



September 23-26, 2019
Santa Clara, CA

SAS Rules the Data Center

Cameron Brett
President, SCSI Trade Association

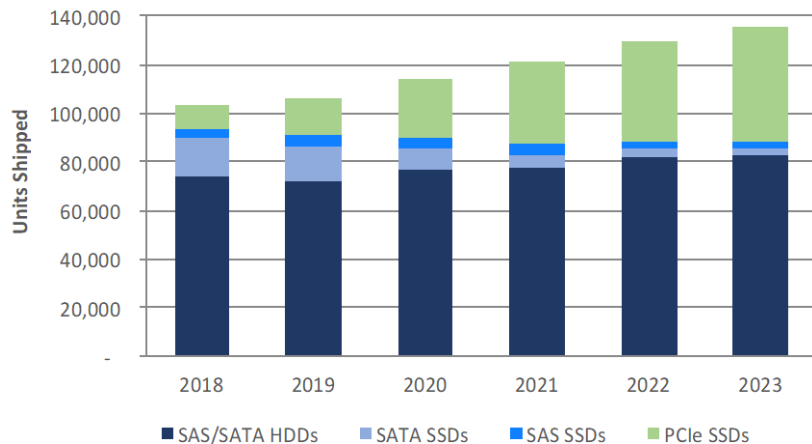
**Director of Marketing, SSD and Storage
Solutions, Toshiba Memory America, Inc.**



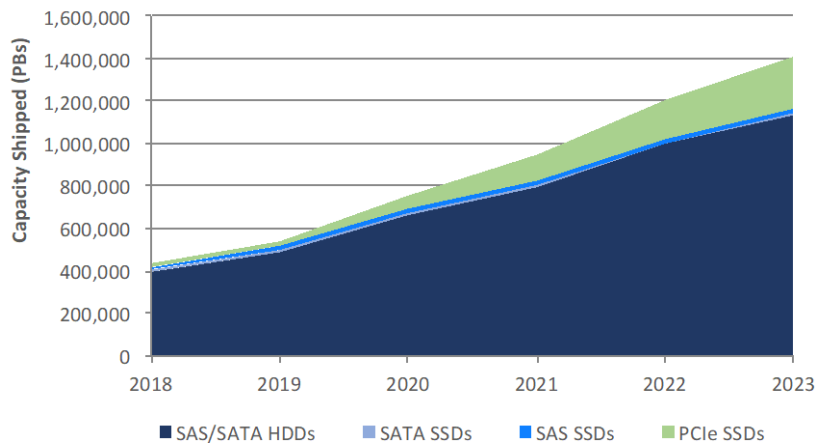
SAS Remains Primary Enterprise Storage Interface

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WW Enterprise Drive Unit Forecast (2018-2023)



WW Enterprise Drive Capacity Forecast (2018-2023)

