SNIA ESF | ETHERNET STORAGE

File vs. Block vs. Object Storage

Part of the SNIA ESF “Great Debate” Webcast Series

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Agenda

- Data Access by block, file, object
  - Differences in access, sharing and workloads
- Block Storage
- File Storage
- Object Storage
- Is one better than the other? Challenge Topics
- Summary

Different Access Methods

- How does the application want to access the data?
  - All at once or piece by piece?
  - Sequentially or randomly?
- What type of data is it?
  - Database, text, video/audio, photo
  - Static or fixed?

Data Sharing

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- Does the data need to be shared?
  - Shared by the application vs. shared by the storage
  - Shared reading vs. shared writing
  - Narrow or broad sharing?
- Security and access controls
  - Applied at what level?

The Type of Storage

- Storage Design Can Affect Access Choice
  - Media: tape, disk, flash, PM
  - Storage controller performance
- Connectivity can affect choice.
  - Local vs. networked
  - Fibre Channel, Ethernet, SAS, SATA, PCIe, etc.

Saqib Jang

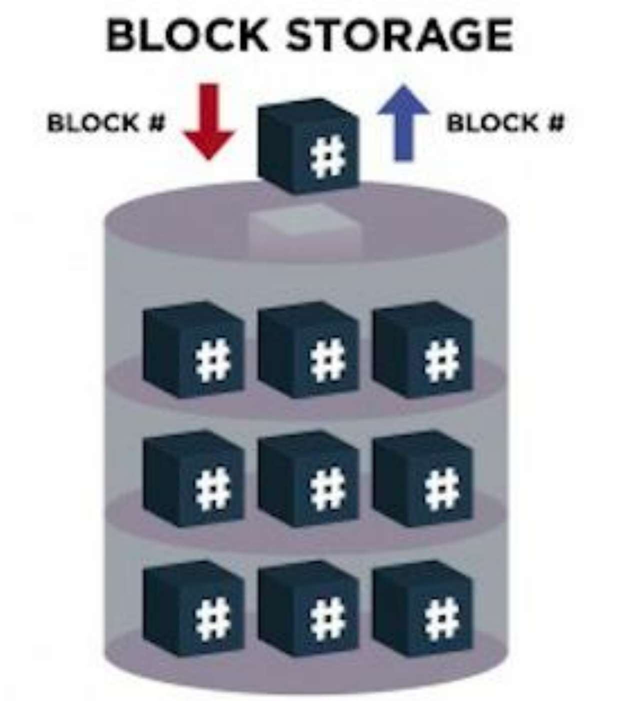
BLOCK STORAGE

Block Storage Use Cases/ Workloads

- Ideal for performance-intensive primary storage
- Use Cases
  - Structured database storage for OLTP and BI
  - Virtual volumes
  - Applications using server-side processing (e.g. Java or PHP)
- Workloads
  - High Change Content
  - Random R/W
  - ”Bursty” IO

How Block Storage is Organized

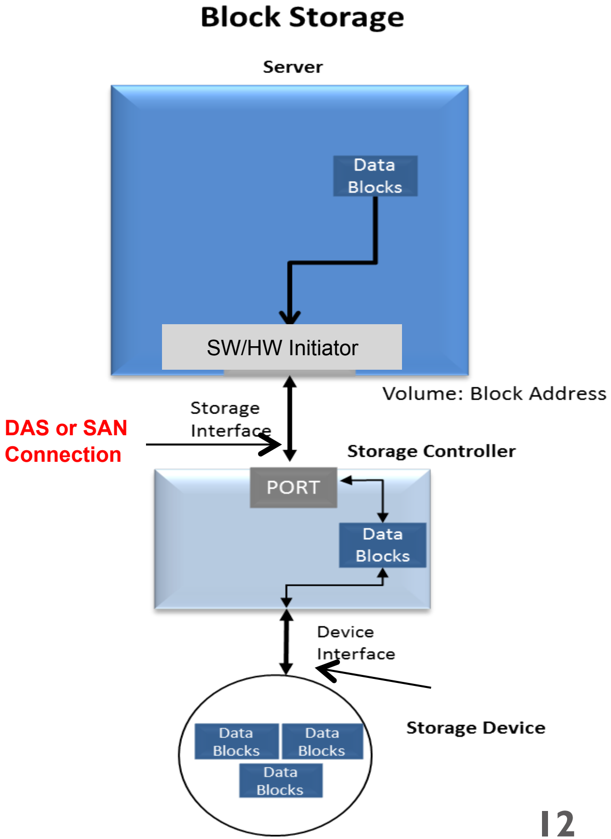
- Data is typically stored on device in fixed-sized blocks (e.g. 512 Bytes)
- Data is stored without any higher-level metadata e.g. for data format, type or ownership
- Accessed by operating system as mounted drive volume
- Applications/file systems decide how blocks are accessed, combined, and modified



