Innovative R&D by NTT

sheepdog: software defined storage system for converged infrastructure

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Outline

1. The trend of SDS and sheepdog
2. Recent development status
3. Performance comparison with Ceph and GlusterFS
4. Introduction of use cases
5. Conclusion

Outline

1. **The trend of SDS and sheepdog**
   - What does “SDS” mean in the context of this presentation?
   - And how does sheepdog relate to it?
2. **Recent development status**
3. **Performance comparison with Ceph and GlusterFS**
4. **Introduction of use cases**
5. **Conclusion**

The trend of Software Defined Storage

- **Many startups and giants are saying "Software Defined Storage"**
  - what is this?
- **4 weeks before, Red Hat, Inc acquired Inktank for $175 million**
  - seems to be hot

Red Hat to Acquire Inktank, Provider of Ceph

Raleigh

April 30, 2014

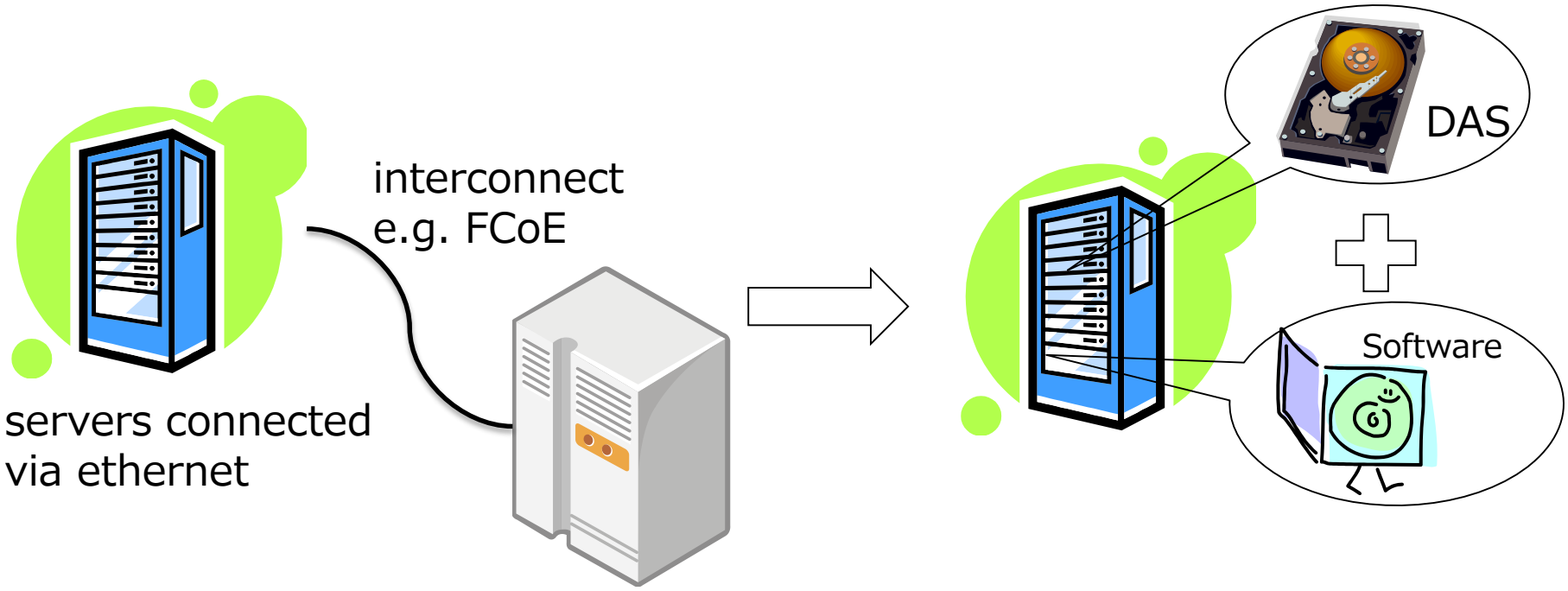
- Open source leaders unite to accelerate adoption of open software-defined storage for enterprises and service providers
- Addition of Inktank positions Red Hat as leading provider of open software-defined storage across object, block, and file system storage

software defined storage?

http://www.redhat.com/about/news/press-archive/2014/4/red-hat-to-acquire-inktank-provider-of-ceph

The trend of Software Defined Storage

- **The trend of throwing out traditional storage appliances from data centers**
  - Instead of appliances, software defined storages utilize DAS in commodity servers and implement functionalities of the appliances.



The trend of Software Defined Storage

- **Why should we through out the appliances?**
  - Because they need careful capacity planning
    - This limitation comes from their inflexibility
      - Storage is just storage even if it is idle (cannot used for other computation)
      - Expanding capacity of the appliances is virtually impossible
    - Capacity planning is difficult
      - Risk of low utilization: your investment would go to waste
      - Risk of resource exhaustion: your service wouldn't work well

How much storage will my service require during its whole lifetime?

The trend of Software Defined Storage

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Two types of SDS products

1. Converged infrastructure
   - co-existing VMs and storage on single hardware
   - e.g. Nutanix, Simplivity OmniCube, Cohodata Difference, VMware virtual SAN, EMC ScaleIO, Maxta MxSP, etc…

2. Scale-out SAN
   - storage which is separated from hypervisor (or bare metal OS)
   - e.g. Nimble storage, HP 3Par, HP LeftHand, IBM XIV, Dell EqualLogic, PureStorage, EMC XtreamIO, etc…

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The trend of Software Defined Storage

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Two key properties of the SDS products

(Virtually) every provider says their products are:

1. Scale-out
   - You can increase performance and capacity when you add a new node to your cluster
2. Easy to manage
   - Procedure of adding a new node doesn't depend on size of your cluster
   - Difficulty isn't changed even your cluster has 10 nodes or 100 nodes

Definition of SDS in this talk: storage system which can satisfy the above two properties

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Sheepdog: SDS in the world of OSS

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- **Distributed storage software for providing block devices of QEMU**
  - Since 2009
- **Design policies**
  - Providing functionalities of typical storage appliances
    - live snapshot, writable snapshot (cloned disk), thin provisioning, etc
  - Symmetric, scale-out architecture
    - no special nodes (e.g. metadata server)
    - difficulty of adding a new node doesn't depend on a number of existing nodes of cluster

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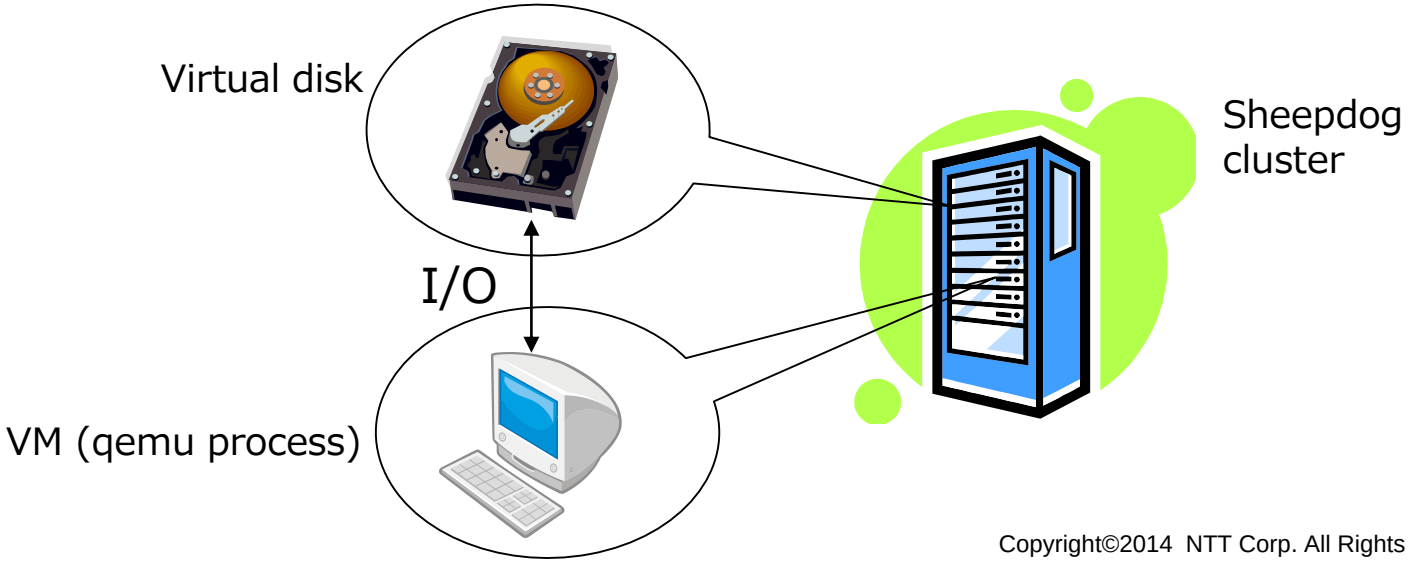
Sheepdog: SDS in the world of OSS

- **Using sheepdog from QEMU**

/* dog is a command for managing sheepdog cluster */
$ *dog vdi create my-new-disk 1TB*

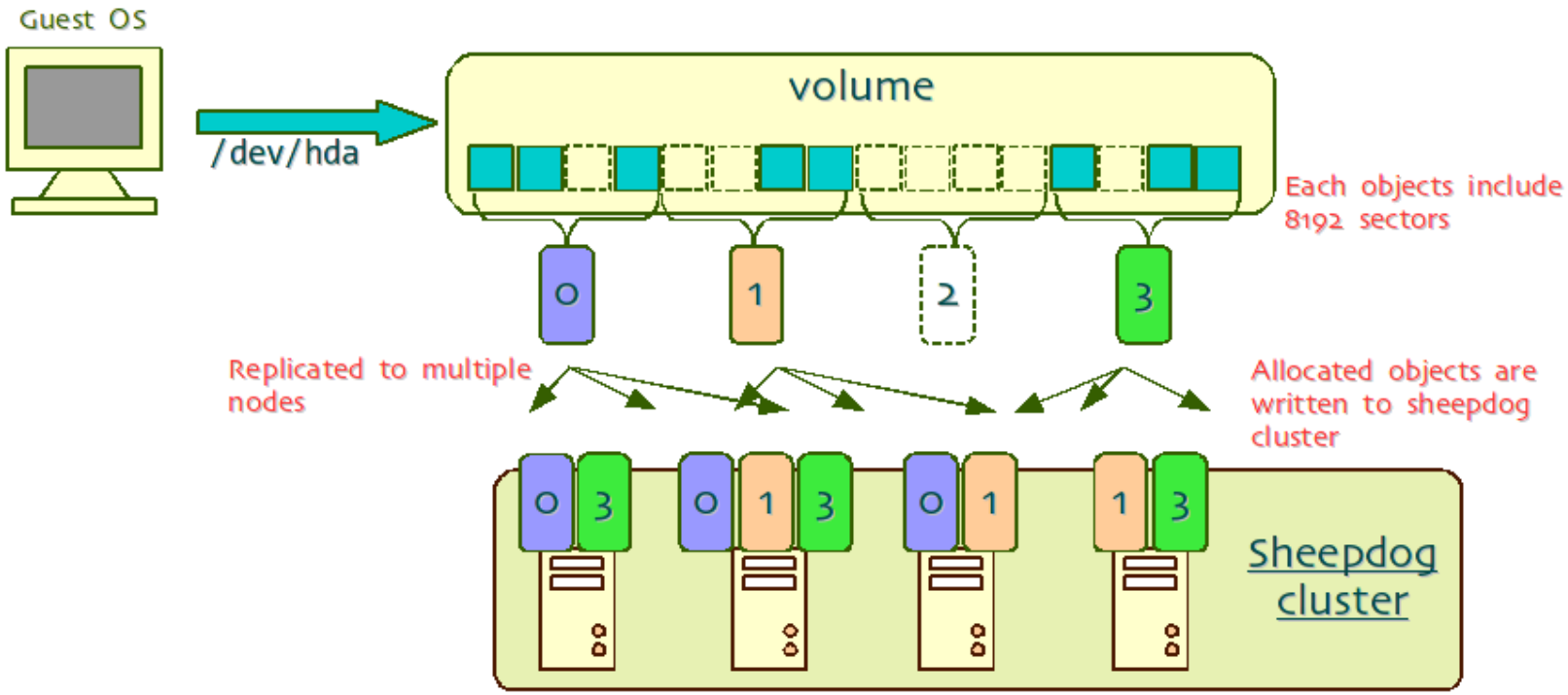
/* launch VM after installing OS. disks can be used like qcow2 */
$ *qemu-system-x86_64 –enable-kvm –hda sheepdog:my-new-disk*

/* you can create snapshot without killing qemu process */
$ *dog vdi snapshot my-new-disk*



How sheepdog store data: representation

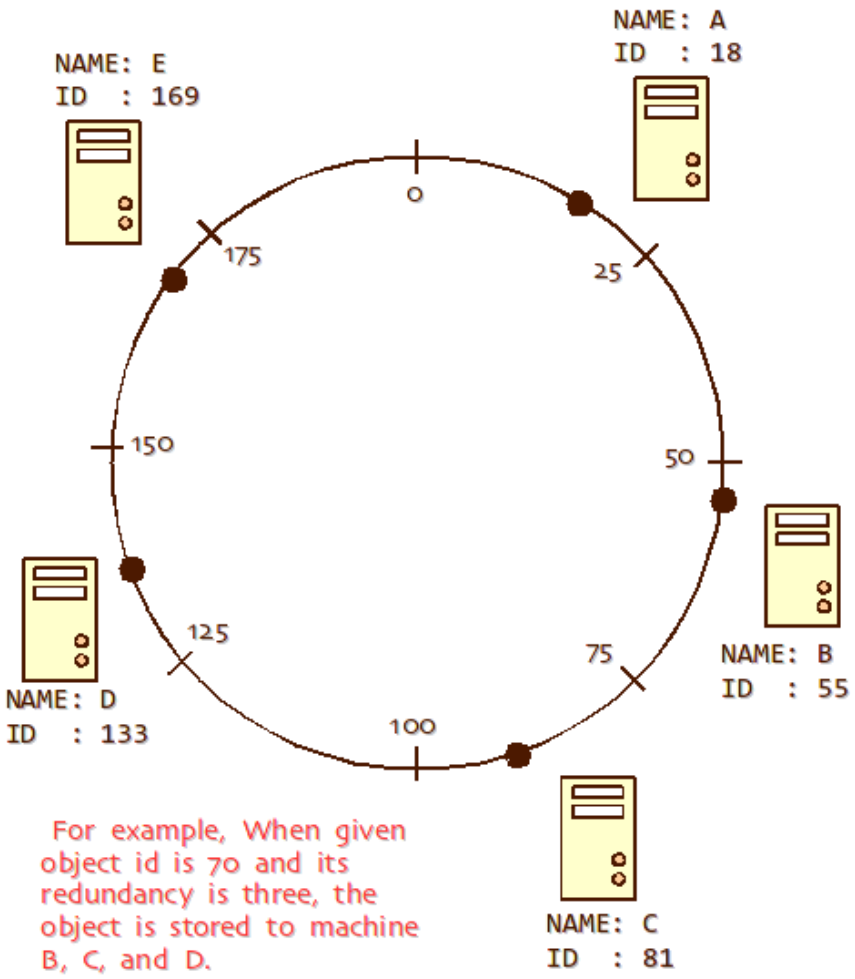
- **Virtual disks are stored as objects**
  - Disks are divided into fixed-size objects
  - Internal of sheepdog is a key-value store (e.g. Amazon's Dynamo)



