NVMe-oF™ JBOFs

Sponsored by NVM Express® organization, the owner of NVMe™, NVMe-oF™ and NVMe-MI™ standards

JBOF Track Speakers

Bryan Cowger

Nishant Lodha

Peter Onufryk

Fazil Osman

Sujoy Sen

JBOF Session Agenda

- Market Overview
- Composable Infrastructure
- PCIe (direct-attached) JBOF
- Fabric-attached FBOF
- Management Options
- Remaining Challenges
- Q & A

Market Overview

Nishant Lodha
Marvell Semiconductor

Storage Trends from all around!

WW Enterprise Storage spend growing (~$42B(2016) → ~$47B(2020))

- Scale up → Scale Out (Hyperscale – public cloud driven by 3rd platform – mobile, social, cloud, analytics)
- ECB revenues stay flat ($25B) – Flash driving enterprise storage @ 26.2% CAGR; HDD declining @ 14.5% CAGR

Traditional storage deployment models being disrupted!

- Proprietary/siloed architectures → Software Defined Storage (SDS)/Hyper Converged (HCI) on commodity HW
- Direct Attach Storage (DAS) → Disaggregated storage (JBOD → JBOF, FBOF)

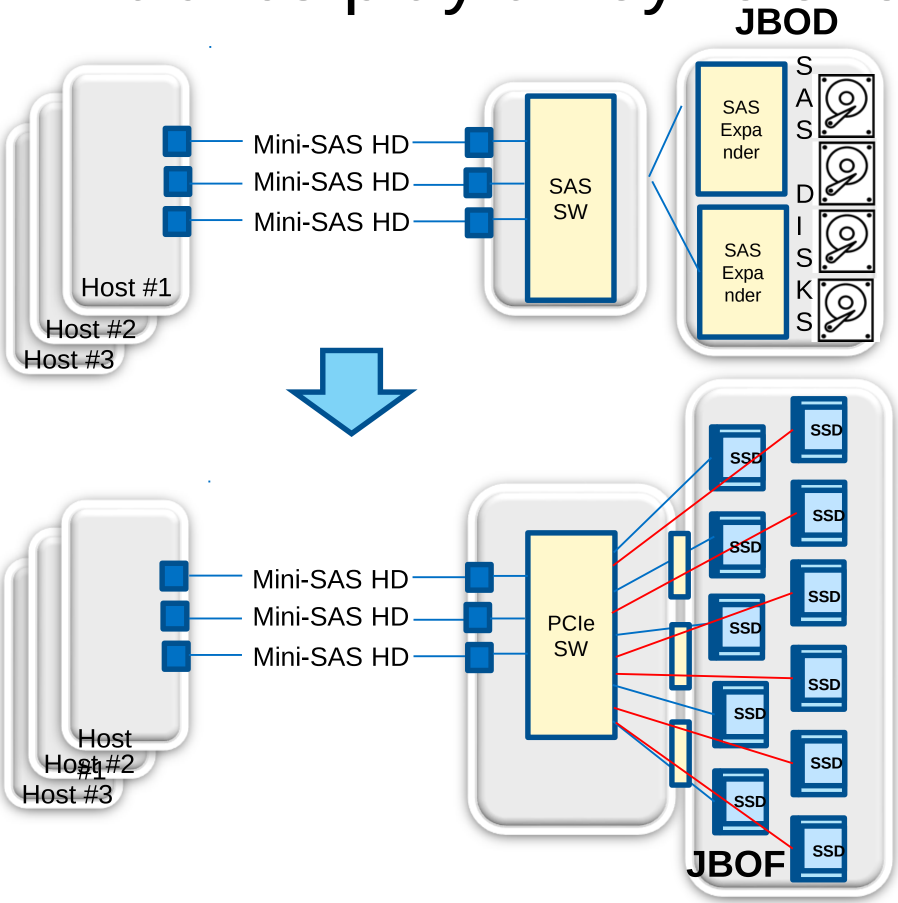
Faster media necessitates new protocol, drives faster interconnects & enables new use cases

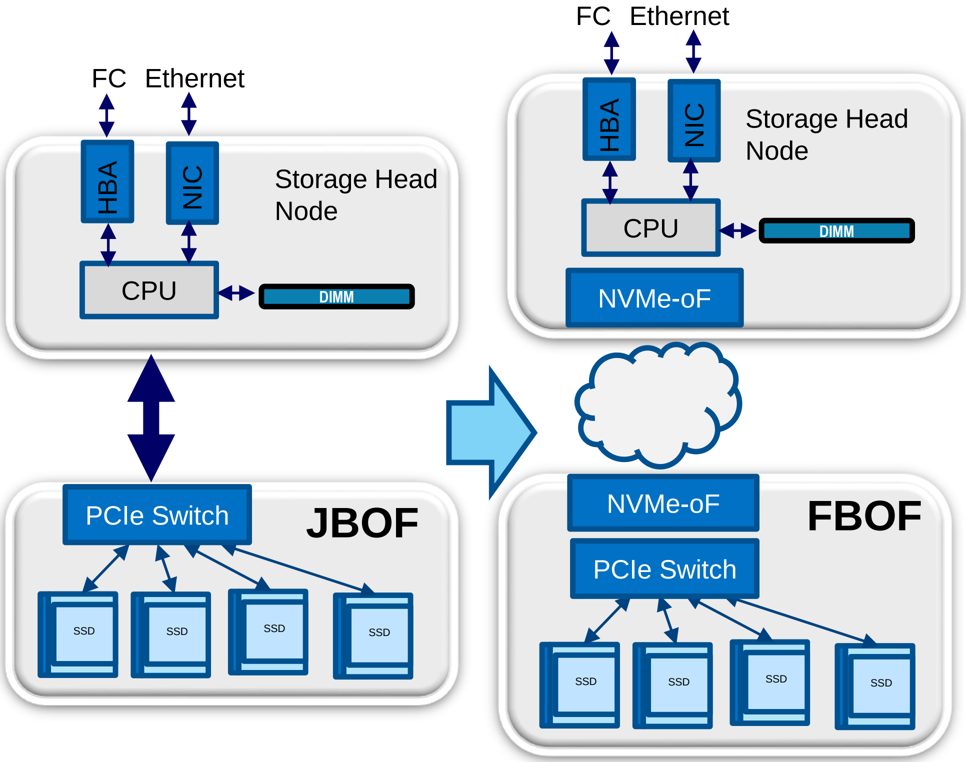
- NVMe™ will displace SCSI as the dominant block storage protocol by 2020 for AFA/CI/Scale-out
- Shared NVMe storage over a variety of Fabrics with NVMe-oF (RDMA (Eth, IB), FC, *TCP*)
- Emerging 3D Xpoint enables storage class memory (SCM)/persistent memory (PMEM)

Cloud storage for Enterprise customers iffy!

- Cost savings questionable; Data security concerns
- Hard to migrate legacy storage; Public cloud SaaS for email/collaboration

Fabrics play a key role for JBOFs -> FBOFs





Scaling our NVMe™ Requires a (Real) Network

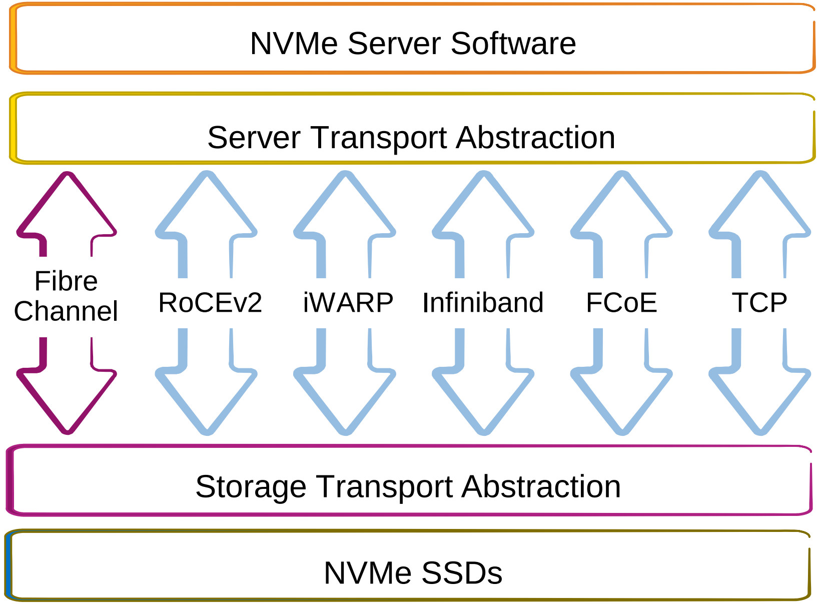
- Many options, plenty of confusion, conversation beyond PCIe®
- Fibre Channel is the transport for the vast majority of today's all flash arrays

  FC-NVMe Standardized in Mid-2017

- RoCEv2, iWARP and InfiniBand are RDMA-based but not compatible with each other

  NVMe-oF RDMA Standardized in 2016

- FCoE is a fabric is a option
- NVMe over TCP - making it way through the standards



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RDMA is Most "Considered", Challenges Remain

Infrastructure and Skillset change required!