How Block Storage is Accessed

- Application writes data block
- Block goes to SW/HW Initiator and over DAS* or SAN** connections
  - DAS: SATA, SAS, FC, NVMe™
  - Ethernet SAN: iSCSI, NVMe-oF
  - Fibre Channel SAN: FCP, NVMe-oF
- Storage controller receives block
- Data written to device as data block

*DAS=Direct-Attached Storage
** SAN=Storage Area Networks

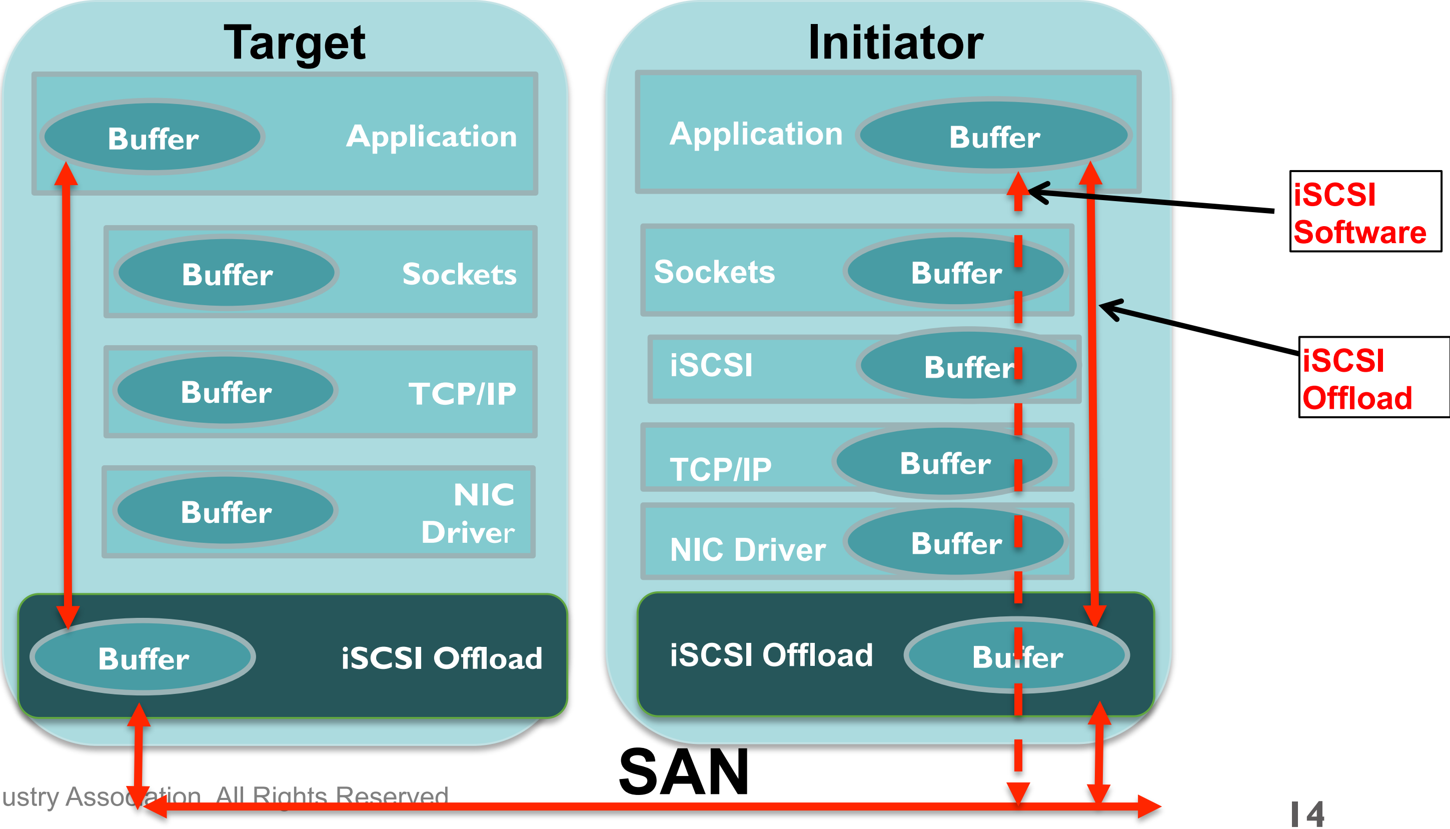


Block Interface Comparison

