



SAS: Today's Fast and Flexible Storage Fabric

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Abstract

- SAS is the backbone of nearly every enterprise storage deployment, rapidly evolving, adding new features and enhanced capabilities, and offering “no compromise” system performance. SAS not only excels as a device level interface, its versatility, reliability and scalability have made it the connectivity standard of choice for creating new enterprise storage architectures.
- This presentation covers the advantages of using SAS as a device interface and how its capabilities as a connectivity solution are changing the way data centers are being deployed. 12Gb/s SAS transfer rates, bandwidth aggregation, SAS fabrics (including switches) active connections, and multi-function connectors allow data center architects to create sustainable storage solutions that scale well into next-generation 24Gb/s SAS designs and beyond.

Today's Takeaways

❖ Flexibility of SAS is Unparalleled

- ◆ Media flexibility
- ◆ Scalability
- ◆ System architectures

❖ SAS Technology Addresses a Very Large, Growing Market

❖ SAS Continues to Evolve through Innovation

- ◆ Performance
- ◆ Features



SAS – Preserving the Past, Creating the Future

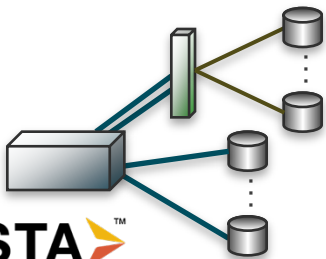
Preserve Legacy SCSI

- 25 years of SCSI middleware



Future Architected

- Protocol extends to new technologies
- Serial, switchable
- SFF connectors



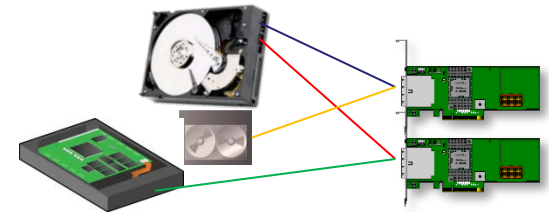
Customer Choice

- 3.5" and 2.5" form factors
- Plug compatible
- Multi-protocol



Usability

- Dual-ported
- Point-to-point
- Cost equal to SCSI



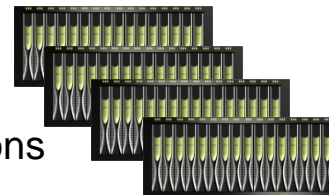
Performance

- Wide ports
 - Interconnect
 - MultiLink SAS[™]
- Low overhead



Scalable

- 1000s of connections

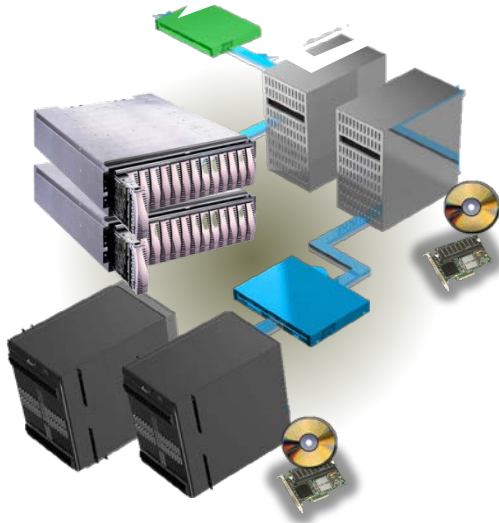


SAS: Today's Fast and Flexible Storage Fabric

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SAS & SATA Span the Storage Spectrum

