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# High Availability and Clustering File Systems on Linux on z

*Neale Ferguson*

*Sine Nomine Associates*



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# Agenda

- Sample Configuration
- GFS2
- GlusterFS
- DRBD
- Ceph

# HA Sample Configuration

## *Components and Connectivity*



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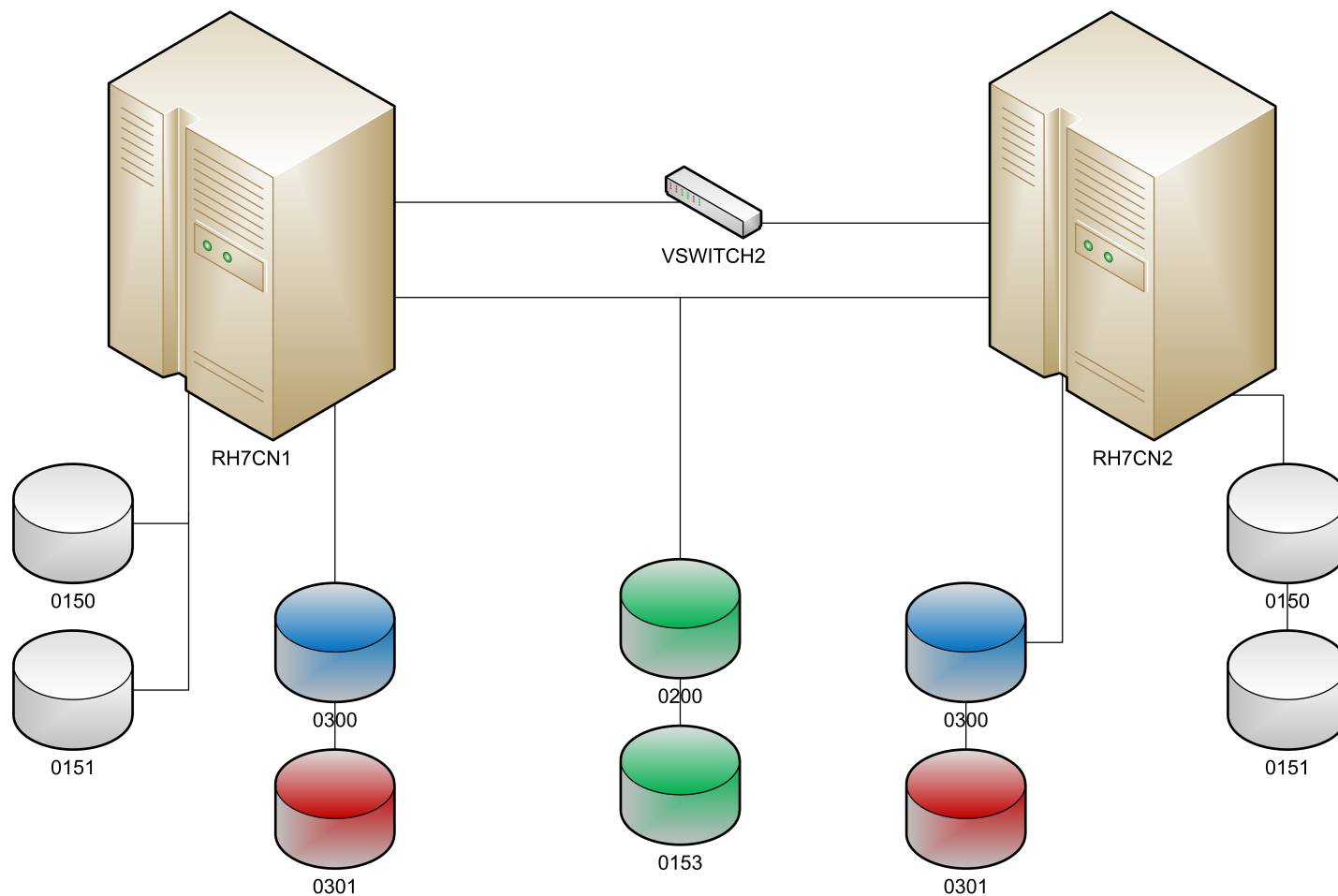
# High Availability

- Eliminate Single Points of Failure
- Failover
- Simultaneous Read/Write
- Node failures invisible outside the cluster

# High Availability

- Major Components
  - Cluster infrastructure — Provides fundamental functions for nodes to work together as a cluster
    - Configuration-file management, membership management, lock management, and fencing
  - High availability Service Management — Provides failover of services from one cluster node to another in case a node becomes inoperative
  - Cluster administration tools — Configuration and management tools for setting up, configuring, and managing the High Availability Implementation

# Sample Configuration



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# Sample Configuration

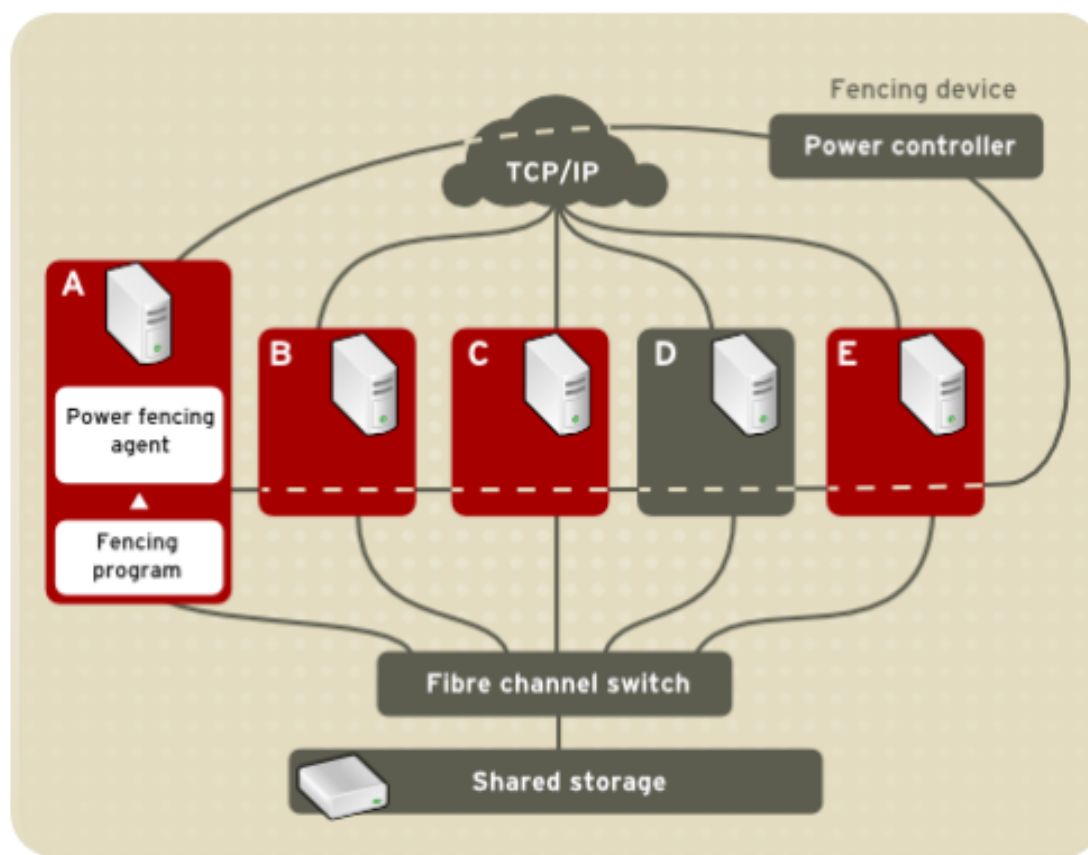
- High Availability Packages – RHEL7/CentOS7
  - pacemaker: HA manager
  - fence-agents: STONITH agents
- Firewall Issues
  - `firewall-cmd --permanent --add-service=high-availability`
  - `firewall-cmd --add-service=high-availability`