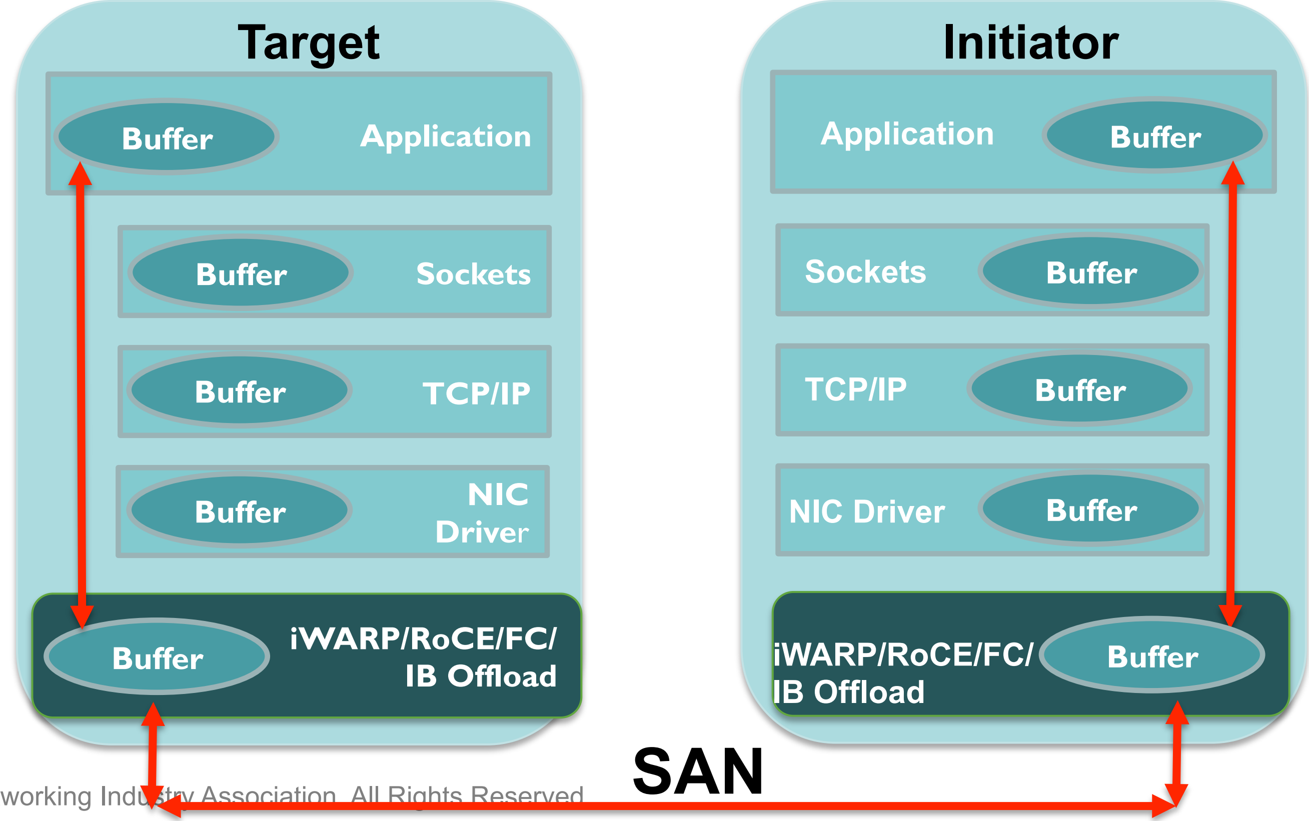
Interface (Protocol)	Deployment Scale	Interface Type	Maximum Transfer Rate (Lanes)
SATA	DAS	On-board	6 GB/s
SAS (SCSI)	DAS	On-board	12 GB/s
Thunderbolt	DAS	On-board	40 Gb/s
NVMe	DAS	On-board	16 GB/s (PCIe 3.0 x16)
Fibre Channel (FCP/NVMe-oF)	DAS/SAN/WAN (FCIP)	HBA	32 Gb/s (1)
Ethernet (iSCSI/iSER/NVMe-oF)	DAS/SAN/WAN	NIC & Offload Adapter	100 Gb/s
InfiniBand (SRP/iSER/NVMe-oF)	SAN	HCA	100 Gb/s