Direct Attach Storage



- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs

SAS Fabrics



- Expanders
- SAS switches
- Bridges
- Port multiplexers

External Storage



- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs
- SAS/SATA tape

Media



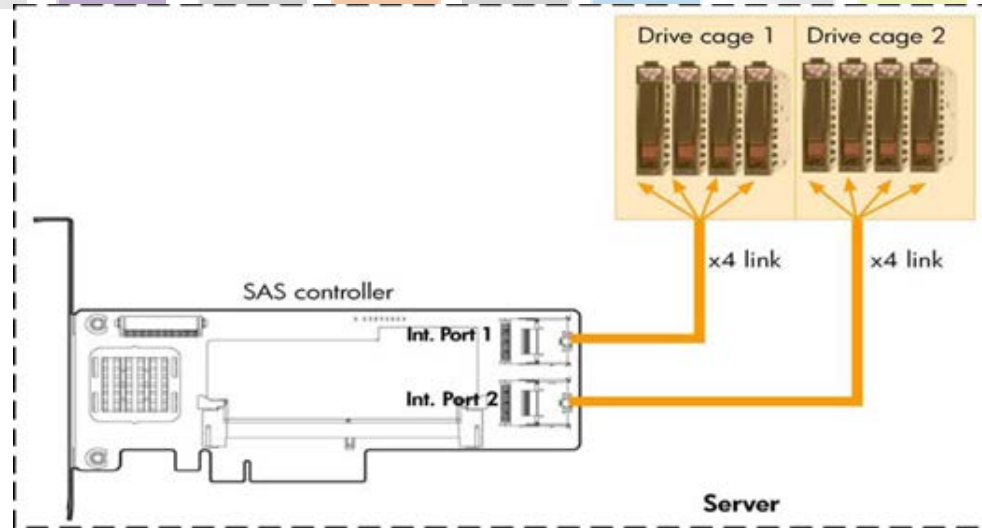
- SAS HDDs
- SAS SSDs
- SATA HDDs
- SATA SSDs
- Near-line SAS HDDs
- SMR HDDs

