

FIBRE CHANNEL SOLUTIONS GUIDE 2021



FCIA

FIBRE CHANNEL INDUSTRY ASSOCIATION

FIBRE CHANNEL

**Powering the next generation private, public,
and hybrid cloud storage networks**

ABOUT THE FCIA

The Fibre Channel Industry Association (FCIA) is a non-profit international organization whose sole purpose is to be the independent technology and marketing voice of the Fibre Channel industry.

We are committed to helping member organizations promote and position Fibre Channel, and to providing a focal point for Fibre Channel information, standards advocacy, and education.

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2021 FCIA's President Emeritus Introduction

By Mark Jones, FCIA Board of Directors and Director of Technical Marketing, Broadcom Inc.

With 2020 in the rearview mirror, we can see the impact the global pandemic has left on us all and the resulting changes to our everyday lives and the way we work. Even as we bring 2021 to a close, it's becoming clear the changes in the way we interact and work together may have longer implications for the future than we imagined.

The back end of all our lives in modern times relies on data like medical records, banking, government and regulatory data that connect us with a touchless workflow. Now more than ever, we rely on reliable application access to data with security and efficient utilization to allow business utility to function seamlessly. Fibre Channel has been relied upon for over two decades to be the network transport most depended on to access enterprise data. The Fibre Channel industry is proud this storage network technology has played a majority role in accessing important data just when society needs it most.

Adoption of Fibre Channel as the enterprise storage networking transport of choice continues to remain strong. The year 2021 is a milestone, for it is forecasted by Quillin Research¹ the number of Fibre Channel ports shipped since 1998 will exceed 150 million at the end of 2021! Over that period of time a number of new storage transport protocols over Ethernet have been hyped as the next greatest thing to replace Fibre Channel but never quite seem to fulfill the promise to do so. Having an estimated 35 million Fibre Channel ports or more in current use² proves that point.

In fact, Fibre Channel continues to show periods of growth even as the trend toward enterprise workload placement has shifted to a hybrid-cloud model over recent years with Fibre Channel being viewed as the safe haven protocol for on-premise data storage networking. Near term forecasts indicate a trend toward continued Fibre Channel growth; Quillin Research forecasts³ single digit growth through 2023.

Fibre Channel is well positioned to continue its preferred role in the datacenter as IT organizations transition to cloud-native applications in their on-premise hybrid-cloud deployments. Fibre Channel is included in the major Kubernetes container orchestration distributions for use as a persistent volume storage interface. Nearly all the major storage array vendors are adding their support by contributing vendor-specific Container Storage Interface (CSI) drivers. Fibre Channel storage arrays that utilize the CSI driver can not only aid the provisioning of persistent volumes of the defined storage class for Kubernetes, but also allow the container management to take advantage of advanced features that enterprise SAN storage customers are used to, like volume snapshots and replication.

The Fibre Channel industry is always innovating through the INCITS T11 standards organization. This continual development of the protocol always keeps Fibre Channel a series of steps ahead of other storage networking technologies. Fibre Channel fabric services and zoning are just a few of the long-standing advancements developed into the protocol for ease of management at a large scale; so valued that other network protocols are now trying to copy it.

Another recent innovation gaining a lot of traction from Fibre Channel component vendors is the addition of fabric notifications. The Fibre Channel fabric switches are a great place to detect and analyze traffic pattern trends and error conditions as end devices (hosts and storage devices) communicate over the fabric, but often the end devices or applications above them are the best places to solve issues. These devices could be contributing to a traffic condition while they remain unaware of how it effects other devices within the fabric; the fabric itself being the best place to gather a global view of traffic conditions.

If an error condition is detected, the fabric can selectively send a fabric notification to the end device and the end device can take action, log, or pass the message higher up the software stack for remediation. These new standards for fabric notifications have strong applicability for issues regarding traffic congestion management, link integrity, oversubscription and many others conditions.

