SOLUTION WHITEPAPER

FUNGIBLE STORAGE CLUSTER DELIVERS BREAKTHROUGH PERFORMANCE FOR IBM SPECTRUM SCALE

Are you seeking higher storage performance for your Spectrum Scale cluster? Are you getting the full benefits of pooled storage without suffering performance bottlenecks? Fungible Storage Cluster, serving as the backend shared storage platform for Spectrum Scale gives you the efficiency ***and*** performance to break through the data bottleneck. This paper shows you the breakthrough performance of the Fungible Storage Cluster with IBM Spectrum Scale.

IBM SPECTRUM SCALE OVERVIEW

IBM Spectrum Scale is a cluster file system that provides concurrent access to a single file system or set of file systems from multiple nodes. The nodes can be SAN attached, network attached, a mixture of SAN attached, and network attached, or in a shared nothing cluster configuration. This enables high performance access to this common set of data to support a scale-out solution or to provide a high availability platform.

IBM Spectrum Scale has many features beyond common data access including data replication, policy-based storage management and multi-site operations. You can create a cluster of AIX nodes, Linux nodes, Windows server nodes or a mix of all three. IBM Spectrum Scale can run on virtualized instances providing common data access in environments, leverage logical partitioning or other hypervisors. Multiple IBM Spectrum Scale clusters can share data within a location or across wide area network (WAN) connections.

BENCHMARK TOPOLOGY

To demonstrate a Spectrum Scale cluster performance with the Fungible Storage Cluster (3xFS1600 nodes), we setup a 10-node Spectrum Scale cluster attached to the FSC configured with 36 Erasure Coded volumes and 48 replicated volumes (shared), via one 100GbE Mellanox CX5 network card on each node running NVMe/TCP. We used gpfsperf performance test tool included in the GPFS software to run a random read with 4K block size. For comparison, we used FIO with 4K block size and compared the two results.

Figure 1 below shows the test topology for a 10-node Spectrum Scale cluster.

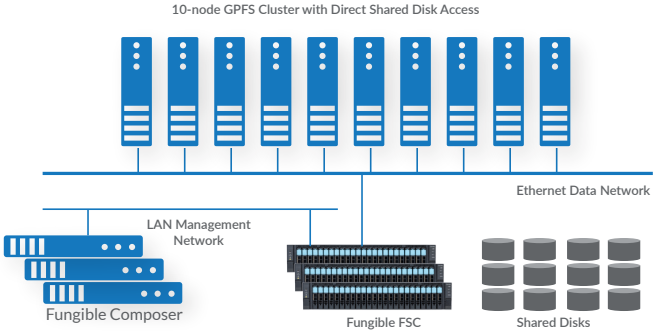


Figure 1: A 10-node Spectrum Scale Cluster

BENCHMARK RESOURCES

The following tables list all the hardware and software used during the benchmark.

Spectrum Scale Cluster Nodes Components	Quantity / Description
Server Type	10 x Supermicro
Memory	256GB per server
CPU	2x20 Intel(R) Xeon(R) Gold 6138 CPU @ 2.00GHz per server
Network Card	1 x Mellanox ConnectX-5 – 100GbE 1 x 10GbE per server
Direct Attached Storage	1 x SATA SSD as Boot Disk per server
Disaggregated Storage	36 x FSC Erasure Coded Volumes (shared)

Table 1: Spectrum Scale Cluster Nodes Component

Software	Description
Operating System	CentOS 8.2
Linux Kernel	4.18.0-193.6.3.el8_2.x86_64
Spectrum Scale	Version 5.0.5.1
FIO	Version 3.7

Table 2: Software Resources

Network Component	Purpose / Model
Network Switches	NVMe-oF / Juniper
	Management Network (LAN) / Cisco

Table 3: Network Component

FSC Component	Quantity / Description
Fungible FSC	3 x FS1600 nodes
FS1600 Network Ports	6 x 100GbE
Fungible Composer	Control Plane

Table 4: Fungible FSC Component

BENCHMARK METHODOLOGY

To compare a random read workload between FIO and gpfsperf, we created a total of 36 Erasure Coded volumes and attached all 36 volumes to all ten Spectrum Scale nodes over NVMe/TCP via the 100GbE Mellanox CX5 network card. We created a single GPFS cluster with ten nodes. Three out of ten nodes were designated as quorum and manager nodes. A single file system was created and mounted under /mnt/gpfs01 across the ten GPFS nodes. We

used gpfsperf tool to create ten 500GB files so each GPFS node can perform the read test on its own file. After the files have been created, we ran a random read test with 4K block size using gpfsperf tool. Then we used FIO to run the same random read workload with 4K block size against the same files which were created by gpfsperf. For the gpfsperf test, we used the DirectIO option (-dio). For the FIO test, we also set "direct=1".

