# What's New in NFS 4.2?

April 28, 2015

SNIA™
Ethernet Storage Forum

# Webcast Presenters

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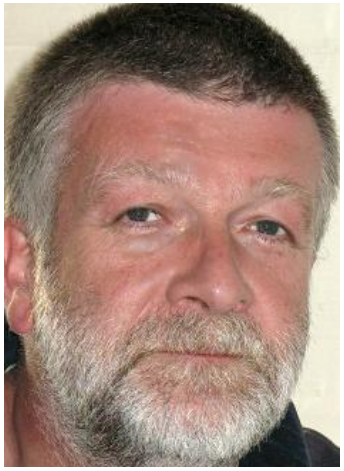

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# Agenda

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- Before we start: NAS Protocols
- NFSv4 Background
- New features in NFSv4.2
  - NFSv4.2 not yet standardized, but many features already available
- pNFS New Layouts; FlexFiles & SCSI
- Other Developments & Beyond NFSv4.2

# Before we start: NAS Protocols

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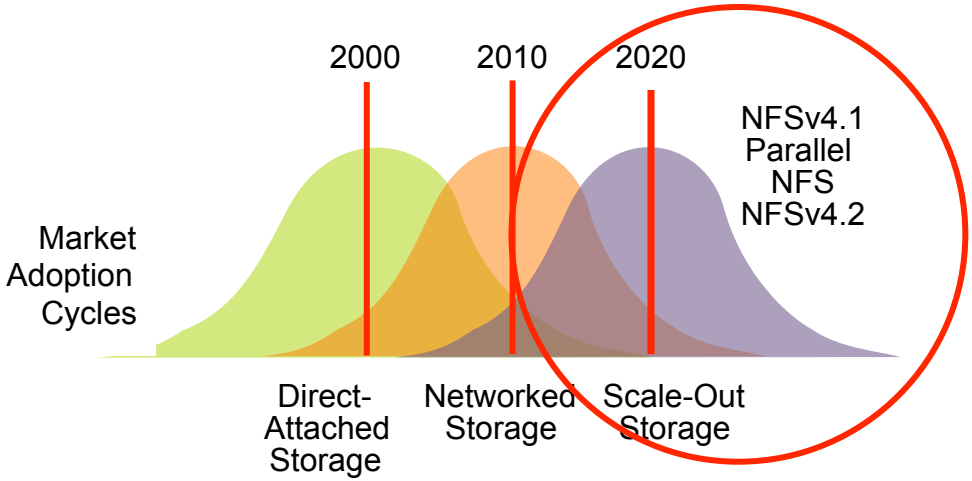
- Compare & contrast with SAN
  - This is a gross simplification!
- NAS (Network Attached Storage) vs SAN (Storage Area Network)
  - Filesystem based (directories, files) vs volume based (LUN)
  - Byte addressable, byte size chunks vs 4K aligned 4K blocks
  - Primarily Ethernet, RDMA vs Fibre Channel, Ethernet …
- Two major dominant NAS protocols
  - NFS (Network File System) protocol
  - SMB (Microsoft's Server Message Block) protocol
    - Formerly known as CIFS (Common Internet File System)

# NFS: Ubiquitous & Everywhere

- NFS is ubiquitous and everywhere
- Industry – and hence NFS – doesn't stand still
  - NFSv2 in 1983
  - NFSv3 in 1995
  - NFSv4 in 2003, updated 2015
  - NFSv4.1 and pNFS in 2010
  - NFSv4.2 to be agreed at IETF shortly
  - Faster pace for minor revisions
  - http://datatracker.ietf.org/wg/nfsv4