The publication of the 64GFC standards in 2019 is the starting signal for Fibre Channel component vendors to design and build 64GFC products. History shows that it takes a few years from when the specification is complete until actual products first become generally available. That is the case again, and we are now seeing the first host bus adapter (HBA) and switch products available from component vendors. 64GFC is capable of 6400MB/s of IO bandwidth in each direction for each port and is an ideal match to the latest generation of servers released this year that ship with PCIe 4.0 IO interfaces. Work is well underway in the INCITS T11 standards committee for the next Fibre Channel speed increase with FC-PI-8 nearing final technical definition.

Fibre Channel SAN education is a key initiative within the FCIA. The [FCIA BrightTalk](#) channel has new webcasts added bimonthly presented by the technology experts that craft the industry standards for storage networking. [FCIA's website](#), is also a key area to find articles, blogs and the latest news on Fibre Channel technologies and products. The FCIA also offers its [YouTube channel](#) highlighting dozens of video presentations organized into [playlists](#) according to skill level, offering something for everyone from Fibre Channel basics to expert courses. Please follow the Fibre Channel industry's progress on FCIA's social media channels on [Twitter](#), [LinkedIn](#), and [Facebook](#).

¹ *Quillin Research 2021 SAN 5-year Forecast Report*

² *Ibid*

³ *Ibid*

Have You Ever Felt Like the Beta Test Site for the Latest Technology Gear?

By David J. Rodgers, FCIA Board Member and Sr. Program Manager, Storage Protocol Solutions, Teledyne LeCroy

You purchased a new Fibre Channel storage system replete with the best new features and functions including support for your legacy implementation and equipment, and it sets the table for incorporating the new, higher speed connectivity and devices you intended. You install the shiny and bright new appliances, connect them to the existing fabric, and voila, to your amazement, it works!

Ever Wonder How?

There's an adage in the automotive industry I've lived by for as long as I've been into cars; you don't buy a first model year of any vehicle. You wait for the subsequent year deliveries of that new car or truck in expectation the manufacturer will have worked out the bugs and made the required operational, structural or functional improvements.

The same has been said for technology products as they roll off the assembly lines. The "latest and greatest" tech products promise fantastic new features, incredible gains in performance and usability and guarantees of support and interoperation with legacy devices and applications. Whereas the "latest and greatest" from any one manufacturer do have the indicated gains in speed and performance, the products have often not held up to their promise of interoperability with legacy implementations and equipment, nor have comparable new products from other manufacturers.

As Fibre Channel speeds have increased – doubling data rates approximately every four years – and as the complexity of communications has evolved, the need for ensuring products in the fabric work seamlessly has become paramount. The test and measurement community works diligently to advance new tools and services to address the interoperability requirements. The network equipment manufacturers have also seriously invested resources, time and money to reach the goal of complete and seamless interoperability.



Fibre Channel Speedmap June, 2020

Interoperability seems easy enough; follow the INCITS T11 technical specifications and you're on your way to a compliant product offering that meets the standard and works with all other equipment in the fabric. Unfortunately, that has not always been the case. Design and validation teams from all corners of the ecosystem strain to accumulate the variety of switch, host bus adapter (HBA) and interconnect solutions in attempt to replicate an "average" system and validate products with the goal of ensuring the best possible purchase and user experience.

The test and measurement community has long engaged in developing tools, equipment and test routines with the sole goal of enabling the Fibre Channel ecosystem to achieve interoperability. Beyond the compelling need to ensure products work for the consumers, there is also the need to reduce the support burden and associated costs when those goods either don't work or require substantial effort to integrate into existing fabrics.

The Rise of the Plugfest

In the late 1990s, when USB products were on the rise, the concept of the open forum "plugfest" was born. These private industry events usually lasted the better part of the work week, brought together the key stakeholders in the ecosystem to a neutral location (often the local Embassy Suites hotel,) and were attended by engineers from each respective company to test out their product designs. That

model has been reused by most every other standards group since. Fibre Channel is no exception. The Fibre Channel Industry Association (FCIA), in conjunction with respected test labs – notably the UNH-IOL and Austin Labs – has hosted these events for many years now.