The tables below show the GPFS cluster setup that was used for the test.

```
GPFS cluster name:      gpfscluster.fungible.local
GPFS cluster id:        13550697441972321508
GPFS UID domain:        gpfscluster.fungible.local
Remote shell command:   /usr/bin/ssh
Remote file copy command: /usr/bin/scp
Repository type:        CCR

 Node  Daemon node name          IP address  Admin node name          Designation
-----------------------------------------------------------------------------------
   1  gtm-server-801.fungible.local  10.90.2.171 gtm-server-801.fungible.local  quorum-manager
   2  gtm-server-802.fungible.local  10.90.2.172 gtm-server-802.fungible.local  quorum-manager
   3  gtm-server-803.fungible.local  10.90.2.173 gtm-server-803.fungible.local  quorum-manager
   4  gtm-server-804.fungible.local  10.90.2.174 gtm-server-804.fungible.local
   5  gtm-server-805.fungible.local  10.90.2.175 gtm-server-805.fungible.local
   6  gtm-server-806.fungible.local  10.90.2.176 gtm-server-806.fungible.local
   7  gtm-server-807.fungible.local  10.90.2.177 gtm-server-807.fungible.local
   8  gtm-server-808.fungible.local  10.90.2.178 gtm-server-808.fungible.local
   9  gtm-server-809.fungible.local  10.90.2.179 gtm-server-809.fungible.local
  10  gtm-server-810.fungible.local  10.90.2.180 gtm-server-810.fungible.local
```

Table 5: GPFS Cluster Information

```
%nsd: device=/dev/nvme0n1 nsd=nsd1 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme12n1 nsd=nsd2 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme13n1 nsd=nsd3 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme15n1 nsd=nsd4 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme16n1 nsd=nsd5 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme18n1 nsd=nsd6 usage=dataAndMetadata pool=system thinDiskType=auto
...
...
%nsd: device=/dev/nvme63n1 nsd=nsd32 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme67n1 nsd=nsd33 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme6n1 nsd=nsd34 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme7n1 nsd=nsd35 usage=dataAndMetadata pool=system thinDiskType=auto
%nsd: device=/dev/nvme8n1 nsd=nsd36 usage=dataAndMetadata pool=system thinDiskType=auto
```

Table 6: NSD Device Files

```
 File system  Disk name    NSD servers
---------------------------------------------------------------------------
 gpfs01       nsd1        (directly attached)
 gpfs01       nsd2        (directly attached)
 gpfs01       nsd3        (directly attached)
 gpfs01       nsd4        (directly attached)
 gpfs01       nsd5        (directly attached)
 gpfs01       nsd6        (directly attached)
 gpfs01       nsd7        (directly attached)
 gpfs01       nsd8        (directly attached)
 gpfs01       nsd9        (directly attached)
 gpfs01       nsd10       (directly attached)
 gpfs01       nsd11       (directly attached)
 gpfs01       nsd12       (directly attached)
 gpfs01       nsd13       (directly attached)
 gpfs01       nsd14       (directly attached)
 gpfs01       nsd15       (directly attached)
 gpfs01       nsd16       (directly attached)
 gpfs01       nsd17       (directly attached)
 gpfs01       nsd18       (directly attached)
 gpfs01       nsd19       (directly attached)
 gpfs01       nsd20       (directly attached)
 gpfs01       nsd21       (directly attached)
 ...
 ...
 gpfs01       nsd30       (directly attached)
 gpfs01       nsd31       (directly attached)
 gpfs01       nsd32       (directly attached)
 gpfs01       nsd33       (directly attached)
 gpfs01       nsd34       (directly attached)
 gpfs01       nsd35       (directly attached)
 gpfs01       nsd36       (directly attached)
```