# Fencing

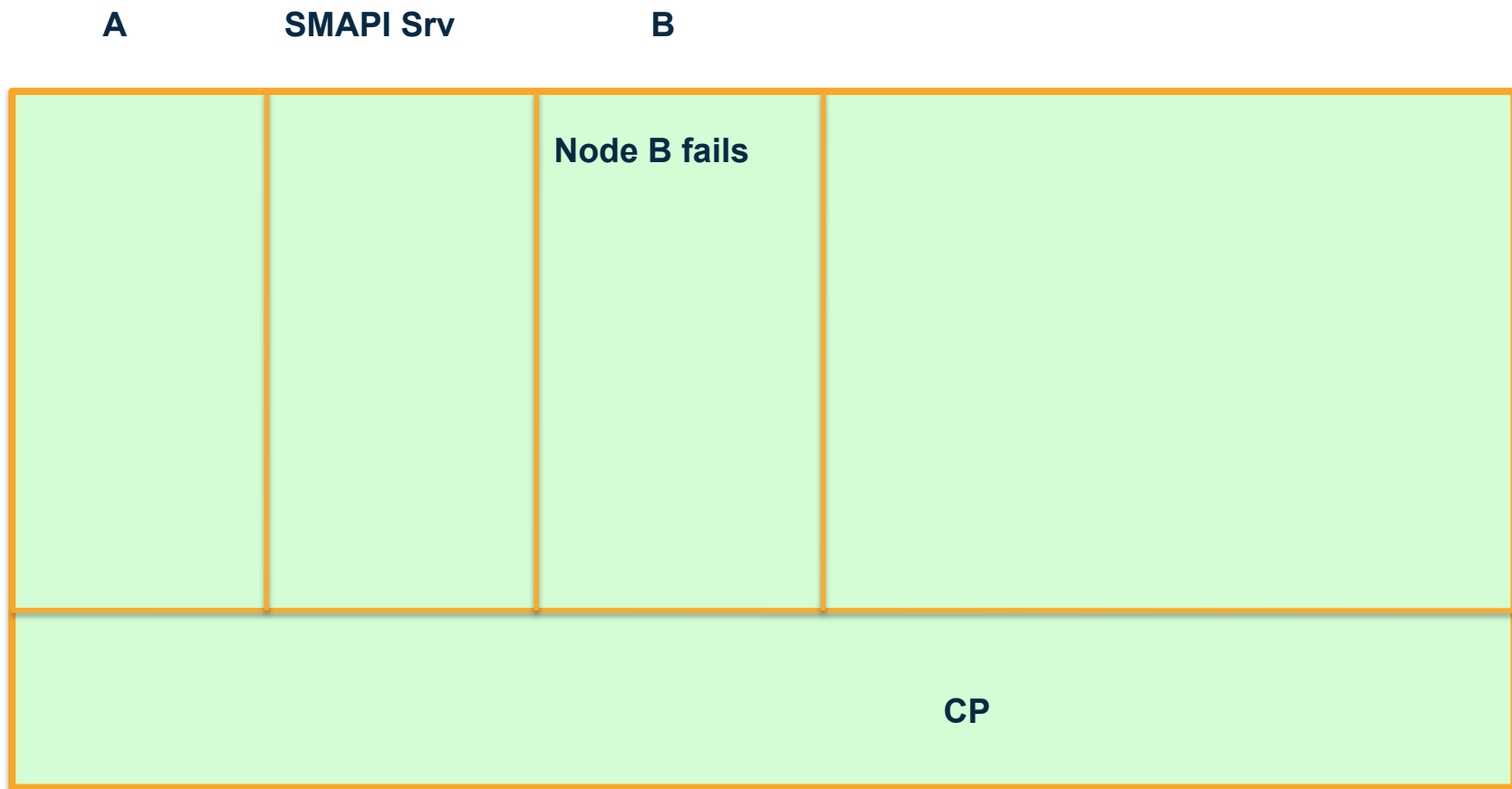
- The disconnection of a node from the cluster's shared storage. Fencing cuts off I/O from shared storage, thus ensuring data integrity
- The cluster infrastructure performs fencing through the fence daemon: fenced
- Cluster determines that a node has failed and communicates to other cluster-infrastructure components that the node has failed
- fenced, when notified of the failure, fences the failed node

# Power Fencing



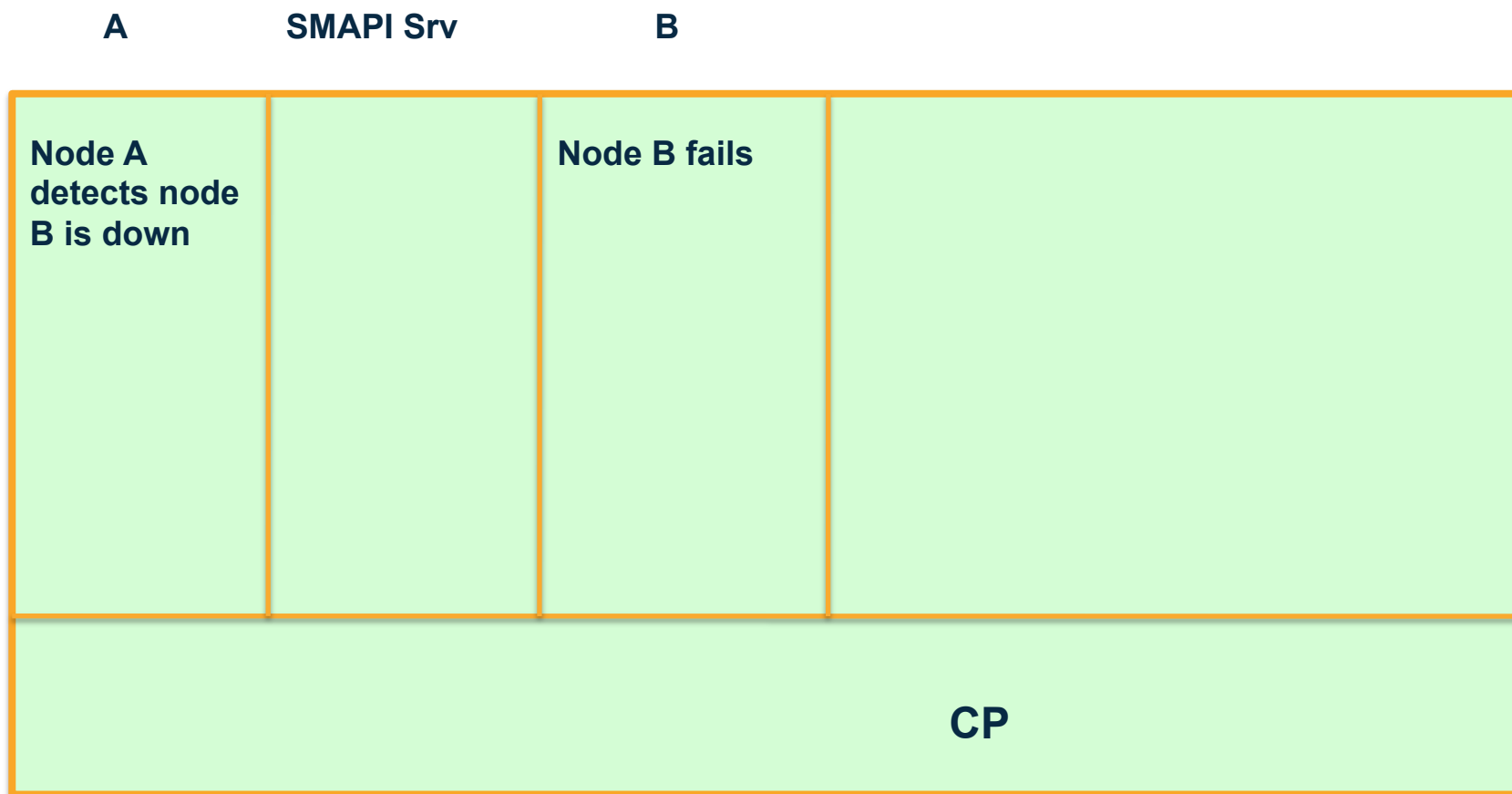
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# z/VM Power Fencing

