Fibre Channel Outlook 2021 and Beyond

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About the Presenters

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FCIA Board of Directors

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About the Fibre Channel Industry Association (FCIA)

25+ Years
Promoting Fibre Channel Technology

Industry Leading
Member Companies

142M+ FC Ports
Shipped Since 2001

Key Tenets of Fibre Channel

- Purpose-built as network fabric for storage and standardized in 1994, Fibre Channel (FC) is a complete networking solution, defining both the physical network infrastructure and the data transport protocols. Features include:
  - **Lossless, congestion free systems**—A credit-based flow control system ensures delivery of data as fast as the destination buffer can receive, without dropping frames or losing data.
  - **Multiple upper-layer protocols**—Fibre Channel is transparent and autonomous to the protocol mapped over it, including SCSI, TCP/IP, ESCON, and NVMe.
  - **Multiple topologies**—Fibre Channel supports point-to-point (2 ports) and switched fabric (224 ports) topologies.
  - **Multiple speeds**—Products are available supporting 8GFC, 16GFC, and 32GFC today.
  - **Security**—Communication can be protected with access controls (port binding, zoning, and LUN masking), authentication, and encryption.
  - **Resiliency**—Fibre Channel supports end-to-end and device-to-device flow control, multi-pathing, routing, and other features that provide load balancing, the ability to scale, self-healing, and rolling upgrades.

Agenda

- Fibre Channel Industry Overview – Mark Jones
- Market Landscape – Casey Quillin
- Fibre Channel Roadmap – Craig Carlson
- Automation & Orchestration – Rupin Mohan