Table 7: NSD List

```
flag                value                description
------------------- -------------------- ------------------------------------
 -f                 819                  Minimum fragment (subblock) size
                                         in bytes
 -i                 4096                 Inode size in bytes
 -I                 32768                Indirect block size in bytes
 -m                 1                    Default number of metadata
                                         replicas
 -M                 1                    Maximum number of metadata
                                         replicas
 -r                 1                    Default number of data replicas
 -R                 1                    Maximum number of data replicas
 -j                 cluster              Block allocation type
 -D                 nfs4                 File locking semantics in effect
 -k                 all                  ACL semantics in effect
 -n                 3                    Estimated number of nodes that
                                         will mount file system
 -B                 1048576              Block size
 -Q                 none                 Quotas accounting enabled
                    none                 Quotas enforced
                    none                 Default quotas enabled
 --perfileset-quota no                   Per-fileset quota enforcement
 --filesetdf        no                   Fileset df enabled?
 -V                 23.00 (5.0.5.0)      File system version
 --create-time      Mon Oct 19 14:04:40 2020 File system creation time
 -z                 no                   Is DMAPI enabled?
 -L                 33554432             Logfile size
 -E                 yes                  Exact mtime mount option
 -S                 relatime             Suppress atime mount option
 -K                 whenpossible         Strict replica allocation option
 --fastea           yes                  Fast external attributes enabled?
 --encryption       no                   Encryption enabled?
 --inode-limit      29491456             Maximum number of inodes
 --log-replicas     0                    Number of log replicas
 --is4KAligned      yes                  is4KAligned?
 --rapid-repair     yes                  rapidRepair enabled?
 --write-cache-threshold 0               HAWC Threshold (max 65536)
 --subblocks-per-full-block 128          Number of subblocks per full block
 -P                 system               Disk storage pools in file system
 --file-audit-log   no                   File Audit Logging enabled?
 --maintenance-mode no                   Maintenance Mode enabled?
 -d
nsd1 ; nsd2 ; nsd3; nsd4 ; nsd5; nsd6 ; nsd7 ;nsd8 ;nsd9 ;nsd10 ;nsd11 ;nsd12 ;nsd13 ;nsd14
;nsd15 ;nsd16 ;nsd17 ;nsd18 ;nsd19 ;nsd20; nsd21 ;nsd22 ;nsd23 ;nsd24 ;nsd25 ;nsd26; nsd27
;nsd28 ;nsd29 ;
 -d                 nsd30;nsd31;nsd32;nsd33;nsd34;nsd35;nsd36  Disks in file system
 -A                 yes                  Automatic mount option
 -o                 none                 Additional mount options
 -T                 /mnt/gpfs01          Default mount point
 --mount-priority   0                    Mount priority
```

Table 8: GPFS Filesystem Information

```
disk         disk size     failure  holds     holds  free in KB             free in KB
name         in KB         group    metadata  data   in full blocks         in fragments
------------ ------------- -------- --------- ------ ---------------------  -------------------
Disks in storage pool: system (Maximum disk size allowed is 32.94 TB)
nsd1         838860800     -1       yes       yes    815367168 ( 97%)       9816 ( 0%)
nsd2         838860800     -1       yes       yes    815369216 ( 97%)       9816 ( 0%)
nsd3         838860800     -1       yes       yes    815370240 ( 97%)       9816 ( 0%)
nsd4         838860800     -1       yes       yes    815367168 ( 97%)       9808 ( 0%)
nsd5         838860800     -1       yes       yes    815369216 ( 97%)       9496 ( 0%)
nsd6         838860800     -1       yes       yes    815366144 ( 97%)       9752 ( 0%)
...
...
nsd29        838860800     -1       yes       yes    815369216 ( 97%)       9752 ( 0%)
nsd30        838860800     -1       yes       yes    815371264 ( 97%)       9752 ( 0%)
nsd31        838860800     -1       yes       yes    815371264 ( 97%)       9784 ( 0%)
nsd32        838860800     -1       yes       yes    815370240 ( 97%)       9752 ( 0%)
nsd33        838860800     -1       yes       yes    815370240 ( 97%)       9752 ( 0%)
nsd34        838860800     -1       yes       yes    815367168 ( 97%)       9816 ( 0%)
nsd35        838860800     -1       yes       yes    815364096 ( 97%)       9816 ( 0%)
nsd36        838860800     -1       yes       yes    815367168 ( 97%)       9816 ( 0%)
             ------------                             ---------------------  -------------------
(pool total) 30198988800                              29353241600 ( 97%)     351608 ( 0%)

             ============                             =====================  ===================
(total)      30198988800                              29353241600 ( 97%)     351608 ( 0%)

Inode Information
-----------------
Number of used inodes:           4047
Number of free inodes:         502833
Number of allocated inodes:    506880
Maximum number of inodes:    29491456
```

Table 9: GPFS Storage Pool Information

BENCHMARK RESULTS

The graph below shows the measured results of gpfsperf and FIO running random reads with 4K block size. What we noticed is that a single GPFS node can deliver a maximum of ~800,000 to ~900,000 4K IOPS. In this test, we used only 10 nodes so the performance is right on par with what GPFS can deliver.