SAS is the Predominant Enterprise Drive Interface

Scalability in Server & Hyper-Converged Architectures

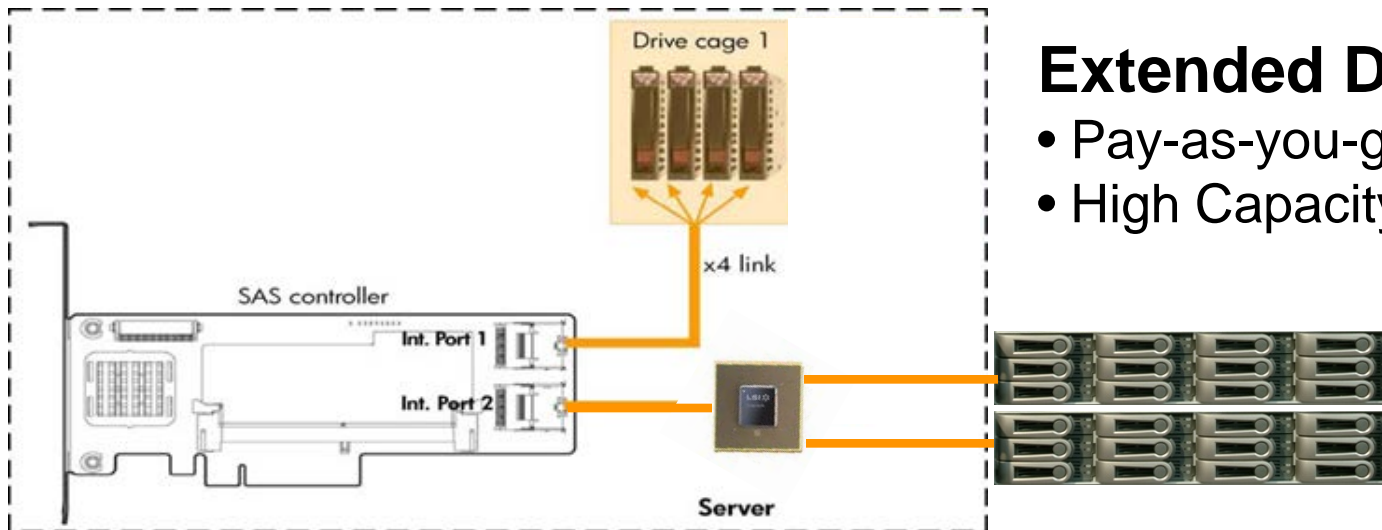
Simple DAS

- High Performance
- Inexpensive
- Modular

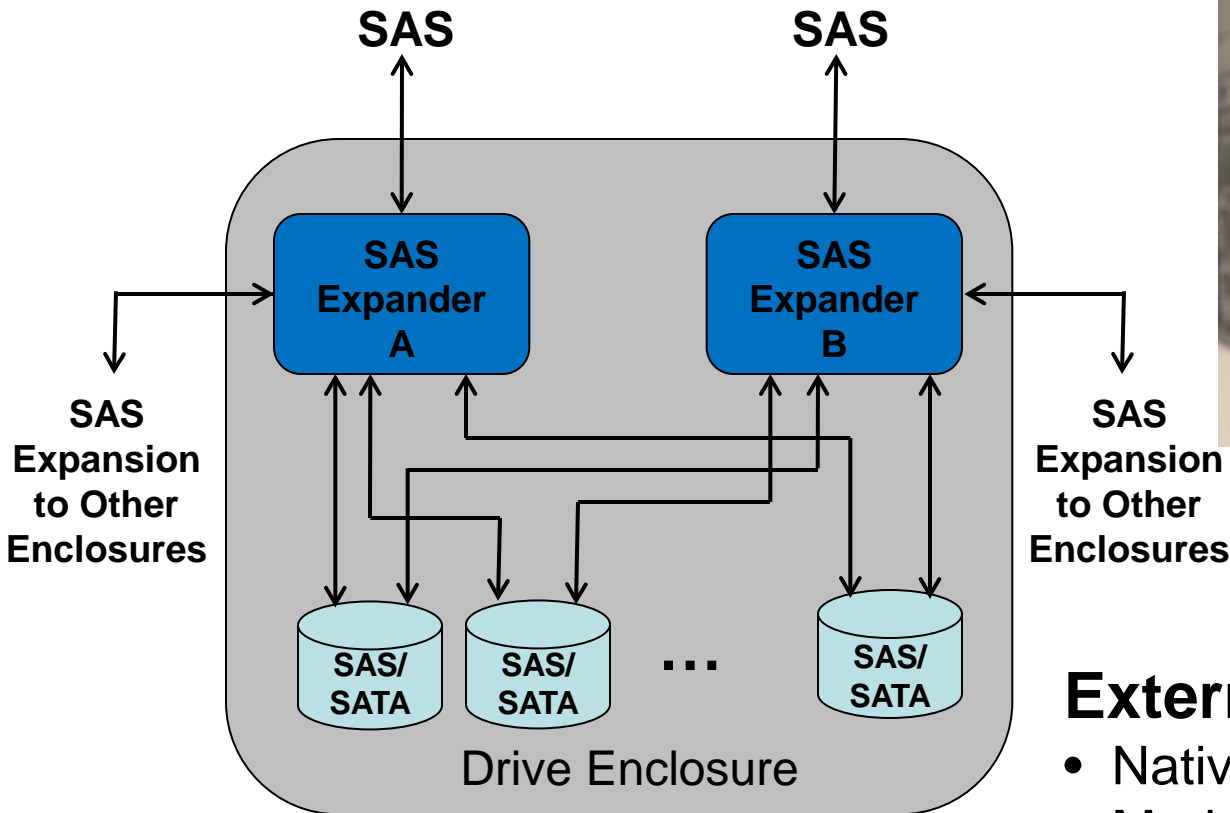


Extended DAS

- Pay-as-you-grow
- High Capacity



Scalability in External Storage Architectures



External Storage:

- Native High-Availability
- Modular
- Simplified, Robust Cabling
- Scales to 1000s of Devices

Protocols Compared

	x1 24G SAS	x1 NVMe (Gen4)	x4 NVMe (Gen4)
Performance (Bandwidth)	19.2 Gb/s	15.8 Gb/s	63.0 Gb/s
Performance (Read Latency*)	15.9us	15.7us	11.3us
Scalability	1000's of Devices	10's of Devices	10's of Devices
Power	9W	9W	25W
Flexibility	12G SAS HDD&SSD 6G SAS/SATA HDD&SSD	NVMe Gen4 SSDs, NVMe Gen3 SSDs	NVMe Gen4 SSDs, NVMe Gen3 SSDs
Manageability	SES-2, SMP	To Be Developed	To Be Developed
Availability	Native Dual Port	Unproven	Unproven
Channel Length	19" FR4, 6m Cu Cable, 300m AOC	4" FR4, Cu Cable TBD	4" FR4, Cu Cable TBD