Block Storage I/O Path – iSCSI

- iSCSI Software
  - Software-based Protocol Processing
- iSCSI Offload
  - Protocol Bypass
  - RDMA



Block Storage I/O Path – NVMe-oF



Block Storage Security

- iSCSI
  - CHAP authentication is available in all iSCSI implementations
  - IPsec is available to secure the communication channel
  - VLANs enable logical isolation of storage and data traffic
    - Large iSCSI SANs may be physically isolated from LANs for optimal storage QoS
- FCP
  - WWN-based access controls for limiting access to storage
    - Includes switch zoning and LUN masking in storage
  - Authentication and in-flight encryption for trusted in-band management and trusted storage networks
  - Switches configured with least amount of access and interconnections restricted
  - FC SAN deployment is always physically isolated from LANs

Managing Block Storage – SNIA Swordfish™ Spec

- Block storage devices (represented by Volumes) provide their capacity to external applications through block-based protocols
- Standard APIs used for management of resources providing access to block storage
- Block storage management functions include
  - Add volume, Allocate volume, Expand storage volume, Review volume metrics
  - Create storage group, Create storage pool
  - Create class of service, Discover class of service, Get capacity by class of service, Find storage service
  - Create line of service, List supported line of service options

Alex McDonald

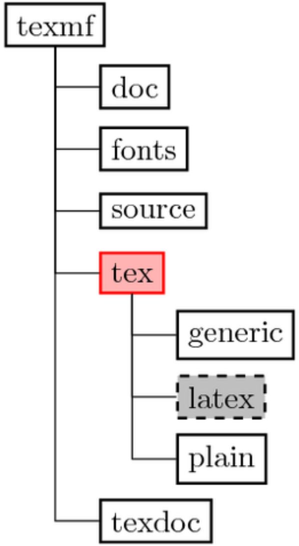
FILE STORAGE

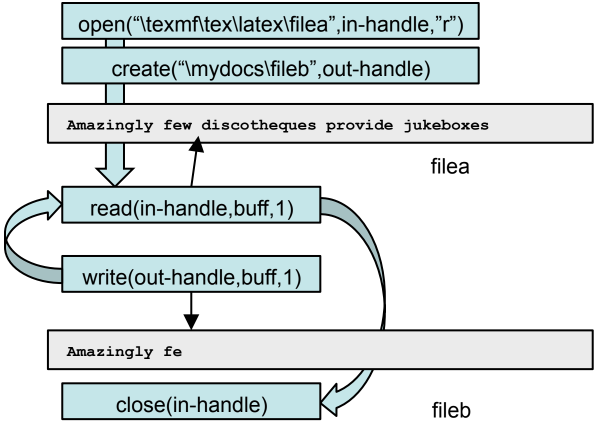
File Storage; Systems & Access

- A little bit of history
