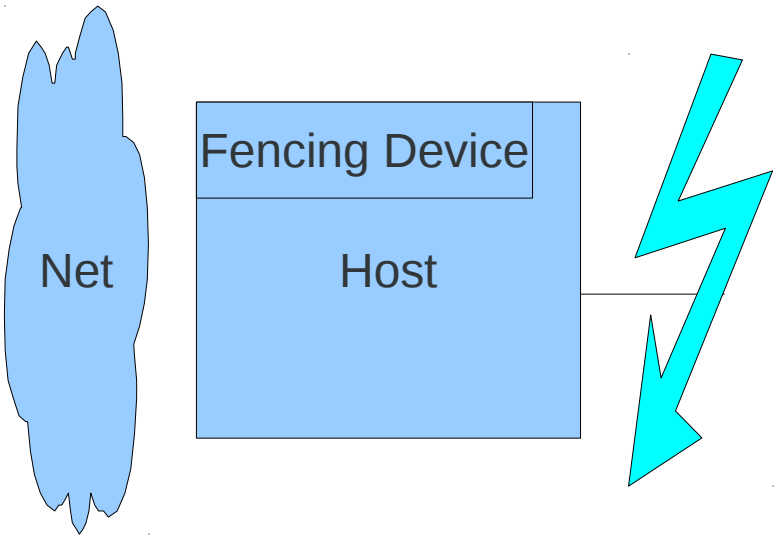
- Difficult to configure
  - No automated way to “discover” fencing devices
  - Fencing devices are all very different and have different permission schemes and requirements
- Typically requires additional hardware
  - Additional cost often not considered when purchasing systems
  - A given “approved” IHV may not sell the hardware you want to use

I/O Fencing – Best Practices

- Integrated power management
  - Use servers with dual power supplies
  - Use a backup fencing device
  - IPMI over LAN fencing usually requires disabling **acpid**
- Single-rail switched PDUs
  - Use 2 switched PDUs
  - Use a PDU with two power rails
  - Use a backup fencing device

Integrated Power Management Pitfall



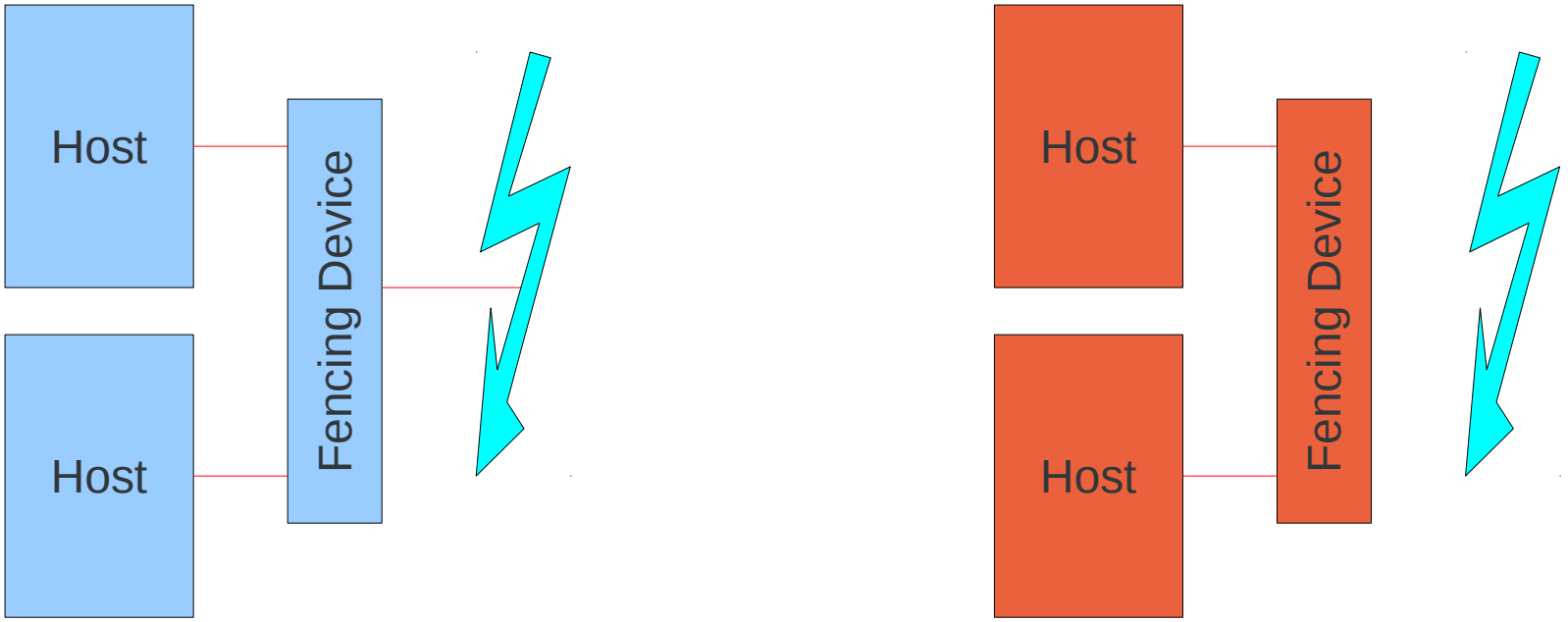


- Host (and fencing device) lose power
- Safe to recover; host is off

- Host and Fencing Device lose network connectivity
- NEVER safe to recover!

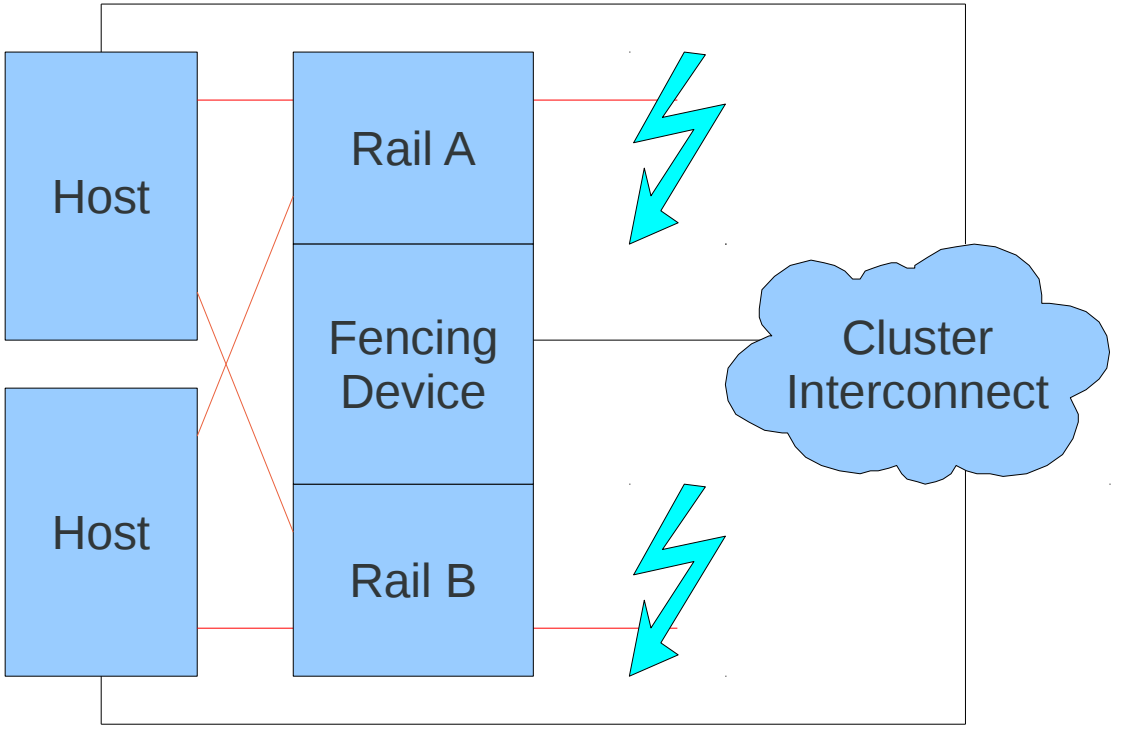
- The two cases are indistinguishable
- A timeout does not ensure data integrity in this case
- Not all integrated power management devices suffer this problem

