GlusterFS

A Scale-out Software Defined Storage

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usenix LISA15

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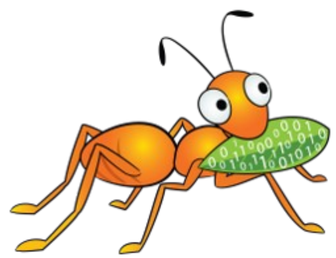
AGENDA

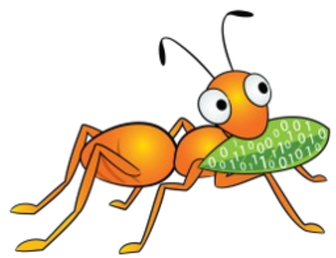
- Introduction
- GlusterFS Concepts
- Architecture
- Additional Features
- Installation
- Setup and Configuration
- Future Work
- Q&A



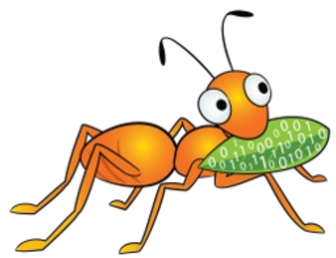
GlusterFS

- Open-source general purpose scale-out distributed file system
- Aggregates storage exports over network interconnect to provide a single unified namespace
- Layered on disk file systems that support extended attributes

- No meta-data server
- Modular Architecture for Scale and Functionality
- Heterogeneous commodity hardware
- Scalable to petabytes & beyond



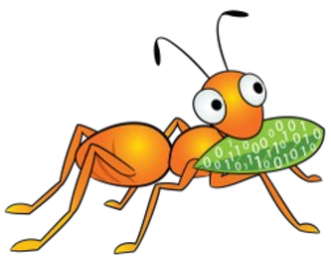
GlusterFS Concepts



Node

A node is server capable of hosting GlusterFS bricks

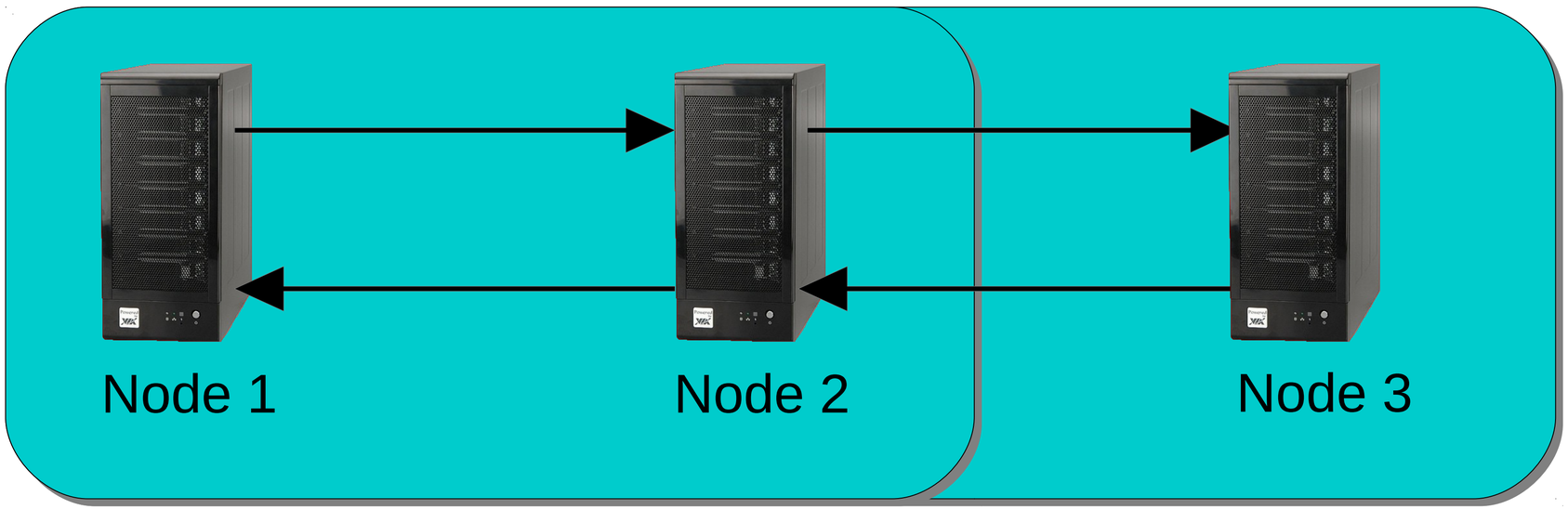
- **Server**
  - Intel/AMD x86 64-bit processor
  - Disk: 8GB minimum using direct-attached-storage, RAID, Amazon EBS, and FC/Infiniband/iSCSI SAN disk backends using SATA/SAS/FC disks
  - Memory: 1GB minimum
- **Logical Volume Manager**
  - LVM2 with thin provisioning
- **Networking**
  - Gigabit Ethernet
  - 10 Gigabit Ethernet
  - InfiniBand (OFED 1.5.2 or later)
- **Filesystem**
  - POSIX w/ Extended Attributes (EXT4, XFS, BTRFS, …)

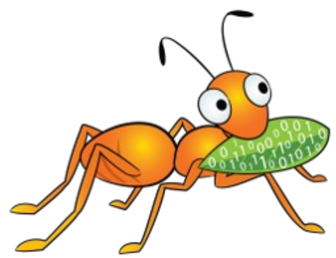


Trusted Storage Pool

A collection of storage servers (Node)

- Also known as Cluster
- Trusted Storage Pool is formed by invitation – ***"probe"***
- Members can be dynamically added and removed from the pool
- Only nodes in a Trusted Storage Pool can participate in volume creation

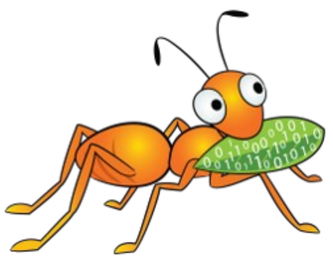




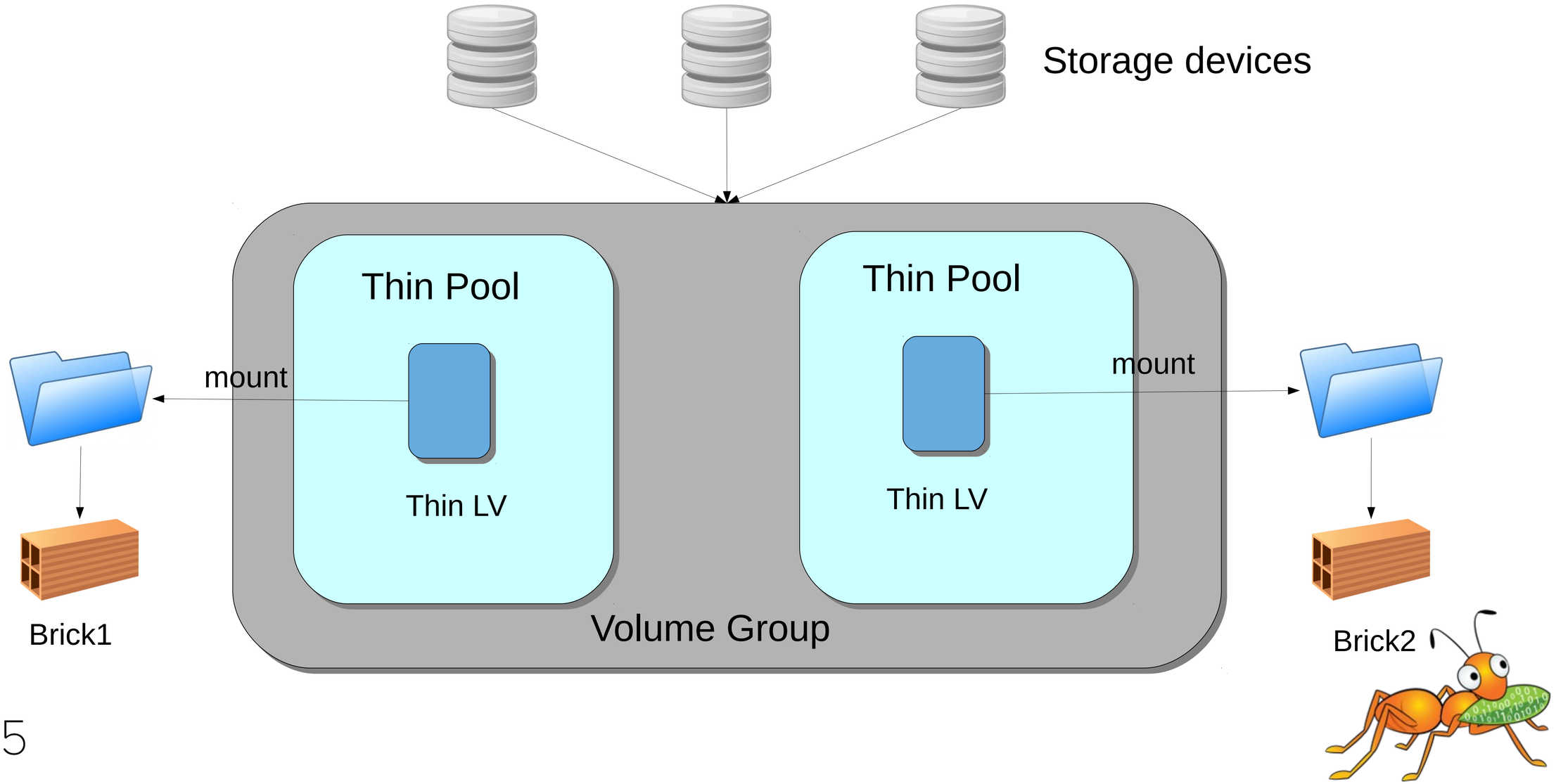
Bricks

A unit of storage used as a capacity building block

- A brick is the combination of a node and an export directory – e.g. hostname:/dir
- Layered on posix compliant file-system (e.g. XFS, ext4)
- Each brick inherits limits of the underlying filesystem
- It is recommended to use an independent thinly provisioned LVM as brick
  - Thin provisioning is needed by Snapshot feature



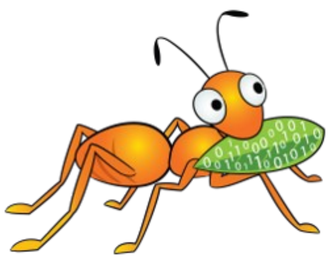
Bricks


Storage devices
Thin Pool
Thin Pool
mount
mount
Thin LV
Thin LV
Volume Group
Brick1
Brick2

