Introduction to Highly Available NFS Server on scale-out storage systems based on GlusterFS

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AGENDA

- What is GlusterFS?
- Integration with NFS-Ganesha
- Clustered NFS
- Step-by-step guide
- Future Directions
- Q&A

GlusterFS

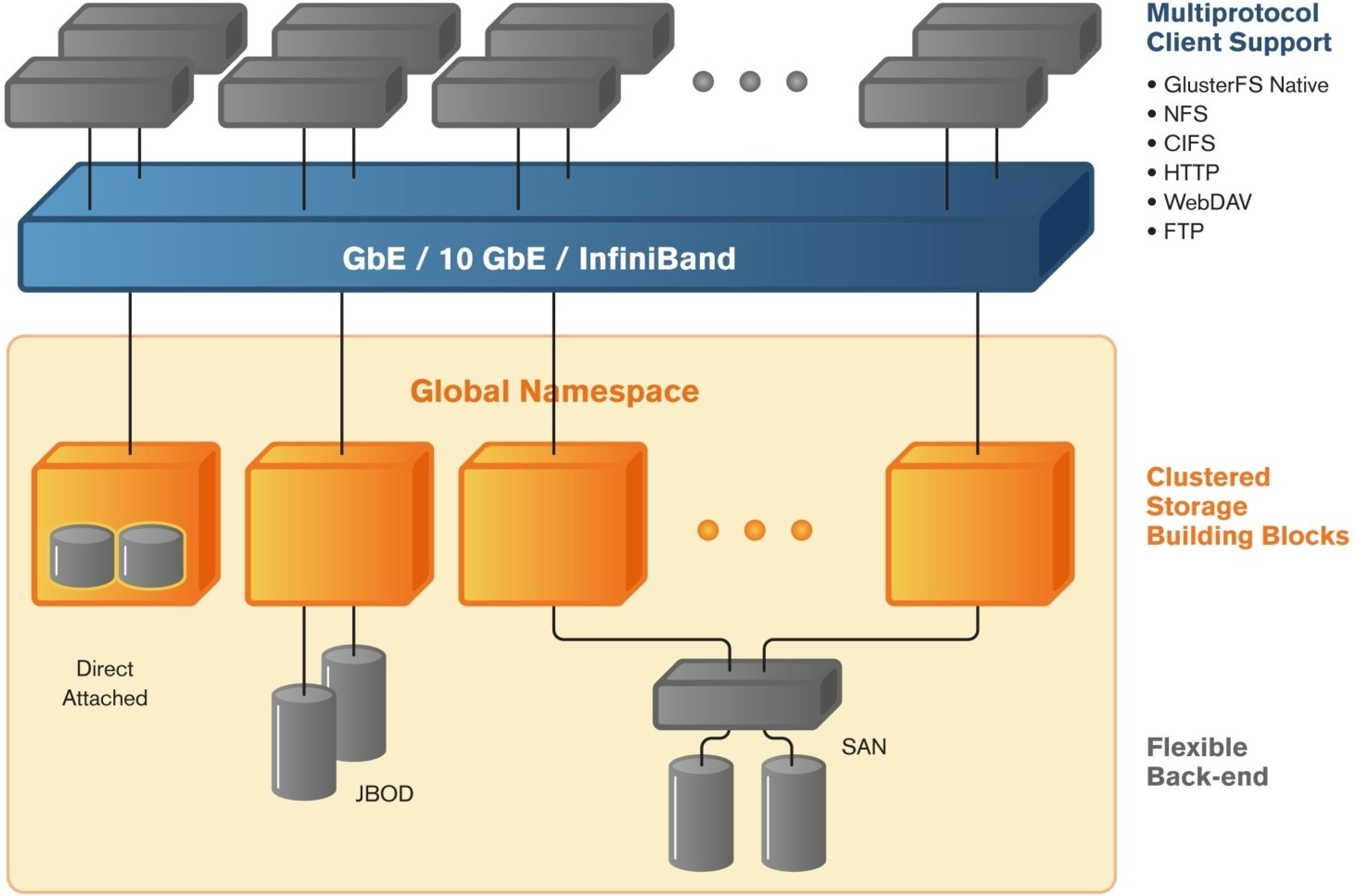
GlusterFS

- An open source, scale-out distributed file system
- Software Only and operates in user-space
- Aggregates Storage into a single unified namespace
- No metadata server architecture
- Provides a modular, stackable design
- Runs on commodity hardware

Architecture

- Data is stored on disk using native formats (e.g. ext4, XFS)
- Has client and server components
  - Servers, known as storage bricks (glusterfsd daemon), export local filesystem as volume
  - Clients (glusterfs process), creates composite virtual volumes from multiple remote servers using stackable translators
  - Management service (glusterd daemon) manages volumes and cluster membership

GlusterFS Deployment



Multiprotocol Client Support

- GlusterFS Native
- NFS
- CIFS
- HTTP
- WebDAV
- FTP

Clustered Storage Building Blocks

Flexible Back-end

Access Mechanisms

- FUSE based Native protocol
- NFSv3
- libgfapi
- ReST/HTTP
- HDFS

libgfapi

- A user-space library with APIs for accessing Gluster volumes.
- Reduces context switches.
- Many applications integrated with libgfapi (qemu, samba, NFS Ganesha).
- Both sync and async interfaces available.
- C and python bindings.
- Available via 'glusterfs-api*' packages.

NFS-Ganesha

NFS access

Why NFS:

- Widely used network protocol
- Many enterprises still heavily depend on NFS to access their data from different operating systems and applications.

Native NFS (referred as Gluster-NFS):

- Acts as GlusterFS client residing on the same node as the GlusterFS server.
- Supports only NFSv3 protocol
- Not strictly protocol-complaint

NFS-Ganesha

- A user-space, protocol-complaint NFS file server
- Supports NFS v3, 4.0, 4.1, pNFS and 9P from the Plan9 operating system.
- Provides a FUSE-compatible File System Abstraction Layer(FSAL) to plug in to any own storage mechanism
- Can provide simultaneous access to multiple file systems.