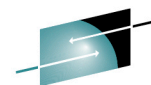


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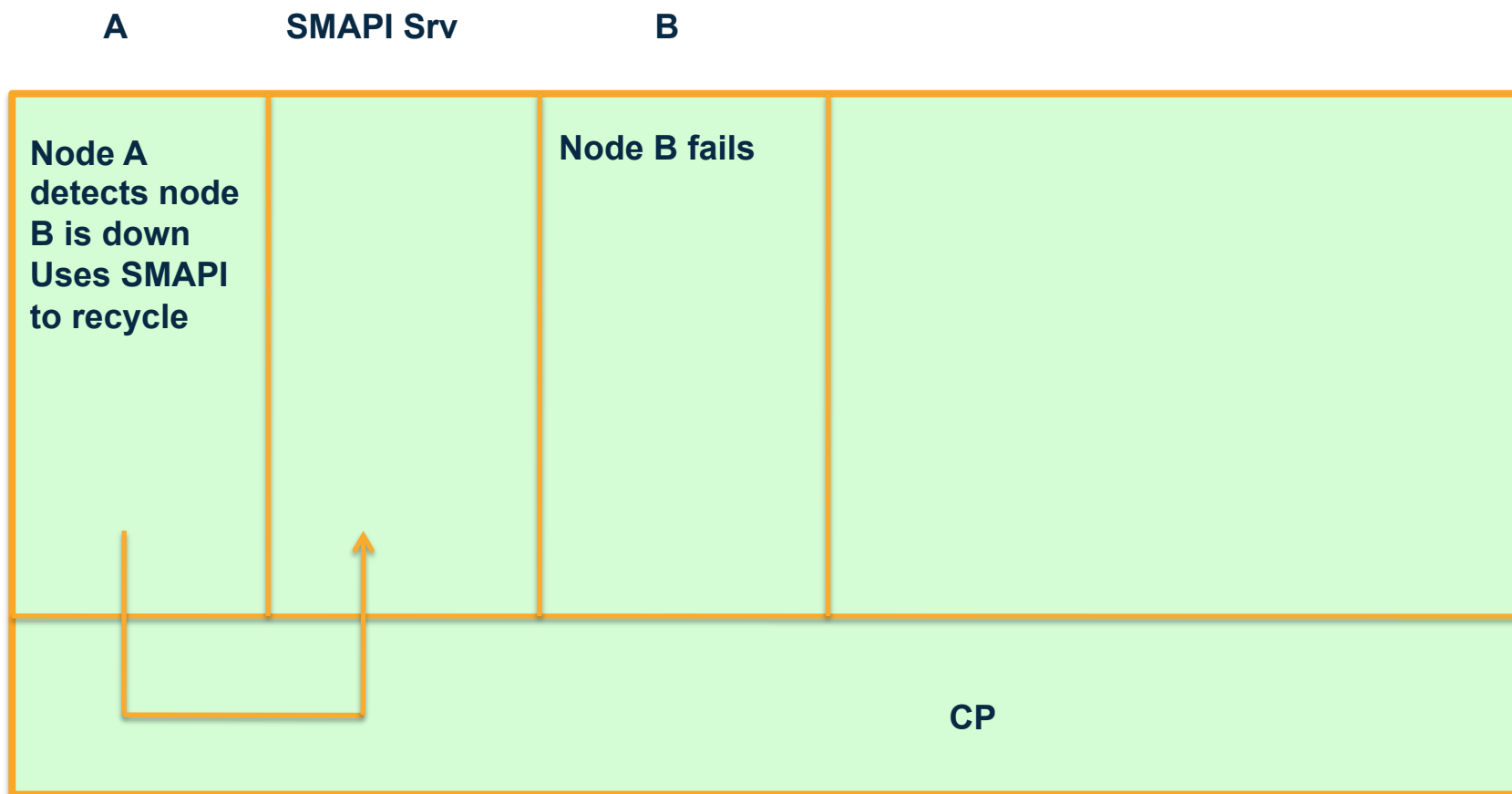