Single Rail Pitfall



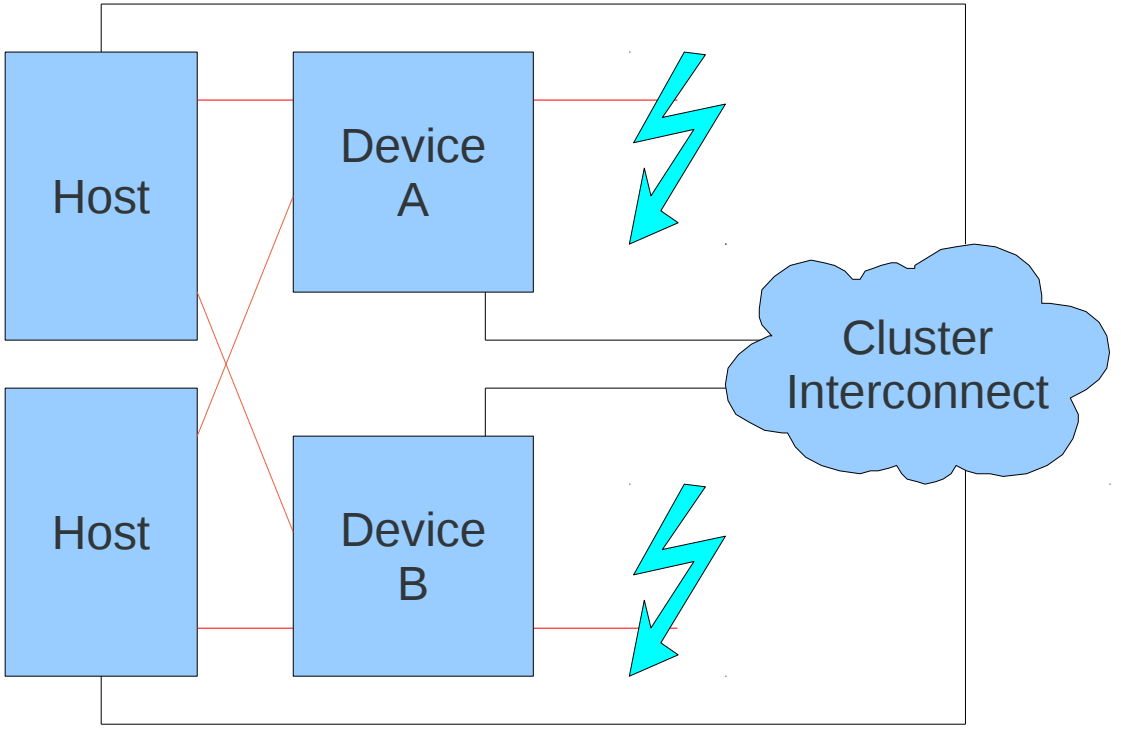
- One power cord = Single Point of Failure

Best Practice: Dual Rail Fencing Device



- Dual power sources, two rails in the fencing device, two power supplies in the cluster nodes
- Fencing device electronics run off of either rail

Best Practice: Dual Single Rail Fencing Devices



- Dual power sources, two fencing devices

I/O Fencing – Pitfalls

- SAN fabric fencing
  - Full recovery typically not automatic
  - Unfencing in RHEL6 allows a host to turn on its ports after reboot
- SCSI-3 PR fencing
  - Not all devices support it
  - Quorum disk may not reside on a LUN managed by SCSI fencing due to quorum “chicken and egg” problem

I/O Fencing - Pitfalls

- SCSI-3 PR Fencing (cont.)
  - *Preempt-and-abort* command is not required by SCSI-3 specification
    - Not all SCSI-3 compliant devices support it
  - LUN detection can be done by querying CLVM, looking for volume groups with the cluster tag set
  - On RHEL6, watchdog script allows reboot after fencing

2-Node Clusters

- Most common use case in high availability / cold failover clusters
- Inexpensive to set up; several can fit in a single rack
- Red Hat has had two node failover clustering since 2002

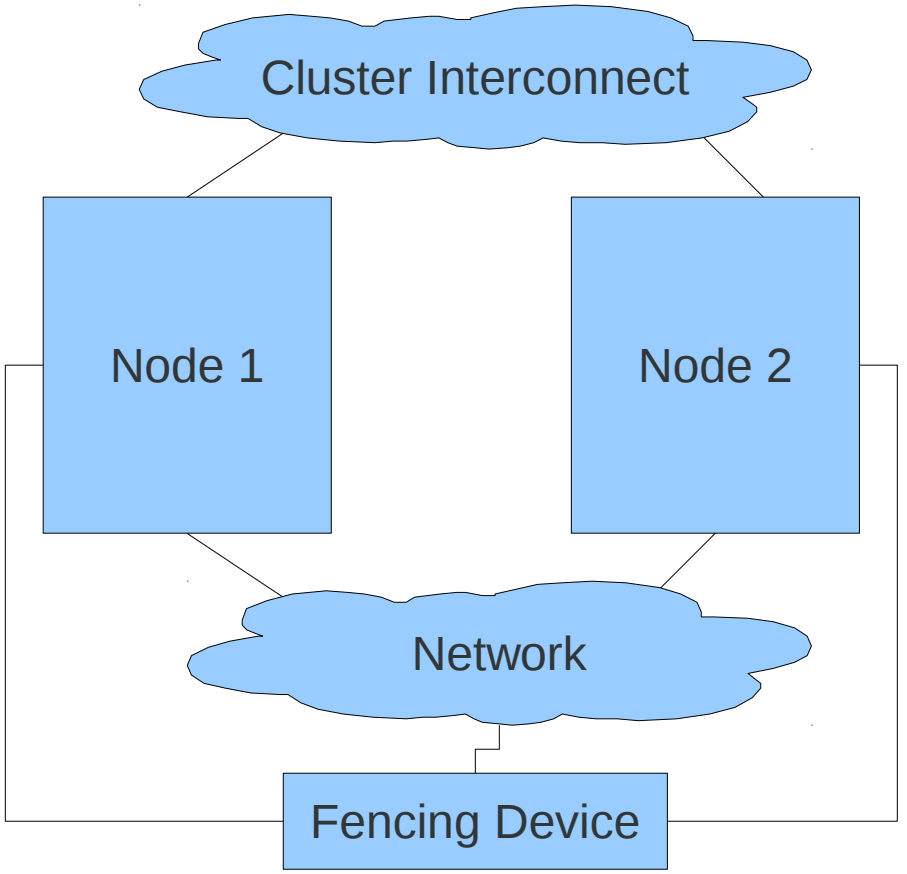
Why 2-Node Clusters are Special

- Cluster operates using a *simple majority* quorum algorithm
  - Best predictability with respect to node failure counts compared to other quorum algorithms (ex: Grid)
- There is never a majority with one node out of two
- Simple Solution: **two_node="1"** mode
  - When a node boots, it assumes quorum
  - Services, gfs2, etc. are prevented from operating until fencing completes

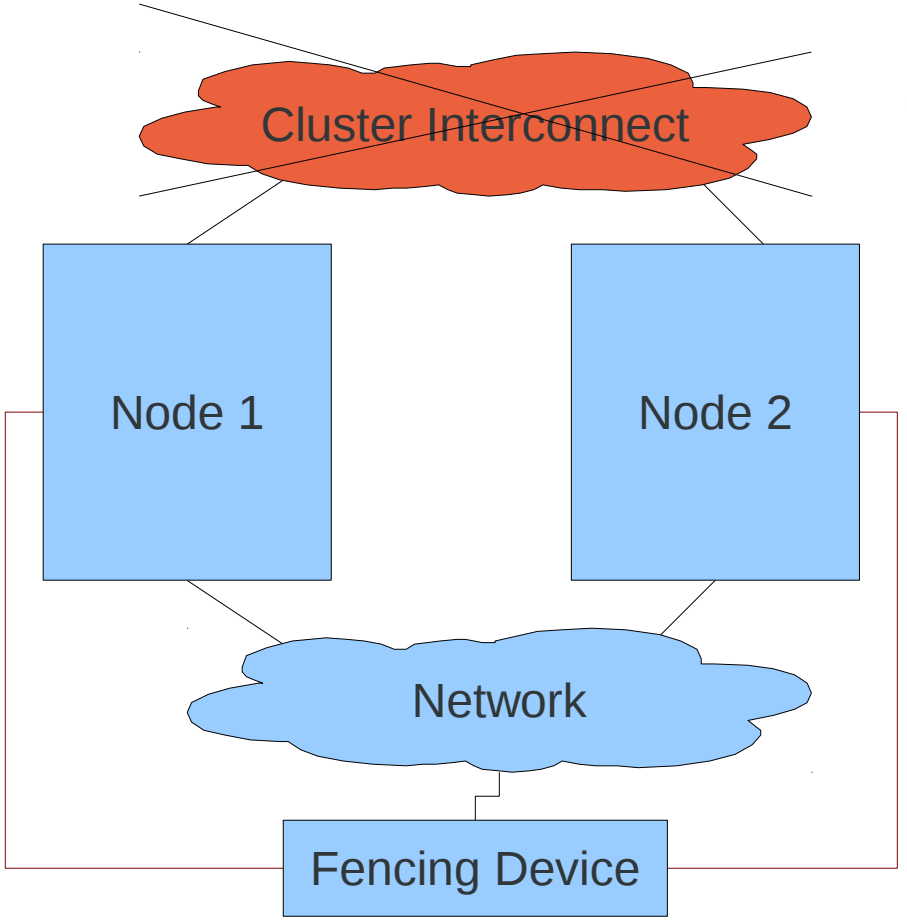
2-Node Pitfalls: Fence Loops

- If two nodes become partitioned, a *fence loop* can occur
- Node A kills node B, who reboots and kills node A... etc.
- Solutions
  - Correct network configuration
    - Fencing devices on same network used for cluster communication
  - Use fencing delays
  - Use a quorum disk

