



# Next Generation Storage Networking for Next Generation Data Centers

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- **About Demartek**
- **Increased Bandwidth Needs for Storage**
- **Storage Interface Technology & Futures**
  - ◆ **Ethernet, Fibre Channel, SAS, Thunderbolt, USB**
- **Cabling – Fiber Optic and Copper**
- **Performance Results**
- **Demartek Free Resources**

# Demartek Video



Click to view this one minute video  
(available in 720p and 1080p)

**Demartek YouTube Channel:**

<http://www.youtube.com/user/Demartek/videos>

- **Industry Analysis and ISO 17025 accredited test lab**
- **Lab includes servers, networking & storage**
  - ◆ **Fibre Channel: 4, 8 & 16 Gbps**
  - ◆ **Ethernet: 1, 10 & 40 Gbps: NFS, SMB (CIFS), iSCSI, FCoE and SR-IOV**
  - ◆ **Servers 8+ cores, large RAM**
  - ◆ **Virtualization: VMware, Hyper-V, Xen**
- **We prefer to run real-world applications to test servers and storage solutions**
- **Website: [www.demartek.com](http://www.demartek.com)**

# The Need for More Bandwidth

## ► Server and Application Growth

### ► Server Virtualization

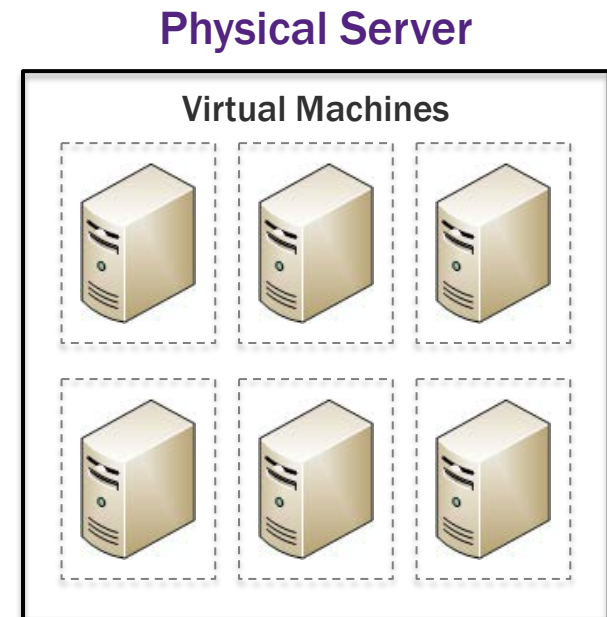
- ◆ How many VMs per physical server do you deploy?
- ◆ Compare the number of VMs today vs. one and two years ago

### ► Application Growth

- ◆ Applications processing more data today

### ► Bootstorm test with 90 VMs in one physical server

[http://www.demartek.com/Demartek\\_Analysis\\_of\\_VDI\\_Storage\\_Performance\\_during\\_Bootstorm.html](http://www.demartek.com/Demartek_Analysis_of_VDI_Storage_Performance_during_Bootstorm.html)



# The Need for More Bandwidth

## ► New Hardware

## ► New Generations of Servers




- ◆ **PCI Express 3.0 since 2012**
  - › **Up to 40 PCIe lanes per processor**
- ◆ **New servers support 10GbE on the motherboard**
- ◆ **More cores per processor**
- ◆ **Larger memory support (up to 1.5TB/processor)**

## ► SSD

- ◆ **Are you deploying enterprise SSDs today?**

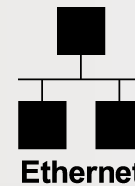
- **Bus used in modern computers for I/O adapters**
- **Measured in gigatransfers/second (GT/s)**
  - ◆ Bandwidth specified by indicating number of lanes such as “x1”, “x2”, etc., and generally spoken as “by 1”, “by 2”, etc.
- **PCIe 4.0 – In November 2011, the PCI-SIG announced the approval of 16 gigatransfers per second as the bit rate for the next generation of PCIe architecture, known as PCIe 4.0. Final specifications are expected in 2015.**