Fibre Channel Industry Overview

Mark Jones

Fibre Channel: Timeline

Today
Gen7
64GFC

NVMe Fabrics
Fibre Channel

2015:
Gen6
32GFC

2012:
16GFC

Converged
Networks

2009: FCOE

Virtualization
NPIV

2008: 8Gb FC

2005: 4Gb FC

2001: 2Gb FC

Fabric
Services

1999: FCIA Formed

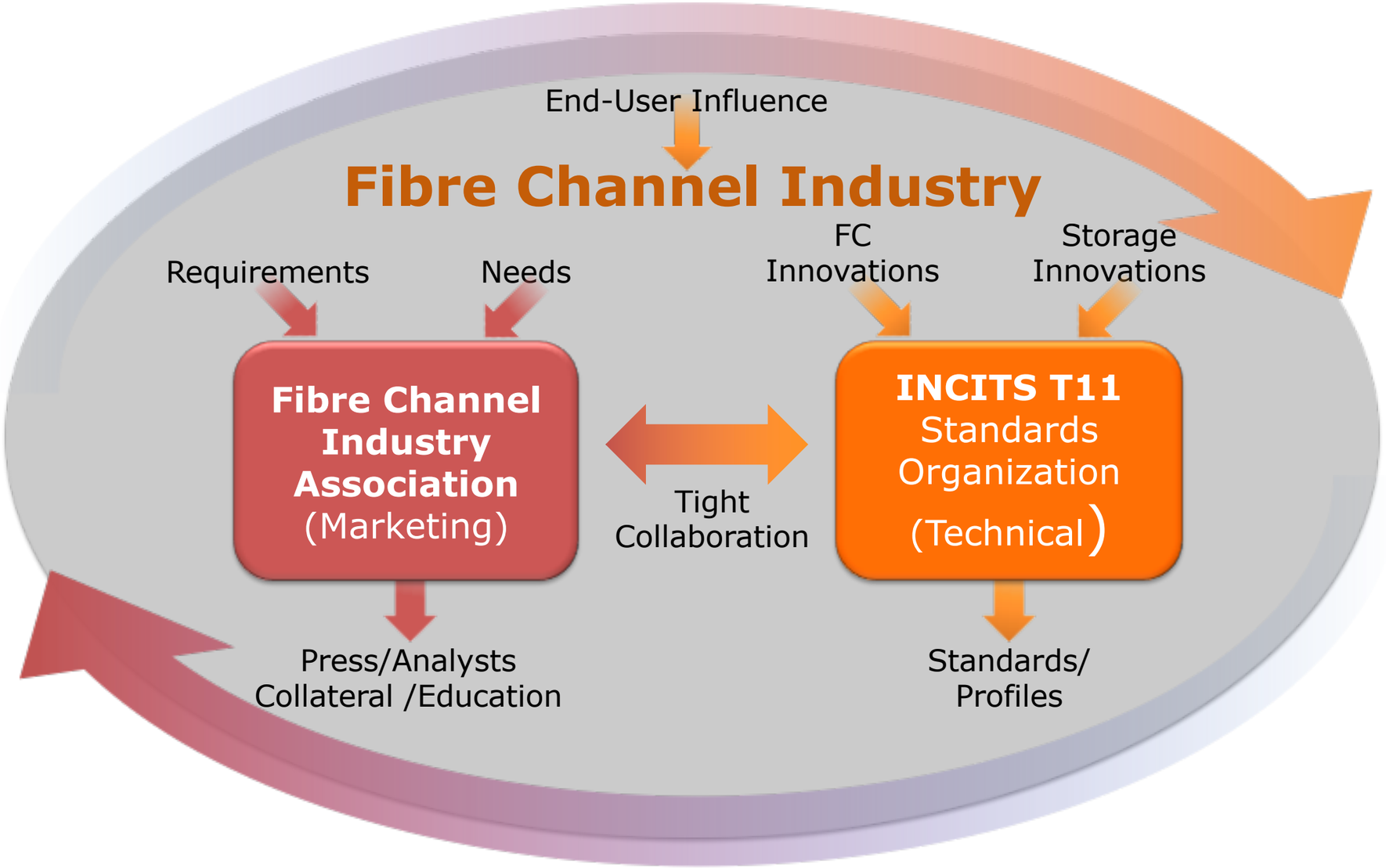
Arbitrated
Loop

1997: 1Gb FC

1994: FCA and FCLC
Formed

1988: Work begins
on FC protocol

How the FC Industry Innovates



In 2020 Fibre Channel is the Premier Storage Transport

- **FC is the most trusted transport for enterprise storage**
  - Nearly all datacenter class storage arrays sell with FC
- **FC is a premium offering**
  - Not the cheapest – you get what you pay for (Performance, Reliability, Data Safety)
  - Most tested and supported of storage transports
- **FC has a healthy ecosystem**
  - Strong T11 standards future development schedule – continuous innovation!
  - Strong participation from the leaders of datacenter technology
  - FCIA leadership for industry direction
- **FC has huge installed base of loyal customers**
  - Repeat customers over 25 years and seven generations of re-investment
  - 142M ports sold, 37M in use today!

NVMe® over Fibre Channel

- Strong Industry-wide development support
  - 2014 T11 began work on FC-NVMe
  - Industry milestones: Demos, Plugfests, first product shipments
  - 2020 FC-NVMe-2 complete
- 2020: FC - Leading Fully Supported NVMe-oF™ Transport Solution
  - FC-NVMe solutions shipping from all major FC component/array storage vendors
  - Support for all major operating systems
  - Significant application performance improvements over traditional SCSI
- Future of NVMe/FC
  - Continued performance improvements as OS's refine NVMe-oF transport
  - Broadened vendor and OS adoption
  - NVMe/FC to be springboard for future FC technology advancements: Stay tuned!