Active participants:

- CEA, Panasas, Red Hat, IBM, LinuxBox

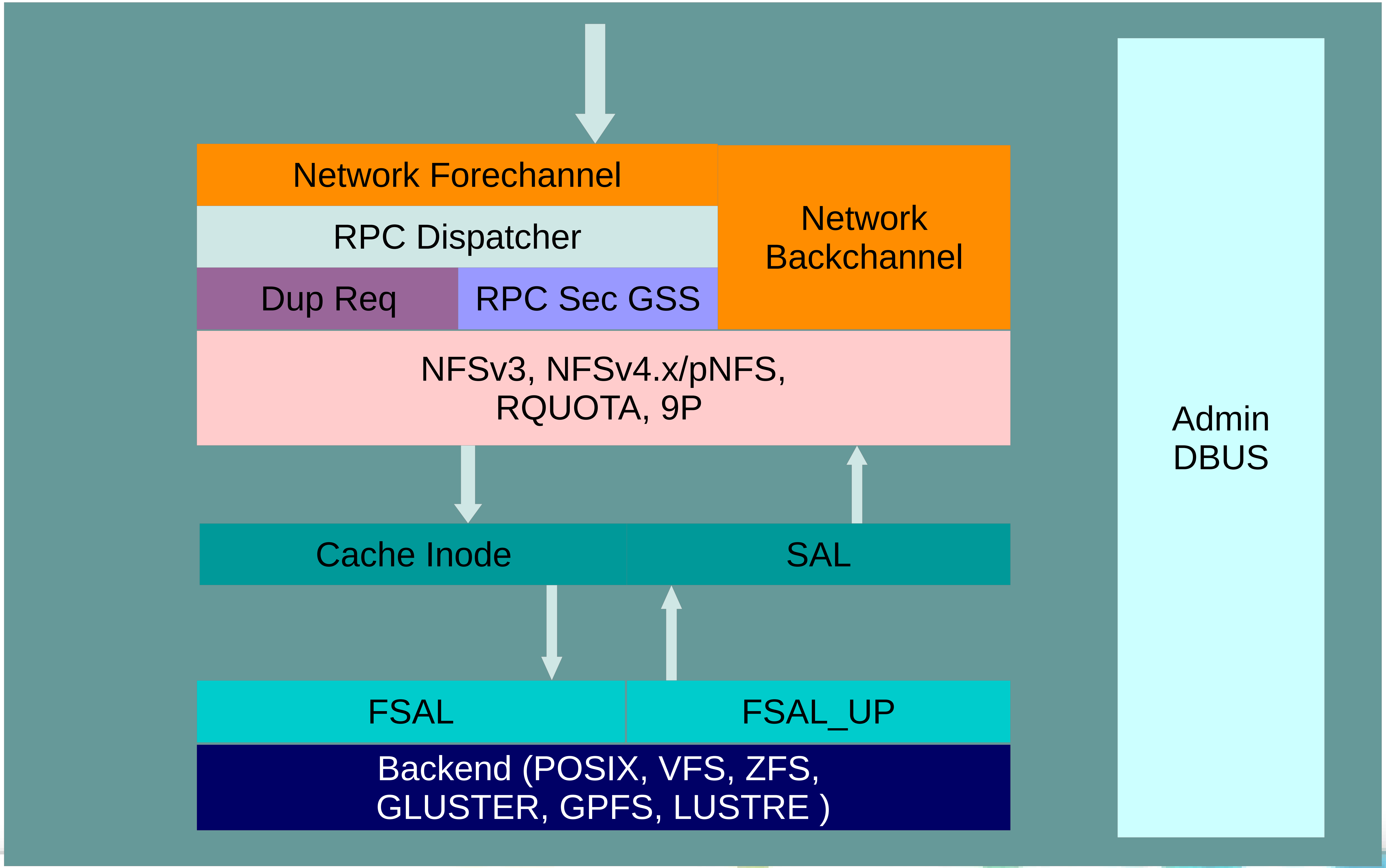
Benefits of NFS-Ganesha

- Dynamically export/unexport entries using D-Bus mechanism.
- Can manage huge meta-data and data caches
- Can act as proxy server for NFSv4
- Provides better security and authentication mechanism for enterprise use
- Portable to any Unix-like file-systems
- Easy access to the services operating in the user-space (like Kerberos, NIS, LDAP)