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

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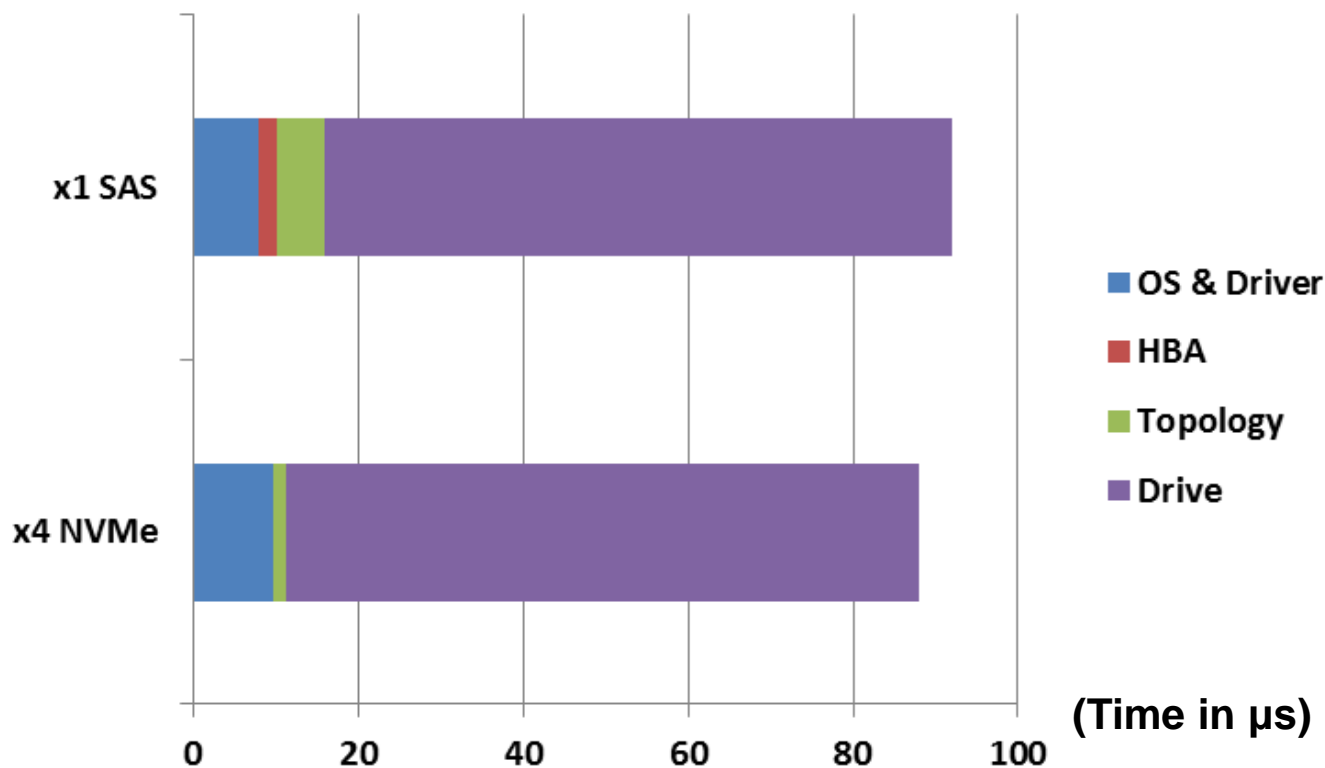
Bandwidth by the Numbers

	SATA	x1 PCIe	x1 SAS	x2 PCIe	x2 SAS MultiLink SAS™	x4 PCIe	x4 SAS MultiLink SAS™
No. of Links / Lanes	1	1	1	2	2	4	4
Transfer Rate per Link/Lane	Half-duplex 6 Gb/s	Full-duplex 8 Gb/s	Full-duplex 12 Gb/s	Full-duplex 8 Gb/s	Full-duplex 12 Gb/s	Full-duplex 8 Gb/s	Full-duplex 12 Gb/s
Max Bandwidth	0.6 GB/s	2.0 GB/s	2.4 GB/s	4.0 GB/s	4.8 GB/s	8.0 GB/s	9.6 GB/s