The upside of the plugfest model is the ability to get into the weeds with product validation and testing to confirm specification compliance, and most importantly, interoperation with other Fibre Channel products currently in use and those expected to be in the market soon. These plugfest events are conducted under the cover of a non-disclosure agreement (NDA) so those new products yet to be released can be tested and validated confidentially.

There is no one arbiter of the test plans used; the Fibre Channel community comes together well in advance of the date to create the test plans and address the concerns of the participants. No stones are left unturned at these events. Often there is “out of band” testing conducted between parties during breaks in the testing schedule (usually after hours and well into the late evening hours). Engineers discuss challenges, test the implementation of specifications and generally lay aside company allegiances to ensure Fibre Channel remains the preeminent storage fabric it is today and well into the world of tomorrow’s fabrics.

Fibre Channel storage fabrics work as well as they do for several reasons. First and foremost is the commitment to advancing and codifying the associated specifications. Physical layer attributes as well as protocol enhancements are discussed at great length by many engineers from all corners of the market. A very close second is the commitment by these same engineers and their teams to validate the interoperability of their products. The culmination of these efforts is then tested in the interoperability events long before any new Fibre Channel product hits the market.

No longer will the end-user be the canary in the coal mine. User satisfaction with their Fibre Channel product purchases is significantly higher, support calls and product

returns are dramatically reduced and confidence in their Fibre Channel deployments is unmatched. To this day, there is still no replacement for the stability, capability and surety of a Fibre Channel storage fabric. Period.

Looking Forward

Fibre Channel will continue to evolve to support the demands of the storage market and the expectations of users. The INCITS T11 technical committee membership remains committed to the advancement and efficacy of relevant specifications, maintaining and updating these to keep pace with new applications and requirements. The FCIA and its member organizations are devoted to the advancement of public awareness and education, hosting the plugfest events and producing webinars and trade show expositions, all in effort to ensure the promise of Fibre Channel remains forefront.

Specifically, the test and measurement community is on the leading edge of the new technologies, the bell-weather if you will. If the test and measurement sector has difficulty with making products for validation and compliance test solutions, it’s likely the rest of the ecosystem will have trouble with actual product development and deployment. Thankfully, the test and measurement folks are committed to the advancement of tools and services to develop specification compliant, and more importantly, completely interoperable Fibre Channel products.

Other technologies will continue to attempt to meet the stability, efficacy and maturity of Fibre Channel storage solutions. The inherent strength of Fibre Channel is currently unmatched despite the good works of many in other technology sectors. Efforts to add capabilities and functions that are the foundation of Fibre Channel solutions abound. There is, however, only one true storage fabric and that is Fibre Channel.

As noted by the late great Oscar Wilde, “imitation is the sincerest form of flattery that mediocrity can pay to greatness.” Fibre Channel is often imitated, but never duplicated.

Why Does Fibre Channel Win All the Time?

By Rupin Mohan, FCIA Board of Directors and Director R&D, Chief Technologist (SAN), HPE

SAN Fabric – Hmm...what is a Fabric? Does calling a Fibre Channel network a SAN Fabric matter? Please continue reading to find out why.

When it comes to designing and deploying a storage network, it does. The fact of the matter is tier 0 and tier 1 storage workloads are demanding and kind of finicky. They have quite a few requirements (or maybe more than a few) and developing a storage solution including the SAN that meets all these requirements is complex and hard.

The SAN fabric has to be designed end-to-end, meaning from servers to storage. It starts with host ports inside storage arrays. Storage arrays have to develop target adapters with host ports that conform to the protocol and meet certain requirements. The host bus adapters inside the servers have to do the same. The operating systems have to develop the storage stack that implements the particular storage protocol. Last, and perhaps most importantly, the switching infrastructure for the SAN fabric has to be developed.