How sheepdog store data: object placement

- **Object placement policy: consistent hashing**
  - A node for storing an object is determined by its ID
  - No metadata server: the policy contributes to the scale-out architecture

You can build the converged infrastructure and scale-out SAN based on sheepdog without any proprietary software

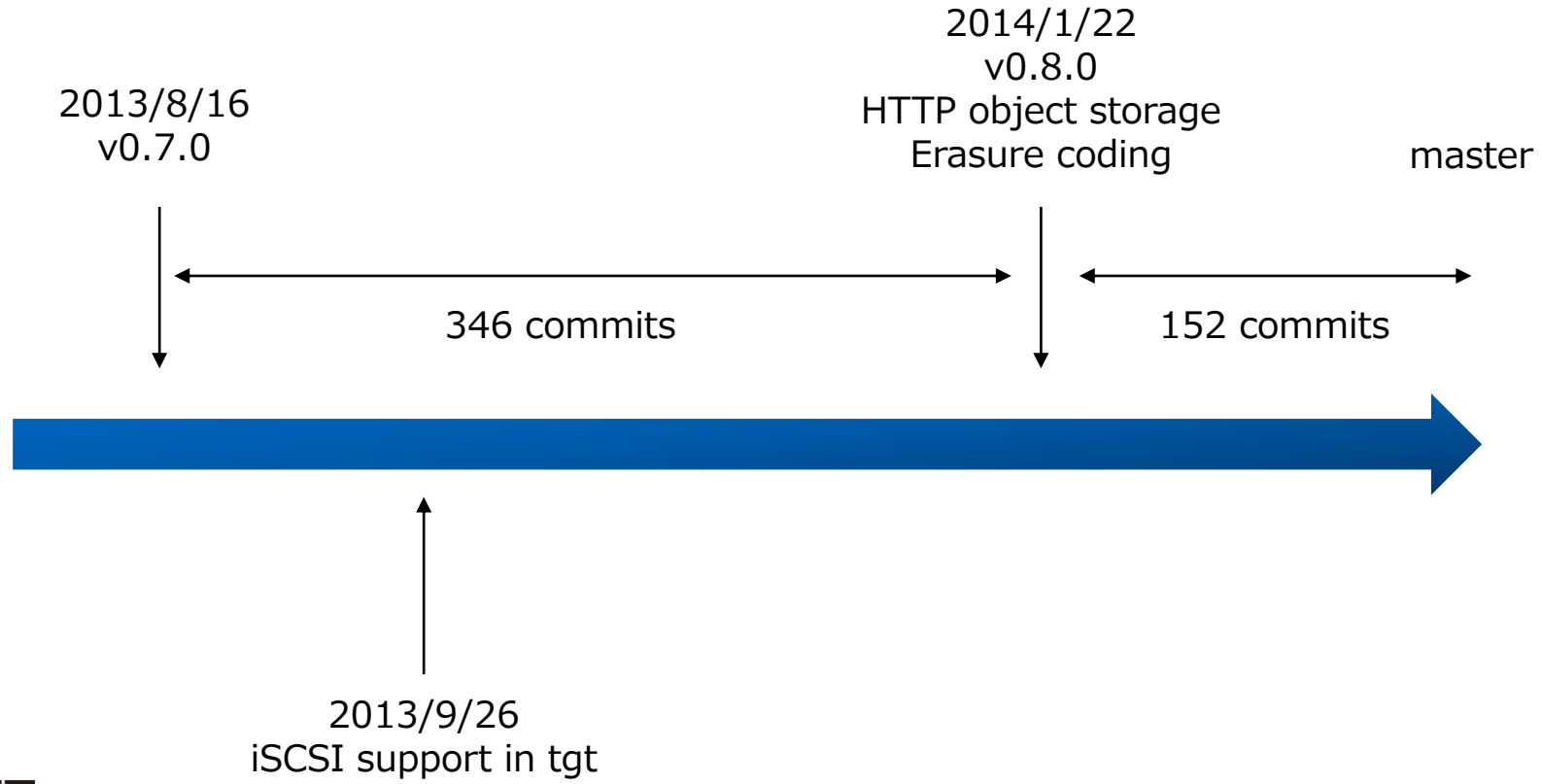


Outline

1. The trend of SDS and sheepdog
2. **Recent development status**
   - Erasure coded VDI
   - iSCSI interface support
   - Object storage support
3. Performance comparison with Ceph and GlusterFS
4. Introduction of use cases
5. Conclusion

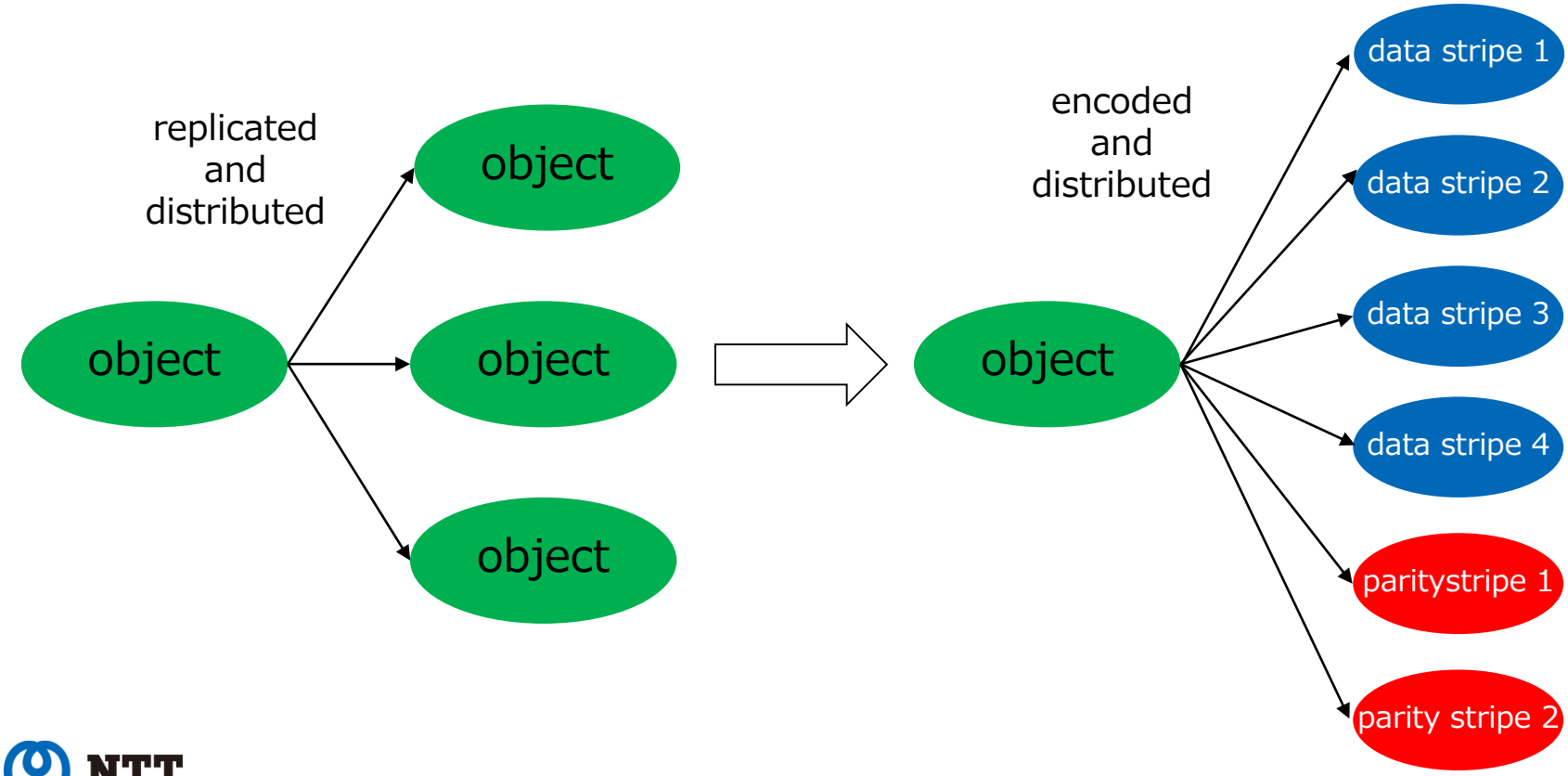
Recent development history

- **Many new features and bunch of bugfixes**
- **Stable releases for long-term support is provided**
  - 9 releases for v0.7.x
  - 2 releases for v0.8.x



Erasure coded VDI

- **New data storing policy**
  - An alternative of naïve replication
  - Objects are encoded to data stripes and parity stripes



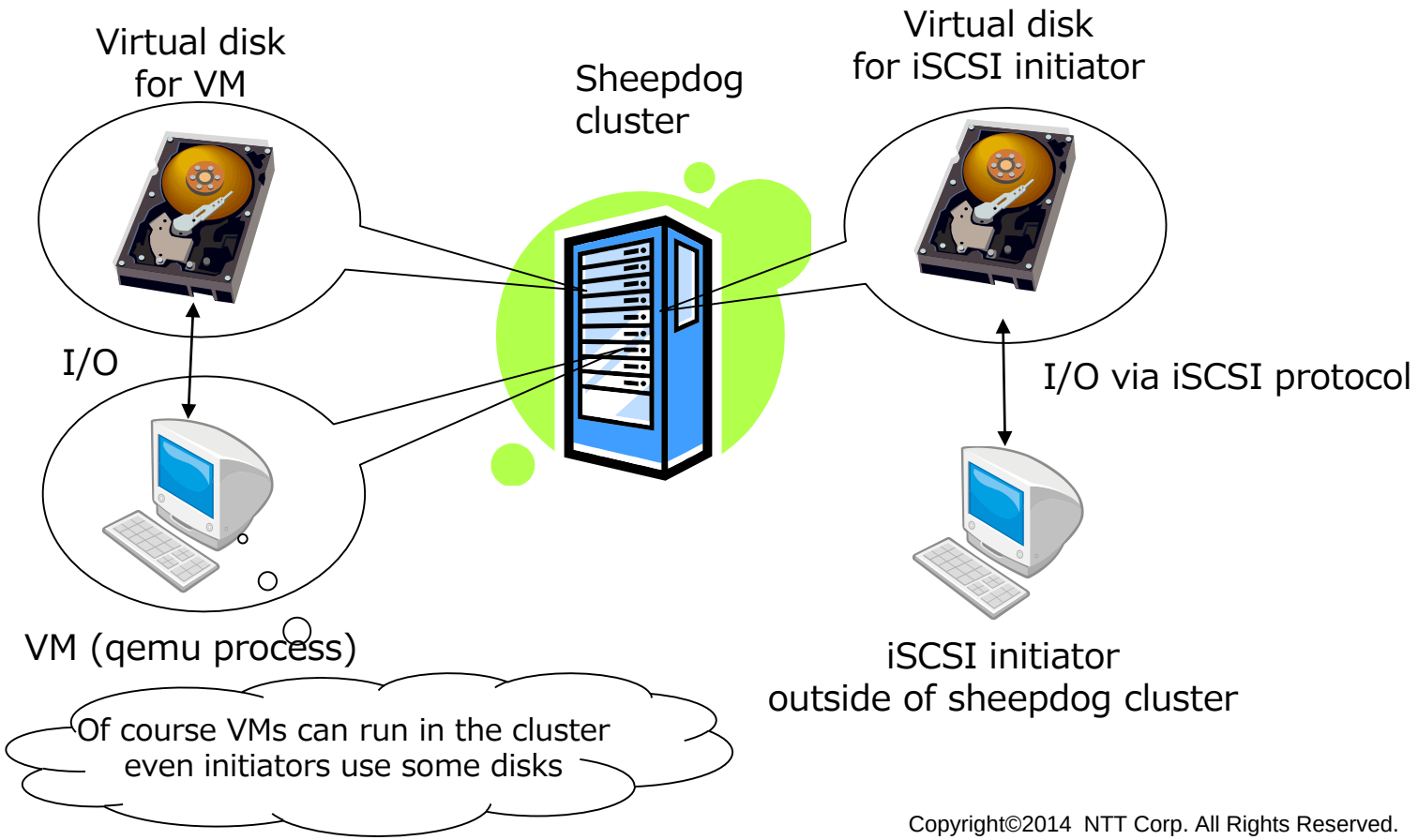
Erasure coded VDI

- **Pros of erasure coding**
  - Improving write performance and space efficiency without degrading durability
    - Also improve read performance in some cases
- **Cons of erasure coding**
  - Degrading read performance in some cases
    - But it can be covered by caching
  - Consume CPU resource for encoding and decoding

- **Coexistence of replication schemes are allowed**
  - Performance comparison of naïve replication and erasure coding is presented later

iSCSI interface support

- **Sheepdog is supporting iSCSI protocol**
  - Any iSCSI initiators (hypervisors other than KVM, bare metal OSes) can use virtual disks of sheepdog



iSCSI interface support

- **iSCSI support is implemented as a backing store driver of tgt: Linux scsi target framework**
  - http://stgt.sourceforge.net/