Congestion	Skillset Requirements	Backward Compatibility
Not Automatic **Not Precise**	Keeping the network '**lossless**' RDMA/**OEFD** expertise	RNIC **Upgrade Required** **RDMA Camps**

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New This Year! NVMe-oF™/TCP

Defines a TCP Transport Binding layer for NVMe-oF

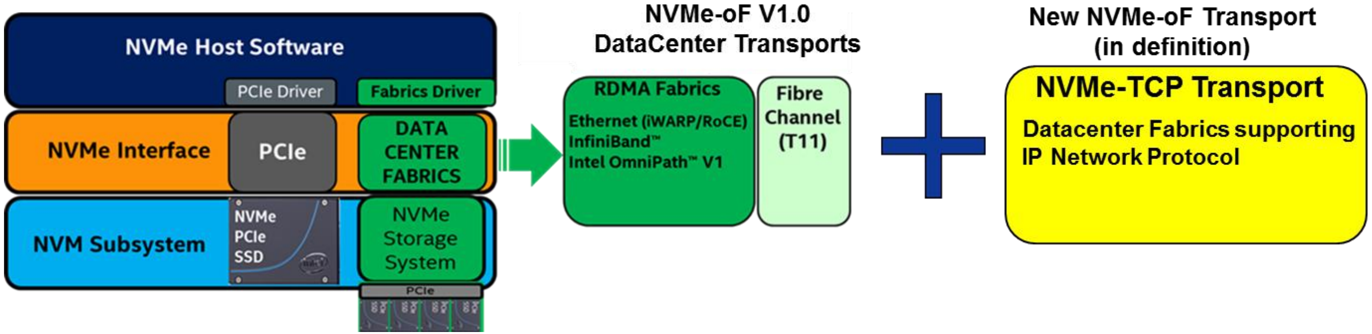
Promoted by Facebook, Google, DELL EMC, Intel, Others. Sweet spots for JBOF/FBOFs

Not RDMA-based

Not yet part of the NVMe-oF standard, Likely in 2018/19

Enables adoption of NVMe-oF into existing datacenter IP network environments that are not RDMA-enabled

TCP offload required to leverage Flash potential



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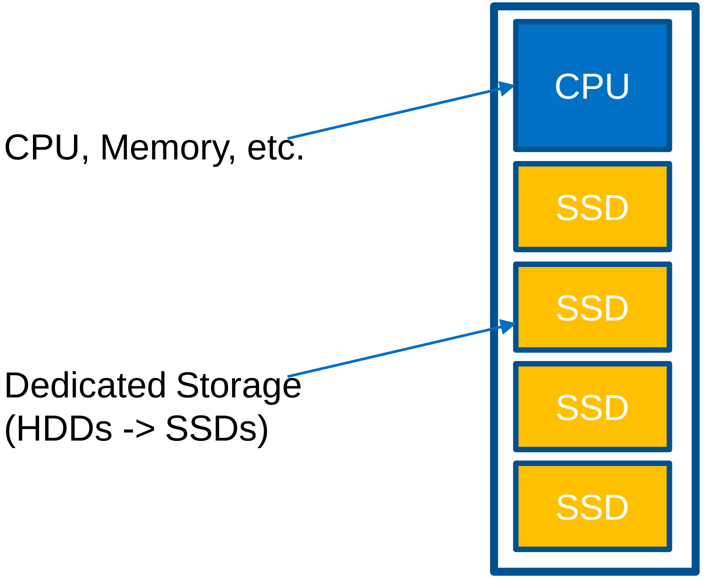
Composable Infrastructure

Bryan Cowger

Kazan Networks

Today's "Shared Nothing" Model
a.k.a. DAS

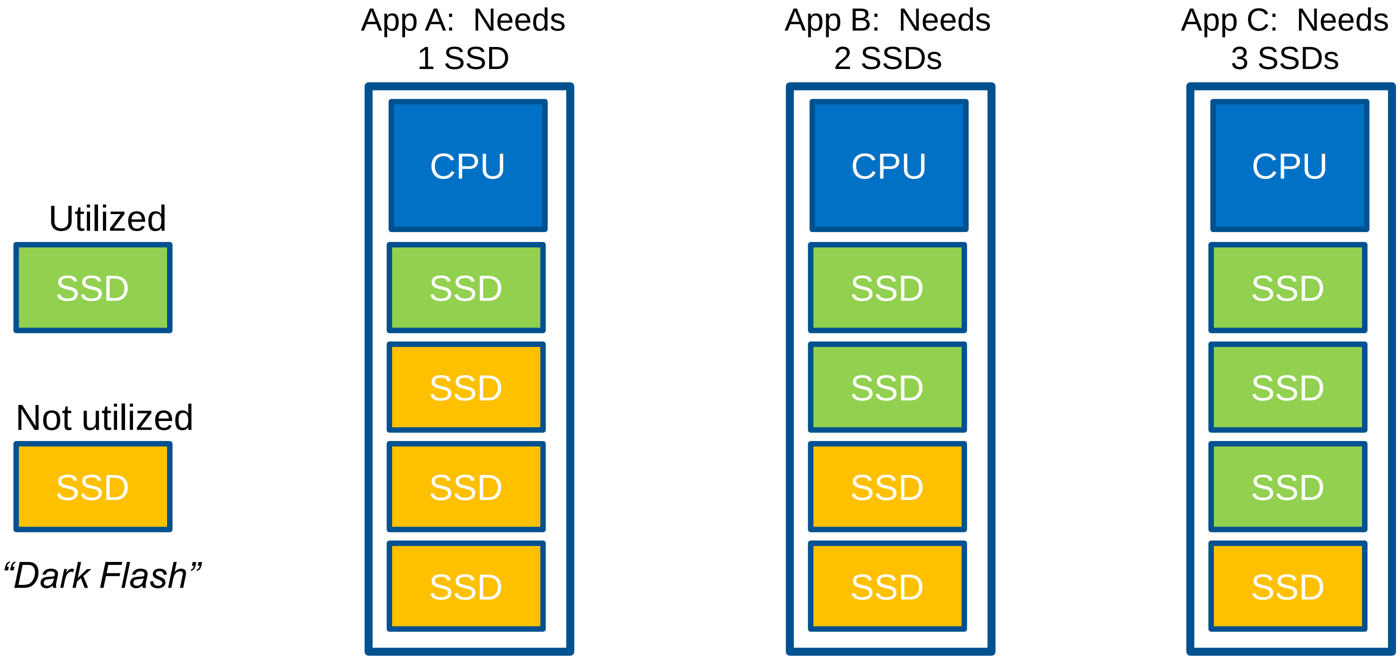


Challenges:
- Forces the up-front decision of how much storage to devote to each server.

- Locks in the compute:storage ratio.