# z/VM Power Fencing



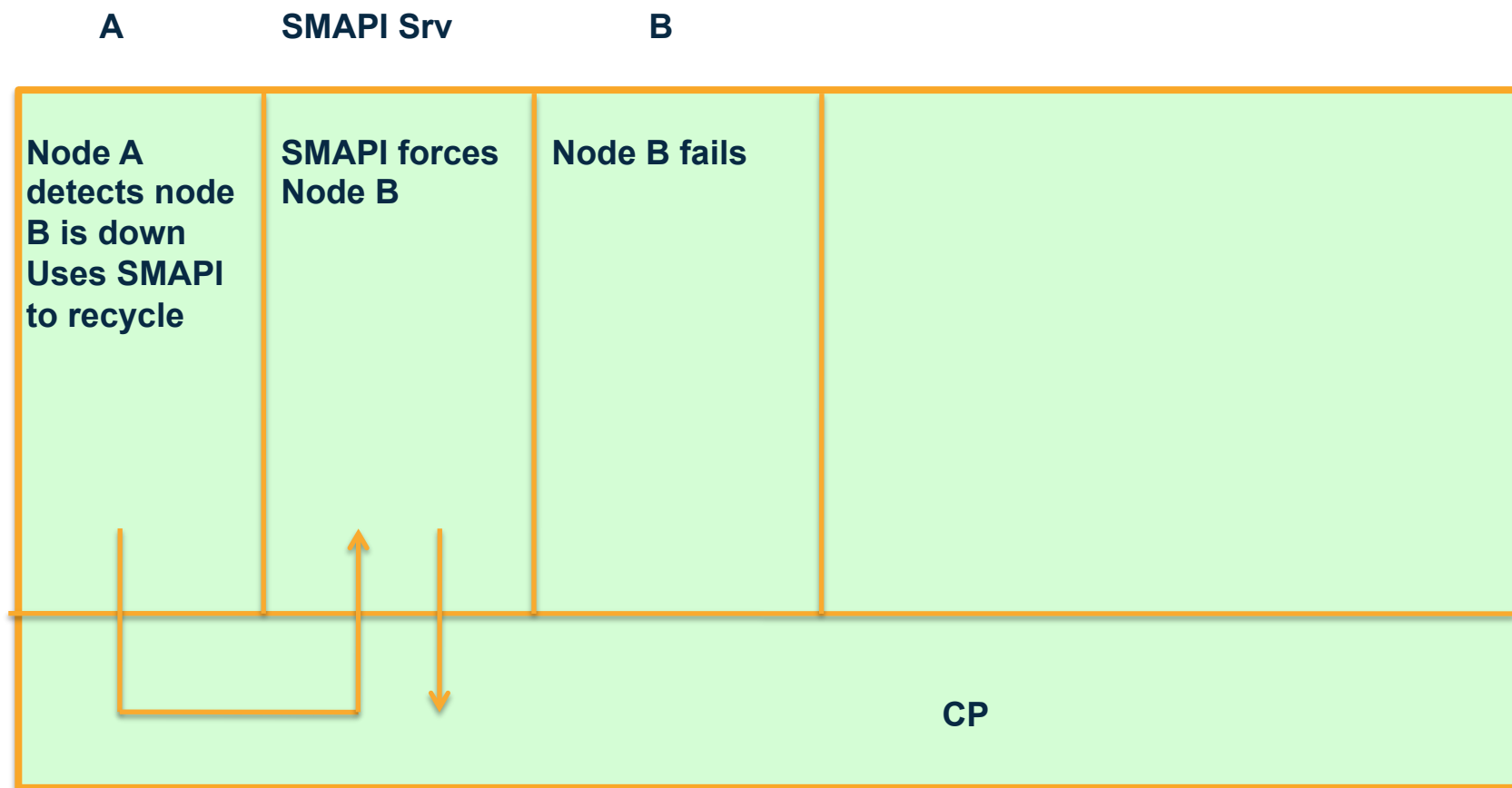
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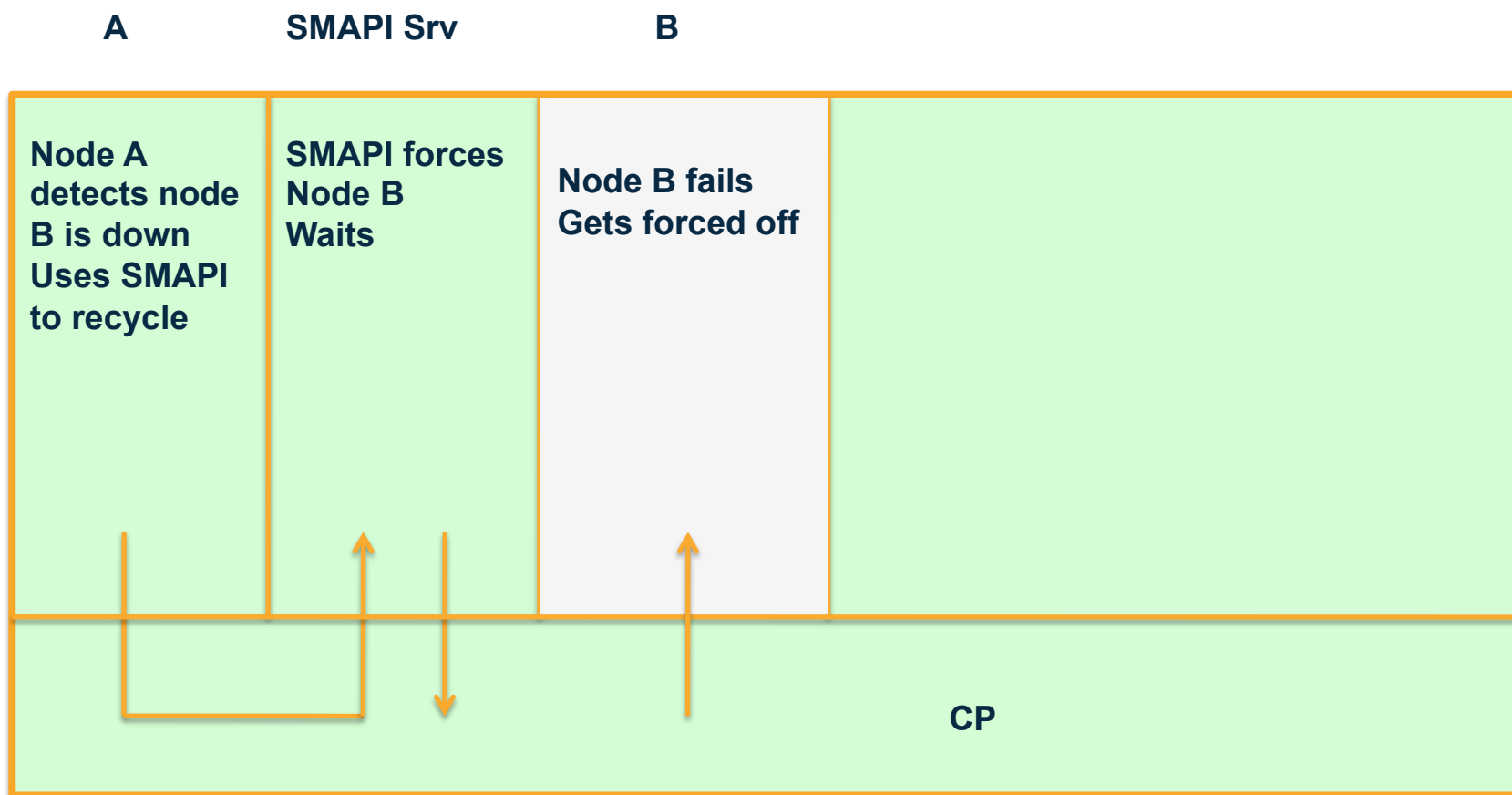
# z/VM Power Fencing