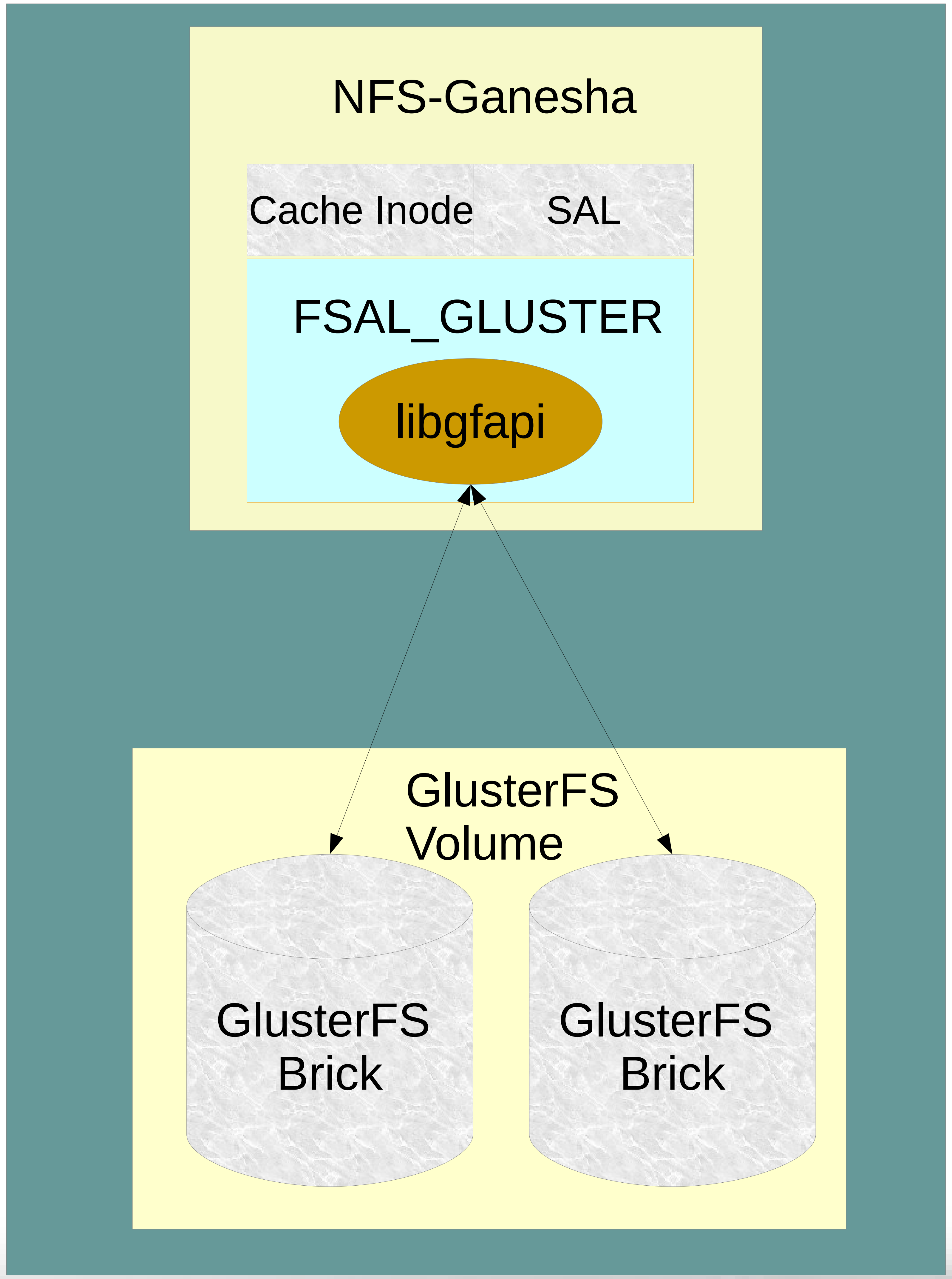
Modular Architecture

- **RPC Layer**: implements ONC/RPCv2 and RPCSEC_GSS (based on libntirpc)
- **FSAL**: File System Abstraction Layer, provides an API to generically address the exported namespace
- **Cache Inode**: manages the metadata cache for FSAL. It is designed to scale to millions of entries
- **FSAL UP**: provides the daemon with a way to be notified by the FSAL that changes have been made to the underlying FS outside Ganesha. These information is used to invalidate or update the Cache Inode.

NFS-Ganesha Architecture



NFS-Ganesha + GlusterFS



Integration with GlusterFS

➢ Integrated with GlusterFS using 'libgfapi' library

That means,

◆ Additional protocol support w.r.t. NFSv4, pNFS

◆ Better security and authentication mechanisms for enterprise use.

◆ Performance improvement with additional caching

Clustered NFS

Clustered NFS

- Stand-alone systems :
  - are always bottleneck.
  - cannot scale along with the back-end storage system.
  - not suitable for mission-critical services
- Clustering:
  - High availability
  - Load balancing
  - Different configurations:
    - Active-Active
    - Active-Passive

Challenges Involved

- Cluster wide change notifications for cache invalidations
- Coordinate Grace period across nodes in the cluster
- Maintain and recover lock, share reservation and delegations state
- Provide "high availability" to stateful parts of NFS
  - Share state across the cluster to allow failover
  - IP Failover in case of node failure
  - Lock recovery in case of node failure

Active-Active HA solution on GlusterFS

Primary Components

- Pacemaker
- Corosync
- PCS
- Resource agents
- HA setup scipt ('ganesha-ha.sh')
- Shared Storage Volume
- UPCALL infrastructure

Clustering Infrastructure

- Using Open-source services
- **Pacemaker**: Cluster resource manager that can start and stop resources
- **Corosync**: Messaging component which is responsible for communication and membership among the machines
- **PCS**: Cluster manager to easily manange the cluster settings on all nodes

Cluster Infrastructure

- **Resource-agents** : Scripts that know how to control various services.
- New resource-agent scripts added to
  - **ganesha_mon**: Monitor NFS service on each node & failover the Virtual IP
  - **ganesha_grace**: Puts entire cluster to Grace
- If NFS service down on any of the nodes
  - Entire cluster is put into grace via D-bus signal
  - Virtual IP fails over to a different node (within the cluster).

HA setup script

- Located at `/usr/libexec/ganesha/ganesha-ha.sh`.
- Sets up, tears down and modifies the entire cluster.
- Creates resource-agents required to monitor NFS service and IP failover.
- Integrated with new Gluster CLI introduced to configure NFS-Ganesha.
- Primary Input: `ganesha-ha.conf` file with the information about the servers to be added to the cluster along with Virtual IPs assigned, usually located at `/etc/ganesha`.