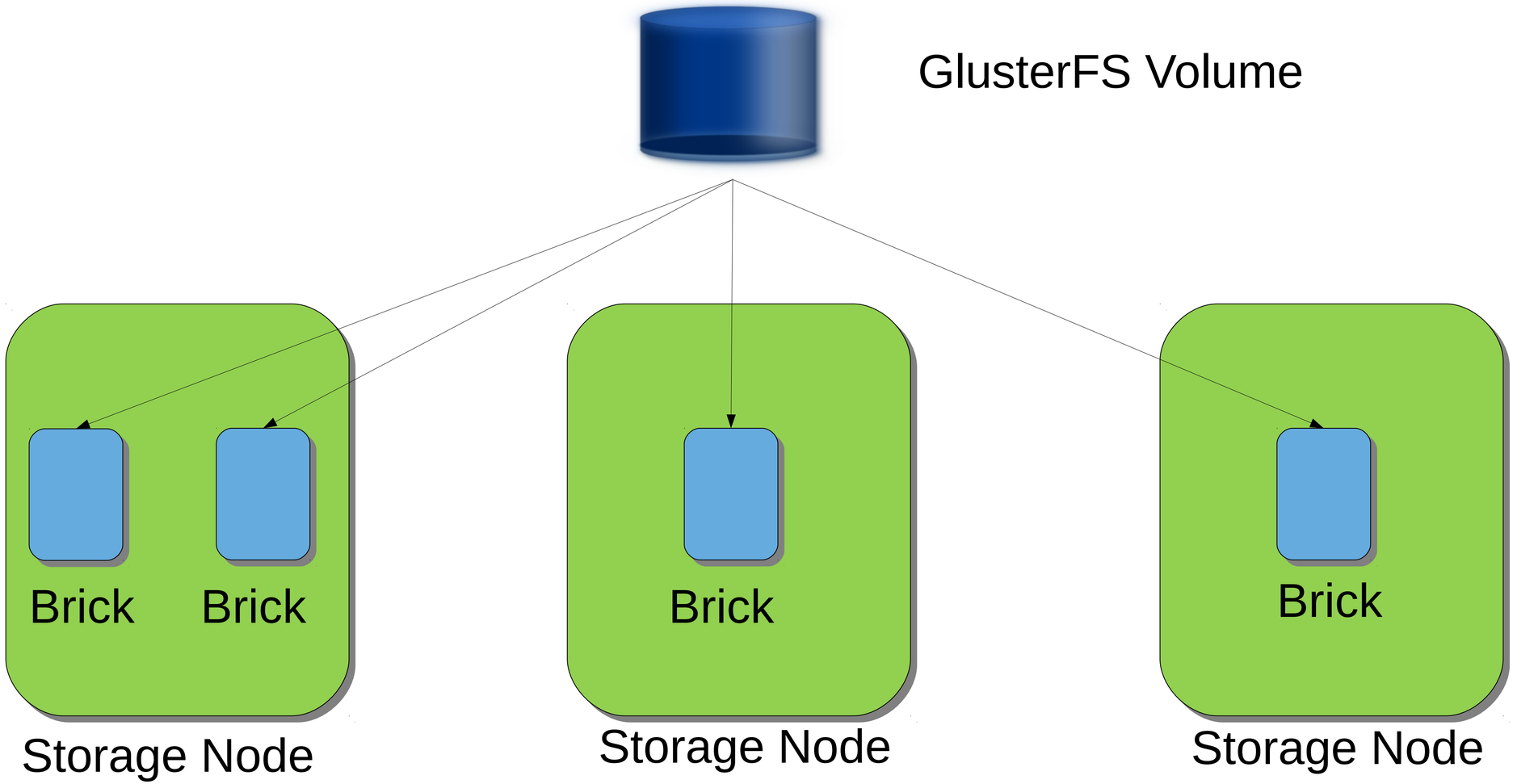
GlusterFS Volume

A volume is a logical collection of one or more bricks

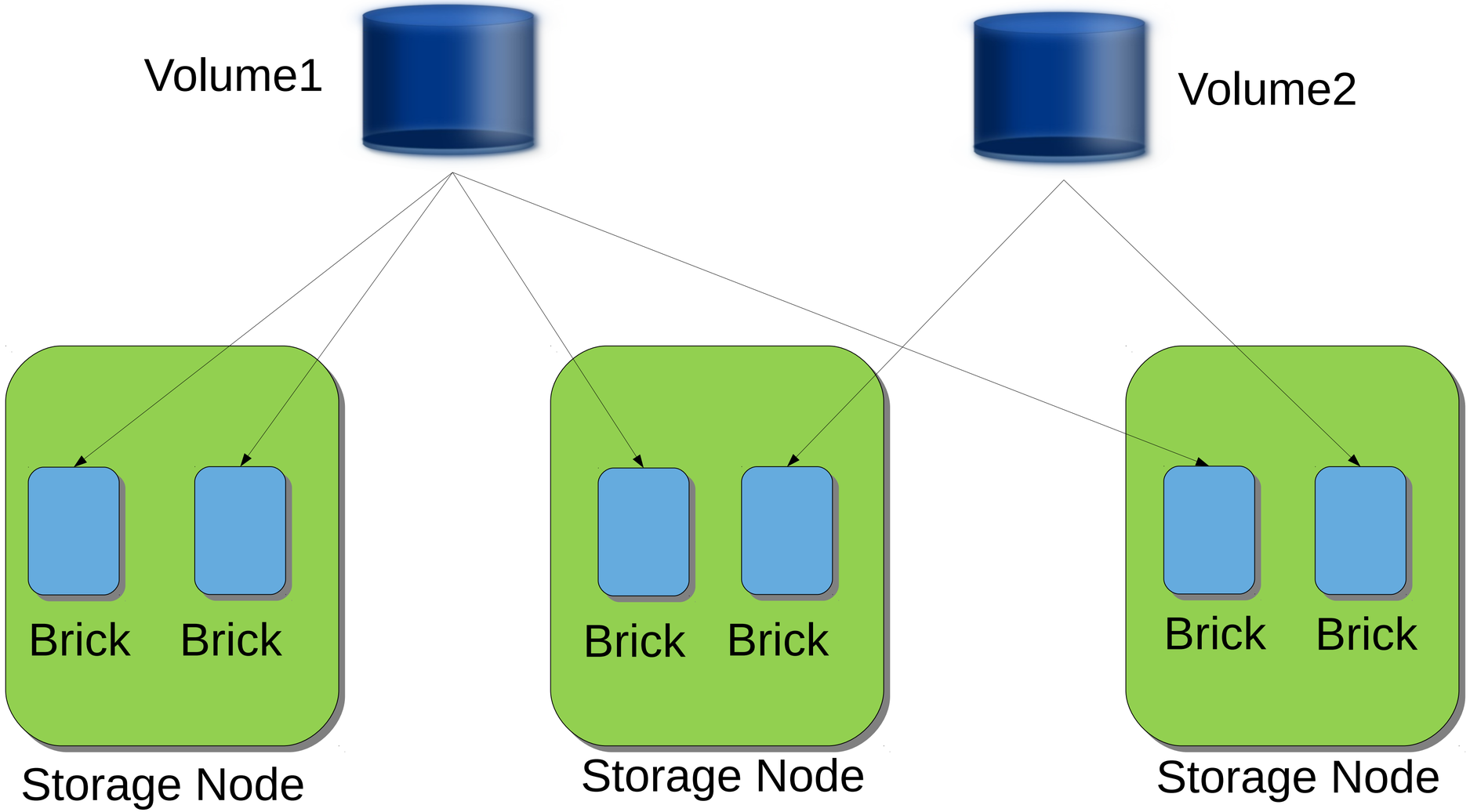
- Node hosting these bricks should be part of a single Trusted Storage Pool
- One or more volumes can be hosted on the same node



GlusterFS Volume



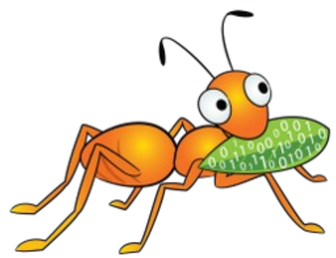
GlusterFS Volume



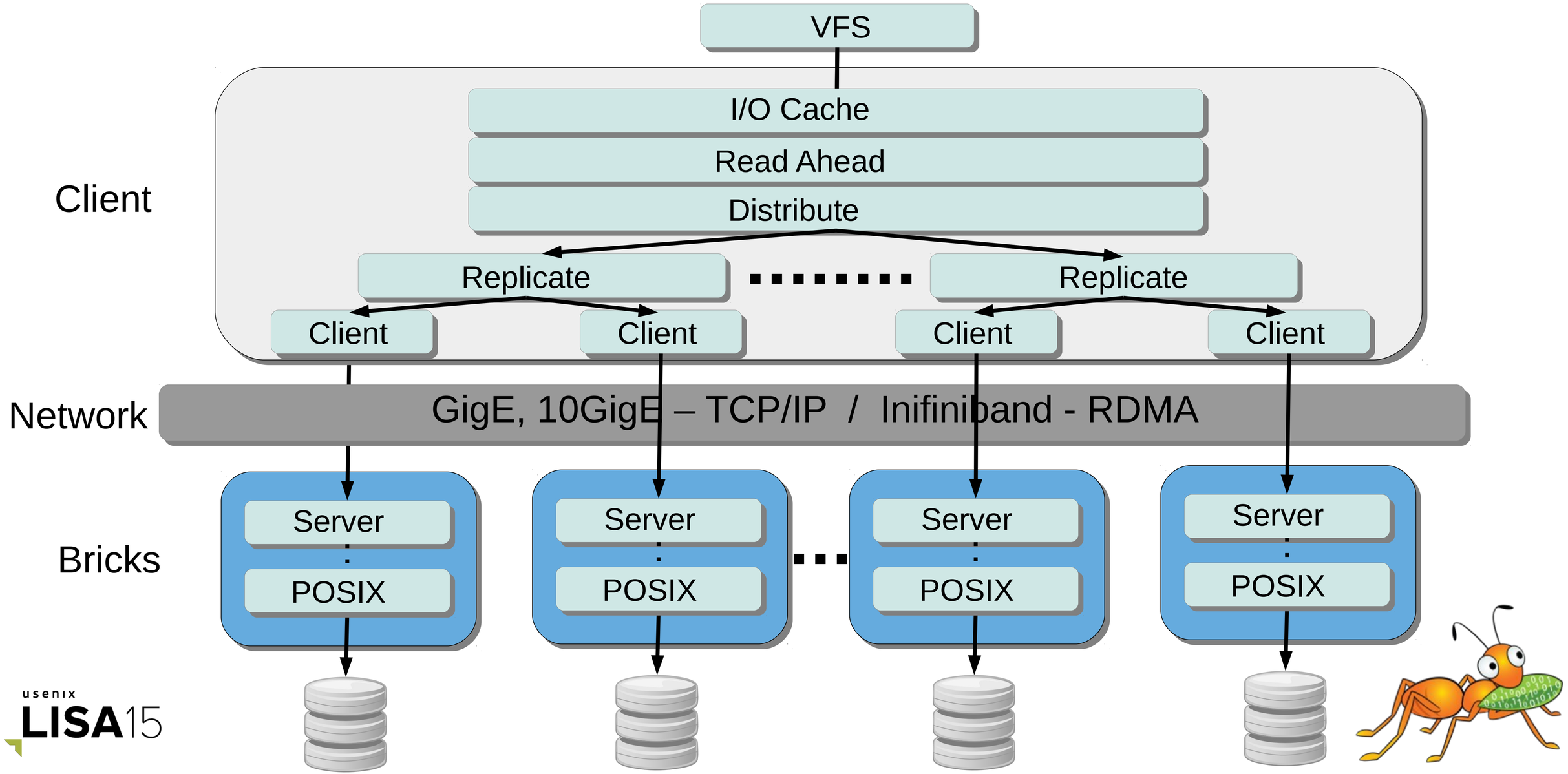
Translators

Building block of GlusterFS process

- Translators can be stacked together for achieving desired functionality
- Translators are deployment agnostic – can be loaded in either the client or server stacks