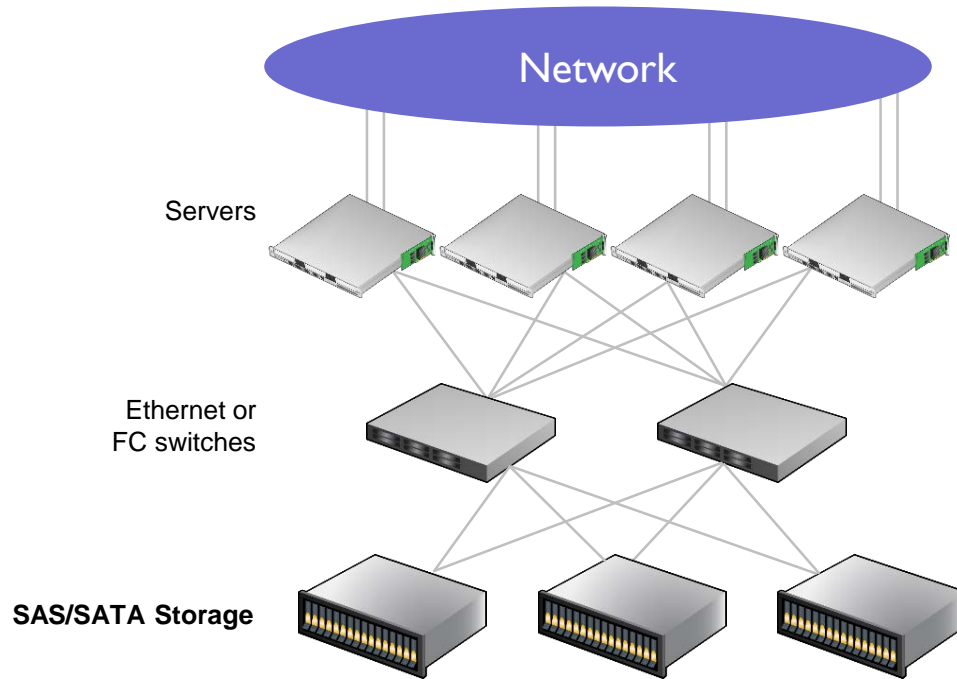


Source: IDC, May 2019

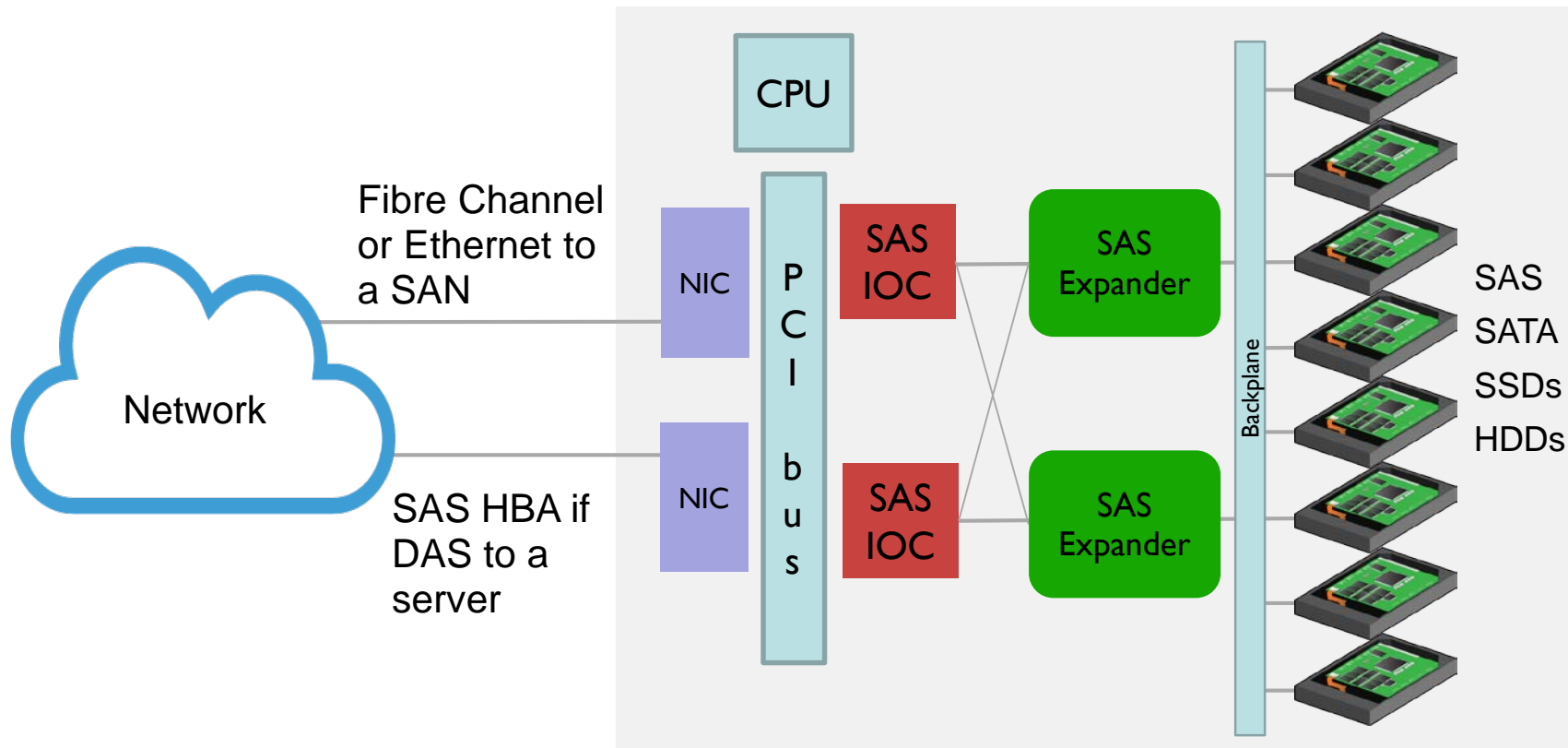
SAS Infrastructure Enables >64% of Enterprise Storage Drives and >80% of Enterprise Storage Capacity thru 2023