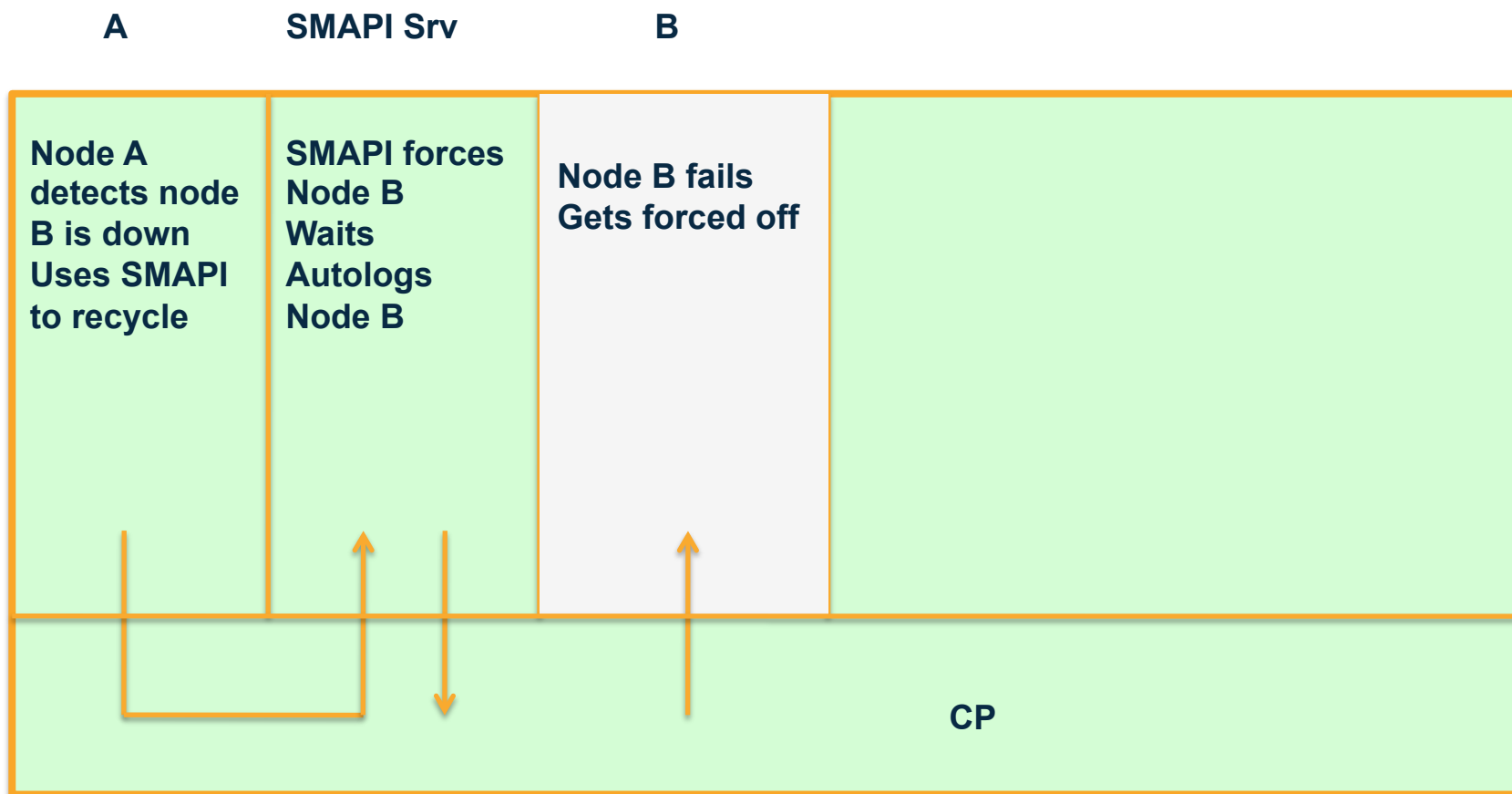
# z/VM Power Fencing



# z/VM Power Fencing

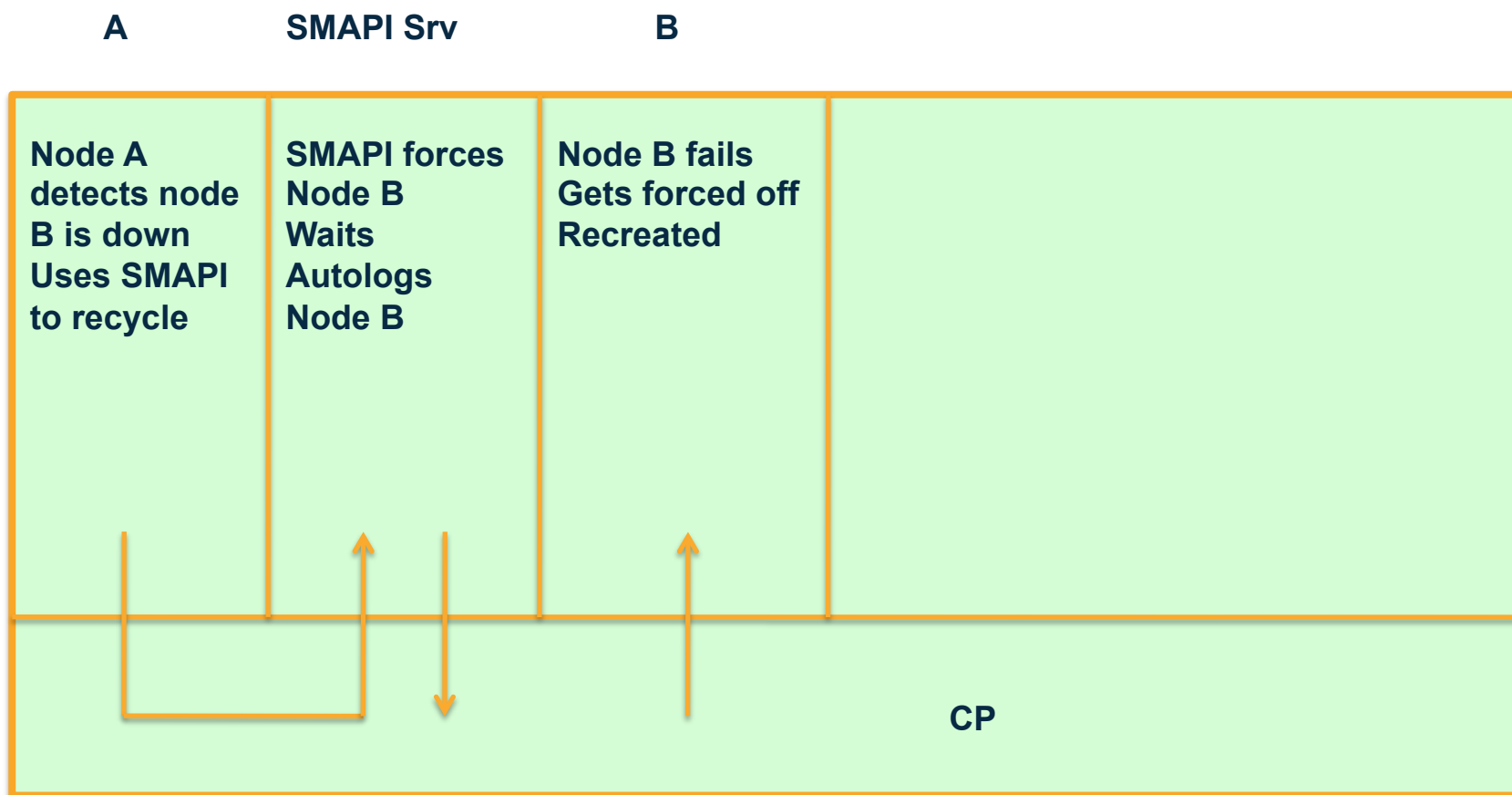


# z/VM Power Fencing





# z/VM Power Fencing



## z/VM Power Fencing

- Two choices of SMAPI-based fence devices
  - IUCV-based
  - TCP/IP
- Uses image\_recycle API to fence a node
- Requires SMAPI configuration update to AUTHLIST:

Column 1	Column 66	Column 131
V	V	V
XXXXXXXX	ALL	IMAGE_OPERATIONS

# Clustered File Systems

*Configuration, Use Cases, and Requirements*



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# GFS2

- Features
- Use cases
- Requirements

## GFS2 - Features

- Shared disk file system for clustering
- Journal file system
- All nodes to have direct concurrent access to the same shared block storage
- May also be used as a local file system
- No client/server roles
- Uses Distributed Lock Manager (dlm) when clustered
- Requires some form of fencing to operate in clusters

## GFS2 - Features

- Theoretically accommodates an 8EB filesystem
- Currently supports 100TB (64-bit mode)
- Almost always used with LVM
- Filesystems have unique names within a cluster
- Part of the Linux kernel source tree

## GFS2 – Use Cases

- High Availability
  - MQSeries
  - Web Server
  - Oracle

# GFS2 – Requirements

- Packages:
  - lvm2-cluster, gfs2-utils, gfs2-kmod
- SELinux
  - SELinux is highly recommended for security reasons in most situations, but should not be used with GFS2
  - SELinux stores information using extended attributes about every file system object
  - Reading, writing, and maintaining these extended attributes is possible but slows GFS2 down considerably
  - You should turn SELinux off on GFS2 file systems



# GFS2 – Sample Configuration

```
USER COMMON NOLOG 8K 8K
MDISK 153 3390 * 3338 *
MINIOPT NOMDC
MDISK 200 3390 * 0500 *
MINIOPT NOMDC
```

```
USER RH7CN1 XXXXXXXX 768M 2G G
ACCOUNT 99999999 CLUSTER
MACHINE ESA
COMMAND SET VSWITCH VSWITCH2 GRANT &USERID
COMMAND COUPLE C600 TO SYSTEM VSWITCH2 IUCV VSMREQIU
IPL CMS PARM AUTOCR
CONSOLE 0009 3215 T OPERATOR
SPOOL 00C 2540 READER *
SPOOL 00D 2540 PUNCH A
SPOOL 00E 1403 A
LINK MAINT 190 190 RR
LINK MAINT 19E 19E RR
LINK COMMON 153 153 MW
LINK COMMON 200 200 MW
NICDEF C600 TYPE QDIO DEVICES 3 MDOPT FORMAT
  MDISK 150 3390 * 3338 * M
  MDOPT FORMAT
  MDISK 151 3390 * 3338 * M
  MDOPT FORMAT
  MDISK 300 3390 * 200 * M
  MDOPT FORMAT
  MDISK 301 3390 * 200 * M
```

# GFS2 – Sample Configuration

```
lvmconf --enable-cluster  
pvcreate /dev/dasdd1  
vgcreate -Ay -cy vg_cluster /dev/dasdd1  
lvcreate -L 500m -n ha_lv vg_cluster  
mkfs.gfs2 -j 2 -r 32 -t rh7cluster:vol1 /dev/mapper/vg_cluster-ha_lv
```

# GlusterFS

- Features
- Use cases
- Requirements

## GlusterFS - Features

- “GlusterFS is a powerful network/cluster filesystem written in user space which uses FUSE to hook itself with VFS layer. GlusterFS takes a layered approach to the file system, where features are added/removed as per the requirement. Though GlusterFS is a File System, it uses already tried and tested disk file systems like ext3, ext4, xfs, etc. to store the data. It can easily scale up to petabytes of storage which is available to user under a single mount point.”
- GPLv3 license

# GlusterFS - Features

- File-based mirroring and replication
- File-based striping
- File-based load balancing
- Volume failover
- Scheduling and disk caching
- Storage quotas
- Volume snapshots with user serviceability