 Demartek	GT/s	Encoding	x1	x2	x4	x8	x16
<b>PCIe 1.x</b>	2.5	8b/10b	250 MB/s	500 MB/s	1 GB/s	2 GB/s	4 GB/s
<b>PCIe 2.x</b>	5	8b/10b	500 MB/s	1 GB/s	2 GB/s	4 GB/s	8 GB/s
<b>PCIe 3.x</b>	8	128b/130b	1 GB/s	2 GB/s	4 GB/s	8 GB/s	16 GB/s

\* This table available at [http://www.demartek.com/Demartek\\_Interface\\_Comparison.html](http://www.demartek.com/Demartek_Interface_Comparison.html)

# Ethernet

## ▶ 1GigE and 10GigE



### ◆ 1GigE

- ◆ Not unusual to have 4, 6 or 8 NIC ports in a server
  - › Consider the number of cables and PCIe slots used
- ◆ Can be quad-port, dual-port or single-port

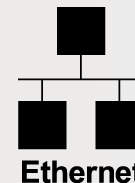
### ◆ 10GigE

- ◆ A dual-port 10GigE NIC provides bandwidth and failover
- ◆ Good choice for 1U servers that have few I/O slots
- ◆ Slot requirements
  - › Dual-port 10GigE NIC – PCIe 3.0 x4 or PCIe 2.0 x8
  - › Single-port 10GigE NIC – PCIe 2.0 x4 or PCIe 1.0 x8



# Ethernet

## ► 40GigE and 100GigE



- ◆ **IEEE 802.3ba (40GigE & 100GigE) ratified June 2010**
- ◆ **The fastest Ethernet cables and connectors today are 10 Gbps per lane or channel**
- ◆ **Higher speeds today are achieved by bundling**
  - ◆ 40GigE today = 4 x 10 Gbps together
  - ◆ 100GigE today = 10 x 10 Gbps together
- ◆ **25 Gbps connectors will soon be available**
  - ◆ These connectors support up to 28 Gbps (“25/28G”)
  - ◆ 100GigE (future) = 4 x 25 Gbps together
  - ◆ 250GigE (future) = 10 x 25 Gbps together
  - ◆ End-user products possibly available in 2014 or 2015
- ◆ **40 Gbps NICs require PCIe 3.0 x8 or x16 slot in the server**

# Fibre Channel

## ▶ 16 Gigabit (16GFC)



- **16GFC is backward compatible with 4GFC & 8GFC**
- **Uses 14 Gbps single-lane connectors**
  - ◆ Doubles speed of 8GFC due to newer 64b/66b encoding
- **First 16GFC switches and HBAs shipped in 2011**
  - ◆ Some of these HBAs can function as 10 Gb NICs
- **FC speeds and server slot requirements (dual-port)**
  - ◆ 4 Gb: PCI-X 2.0, PCIe 1.0
  - ◆ 8 Gb: PCIe 2.0 x4 or PCIe 1.0 x8
  - ◆ 16 Gb: PCIe 3.0 x4 or PCIe 2.0 x8

\* This information available at [http://www.demartek.com/Demartek\\_Interface\\_Comparison.html](http://www.demartek.com/Demartek_Interface_Comparison.html)

# Fibre Channel



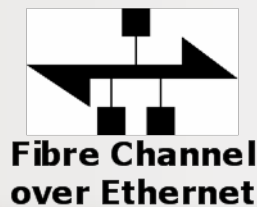
Fibre Channel



## ▶ 32 Gigabit and 128 Gigabit (“Generation 6”)

- ▶ **In February 2014, “Gen 6” Fibre Channel was announced**
- ▶ **32 Gbps single-lane connection (“32GFC”)**
  - ◆ OM4 fiber-optic expected cable distance: 100m
- ▶ **128 Gbps parallel connection (4 x 32, “128GFCp”)**
  - ◆ Initially used for switch-to-switch connections
- ▶ **Forward Error Correction (FEC)**
- ▶ **Energy Efficiency**
  - ◆ Power at transceiver is reduced when not in use (“dimmer switch”)
- ▶ **Backward Compatible with 16GFC and 8GFC**
- ▶ **Products expected to be available in 2016**

