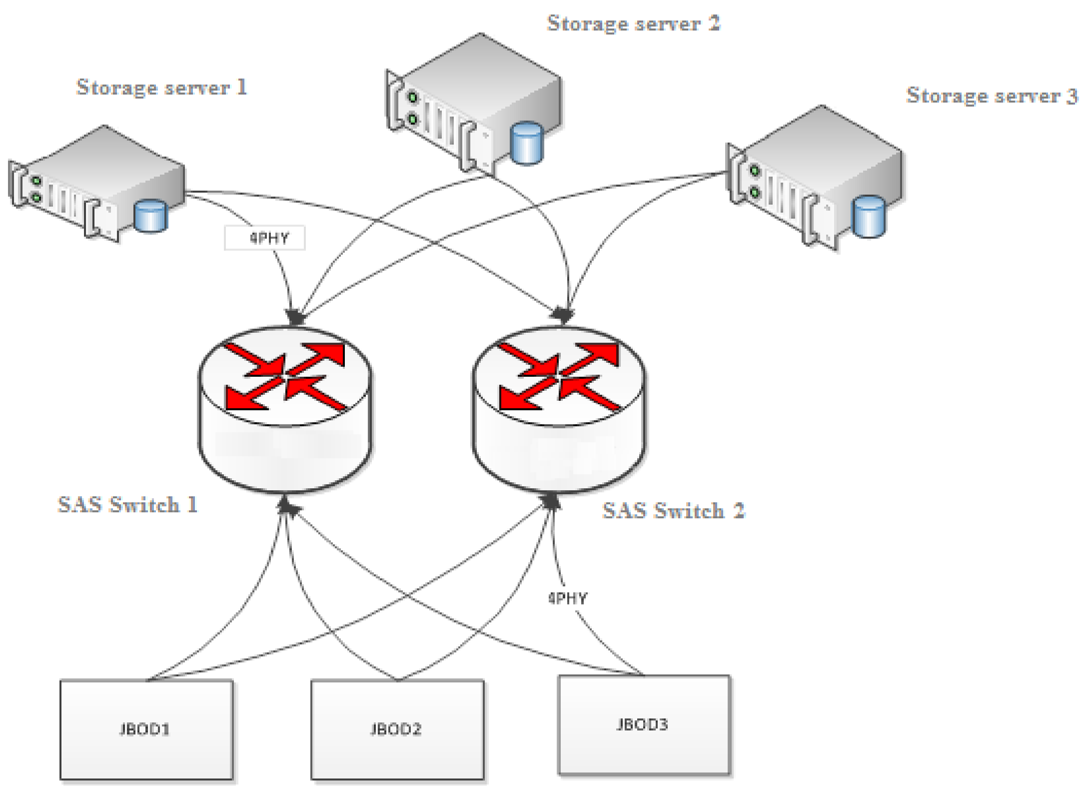
SurFS Product Description

1. ABSTRACT

SurFS — An innovative technology is evolving the network storage ecosystem. SurFS is designed for enterprise-class SAN and NAS with extreme performance at a price that is significantly less expensive than traditional network storage systems. Short I/O path, large bandwidth and short latency together with fast re-balancing are the essential factors that constitute an ultra-fast storage system. SurFS also incorporates a redundant design that guaranteed high availability and a reliable scale-out storage system. SurFS storage is highly efficient for virtualization and cloud environments, which will enable cloud vendors to take full advantage of this innovative technology. Last but not least, SurFS is 100% compatible with OpenStack.

2. INNOVATIVE HARDWARE ARCHITECTURE

The SurFS distributed storage system is based on a SAS (Serial Attached SCSI) network, instead of traditional Ethernet. All components are connected to the SAS switch by 4PHY.



SurFS is build on three main components:

1) SAS switch: The LSI 6160 SAS-2 switch offers 16 4PHY ports, each PHY has 6Gbit/s bandwidth, thus a physical port has 24Gb/s of total bandwidth. Its retail price is around $2,000; more advanced and less expensive SAS switches will be available in the near future, e.g. a 68 ports SAS-3 switch which provides 48Gb/s bandwidth per physical port.
2) JBOD (Just a Brunch Of Disks): JBOD is a storage device which holds many hard drives without any built-in intelligence, such as mainboard, CPU or memory. E.G., the SuperMicro 847E16 JBOD can hold up to 45 3.5” SAS or SATA disks. JBOD is connected to the SAS switch by a 4PHY port.
3) Storage server: the storage server is normal x86 server with the SurFS storage node software installed. It is connected to the SAS switch through HBA cards by 4PHY ports too. The storage server is used to deploy cloud computing nodes on it (such as virtual machines or containers) to constitute a hyper-converged server.