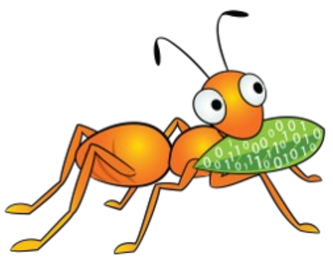


Translators



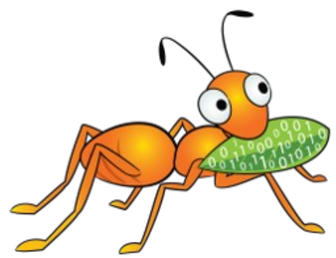
GlusterFS Processes

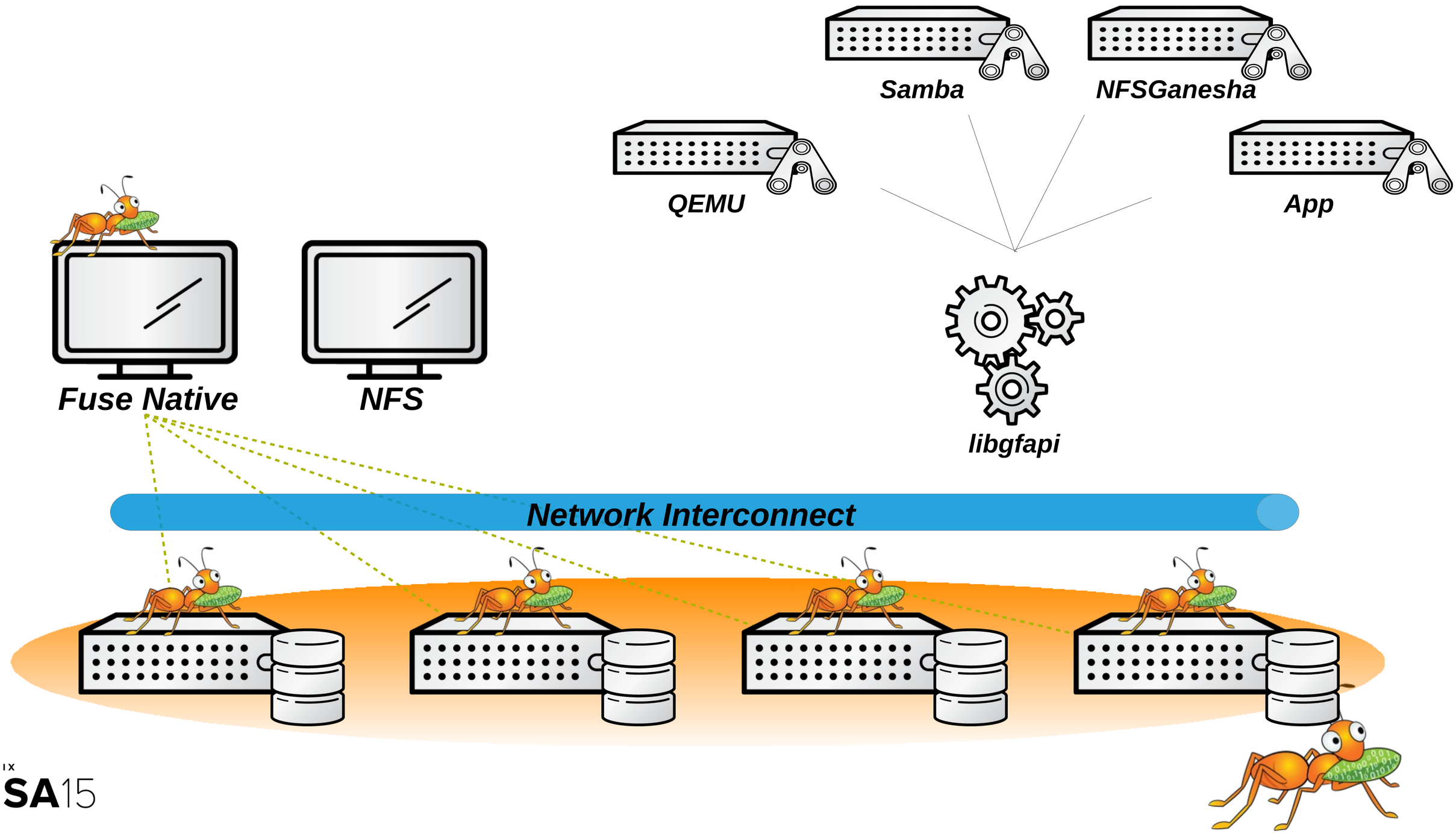
- ***glusterd***
  - Management daemon
  - One instance on each GlusterFS node
- ***glusterfsd***
  - GlusterFS brick daemon
  - One process per brick on each node
  - Managed by glusterd
- ***gluster***
  - Gluster console manager (CLI)
- ***glusterfs***
  - Node services
  - One process for each service
    - NFS Server, Self heal, Quota, ...
- ***mount.glusterfs***
  - FUSE native client mount extension



Accessing Volume

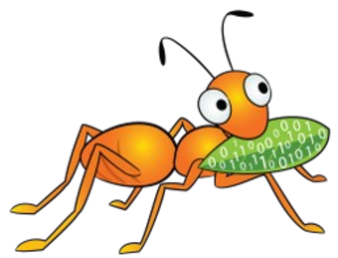
- Volume can be mounted on local file-system
- Following protocols supported for accessing volume
  - GlusterFS Native client
    - Filesystem in Userspace (FUSE)
  - libgfapi flexible abstracted storage
    - Samba, NFS-Ganesha, QEMU
  - NFS
    - NFS Ganesha
    - Gluster NFSv3
  - SMB / CIFS
    - Windows and Linux
  - Gluster For OpenStack
    - Object-based access via OpenStack Swift



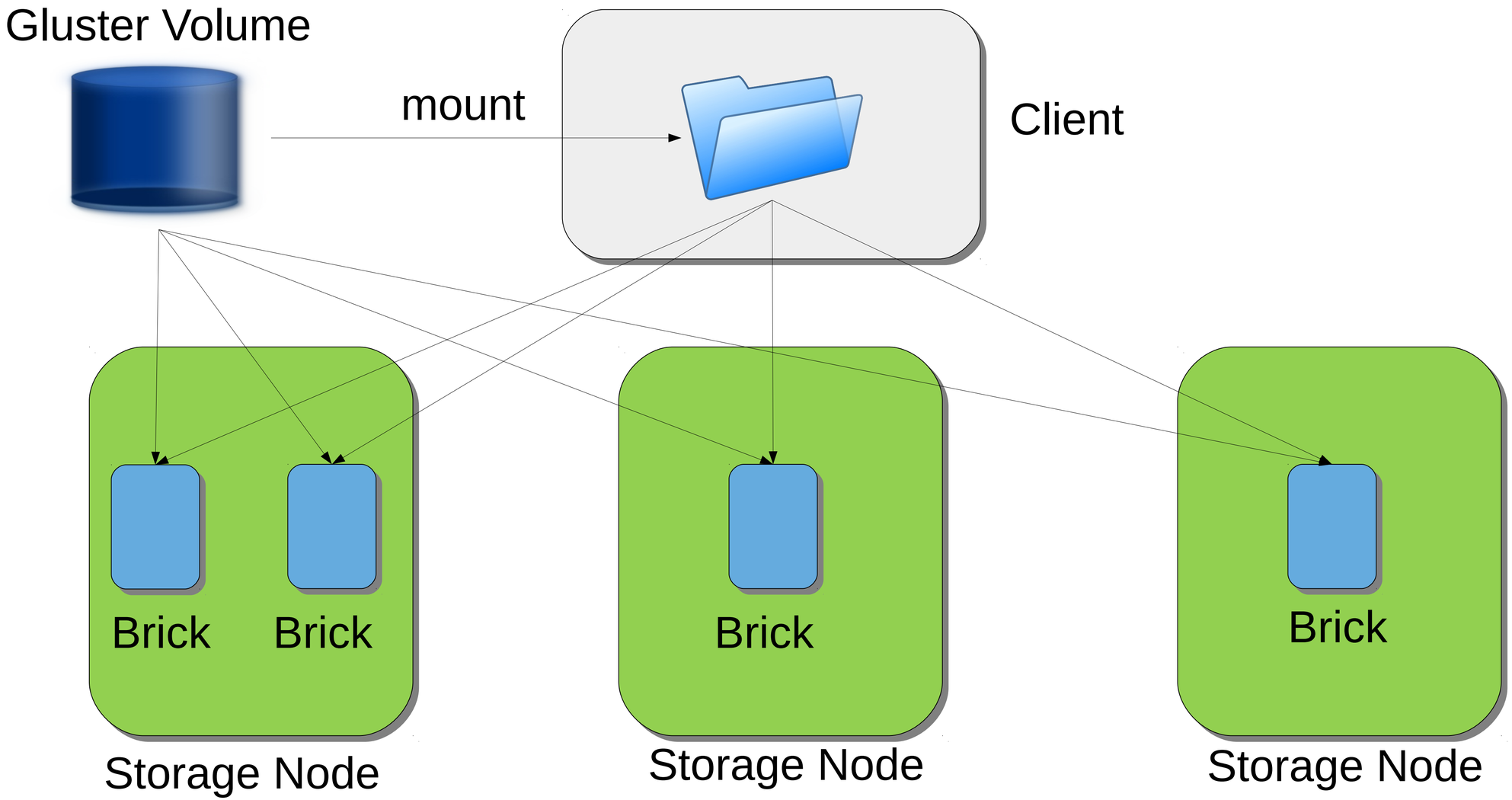

Samba
NFSGanesha
QEMU
App
Fuse Native
NFS
libgfapi
Network Interconnect

GlusterFS Native Client (FUSE)

- FUSE kernel module allows the filesystem to be built and operated entirely in userspace
- Specify mount to any GlusterFS server
- Native Client fetches volfile from mount server, then communicates directly with all nodes to access data