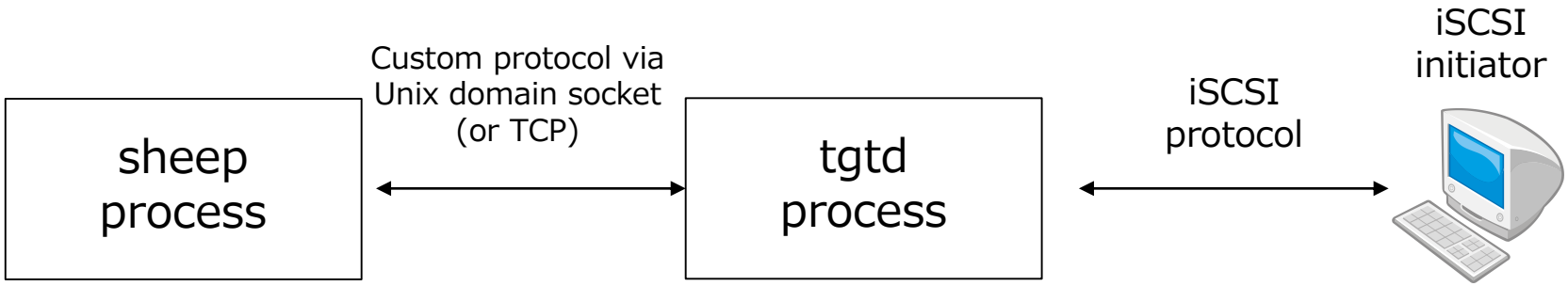
/* creating disks for iSCSI requires no special step */
$ dog vdi create my-new-disk 1TB

/* use the disk as a logical unit of tgtd in a similar way of other backing stores */
$ tgtd
$ tgtadm --op new --mode target --tid 1 --lld iscsi --targetname ¥
iqn.2013-10.org.sheepdog-project
$ tgtadm --op new --mode lu --tid 1 --lun 2 --bstype sheepdog ¥
--backing-store unix:/sheep_store/sock:my-new-disk

Instruction of setup iSCSI target:
https://github.com/sheepdog/sheepdog/wiki/General-protocol-support-(iSCSI-and-NBD)

iSCSI interface support

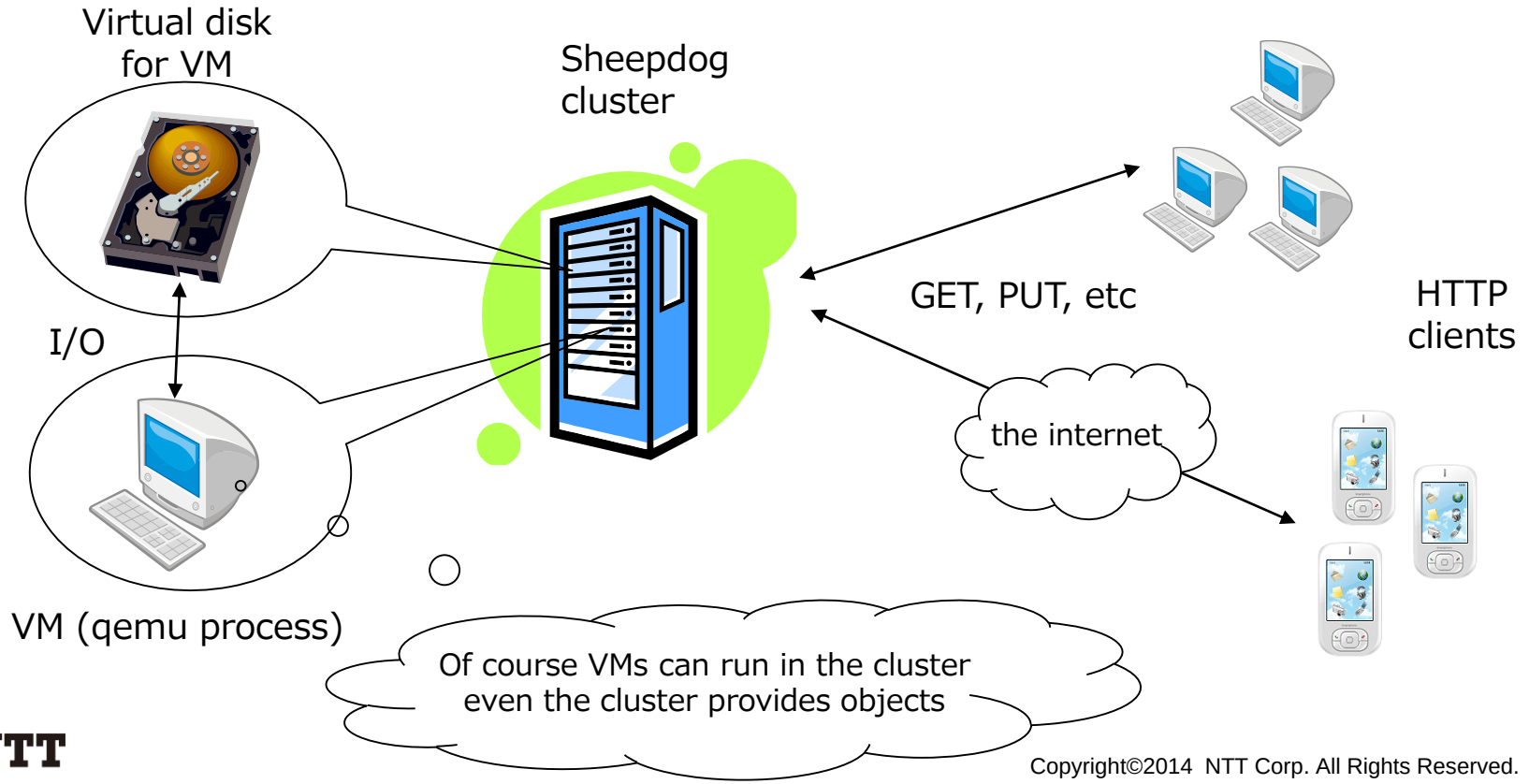
- **Relation of sheepdog, tgt and iSCSI initiator**



- **Who should care about this feature**
  - Non KVM users (e.g. VMware)
  - Owners of machines which have virtualization unfriendly facilities
    - GPUs, many-core based accelerators, etc
  - Owners of non green-field projects
    - e.g. you already have clusters for VMs and storage appliances, and need to migrate them gradually

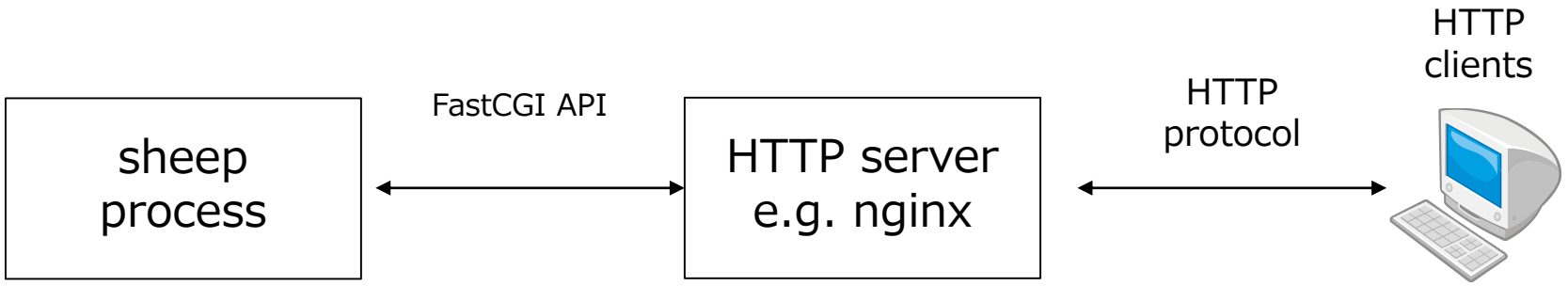
Object storage support

- **Object storage via HTTP interface is supported**
  - account/container/object style interface like AWS S3 and OpenStack Swift
  - suitable for storing static blob contents (e.g. photos, videos)



Object storage support

- **Benefit of providing both of disks and objects in a single cluster**
  - You don’t have to prepare two dedicated clusters for each purpose
  - Entire disk space of cluster can be used for both of disks and objects
    - Contribute to high utilization of resource



Instruction of setup object storage:
https://github.com/sheepdog/sheepdog/wiki/HTTP-Simple-Storage

Outline

1. The trend of SDS and sheepdog
2. Recent development status
3. **Performance comparison with Ceph and GlusterFS**
   - KVM: as a foundation of converged infrastructure
   - tgt: as a scale-out SAN
4. Introduction of use cases
5. Conclusion

Performance comparison

- **Environment**
  - 12 nodes cluster, connected via 10GbE
- **Workload**
  - fio with 16 pattern
    - sequential read, sequential write, random read, random write
    - block sizes: 4MB, 1MB, 512KB, 4KB
- **Assumed failure**
  - 2 node failure at the same time
- **Versions of storage software**
  - Sheepdog: 0.8.1
  - Ceph: 0.72.1
  - GlusterFS: 3.4.3-3

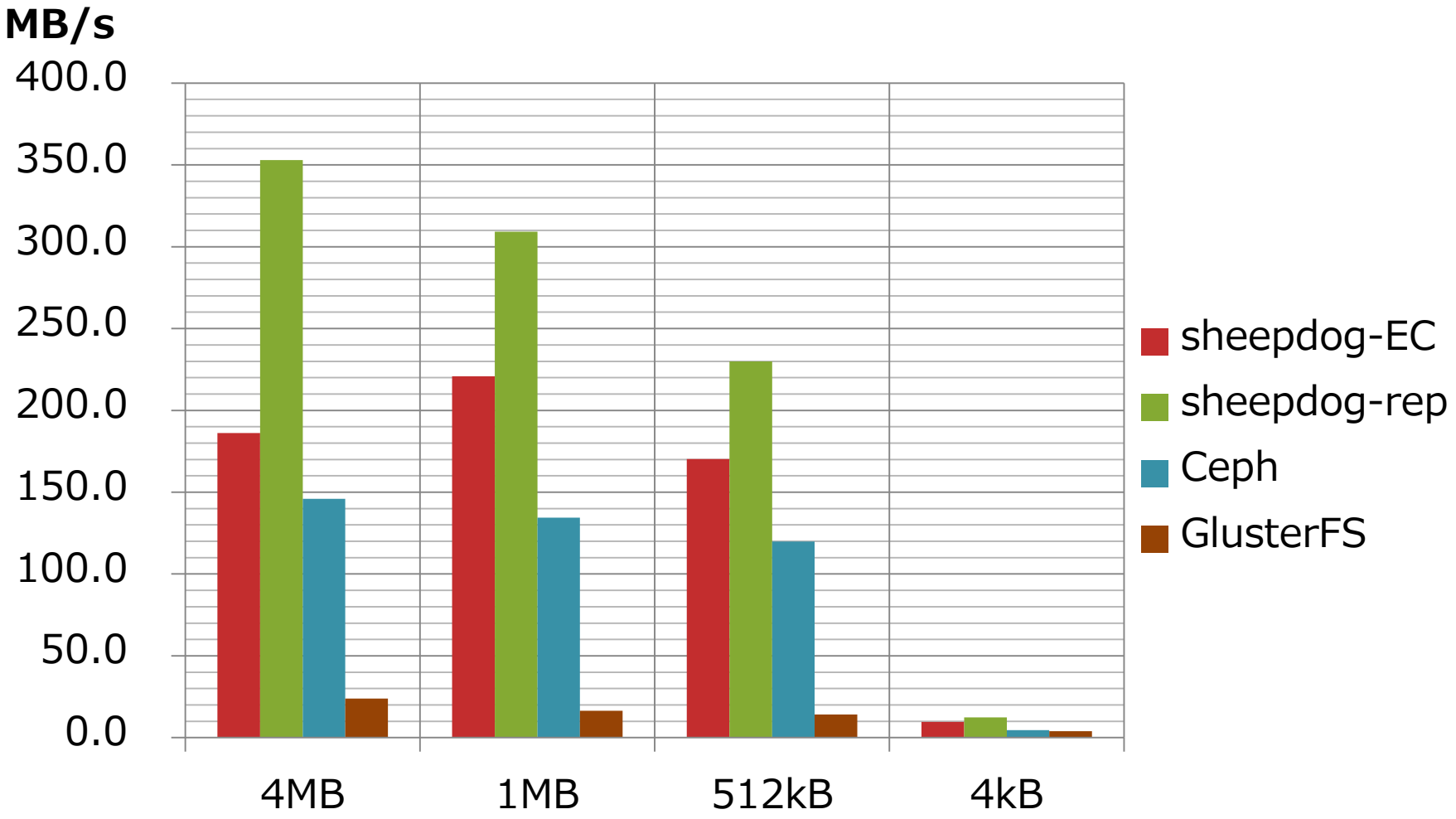
(more detailed information is described in appendix)

Performance comparison: KVM

- **Configurations for the case of KVM**
  - QEMU version: 1.7.1
  - 4 nodes of the cluster run 3 VM
    - 8 nodes are for storage only
    - Average score of the 12 VMs is presented (5 times run)
  - Sheepdog
    - 3 replicas and 4:2 erasure coding
  - Ceph
    - 3 replicas
  - GlusterFS
    - 3 replicas + 4 stripes