SAS Enterprise Architecture

Storage Area Network



SAS Enterprise Architecture: A Closer Look



OCP Hyperscale Design Example #1

Wiwynn Honeybadger 12Gb/s SAS Storage Server



- Designed to support up to 30 SAS HDDs in a 2U chassis
- Based on Facebook's Open Vault Storage Hardware specification

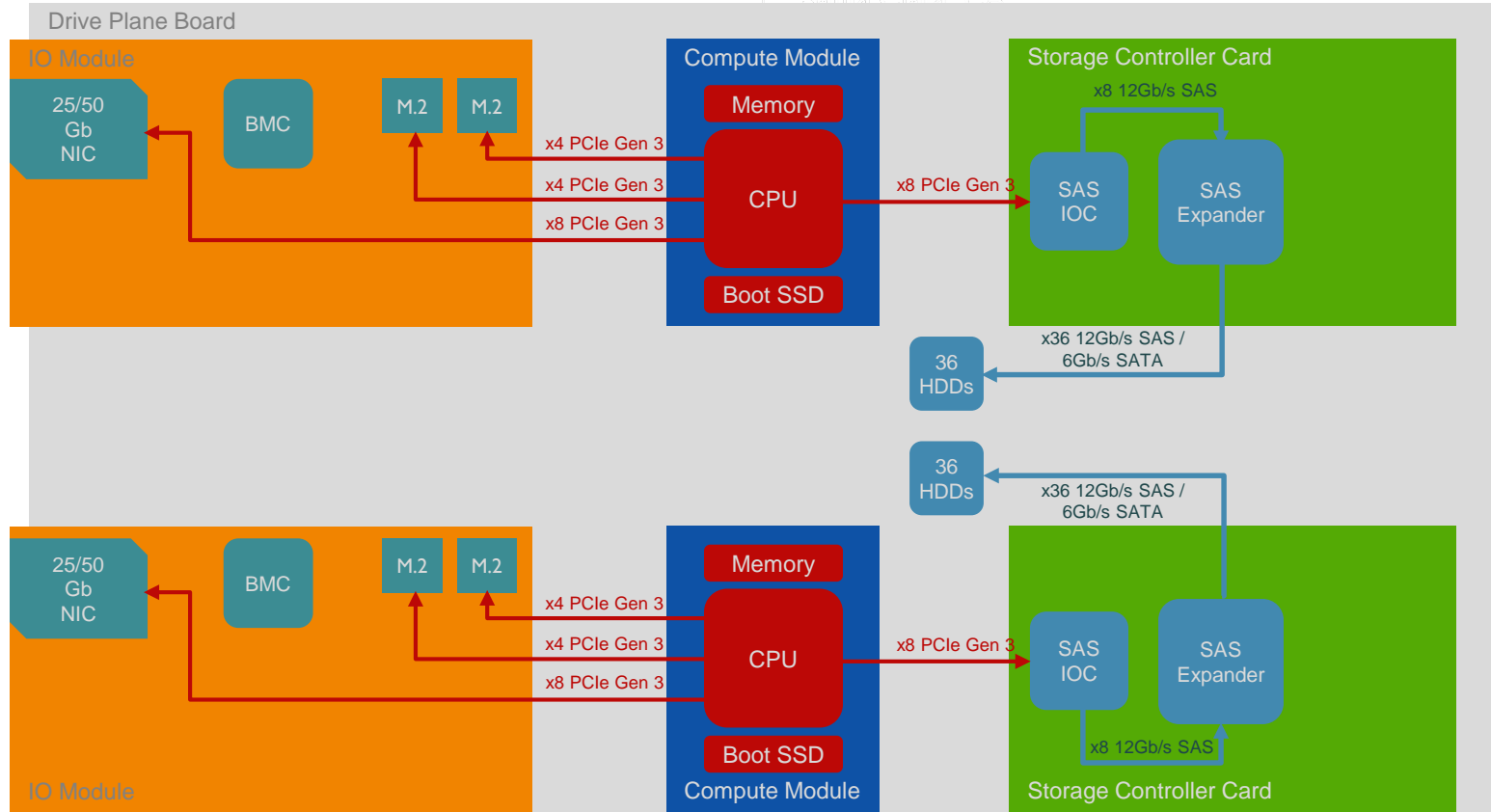
OCP Hyperscale Design Example #2

Wiwynn Bryce Canyon 12Gb/s SAS Storage Server



- Designed to support up to 72 hot-pluggable SAS HDDs
- Based on Facebook's Storage System specification