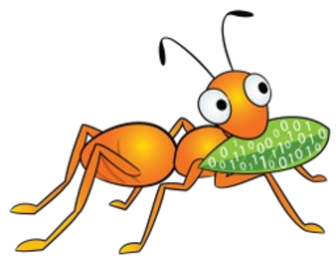


Accessing Volume – Fuse client

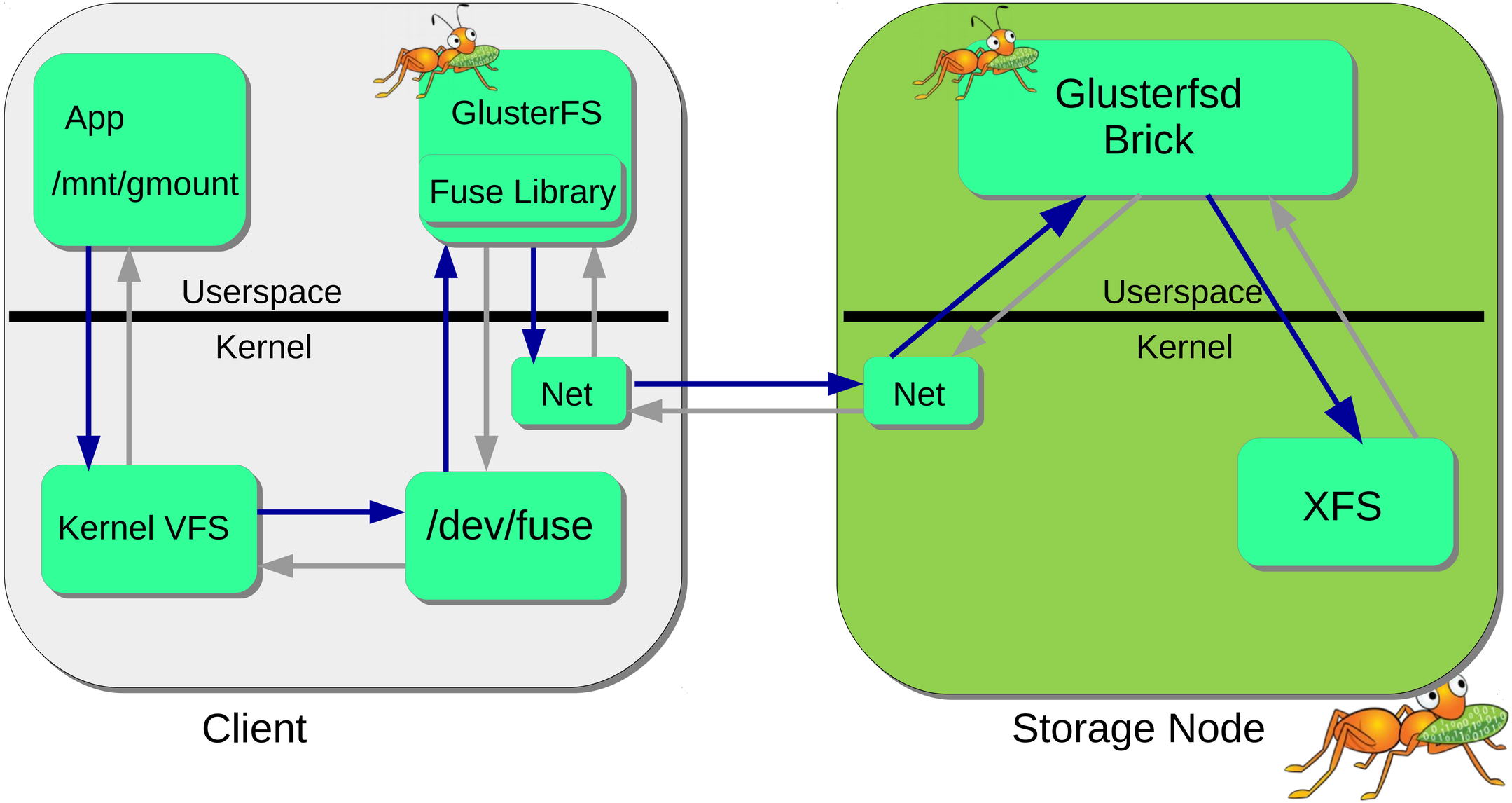


libgfapi

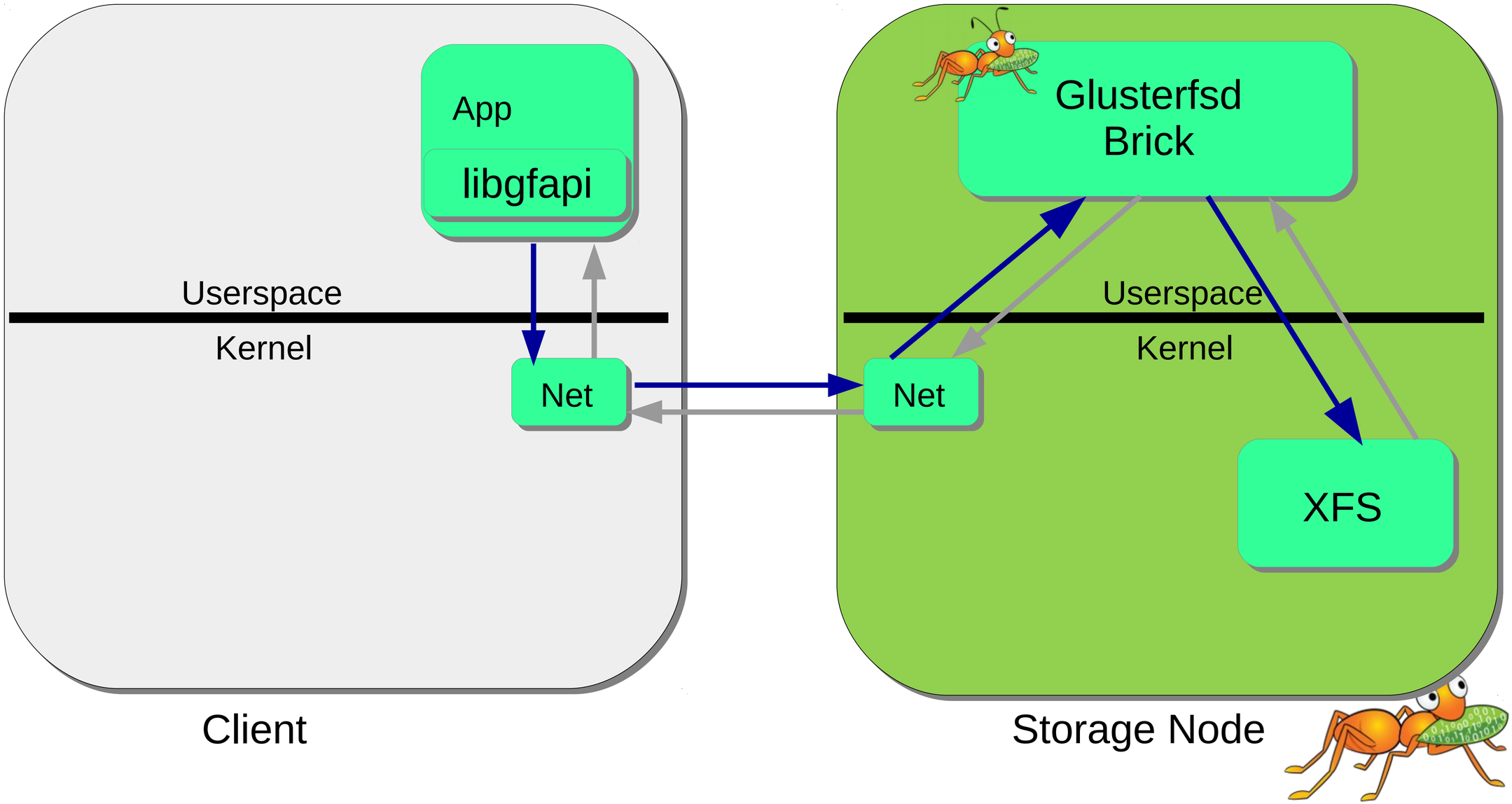
- Userspace library for accessing GlusterFS volume
- File-system like API
- No FUSE, No copies, No context switches
- Samba, QEMU, NFS-Ganesha integrated with libgfapi



Libgfapi - Advantage

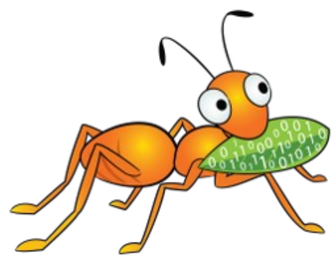


Libgfapi - Advantage

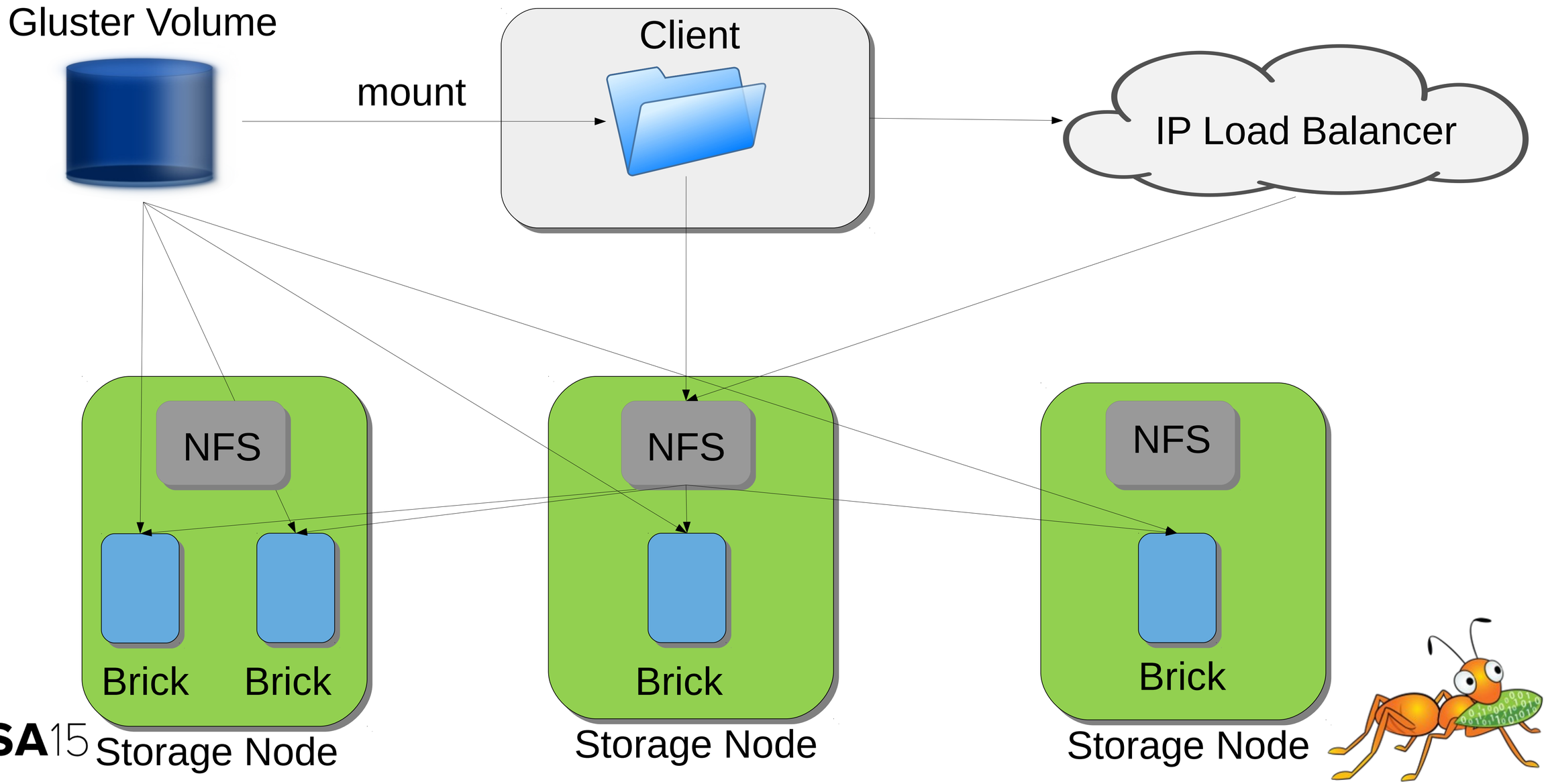


Gluster NFS

- Supports NFS v3 protocol
- Mount to any server or use load-balancer
- GlusterFS NFS server uses Network Lock Manager (NLM) to synchronize locks across clients
- Load balancing should be managed externally

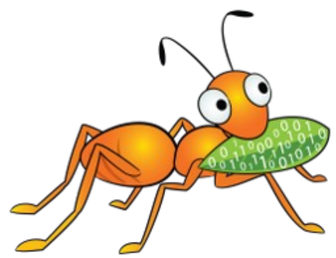


Accessing Volume – Gluster NFS

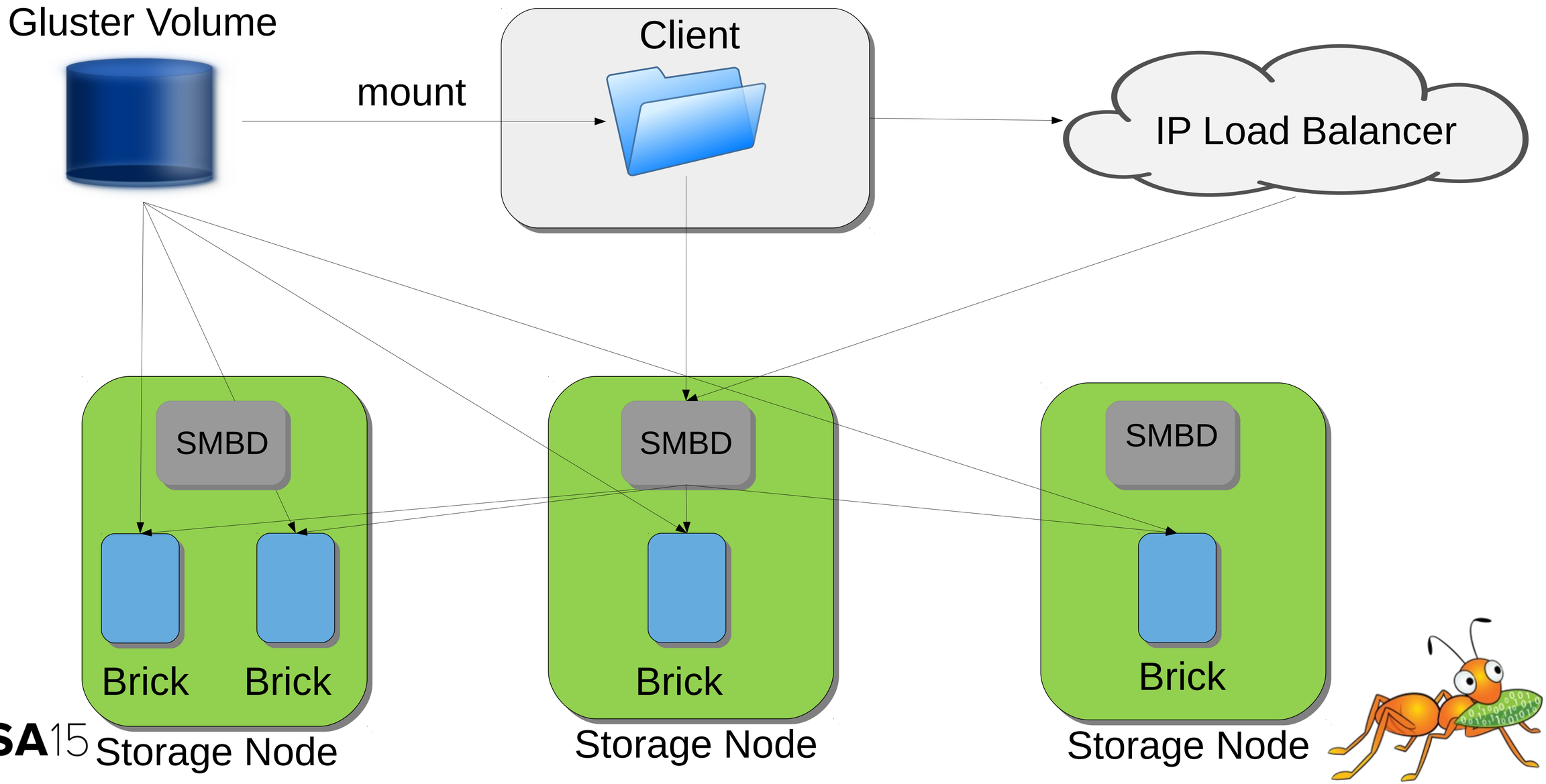


SMB / CIFS

- Samba VFS plugin for GlusterFS
- Uses libgfapi
- Must be setup on each server you wish to connect
- CTDB is required for Samba clustering