Fence Loop

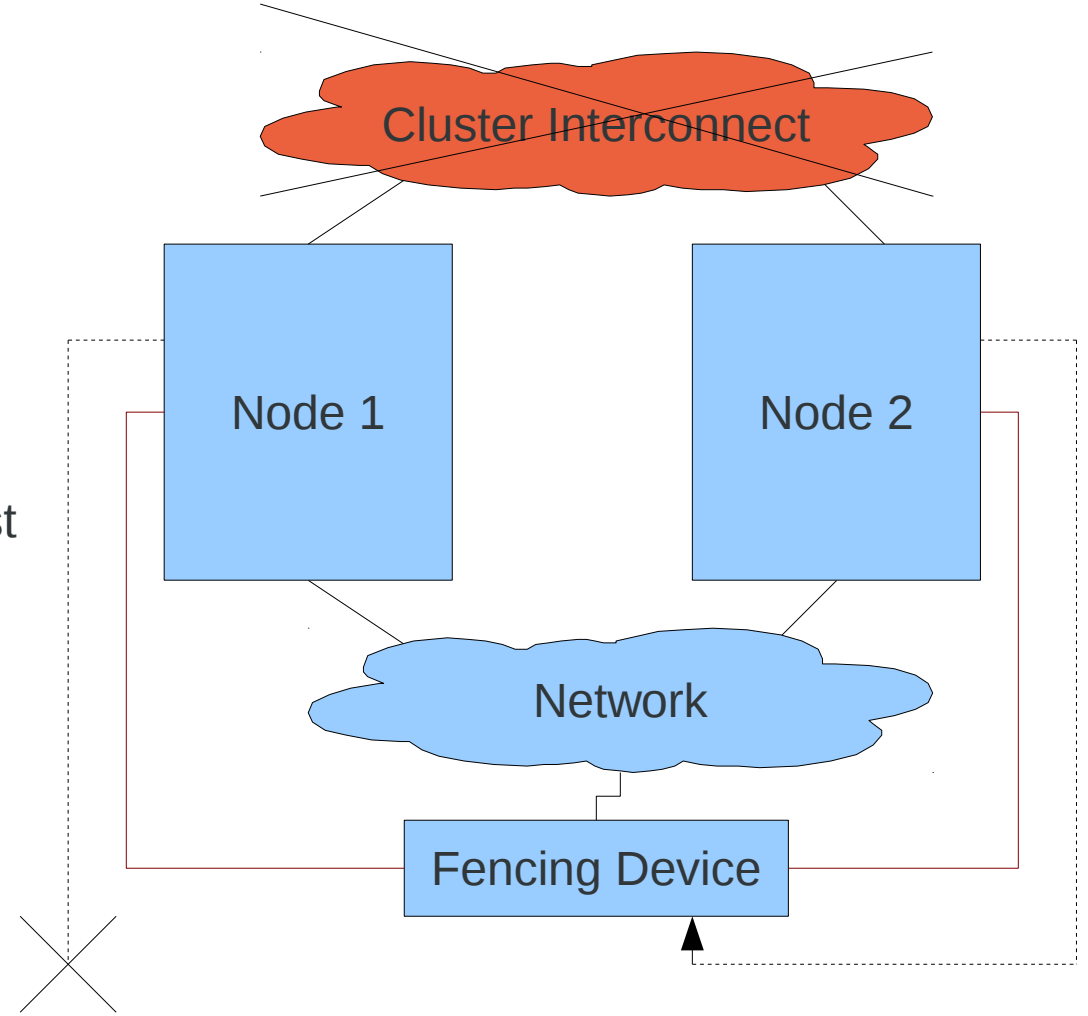


Fence Loop



Cable pull or switch loses power

Fence Loop

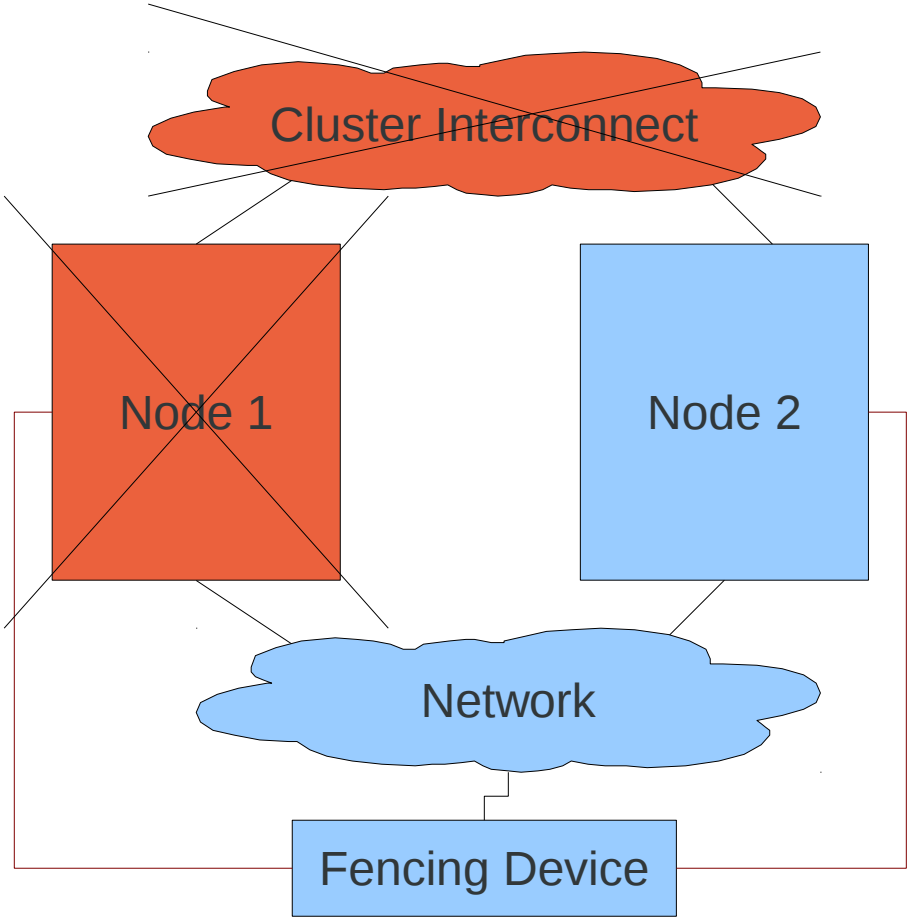


Fencing Request blocked; device allows only one user at a time

Fencing Request

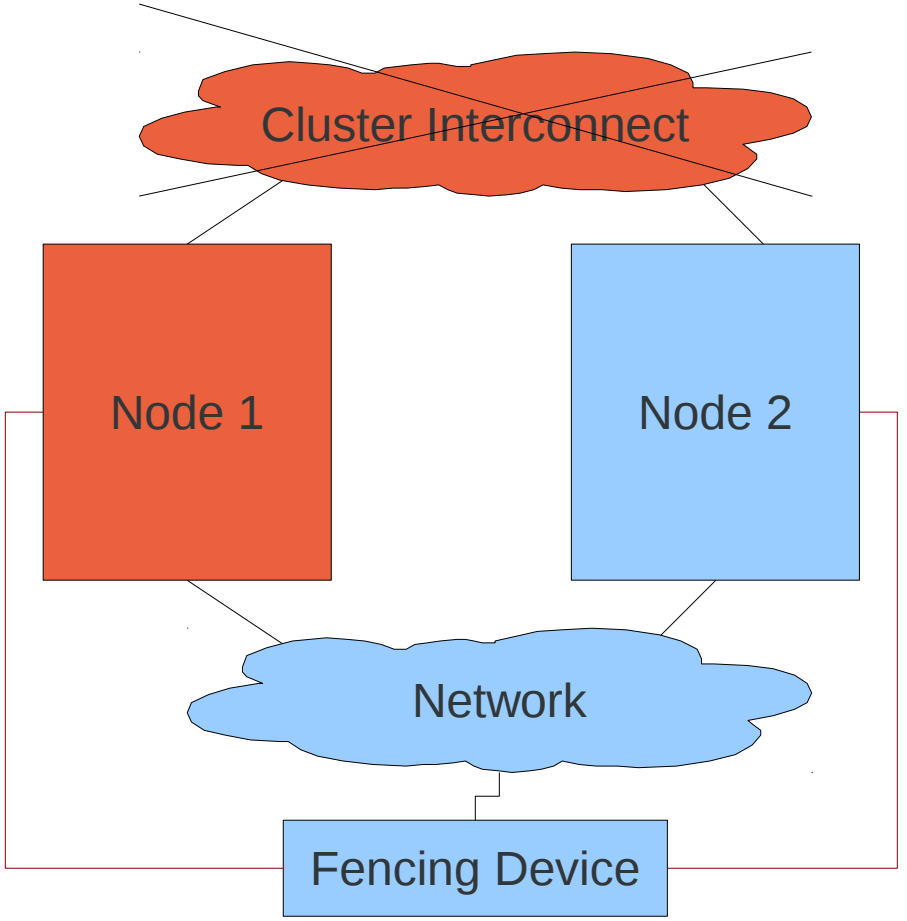
Fence Loop