  - Filing cabinets for paper based documents
  - File systems are a similar construct; collections of documents
- Use cases
  - Document sharing
  - Clustered databases
  - Big data
  - Media and entertainment
  - Technical computing or HPC
  - Foundation for application independence
    - Provide consistent set of APIs

Files Application View

- Characteristic of a file
  - Files have *names* and are *byte addressable*
  - Randomly accessible
  - Named, with IO operations through a *file handle*
- Organized into *named directories* which are themselves structured files
- Several effective layers (but may be blended)
  - Logical, virtual & physical file systems
  - Network access layer





open("\texmf\tex\latex\filea",in-handle,"r")

create("\mydocs\fileb",out-handle)

`Amazingly few discotheques provide jukeboxes`

filea

read(in-handle,buff,1)

write(out-handle,buff,1)

`Amazingly fe`

close(in-handle)

fileb

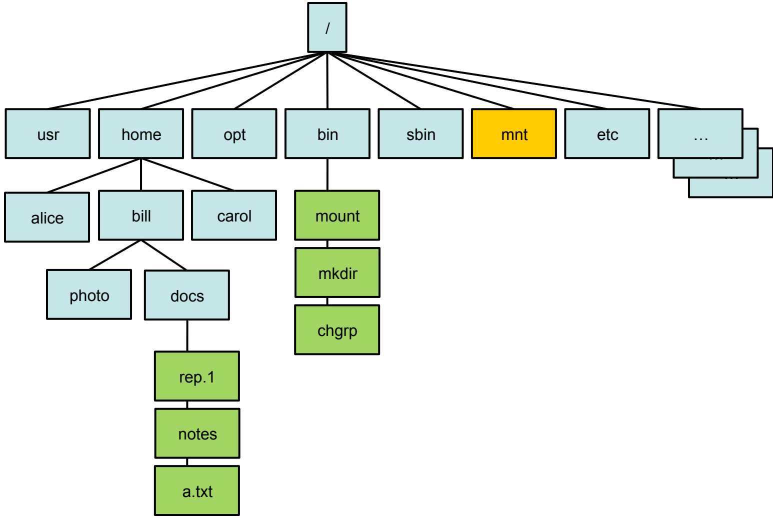
Files Application View

- POSIX or close to POSIX-like support in all major Oses
  - Operations
    - Opening and closing
    - Reading, updating and writing
    - Creating, renaming and deleting
- Same system calls used allows source code portability
- Applications can treat files as
  - Streams or objects; a set of unstructured data
  - Structured data; sets of discrete units contained in a file
  - Block; set of randomly accessible blocks
  - …

POSIX™ defines a standard operating system interface and environment … to support applications portability at the source code level
http://pubs.opengroup.org/onlinepubs/9699919799/