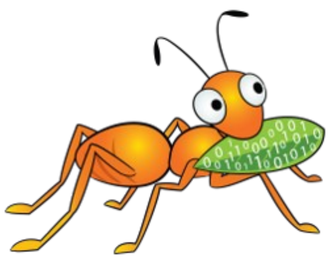


Accessing Volume – SMB



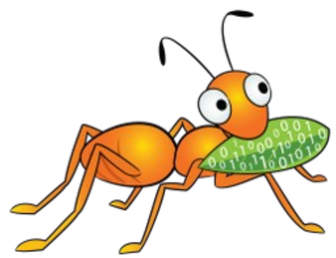
Volume Types

- Type of a volume is specified at the time of volume creation
- Volume type determines how and where data is placed
- Basic Volume Types
  - Distributed
  - Replicated
  - Dispersed
  - Striped
  - Sharded
- Advance Volume Types
  - Distributed Replicated
  - Distributed Dispersed
  - Distributed Striped
  - Distributed Striped Replicated

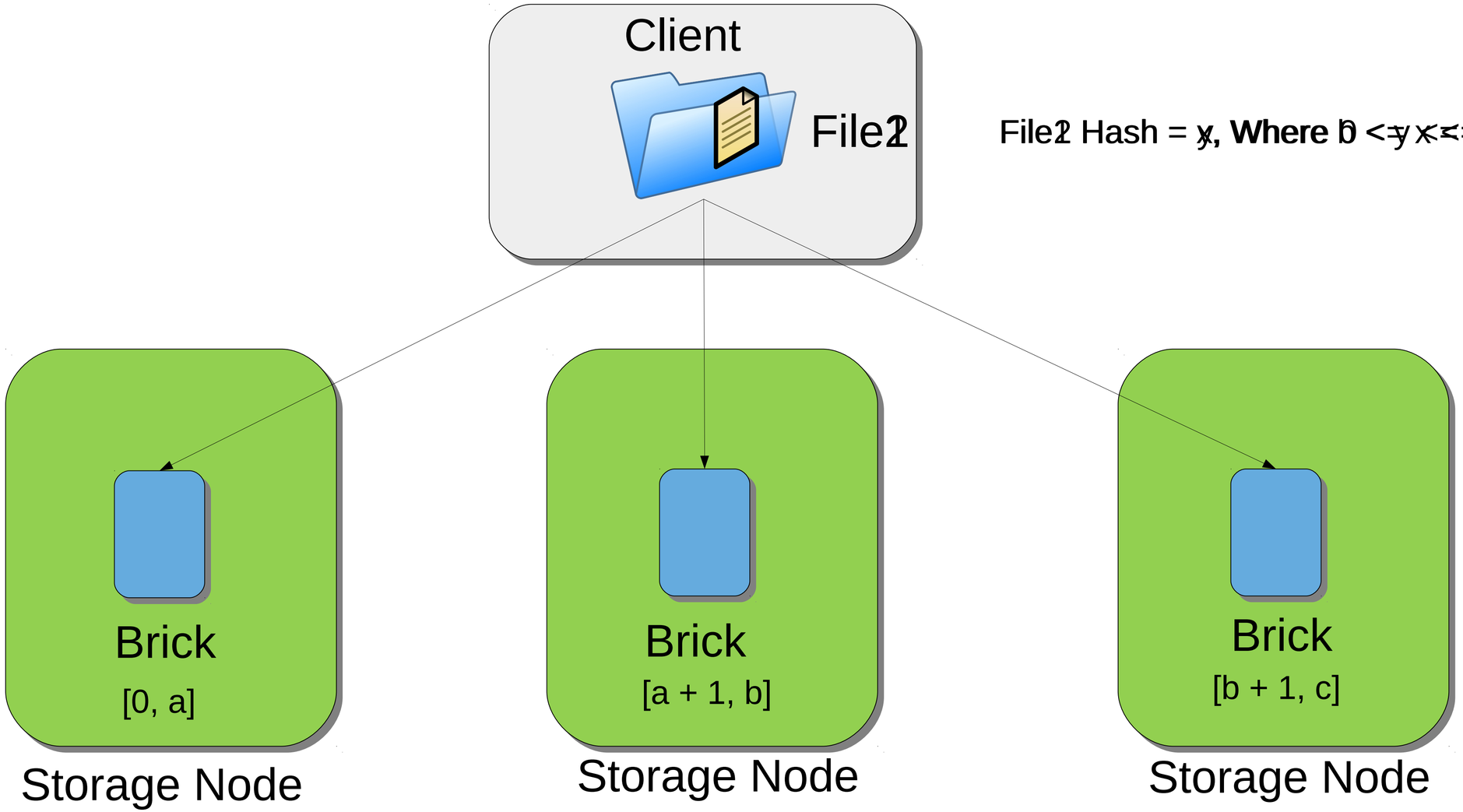


Distributed Volume

- Distributes files across various bricks of the volume
- Similar to file-level RAID-0
- Scaling but no high availability
- Uses Davies-Meyer hash algorithm
- A 32-bit hash space is divided into N ranges for N bricks
- Removes the need for an external meta data server

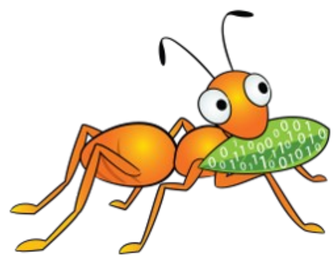


Distribute Volume

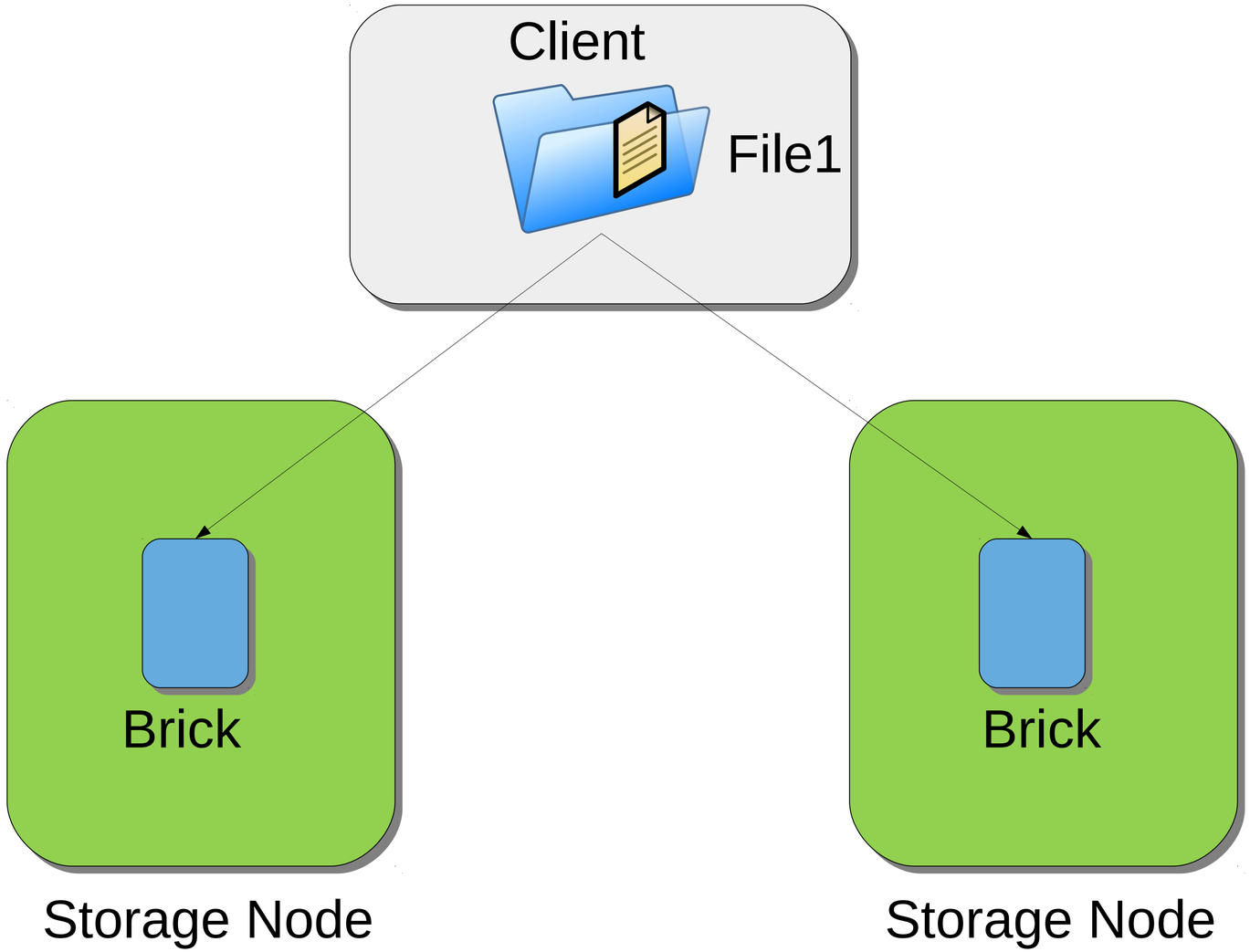


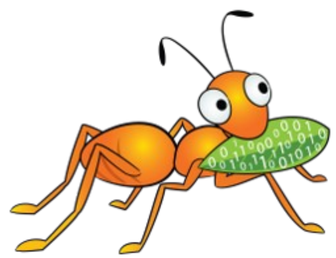
Replicate Volume

- Synchronous replication of all directory and file updates
- Similar to file-level RAID-1
- High availability but no scaling
- Replica pairs are decided at the volume creation time
- Its recommended to host each brick of replica set on different node