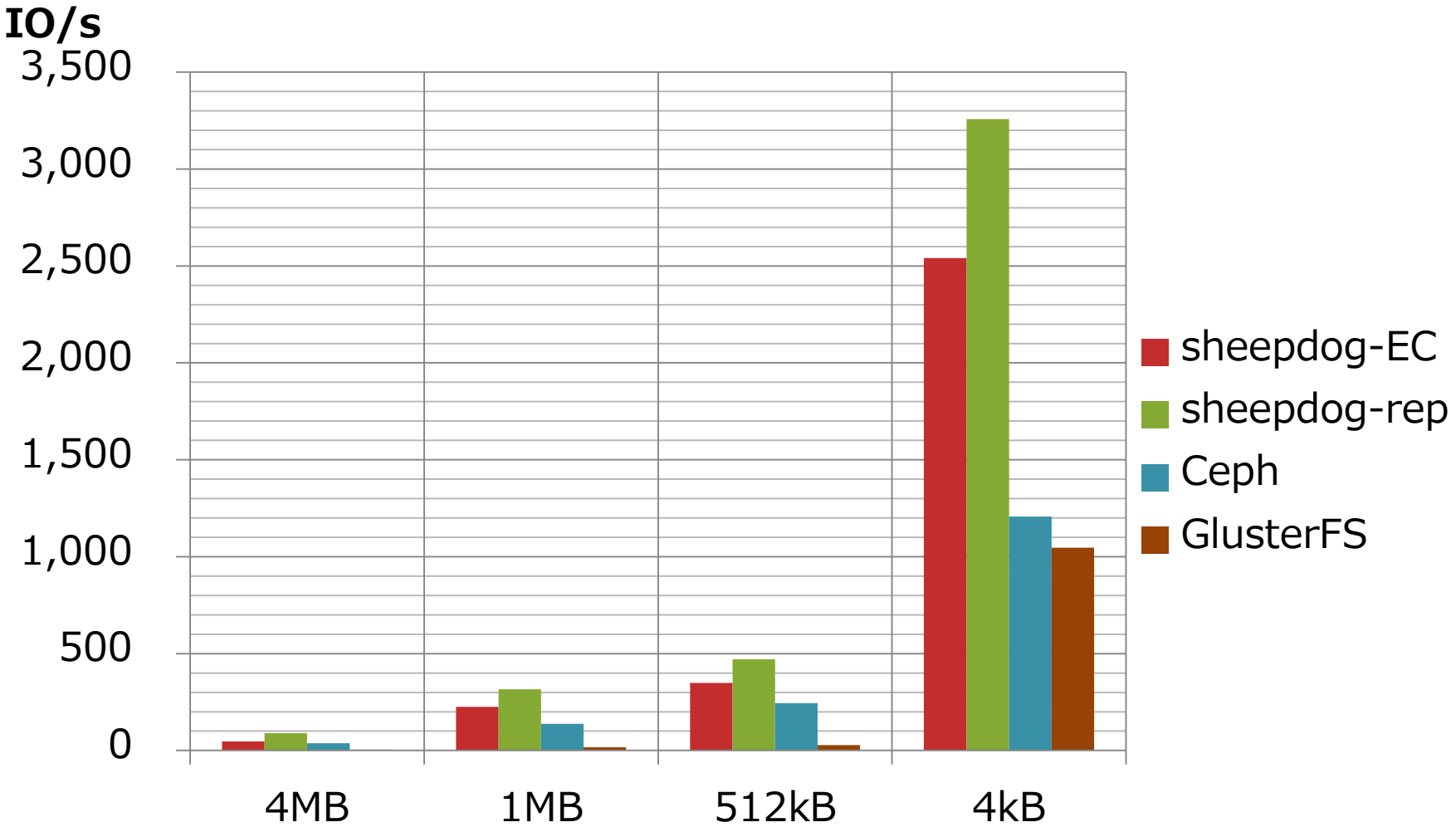
Performance comparison: KVM

- **Sequential Read: Bandwidth**



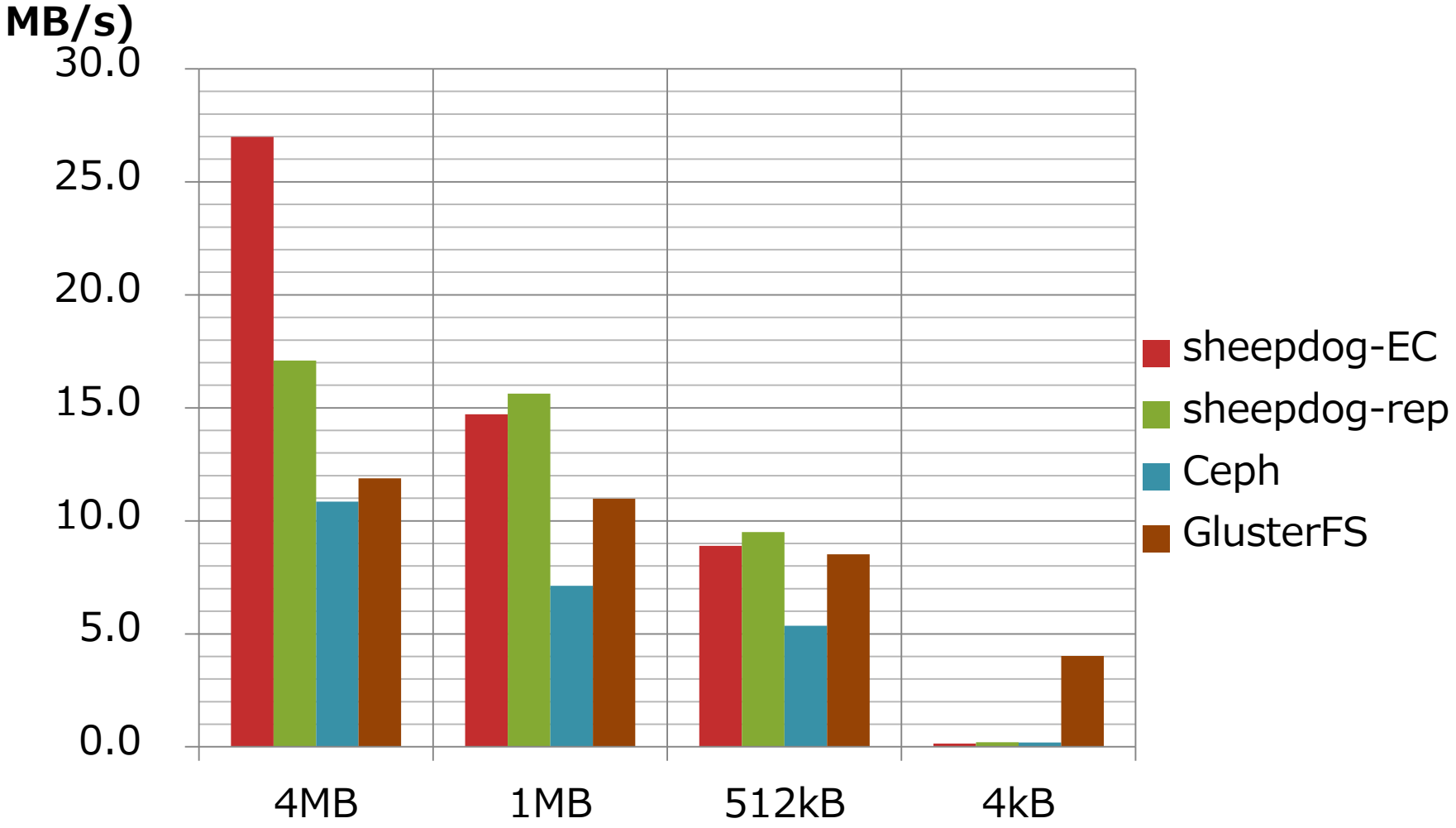
Performance comparison: KVM

- **Sequential Read: IOPS**



Performance comparison: KVM

- **Sequential Write: Bandwidth**



Performance comparison: KVM

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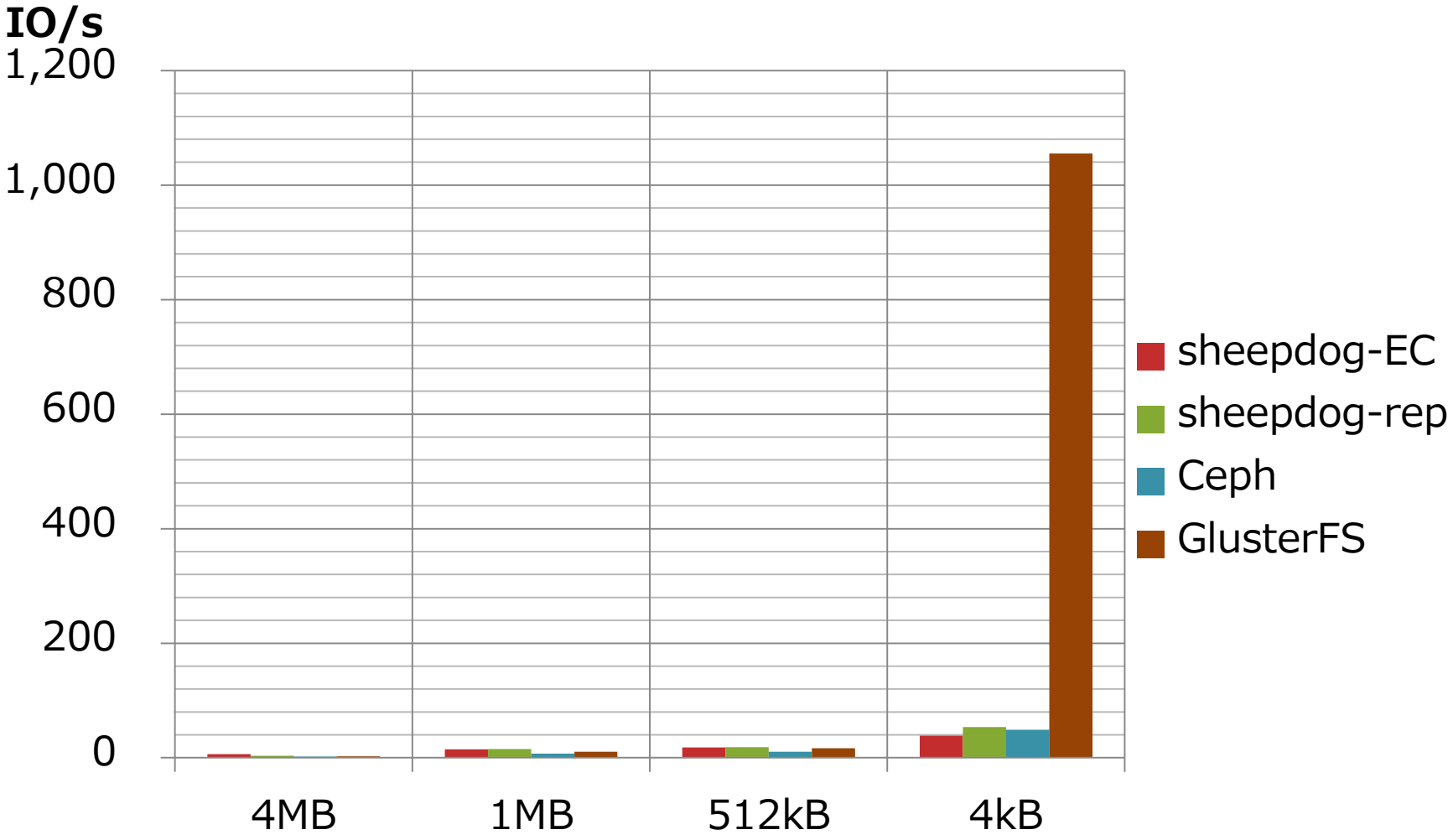
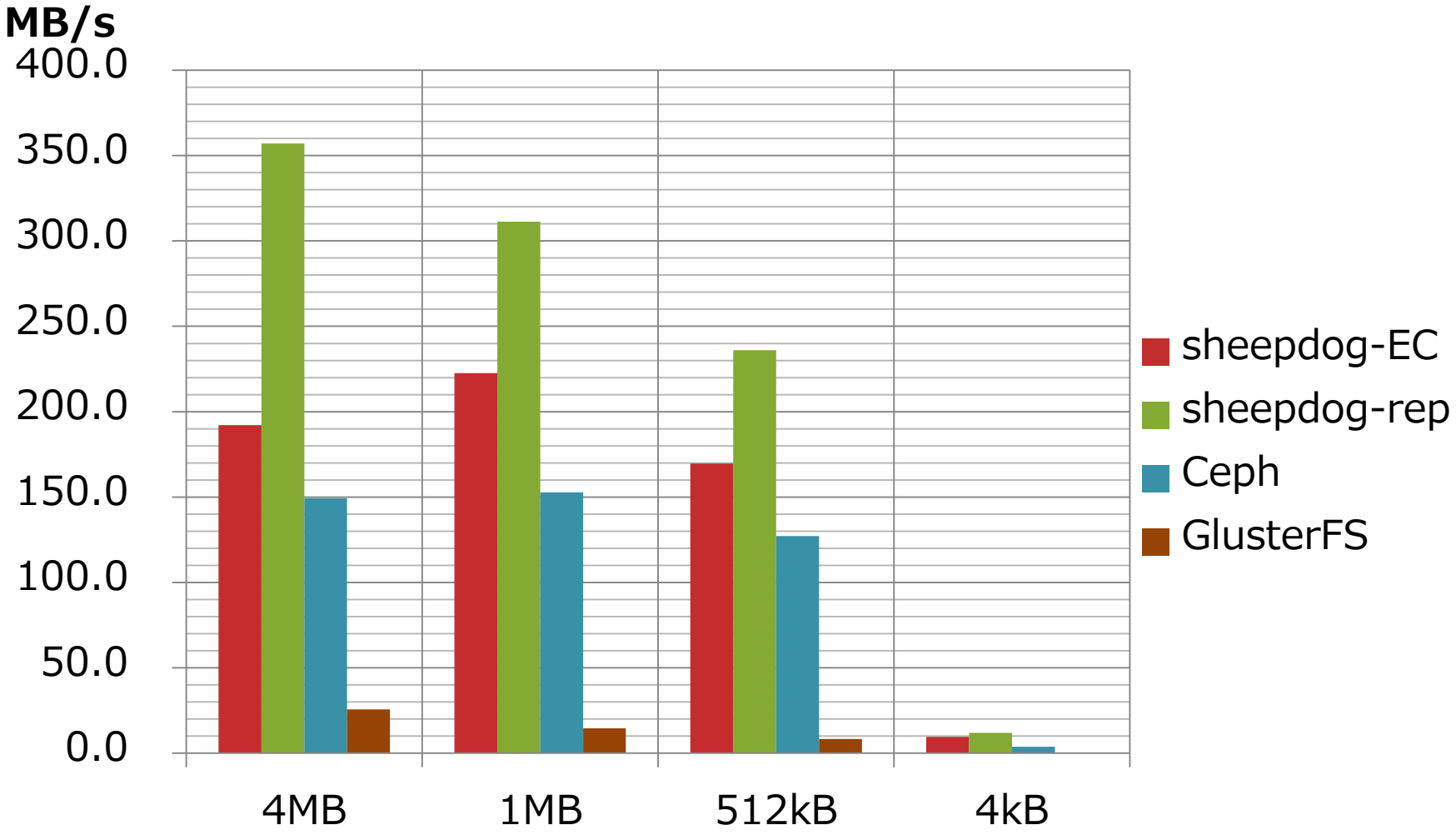