**SAS Supplies 20% More bandwidth
Per Lane**

4k Random Read Latency

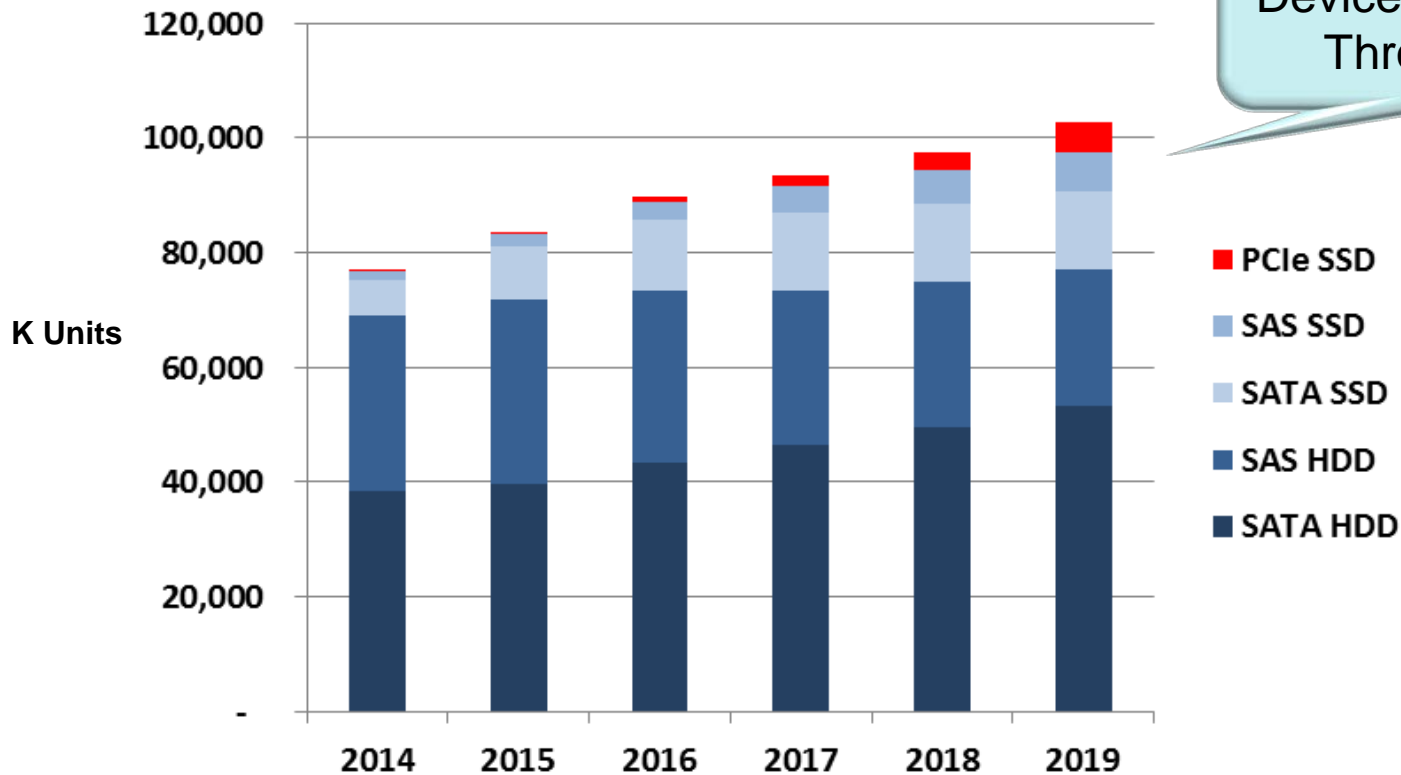
QD1



Read Latencies Dominated by NAND Latencies (and will continue to increase)