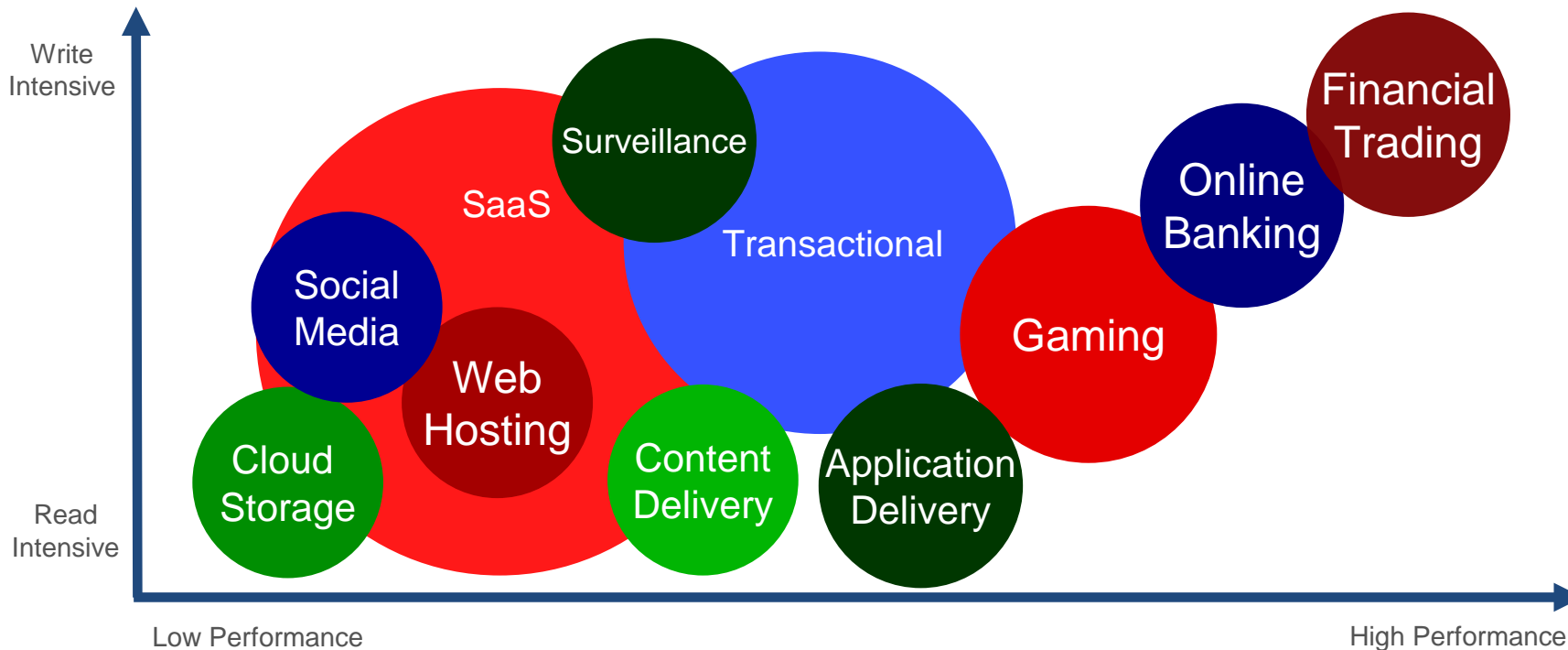
OCP Hyperscale Bryce Canyon Design



Source: FB.engineering.com

Data Center Storage Applications

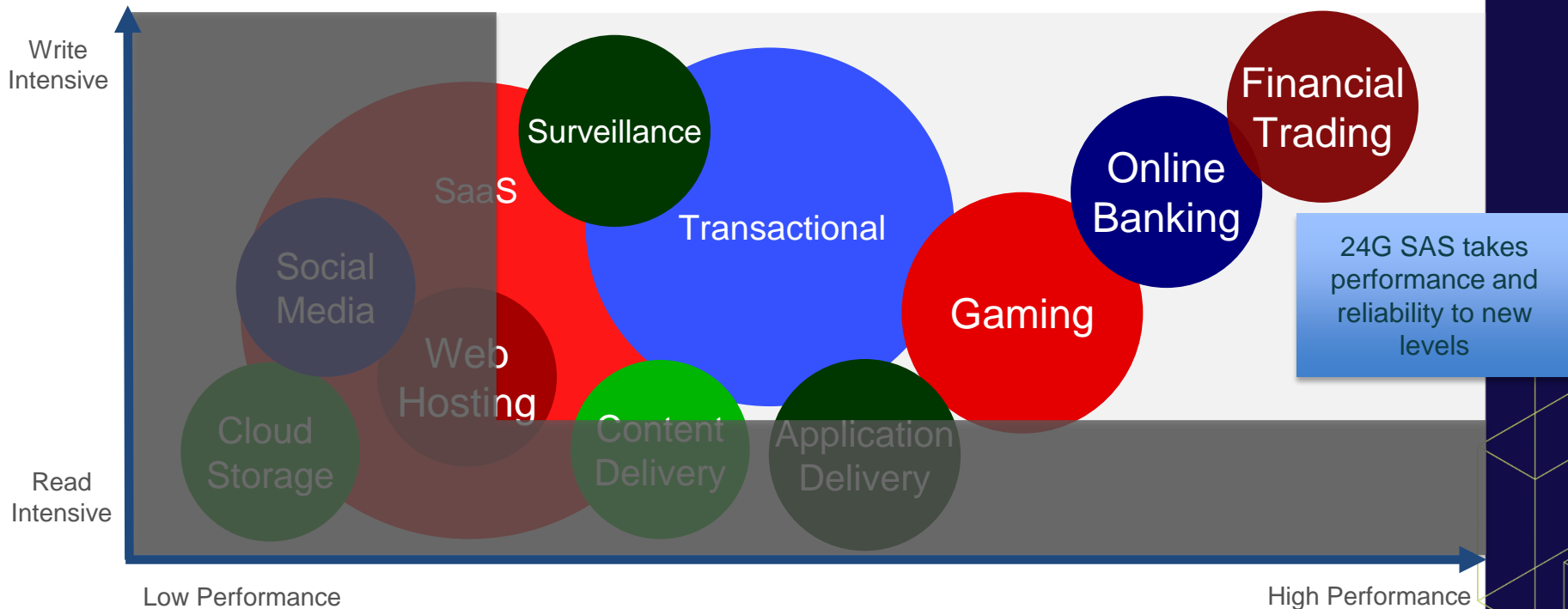
SDC¹⁹



SAS in the Data Center

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SDC¹⁹



SAS Infrastructure Supports Diverse Workloads

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SDC¹⁹

Application/ Use Case	Workload Characteristic	Storage Requirements	Key Performance Metrics								Storage Performance Objective
			Sm SR	Lg SR	Sm SW	Lg SW	Sm RR	Lg RR	Sm RW	Lg RW	
Machine Learning	Large highly parallel reads	Direct Attached SATA									Ability to process large amounts of data, mostly read operations
Sensor, Radar & Signal Processing	Small highly parallel writes	Direct Attached SAS									Ability to ingest large amounts of unprocessed sensor/signal inputs
Financial Trading	Very small parallel writes & check pointing operations	Direct Attached SAS									Minimize logging time & checkpoint operations
Transactional Databases	High intensity random reads & writes. Sequential log writes	RAID: SATA/SAS									Maximize random I/O performance
File + App Services	80% Read/20% Write (OLTP), Varying sizes, Sequential log writes	RAID: SATA/SAS									Manage a high number of small random requests & effective cache utilization
OLAP & ETL (Business Intelligence)	Large reads followed by ad-hoc queries of small random reads	RAID: SATA/SAS									Provide high read bandwidth for quick ETL's & high IOPs for fast business queries