Node 1 power cycled



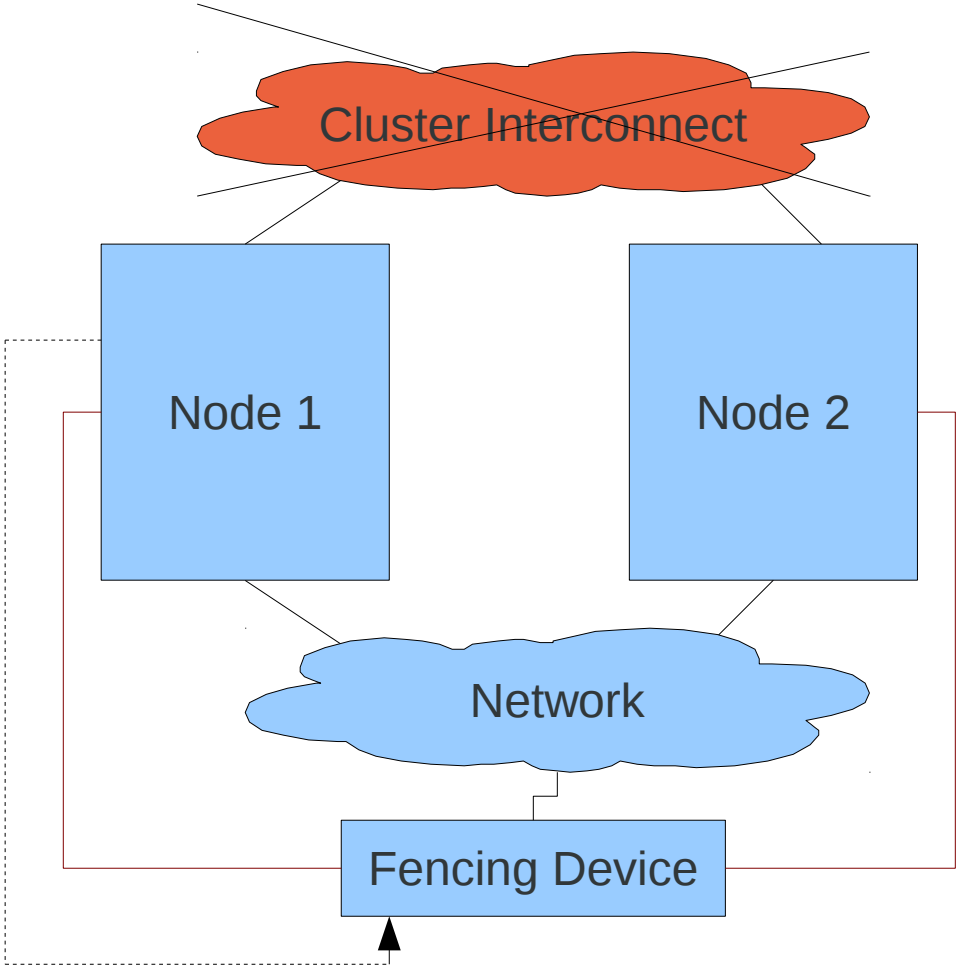
Fence Loop

Node 1
boots

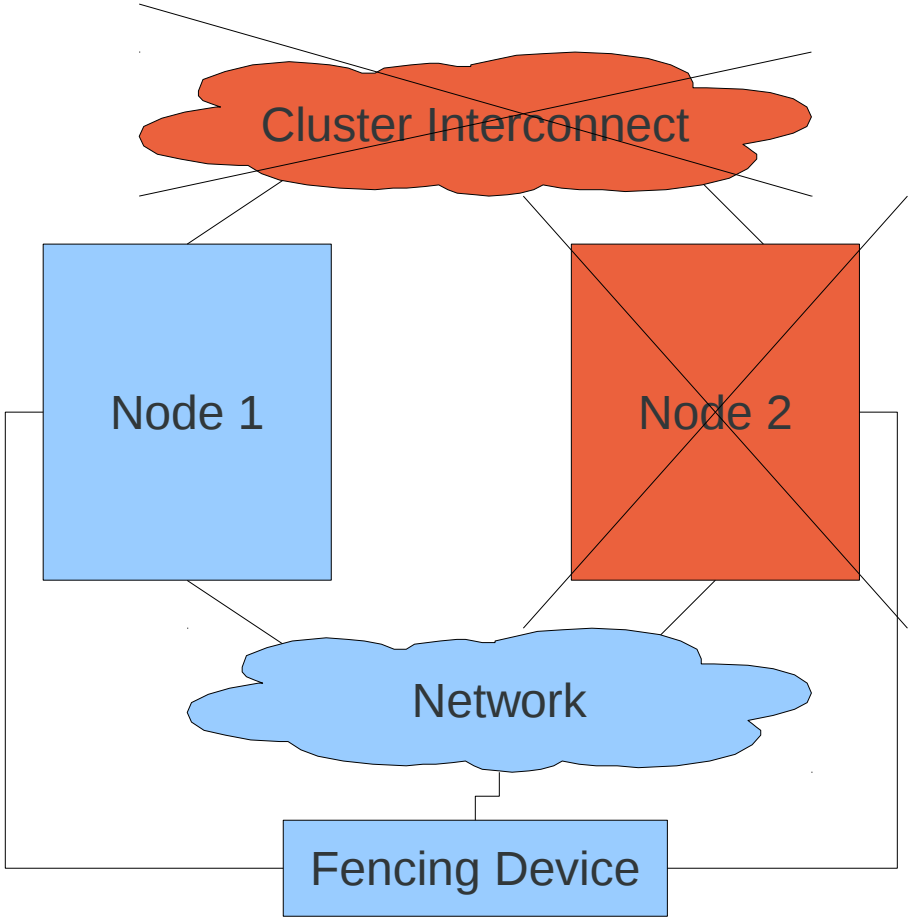


Fence Loop

Fencing Request

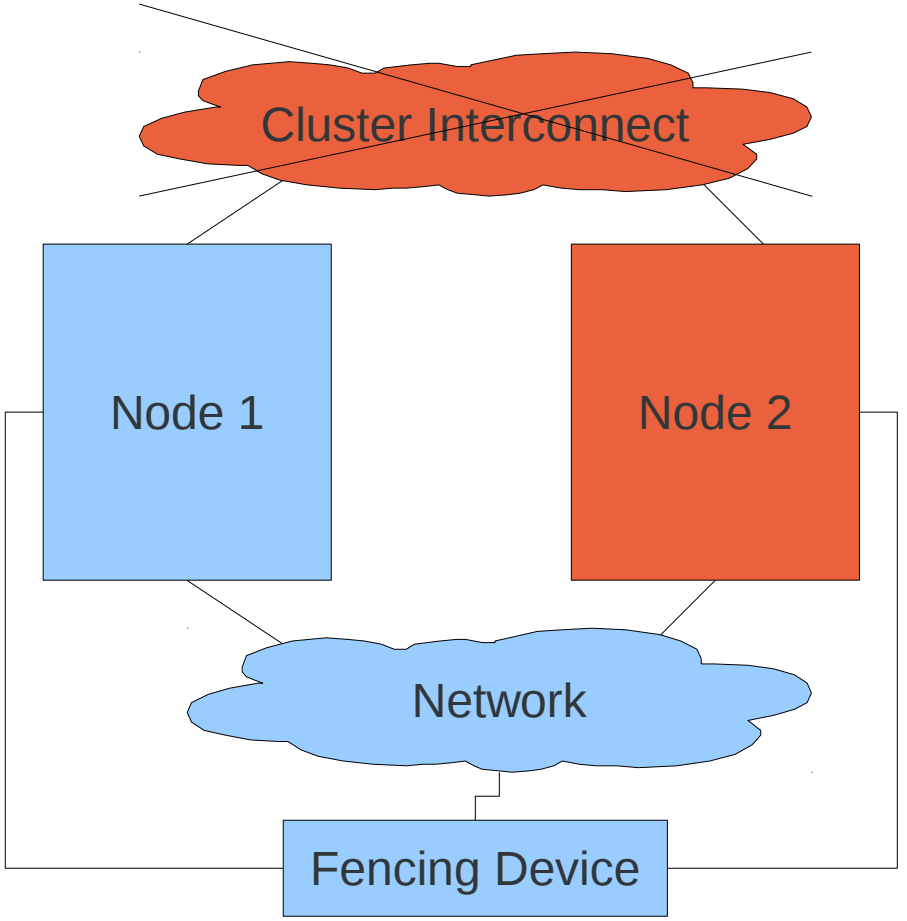


Fence Loop



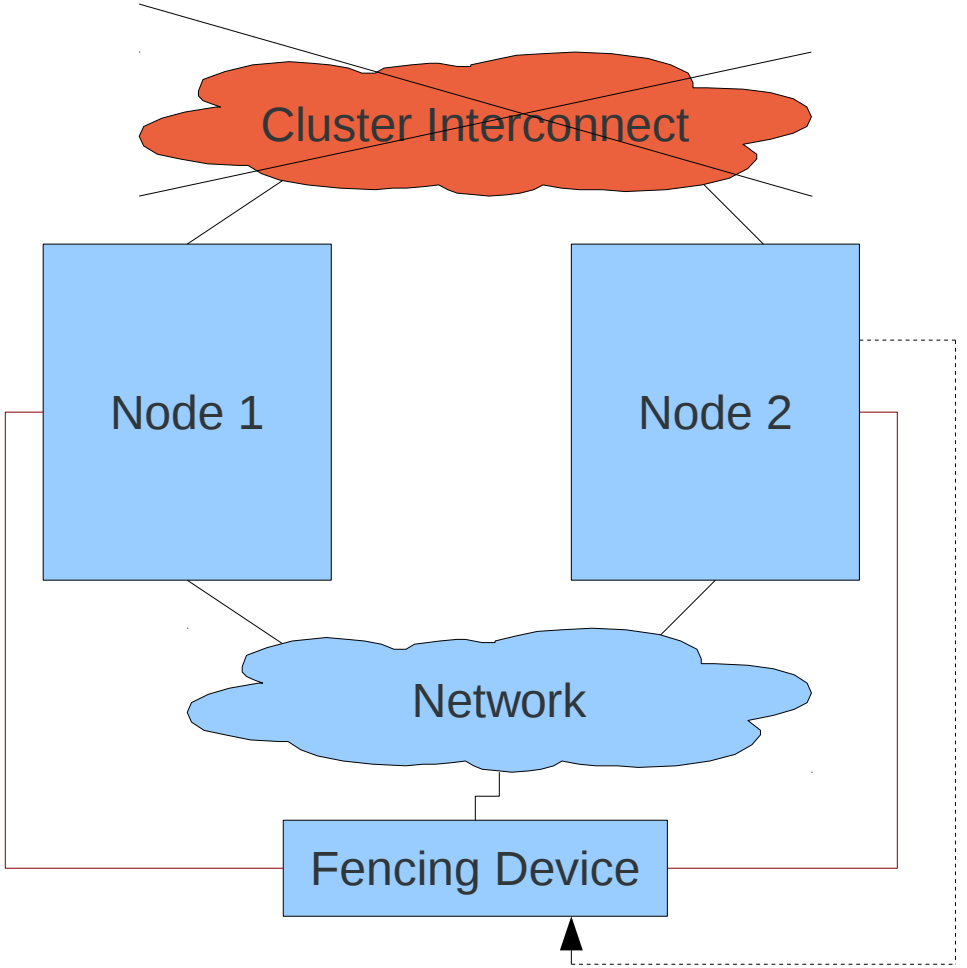
Node 2 power cycled

Fence Loop