Shared Nothing Model

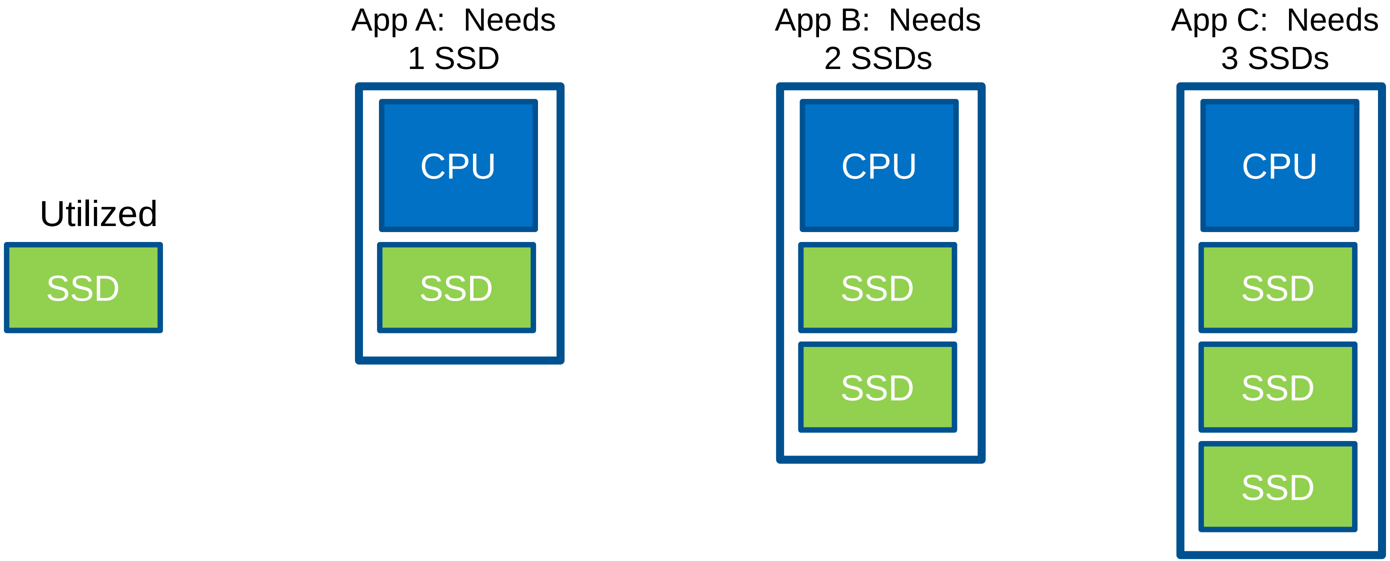
Option A: One Model Serves All Apps



Net utilization: 6 SSDs out of 12 = 50%

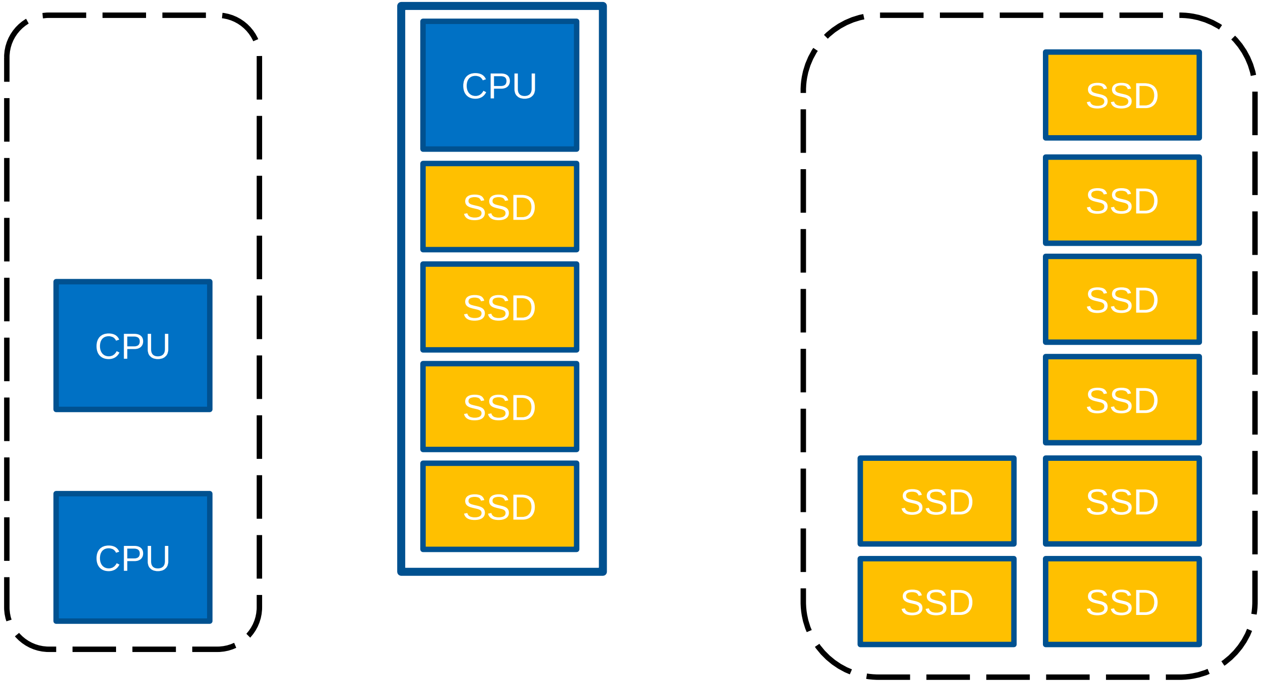
Shared Nothing Model

Option B: Specialized Server Configurations



Dark Flash eliminated, but limits agility and future app deployments

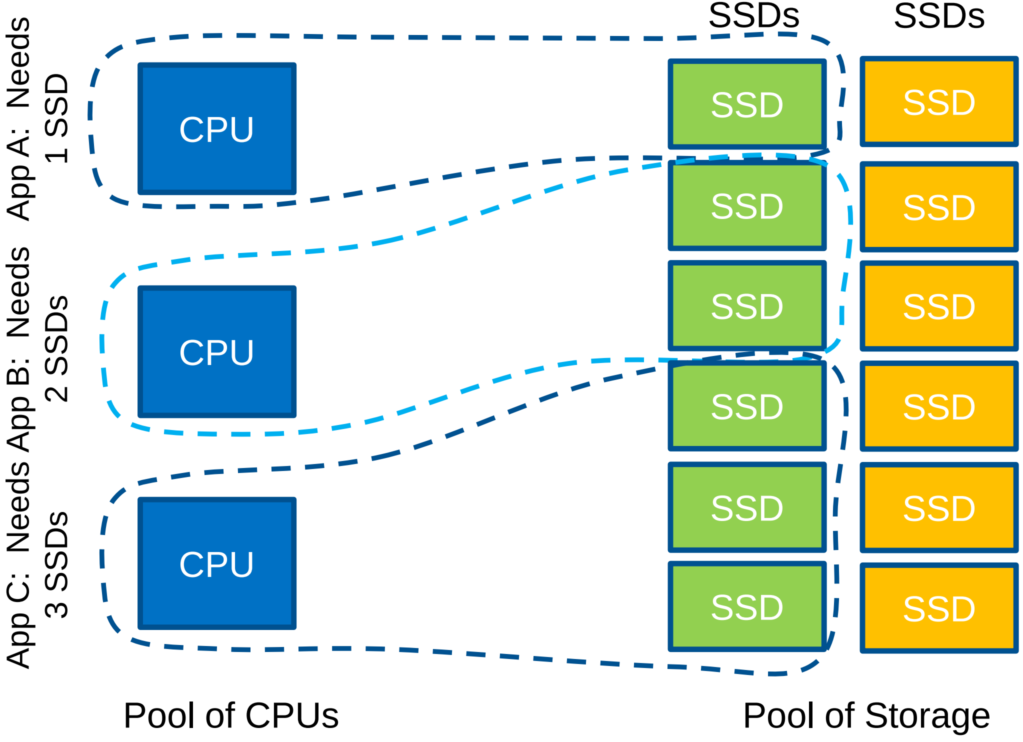
Disaggregated Datacenter



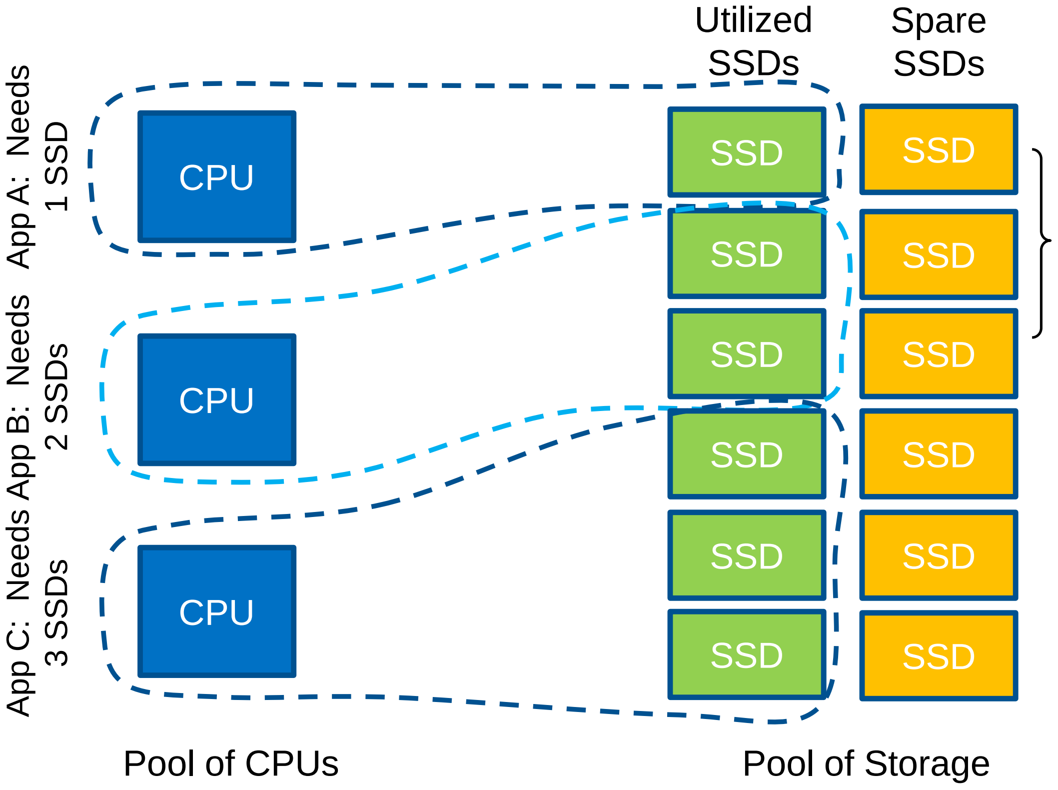
Pool of Compute

Pool of Storage – JBOF/FBOF

The Composable Datacenter



The Composable Datacenter



Spares / Expansion Pool

- Minimize *Dark Flash*!
- Buy them only as needed
- Power them only as needed

Other benefits

- Dynamically allocate more or less storage
- Return SSDs to Pool as apps are retired
- Upgrade SSDs independently

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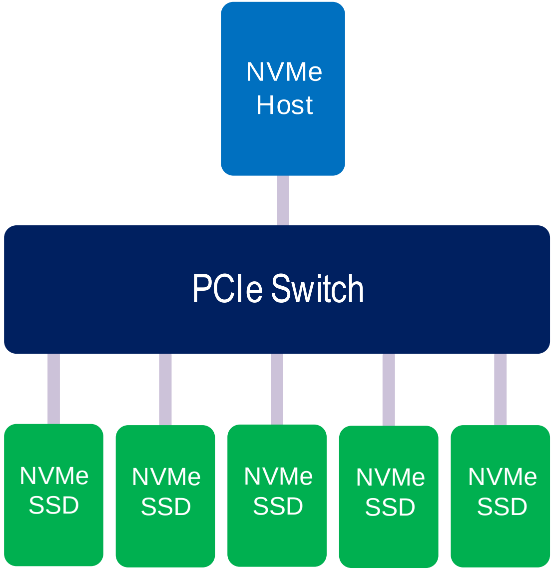
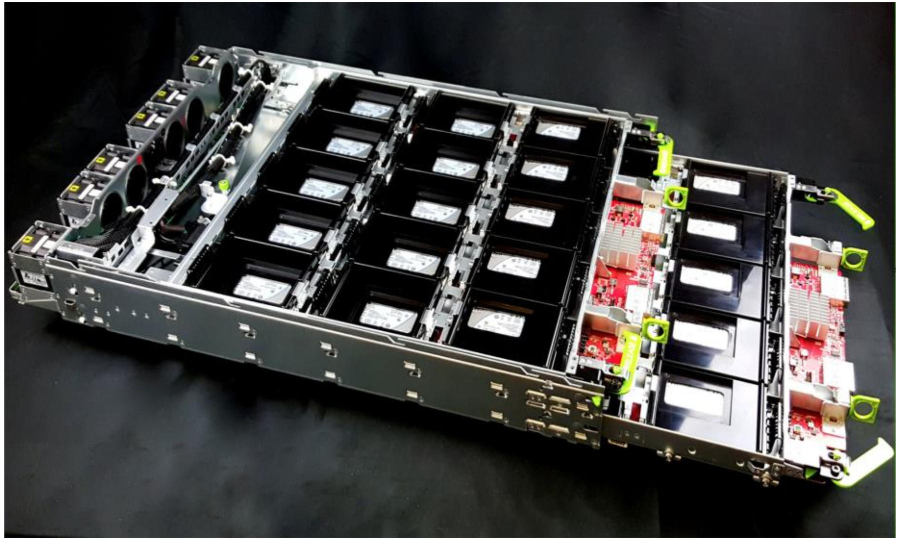
PCIe® NVMe™ JBOF