# Evolving Requirements

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- Pace of NFSv4 adoption now increasing
- Beyond traditional home directories
  - VMware announces support for NFSv4.1 as a client for storing VMDKs
  - Amazon announces support for NFSv4.0 in AWS Elastic File System (EFS)
- Industry is changing, as are requirements
  - Economic Trends
    - Cheap and fast computing clusters
    - Cheap and fast network (1GbE to 10GbE, 40GbE and 100GbE in the datacenter)
    - Cost effective & performant storage based on flash, flash & SATA
  - Performance
    - Exposes NFSv3 single threaded bottlenecks in applications
    - Increased demands of compute parallelism and consequent data parallelism
    - Analysis begets more data, at exponential rates
    - Competitive edge (ops/sec)
  - Business requirement to reduce solution times
    - NFSv4.1 brings increased scale & flexibility
    - Outside of the datacenter; requires good security, scalability

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# NFS as a Standard

- How the IETF Works
  - https://www.ietf.org/about/standards-process.html
  - “a specification undergoes a period of development and several iterations of review by the Internet community and revision based upon experience, is adopted as a Standard by the appropriate body... and is published.”
  - Open process
  - Technical competence; “engineering quality”
  - Volunteer Core
  - Rough consensus and running code
  - Protocol ownership
- NFS Working Group
  - http://datatracker.ietf.org/wg/nfsv4/charter/

# NFSv4 background

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- Areas addressed by NFSv4, NFSv4.1 and pNFS
  - Security
  - Uniform namespaces
  - Statefulness & Sessions
  - Compound operations
  - Caching; Directory & File Delegations
  - Layouts & pNFS (parallel NFS)
  - Trunking (NFSv4.1 & pNFS)
- SNIA has entire set of white papers & tutorials
  - https://www.brighttalk.com/search?duration=0..&keywords[]=nfs&q=snia&rank=webcast_relevance
    http://www.snia.org/sites/default/files/SNIA_An_Overview_of_NFSv4-3_0.pdf
    http://www.snia.org/sites/default/files/Migrating_to_NFSv4_v04_-Final.pdf
- NB: NFSv4.2 not yet standardized
  - But some features already available

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- Before we start: NAS Protocols
- NFSv4 Background
- New features in NFSv4.2
  - NFSv4.2 not yet standardized, but many features already available
  - Sparse File Support
  - Space Reservation
  - Labeled NFS
  - IO_ADVISE
  - Server Side Copy
  - Application Data Holes
- pNFS New Layouts; FlexFiles & SCSI
- Other Developments & Beyond NFSv4.2

# New Features in NFSv4.2

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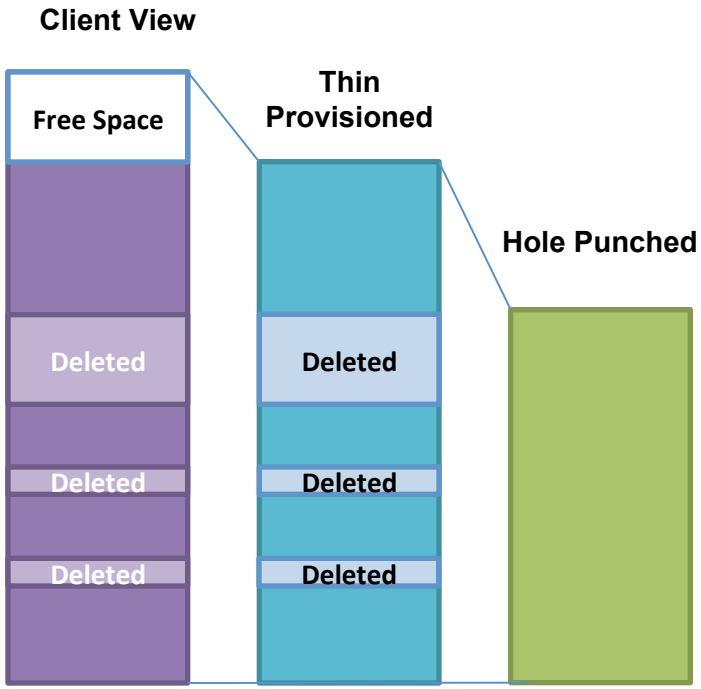
- Sparse file support
  - "Hole punching" and the reading of sparse files
  - Key to effective management of expensive storage devices (like SSDs)
  - VM datastores benefit
  - In 3.18 kernel (October 2014)