Upcall infrastructure

- A generic and extensible framework.
  - used to maintain states in the glusterfsd process for each of the files accessed
  - sends notifications to the respective glusterfs clients in case of any change in that state.
- Cache-Invalidation: Needed by NFS-Ganesha to serve as Multi-Head

  Config options:

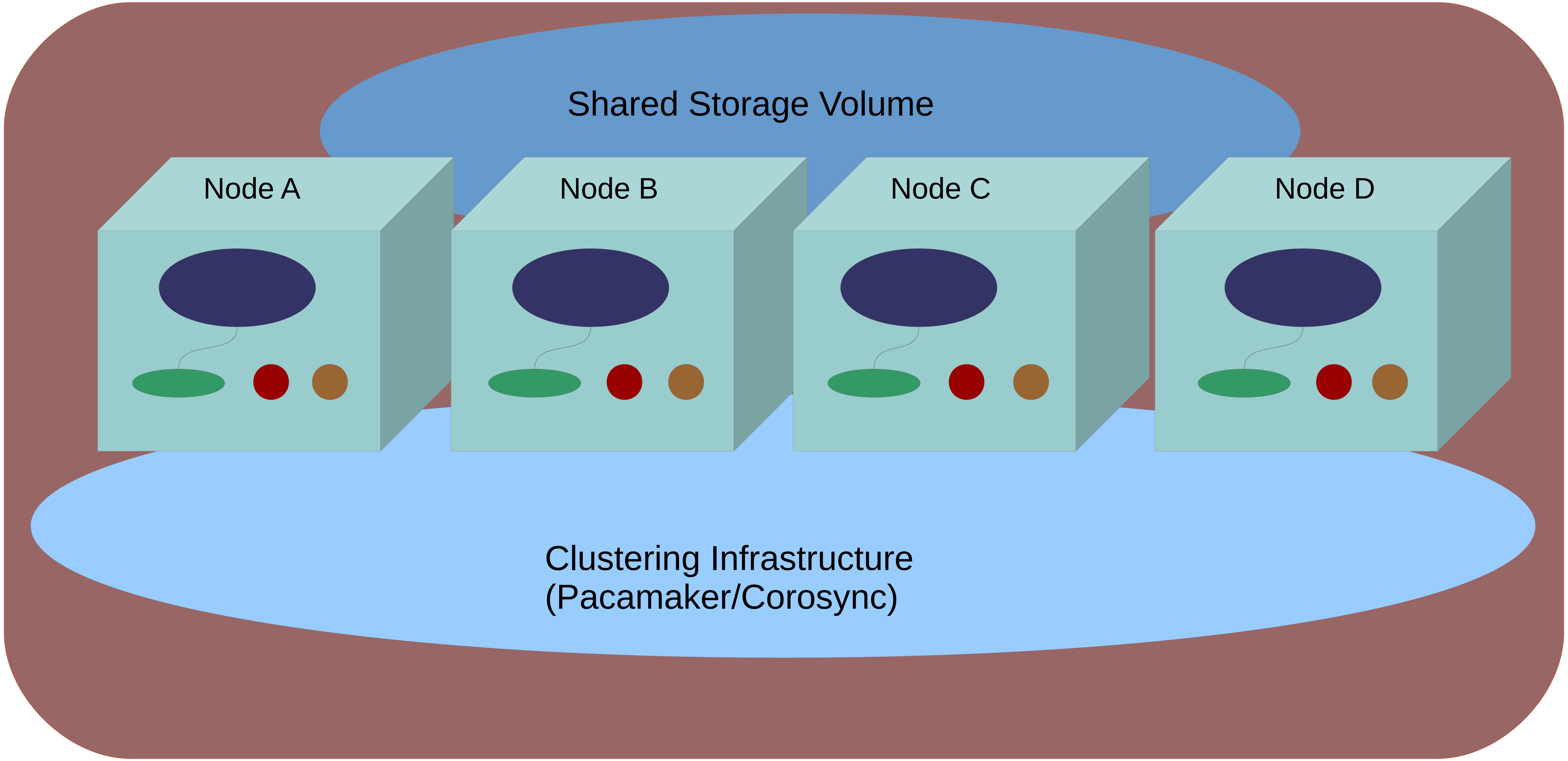
```
#gluster vol set <volname> features.cache-invalidation on/off
#gluster vol set <volname> features.cache-invalidation-timeout
<value>
```

Shared Storage Volume

- Provides storage to share the cluster state across the NFS servers in the cluster
- This state is used during failover for Lock recovery
- Can be created and mounted on all the nodes using the following gluster CLI command -

```
#gluster volume set all cluster.enable-shared-storage
enable
```