Performance comparison: KVM

- **Random Read: Bandwidth**



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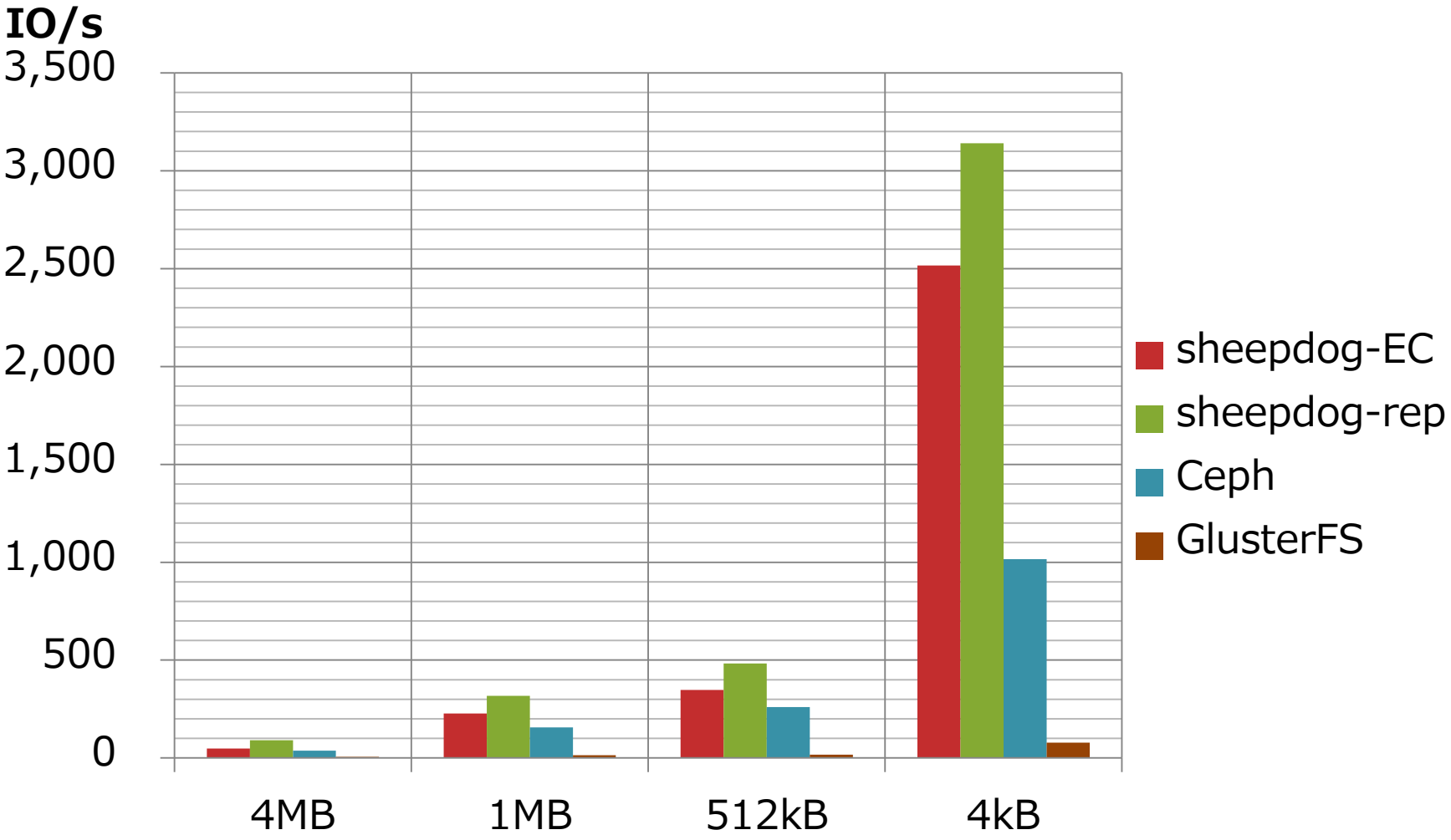

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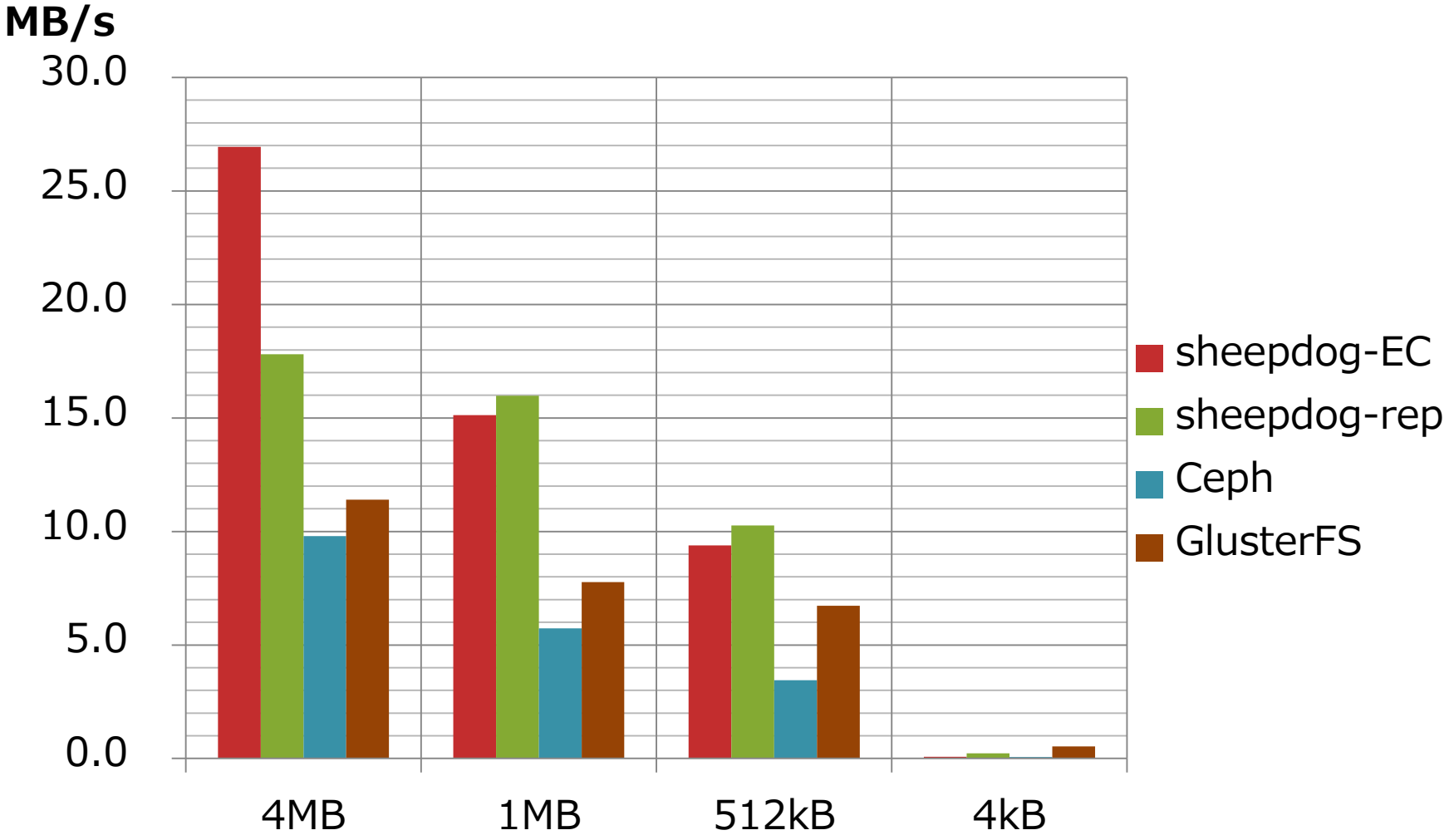

Performance comparison: KVM

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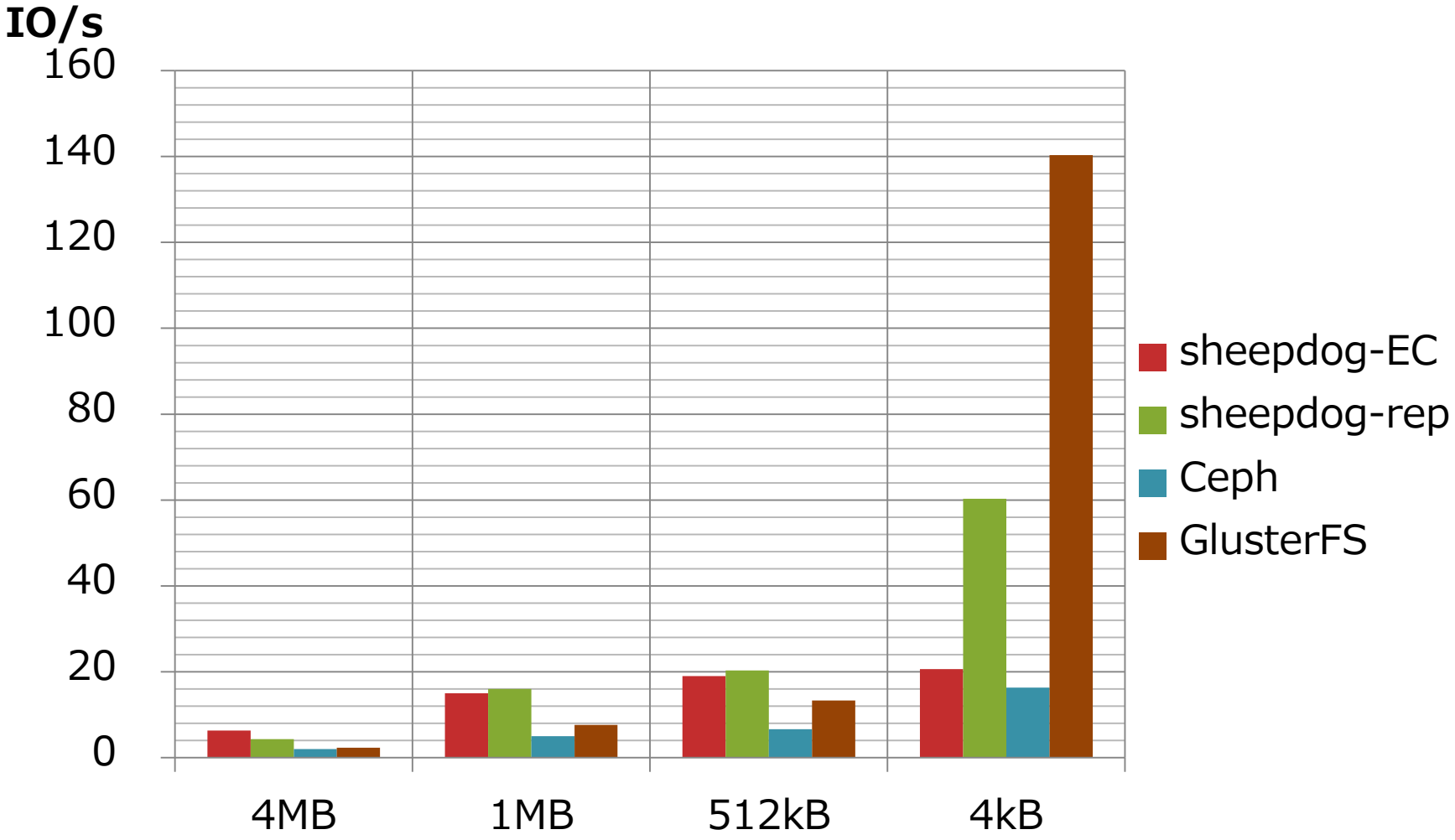


Performance comparison: KVM

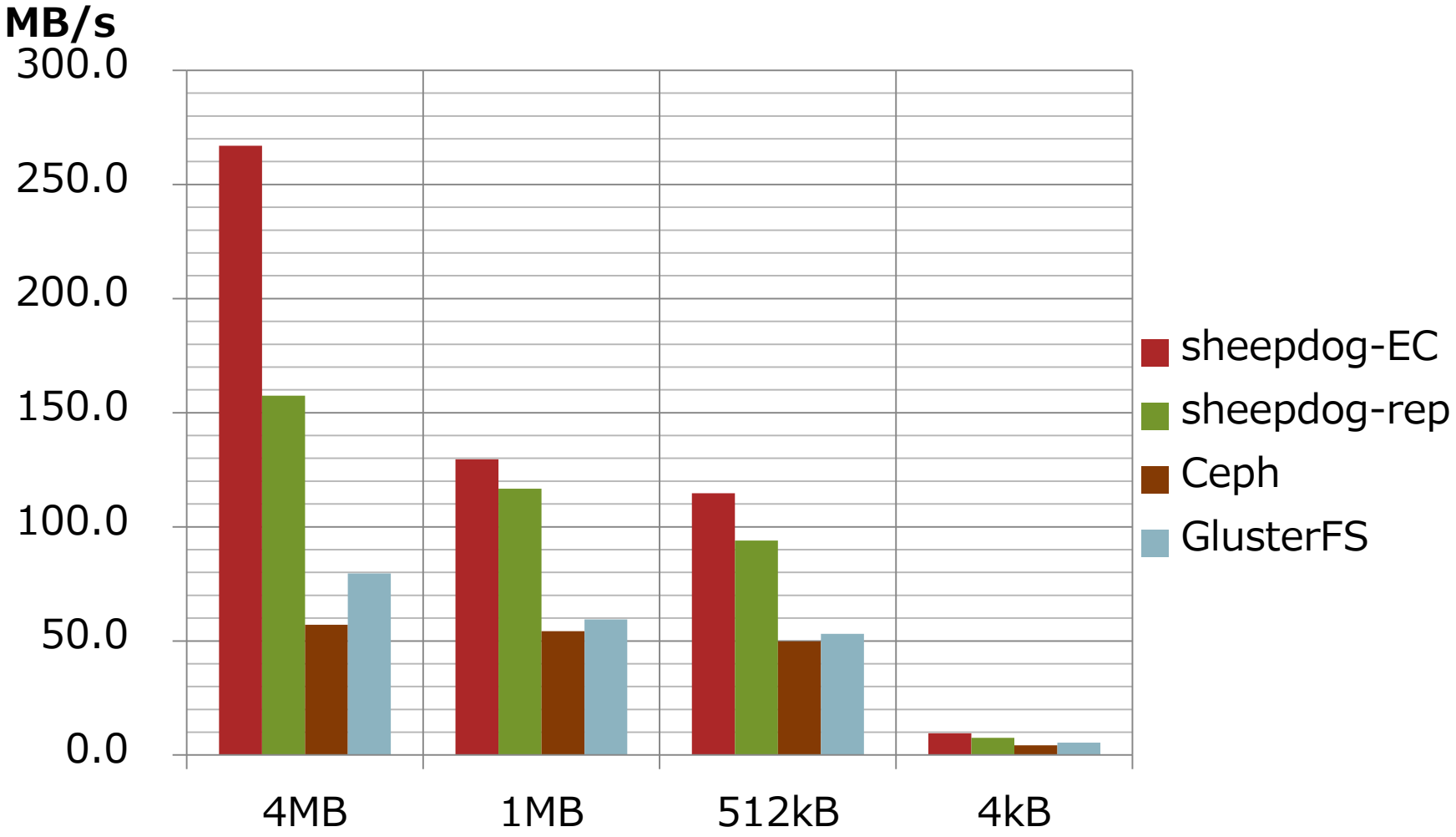
- **Summary**
  - Sheepdog is superior in larger (512KB <) block sizes
    - Under all workloads
    - Erasure coding is effective for improving large block writes
  - GlusterFS is superior in small block writes
    - Especially, tt can be seen in IOPS score