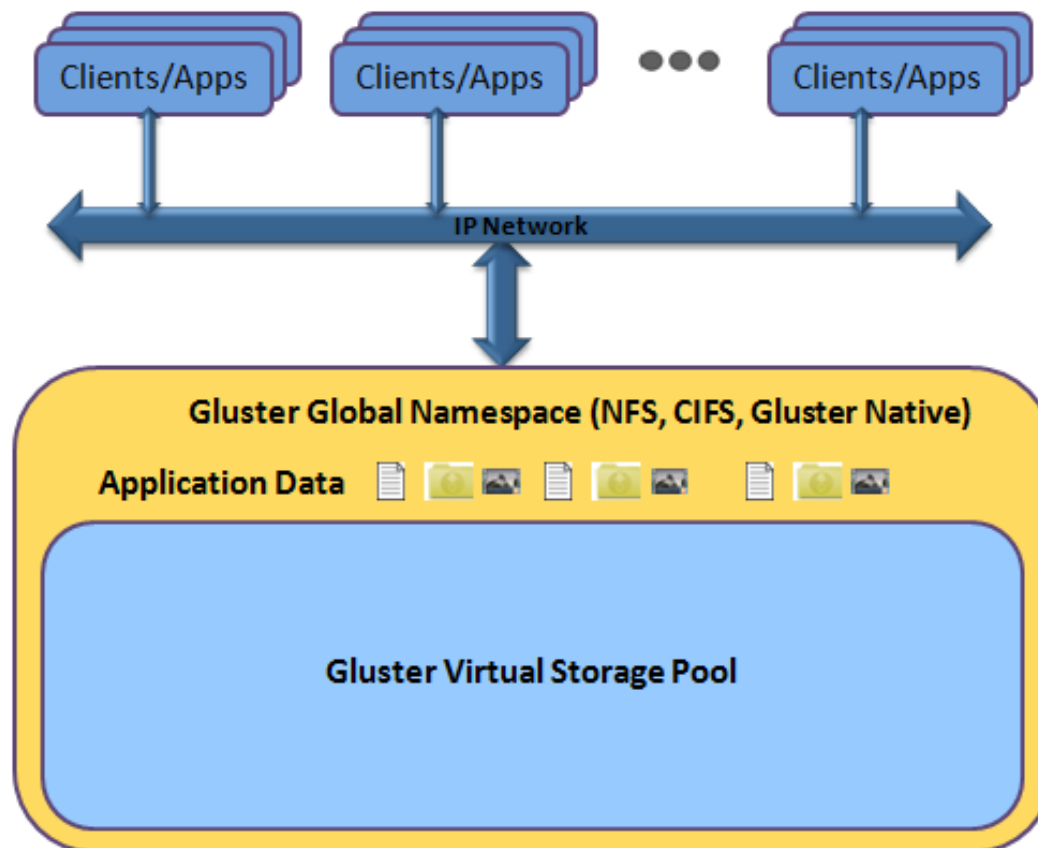
## GlusterFS - Terms

- **Brick** - The storage filesystem that has been assigned to a volume
- **Client** - The machine which mounts the volume (this may also be a server)
- **Server** - The machine (virtual or bare metal) which hosts the actual filesystem in which data will be stored
- **Subvolume** - A brick after being processed by at least one translator
- **Volume** - The final share after it passes through all the translators
- **Translator** - Connects to one or more subvolumes, does something with them, and offers a subvolume connection

## GlusterFS - Features

- **Server:** Exports a filesystem “as-is” leaving it to client to structure the data
- **Client:** Stateless, independent, consistent configurations
- Volumes can be added, deleted, or migrated dynamically enabling massive scaling

# GlusterFS – Conceptual View



Source: [http://www.gluster.org/documentation/About\\_Gluster/](http://www.gluster.org/documentation/About_Gluster/)

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## GlusterFS – Use Cases

- Red Hat targets three markets:
  - On site
  - Public cloud
  - Private cloud

# GlusterFS – Requirements

- Packages:
  - `ntp glusterfs-server glusterfs-fuse glusterfs nfs-utils, selinux-policy-targeted`
- Extra daemons:
  - `systemctl enable ntpd`
  - `systemctl start ntpd`
  - `timedatectl set-ntp 1`
- Firewall rules

# GlusterFS – Sample Configuration

- On both nodes:
  - `dasdfmt -b 4096 -y /dev/dasdf`
  - `fdasd -a /dev/dasdf`
  - `pvccreate /dev/dasdf1`
  - `vgcreate -cn vg_gluster /dev/dasdf1`
  - `vgchange -ay vg_gluster`
  - `lvcreate -L120M -n gluster_vol vg_gluster`
  - `mkfs.xfs /dev/mapper/vg_gluster-gluster_vol`
  - `mount /dev/mapper/vg_gluster-gluster_vol /mnt/gluster/`
  - `gluster volume create vol1 replica 2 rh7cn1:/mnt/gluster/brick rh7cn2:/mnt/gluster/brick`
  - `gluster volume start vol1`
  - `mount -t glusterfs localhost:/vol1 /mnt/store`

# GlusterFS – Sample Configuration

- On one node:
  - echo “ABCDEF” >/mnt/store/test.file
- On both nodes:
  - ls -l /mnt/store  
total 1  
-rw-r--r--. 1 root root 7 Oct 7 15:26 test.file
  - cat /mnt/store/test.file  
ABCDEF

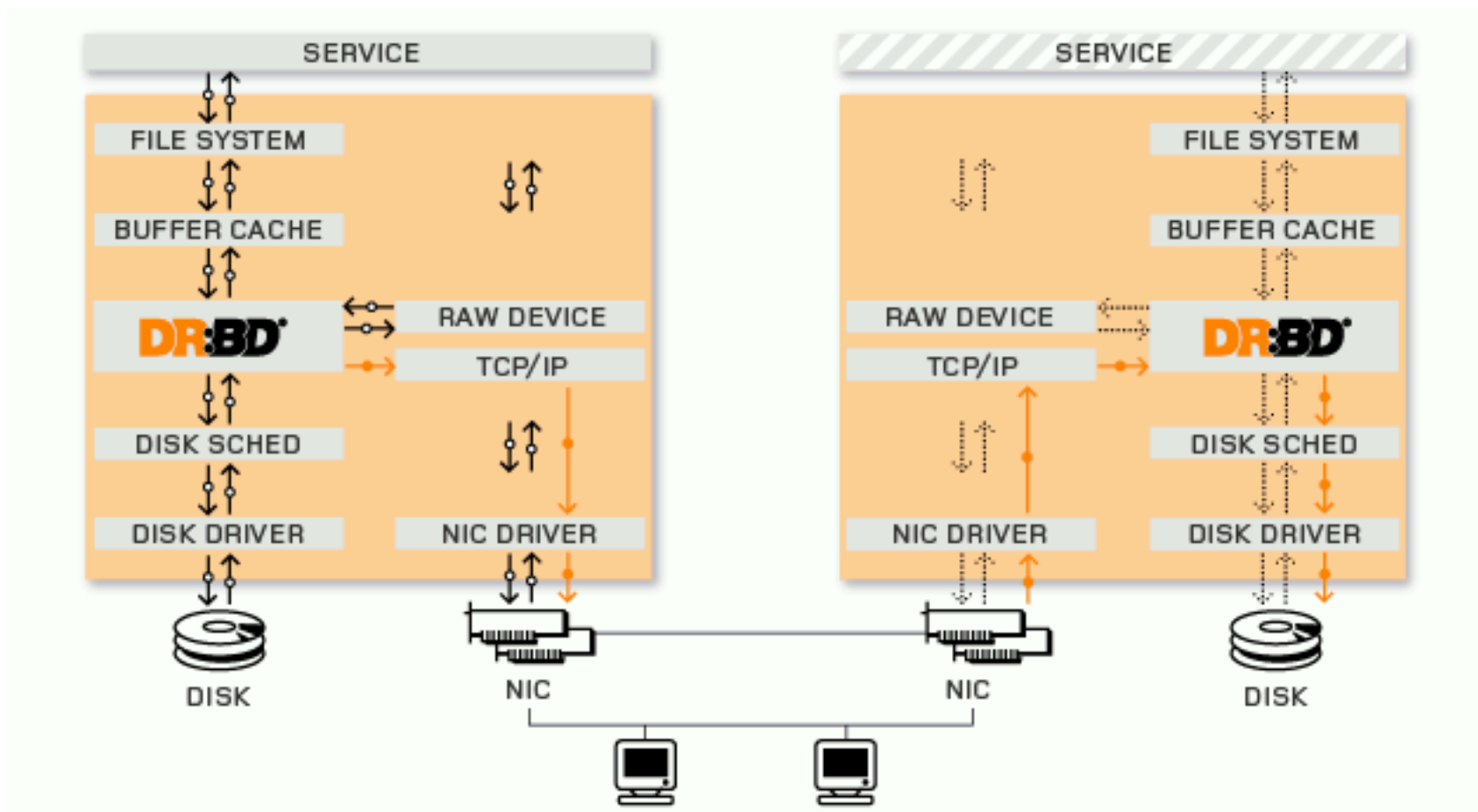
# DRBD

- Features
- Use cases
- Requirements

## DRBD - Features

- DRBD refers to block devices designed as a building block to form high availability (HA) clusters
- A whole block device is mirrored via the network
- DRBD often described as network based RAID-1
- Implemented as several userspace management applications
- Very loosely - PPRC/*XDR-lite*
- GPLv2 license