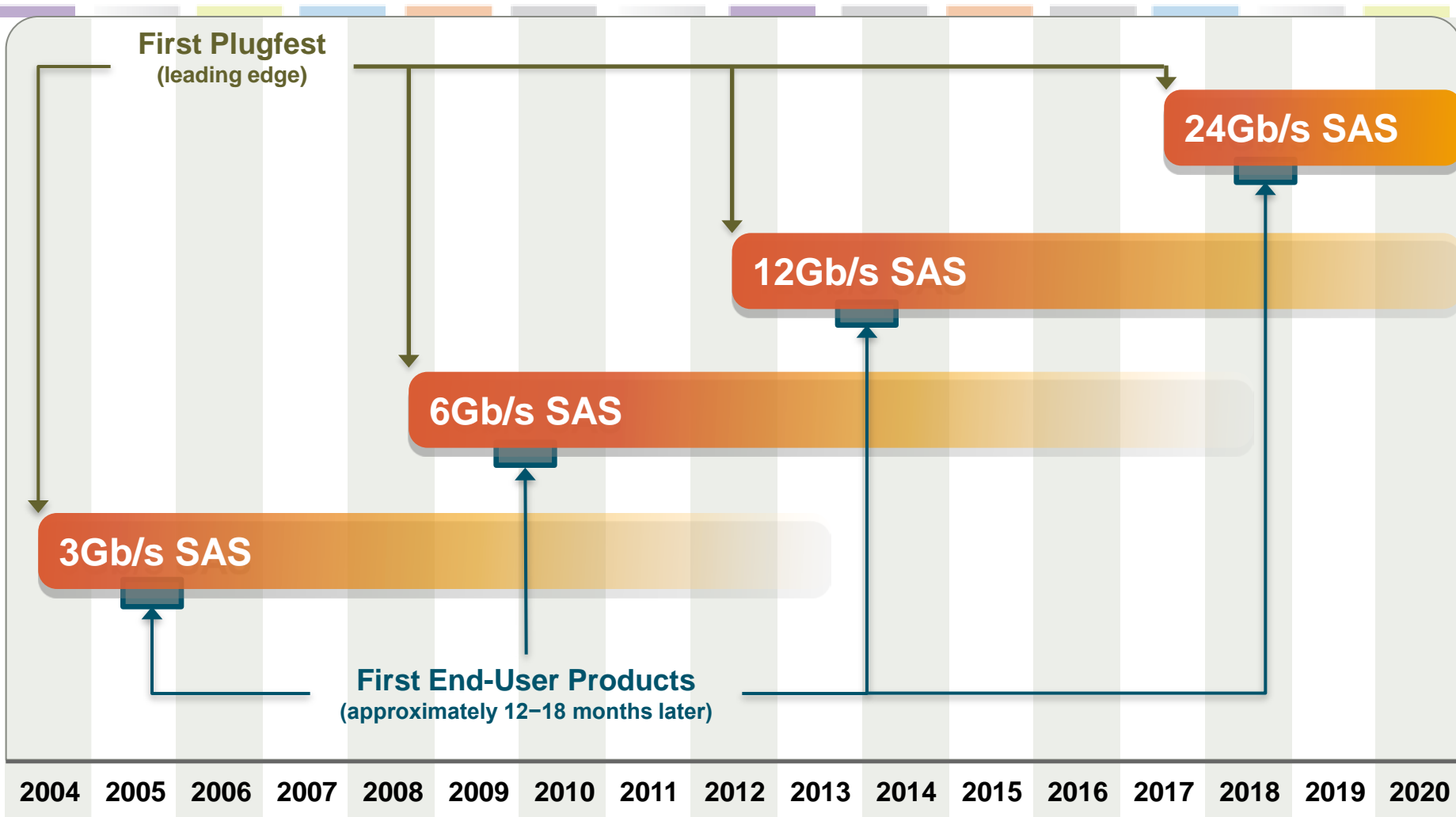
Enterprise Unit Shipments

SAS Attached
Devices Grow at 5%
Through 2019



**95% of All Enterprise Shipments in 2019
Require SAS Infrastructure**

SAS Technology Roadmap



Source: SCSI Trade Association – Aug 2015

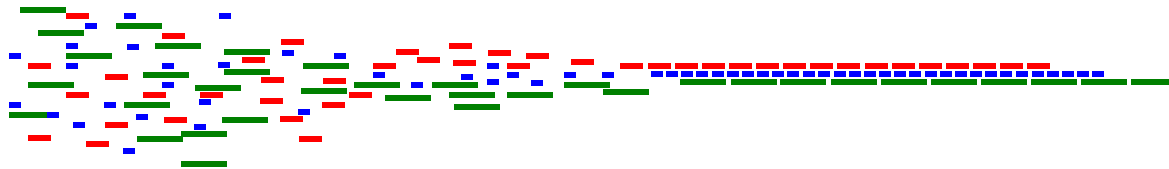
Recent Innovations in SAS

- Storage Intelligence
- Persistent Connections
- Enhanced Power Control
- Shingled Magnetic Recording Support