Performance comparison: iSCSI

- **Configurations for the case of iSCSI**
  - tgt version: 1.0.46
  - iSCSI initiator: Linux + open-iscsi 6.2.0.873-10
  - 9 nodes for storage, 3 nodes for client (iSCSI initiator)
    - 3 of 9 storage nodes run tgtd (iSCSI target)
  - Average score of 3 initiators is presented (5 times run)
  - Sheepdog
    - 3 replicas and 4:2 erasure coding
  - Ceph
    - 3 replicas
  - GlusterFS
    - 3 replicas + 3 stripes

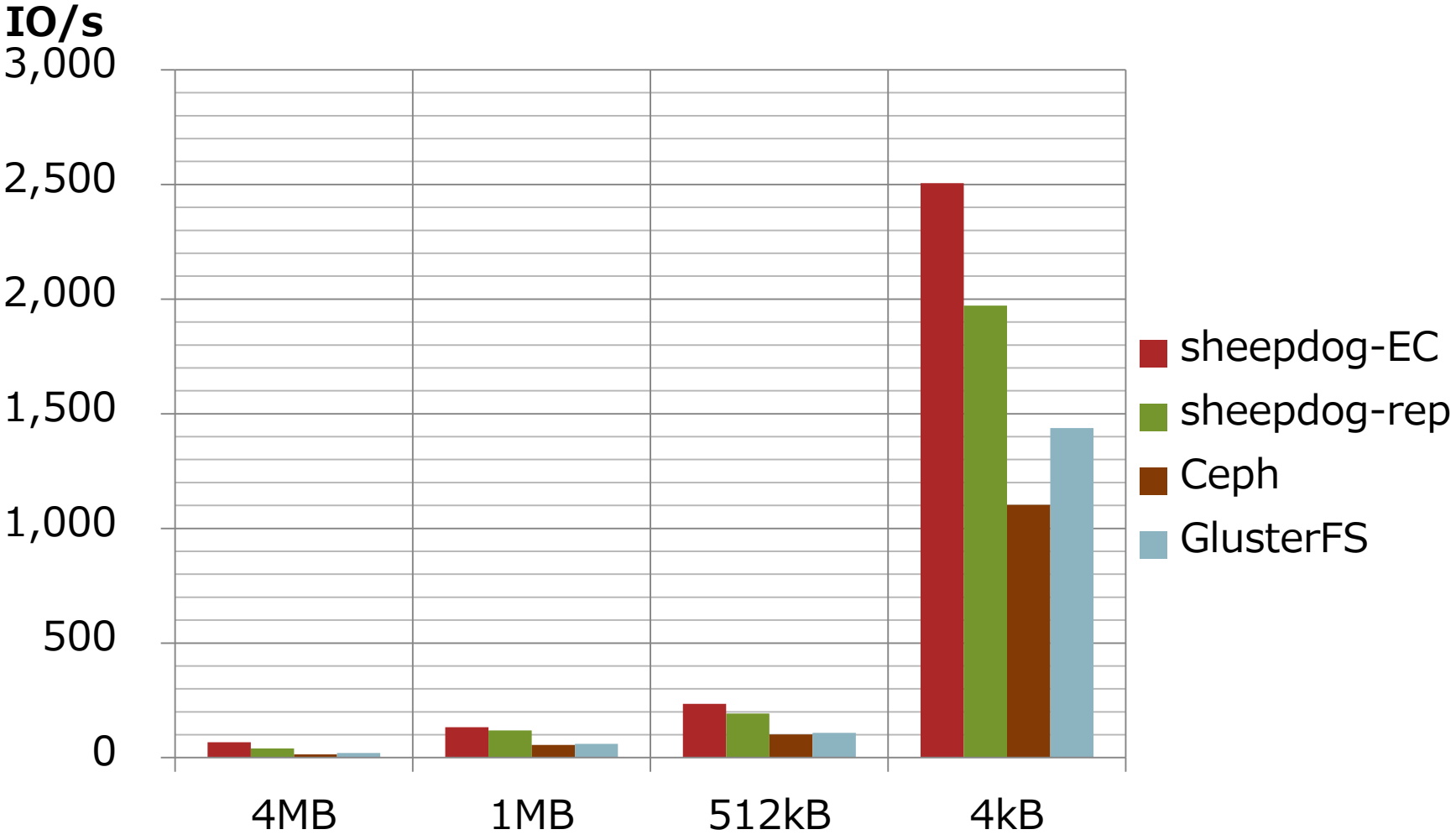
Performance comparison: iSCSI

- **Sequential Read: Bandwidth**



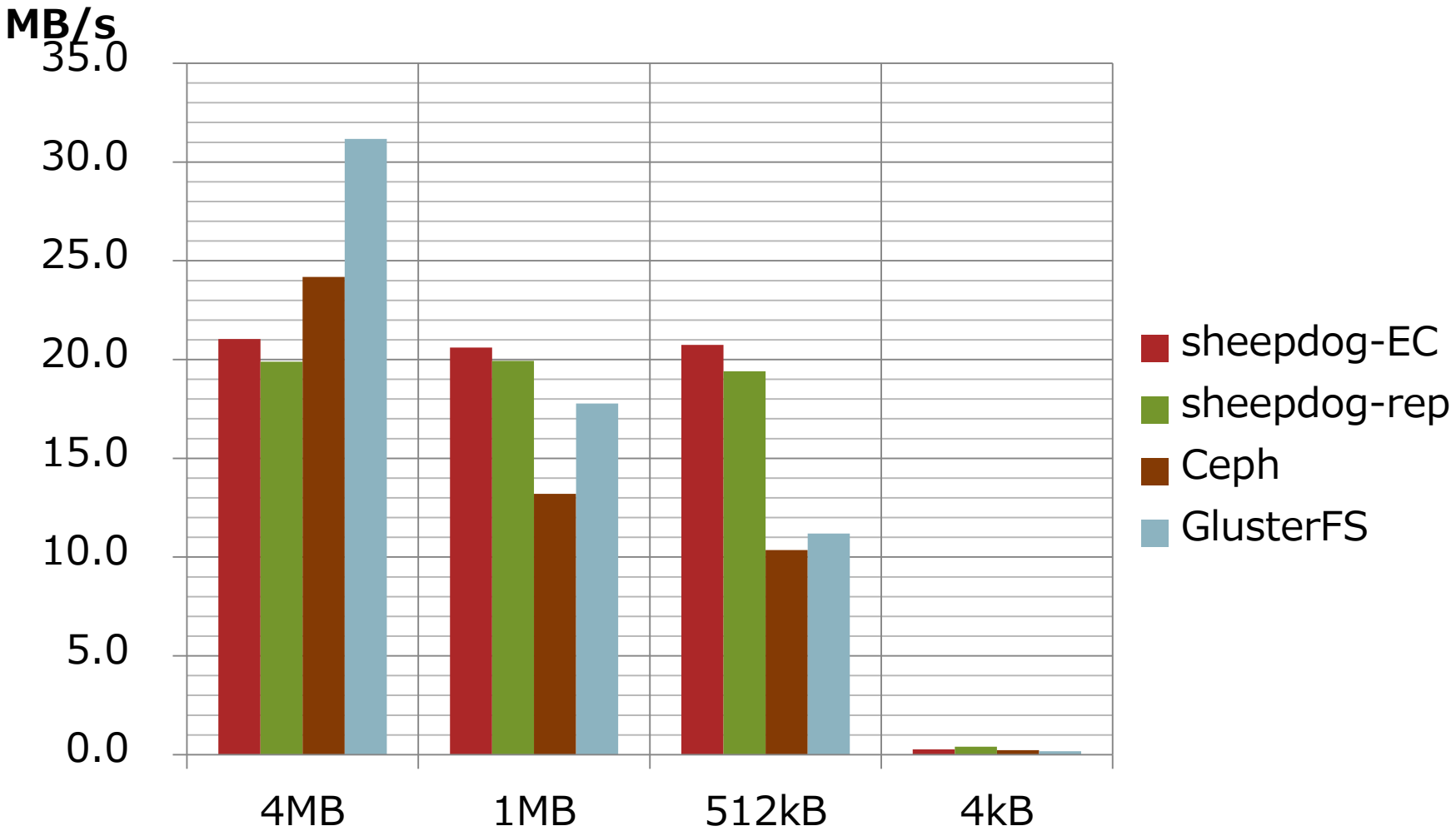
Performance comparison: iSCSI

- **Sequential Read: IOPS**



Performance comparison: iSCSI

- **Sequential Write: Bandwidth**



Performance comparison: iSCSI

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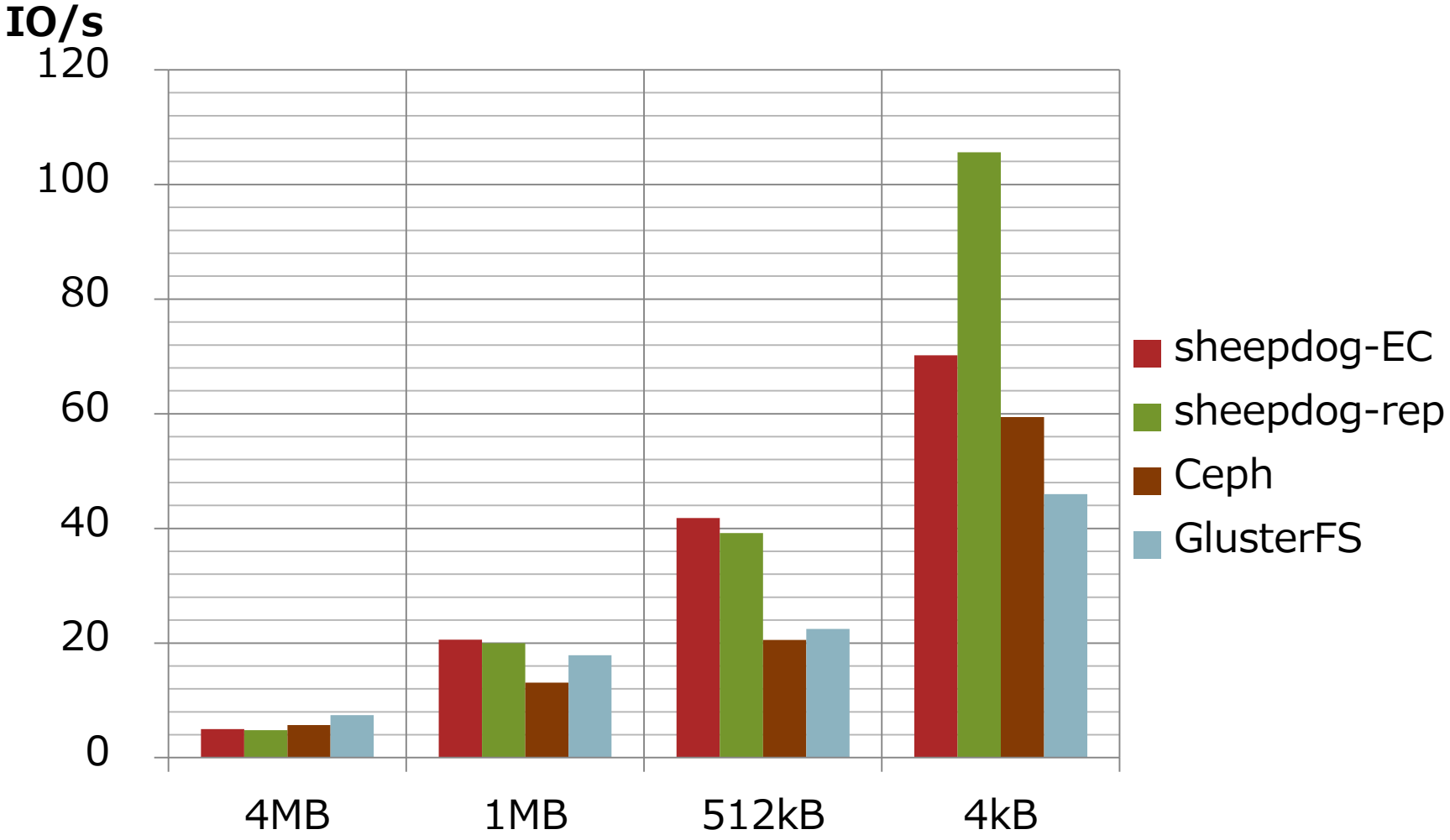
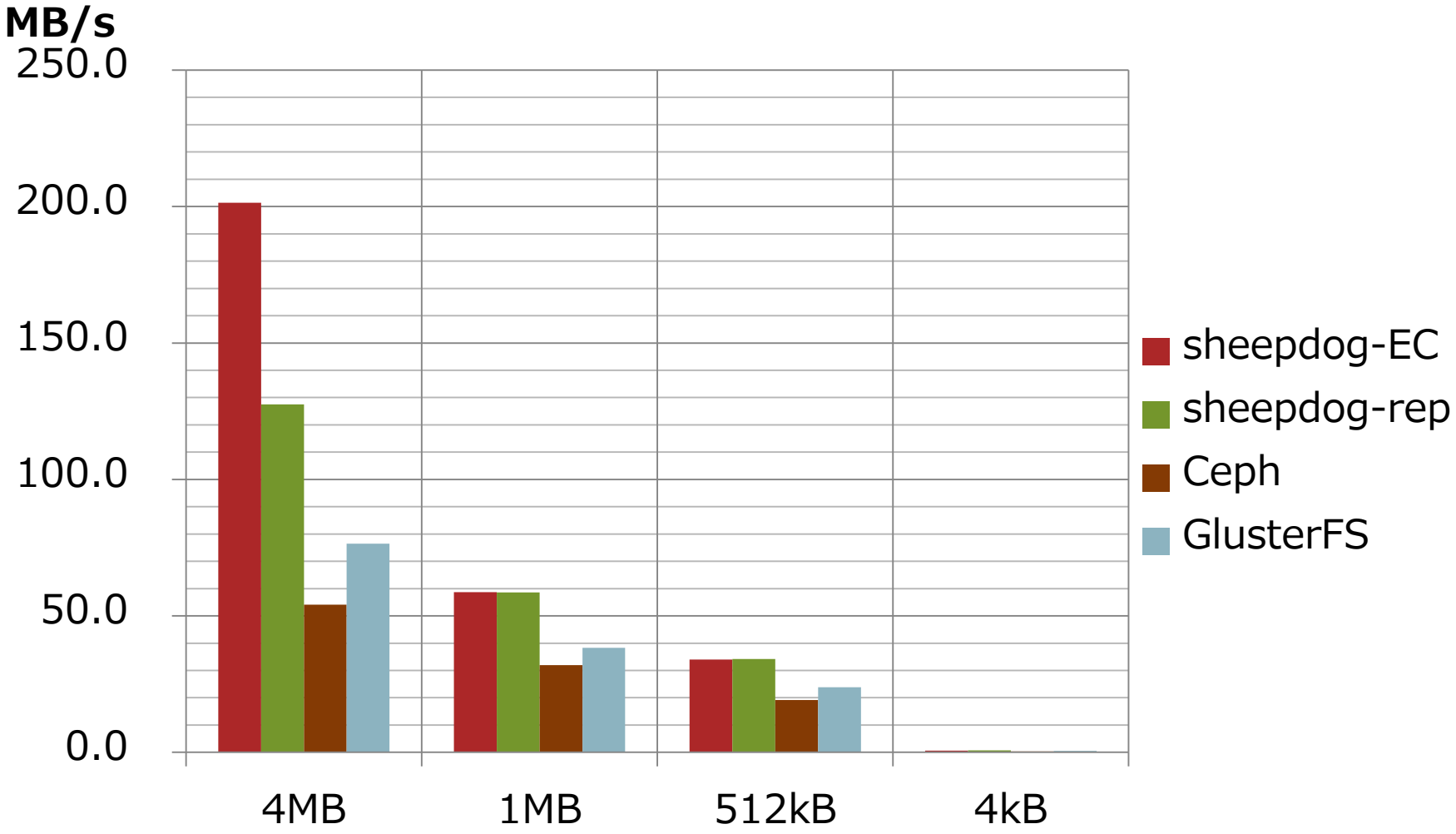