- **SAS Switch**

  SAS switches are the core components of the SurFS storage system. Storage servers communicate with JBODs via the SAS switches. All components are connected to the SAS switch by 4PHY, thus the bandwidth between SAS switch and the storage nodes is 24Gb/s (SAS-2) or 48Gb/s (SAS-3). SurFS uses 2 SAS switches to implement a redundant design, thus there are two physical links between each storage node and the JBOD. If one physical link is unavailable, then the other one is still in service.

- **JBOD**

  With SurFS all mounted disks are part of the JBOD array, connected by the SAS switch, which means that all disks in one JBOD will share 24Gbit/s (SAS-2) or 48Gb/s (SAS-3) bandwidth.

- **Storage Nodes**

  The SurFS storage node software is running on Linux at the (physical) hyper-converged server. SurFS storage node software includes the ZFS file system, custom management tools, and the NAS server. ZFS is an advanced file system; find more info at http://zfsonlinux.org/.

  NOTE: Every disk in the JBODs could be accessed by different storage servers at the same time, which is a very important feature. E.g., when a server is unavailable, another server will get control of the data within seconds, including the virtual machine image and block devices.

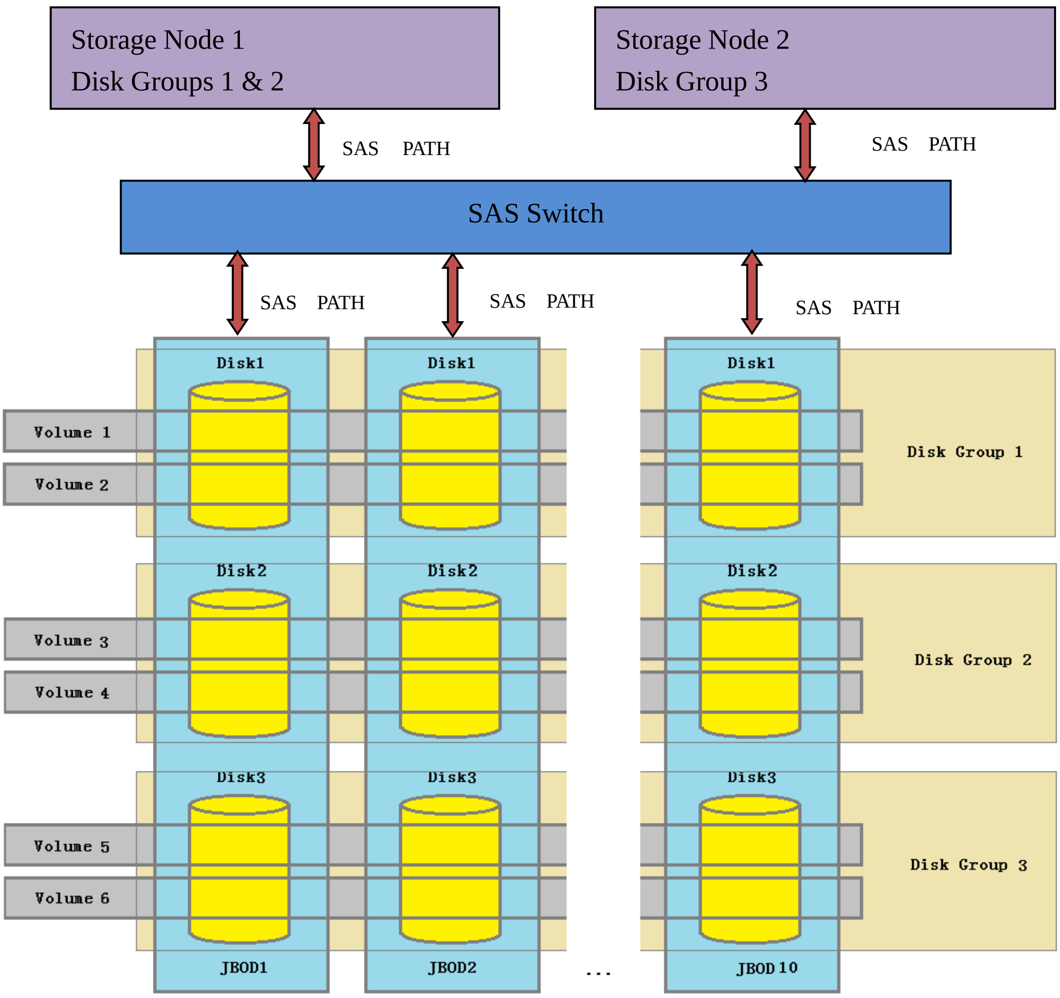
- **Disk Groups**

  A disk group is composed by several disks (one disk from each JBOD). The disks at same position of each JBOD compose a disk group, e.g., if there are ten JBODs in the system, all 'Disk 1' of each JBOD will compose a disk group of ten disks, and all 'Disk 2' of each JBOD will compose another disk group. Redundant mechanisms (such as RAID and erase code) can be set up for these disk groups as safeguard against both disk failures and device failures.