# New Features in NFSv4.2

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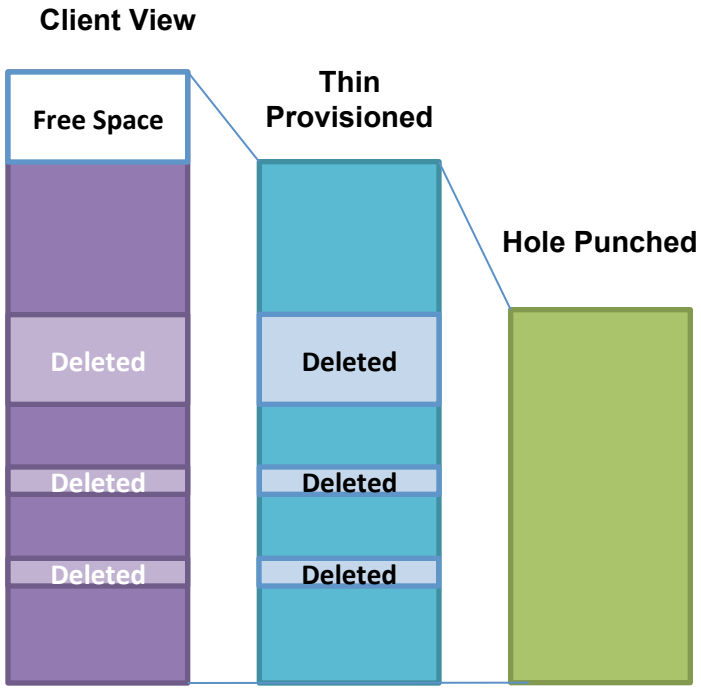
- Space reservation
  - Ensure a file will have storage available
  - Make sure client view of the storage is reflected by the server's space allocation policies
  - Still able to hole punch & thin provision; it's a commitment, not a physical requirement
  - In 3.19 kernel (December 2014)



# New Features in NFSv4.2

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- Labeled NFS (LNFS)
  - Allows (partial) SELinux support
  - In 3.11 (September 2013), in RHEL7 (June 2014)
- IO_ADVISE
  - Client or application can inform the server IO patterns and hence possible caching requirements of the file (including hints for pNFS)
  - Predicting IO patterns is hard without hints
  - Sequential, random, read, write…

# New Features in NFSv4.2

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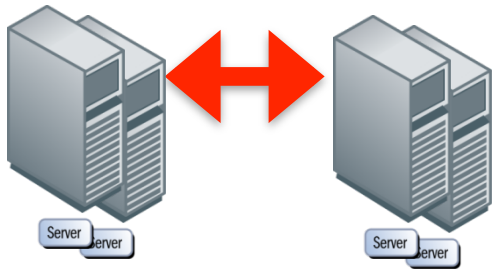
- Server-Side Copy (SSC)
  - Removes one leg of the copy
  - Destination reads directly from the source
  - Two proposed types
    - CLONE: local to the server
    - COPY: server to server, potentially different physical systems
  - Security a big issue, requires updated security model (RPCSEC_GSS Version 3)



# New Features in NFSv4.2

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- Application Data Holes
  - (previously Application Data Blocks or ADB)
  - Allows definition of the format of file
  - Examples: database or a VM image.
  - INITIALIZE blocks with a single compound operation
    - Initializing a 30G database takes a single over the wire operation instead of 30G of traffic.

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# Flex Files: A New pNFS Layout