Performance comparison: iSCSI

- **Random Read: Bandwidth**



Performance comparison: iSCSI

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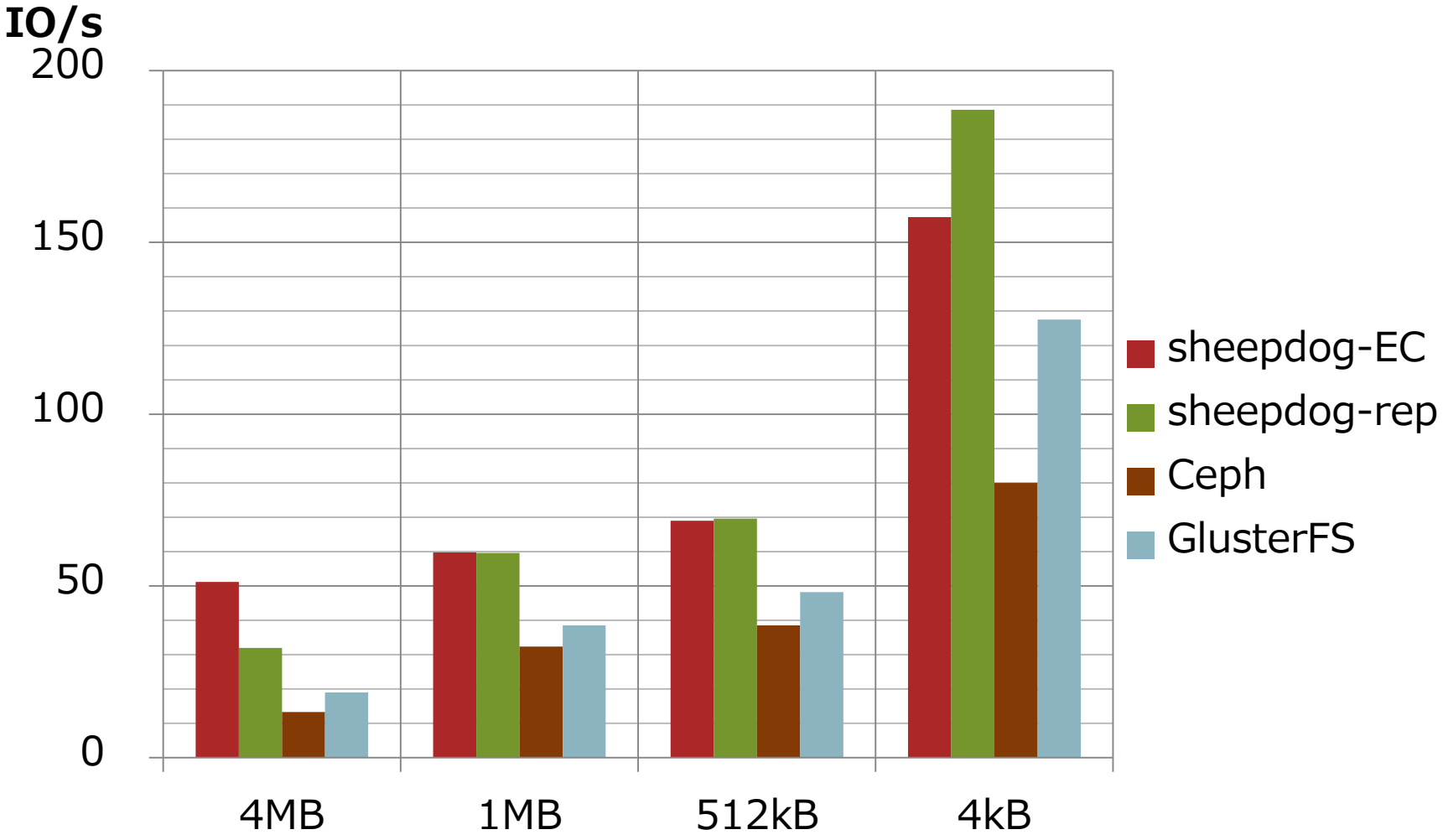

Performance comparison: iSCSI

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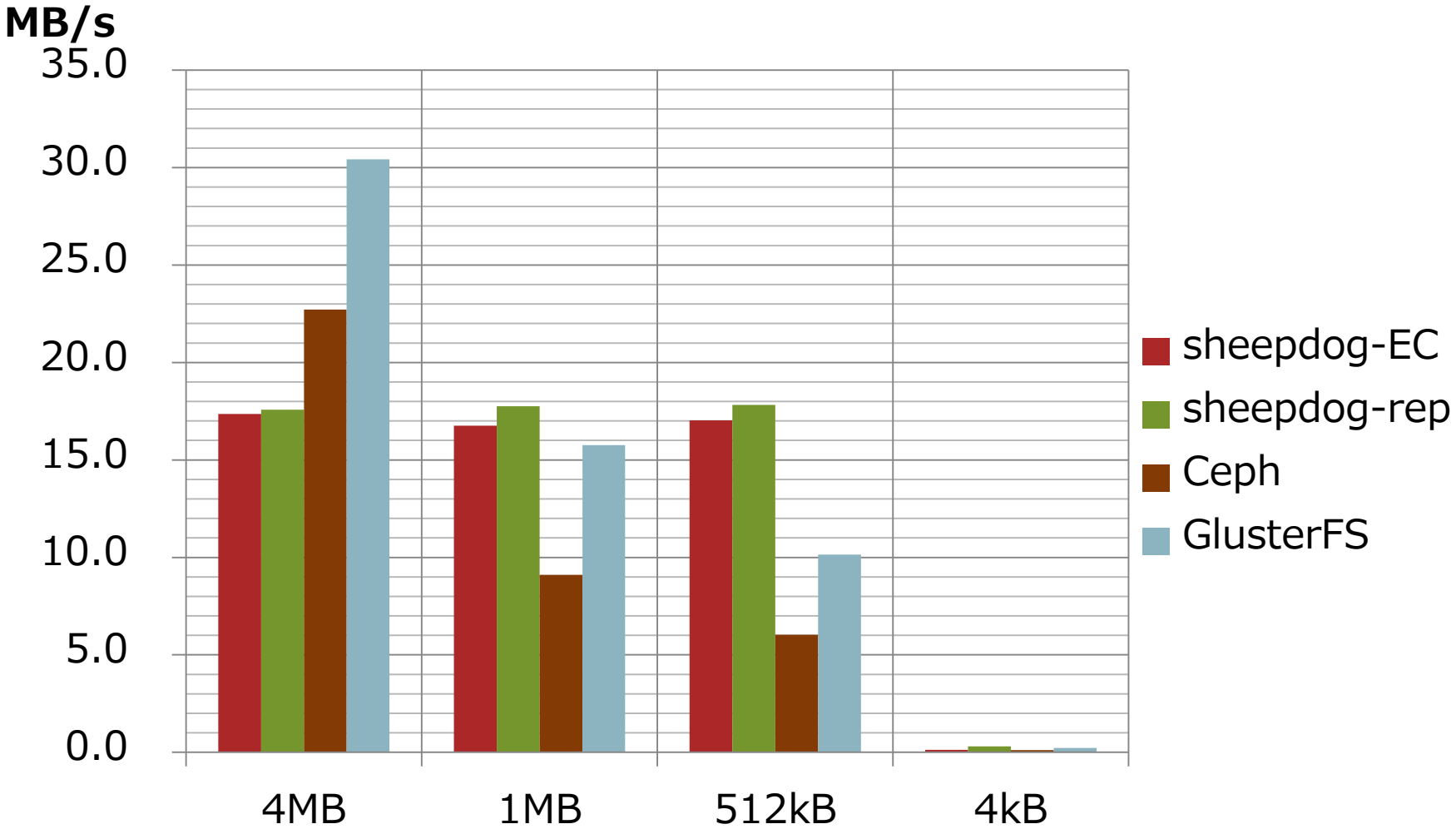

Performance comparison: iSCSI

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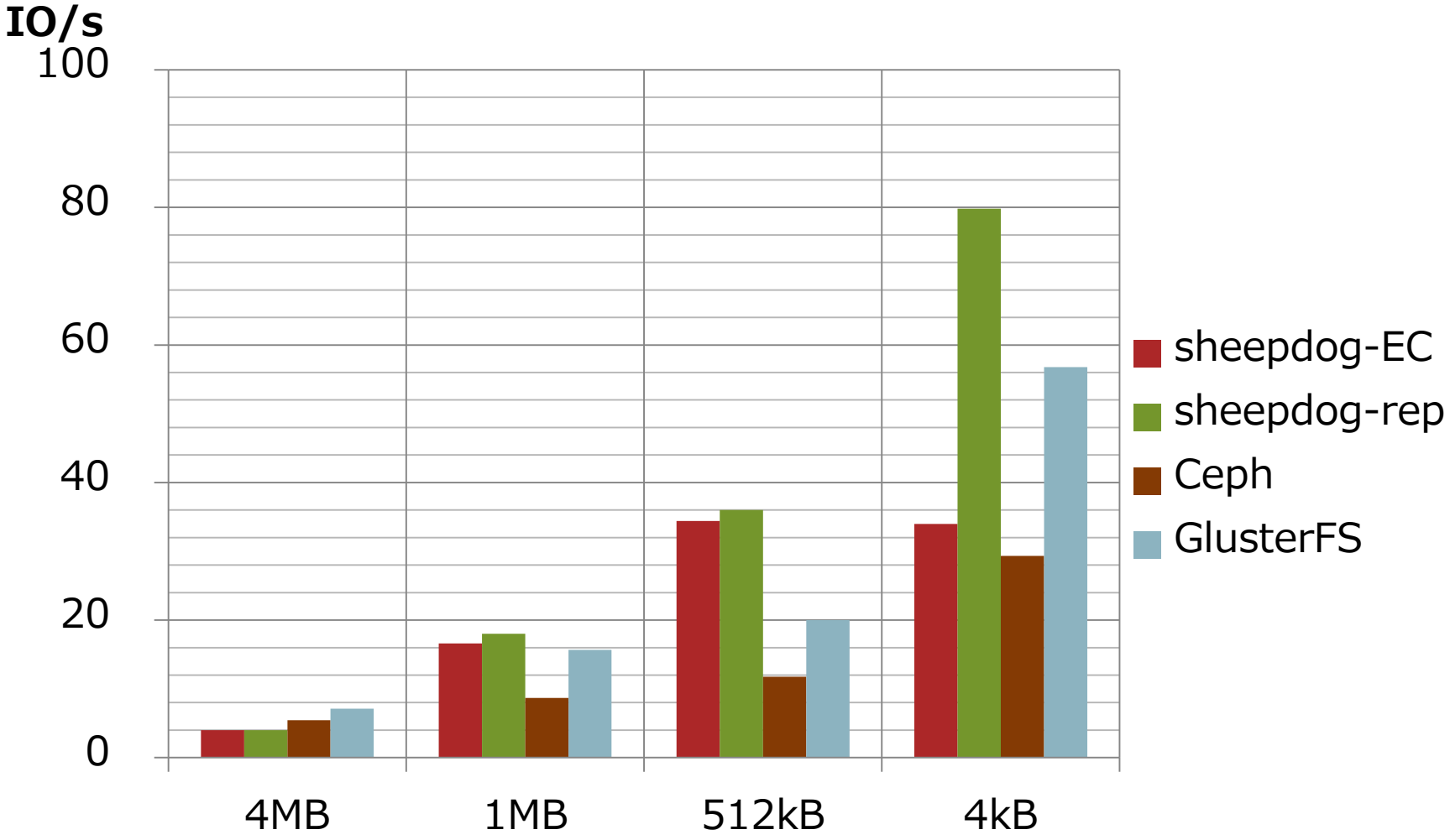
- **Random Write: IOPS**



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Performance comparison: iSCSI

- **Summary**
  - Sheepdog is superior in many cases other than large block writes
  - Unlike the case of KVM, small block access is better than GlusterFS

Performance comparison: Summary

- **Sheepdog is superior in many cases**

- **Call for your evaluation**
  - Evaluating distributed storage is hard
    - very time consuming
    - innumerable workloads and configurations both in hardware and software
    - many perspectives
      - Scalability
      - Performance during recovery process caused by node failure
      - Worst case of latency
      - Fairness between clients
      - Etc…
  - We are not expert of Ceph and GlusterFS ☹