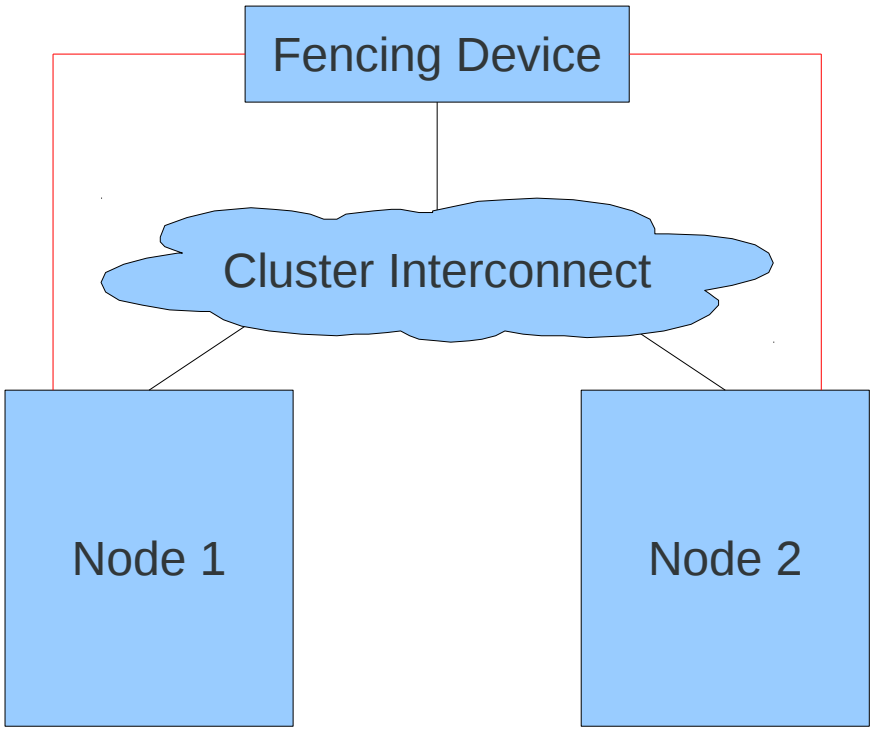
Node 2 boots

Fence Loop



Fencing Request

Immune to Fence Loops

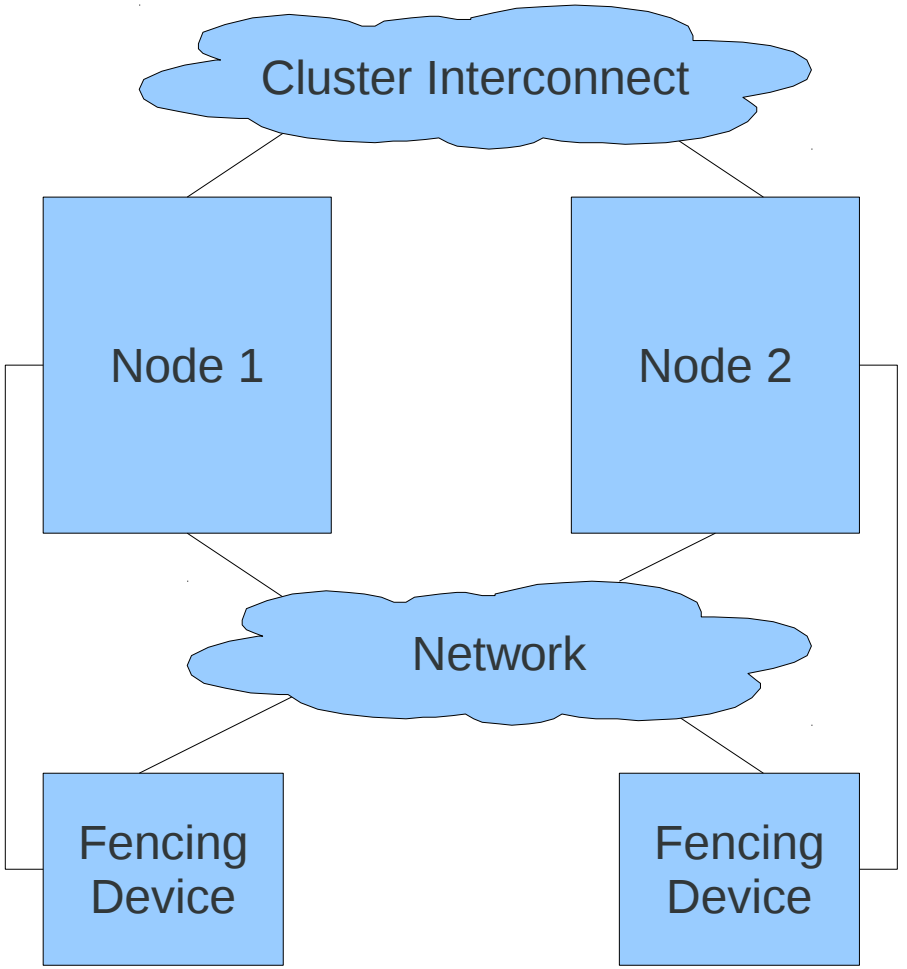


- On cable pull, node without connectivity can not fence
- If interconnect dies and comes back later, fencing device serializes access so that only one node is fenced