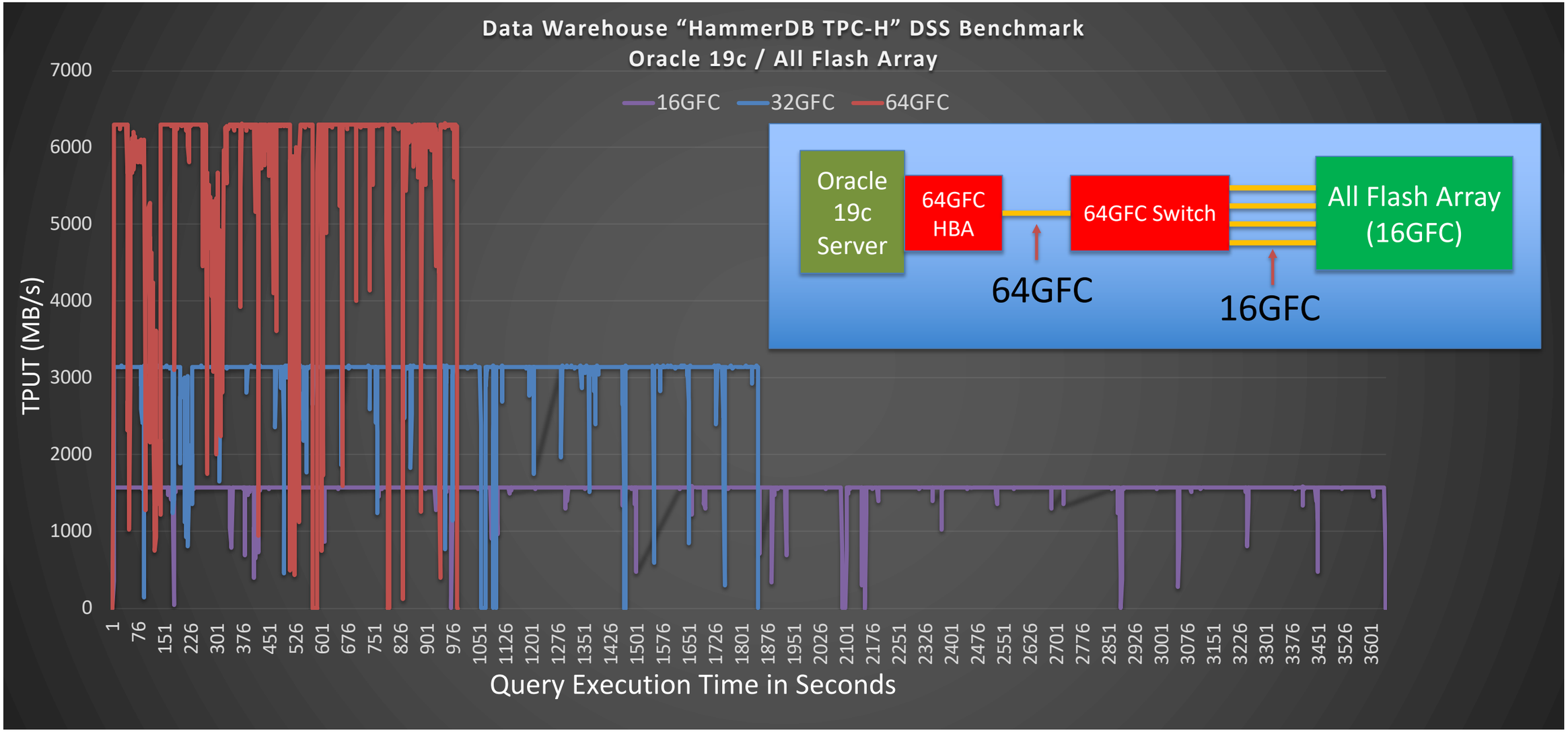
64GFC Gen7 Gets Real in 2021

2016 32GFC vs 2021 64GFC

	Users **The Need for Higher Performance Data Access**	**Servers** **The capacity to process and use the performance**	**Storage** **The ability for arrays to fulfill data requests at higher data rates**
2016 - 32GFC	• DB - Increase adoption of DB data warehousing • VM - Storage migration a new thing • VM - VDI fairly new	• PCIe gen 3 x8 = 2P 32G(6.6G) • Memory BW/density increase 150%	• All Flash arrays gaining traction - capable of high performance in modest config sizes
2021 – 64GFC	• WW Data grew by 4x • DB Data Warehousing to double in 5 years • DB – BI use exploding • DB – AI has increased DB Query exponentially • DB – IT Governance means regional replication of data	• PCIe gen 4 x8 = 2P 64G(13.2G) • Memory BW/density (1.6x more BW, 2.6x greater capacity)	• All Flash now commonplace • NVMe drives replacing SSDs • Cost of flash dropping • Performance of Flash increasing • SCM growth in server/storage

64GFC Accelerates Application Performance

Oracle DB Data Warehousing Query time/FC Link Speed



The Need for Fibre Channel Education

- **Changes in IT Education Trends:**
  - Fewer specialists – more generalists
  - Survey results*: 62% of new IT positions are being filled by generalists
  - Seasoned FC storage/SAN specialists are entering retirement age
- **FCIA Education Initiative**
  - Bi-monthly BrightTALK Expert webinars: https://www.brighttalk.com/channel/14967/
  - FCIA YouTube Channel: https://www.youtube.com/channel/UCeSb0O94Ot-RfZSDg2ykRBA
  - YouTube Playlists: Basics, Fibre Channel Expert Courses, FC-NVMe
  - www.Fibrechannel.org/fcia-blog

*ESG storage trend survey 62% of new IT positions are being filled by generalists