# DRBD - Features



Source: <http://drbd.linbit.com/>

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## DRBD – Use Cases

- Consistency:
  - Design point is 100% consistency
  - Uptime is a secondary goal
  - Use with databases such as mysql
- Access:
  - Multiple primaries with multiple secondaries all interconnected
- Scale-out



# DRBD – Requirements

- Packages:
  - drbd-kmod, drbd-utils, drbd-pacemaker
- Firewall:
  - Access to port 7789

```
<?xml version="1.0" encoding="utf-8"?>
```

```
<service>
```

```
  <short>Distributed Replicated Block Device</short>
```

```
  <description>This allows you to use the Distributed Replicated Block Device</description>
```

```
  <port protocol="tcp" port="7789"/>
```

```
</service>
```

- `firewall-cmd --permanent --add-service drbd`

# DRBD – Sample Configuration

```
resource disk1
{
    :
    syncer {
        rate 100M;
        verify-alg sha1;
    }

    on rh7cn1.devlab.sinenomine.net {
        device minor 1;
        disk /dev/disk/by-path/ccw-0.0.0301-part1;
        address 172.17.16.147:7789;
        meta-disk internal;
    }

    on rh7cn2.devlab.sinenomine.net {
        device minor 1;
        disk /dev/disk/by-path/ccw-0.0.0301-part1;
        address 172.17.16.148:7789;
        meta-disk internal;
    }
}
```

# DRBD – Sample Configuration

- On both nodes
  - drbdadm create-md disk1
- On primary node
  - /sbin/drbdadm -- --overwrite-data-of-peer primary disk1
  - mkfs.xfs /dev/drbd1
  - tail -20 /var/log/messages >/mnt/drbd/test.file
  - cat /mnt/drbd/test.file

```
Oct 23 13:44:42 rh7cn1 kernel: block drbd1: peer
0000000000000004:0000000000000000:0000000000000000:0000000000000000 bits:35986 flags:0 Oct 23 13:44:42
rh7cn1 kernel: block drbd1: uuid_compare()=2 by rule 30
Oct 23 13:44:42 rh7cn1 kernel: block drbd1: Becoming sync source due to disk states.
```
  - umount /mnt/drbd
  - drbdadm secondary disk1
- On secondary node
  - drbdadm primary disk1
  - mount /dev/drbd1 /mnt/drbd
  - ls -l /mnt/drbd

```
total 4
-rw-r--r--. 1 root root 2076 Oct 23 13:55 test.file
```

# Node 1 & 2 – Cluster Status

```
ZVMPOWER (stonith:fence_zvm): Started rh7cn2.devlab.sinenomine.net
Clone Set: dlm-clone [dlm]
  Started: [ rh7cn2.devlab.sinenomine.net ]
  Stopped: [ rh7cn1.devlab.sinenomine.net ]
Resource Group: apachegroup
  VirtualIP (ocf::heartbeat:IPaddr2): Started rh7cn2.devlab.sinenomine.net
  Website (ocf::heartbeat:apache): Started rh7cn2.devlab.sinenomine.net
  httplvm (ocf::heartbeat:LVM): Started rh7cn2.devlab.sinenomine.net
  http_fs (ocf::heartbeat:Filesystem): Started rh7cn2.devlab.sinenomine.net
Clone Set: clvmd-clone [clvmd]
  Started: [ rh7cn2.devlab.sinenomine.net, rh7cn1.devlab.sinenomine.net ]
Clone Set: clusterfs-clone [clusterfs]
  Started: [ rh7cn2.devlab.sinenomine.net, rh7cn1.devlab.sinenomine.net ]
Master/Slave Set: GDPSClone [GDPS]
  Masters: [ rh7cn2.devlab.sinenomine.net ]
  Slaves: [ rh7cn1.devlab.sinenomine.net ]
GDPSFS (ocf::heartbeat:Filesystem): Started rh7cn2.devlab.sinenomine.net
brick1 (ocf::heartbeat:Filesystem): Stopped
brick2 (ocf::heartbeat:Filesystem): Started rh7cn2.devlab.sinenomine.net
Clone Set: glusterd-clone [glusterd]
  Started: [ rh7cn2.devlab.sinenomine.net, rh7cn1.devlab.sinenomine.net ]
gvoll1 (ocf::glusterfs:volume): Started rh7cn1.devlab.sinenomine.net
gvoll2 (ocf::glusterfs:volume): Started rh7cn2.devlab.sinenomine.net
store1 (ocf::heartbeat:Filesystem): Started rh7cn1.devlab.sinenomine.net
store2 (ocf::heartbeat:Filesystem): Started rh7cn2.devlab.sinenomine.net
```

# Node 1 & 2 – Active File Systems

Filesystem	Type	Size	Used	Avail	Use%	Mounted on
/dev/mapper/rhel_rh7cn2-root	xfs	3.7G	1.9G	1.8G	53%	/
/dev/mapper/rhel_rh7cn2-boot	xfs	494M	104M	391M	21%	/boot
/dev/mapper/vg_gluster-gluster_vol	xfs	114M	6.3M	108M	6%	/mnt/gluster
localhost:/voll	fuse.glusterfs	114M	6.3M	108M	6%	/mnt/store
/dev/drbd1	xfs	135M	7.3M	128M	6%	/mnt/drbd
/dev/mapper/vg_cluster-ha_lv	gfs2	300M	35M	266M	12%	/mnt/gfs2-demo
/dev/mapper/vg_apache-apache_lv	xfs	294M	16M	279M	6%	/var/www

# Ceph

- Features
- Use cases
- Requirements

## Ceph - Features

- Designed to present object, block, and file storage from a single distributed computer cluster
- Goals:
  - To be completely distributed without a single point of failure
  - Scalable to the exabyte level
- Fault tolerance via data replication

# Ceph - Components

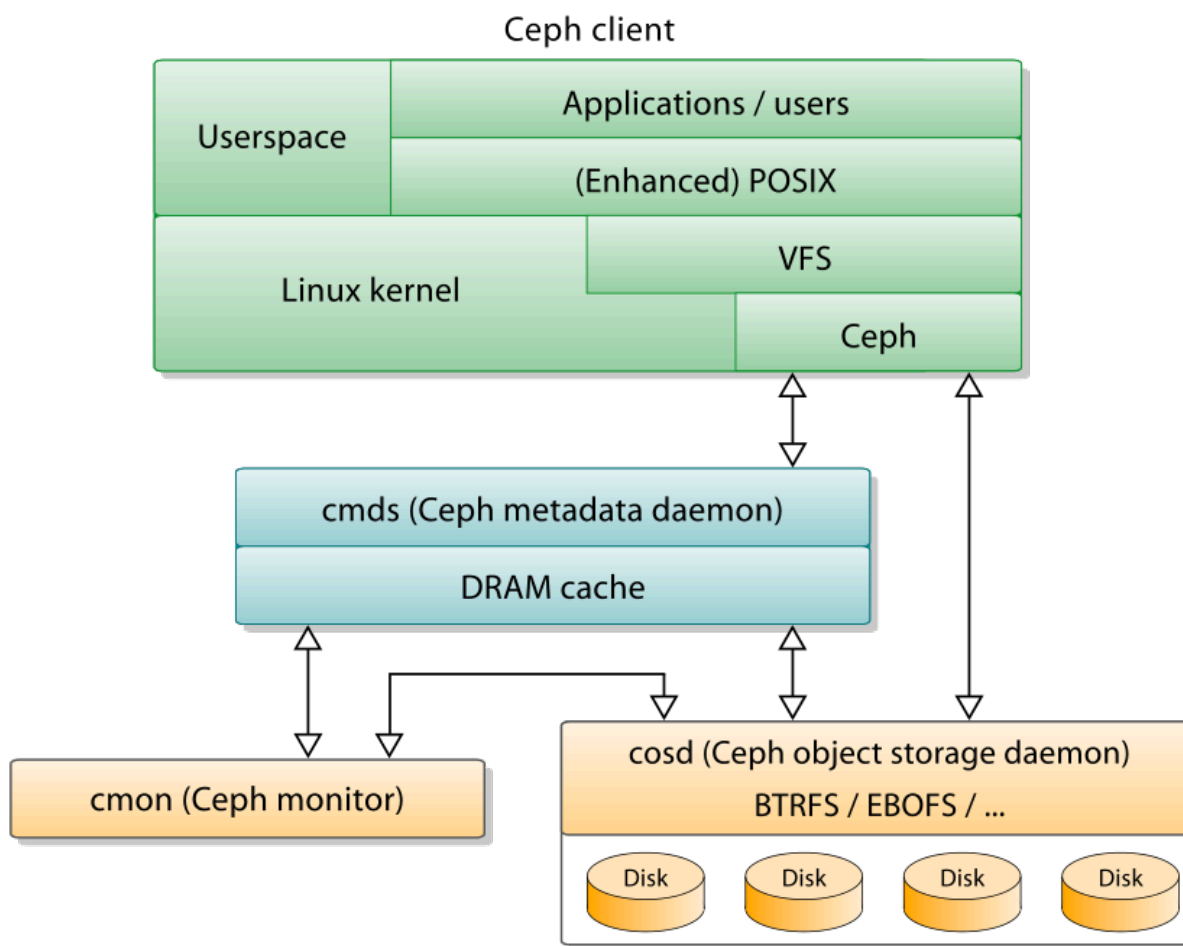
- Object servers
  - Stores data, handles data replication, recovery, backfilling, rebalancing, and provides some monitoring information
- Monitor
  - Maintains maps of the cluster state
- Metadata servers
  - Stores metadata enabling POSIX file system users to execute basic commands like `ls`, `find`, etc. without placing an enormous burden on the Ceph Storage Cluster
- Restful gateway
  - An object storage interface to provide applications with a RESTful gateway to Ceph Storage Clusters