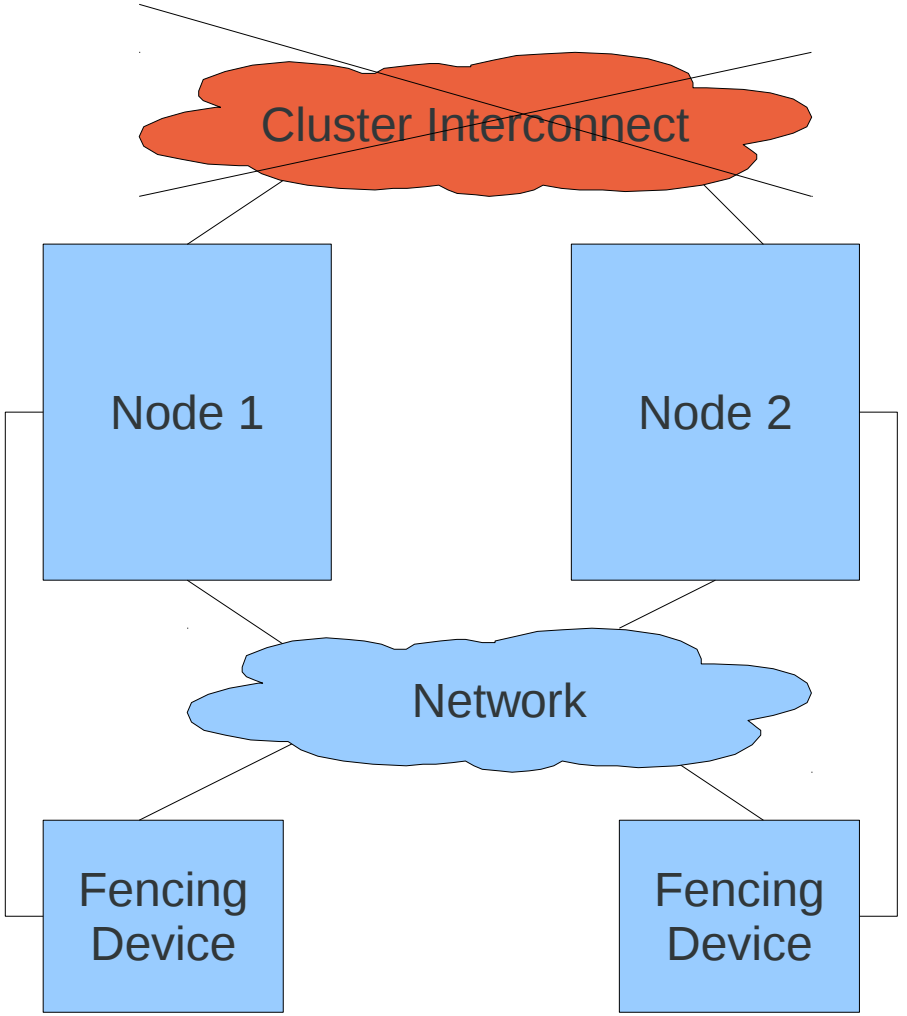
2-Node Pitfalls: Fence Death

- A combined pitfall when using integrated power in two node clusters
- If a two node cluster becomes partitioned, a *fence death* can occur if fencing devices are still accessible
- Two nodes tell each other's fencing device to turn off the other node at the same time
- No one is alive to turn either host back *on*!
- Solutions
  - Same as *fence loops*
  - Use a switched PDU which serializes access

Fence Death

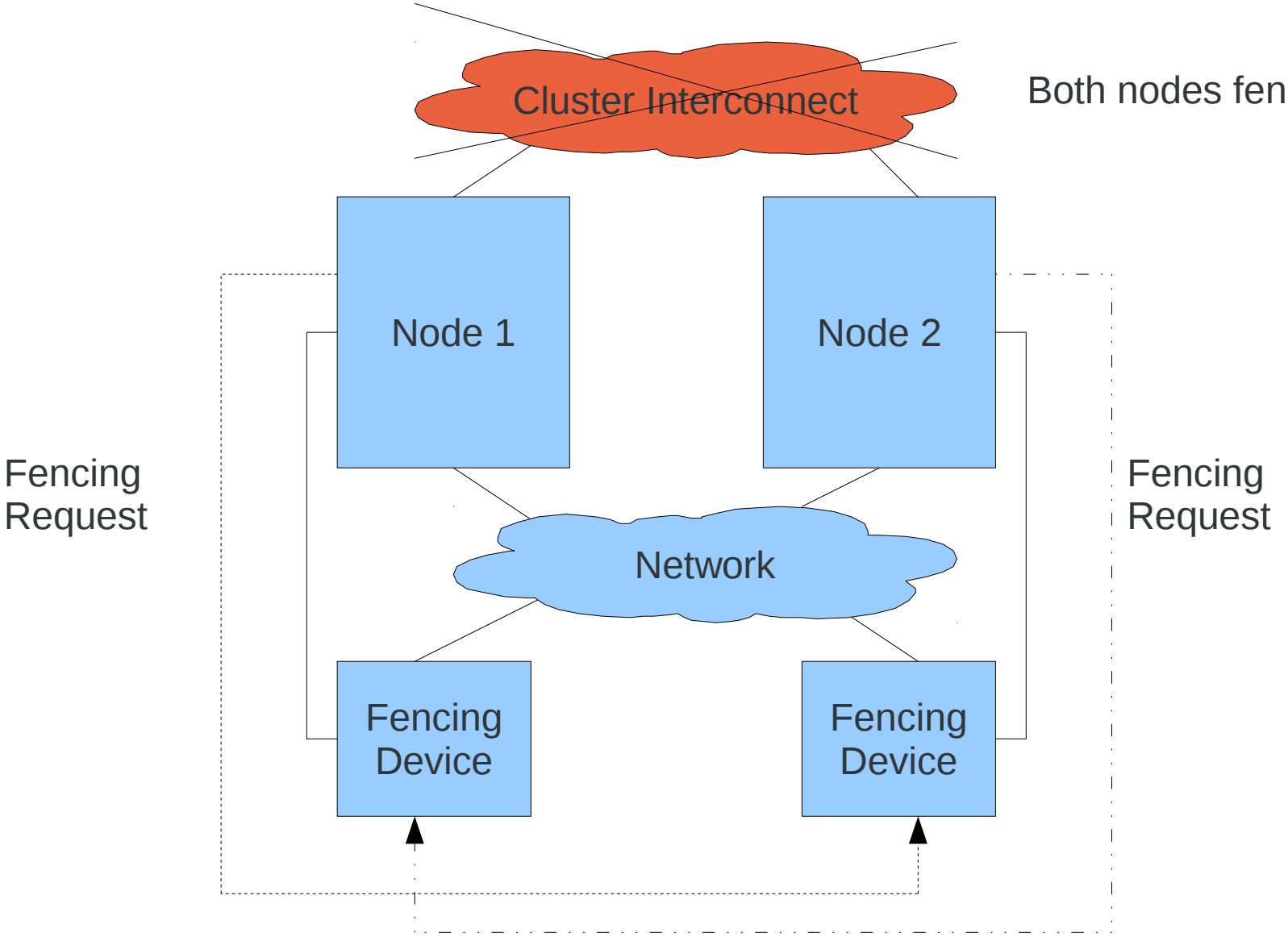

Cluster Interconnect
Node 1
Node 2
Network
Fencing Device
Fencing Device

Fence Death

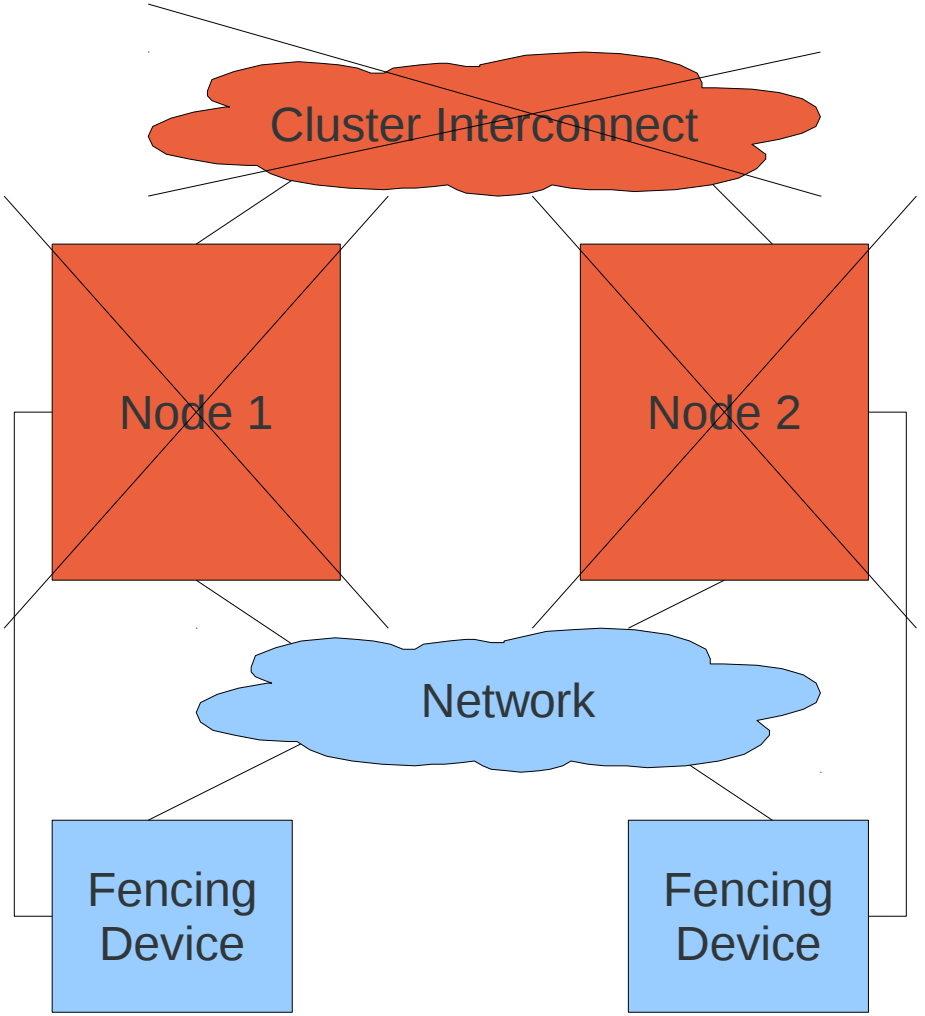


Cluster interconnect is lost (cable pull, switch turned off, etc.)