Fibre Channel is the only SAN protocol that has been custom designed (end-to-end) specifically to meet these storage requirements. And it is a “real” fabric wherein every path and end point is stitched appropriately. These requirements help customers meet storage performance parameters like IOPs, throughput, latency, and more importantly, tail latency. Meeting these performance requirements to enable applications to deliver the best performance to their customers is key. In this day and age of instant everything and wanting it all, nobody has the time or patience to wait for anything. Competition is just a click away, hence applications need blazing fast storage access.

Three things that make Fibre Channel fabrics very unique are:

- **Name Server**
- **Zoning**
- **Buffer Credits**

You will find great articles discussing these features in this Solutions Guide titled “Gen 7 Fibre Channel Delivers So Much More Than Speed,” by Marc Angelinovich, and in a past Solutions Guide titled “Fibre Channel Automation and Orchestration,” that I authored. The latter can be accessed at: fibrenchannel.org/fibre-channel-san-automation-and-orchestration.

The foundation of a SAN fabric is reliability. Reliability is a loaded word. What makes something reliable? Also, what happens when something breaks? Are there redundancies built in? Good times are always great and fun, but the real test happens when things break. How does the protocol treat failures in transmitting packets? Is there failover and fallback?

Fibre Channel has been built from scratch with features like forward error detection and correction and flow control specifically designed for lossless delivery of frames. Without the reliable SAN fabric, storage arrays would not have the capacity to deliver 5 Nines Uptime (99.999%) of system availability that customers demand. The Fibre Channel protocol shines with its built-in mechanisms that address these requirements. When the foundation (aka protocol) has this type of built-in core functionality, you have a rock-solid storage fabric protocol that customers can take advantage of to deploy their mission critical applications.

How much is Fibre Channel used today? Well, According to Quillin Research, the Fibre Channel industry will have shipped over 150M ports by the end of 2021. That is a lot of ports. We at the Fibre Channel Industry Association (FCIA) believe that Fibre Channel will continue to be popular with customers to deploy storage networks. With FC-NVMe, customers have the capability to deploy the most contemporary storage protocol on a time-tested and proven storage fabric. We see no slowdown in this area.

Fibre Channel Delivers So Much More Than Speed

By Marc Angelinovich, Principal Product Marketing Manager, Broadcom Inc.

For decades now, Fibre Channel has been the network of choice for storage when deploying critical applications like ERP to run highly complex and large organizations or financial applications at the largest banks and global stock exchanges. Reliability is the main reason why Fibre Channel has won over the competition time after time. Anyone can deliver performance numbers in a test environment, but when customers are running all resources and maximum performance and scale, reliability is tested. This brings me to the reason for this article, why beyond the need for speed, a Fibre Channel network is required for any enterprise that relies on their storage infrastructure to conduct critical business operations like revenue-generating applications.

Regardless of the vendor of choice, Fibre Channel is designed with the customer in mind first. Even though Ethernet providers would like to say the same thing, they can't. It starts at the foundation of why Fibre Channel exists. Fibre Channel is a purpose-built network with the sole purpose to ensure storage traffic connectivity regardless of distance, performance degradation, physical issues or any other issues that come up. Ethernet networks are designed for many different things like connecting manufacturing equipment, servers, smart devices and the list goes on, making it hard for a general-purpose network as an industry collective to focus on storage.

Fibre Channel delivers so much more than speed to the largest companies in the world. If the design goal of the network is to ensure storage traffic in the data center is always available, reliable and secure, then more often than not, Fibre Channel is the network of choice.

So, let's talk about the areas the Fibre Channel industry focuses on beyond speed. First is fabric services that any device can subscribe to. The second is end-to-end communication between devices. The third is reliability across the industry. All of these capabilities enables the Fibre Channel industry to do so much more like share actionable intelligence across all devices in the data center to ensure the greatest reliability.