# Converged Networks



- **Combined LAN and SAN networks**
  - ◆ Lossless features of Fibre Channel with ubiquity of Ethernet
- **Data Center Bridging (DCB)**
  - ◆ Enhanced Ethernet to support FC storage traffic and more
- **FCoE – Fibre Channel over Ethernet**
  - ◆ First major application for DCB – runs FC at 10 Gbps
- **CNA – Converged Network Adapter**
  - ◆ Supports 10 Gb Ethernet and 10 Gb FCoE at the same time on the same cable

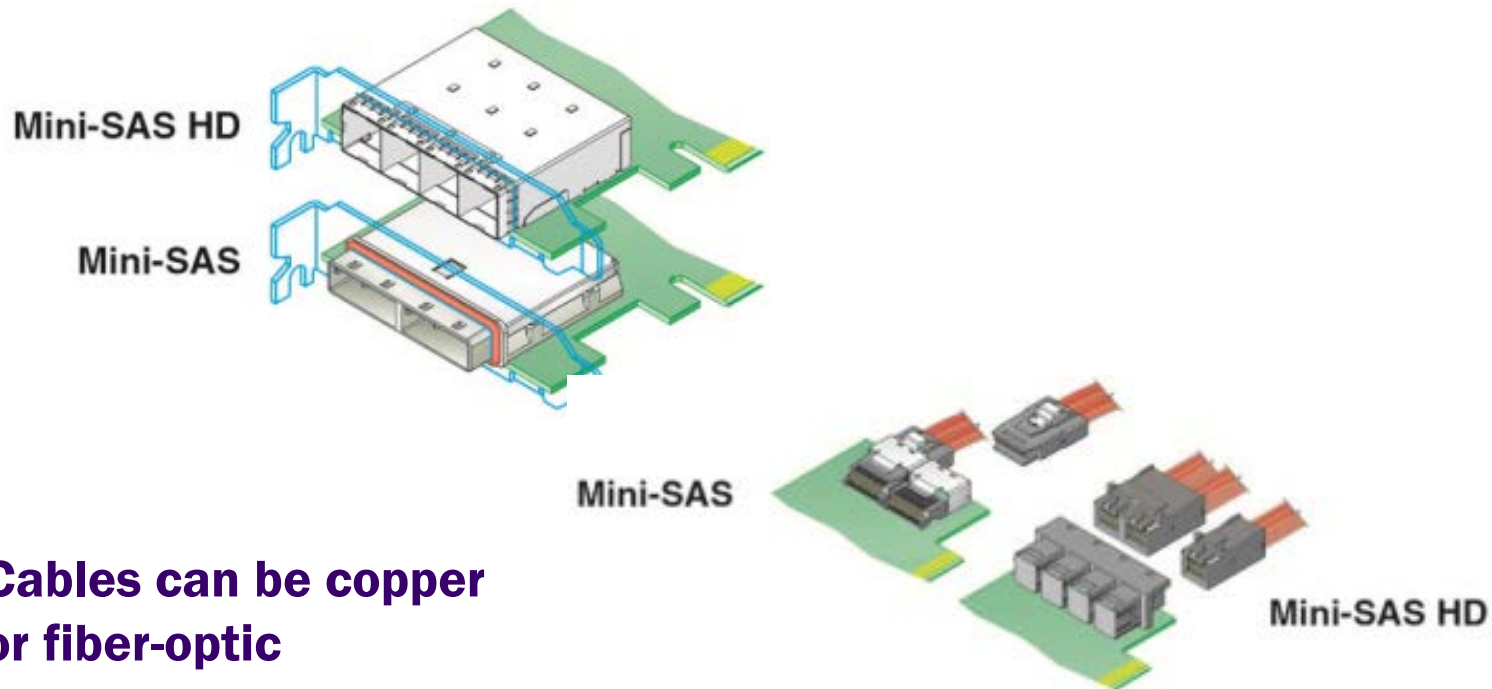
# SAS - Serial Attached SCSI



- **12Gb/s SAS also known as SAS3**
- **12Gb/s began shipping in 2H 2013**
  - ◆ SAS HBAs and RAID controllers
  - ◆ Drives – SSDs and some HDDs
  - ◆ Some external storage arrays
- **Volume production ramp-up expected in 2014**
- **For best results use servers that support PCIe 3.0**
  - ◆ PCIe 3.0 x8 for typical 12Gb/s SAS adapter
- **12Gb/s SAS uses mini-SAS HD connectors**

# SAS

## ▶ Mini-SAS HD connectors



- ▶ Cables can be copper or fiber-optic
- ▶ See larger versions of these diagrams and information for other storage interfaces on the Demartek Storage Interface Comparison page: [http://www.demartek.com/Demartek\\_Interface\\_Comparison.html](http://www.demartek.com/Demartek_Interface_Comparison.html)

- ◆ **Doubles previous speed to 20 Gbps**
- ◆ **Target audience is media creators and editors who use premium laptops, desktops, workstations and peripherals that connect to them.**
  - ◆ Includes storage devices, especially SSDs
- ◆ **Currently limited to six (6) devices on one connection**
  - ◆ Devices can be daisy-chained
- ◆ **Available on motherboards now**
  - ◆ Add-in cards becoming available
- ◆ **Thunderbolt will support NVMe**
- ◆ **Expect more activity during 2014 and 2015**



Thunderbolt and the Thunderbolt logo are trademarks of Intel Corporation in the U.S. and/or other countries

# USB 3.1



## ➤ **USB 3.1 specification completed July 2013**

- ◆ Doubles speed to **10 Gbps** (USB 3.0 is rated for 5 Gbps)
- ◆ Works with existing USB 3.0 and 2.0 products

## ➤ **USB 3.1 Power Delivery**

- ◆ Can deliver up to 100 watts, bi-directionally
- ◆ Can deliver audio/video, data and power concurrently

## ➤ **Media Agnostic USB protocol**

- ◆ Allows wireless devices and docking stations to communicate using the USB protocol

## ➤ **New USB Type-C bi-directional connector**

- ◆ Similar in size to existing USB 2.0 micro-B

## ➤ **Products expected by end of year 2014**



# USB 3.1 Type-C Connector



## ◆ Entirely New Design

- ◆ Tailored for emerging product designs
- ◆ Robust enough for laptops and tablets; slim enough for mobile phones

## ◆ New Smaller Size

- ◆ Similar to size of USB 2.0 Micro-B
- ◆ Listen for the “click”

## ◆ Reversible plug orientation & cable direction

## ◆ Supports scalable power charging

## ◆ Designed to establish future USB performance needs

## ◆ Type-C Connector Specification anticipated to be published in July 2014

# USB 3.1 Type-C Connector



*Artist renderings courtesy of Foxconn, final design subject to change*

# NVM Express (NVMe)




- ◆ **Scalable host controller interface designed for enterprise and client systems that use PCI Express SSDs**
- ◆ **Designed with Flash memory and technologies coming after Flash memory in mind (non-volatile memory)**
- ◆ **Much faster (lower latency) software stack than existing storage stacks such as SAS and SATA**
- ◆ **In-box drivers for Windows and Linux now, others planned**
- ◆ **Expect SSD product announcements in 2014 and 2015**
  - ◆ **First shipping product available late March 2014**
- ◆ **Additional comments and explanation:**  
[http://www.demartek.com/Demartek\\_Comments\\_IDF2013\\_and\\_NVMe.html](http://www.demartek.com/Demartek_Comments_IDF2013_and_NVMe.html)

# Cabling Recommendations

## ► Fiber Optic Cables

- **Fiber optic cabling service life: 15 – 20 years**
- **Recommendation: OM4 cables for current & future**
  - ◆ **OM4 will support 40/100 GigE and 32GFC**