Clustered NFS-Ganesha



Shared Storage Volume

Node A

Node B

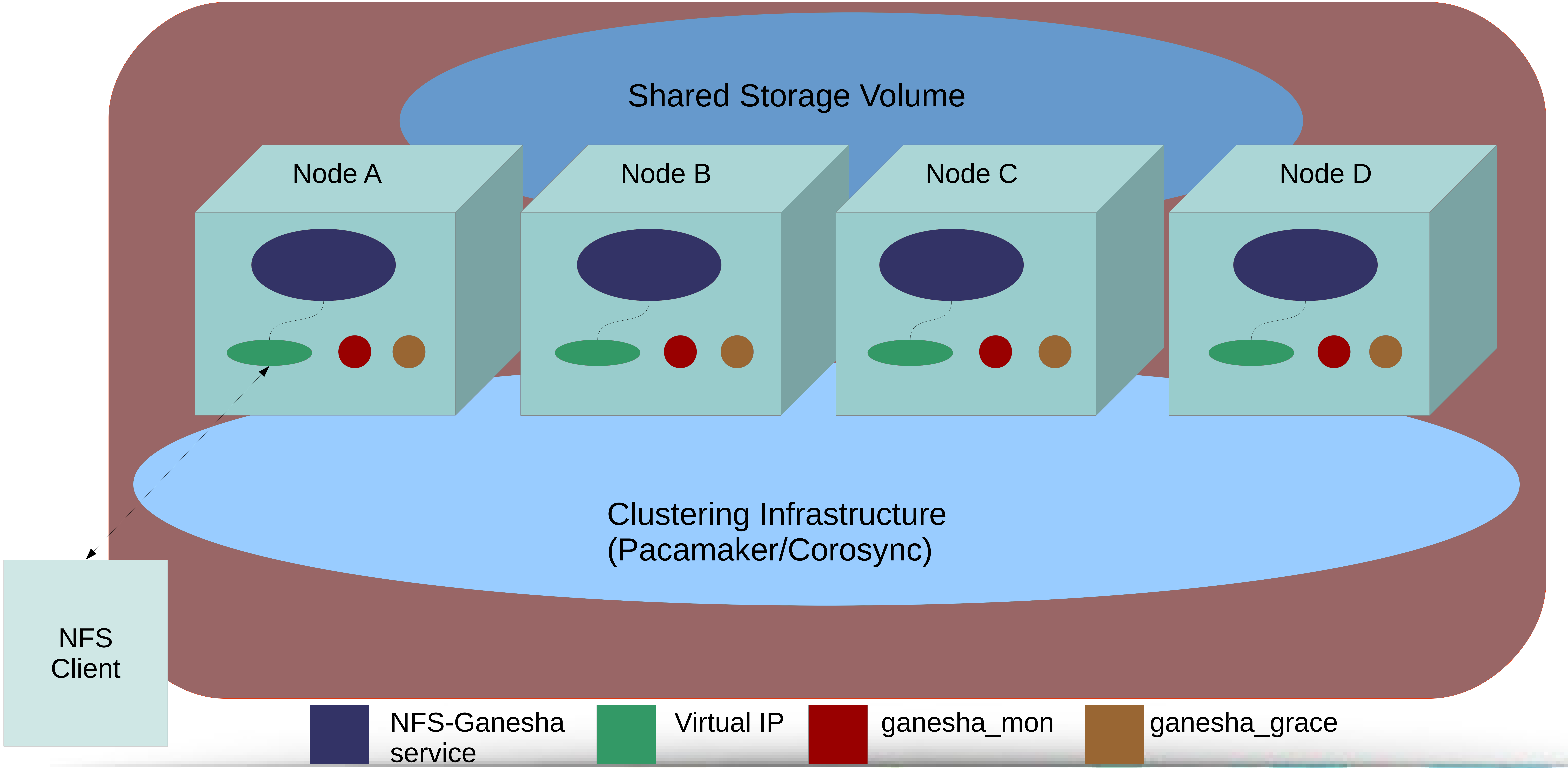
Node C

Node D

Clustering Infrastructure
(Pacamaker/Corosync)

🟦 NFS-Ganesha service 🟩 Virtual IP 🟥 ganesha_mon 🟫 ganesha_grace

Clustered NFS-Ganesha



Shared Storage Volume

Node A

Node B

Node C

Node D

Clustering Infrastructure
(Pacamaker/Corosync)