Fabric services

Fabric services are a set of functions shared across different Fibre Channel vendors to provide centralized capabilities to build the foundation for simple discovery, access control (security), and management. Fabric services are provided by the following, standardized well-known servers and controllers:

- **Fabric Controller** – Facilitates the exchange of information between switches in the fabric.
- **Name Server (Directory)** – Provides a means to discover information about the end device, host bus adapter (HBA) and the port attached to a Fabric.
- **Management Server** – Provides a single management access point within the fabric for services such as fabric configuration, access control management (e.g. zoning and unzone name server), security policy distribution, device management and application services).
- **Domain Controller** – Facilitates features and functions unique to each switch.

Fabric services mean, if you have a Marvell or Broadcom Host Bus Adapter (HBA), a Cisco or a Brocade switch, and any Fibre Channel storage array, these devices will log in and register with each other and share common capabilities. Saying it a different way, each device will call out if they support functions like hardware signaling if congestion is identified or if they can support the identification of virtual machines. Once each device understands each other's capabilities, they can start working together.

These shared Fabric services are the foundation for customers to build very large fabrics with maximum reliability. But just as critically, the fabric services are not independent of the network. You don't have a Domain Name Server (DNS) sitting off to the side of the environment, but rather these services are integrated and distributed within the fabric. This provides an incredible level of resiliency as every switch has a copy of the Name Server registry. Therefore, the loss of a single switch in the fabric doesn't cause the network to reconverge (where OSPF might take seconds to achieve a convergent view of the network to avoid potential loop creation for example) because all of the switches know the environment. If a known good alternate path exists from Initiator to Target, it will immediately be used and all non-affected traffic will never know the difference. This distributed environment also helps reduce the management time. As an example, a new switch added to the configuration will immediately learn its Name Server and Zoning databases from the existing fabric.

Since 1994 when Fibre Channel received its ANSI standard approval, companies have relied on and grown with it. As companies' storage requirements increased for higher availability, security and reliability, so did Fibre Channel fabric services to keep pace. Fibre Channel is a standards-driven protocol that addresses these concerns and today there are more than 100+ Industry Standards posted on Broadcom.com.

End-to-End Communication

The amount of data moving through the data center continues to grow faster than ever before, which makes it challenging to manage your infrastructure properly and extract business-level insights. On top of that, the company's success is now dependent on its ability to extract insights quickly. These demands drive up complexity. In fact, according to a January 2021 research report titled "Technology Spending Intention Survey," from IT and analyst firm ESG, 75% of organizations surveyed view their IT environments as more complex than they were two years ago. Adding to the complexity is how application owners access their data. Are the application owners wanting to get access through containers, virtual machines or a cloud? How does the storage keep track when applications are spun up and down so quickly?

The answer goes back to Fibre Channel being a collaborative protocol and evolving with the new requirements. Meaning the applications, server, storage and network vendors work together to address problems at the standards level to guarantee performance and reliability when application owners change the way they access storage. This is no small advantage. The ecosystem of Fibre Channel constantly tests hardware and standards-based functionality to ensure that the customer experience will not be the "we'll debug the new equipment in production," that IP storage environments can suffer from.

In most cases, the majority of storage networking issues can be addressed if the devices are aware of what is happening outside of their device. In other words, if the host, network and storage can talk and share events, then they each can take action to address issues that come up like speed mismatch, a failed cable or misconfigured MPIO path.

This is where the storage network plays the lead role in communication. The device in the middle sees almost everything and needs a way to share. For example, it's a standard practice to try and maximize your server resources by adding more and more virtual machines (VMs) because you have on average more compute power and storage capacity. But let's say one of those VMs starts to be overutilized and requests more storage resources than are available? The server side seems fine because the management tools say compute is fine so it must be a storage issue. The storage management tool says it's busy because of the host. So the finger-pointing starts.

Now with end-to-end communication between devices, the SAN switches can say tell the host that VM #xyz is the issue because it was not waiting for the storage response and was just dumping data. This communication is done through a fabric notifications mechanism that provides end devices with more information about events in the fabric. This includes notifications regarding link integrity issues, delivery notification issues and congestion issues. This means that instead of the management software trying to interpret what happened on the edge, the entire ecosystem (server, switch, storage) can be engaged in both identifying and correcting the problem.