 <b>Demartek</b>	<b>OM1</b>	<b>OM2</b>	<b>OM3</b>	<b>OM4</b>
<b>Jacket color</b>	Orange	Orange	Aqua	Aqua
<b>1 Gb/s</b>	300m	500m	860m	–
<b>2 Gb/s</b>	150m	300m	500m	–
<b>4 Gb/s</b>	70m	150m	380m	400m
<b>8 Gb/s</b>	21m	50m	150m	190m
<b>10 Gb/s</b>	33m	82m	Up to 300m	Up to 400m
<b>16 Gb/s</b>	15m	35m	100m	125m

\* This table available at [http://www.demartek.com/Demartek\\_Interface\\_Comparison.html](http://www.demartek.com/Demartek_Interface_Comparison.html)

# Cabling Recommendations

## ► Copper Cables

### ◆ 10 GigE – SFP+ Copper

- ◆ SFP+ copper cables are known as Direct Attach Copper (DAC)
- ◆ SFP+ “transceiver” is directly attached to the cable
- ◆ Common lengths of 10 GigE DAC are 3 and 5 meters

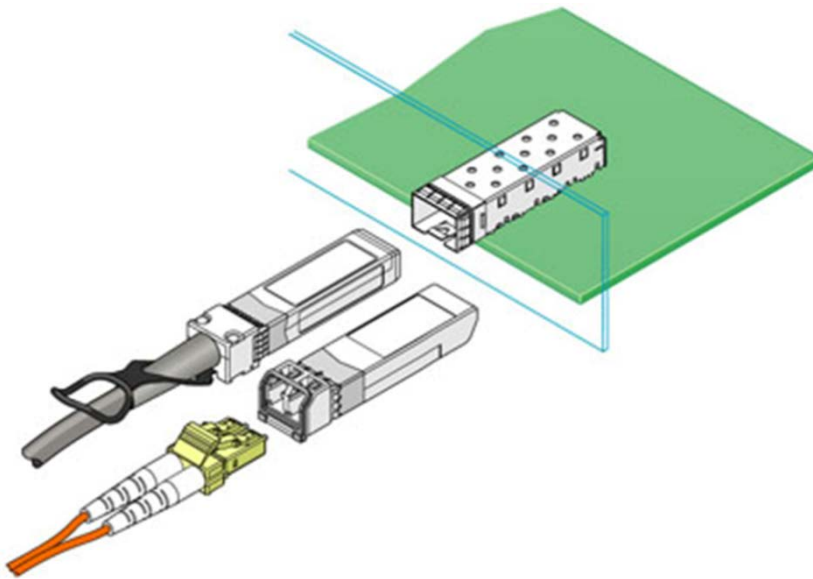
### ◆ 10 GigE – RJ45 / 10GBASE-T

- ◆ Cables must be certified to at least 500MHz to ensure 10GBASE-T compliance
- ◆ *Recommendation* – Cat6a & Cat7 up to 100 meters
- ◆ Cat6 can be used up to 55 meters, but should be tested first
- ◆ Cat5e is not recommended for 10 GigE