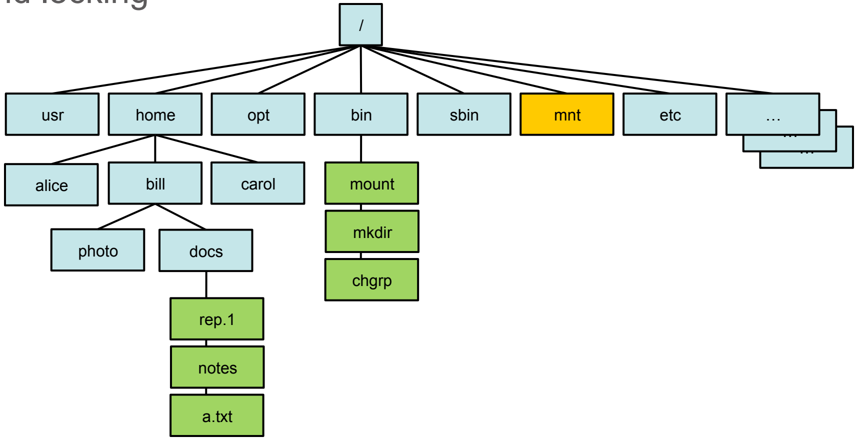
File Systems

- Physical layer built on storage devices
  - Tape, disk, flash, persistent memory…
- Virtual layer built on physical layer
  - Many 100s of file systems:
    - EXT3 EXT4 JFS ZFS GPFS ResierFS and many more
    - Each has different characteristics
  - This layer is typically the mount point or share
- Logical layer brings together virtual levels in a single root
  - Rooted tree of directories and files
  - Names and paths through directory
    - Fully qualified name: /home/bill/docs/a.txt



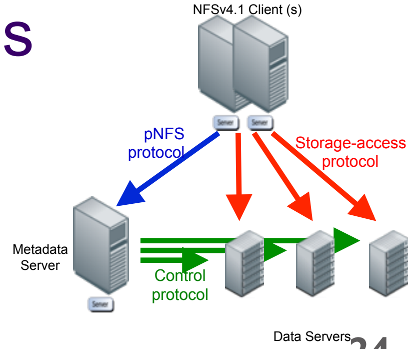
Distributed File Systems

- NFS and SMB
  - *nix and Windows
  - Allow creation, deletion, reading, writing, sharing and locking
  - Supported by all major OSes and hypervisors
  - (typically) No extra client software needed
  - Provide access over networks
- Distributed File Systems
  - Make distributed look exactly like local file system
- Key is transparency
  - Access & location
  - Consistency & concurrency
  - High level of tolerance to failure
  - Heterogeneous, scalable, replicatable, migratable
- Uses RPCs (Remote Procedure Calls) & network protocol
  - Ethernet and TCP/IP
- No knowledge required of underlying structures; nothing “pokes through” to the end user



File System Performance

- Can be very good indeed
  - Competes with iSCSI
    - Suitable for VM datastores, containers
  - Parallelization (for example, pNFS)
  - Abstraction layer is deeper (hence higher latencies than block)
- Space requirements can be significantly less
  - Compression
  - Hole punching or sparse files



Security & Privacy

- NFS & SMB use Kerberos or LDAP
  - “network authentication protocol which works on the basis of 'tickets' to allow nodes communicating over a non-secure network to prove their identity to one another in a secure manner” https://en.wikipedia.org/wiki/Kerberos_%28protocol%29

Authentication

Proving to a system that you are who you claim to be

- Name mapping
- Kerberos tickets

Authorization

What a user is allowed to do once in a system

- Group membership
- Access Control Lists (ACLs)

Terms are often confused with each other; not interchangeable

Managing File Storage

- Meta data
  - Attributes & extended attributes
  - Times & dates, size, …
- Many thousands of utilities
  - Archival, backup, restore (NDMP)
  - Compression, deduplication
  - Specific structured file type management
    - For instance: video, sound, documents

Mark Carlson

OBJECT STORAGE

Object Use Cases

- Public, Private and Hybrid Cloud Storage
  - Sync and share from desktop to devices, offload from email, etc.
- Archival Storage
  - Ultimate tier is Object Repository with policies for retention
- Server-less Container Storage
  - Shared state among micro-services
- Analytics and IoT, Machine (Deep) Learning
  - Ingest from edge, dump in a lake, analyze and train, make decisions
- Green Field applications with need for rich metadata capabilities

How is the data organized for Objects?