## Ceph - Components

- All of these are fully distributed which may run on the same set of servers
- A Ceph Storage Cluster requires:
  - At least one Ceph Monitor
  - At least two Ceph OSD Daemons
  - The Ceph Metadata Server is essential when running Ceph Filesystem clients
- OSDs may be added and removed at runtime

# Ceph Architecture

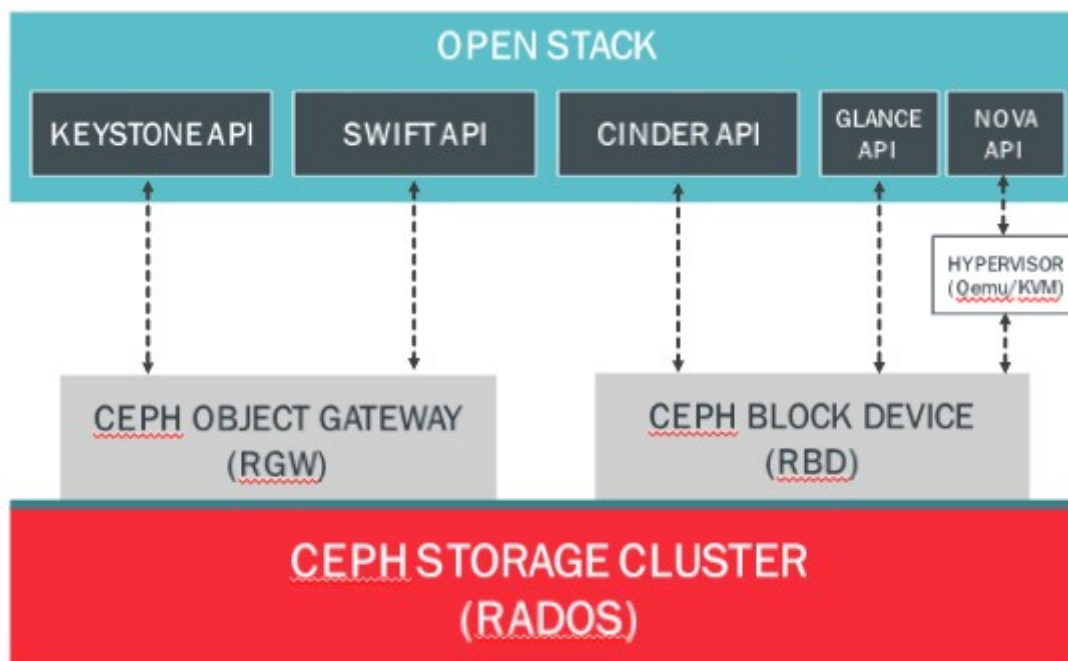


Source: M. Tim Jones (2010-06-04). "Ceph: A Linux petabyte-scale distributed file system" (PDF). IBM

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# Ceph – Use Cases

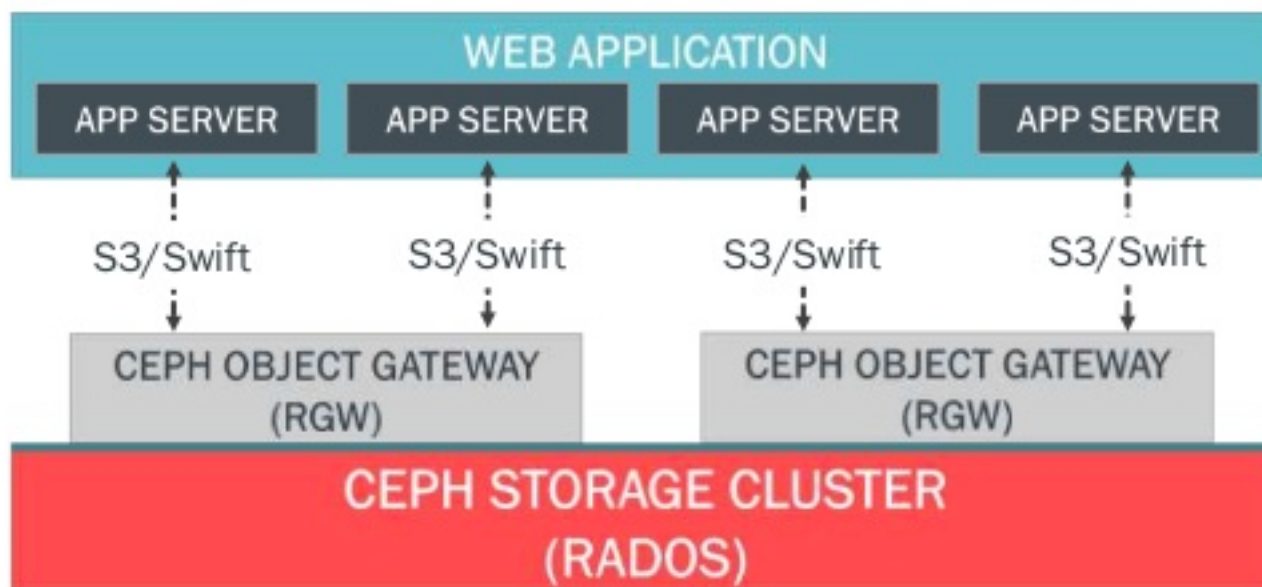
- Storage for an OpenStack-based cloud



Source: <http://www.enterprisetech.com/2014/07/16/ceph-clustered-storage-dons-red-hat/>

# Ceph – Use Cases

- Cloud storage for Web Applications

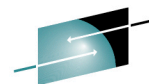


Source: © Inktank 2013

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# Ceph – Requirements

- Lots of RPMs (a pig to build):
  - ceph: User space components
  - ceph-common: Utilities to mount and interact with a storage cluster
  - cephfs-java: Java libraries for the Ceph File System
  - ceph-fuse: FUSE based client
  - ceph-radosgw: Rados REST gateway
  - libcephfs1: File system client library
  - libcephfs\_jni1: Java Native Interface library
  - librados2: RADOS distributed object store client library
  - python-ceph: Libraries for interacting with RADOS object storage
  - rbd-fuse: FUSE based client to map Ceph rbd images to files



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