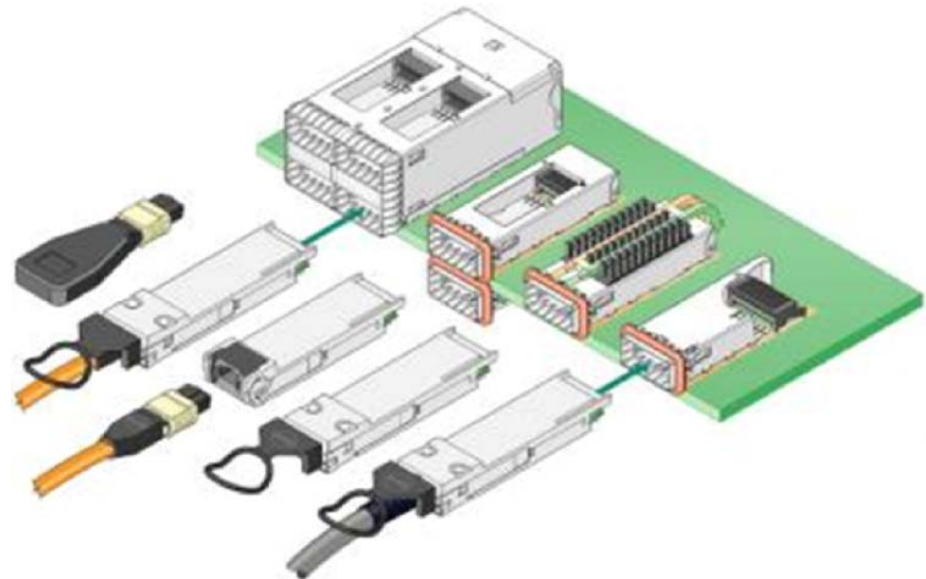
- ◆ **As interface speeds increase, expect increased usage of fiber-optic cables and connectors for most interfaces**
  - ◆ **At higher Gigabit speeds, passive copper cables and interconnects experience “amplitude loss” and become too “noisy” except for short distances (within a rack or to adjacent racks)**
  - ◆ **Expect to see “active copper” for some higher-speed connection types**
    - › **Active copper can go longer distances than passive copper**
    - › **Active copper is thinner allows for better airflow than passive copper**
    - › **Active copper uses more power than passive copper**