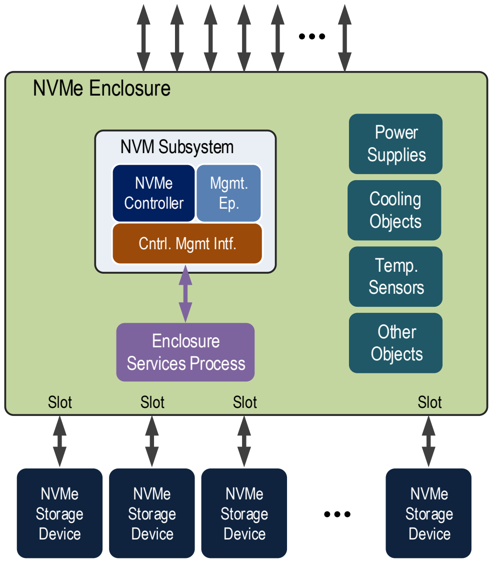




Facebook Lightning PCIe NVMe JBOF

PCIe® JBOF Enclosure Management

- Native PCIe Enclosure Management (NPEM)
  - Submitted to the PCI-SIG® Protocol Workgroup (PWG) on behalf of the NVMe™ Management Interface (NVMe-MI™) Workgroup
  - Approved by PCI-SIG on August 10th, 2017
  - Transport specific basic enclosure management
- SCSI Enclosure Services (SES) Based Enclosure Management
  - Technical proposal developed in the NVMe-MI workgroup
  - While the NVMe and SCSI architectures differ, the elements of an enclosure and capabilities to manage them are the same
    - Example enclosure elements: power supplies, fans, display or indicators, locks, temperature sensors, current sensors, voltage sensors, and ports
  - Comprehensive enclosure management for NVMe that leverages (SES), a standard developed by T10 for management of enclosures using the SCSI architecture