NFS
Client

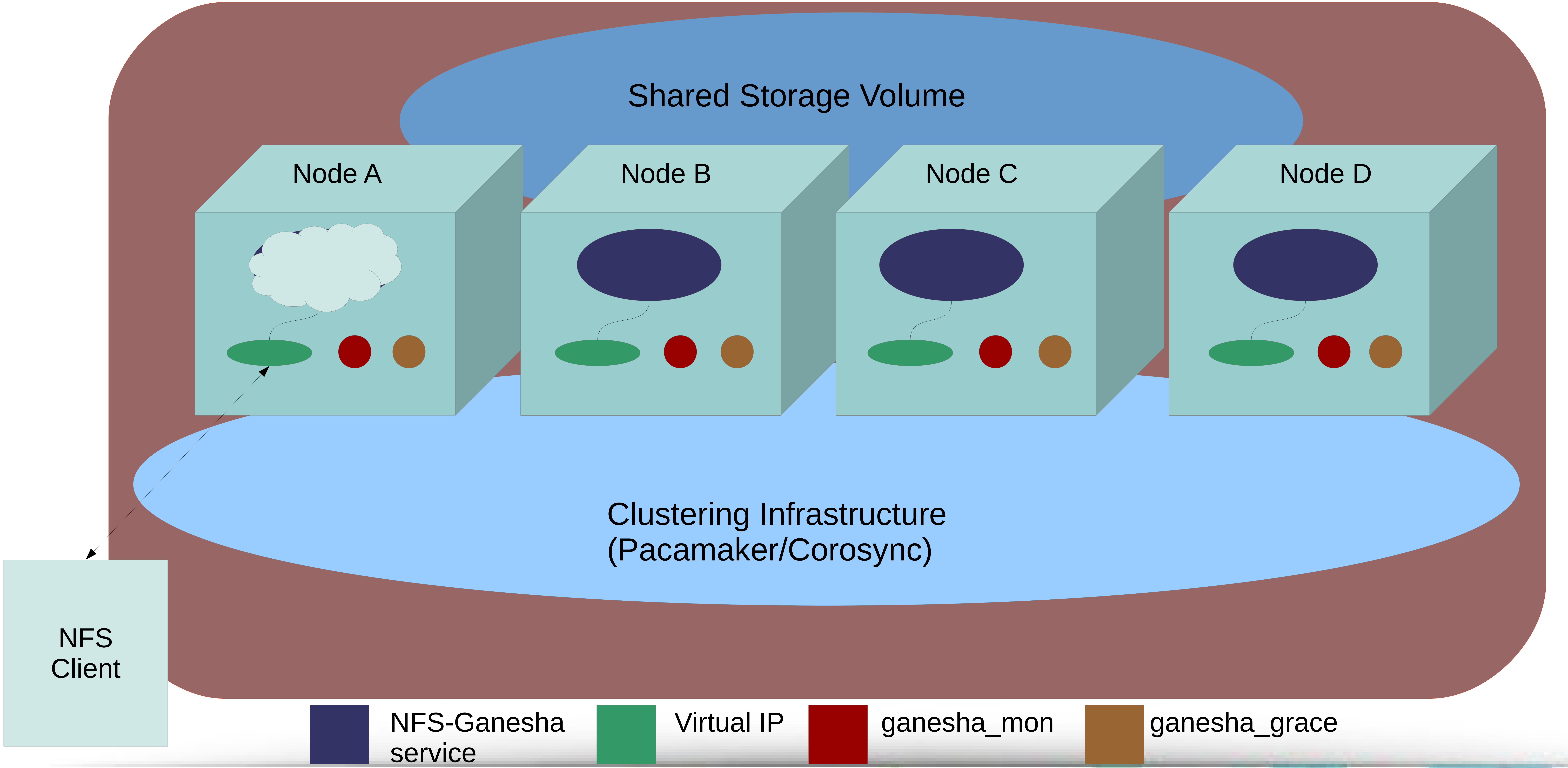
🟦 NFS-Ganesha service

🟩 Virtual IP

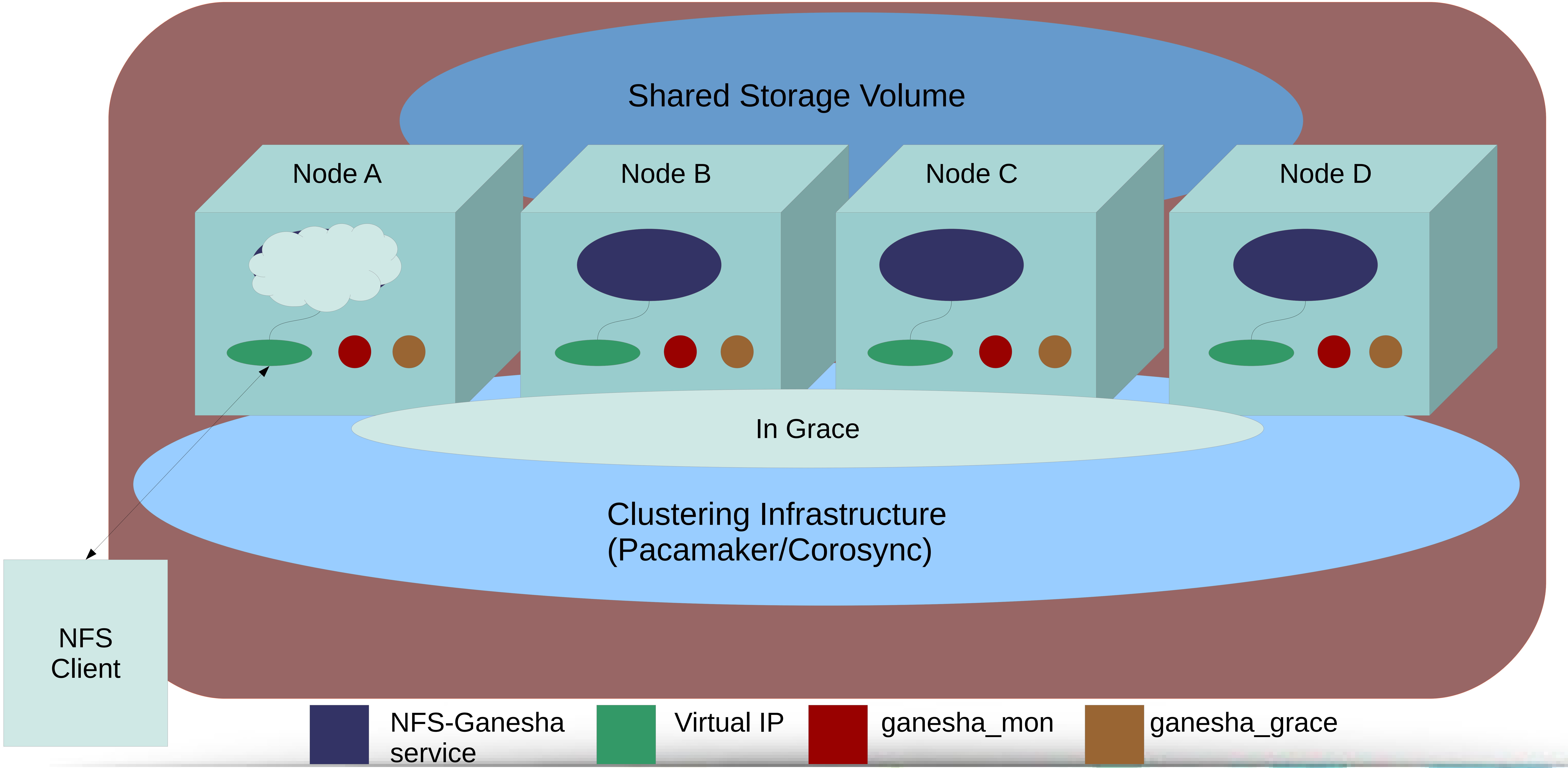
🟥 ganesha_mon

🟫 ganesha_grace

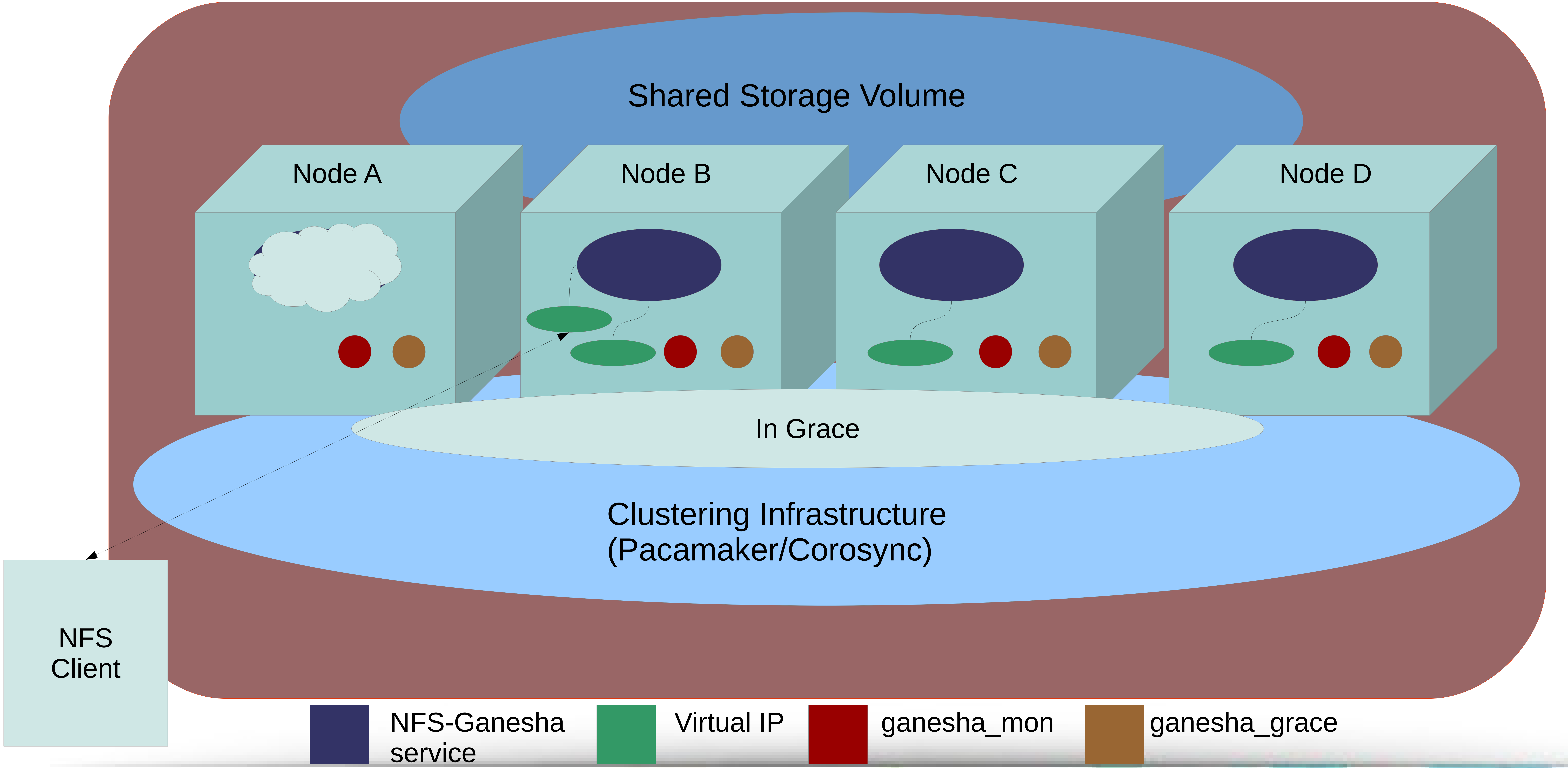
Clustered NFS-Ganesha



Clustered NFS-Ganesha



Clustered NFS-Ganesha



Step-by-step guide

Required Packages

Gluster RPMs (>= 3.7)

- glusterfs-server
- glusterfs-ganesha

Ganesha RPMs (>= 2.2)

- nfs-ganesha
- nfs-ganesha-gluster

Pacemaker & pcs RPMs

Pre-requisites

- Ensure all machines are DNS resolvable
- Disable and stop NetworkManager service, enable and start network service on all machines
- Enable IPv6 on all the cluster nodes.
- Install pacemaker pcs ccs resource-agents corosync
  - `#yum -y install pacemaker pcs ccs resource-agents corosync`` on all machines`
- Enable and start pcsd on all machines
  - `#chkconfig --add pcsd; chkconfig pcsd on; service pcsd start`
- Populate `/etc/ganesha/ganesha-ha.conf` on all the nodes.

Pre-requisites

- Create and mount the Gluster shared volume on all the machines
- Set cluster auth password on all machines

```
#echo redhat | passwd --stdin hacluster
#pcs cluster auth on all the nodes
```

- Passwordless ssh needs to be enabled on all the HA nodes.
  - On one (primary) node in the cluster, run:

    #ssh-keygen -f /var/lib/glusterd/nfs/secret.pem
  - Deploy the pubkey ~root/.ssh/authorized keys on _all_ nodes, run:

    ```
    #ssh-copy-id -i /var/lib/glusterd/nfs/secret.pem.pub root@$node
    ```