What does this mean in context to Fibre Channel? This means that the SAN switch can send a notification to the HBA to address too many writes coming from the host. The HBA can take action by slowing down the traffic coming from that VM by throttling its performance.

This type of communication across Fibre Channel devices is only one aspect of reliability and leads me to the last topic.

Reliability

The reality of IT is that the lifecycle of infrastructure is based on getting the most use out of every device. This means that servers and storage purchased 3-5 years ago are still in use while new servers and storage are still being added. By connecting all of the elements to a network the new equipment may be dropped in next to the existing equipment.

This sounds like a great idea on paper but the intermix of multiple generations of SAN technology can frequently cause network issues. This is true regardless of the type of network as virtually no customer has an environment (Ethernet or Fibre Channel) where all of the servers are the same generation with the same versions of network interface controllers (NICs) and HBAs or where the storage elements are all the same model and generation. In fact, in networks that don't use buffer credits, the issue is even more significant as the mismatch in performance between generations will almost invariably lead to levels of congestion and the recovery mechanisms in networks where buffer-to-buffer credits are not in use take more time.

A simple way to think of this is that in a buffer-to-buffer credit environment data is never forwarded unless there is space to receive it. Whereas a TCP network will put the data on the wire and it is incumbent upon an upper-layer protocol at the end target to understand that data was lost and send a message back for recovery (a much longer relative wait time). Additionally, on packet loss, the congestion windowing algorithm in TCP will generally cut the throughput by 50% as a start point to begin bringing the traffic back under control which impacts the performance.

A standard definition of congestion, regardless of the protocol, would be when the rate of frames entering the fabric exceeds the rate of frames exiting the fabric. A simple solution to address this would be to tell applications to stop! That's not very customer-centric though. The goal of infrastructure should be that the application user never even notices when the infrastructure hits an issue and has to work around it. So, in the true spirit of collaboration across the Fibre Channel industry, they came up with a solution. The industry worked together to address reliability issues include features like:

- **Buffer credit** – Prevents a device from overrunning its peer
- **Flow control** – Paces the rate that devices can send data
- **Error detection/resource allocation** – Provides a mechanism for handling failing or misbehaving devices

Many network types indeed have recovery mechanisms. TCP/IP for instance will notice that packets were dropped and retransmit them. Fibre Channel by comparison uses the buffer-to-buffer credit mechanism to know in advance that there is space for the data about to be sent. Effectively, don't drop the traffic in the first place (it could be noted that the Peripheral Component Interconnect and InfiniBand protocols are also "buffer-to-buffer" credit mechanisms). So when typical Ethernet TCP/IP environments engage congestion management and congestion windowing reduces the traffic by 50%, the Fibre Channel environment will simply continue to process.

Summary

Companies, and specifically IT organizations, are facing numerous challenges when it comes to managing increasingly complex storage infrastructures. The storage network should not be adding to the stress. While no network is perfect and no single tool is ever perfect for every conceivable environment, the Fibre Channel storage area network continues to be the global workhorse when the requirements are high performance, lossless, low latency, reliable, time deterministic and secure delivery of storage traffic in the data center. To be fair, the same can be said about TCP/IP doing a brilliant job at delivering data in an unreliable physical network.

I expect both networks to continue to hold their place of prominence when traffic is mission-critical. TCP/IP will always be the best choice for connecting the Internet of Things and Fibre Channel for storage connectivity.

Learn to Succeed With Fibre Channel

By Chris Lyon, President, FCIA and Business Development Manager, Americas, Amphenol ICC

Fibre Channel has come a long way since it was first approved as an ANSI standard in 1994 to become the trusted and reliable networking solution it is today that delivers the efficiency and speed necessary for storage to be networked and shared across multiple hosts. Yet even as innovation in the protocol continues, many of the universities no longer teach the basic fundamentals of Fibre Channel in their engineering programs since they consider the technology mature.