Fence Death

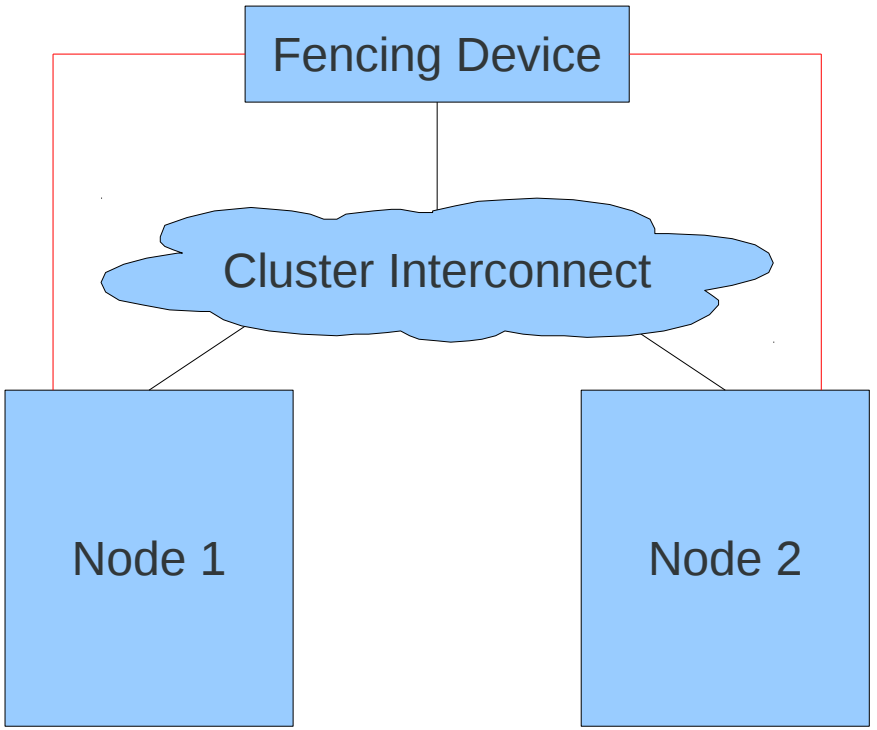

Cluster Interconnect
Both nodes fence each other
Node 1
Node 2
Fencing Request
Fencing Request
Network
Fencing Device
Fencing Device

Fence Death



No one is alive to turn the other back on.

Immune to Fence Death



- Single *power* fencing device serializes access
- Cable pull ensures one node “loses”

2-Node Pitfalls: Crossover Cables

- Causes both nodes to lose link on cluster interconnect when only one link has failed
- Indeterminate state for quorum disk without *very* clever heuristics (use *master_wins*)
- Fencing can't be placed on the same network
- We don't test this

2-Node Clusters: Pitfall avoidance

- Network / fencing configuration evaluation
- Use a quorum disk
- Create a 3 node cluster :)
  - Simple to configure, increased working capacity, etc.

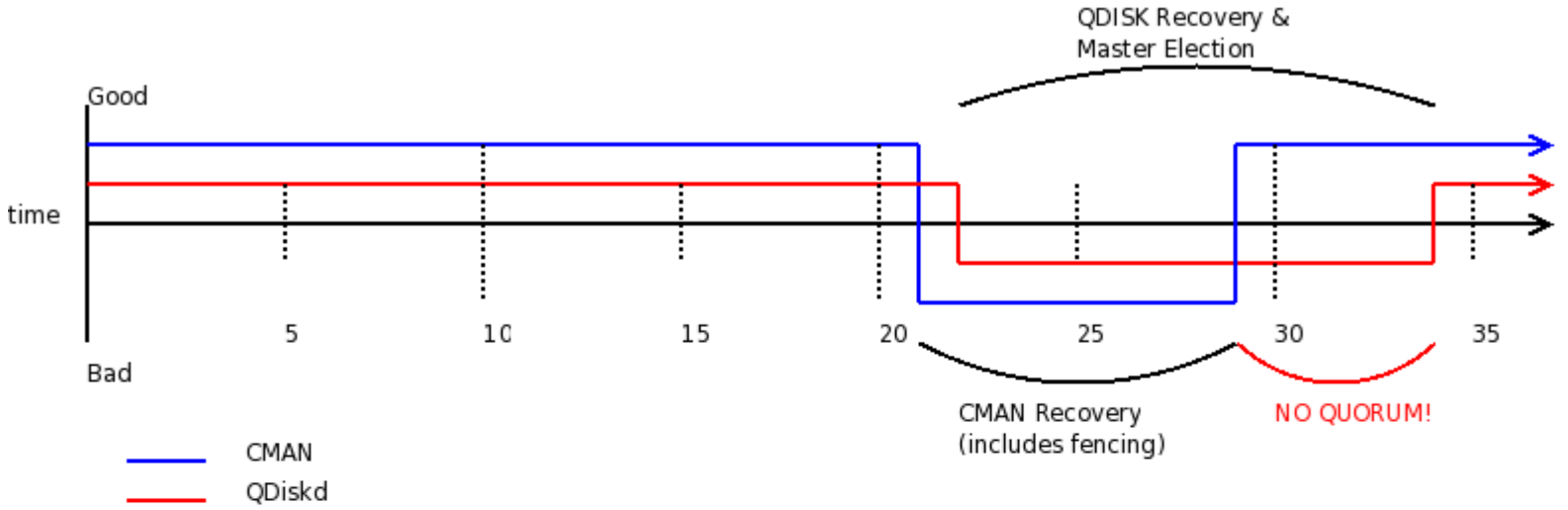
Quorum Disk - Benefits

- Prevents *fence-loop* and *fence death* situations
  - Existing cluster member retains quorum until it fails or cluster connectivity is restored
  - Heuristics ensure that administrator-defined “best-fit” node continues operation in a network partition
- Provides *all-but-one* or *last-man-standing* failure mode
  - Examples:
    - 4 node cluster, and 3 nodes fail
    - 4 node cluster and 3 nodes lose access to a critical network path as decided by the administrator
  - Note: Ensure capacity of remaining node is adequate for *all* cluster operations before trying this

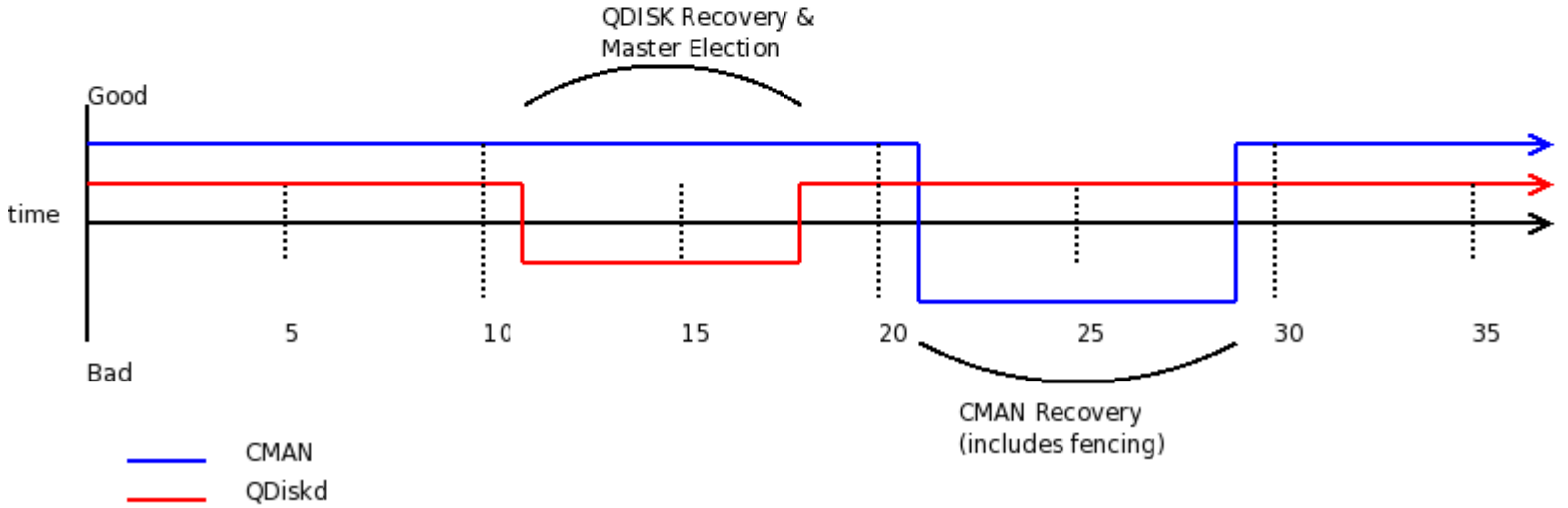
Quorum Disk - Drawbacks

- Used to be complex to configure, but RHEL 6.3 fixes most of this
  - Heuristics need to be written by administrators for their particular environments
  - Incorrect configuration can *reduce* availability
- Algorithm used is non-traditional
  - Backup membership algorithm vs. ownership algorithm or simple “tie-breaker”