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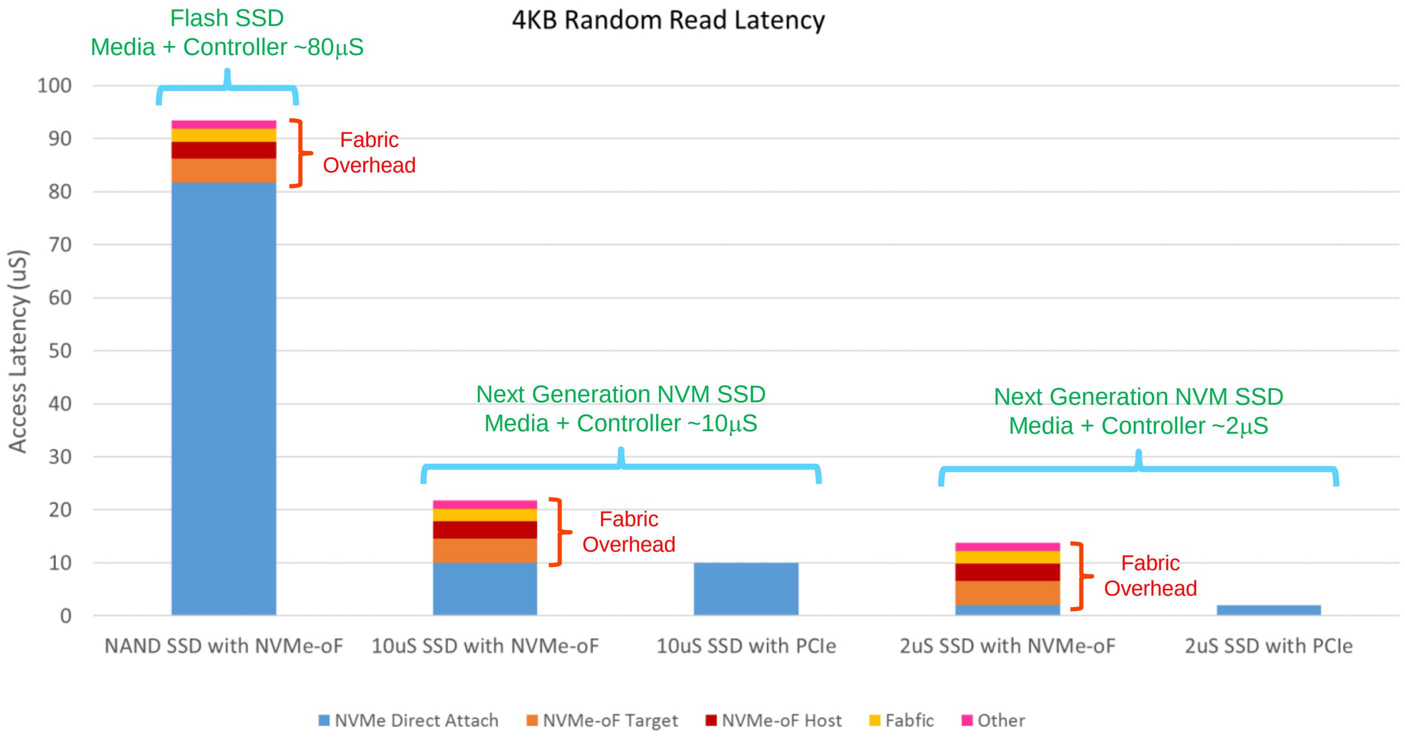
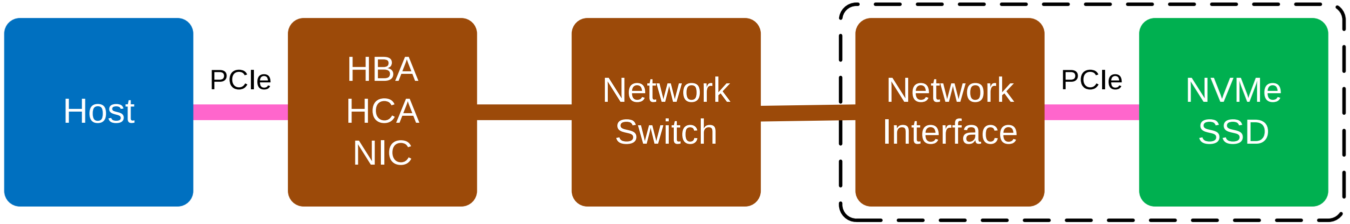
The PCIe® Latency Advantage



Latency data from Z. Guz et al., “NVMe-over-Fabrics Performance Characterization and the Path to Low-Overhead Flash Disaggregation” in SYSTOR ‘17