Market Landscape

Casey Quillin

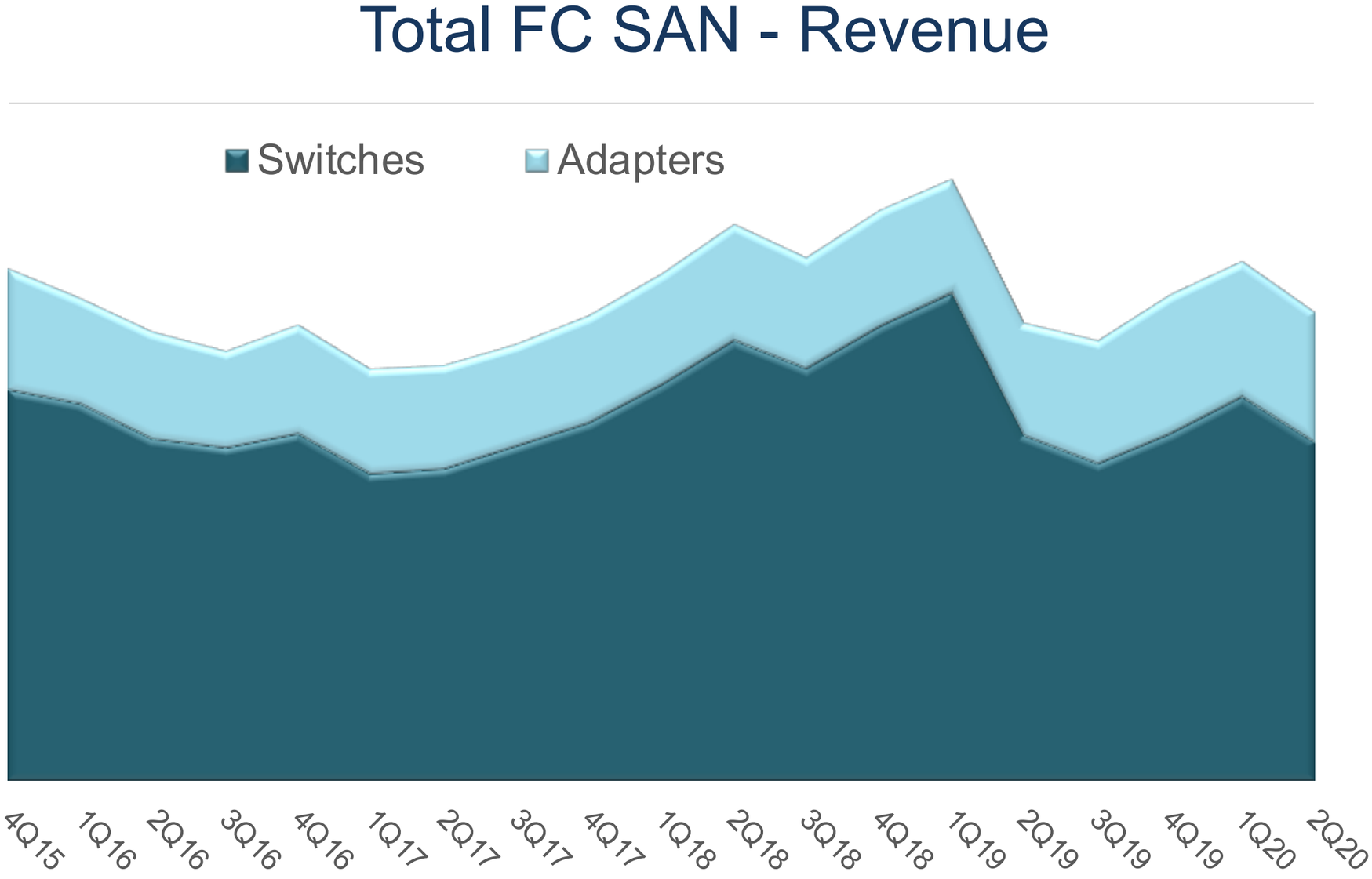
FC SAN MARKET

2Q20

Total SAN Market
+2% Y/Y

Adapter Revenue
+15% Y/Y

Switch Revenue
-2% Y/Y



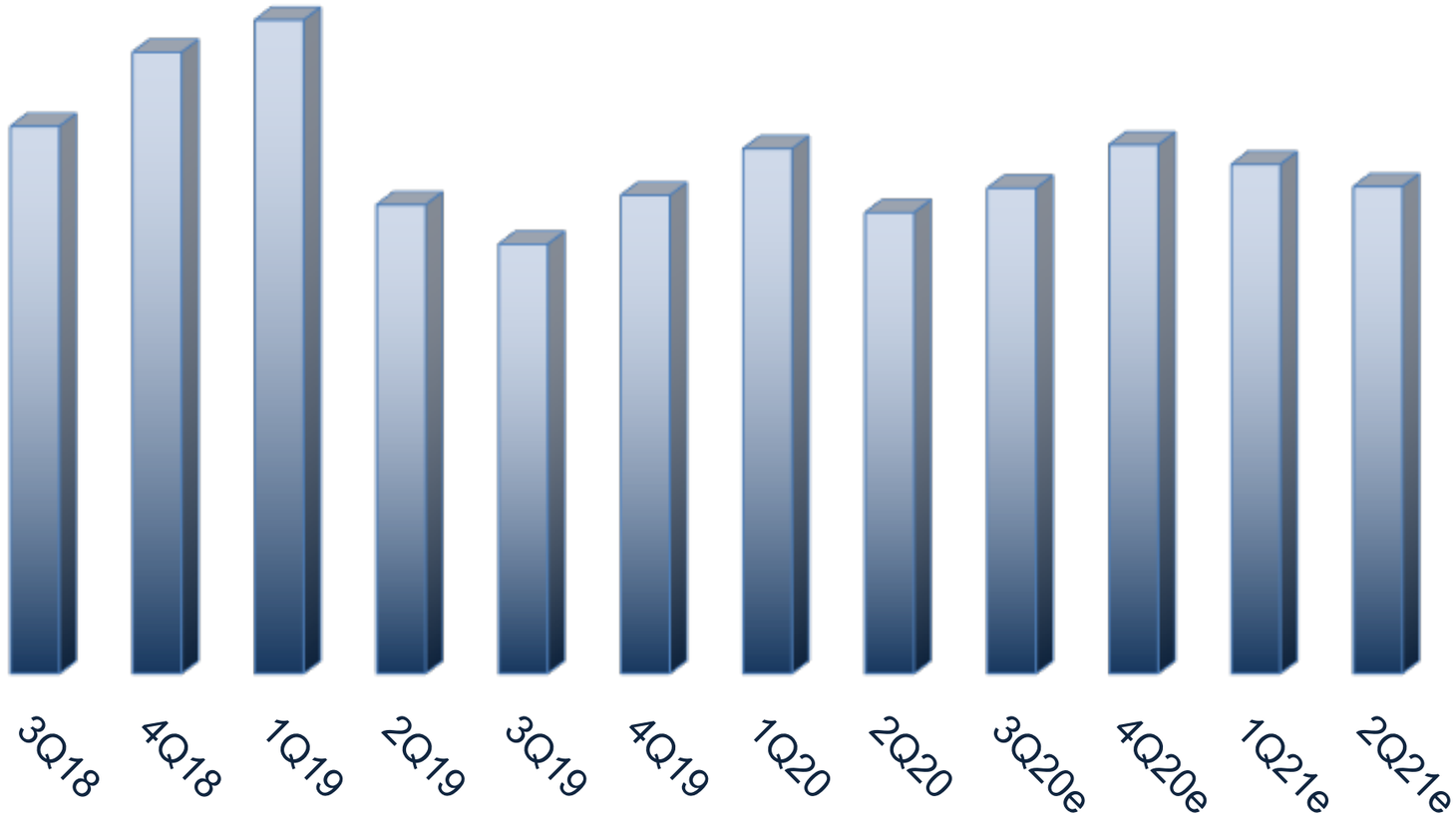
FC SAN MARKET

FC Switches – Port Shipments

<u>2Q20</u>

Port Shipments

Down low-single-digit Y/Y
Down low-double-digit Q/Q

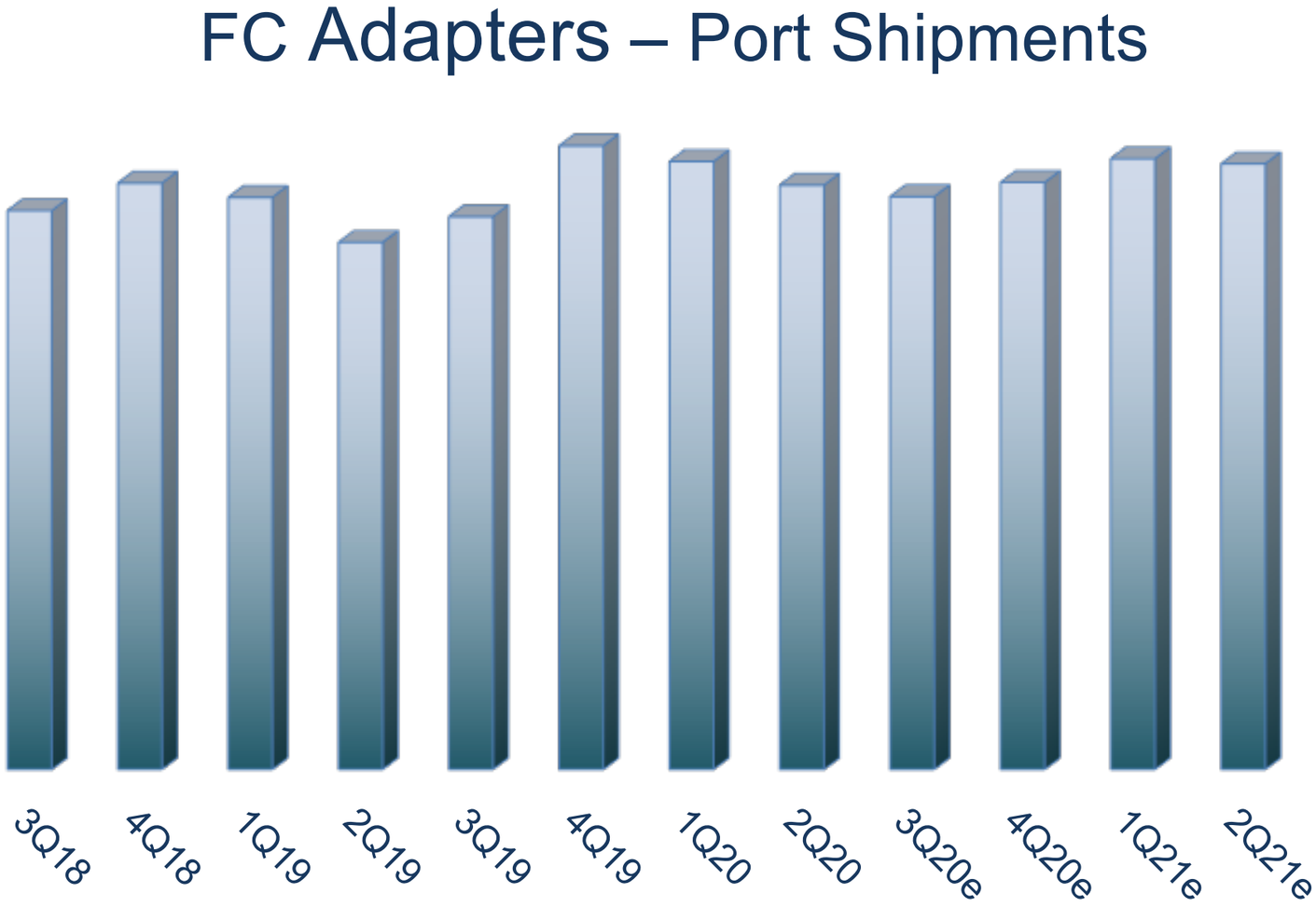


FC SAN MARKET

2Q20

Port Shipments

Up low-single-digit Y/Y
Down mid-single-digit Q/Q



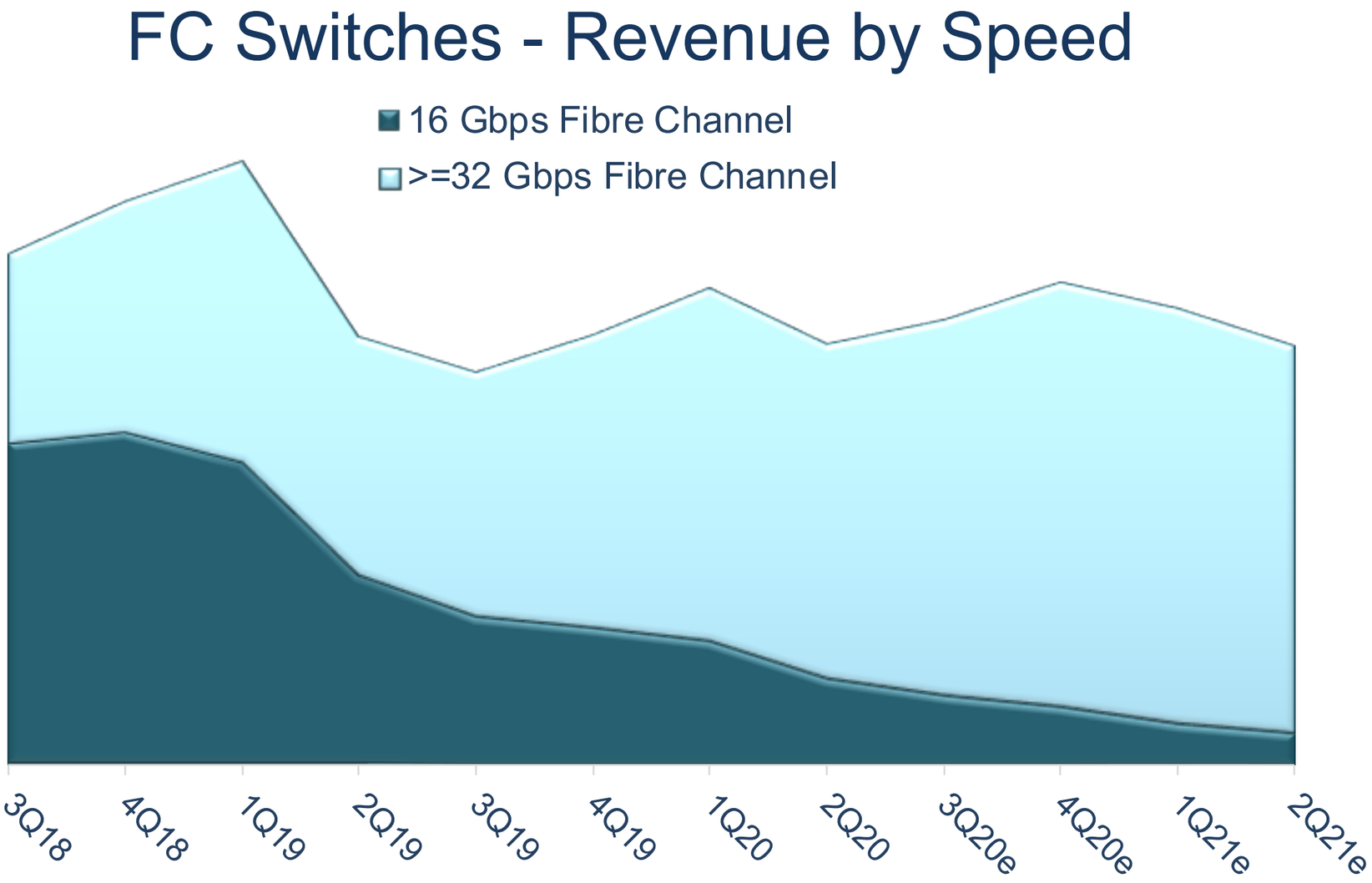
FC SAN MARKET

MARKET TRENDS

Flash Arrays

NVMe

FC for Mission Critical Storage