Quorum Disk Timing Pitfall (RHEL5)



Bad configuration: Qdisk timeout = 21 seconds, CMAN timeout = 21 seconds



Good configuration: Qdisk timeout = 10 seconds, CMAN timeout = 21 seconds

Quorum Disk Made “Simple” (RHEL5)

- Quorum disk failure recovery should be a bit less than half of CMAN's failure time
  - This allows for the quorum disk arbitration node to fail over before CMAN times out
- Quorum disk failure recovery should be approximately 30% longer than a multipath failover. Example [1]:
  - x = multipath failover
  - x * 1.3 = quorum disk failover
  - x * 2.7 = CMAN failover

[1] http://kbase.redhat.com/faq/docs/DOC-2882

Quorum Disk Best Practices

- Don't use it if you don't *need* it
  - Fencing delays can usually provide adequate decision-making
- If required, use heuristics for *your* environment
- Prefer *master_wins* over heuristics
- I/O Scheduling
  - *deadline* scheduler
  - *cfq* scheduler with realtime prio
    - `ionice -c 1 -n 0 -p `pidof qdiskd``

Clustered Services – Best Practices

- Service structure should be as flat as possible
  - Improves readability / maintainability
  - Reduces configuration file footprint
  - Rgmanager fixes most common ordering mistakes
- The resources block is not required
- Virtual machines should not exceed memory limits of a host *after* a failover for best predictability

On Multipath

- With SCSI-3 PR Fencing, multipath works, but only when using device-mapper
- When using multiple paths and SAN fencing, you must ensure *all* paths to *all* storage is fenced for a given host
- When using multipath with a quorum disk, you *must not* use **no_path_retry = queue**.
- When using multipath with GFS2, you *should not use* **no_path_retry = queue**.

On Multipath

- Do not place /var on a multipath device without relocating the bindings file to the root partition
- Not all SAN fabrics behave the same way in the same failure scenarios
- Test all failure scenarios you expect to have the cluster handle
- Use device-mapper multipath rather than vendor supplied versions for the best support from Red Hat

GFS2 – Shared Disk Cluster File System

- Provide uniform views of a file system in a cluster
- POSIX compliant (as much as Linux is, anyway)
- Allow easy management of things like virtual machine images
- Good for getting lots of data to several nodes quickly

GFS2 Considerations

- Journal count (cluster size)
  - One journal per node
- File system size
  - Online extend supported
  - Shrinking is not supported
- Workload requirements & planned usage

GFS2 Pitfalls

- Making a file system with *lock_nolock* as the locking protocol
- Failure to allocate enough journals at file system creation time and adding nodes to the cluster (GFS only)
- NFS lock failover *does not work*!
- Never use a cluster file system on top of an md-raid device
  - Use of local file systems on md-raid for failover is also not supported

Other Topics

- Stretch clustering – multiple buildings on the same campus in the same cluster
  - Minimal support for this
- Geographic clustering / disaster tolerance – longer-distance
  - Evaluated typically on a case-by-case basis; requires site to site storage replication and a backup cluster
  - Active/active clustering across sites is not supported

Troubleshooting corosync & CMAN

- corosync does not have an easy tool to assist troubleshooting; check system logs (it is *very* verbose if problems occur)
  - Most common problem w/ corosync is incorrect multicast configuration on the switch
  - UDPU (6.2+) more reliable
- **cman_tool status**
  - Shows cluster states (incl. votes)
- **cman_tool nodes**
  - Show cluster node states

Troubleshooting Fencing

- **group_tool ls** – The *fence* group should be in NONE (or “run” depending on version)
  - If it is in another state (FAIL_STOP_WAIT, FAIL_START_WAIT), check logs on the low node ID
- **cman_tool nodes -f** – Show nodes and the last time each were fenced (if ever)
- **fence_ack_manual -e -n <node>** - emergency fencing override. Use if you are sure the host is dead and the fencing device is inaccessible (or if fencing is incorrectly configured) to allow the cluster to recover.

Summary

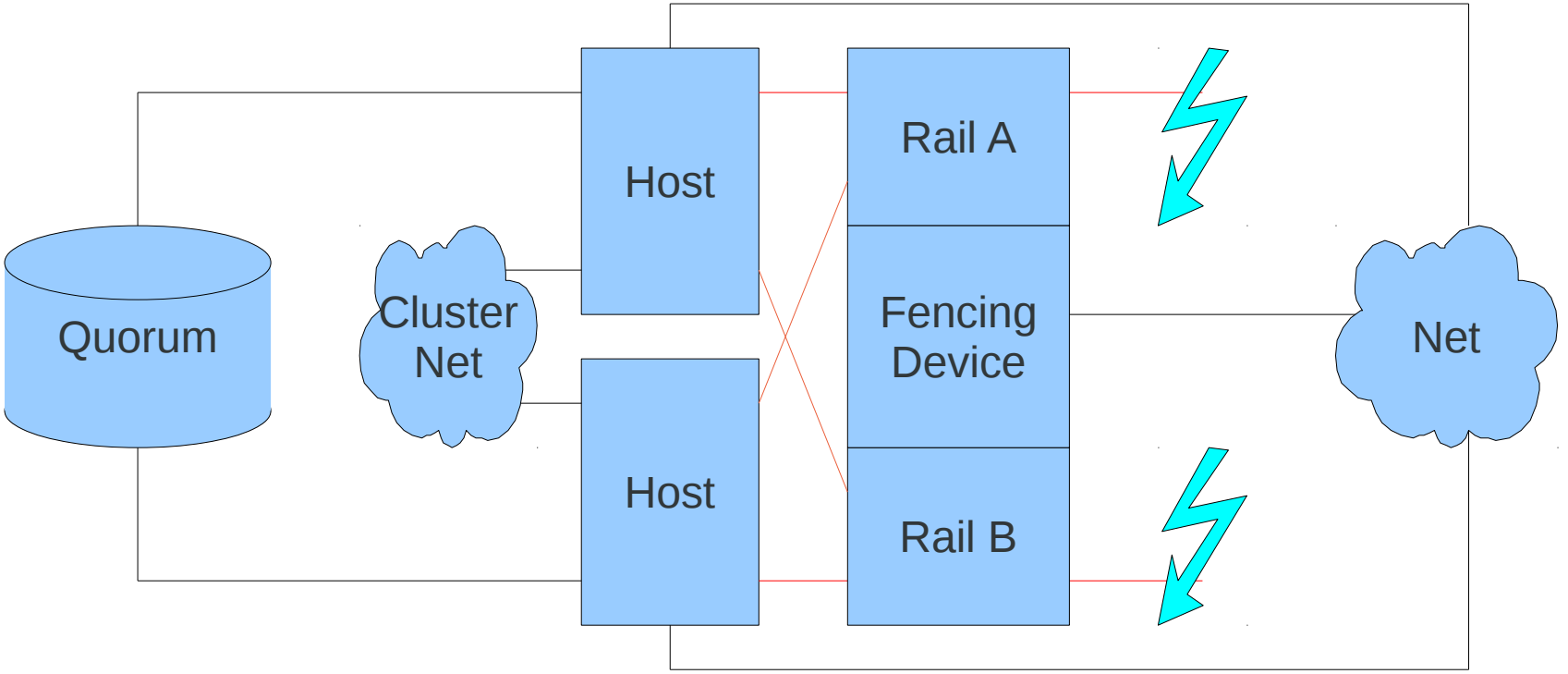
- Choose a fencing configuration which works in the failure cases you expect
- Test all failure cases you expect the cluster to recover from
- The more complex the system, the more likely a single component will fail
  - Use the simplest configuration whenever possible
- When using clustered file systems, tune according to your workload

References

- https://access.redhat.com/knowledge/solutions/17784
- https://access.redhat.com/knowledge/node/28603
- https://access.redhat.com/knowledge/node/29440
- https://access.redhat.com/knowledge/articles/40051

- http://people.redhat.com/lhh/ClusterPitfalls.pdf

Complex NSPF Cluster



- Any single failure in the system either allows recovery or continued operation
- Bordering on insane

Simpler NSPF configuration