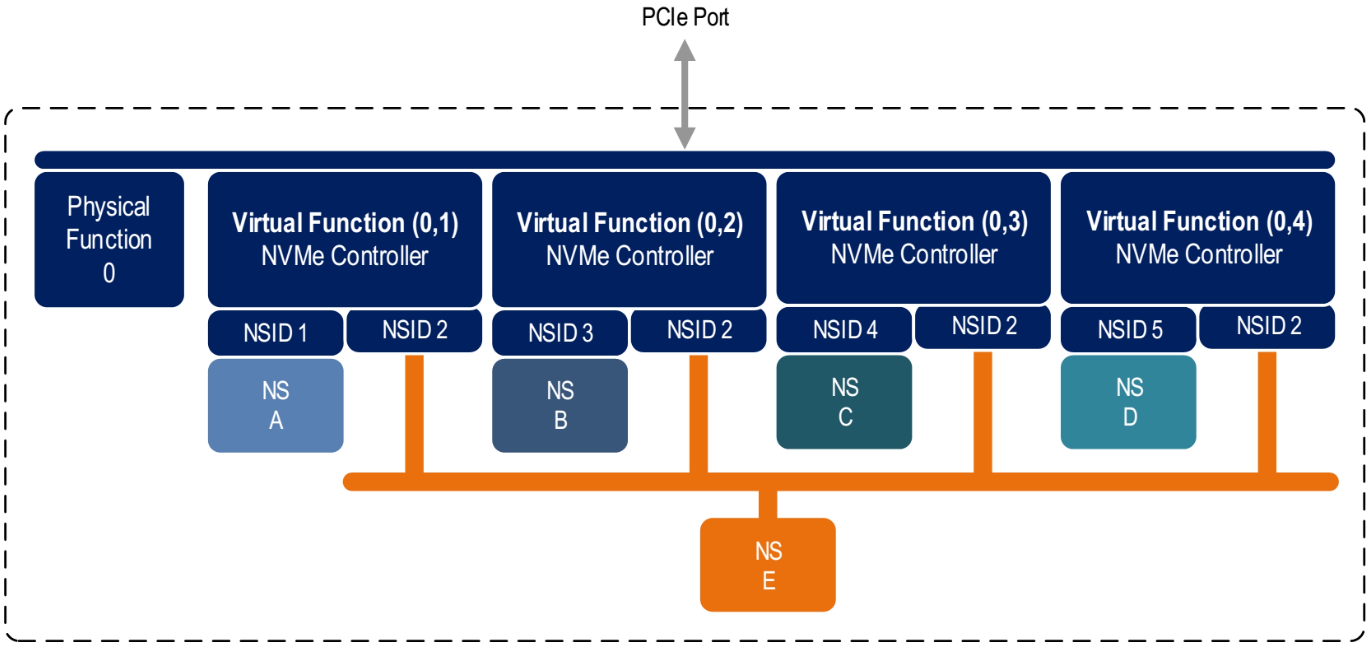
The PCIe® Advantage



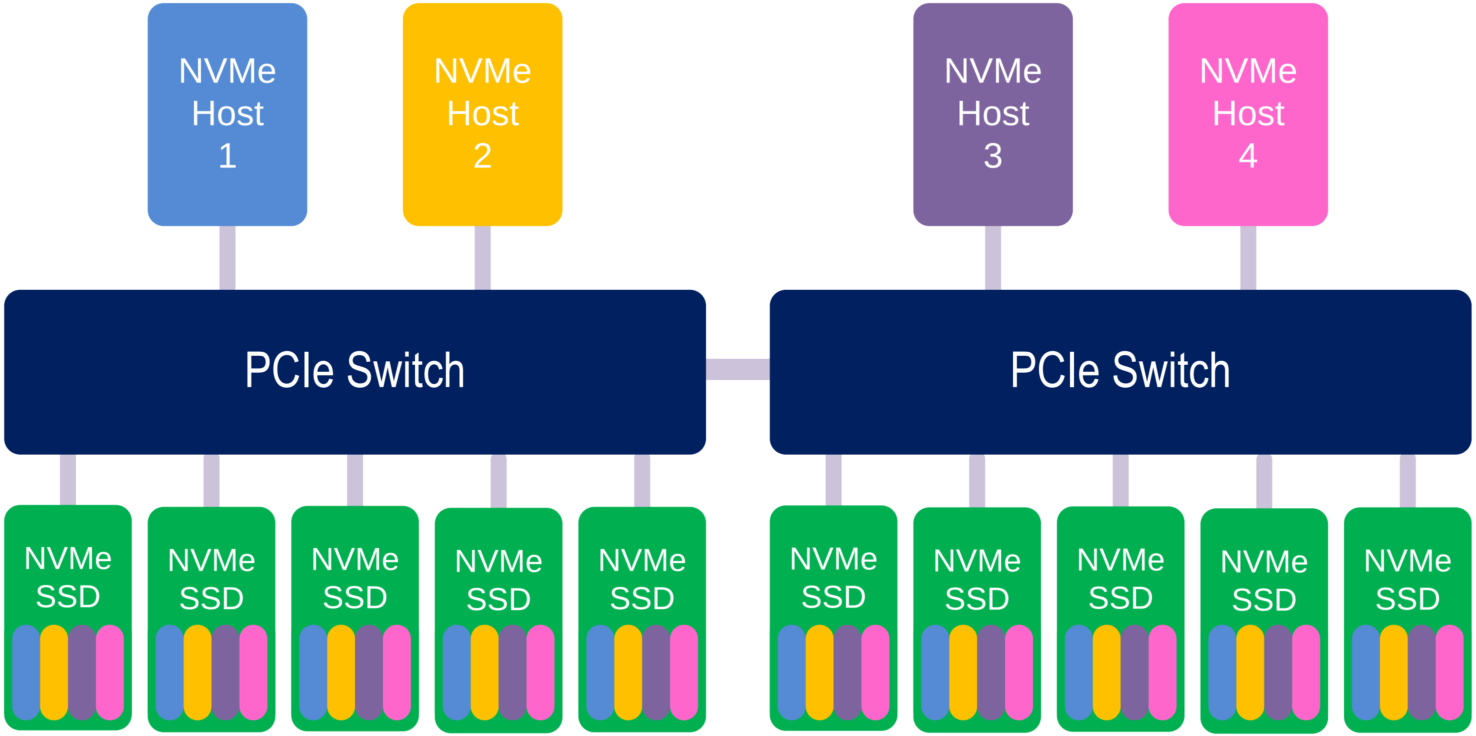
Other Flash Storage Networks

PCIe Fabric

NVMe™ SR-IOV


PCIe Port
Physical Function 0
Virtual Function (0,1) NVMe Controller
Virtual Function (0,2) NVMe Controller
Virtual Function (0,3) NVMe Controller
Virtual Function (0,4) NVMe Controller
NSID 1
NSID 2
NSID 3
NSID 2
NSID 4
NSID 2
NSID 5
NSID 2
NS A
NS B
NS C
NS D
NS E

Multi-Host I/O Sharing



Storage is Not Just About CPU I/O Anymore

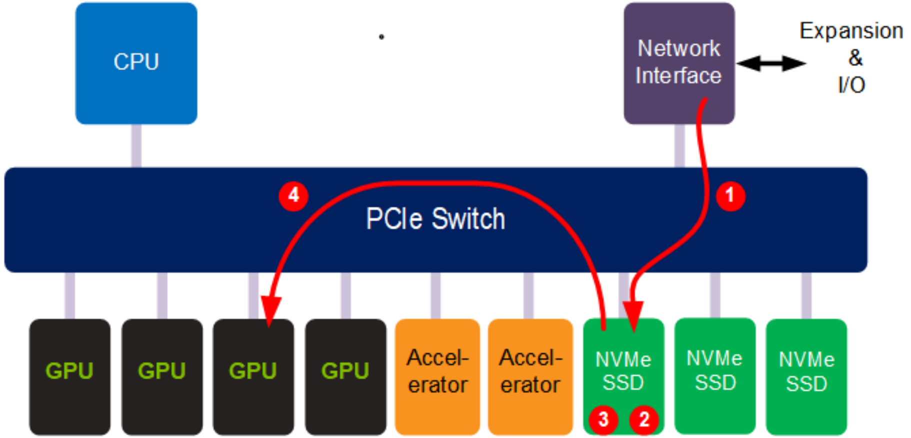
- NVMe™ together with a PCIe® fabric allow direct network to storage and accelerator to storage communications

Example:

1. Data transferred from network to NVMe CMB
2. NVMe block write operation imitated from CMB to NVM

… sometime later …

3. NVMe block read operation initiated from NVM to CMB
4. GPU/Accelerator transfers data from NVMe CMB for processing



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FBOF Architecture

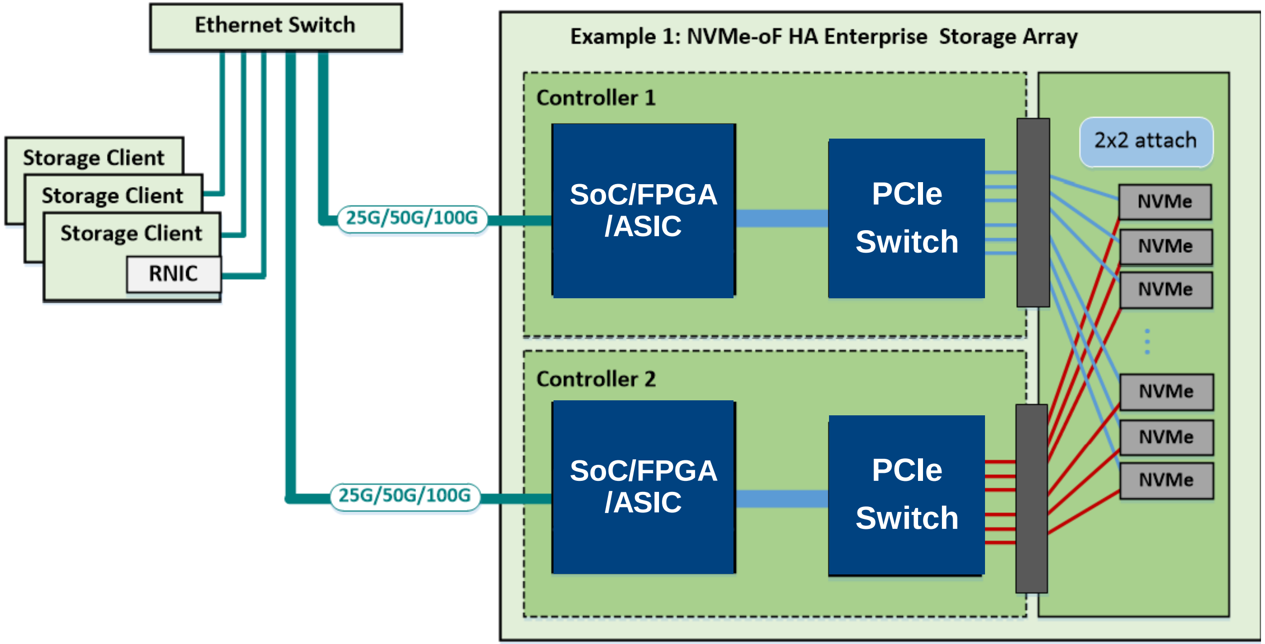
Fazil Osman, Broadcom

NVMe-oF™ Market

SAS Replacement	Composible
High performance Low latency Better scalability than PCIe® Solution for traditional Enterprise iSCSI, cluster architectures etc.	TCP IO Determinism Data Integrity Application Offload Cloud Scale Out