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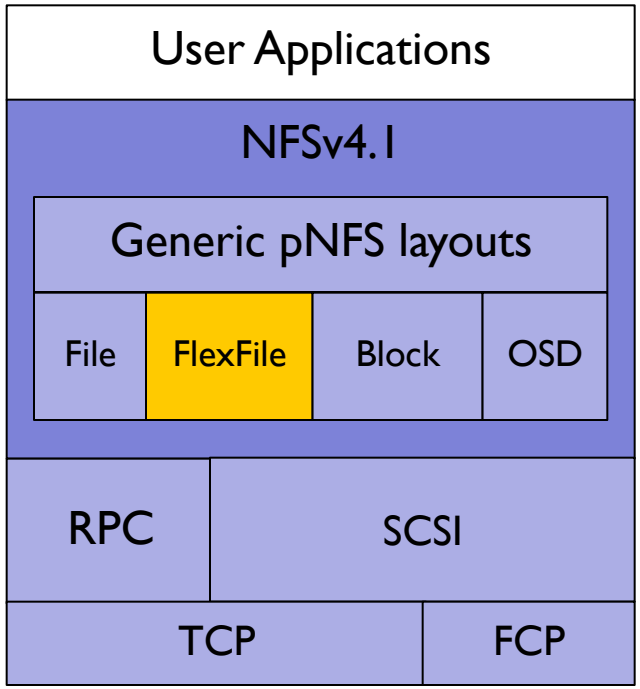
- Advance in Clustering
  - Aggregation of standalone NFS servers
    - Customers heavily invested in NFSv3
    - Allows reuse of legacy filers as data servers in a clustered configuration
  - Exporting of existing clustered file system
    - For example: Ceph, Gluster
    - No standard storage access protocol; pNFS could be used instead
  - Flexible, per-file striping patterns
    - Application SLAs and management policies as well as dynamic load balancing and tiering decisions require per-file control over striping
    - Existing clustered file systems do not map to the files layout striping patterns

# Flex-files pNFS layout

- pNFS is dependent on session support, which is only available in NFSv4.1
- Flex-files pNFS layout
  - Flexible, per-file striping patterns and simple device information suitable for aggregating standalone NFS servers into a centrally managed pNFS cluster
- SCSI pNFS Layout
  - Extends pNFS Block/Volume Layout
  - Provides closer integration into the SCSI Architecture
- These are proposed, but remember not yet ratified or available!
- Brief pNFS backgrounder