**Recent SAS Innovations - the Focus
of the May SAS Plugfest**

➤ Streams

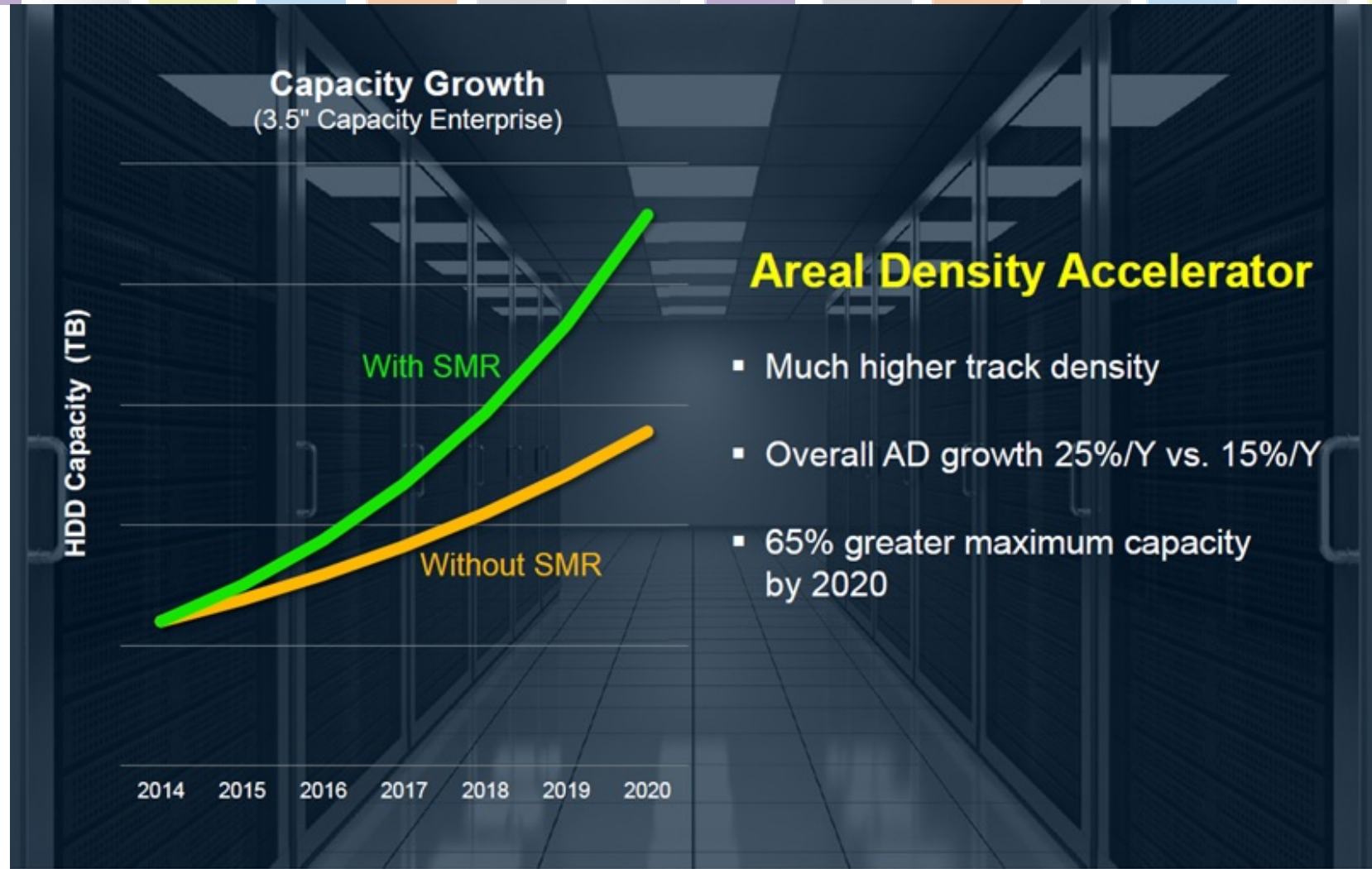
- ◆ Provides hints to SSD about data sets that have similar expected lifetimes
- ◆ Reduces intermixing of data from different applications, thus reducing fragmentation during garbage collection
- ◆ Improves performance
- ◆ Reduces write amplification and improves endurance