# Connectors

## Single-lane – SFP, SFP+



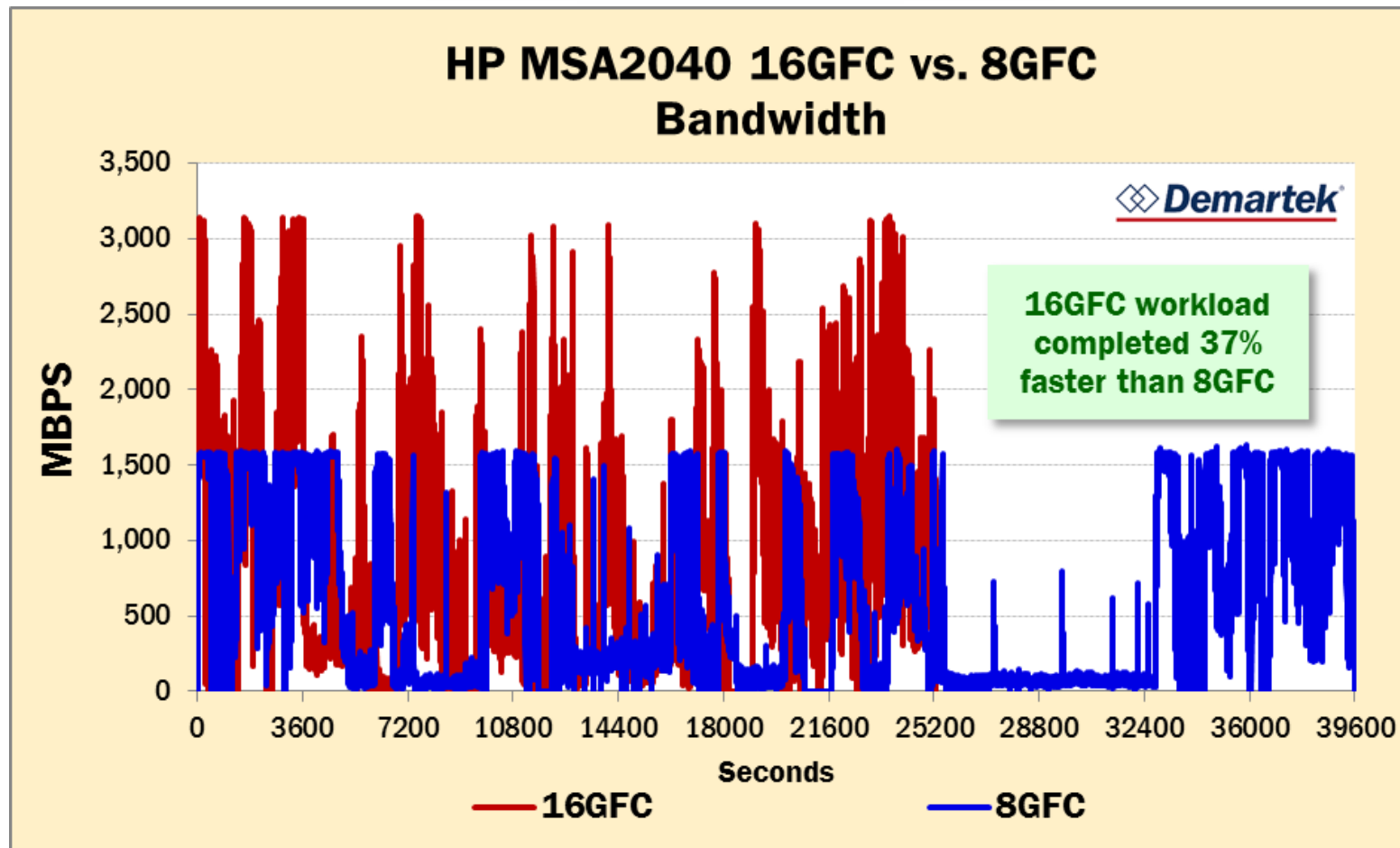
## Four-lane – QSFP, QSFP+



 <b>Demartek</b>	<b>SFP</b>	<b>SFP+</b>	<b>QSFP+</b>
<b>Ethernet</b>	1GbE	10GbE	40GbE