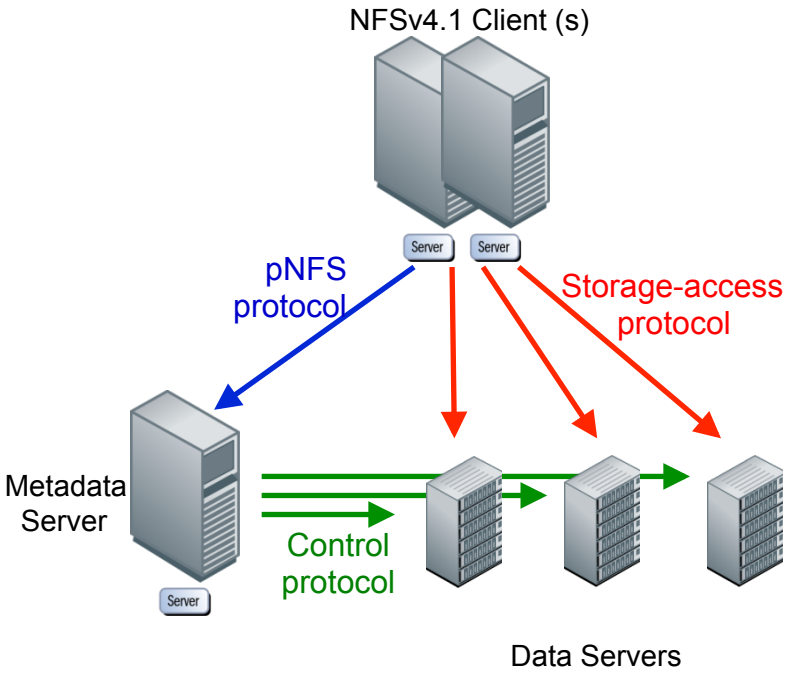

OSD: Object based Storage Device

# Why pNFS

## NFSv4.1 (pNFS) can aggregate bandwidth

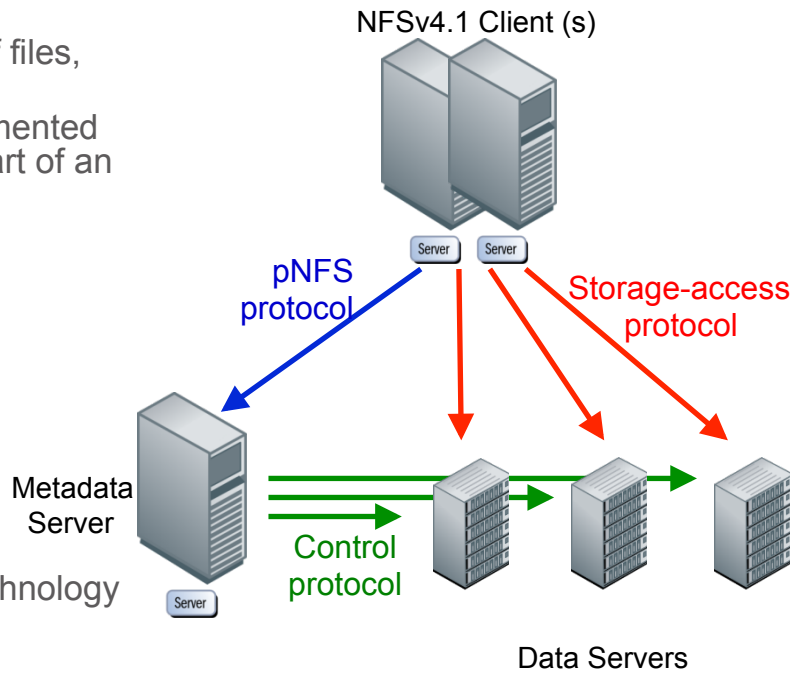
- Modern approach; relieves issues associated with point-to-point connections

- pNFS Client
  - Client read/write a file
  - Server grants permission
  - File layout (stripe map) is given to the client
  - Client parallel R/W directly to data servers
- Removes IO Bottlenecks
  - No single storage node is a bottleneck
  - Improves large file performance
- Improves Management
  - Data and clients are load balanced
  - Single Namespace



# pNFS Terminology

- Metadata Server; the MDS
  - Maintains information about location and layout of files, objects or block data on data servers
  - Shown as a separate entity, but commonly implemented on one or across more than one data server as part of an array
- pNFS protocol
  - Extended protocol over NFSv4.1
  - Client to MDS communication
- Storage access protocol
  - Files; NFS operations
  - Objects: OSD SCSI objects protocol (OSD2)
  - Blocks; SCSI blocks (iSCSI, FCP)
- Control protocol
  - Not standardised; each vendor uses their own technology to do this
- Layout
  - Description of devices and sector maps for the data stored on the data servers
  - 3 types; files, block and object
- Callback
  - Asynchronous RPC calls used to control the behavior of the client during pNFS operations



# pNFS Operations

- Client requests layout from MDS
- Layout maps the file/object/ block to data server addresses and locations
- Client uses layout to perform direct I/O to the storage layer
- MDS or data server can recall the layout at any time using callbacks
- Client commits changes and releases the layout when complete
- pNFS is optional
  - Client can fall back to NFSv4

- pNFS operations
  - LAYOUTCOMMIT Servers commit the layout and update the meta-data maps
  - LAYOUTRETURN Returns the layout or the new layout, if the data is modified
  - GETDEVICEINFO Client gets updated information on a data server in the storage cluster
  - GETDEVICELIST Clients requests the list of all data servers participating in the storage cluster
  - CB_LAYOUT Server recalls the data layout from a client if conflicts are detected