SAS Infrastructure Supports Diverse Workloads (cont'd)

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SDC¹⁹

Workload	Workload Characteristic	Storage Requirements	Key Performance Metrics								Storage Performance Objective
			Sm SR	Lg SR	Sm SW	Lg SW	Sm RR	Lg RR	Sm RW	Lg RW	
Medical Imaging	Large sequential reads and writes	RAID: SATA/SAS									Provide high bandwidth for large writes to storage. Read bandwidth for image access
Content Management	Large sequential reads/writes, meta-data indexing, random content access	RAID: SATA/SAS									Provide high read & write bandwidth for large content movement. Also support a large number of concurrent random file reads and writes.
Big Data	Large sequential reads and writes	Direct Attached SATA/SAS									Provide high bandwidth reads and writes to complete operations
Software Defined Storage	Application dependent. Primarily random workloads	Direct Attached SATA/SAS									High random IOPs needed to support broad range of SDS based workloads
Backup/Disaster Recovery	Large sequential reads and writes	RAID: SATA/SAS									Provide high bandwidth reads and writes to complete operations and comply with SLA obligation
Analytics / Data Mining	Highly parallel random reads	RAID: SATA/SAS									High IOPs and read bandwidth to maximize completions of complex and real time queries.

24G SAS Highlights

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Physical Layer Enhancements

2.4 GB/s
effective
single-lane
bandwidth
(22.5 Gbaud rate)

Higher throughput
and IOPS
performance

Enhanced
20-bit
Forward
Error
Correction
(FEC)