Sample 'ganesha-ha.conf'

```
# Name of the HA cluster created. must be unique within the subnet
HA_NAME="ganesha-ha-360"
# The gluster server from which to mount the shared data volume.
HA_VOL_SERVER="server1"
# The subset of nodes of the Gluster Trusted Pool that form the ganesha HA cluster.
# Hostname is specified.
HA_CLUSTER_NODES="server1,server2,..."
#HA_CLUSTER_NODES="server1.lab.redhat.com,server2.lab.redhat.com,..."
# Virtual IPs for each of the nodes specified above.
VIP_server1="10.0.2.1"
VIP_server2="10.0.2.2"
```

Setting up the Cluster

New CLIs introduced to configure and manage NFS-Ganesha cluster & Exports

```
#gluster nfs-ganesha <enable/disable>
```

- Disable Gluster-NFS
- Start/stop NFS-Ganesha services on the cluster nodes.
- Setup/teardown the NFS-Ganesha cluster.

```
#gluster vol set <volname> ganesha.enable on/off
```

- Creates export config file with default parameters
- Dynamically export/unexport volumes.

Modifying the Cluster

- Using HA script `ganesha-ha.sh` located at `/usr/libexec/ganesha`.
- Execute the following commands on any of the nodes in the existing NFS-Ganesha cluster
- To add a node to the cluster:

```
#./ganesha-ha.sh --add <HA_CONF_DIR> <HOSTNAME> <NODE-VIP>
```

- To delete a node from the cluster:

```
#./ganesha-ha.sh --delete <HA_CONF_DIR> <HOSTNAME>
```

Where, HA_CONF_DIR: The directory path containing the ganesha-ha.conf file.
HOSTNAME: Hostname of the new node to be added
NODE-VIP: Virtual IP of the new node to be added.