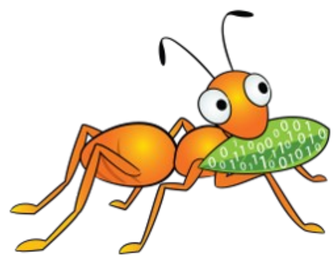
Replicate Volume



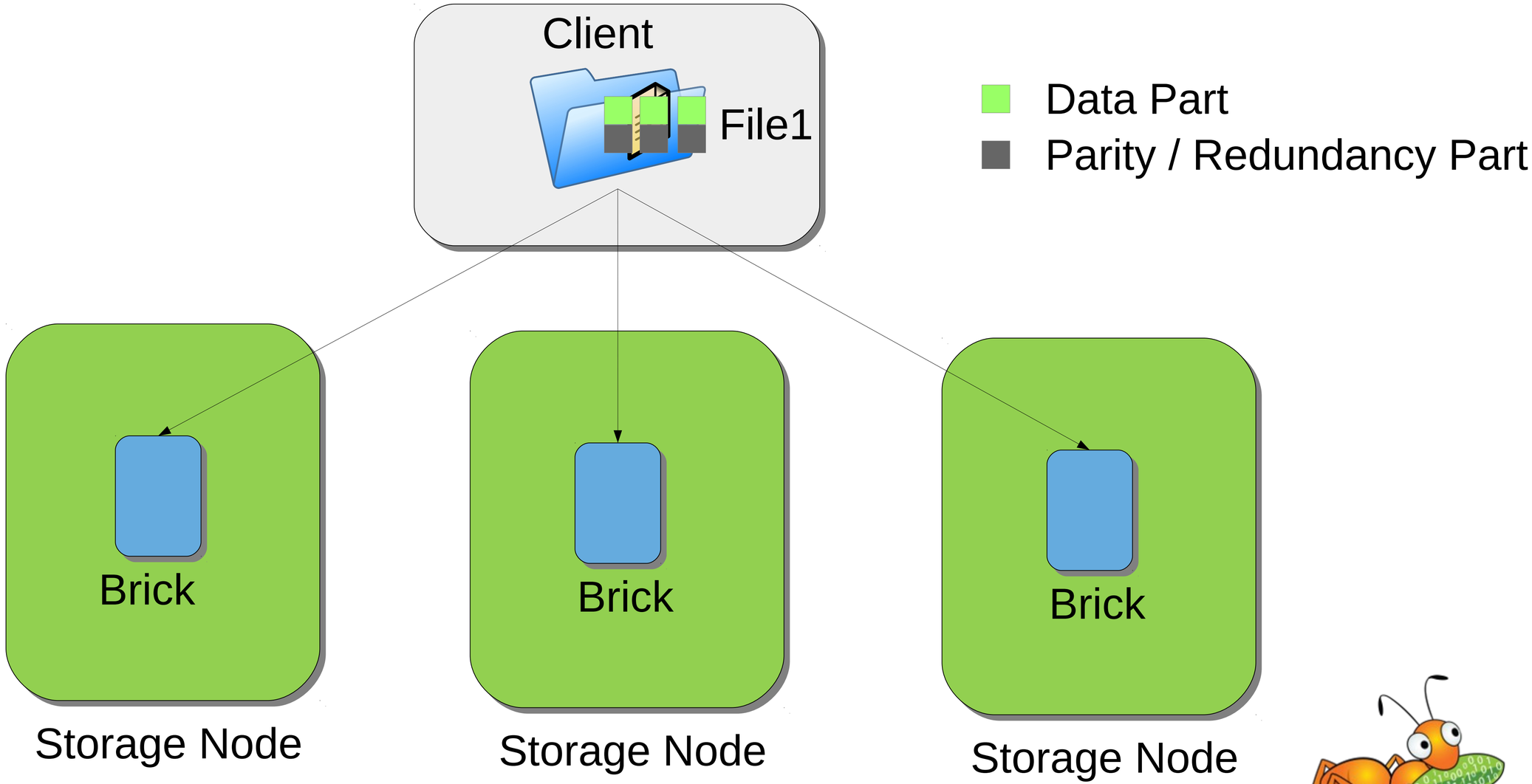


Disperse Volume

- Erasure Coded volume
- High availability with less number of bricks
- Store m disk of data on k disk (k > m)
- n (k-m) redundant disks
- Following setup is the most tested configuration
  - 6 bricks with redundancy level 2 (4 +2)
  - 11 bricks with redundancy level 3 (8 +3)
  - 12 bricks with redundancy level 4 (8 + 4)

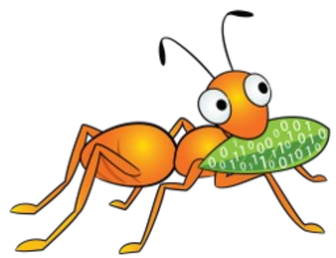


Disperse Volume

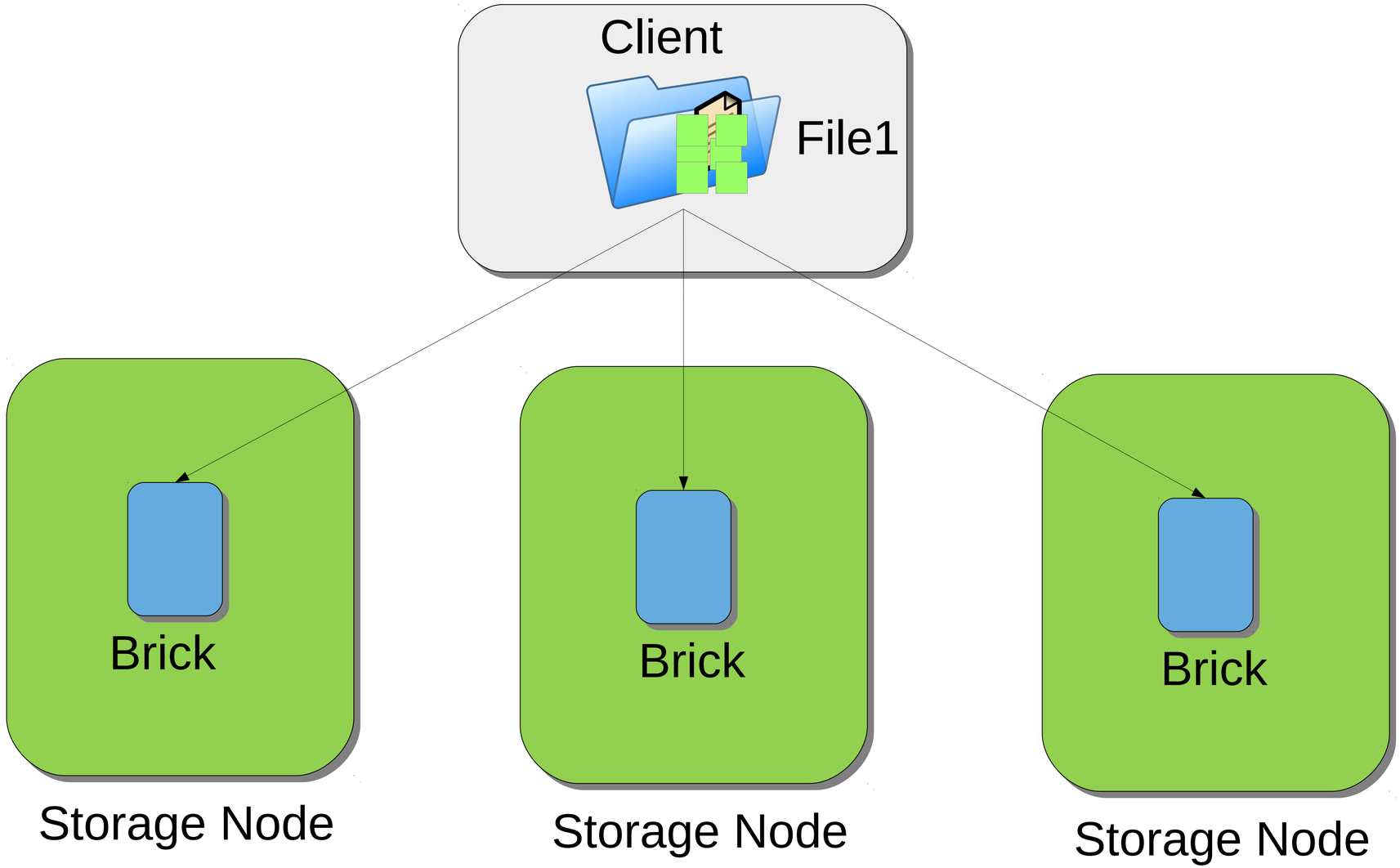


Striped Volume

- Individual files split among bricks (sparse files)
- Similar to block-level RAID-0
- Recommended only when very large files greater than the size of the disks are present
- Chunks are files with holes – this helps in maintaining offset consistency

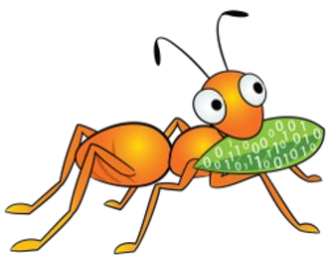


Striped Volume

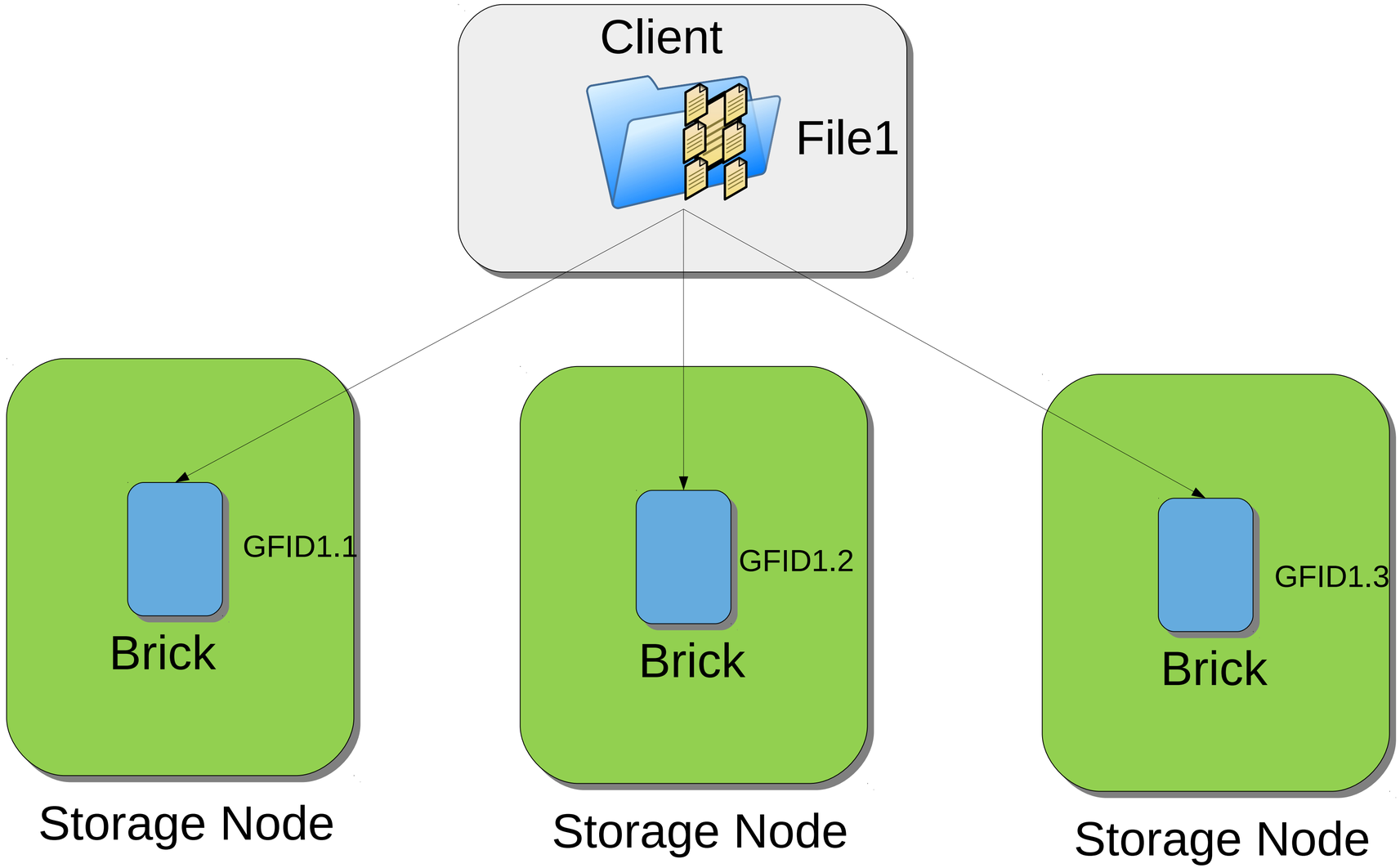


Sharded (Stripe – 2.0) Volume

- Individual files split among bricks
  - Each part split is a different file in the backend
  - File name of each part derived from GFID (UUID) of actual file
- Unlike Stripe file rename will not have any impact on these parts.
- Unlike other volume types shard is a volume option which can be set on any volume
- Recommended only when very large files greater than the size of the disks are present