With Fibre Channel expected to continue its growth, that's creating a challenge for young engineers being trained in the field that need beginner-level courses or professionals wanting advanced courses to achieve a deeper level of technical understanding in the subject. Network administrators, storage area network (SAN) managers and directors of infrastructure programs, seek greater knowledge of how Fibre Channel works so they can troubleshoot faster and make better technical decisions. Technical marketing personnel from companies that sell Fibre Channel also benefit from having a better foundational understanding of the subject beyond technical specifications. And with the increasing adoption of the NVMe over Fibre Channel technology to help realize the benefits of flash-based storage at a much larger scale, the need goes beyond professionals involved in SANs.

The lack of training at the academic level has led to a number of companies active in the Fibre Channel industry to step up and fill the void. The good news is the companies that do offer training, do it really well. They have a vested interest in expanding the knowledge of their own staffs as well as the pool of available talent for future hire. These companies offer a plethora of classes, everything from Fibre Channel basics, to instructions on how to become a Fibre Channel-based SAN administrator. Some companies even offer training to their customers to keep them up-to-date on the latest information on their specific Fibre Channel products.

Fibre Channel Industry Association (FCIA) members that offer Fibre Channel courses include:

Austin Labs

A subsidiary of Teledyne LeCroy, Austin Labs offers a full line of in-person and online instructor-led advanced Fibre Channel protocol training courses. All classes are instructor-led and guide students through the protocol specifications while using hands-on labs with trace analysis to help students discover how the protocol is implemented.

Find Austin Labs courses at: teledynelecroy.com/services/austinlabs-training.aspx.

Brocade

Brocade has over 70 free online classes available within its learning portal. Classes include everything from an introduction to Fibre Channel, product training, Fibre Channel protocols and Fabric OS features, to troubleshooting Brocade Fibre Channel fabrics. The company also offers free certification and accreditation-style knowledge assessment exams within its learning portal. The exams are intended to validate a person's Brocade Fibre Channel competency and are on par with Brocade's earlier certifications and accreditations without the need for a proctored environment while still providing a permanent transcript and downloadable certificates.

Find Brocade courses at: www.broadcom.com/support/education/brocade/courses.

Cisco

Cisco skills and certifications are some of the most sought after for professionals who work in technology. Networks and organizational infrastructures are evolving into complex solutions intended to support increasingly sophisticated business functions. The courses that Cisco offers to help trainees set up and manage the systems that serve as the backbone of an organization's day-to-day operations and communications include: Understanding Networking Fundamentals, Storage Area Networking Fundamentals and Network Administrator Essentials.

Find Cisco courses at: www.globalknowledge.com/us-en/search/?f=course&q=Fibre+Channel.

HPE

With decades of experience, HPE is a global leader in delivering innovative online (both live and on-demand) and in-person training. The company meets the needs of organizations and individuals through flexible continuous learning options, a broad catalog of course offerings and world-class instructors. HPE storage training is dedicated to mastering HPE-specific products and provides the skills needed to optimize a storage solution, keeping a business agile and responsive. HPE covers topics such as: Storage Capabilities, How to Ensure High-Speed Data Access, and How to Eliminate Downtime. HPE also offers a Master Accredited Solutions Expert (ASE) credential that has technical skills in advanced enterprise solutions combined with IT business acumen.

Find HPE Storage courses at: education.hpe.com/ww/en/training/portfolio/storage.html.

Another rich resource for keeping up-to-date on the capabilities and latest features of Fibre Channel is the Fibre Channel Industry Association (FCIA) itself. Anyone can access the FCIA BrightTALK or YouTube channel that contains educational webcasts from some of the top experts in the industry. To keep abreast of the upcoming webcasts, follow FCIA on LinkedIn, Facebook and Twitter or visit the FCIA web page at fibrechannel.org. If you have suggestions for future webcast topics, please email office@fibrechannel.org. We'd love to hear from you!

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