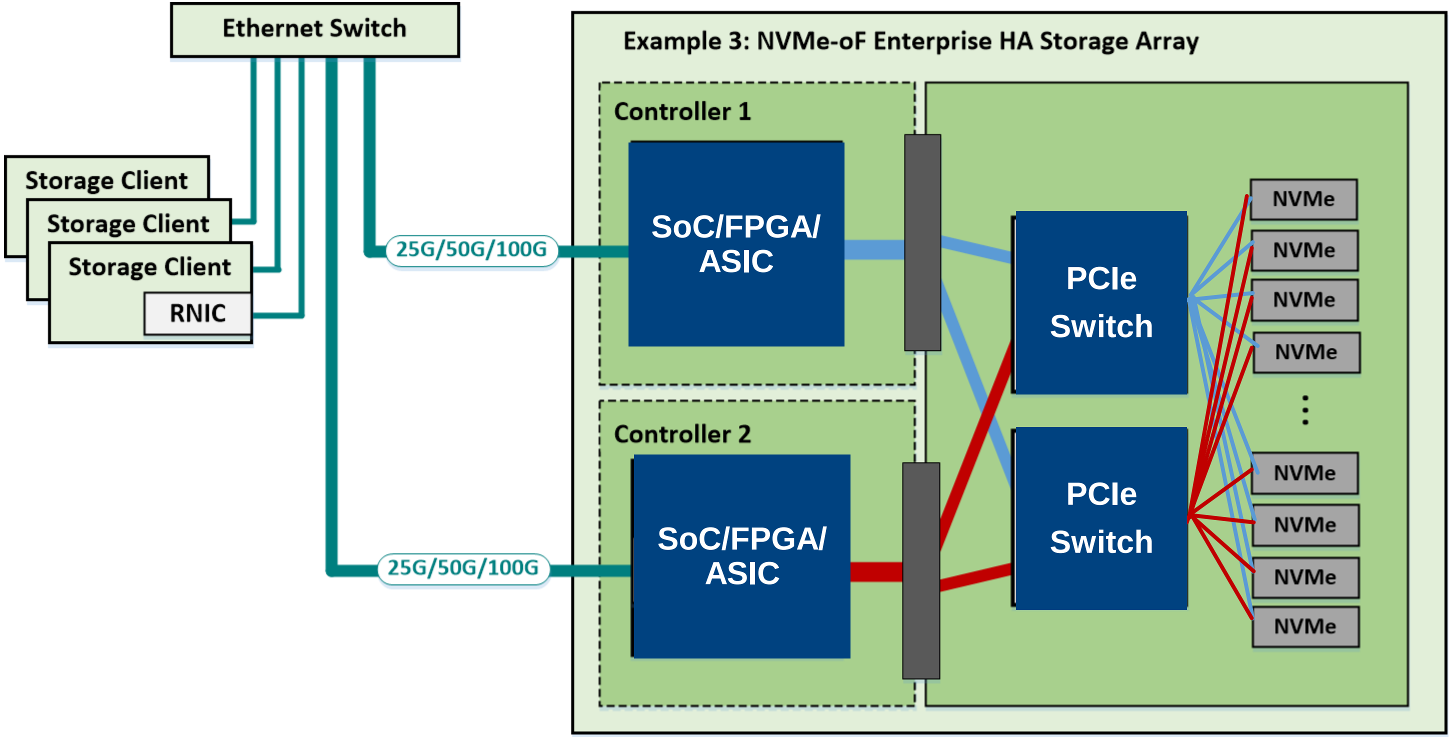
Form Factor		
Today	**24 x U.2**	**30/60 x M.2**
Future	**Ruler (16/32 x 1U)** **EDSFF, NF1**	**Modular w/Ethernet** **EDSFF Derivative**