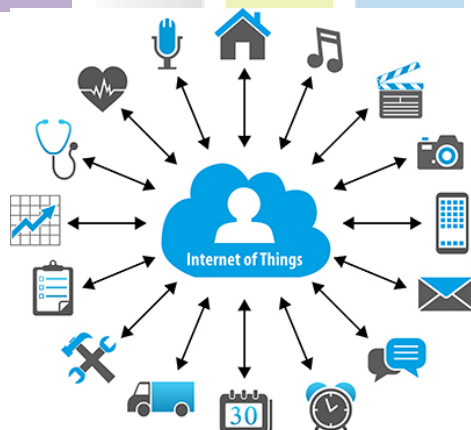
➤ Background Activity Control

- ◆ Provides hints to SSD to optimize timing of background activities (e.g., garbage collection)
- ◆ Provides more consistent performance during peak activity times

Why Shingled Magnetic Recording?



The Need for Speed



**Estimated 50B
Connected Devices
in 2020**

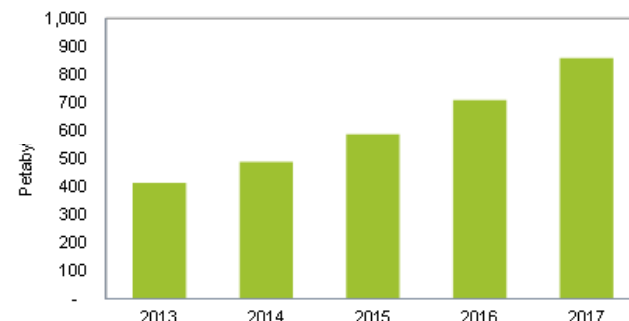


**400 Hours of Video Uploaded
Per Minute, Nov. 2015**



**DoD Drones Capable of
Capturing 430 PB/Day**

Global Forecast of Data Generated Daily by Surveillance Cameras Shipped in a Year (in Petabytes)



Source: IHS Inc. October 2013

**Surveillance Cameras Capture
859 PB/Day in 2017**

24Gb/s SAS Objectives

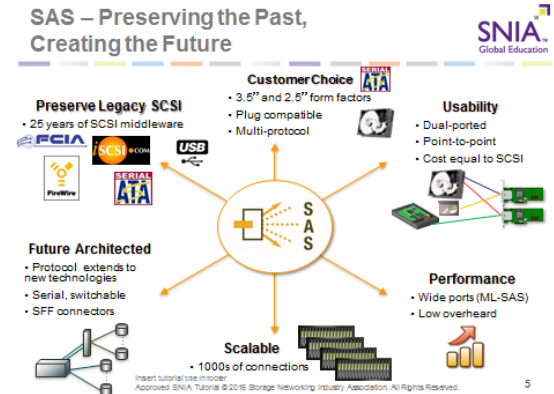
- Double the Effective Bandwidth of 12Gb/s SAS
- Backwards Compatibility
 - ◆ Support for two generations of backward compatibility
 - ◆ Leverage existing ecosystem (tools, test equipment)
- Preserve the Existing SAS Value Proposition
 - ◆ **Reliability** – Robust error handling
 - ◆ **Scalability** – Scalable to 1,000s of devices
 - ◆ **Flexibility** – SAS infrastructure supports SAS and SATA devices
 - ◆ **Serviceability** – Surprise add/remove media and cables
 - ◆ **Manageability** – Storage management built into the standard
- Align with a 2019 Platform Launch



Key Messages

❖ Flexibility of SAS is Unparalleled

- ◆ Media flexibility
- ◆ Scalability
- ◆ System architectures



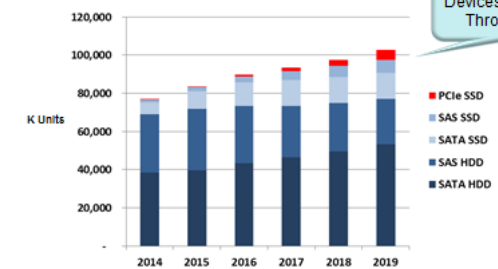
❖ SAS Technology Addresses a Very Large, Growing Market

❖ SAS Continues to Evolve

- ◆ Performance
- ◆ Features



Enterprise Unit Shipments



95% of All Enterprise Shipments in 2019 Require SAS Infrastructure

SAS Attached Devices Grow at 5% Through 2019

Source: TRENDFOCUS, Jan 2016

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