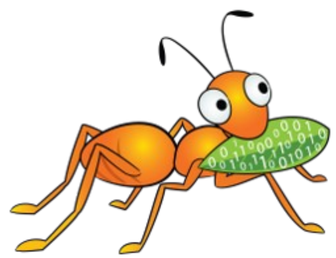


Sharded Volume

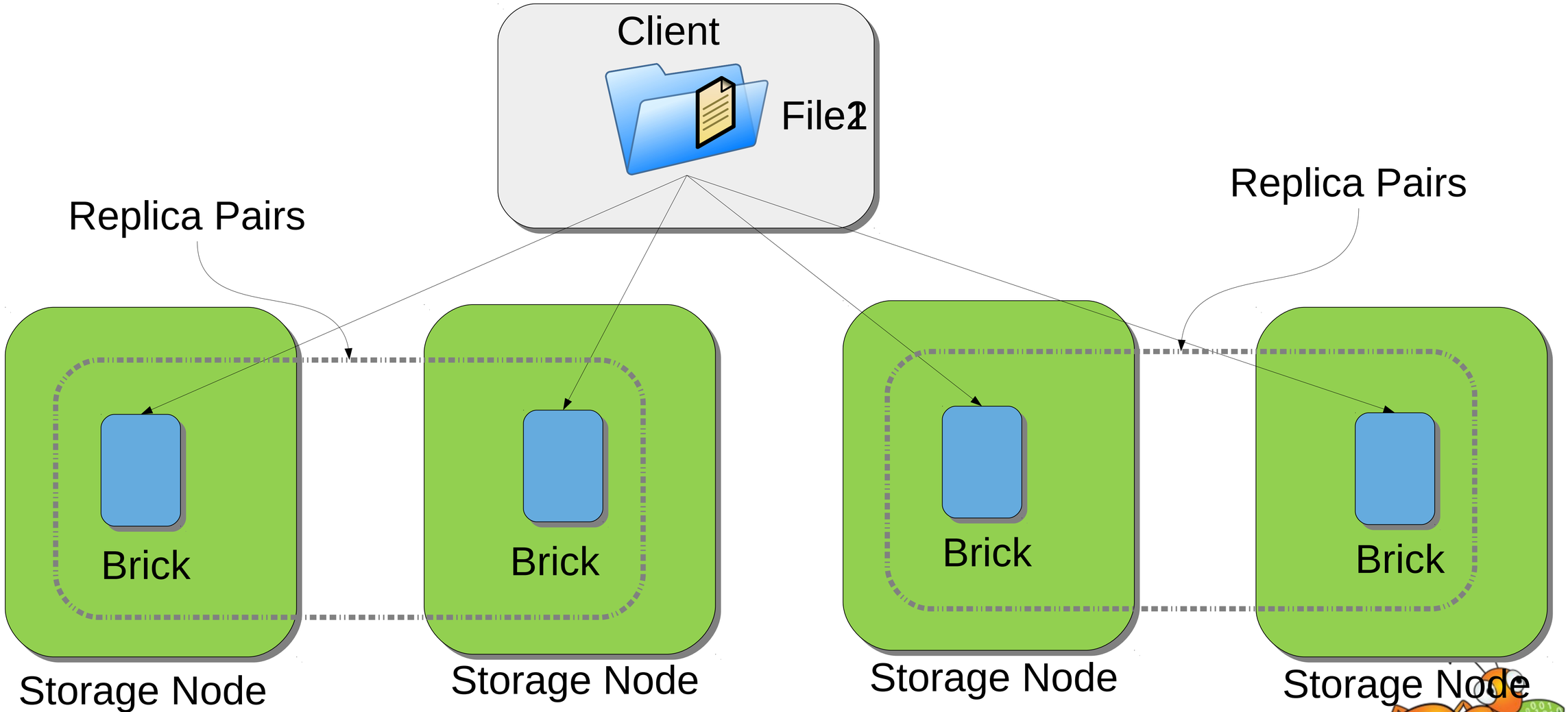


Distribute Replicate Volume

- Distribute files across replicated bricks
- Number of bricks must be a multiple of the replica count
- Ordering of bricks in volume definition matters
- Scaling and high availability
- Most preferred model of deployment