# Flex Files: A New pNFS Layout

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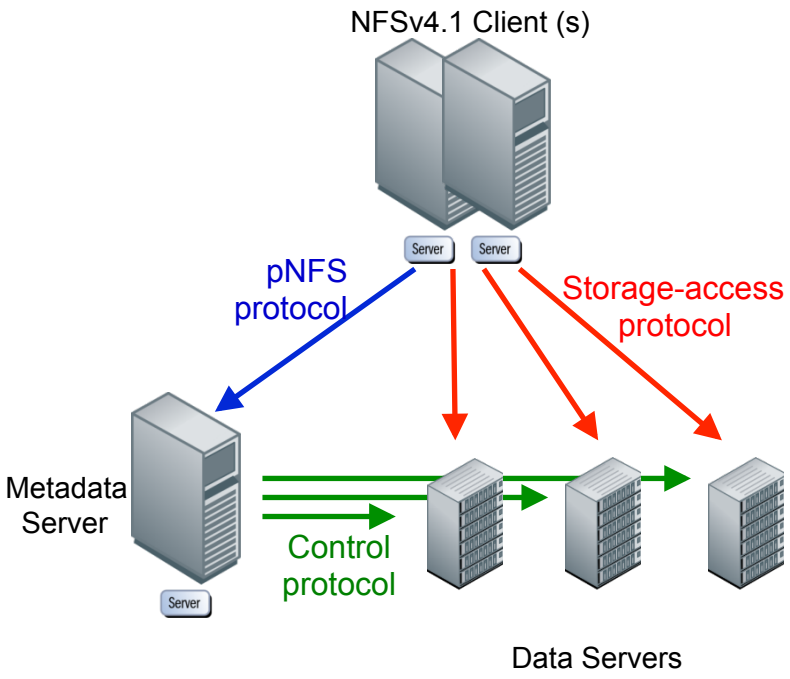
- Flex-files pNFS layout
  - Flexible, per-file striping patterns and simple device information suitable for aggregating standalone NFS servers into a centrally managed pNFS cluster
  - Assumption was that data servers would be NFSv4.1 or better
  - Flex-files layout allows various data servers
- Encourage best-of-breed solutions
  - NFS as the basic back-end control protocol allows one to mix and match a metadata server and data servers from different vendors

# Flex Files: A New pNFS Layout

- Permit layout to extend over non-pNFS data servers
- Example with NFSv3
  - File gets private UID and GID that client uses to access the file
  - To fence the file: the MDS changes the UID or GID
    - Requires exclusive root access to the data server
  - Fences access from clients, and forces clients to:
    - Return the file's layout
    - Request a new layout for the file
  - MDS grants access via new UID/ GID to clients it does NOT want to fence
  - Only AUTH_SYS is supported to the data servers, not full Kerberos



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# Other Developments & Beyond NFSv4.2



- Other work in Progress
  - Formalization of NFS/RDMA
  - RPCSEC_GSSv3 (security)
- Beyond NFSv4.2
  - NFS xattrs?
  - pNFS for directories (metadata striping)?
  - Byte-range delegations?

# Summary/Call to Action

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- NFS has more relevance today for commercial, HPC and other use cases than it ever did
  - Features for a virtualized data centers
- Developments driven by application & business requirements
- Adoption slow, but will continue to increase
  - NFSv4 support widely available
  - New NFSv4.1 with client & server support
  - NFS defines how you get to storage, not what your storage looks like
- Start using NFSv4.1 today
  - It works & it's available
  - pNFS offers performance support for modern NAS devices
  - Ask vendors to include NFSv4.1 and pNFS support for client/servers
  - pNFS has wide industry support
  - Commercial implementations and open source
- NFSv4.2 & future pNFS
  - Indicates industry commitment & development to NFS

- Q&A
- Supporting white papers and information can be found at

https://www.brighttalk.com/search?duration=0..&keywords[]=nfs&q=snia&rank=webcast_relevance
http://www.snia.org/sites/default/files/SNIA_An_Overview_of_NFSv4-3_0.pdf
http://www.snia.org/sites/default/files/Migrating_to_NFSv4_v04_-Final.pdf
http://linux-nfs.org
http://datatracker.ietf.org/wg/nfsv4
https://tools.ietf.org/wg/nfsv4/draft-ietf-nfsv4-minorversion2/

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- This webcast and a PDF of the slides will be posted to the SNIA Ethernet Storage Forum (ESF) website and available on-demand
  - http://www.snia.org/forums/esf/knowledge/webcasts
- A full Q&A from this webcast, including answers to questions we couldn't get to today, will be posted to the SNIA-ESF blog
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