3. SOFTWARE ARCHITECTURE

- **Storage Server OS**

  The SurFS storage server uses Linux as operating system, CentOS is recommended.



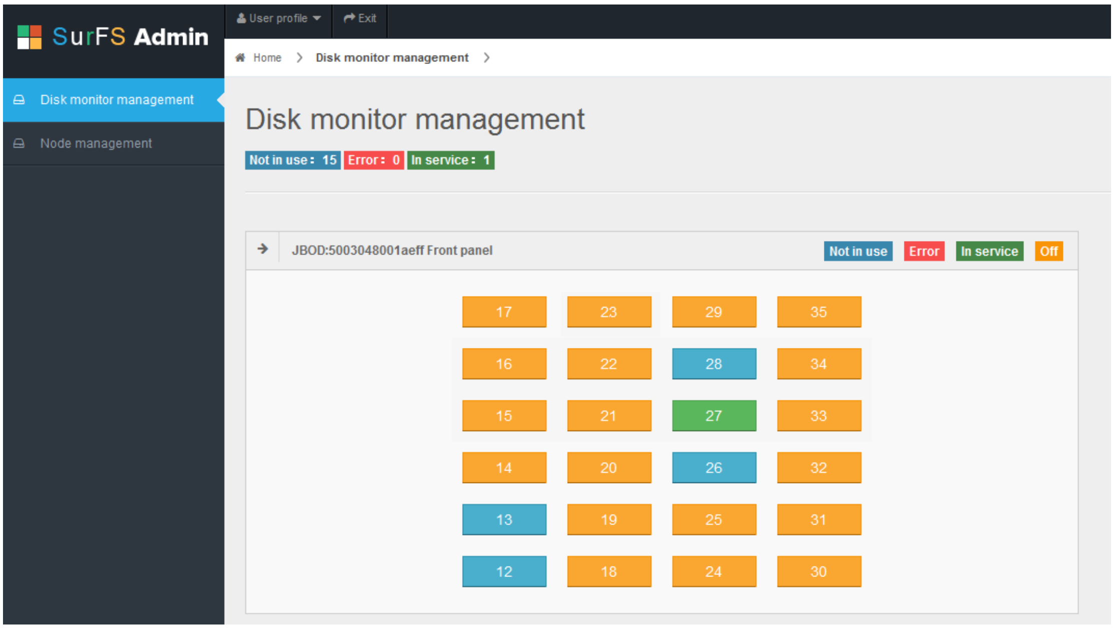
- **SurFS Storage Node**

  SurFS storage node software is installed on each storage server. Each storage node is allocated to one or more disk groups to build a storage pool. Disk groups are managed by ZFS. One or more volumes are created on each disk group and each volume has a unique ID as shown in the figure above. There are two servers and ten JBODs in the system with four disks in each JBOD. All ‘Disk 1’ in each JBOD compose ‘Disk Group 1’ and so on. Thus there are four disk groups with ten disks per disk group. ‘Storage Node 1’ has the control of ‘Disk Group 1’ and ‘Disk Group 2’ and ‘Storage Node 2’ has the control of ‘Disk Group . Each storage node builds a ZFS file system on all disk groups that it manages. There is one or more volume within a disk group.

  ZFS provides redundant storage ability for a disk group. ZFS RAIDZ-1 is similar to RAID 5, which allows one disk failure of a disk group to maintain the data; ZFS RAIDZ-2 is similar to RAID 6, which allows two disk failures of a disk group to maintain the data; ZFS RAIDZ-3 allows three disk failures of a disk group to maintain the data. A statistical evaluation shows that the durability of RAIDZ-3 is very close to ‘three copies’ (both are around 99.999999999%). With the system outlined above a RAIDZ-3 disk group in 7+3 configuration has a redundancy rate of 10/7=143%, which is much better than ‘three copies’ with a redundancy rate of 300%.