FBOF architecture examples



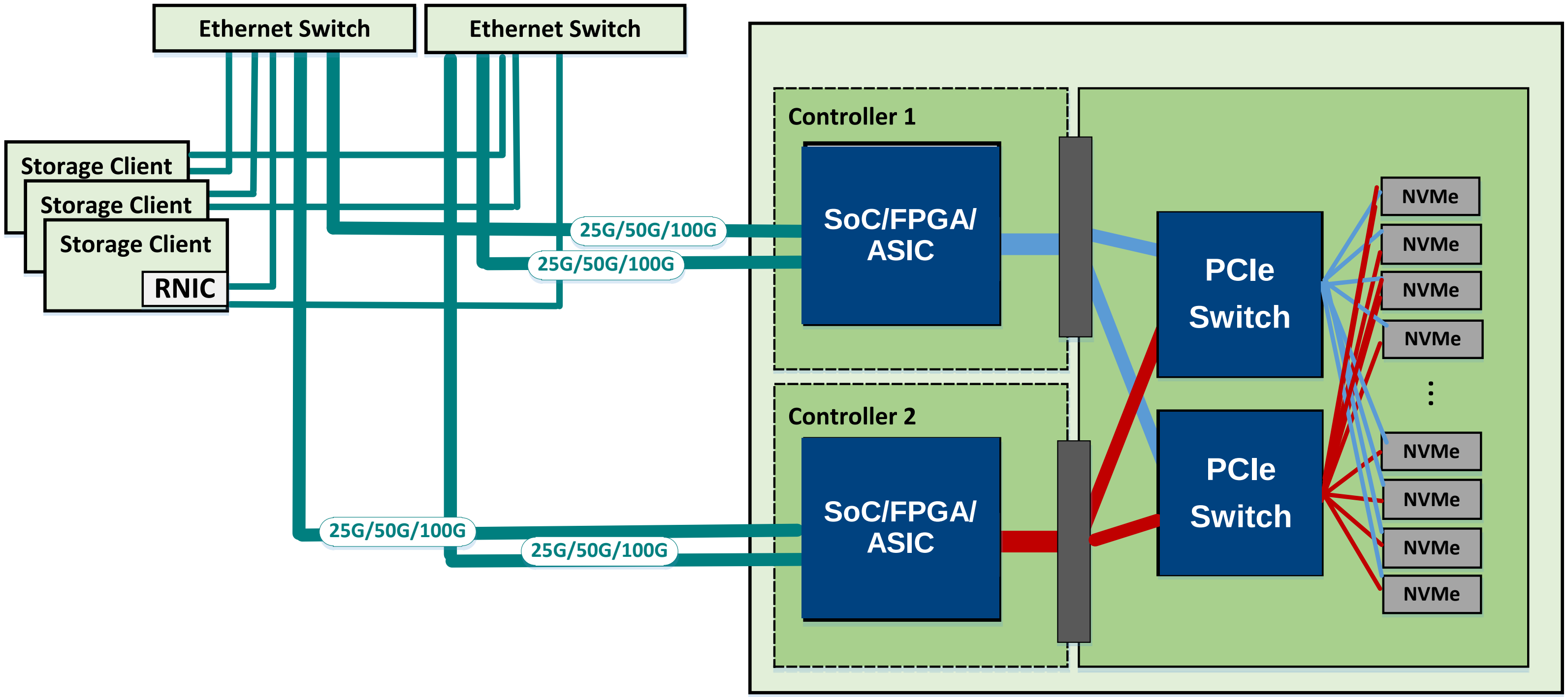
High Availability option 1

HA FBOF architecture



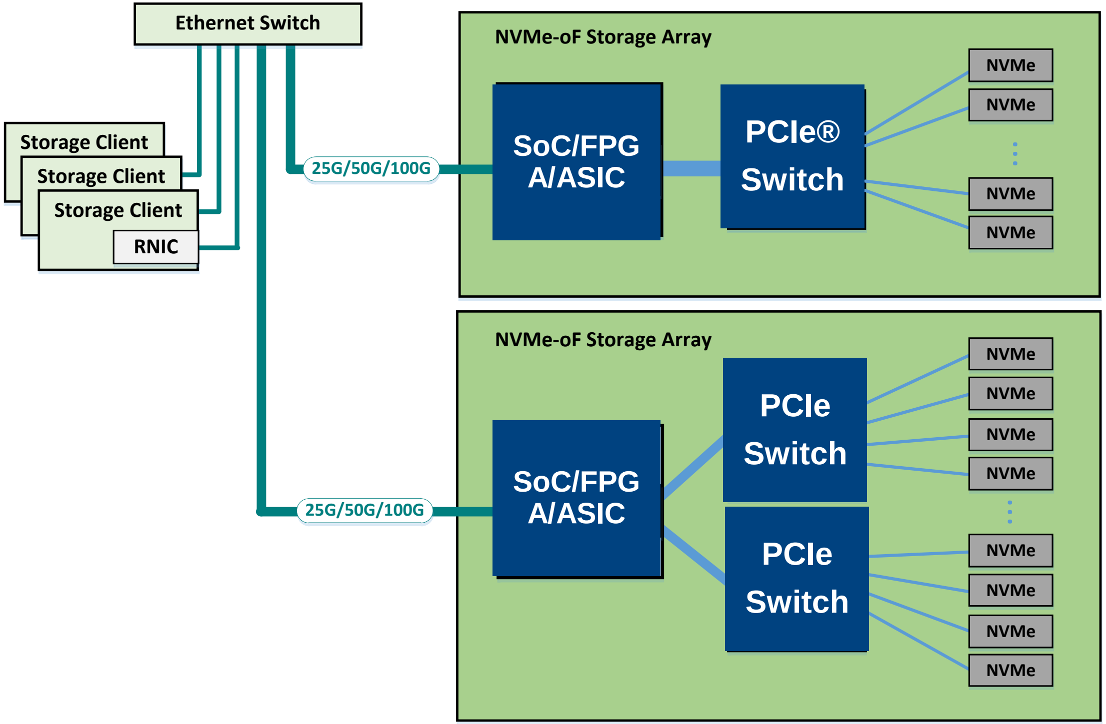
High Availability option 2

HA FBOF architecture with redundant switches



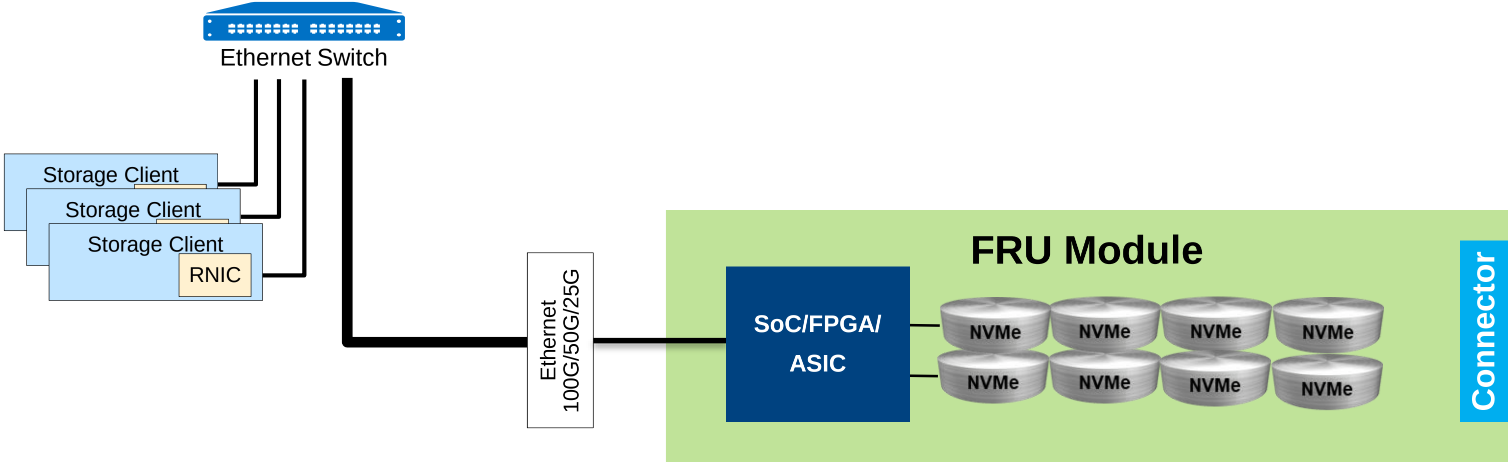
High Availability option 3

FBOF high fanout architecture



High Fanout

Scale Out Cloud Architecture



1U ruler based designs on PCIe® attach being introduced into the market

– i.e. White River Glacier etc., various ODM offerings

Designs provide high density NVMe™ but lack scalability

Goal is to extend concept for cloud scale using NVMeoF™

Gain scalability of fabrics attached

Simplify design by removing PCIe switch

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FBOFs in the Cloud

Sujoy Sen, Intel

Making FBOFs Successful in the Cloud

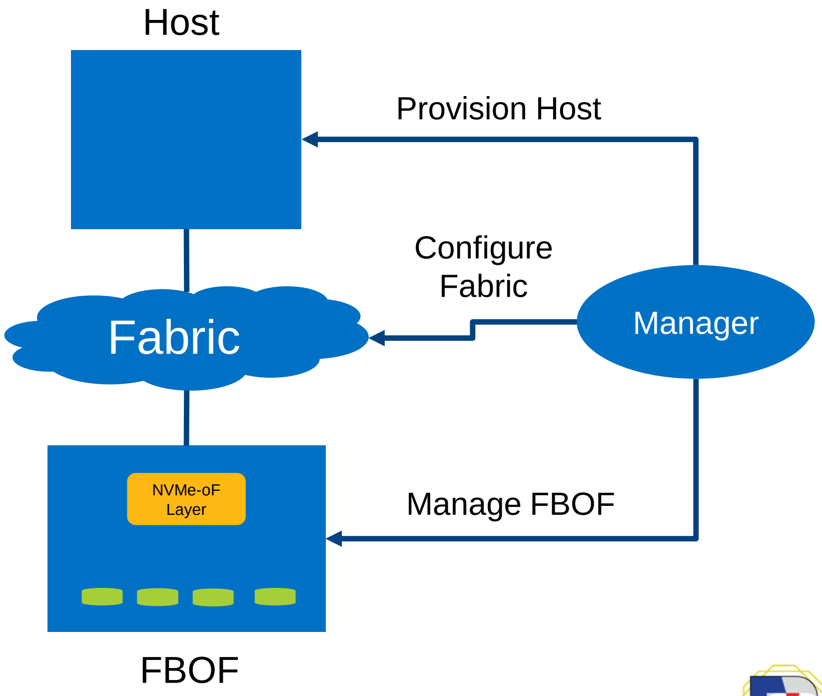
FBOFs in the cloud enable the composable and disaggregated use case

Success will require the following

- Network QoS (especially RDMA@scale)
- Easy to deploy and manage@scale
- Enable Scale-out Distributed Storage architectures

Ease of Use

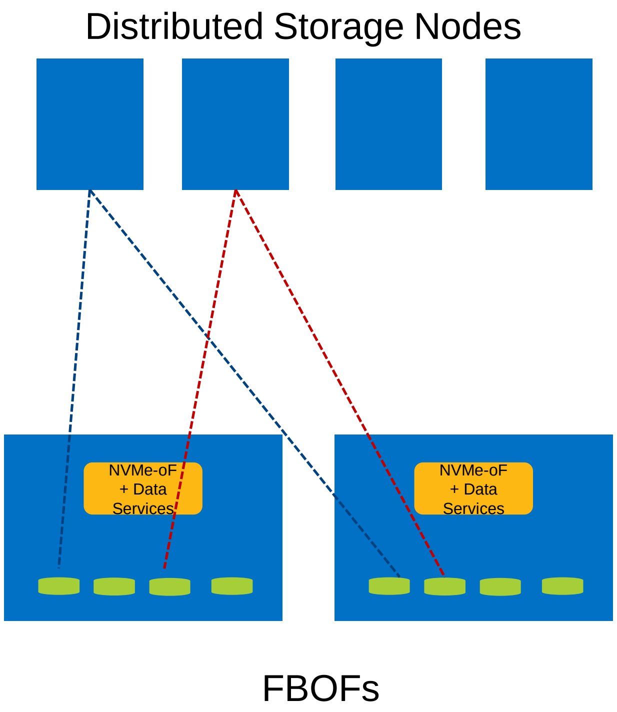
- E2E management
  - Not just FBOFs but the hosts and the network in-between
- Cloud OS Enablement
  - Develop drivers/plug-ins for NVMe-oF™
- Bare Metal
  - Server platform and OS native support for NVMe-oF provisioning



Drive standards-based management eco-system

Scale-Out Distributed Storage

- Blast Radius and Failure Domains
  - Soft vs hard error handling
  - Single Point-of-Failure avoidance
- Partitioning of Data Services between storage node and FBOF, e.g.
  - Data Layout and Media Management
  - Replication/HA
  - Data Compression and Security
- Distributed storage-aware NVMe-oF™
  - Cluster-aware protocol enhancements



Key Takeaways

- JBOF / FBOF represents a key building block for NVMe™ based datacenters
- Two options:
  - PCIe® Direct Connect JBOFs
    - Lowest Latency
    - Limited Scale / Distance
  - Fabric Attached FBOFs
    - Scale at the levels of FC or Ethernet
    - Additional latency, networking / fabric bandwidth
- Manageability represents new opportunities and challenges

Contact Information

For more information please contact the following:

Fazil Osman fazil.osman@broadcom.com

Nishant Lodha Nishant.Lodha@cavium.com

Sujoy Sen sujoy.sen@intel.com

Bryan Cowger bryan.cowger@kazan-networks.com

Peter Onufryk Peter.Onufryk@microchip.com

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