<b>Fibre Channel</b>	1GFC, 2GFC, 4GFC	8GFC, 16GFC	–
<b>Infiniband</b>	–	–	QDR, FDR

# Performance Example: 16GFC vs 8GFC

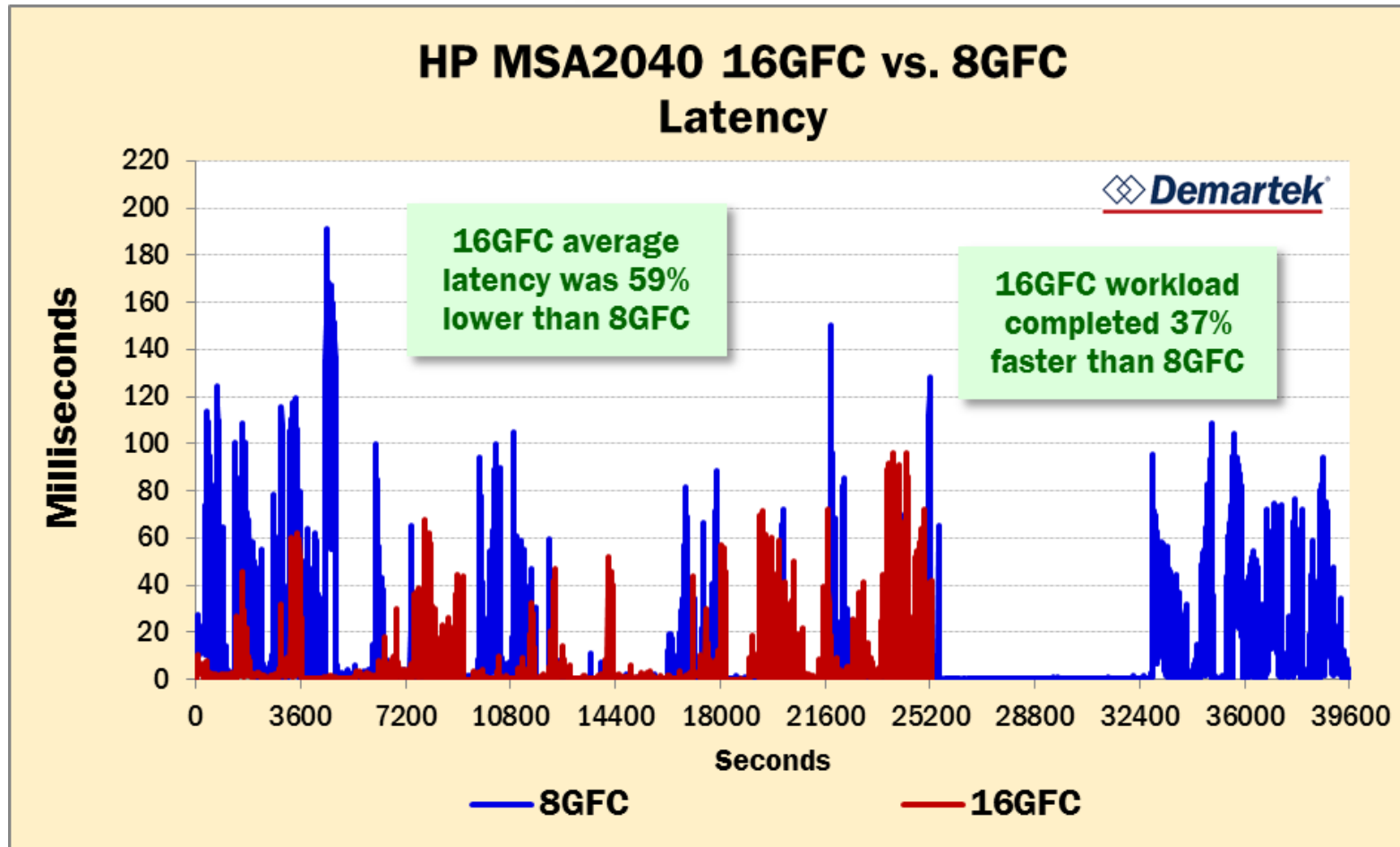
► Bandwidth – SQL Server data warehousing workload