Fibre Channel Roadmap

Craig Carlson

Roadmap at a glance

Fibre channel speeds

FC

Product Naming	Throughput (Mbytes/s)*	Line Rate (Gbaud)	T11 Specification Technically Complete (Year) †	Market Availability (Year) †
8GFC	1,600	8.5 NRZ	2006	2008
16GFC	3,200	14.025 NRZ	2009	2011
32GFC	6,400	28.05 NRZ	2013	2016
64GFC	12,800	28.9 PAM-4	2017	2020
128GFC	24,850	56.1 PAM-4	2021	2024
256GFC	TBD	TBD	2025	Market Demand
512GFC	TBD	TBD	2029	Market Demand
1TFC	TBD	TBD	2033	Market Demand

"FC" used throughout all applications for Fibre Channel infrastructure and devices, including edge and ISL interconnects. Each speed maintains backward compatibility at least two previous generations (I.e., 32GFC backward compatible to 16GFC and 8GFC)

*These numbers are representative throughput values for the line rate and are payload dependent

† Dates: Future dates estimated

ISL Speeds

ISL

(Inter-Switch Link)

Product Naming	Throughput (MBytes/s)*	Line Rate (Gbaud)†	Standard Technically Complete (Year)‡§	Market Availability (Year)‡
10GFC	2,400	10.52 NRZ	2003	2009
40GFCoE	9,600	4X10.3125 NRZ	2010	2013
100GFCoE	24,000	4X25.78125 NRZ	2010	2017
128GFC	25,600	4X28.05 NRZ	2014	2016
200GFCoE	48,000	4X26.5625 PAM-4	2018	2020
256GFC	51,200	4X28.9 PAM-4	2018	2020
400GFCoE	96,000	8X26.5625 PAM-4	2020	Market Demand
1TFCoE	TBD	TBD	TBD	Market Demand

ISLs are usually multi-lane interconnects used for non-edge, core connections, and other high speed applications demanding maximum bandwidth.

ISL's utilize high bit-rates to accommodate the funneling of edge connections. Some ISL solutions are vendor-proprietary.

*These numbers are representative throughput values for the line rate and are payload dependent

† Equivalent Line Rate: Rates listed are equivalent data rates for serial stream methodologies.