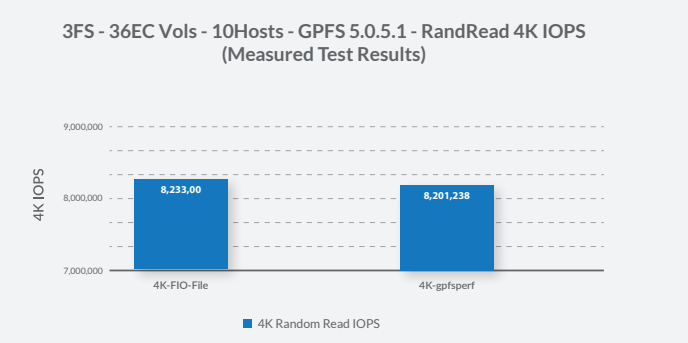
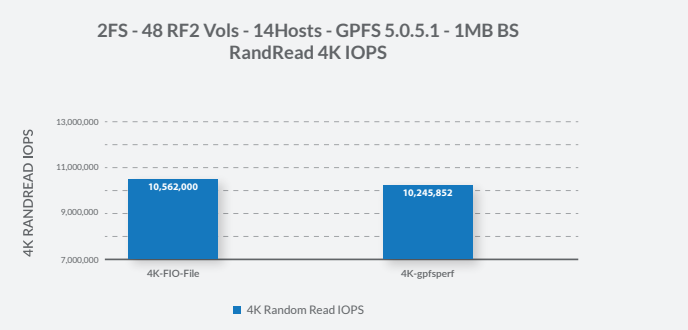


Figure 2: gpfsperf & FIO Results

We also tested the FSC's replicated volumes feature (RF=2) by creating 48 RF2 volumes across 2 FS1600 and attached those 48 volumes to 14 GPFS nodes. Similar to the Erasure Coded volumes, we created a single GPFS file system and ran the gpfsperf tool on all 14 GPFS nodes. Below is the graph that shows the results of gpfsperf and FIO.



KEY TAKEAWAY

The Fungible FSC is a scale-out storage platform that provides unprecedented performance on IBM Spectrum Scale. Measured on a IOPS / PB basis, **FSC delivers 87 M IOPS / PB**. In addition, you can offload the computational intensive work such as compression, erasure coding and encryption to the FSC with little performance hit, thus freeing up CPU resources on the server to process additional workloads. The FSC tests have proven it to be the fastest disaggregated storage for IBM Spectrum Scale, achieving significantly higher IOPS performance than any other storage system.

Whether you need high performance for your analytic workloads or database workloads, rest assured the FSC can meet your requirement expectations because it is a scale-out platform. Multiple workloads such as GPFS clusters, RDBMS databases or NoSQL database clusters (Cassandra, CockroachDB or MongoDB just to name a few), can use the same FSC. Since the FSC uses erasure coding or replications across appliances or nodes, data is protected even for rack failures.

The figure below shows a sample FSC setup which can be used for multiple workloads.

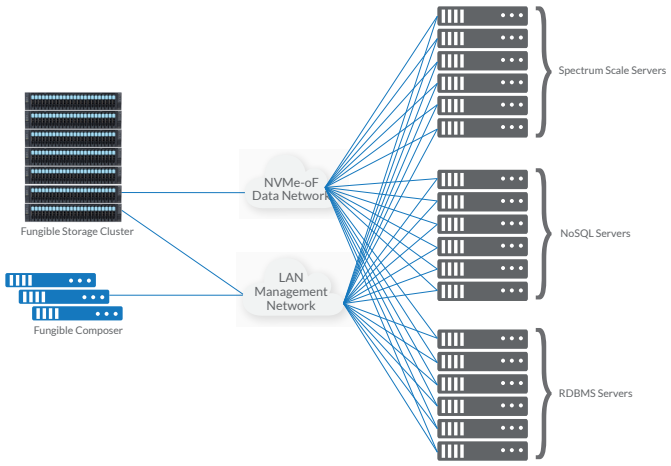


Figure 3: Sample FSC Configuration for Multiple Workloads

CONCLUSION

This whitepaper showed that running IBM Spectrum Scale on the Fungible Storage Cluster would give you a highly performant GPFS cluster. The Fungible Storage Cluster provides all the benefits of pooled storage with outstanding GPFS performance.

ABOUT FUNGIBLE

Silicon Valley-based Fungible is reimagining the performance, economics, reliability, security and agiliy of today's data centers.

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