# Performance Example: 16GFC vs 8GFC

► Latency – SQL Server data warehousing workload



# Demartek Free Resources

- ◆ Demartek comments on CES 2014 (USB & Thunderbolt)  
[www.demartek.com/Demartek\\_CES\\_2014.html](http://www.demartek.com/Demartek_CES_2014.html)
- ◆ Demartek comments on IDF2013 & NVMe  
[www.demartek.com/Demartek\\_Comments\\_IDF2013\\_and\\_NVMe.html](http://www.demartek.com/Demartek_Comments_IDF2013_and_NVMe.html)
- ◆ Demartek SSD Deployment Guide  
[www.demartek.com/Demartek\\_SSD\\_Deployment\\_Guide.html](http://www.demartek.com/Demartek_SSD_Deployment_Guide.html)
- ◆ Demartek Video Library -  
[http://www.demartek.com/Demartek\\_Video\\_Library.html](http://www.demartek.com/Demartek_Video_Library.html)
- ◆ Demartek FC Zone - [www.demartek.com/FC](http://www.demartek.com/FC)
- ◆ Demartek iSCSI Zone - [www.demartek.com/iSCSI](http://www.demartek.com/iSCSI)
- ◆ Demartek SSD Zone - [www.demartek.com/SSD](http://www.demartek.com/SSD)

Performance reports,  
Deployment Guides and  
commentary available  
for free download.

# Demartek Storage Interface Comparison



## Contents

- ◆ Acronyms
- ◆ Storage Networking Interface Comparison Table
- ◆ Transfer Rate, Bits vs. Bytes, and Encoding Schemes
- ◆ History
- ◆ Roadmaps
- ◆ Cables: Fiber Optics and Copper
- ◆ Connector Types
- ◆ PCI Express® (PCIe®)

- ◆ Downloadable interactive PDF version now available.
- ◆ [www.demartek.com/Demartek\\_Interface\\_Comparison.html](http://www.demartek.com/Demartek_Interface_Comparison.html)
- ◆ Or search for “storage interface comparison” in your favorite search engine.

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# Thank You!

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  - ◆ View image below with viewfinder.



\*also on the back of Dennis' business card