Distribute Replicate Volume



Performance

- Different SLA than a local file-system
- Uneven performance distribution between nodes and clients
- Various performance options available (e.g., read-ahead, md-cache, etc)
  - Based on workload use various options
- Don't forget to attend detailed session on performance by Jeff Darcy

```
Topic  : Evaluating Distributed File System Performance (GlusterFS and Ceph)
When   : Friday, November 13, 2015 - 9:00am-10:30am
Detail : https://www.usenix.org/conference/lisa15/conference-program/presentation/darcy
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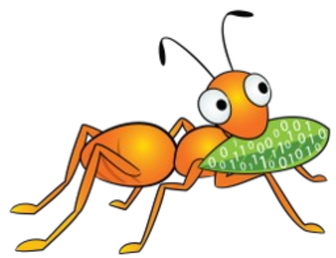
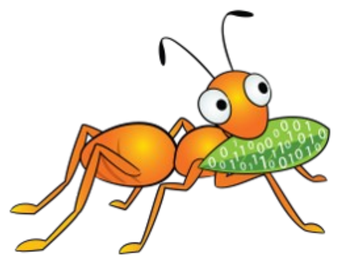


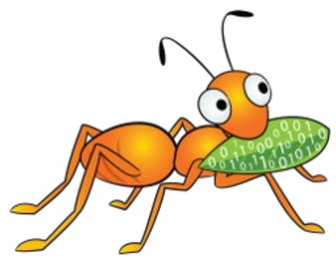
Additional Features



Additional Features

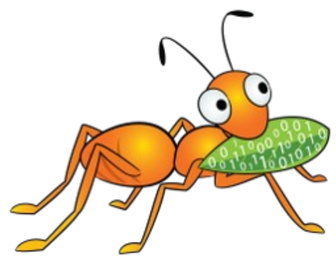
- Geo Replication
- Volume Snapshot
- Quota
- Bit-rot
- Compression
- Encryption at rest
- Trash / Recycle-bin
- pNFS with NFS-Ganesha

- Data Tiering
- User Serviceable Snapshots
- Server side Quorum
- Client side Quorum
- And many more ...

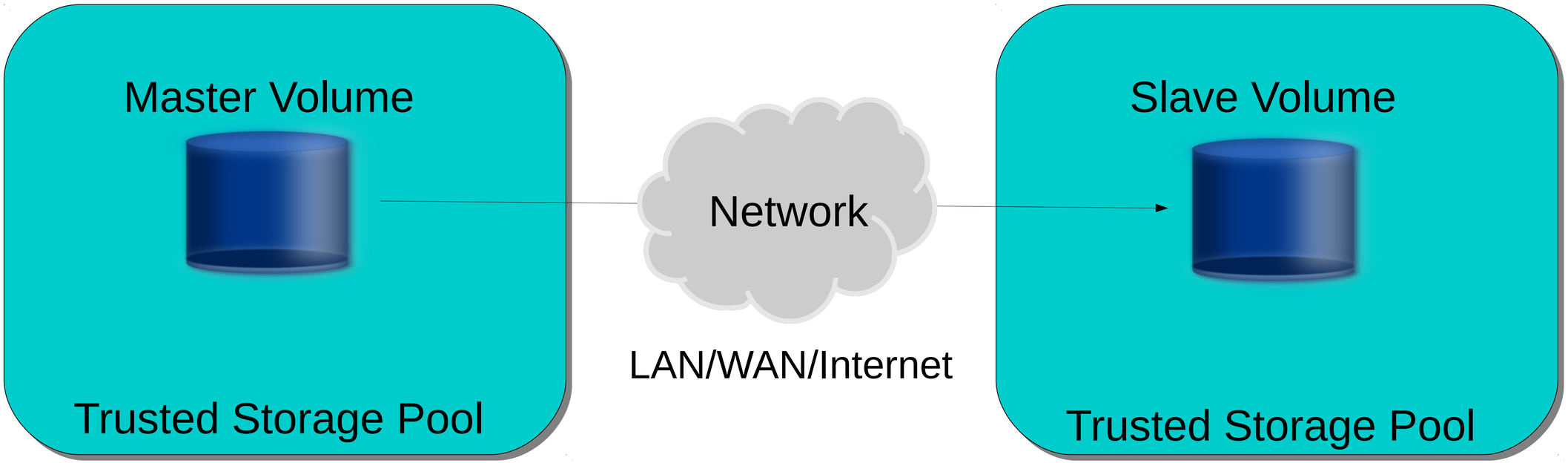


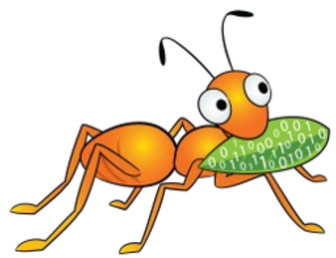
Geo-Replication

- Mirrors data across geographically distributed trusted storage pools
- Provides back-ups of data for disaster recovery
- Master-Slave model
- Asynchronous replication
- Provides an incremental continuous replication service over
  - Local Area Networks (LANs)
  - Wide Area Network (WANs)
  - Internet



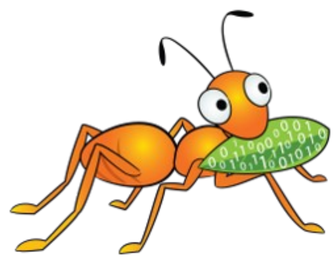
Geo-Replication



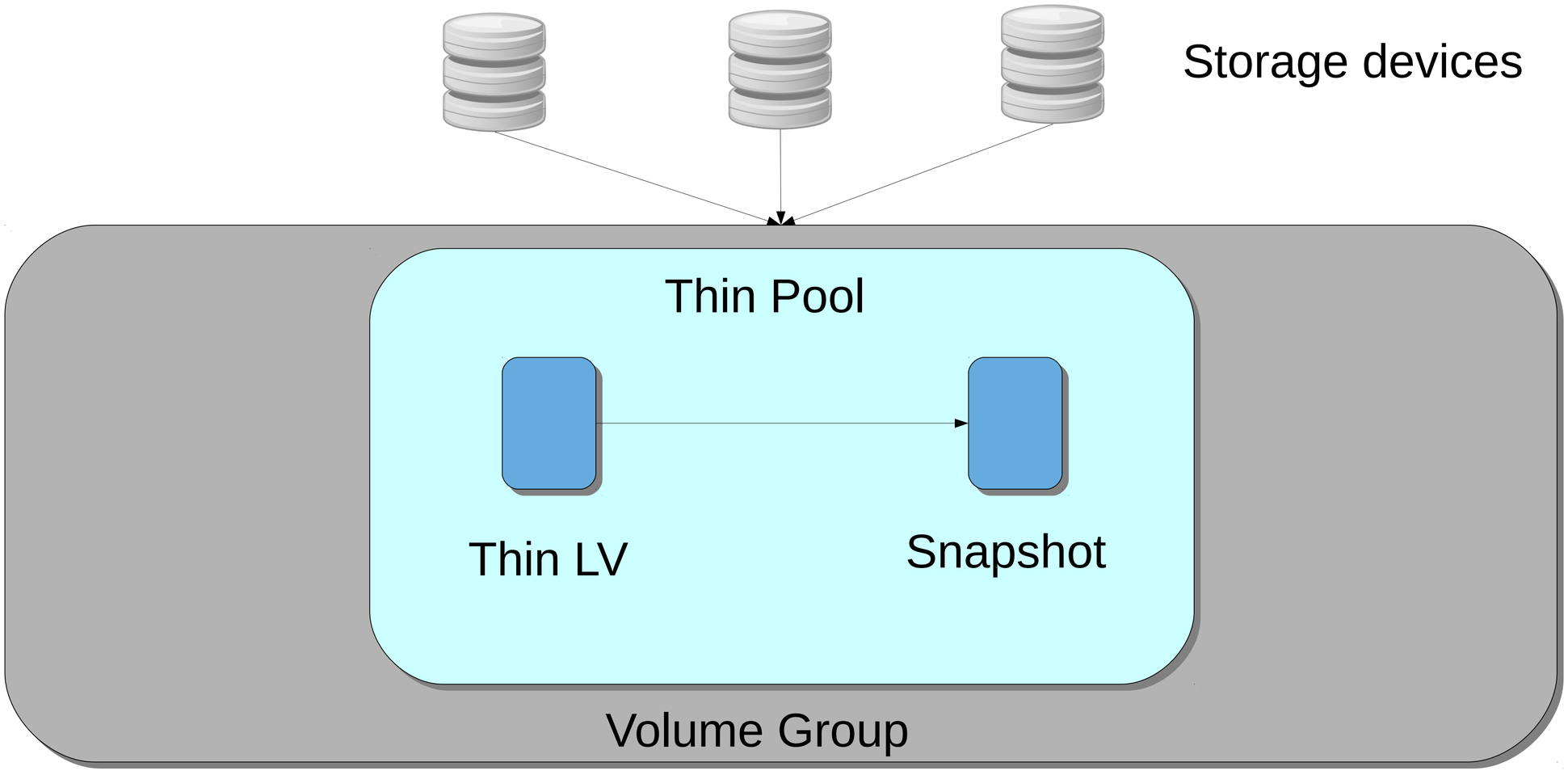


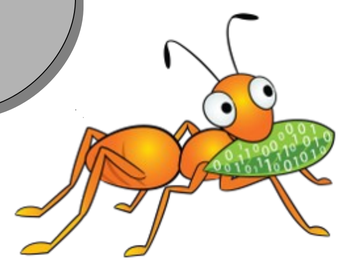
GlusterFS Snapshot

- Volume level crash consistent snapshots
- LVM2 based
  - Operates only on thin-provisioned volumes
- Snapshots themselves are thin-provisioned snapshot volumes
- A GlusterFS volume snapshot consists of snapshots of the individual bricks making up the volume
- Snapshot of a GlusterFS volume is also a GlusterFS volume

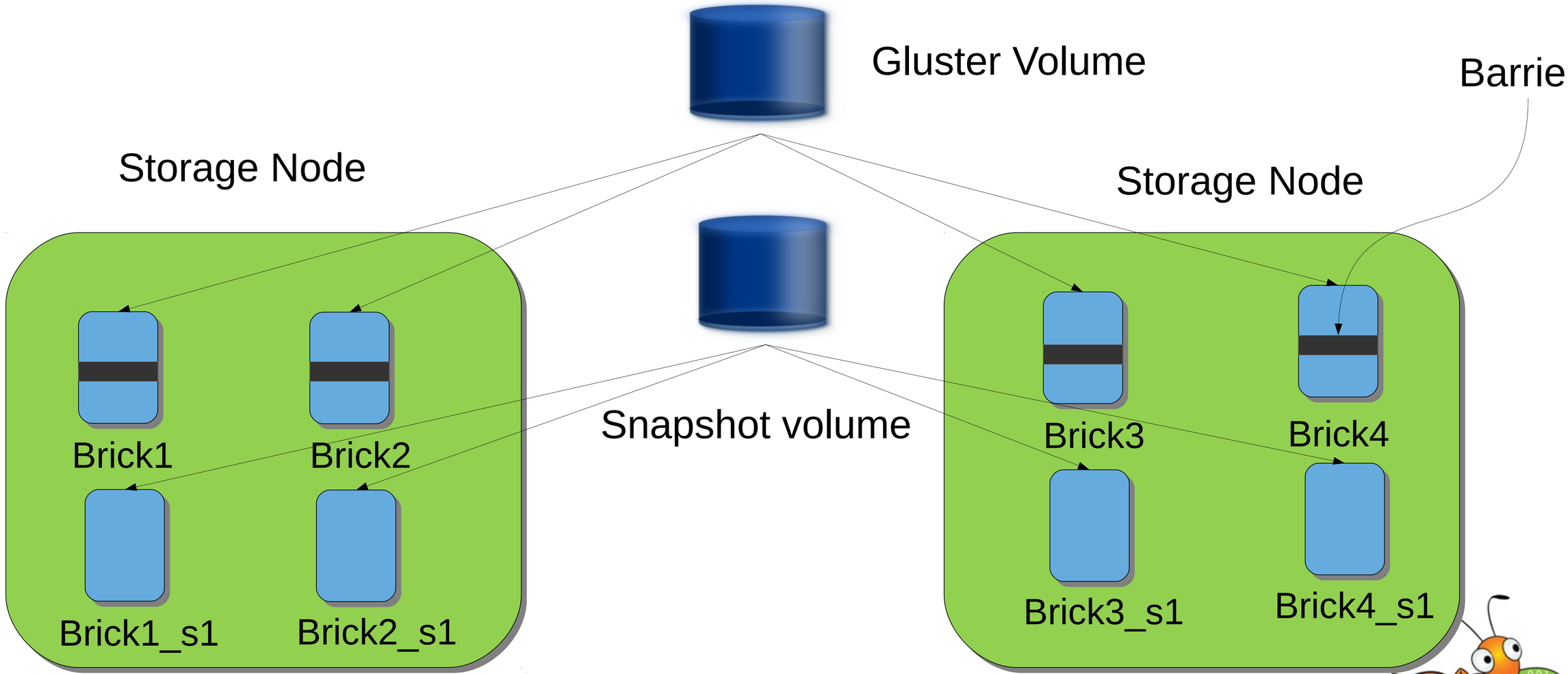


Thinly Provisioned LVM2 Volume & Snapshot



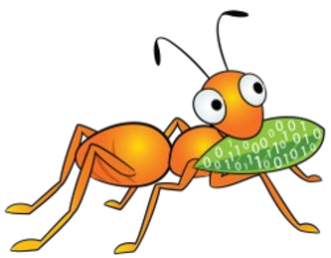


Gluster Volume Snapshot

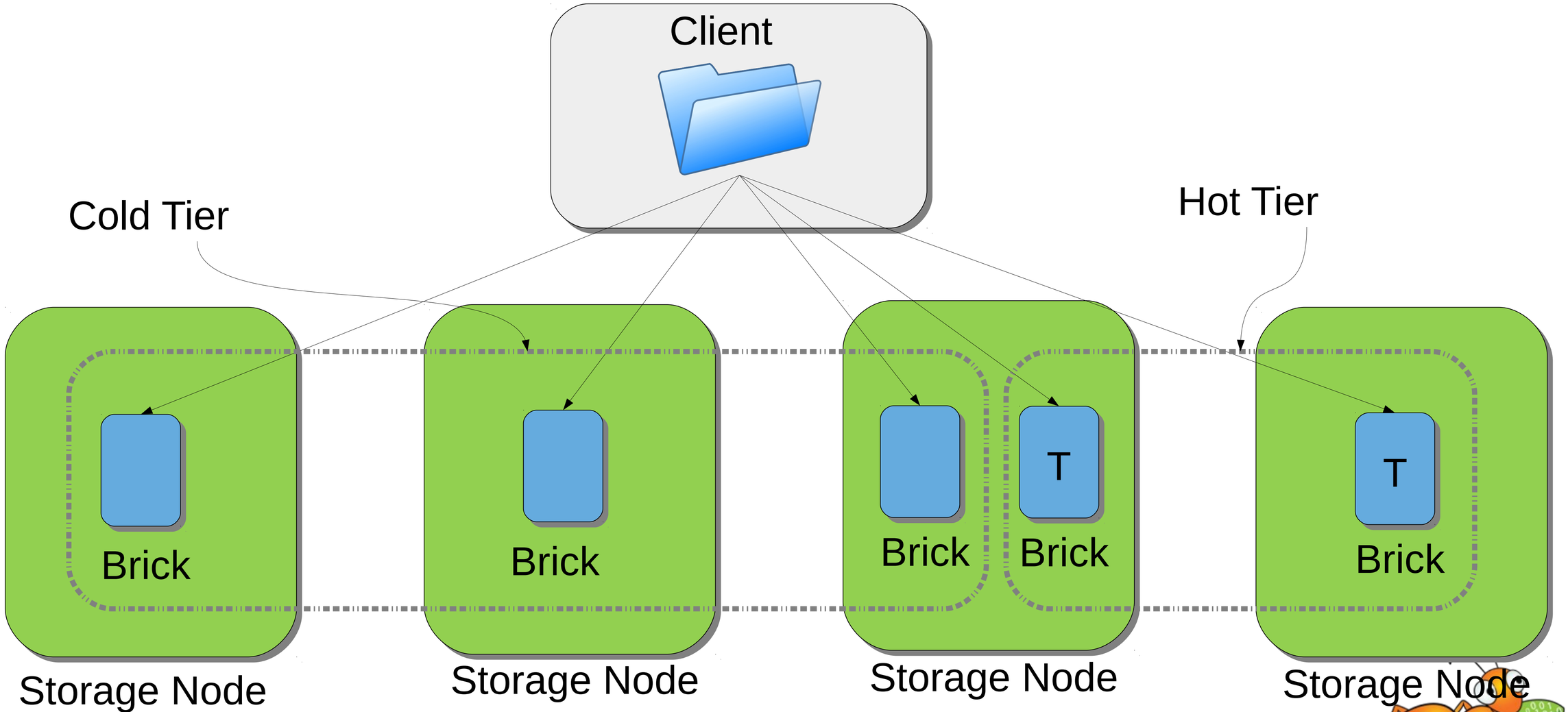


Data Tiering

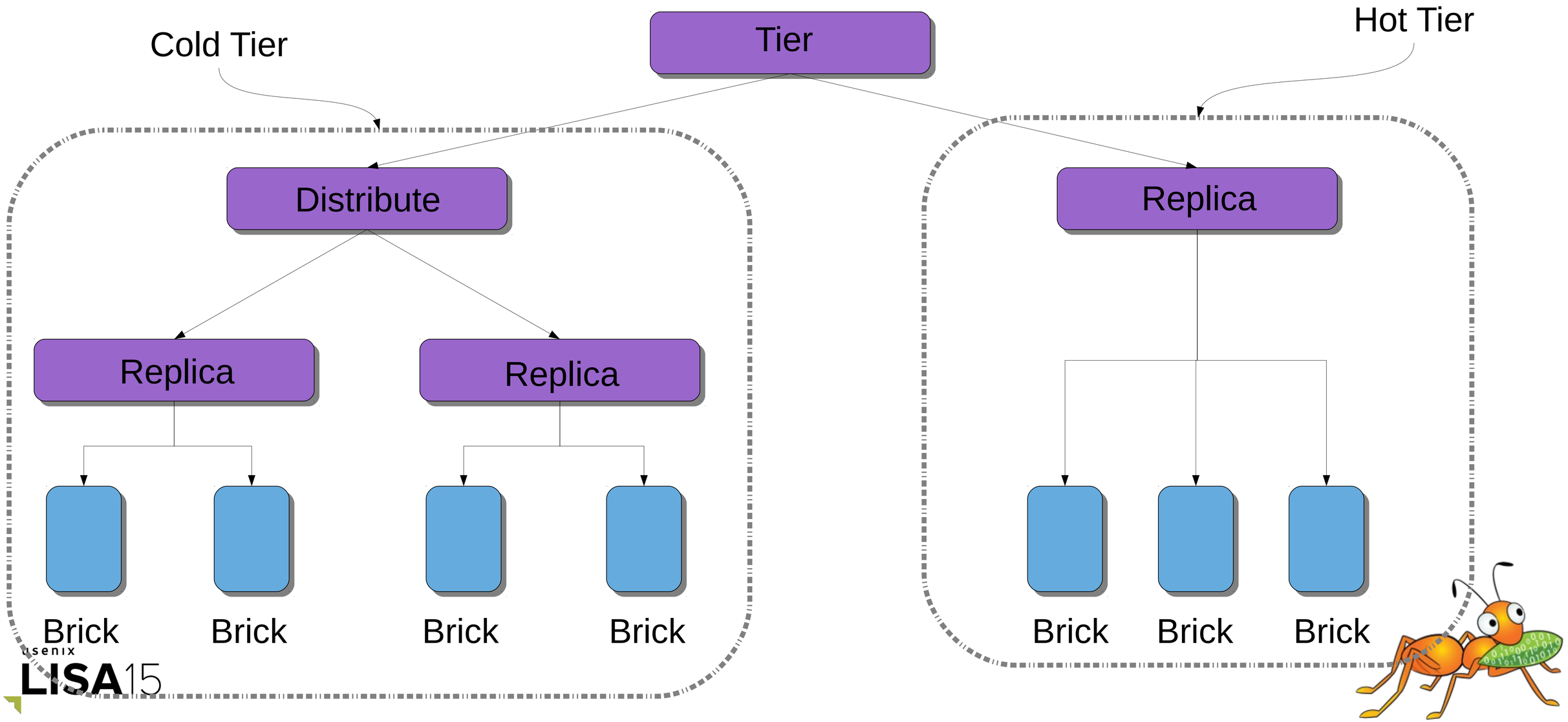
- Data classification and placement of data
  - Currently based on access rate
- Tiered volume can be created by attaching a tier
- Bricks in original volume are “cold” bricks
- Bricks in attached tier are “hot” bricks
- Hot bricks are normally hosted on faster disks e.g. SSDs
- Tier can be attached or detached using volume commands



Tiered Volume



Tiered Volume



Future Work

- New Style Replication (NSR)
- Scalability improvements (1000+ Nodes)
- Multi-protocol support
- Multi-master Geo-Replication
- Caching Improvements
- Btrfs Support
- And many more…