  If ‘Storage Node 1’ becomes unavailable, then ‘Storage Node 2’ will get the control over ‘Disk Group 1’ and ‘Disk Group 2’, until ‘Storage Node 1’ gets back to service. This fail-over strategy of SurFS guarantees to meet high availability requirements.

  SurFS offers a monitoring web UI, where users can see all disk statuses. Users can also check for status of the storage servers.

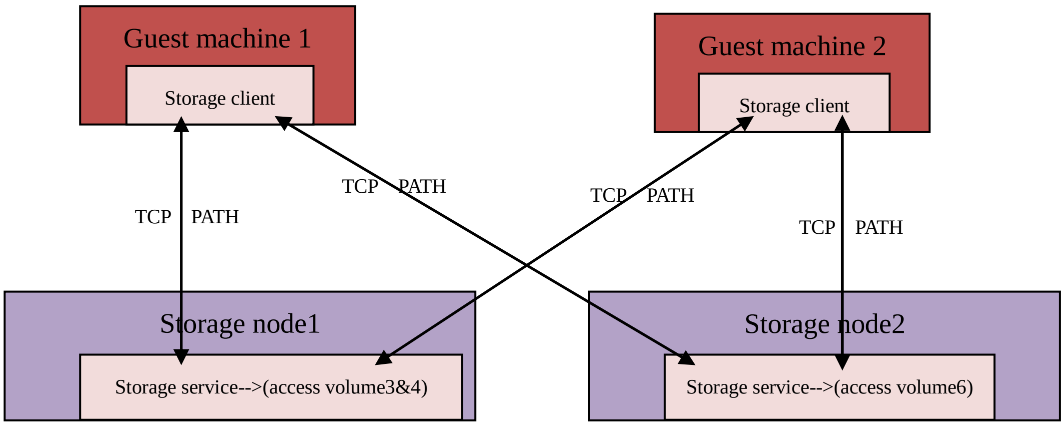


NOTE: ZFS is currently used to manage the volumes in the storage pool. The next version of SurFS will be using software RAID to instead ZFS.

- **Block Storage Service**

Each ZFS volume can be exported as a high performance, high durability, high availability and large capacity block device and can be configured with SurFS command line tools.

Client computers and storage servers are connected by the iSCSI protocol. In a hyper-converged model, the compute node is able to mount this block device directly to gain higher performance than iSCSI.



SurFS offers a set of command line tools used to manage block device services, such as:

- Global information of SurFS block storage
- Pool management
- Volume management
- Snapshot management
- Management of volume export

- **NAS Storage Service**

SurFS provides a NAS service via the standard CIFS and NFS protocols. SurFS NAS server and SurFS NAS client work together to provide the NAS service. The SurFS NAS server is a part of SurFS storage node software to manage the ZFS volumes of its storage node. The SurFS NAS client works with the compute node. SurFS NAS client and SurFS NAS server can be located in different servers. A SurFS NAS client is able to connect to multiple NAS servers, the compute node connected with NAS client is able to use all of space of all NAS servers, so that it is easy to expand the size of NAS storage by adding new volumes to the NAS server or adding new NAS servers to the NAS client. In the system shown in figure 1, 'Volume 1' and 'Volume 2' of 'Storage Node 1' can be allocated to the NAS server of 'Storage Node 1', allocate 'Volume 6' to the NAS server of 'Storage Node 2' (volume 3, volume 4 and volume 5 are reserved to be exported to block devices). A NAS client which connects both the NAS server of 'Storage Node 1' and the NAS server of 'Storage Node 2' can provide NAS storage with a volume size of 'Volume 1', 'Volume 2' and 'Volume 6' summed up.

The NAS storage offers storage node load balancing. If a user sends a write request, the client needs the storage to determine which node to write to, the write strategies are:

1) Round Robin
2) Nearby, finding the node with the best bandwidth. Most of time the client is a VM, thus 'Nearby' will be the best performance strategy.
3) Dynamic polling: the client will collect the IO loading information of all nodes, then taking the node with the lowest load to write to.

NOTE: The SurFS NAS client has a separated SurFS-Protocol. It is a separated open source project based on Alfresco-JLAN which uses different license agreement from SurFS.

4. SURFS ADVANTAGES

The SurFS storage architecture offers a much higher performance at much lower costs than existing distributed file systems, because it takes full advantage of the SAS technology, allows RAID or erase code for data durability, high availability and unique global storage pool features.

- **Low Cost**

  The RAIDZ-3 model guarantees almost the same data durability as 'three copies' but at less than half redundancy rate, thus it has less than half costs.