Outline

1. The trend of SDS and sheepdog
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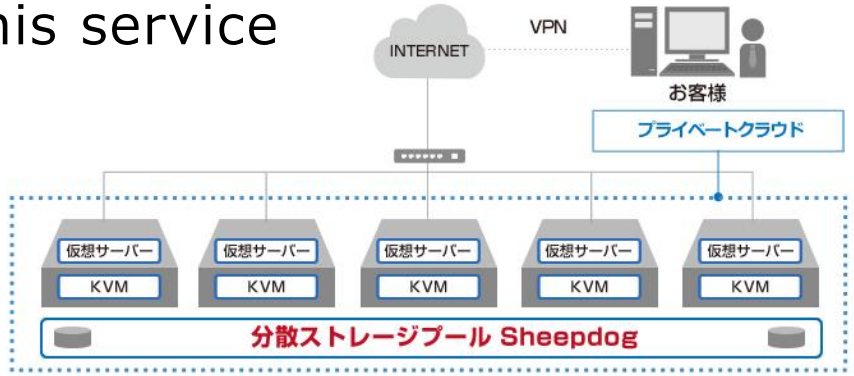
4. **Introduction of use cases**
   - Examples of commercial users
   - Introducing names of people who can be reached in our mailing list
5. Conclusion

A.T. WORKS, Inc. (Japan)

- **A server vendor and service provider famous of “red server”**
  - http://atworks.co.jp/
  - Person: Masahiro Tsuji

- **Use case: Rental private cloud**
  - http://rental-private-cloud.jp/
  - Kind of private IaaS
    - dedicated hardware in DC of A.T. WORKS
    - no resource conflict between other users
  - sheepdog is a storage of this service



Extensys, Inc. (Italy)

- **A system integrator**
  - http://extensys.it/
  - People: Valerio Pachera and Alessandro Bolgia
- **Use case: build services based on sheepdog for their customers**
  - Cooperating with proxmox server solutions, GmbH
    - for official support of sheepdog in the proxmox VE package

UCWeb, Inc. (China)

- **A software and service company famous for UC Browser**
  - http://www.ucweb.com/
  - Person: Ruoyu
- **Use case: backend services of UC Browser**
  - They are also planning to migrate their online game service (http://www.9game.com/) in the near future.

Delaware State University (U.S.)

- **A university**
  - http://desu.edu/
  - Person: Andrew J. Hobbs
- **Use case: virtualization environment for hosting various services in the campus network**
  - websites based on LAMP, NFS, VPN server, Matlab licensing server, etc…
  - Their cluster started from “retired workstations”, and is expanded by adding new machines.

Argonne National Laboratory (U.S.)

- **A national laboratory**
  - http://www.anl.gov/
  - People: Scott Devoid and Ryan M. Aydelott
- **Use case: cluster for scientific computation**
  - Primary purposes: bioinformatics
    - genome assembly and metagenomics
    - a cosmology project is running on the cluster, too
  - 20 nodes, 14 disks per node, infiniband based cluster
  - They are also working on OpenStack integration
    - http://goo.gl/k9hxeu

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Conclusion

- **Sheepdog can provide a storage functionality for OSS-based SDS products**
  - Both of converged infrastructure and scale-out SAN
- **Future directions and major ToDos**
  - Towards polyglot, all-in-one storage
    - completing NFS interface
  - Cooperation with other software and ecosystems
    - integration with OpenStack, CloudStack
  - Workload aware optimizations
    - smart cache replacement and prefetching policies
    - deduplication, especially for read only objects
  - Advanced hardware support
    - Infiniband
    - PCIe-connected flash drives

Conclusion

- **Getting started**
  - web site: http://sheepdog.github.io/sheepdog/
  - start your sheepdog cluster: https://github.com/sheepdog/sheepdog/wiki/Getting-Started
  - mailing lists
    - for developers: http://lists.wpkg.org/mailman/listinfo/sheepdog
    - for users: http://lists.wpkg.org/mailman/listinfo/sheepdog-users
  - repository: https://github.com/sheepdog/sheepdog
  - latest stable release: v0.8.1
    - https://github.com/sheepdog/sheepdog/tarball/v0.8.1

Thanks a lot for your attention!

Any questions?

APPENDIX

Hardware configuration

- **Machine: Fujitsu PRIMERGY RX200 S8 * 12**
  - Hostname
    - sds01 – sds12
  - CPU
    - Intel Xeon CPU E5-2620 v2 @ 2.10GHz
    - 2CPU*6core*HT=24 logical cores
  - Memory
    - DDR3 4GB 1600MHz * 8, 32GB total
  - HDD
    - SATA 250GB 7.2krpm * 4
    - 1 for system area, 3 for data area with RAID 0
  - NICs
    - Intel 82599ES SFP+ (10Gbps) for traffic of storage
    - Intel I350 (1Gbps) for management
  - RAID card
    - LSI MegaRAID SAS 2208
      - 1GB cache, 6Gbps bandwidth
      - Write through, no read ahead

fio parameter for QEMU

```
[global]
thread=1
time_based=1
runtime=60
ramp_time=10
invalidate=1
stonewall=1
direct=1
fsync=1
unlink=1
ioengine=sync
numjobs=1
directory=/var/tmp/
size=1G
```

```
; workload specific part, example of 512k sequential write
[512k-seqwrite-fs-1thread-sync]
bs=512k
rw=write
```

fio parameter for iSCSI

```
[global]
thread=1
time_based=1
runtime=60
ramp_time=10
invalidate=1
stonewall=1
direct=1
fsync=1
unlink=1
ioengine=sync
numjobs=1
directory=/dev/sdg
size=10G
```

```
; workload specific part, example of 512k sequential write
[512k-seqwrite-fs-1thread-sync]
bs=512k
rw=write
```

Sheepdog boot parameter

- run on every node with different IP address

```
# sheep -p 7000 -b 192.168.2.11 -i host=192.168.2.11,port=7001 -l
dir=/var/log/sheepdog,level=info /data/sheepdog/sheepdog_qemu
```

- Cluter initialization for erasure coding

```
# dog cluster format –c 4:2
```

- Cluster initialization for 3 replication

```
# dog cluster format –c 3
```

Configuration of ceph

```
[osd.9]
public_addr = 192.168.2.19
cluster_addr = 192.168.2.19

[osd.8]
public_addr = 192.168.2.18
cluster_addr = 192.168.2.18

[global]
auth_service_required = cephx
filestore_xattr_use_omap = true
auth_client_required = cephx
auth_cluster_required = cephx
mon_host = 172.16.2.22
mon_initial_members = sds12
cluster_network = 192.168.2.0/24
cluster_addr = 192.168.2.22
fsid = 1b15baf1-17fb-454a-a051-df32db6e9708

[osd.1]
public_addr = 192.168.2.11
cluster_addr = 192.168.2.11

[osd.3]
public_addr = 192.168.2.13
cluster_addr = 192.168.2.13

[osd.2]
public_addr = 192.168.2.12
cluster_addr = 192.168.2.12
```

```
[osd.5]
public_addr = 192.168.2.15
cluster_addr = 192.168.2.15

[osd.4]
public_addr = 192.168.2.14
cluster_addr = 192.168.2.14

[osd.7]
public_addr = 192.168.2.17
cluster_addr = 192.168.2.17

[osd.6]
public_addr = 192.168.2.16
cluster_addr = 192.168.2.16

[osd.11]
public_addr = 192.168.2.21
cluster_addr = 192.168.2.21

[osd.10]
public_addr = 192.168.2.20
cluster_addr = 192.168.2.20

[mon.sds01]
host = sds01
addr = 192.168.2.11:6789

[mon.sds03]
host = sds03
addr = 192.168.2.13:6789

[mon.sds02]
host = sds02
addr = 192.168.2.12:6789
```

Procedure of creating volumes of Ceph: for the case of QEMU/KVM

Innovative R&D by NTT

```
# ceph-deploy new sds12
•    modify config on sds12
# ceph-deploy install sds12 sds01 sds02 sds03 sds04 sds05 sds06 sds07 sds08 sds09 sds10 sds11
# ceph-deploy mon create-initial
# ceph-deploy gatherkeys sds12
# ceph-deploy osd prepare sds01:/data/ceph/osd sds02:/data/ceph/osd
# ceph-deploy osd prepare sds03:/data/ceph/osd sds04:/data/ceph/osd sds05:/data/ceph/osd
# ceph-deploy osd prepare sds06:/data/ceph/osd sds07:/data/ceph/osd sds08:/data/ceph/osd
# ceph-deploy osd activate sds01:/data/ceph/osd sds02:/data/ceph/osd
# ceph-deploy osd activate sds03:/data/ceph/osd sds04:/data/ceph/osd sds05:/data/ceph/osd
# ceph-deploy osd activate sds06:/data/ceph/osd sds07:/data/ceph/osd sds08:/data/ceph/osd

# ceph-deploy osd activate sds09:/data/ceph/osd sds10:/data/ceph/osd sds11:/data/ceph/osd
# ceph osd tree

# ceph osd pool create pool01 400 400
# ceph osd pool set pool01 size 3
# ceph osd dump | grep 'rep size'

•    Configuring authentication on sds12
# ceph auth get-or-create client.libvirt mon 'allow r' osd 'allow class-read object_prefix rbd_children, allow rwx pool=pool01'

•    Add mon, on sds12
# ceph-deploy --overwrite-conf mon add sds01
# ceph-deploy --overwrite-conf mon add sds02
# ceph-deploy --overwrite-conf mon add sds03

•    Cluster configuration on sds12
# ceph-deploy admin sds12 sds01 sds02 sds03 sds04 sds05 sds06 sds07 sds08 sds09 sds10 sds11

•    Create volume from golden image, on sds12, repeat for 12 VMs with different names
# qemu-img convert -t directsync /root/sds/goldgen_image/vm_golden_image.raw rbd:rbd/sds12-vm01-ceph.img
```

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Procedure of creating volumes of Ceph: for the case of iSCSI

```
# ceph-deploy new sds12
•    modify config on sds12
# ceph-deploy install sds12 sds01 sds02 sds03 sds04 sds05 sds06 sds07 sds08 sds09 sds10 sds11
# ceph-deploy mon create-initial
# ceph-deploy gatherkeys sds12
# ceph-deploy osd prepare sds01:/data/ceph/osd sds02:/data/ceph/osd
# ceph-deploy osd prepare sds03:/data/ceph/osd sds04:/data/ceph/osd sds05:/data/ceph/osd
# ceph-deploy osd prepare sds06:/data/ceph/osd sds07:/data/ceph/osd sds08:/data/ceph/osd
# ceph-deploy osd activate sds01:/data/ceph/osd sds02:/data/ceph/osd
# ceph-deploy osd activate sds03:/data/ceph/osd sds04:/data/ceph/osd sds05:/data/ceph/osd
# ceph-deploy osd activate sds06:/data/ceph/osd sds07:/data/ceph/osd sds08:/data/ceph/osd

# ceph osd tree

•    Pool configuration, on sds12
# ceph osd pool set rbd size 3
# ceph osd dump | grep 'rep size'

•    Cluster configuration, on sds12
# ceph-deploy admin sds12 sds01 sds02 sds03 sds04 sds05 sds06 sds07 sds08

•    Create volume, on sds12
# rbd create image1 --size 15360
# rbd create image2 --size 15360
# rbd create image3 --size 15360
```

Configuration of GlusterFS

Innovative R&D by NTT

- /etc/glusterfs/glusterd.vol

```
volume management
    type mgmt/glusterd
    option working-directory /var/lib/glusterd
    option transport-type socket,rdma
    option transport.socket.keepalive-time 10
    option transport.socket.keepalive-interval 2
    option transport.socket.read-fail-log off
end-volume
```

NTT

Procedure of creating volume of GlusterFS: the case of QEMU/KVM

・create a directory for blick

```
# mkdir /data/gluster/brick-qemu
(# dsh -g sds mkdir /data/gluster/brick-qemu/)
```

・create a volume

```
# gluster vol create vol-qemu replica 3 stripe 4
192.168.2.11:/data/gluster/brick-qemu 192.168.2.12:/data/gluster/brick-
qemu 192.168.2.13:/data/gluster/brick-qemu
192.168.2.14:/data/gluster/brick-qemu 192.168.2.15:/data/gluster/brick-
qemu 192.168.2.16:/data/gluster/brick-qemu
192.168.2.17:/data/gluster/brick-qemu 192.168.2.18:/data/gluster/brick-
qemu 192.168.2.19:/data/gluster/brick-qemu
192.168.2.20:/data/gluster/brick-qemu 192.168.2.21:/data/gluster/brick-
qemu 192.168.2.22:/data/gluster/brick-qemu force
```

Procedure of creating volume of GlusterFS: the case of iSCSI

Innovative R&D by NTT

•create directory for blick area
mkdir /data/gluster/brick-iscsi
(# dsh -w sds01,sds02,sds03,sds04,sds05,sds06,sds07,sds08,sds09 mkdir /data/gluster/brick-iscsi/)

•create volume
gluster vol create vol-iscsi replica 3 stripe 3 192.168.2.11:/data/gluster/brick-iscsi 192.168.2.12:/data/gluster/brick-iscsi 192.168.2.13:/data/gluster/brick-iscsi 192.168.2.14:/data/gluster/brick-iscsi 192.168.2.15:/data/gluster/brick-iscsi 192.168.2.16:/data/gluster/brick-iscsi 192.168.2.17:/data/gluster/brick-iscsi 192.168.2.18:/data/gluster/brick-iscsi 192.168.2.19:/data/gluster/brick-iscsi force

•activate volume
gluster vol start vol-iscsi

•mount
mkdir /mnt/glustervol/
mount -t glusterfs 192.168.2.11:vol-iscsi /mnt/glustervol/

•create file for logical unit
dd if=/dev/zero of=/mnt/glustervol/lun1 bs=1024M count=15

• Create target
/root/work/tgt/usr/tgtadm --lld iscsi --mode target --op new --tid 1 -T iqn.tgt01.local
/root/work/tgt/usr/tgtadm --lld iscsi --mode target --op bind --tid 1 --initiator-address ALL
/root/work/tgt/usr/tgtadm --lld iscsi --mode logicalunit --op new --tid 1 --lun 1 --bstype glfs --backing-store="vol-iscsi@192.168.2.11:lun1"

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