More robust data
reliability and
connectivity

SAS-4
transmitter
training
algorithm

Better signal
integrity via
continuous optimal
signal tuning

Protocol & Block Level Enhancements

Fairness
enhancements

Performance
consistency across
large and mixed
protocol topologies

Storage
intelligence
and persistent
connections

Improves SSD
efficiency,
latency, and QoS

SMP
priorities

Determines priority
for management-
class
communications

SAS Innovations in HDD and SSD Technologies

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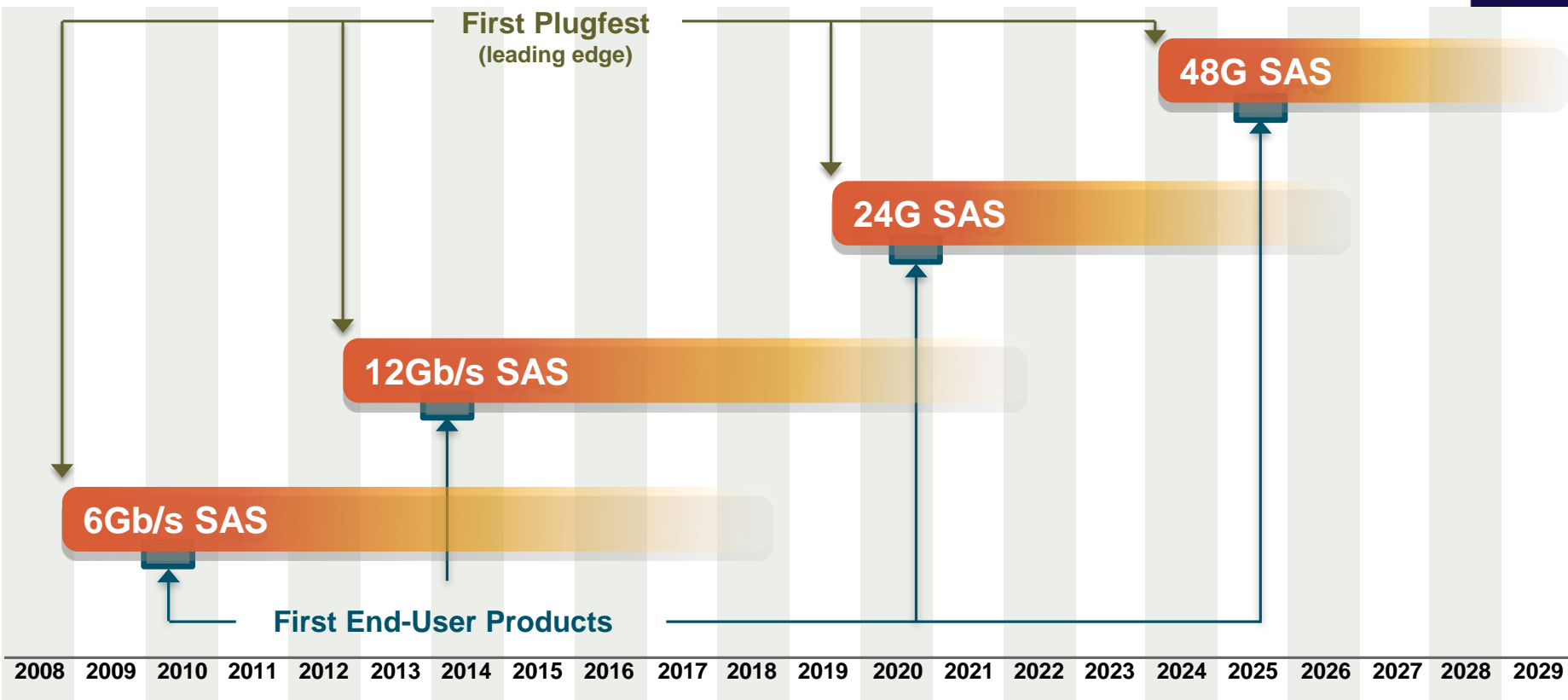
SDC¹⁹

Storage media is ever-changing to increase IOPS and capacity



SAS takes advantage of these new drive technologies

SAS Technology Roadmap



Summary Comparison of a Typical Drive Deployment

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	SAS	NVMe™	SATA
Performance (IOPS, GB/s)	Better (x1 lane)	Best (x4 lanes)	Good
Performance (Read Latency ¹)	Better	Best	Good
Scalability	Best	Good (*Better w/ NVMe-oF™)	Better (SAS infrastructure)
Flexibility	Best (SAS, SATA, HDDs, SSDs)	Good (SSDs)	Better (SSDs, HDDs)
Manageability and Hot Plug ²	Best (most mature)	Good (recent spec)	Better (SAS infra)
Reliability	Best	Better	Good
System cost	Higher	Highest (performance premium)	Lowest
Roadmap future	Long-term	Long-term	Limited

¹ Latency includes OS, driver, HBA (if required) and flight time, media access times not included

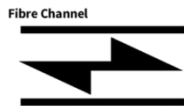
² includes surprise hot plug and managed hot plug

SCSI Command Set is Pervasive

- SCSI protocol is a highly robust command set used in high-performance workstations, servers, and storage appliances
- Industry-proven – SCSI command set implemented by other storage interfaces, including:



24G SAS
(and all previous
generations of SAS)



Fibre Channel



**USB Mass
Storage Class**



Infiniband



Ultra320 SCSI
(and all previous generations
of parallel SCSI)



iSCSI

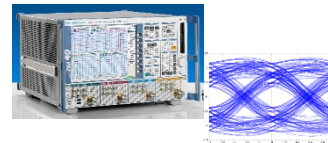


**IEEE 1394
(Firewire)**

24G SAS Ecosystem Readiness in 2020

- Ecosystem is on track for SAS-4 production readiness in 2020

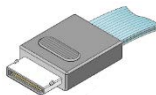
- SAS-4 analyzers have been sampling since last year



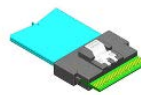
- Cables and connectors: both existing and new form-factors ready for 24G SAS



Mini SAS HD



SAS MiniLink



SlimSAS

- SAS-4 controllers and expanders aligned with upcoming Gen4 platform launches
 - New HDD/SSD capabilities to intersect with 24G SAS ecosystem
 - MultiLink SSDs
 - Multiple Actuator
 - Hybrid SMR
 - HAMR / MAMR