Modifying Export parameters

On any of the nodes in the existing ganesha cluster:

- Edit/add the required fields in the corresponding export file located at `/etc/ganesha/exports`.
- Execute the following command:

```
#./ganesha-ha.sh --refresh-config <HA_CONFDIR> <Volname>
```

Where,

- HA_CONFDIR: The directory path containing the ganesha-ha.conf file
- Volname: The name of the volume whose export configuration has to be changed.

Next

pNFS (Parallel Network File System)

- Introduced as part of NFSv4.1 standard protocol
- Needs a cluster consisting of M.D.S. (meta data server) and D.S. (Data server)
- Any filesystem can provide pNFS access via NFS-Ganesha by means of the FSAL easy plugin architecure
- Support for pNFS protocol ops added to FSAL_GLUSTER (in NFS-Ganesha V2.2)
- Currently supports only FILE LAYOUT

Future Directions

- NFSv4 paves the way forward for interesting stuff
- Adding NFSv4.x feature support for GlusterFS
  - Directory Delegations
  - Sessions
  - Server-side copy
  - Application I/O Advise (like posix_fadvise)
  - Sparse file support/Space reservation
  - ADB support
  - Security labels
  - Flex File Layouts in pNFS

Contact

Mailing lists:

- nfs-ganesha-devel@lists.sourceforge.net
- gluster-users@gluster.org
- gluster-devel@nongnu.org

IRC:

- #ganesha on freenode
- #gluster and #gluster-dev on freenode
- team: Apeksha, ansubram, jiffin, kkeithley, meghanam, ndevos, saurabh, skoduri

References & Links

Links (Home Page):

- https://github.com/nfs-ganesha/nfs-ganesha/wiki
- http://www.gluster.org

References:

http://gluster.readthedocs.org

http://blog.gluster.org/

http://www.nfsv4bat.org/Documents/ConnectAThon/2012/NFS-GANESHA_cthon_2012.pdf

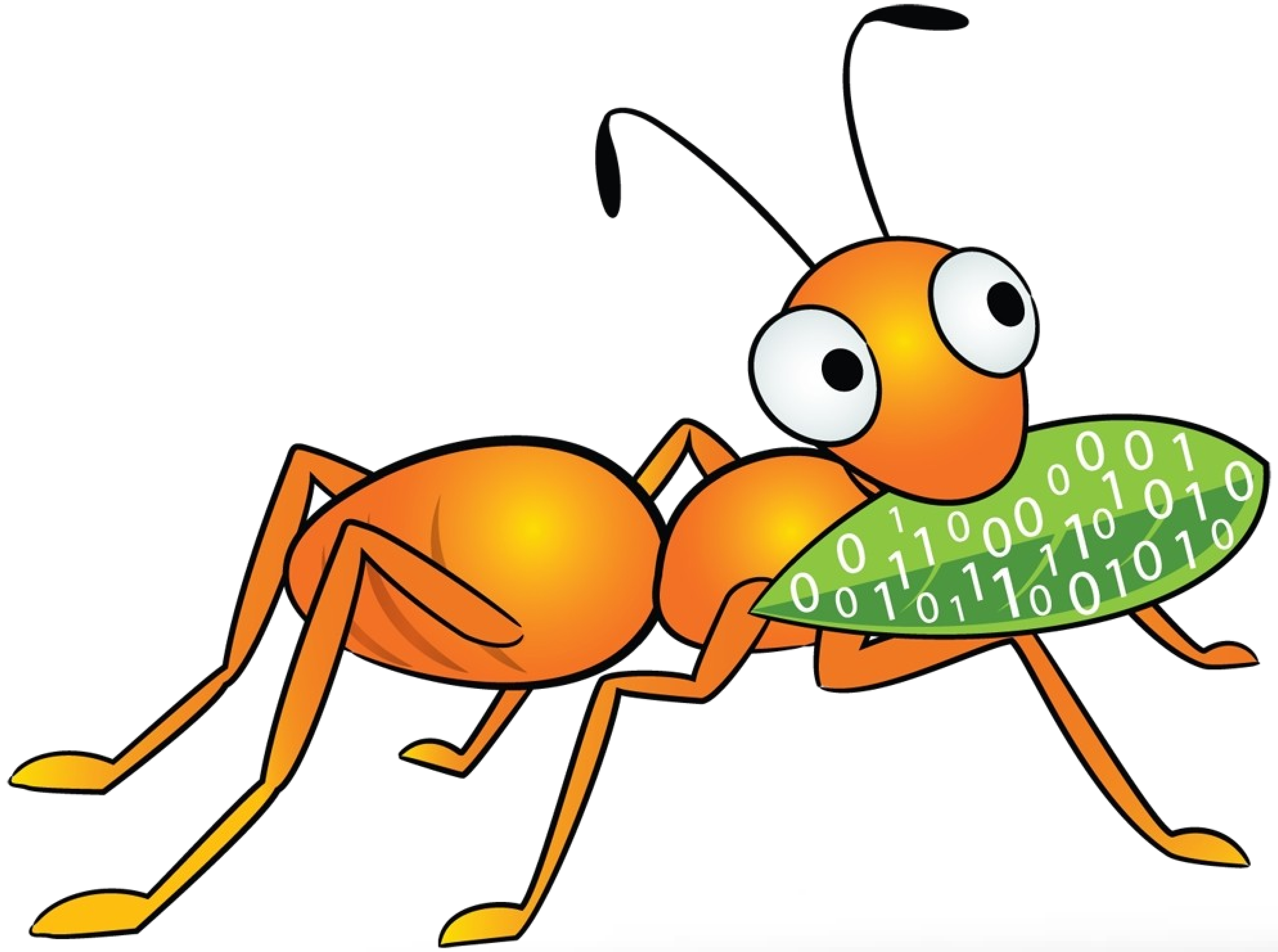
http://events.linuxfoundation.org/sites/events/files/slides/Collab14_nfsGanesha.pdf

http://www.snia.org/sites/default/files/Poornima_NFS_GaneshaForClusteredNAS.pdf

http://clusterlabs.org/doc/

Q & A

Thank you!



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