  Even under the same redundancy rate SurFS is still much less expensive than traditional storage systems because a SAS network is much cheaper than an Ethernet network of the same bandwidth (24Gb for SAS-2, 48Gb for SAS-3). And the storage node is running on hyper-converged server instead of storage device (in general, the number of storage devices is much higher than the number of computing servers, and storage node can share the computing resource with compute nodes).

- **Large Capacity**

  In SurFS storage system, the disks are connected to a SAS storage network by JBOD. A single SAS zone could hold up to 500 hard disks (exact number depends on the number and type of JBODs), which will get 3PB capacity by using 8TB hard disk and 9+3 RAIDZ-3 redundant strategy. However, multiple SAS zones are allowed, thus the capacity of single cluster can reach 10PB or more.

- **High Performance**

  In SurFS storage system, all the components are connected to SAS switch by 4PHY ports, each port will get a 24Gb or 48Gb bandwidth, which is several times more than a 10GbE network. At the same time, the SAS protocol has much shorter (10 times or more) latency than TCP/IP.

  There is another reason why SurFS has good performance: SAS is the native interface of all hard drives and SSD, SAS network doesn't need any conversion between different protocols.

- **High Durability**

  RAIDZ-3 can reach the highest standard of data durability of 99.999999999% under the condition that defect disks can be replaced on time.

- **High Availability**

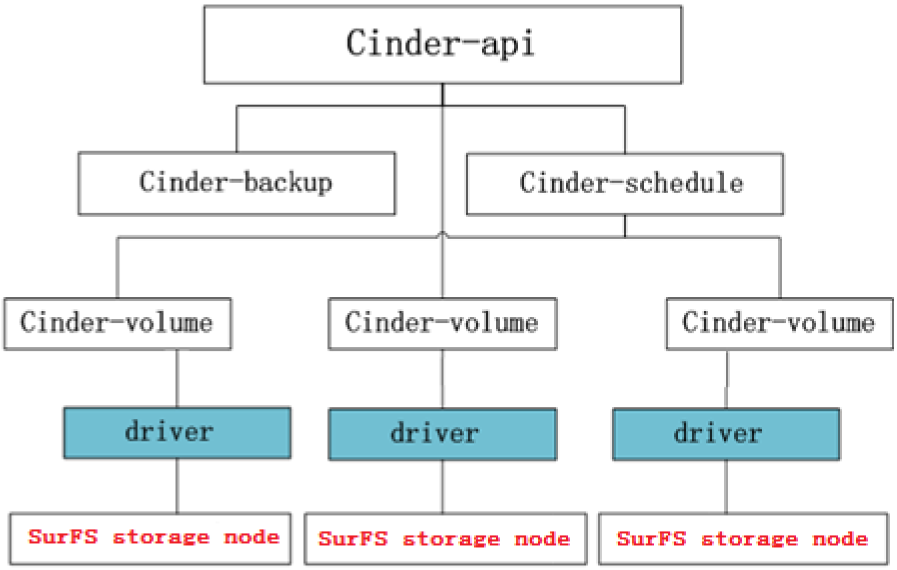
  1) With regard to disk level failures, since all the volumes are organized by ZFS RAID-Z, the volumes will always available as long as the number of failed disks does not exceed the redundancy degree within one disk group.
  2) With regard to the JBOD level failure, it means there is one disk offline for all disk group. All volumes are still available as long as there are no more than three unavailable JBOD at same time for RAIDZ-3.
  3) With regard to the storage server failure, all the volumes in this node will migrate to other nodes within seconds until the storage server geta back to service.

- **Different access way and unified storage backend**

  Based on SurFS storage, users can implement different kinds of storage services, including NAS storage service, block storage service and object storage service (object storage service does not belong to the SurFS open source project). Because of the unified storage backend, all the above services can get the advantage of low cost, large capacity, high performance, as well simplifying the system installation and maintenance.

5. SURFS FOR OPENSTACK

SurFS's block device service is optimized for OpenStack. SurCloud has contributed the SurFS cinder-volume drivers to the OpenStack community.



SurFS features:

Type	Features
volume	Create volume
	Clone
	Volume extend
	Delete volume
volume-VM	Attach to VM
	Detach from VM
snapshot	Create snapshot for a volume
	Create a volume from a snapshot
	Delete volume
image	Create volume from a image
	Create an image for a volume
volume migration	Move volume from A to B

Users can optimize the performance by converged architecture. The VMs will access the disks directly through the SAS path to increase the IOPS and bandwidth of I/O throughput.