‡ Dates: Future dates estimated

§ FCoE standard completion date is the completion of the Ethernet standard

FCoE Speeds

Product Naming	Throughput (MBytes/s)*	Line Rate (Gbaud)†	IEEE Standard Complete (Year)‡	Market Availability (Year)‡
10GFCoE	2,400	10.3125 NRZ	2002	2008
25GFCoE	6,000	25.78125 NRZ	2016	Market Demand
40GFCoE	9,600	4X10.3125 NRZ	2010	2013
50GFC0E	12,000	2x25.78125 NRZ	2016	Market Demand
50GFCoE	12,000	26.5625 PAM-4	2018	Market Demand
100GFCoE	24,000	4X25.78125 NRZ	2010	2017
200GFCoE	48,000	4X26.5625 PAM-4	2018	Market Demand
400GFCoE	96,000	8X26.5625 PAM-4	2020	Market Demand

Fibre Channel over Ethernet tunnels FC through Ethernet. 10GFCoE was not available until after FC-BB-5, the FCoE protocol standard, was completed in 2007. For compatibility, all 10GFCoE FCFs and CNAs are expected to use SFP+ devices, allowing the use of all standard and non-standard optical technologies and additionally allowing the use of direct connect cables using the SFP+ electrical interface. FCoE ports otherwise follow Ethernet standards and compatibility guidelines.

*These numbers are representative throughput values for the line rate and are payload dependent

† Equivalent Line Rate: Rates listed are equivalent data rates for serial stream methodologies.

‡ Dates: Future dates estimated

The Roadmap

- Goal is to double every speed increase (every 3 to 4 years)
  - Now working on 128GFC
- Speed increases are always backwards compatible with at least the previous 2 speeds
- Goal remains 100m reach for multi-mode
- Goal to decrease Latency
- Add more value-ad features
  - Automation and orchestration

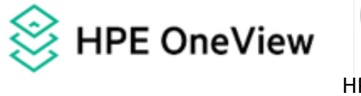
Automation & Orchestration

Rupin Mohan

SAN Automation – Enabling Deployment & Managing SAN's Simple

Cloud Orchestration Platforms

Industry Tools



HPE Smart SAN

HPE Network Orchestrator

Fibre Channel SAN Automation

Python Libraries

REST API

Fabric Notifications, Peer Zoning, Target Driven Peer Zoning

Fabric Notifications

FPIN Type Fabric Performance Impact Notification	What it does
Congestion Notification (FPIN-CN)	Notifies the port that is causing congestion that it is causing congestion.
Link Integrity (FPIN-LI)	Notifies the server port that the link it is connected to is ‘sick but not dead.’
Peer Notification (FPIN-PN)	When a FPIN-CN is sent to the server causing congestion, a Peer Notification is sent to all of the other ports in the zone.
Delivery Notification (FPIN-DN)	Delivery Notification - Best example is if a switch drops a frame due to egress hold time expiring (220ms).
Signals	Instead of using ELS, in Gen 7 ASICs providing congestion notifications at the hardware level. In essence, congestion signals look like rapid FPIN-CNs.

The details are in FC-FS-6 (Congestion Signal) and FC-LS-5 (EDC, RDF, and FPIN ELSs).

Target Driven Peer Zoning

Feature	What it does?
Peer Zoning	A Peer Zone is a Zone that allows a “Principal” member to communicate with “Peer” members, and does not allow Peer members to communicate among themselves. Peer Zone identifies a Principal member through the Peer Zone Attribute as defined in the FC-GS-x standard.
Target Driven Peer Zoning	When a target device defines/creates and manages Peer Zones using in-band FC-CT commands (shown in this table), then it is called Target Driven Peer Zoning (TDPZ). Peer Zones can be defined/created by other mechanisms as well.
AAPZ	Add/Replace Active Peer Zone (AAPZ) Operation A Target that supports TDPZ sends this command (along with the right attributes) to the Fabric Zone Server (that resides in the attached switch) to create a new Peer Zone or update an existing Peer Zone with the same name.
RAPZ	Remove Active Peer Zone (RAPZ) Operation A Target that supports TDPZ sends this command to the Fabric Zone Server (that resides in the attached switch) to remove an existing Peer Zone that matches with the Zone Name specified in the command payload.
GAPZ	Get Active Peer Zone (GAPZ) Operation A Target that supports TDPZ sends this command to the Fabric Zone Server (that resides in the attached switch) to retrieve an existing Peer Zone. The Fabric Zone Server shall return the Peer Zone definition in the Active Zone Set having the specified Zone Name.

Peer Zoning and details of AAPZ/RAPZ/GAPZ are described in FC-GS-x standard.

Fibre Channel 2020 Solutions Guide

FIBRE CHANNEL INDUSTRY ASSOCIATION

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- https://fibrechannel.org/fibre-channel-solution-guide-2020/

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  - FICON
  - Fibre Channel Cabling
  - 64GFC
  - FC Zoning Basics
  - Fibre Channel Standards

Thank You