- Objects have a handle that is a URL, or ObjectID (both)
  - Objects may be grouped into flat buckets or hierarchical containers (also with URLs)
- Objects have metadata
  - User metadata, system metadata
- Objects may have versions
  - Underlying infrastructure may be immutable storage
- Storage of Objects may be RAID-less
  - Shard into smaller pieces, erasure code protection and then distribute

Object Access

- No need for a “mount” operation
- Access any Object from any endpoint modulo security
  - Resolve the location from the URL
- RESTful interfaces scale out better with load balancers
- Objects in a Hybrid cloud can move back and forth between private and public infrastructure transparently
- Object store can utilize an underlying file system, or can organize the data itself

Key Value

- Application level Key Value can be thought of as an object interface
  - Access not by URL, but by using a Key in a specific store
- A Key Value drive interface can also underlay the Object or KV store
  - Key based on the ObjectID or hash of the value perhaps
  - Each shard is a Key/Value across multiple drives
  - More efficient (less costly) interface to PCIe SSDs

Performance

- Performance (and Availability) of Objects is AT SCALE
  - The interface allows for scale out implementations that also provide redundancy
  - Data is in multiple places and the result can be created from the fastest responses
  - Globally unique handles allow response from the least loaded node
- May not be the highest throughput or lowest latency for single machine applications with attached drives

Using Objects

- Access via standard Internet networking infrastructure
  - DNS, HTTP, TCP/IP, Ethernet (CE not required)
- Broad support from nearly any programming environment
- More intuitive (click to view)
  - Javascript and HTML brings the access client into your browser
- Any device, server or IoT sensor can access worldwide

Security and Privacy

- Rich Object metadata may be used to provide additional service levels
  - Share Objects with only those you choose
  - Grant temporary (time based) access
  - Audit trails help after an intrusion, monitor compliance
- Data management is interoperable and enhanced
  - Requirements for services over the lifetime of the object
- Privacy is defined by the Object owner

Managing Objects

- Once you put your data into an Object how is it managed?
- Each Object has “knobs” that control the underlying data services and how they treat this Object
  - Data System Metadata is used for this purpose
  - How performant, available, protected is the Object right now?
- SREs and Admins can use these knobs to optimize the treatment of this data at this point in its lifecycle

Should I use block, file or object storage?

COMPARE AND CONTRAST

Workloads

- Do databases prefer block or file storage? Why?
- Which is best for video storage?
- Where should I store VMs and containers?
- How do you know which is best for your application?
  - Do some apps support *only* block, or file, or object?

Comparing Performance

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- Is one faster than the other? Does it matter?
- Can block, file and object all use flash storage?
- Do they run on different-speed networks?
- What about distributed/scale-out performance?

Comparing Manageability

- Which solution is best for managing…
  - Big vs. small chunks of data
  - Shared vs. non-shared data
  - Very large volumes of data
- Meta-analysis on metadata
  - Does Block storage lack useful metadata?
  - How do file and object metadata differ?

Sharing & Security?

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- Which solution has the best sharing?
  - Most granular vs. most scalable
  - Most secure vs. easiest
- Which solution has the best security?
  - For protecting against external threats
  - For controlling levels of internal app/employee access
- How do security needs influence sharing?

Summary

- Almost all storage accessed via block, file or object
- They provide differing ways to access and manage data
- Not a question of which one is “better” but which one is the best fit for your application and workload

More Webcasts

- Next Live Webcast: Everything You Wanted To Know About Storage But Were Too Proud To Ask - Part Aqua: Storage Controllers
  - May 15, 2018, 10:00 am PT
  - Register at: https://www.brighttalk.com/webcast/663/312607
- On-Demand “Everything You Wanted To Know About Storage But Were Too Proud To Ask” Series
  - https://www.snia.org/forums/esf/knowledge/webcasts-topics
- SNIA resources on File, Block and Object
  - Evolution of iSCSI: https://www.brighttalk.com/webcast/663/197361
  - Comparing iSCSI and NVMe-oF blog: http://sniaesfblog.org/?p=647
  - What is NFS Webcast: https://www.brighttalk.com/webcast/663/191035
  - Object Storage 101 Webcast: https://www.brighttalk.com/webcast/663/110683

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