Executive Summary

We believe when the dust settles in ten years, we will have networking companies with Ethernet roots and ones with Fibre Channel roots. In our view, the key for investors is not to pick a technology, but quality companies that have displayed technology leadership and adaptability.

Ethernet TCP/IP is years away from being able to compete with Fibre Channel for block level storage data traffic.

While we have heard some very good arguments that IP is a preferred protocol as a result of its broad acceptance and use on the Internet, we believe it is many years away from being able to service block level storage data traffic reliably..

IT managers need a solution today!

The only solution ready for primetime is Fibre Channel, in our view. IT managers have already begun using Fibre Channel to network servers and storage. In fact, they spent an estimated $478.4 million dollars on Fibre Channel networking equipment alone in 1999 and they are projected to increase that spending almost three fold in 2000 (just on the networking equipment). In our estimation, the promise of Ethernet TCP/IP to provide a reliable block level data transport protocol equal to today's Fibre Channel is at least two or three years away. Many of the industry experts we polled agree that our time frame is accurate, if conservative.

We believe investors should be focussed on companies, not technologies.

We believe the ultimate winners will be companies from both Ethernet and Fibre Channel networking ancestries that have displayed 1) technology leadership, 2) visionary management leadership, 3) the ability to *react quickly* to changing technologies and changing customer demands, and 4) a willingness to migrate their core competencies to suit customer needs two to three years out by developing fresh technologies in new directions.

Focus on *storage* companies.

Brocade is one of the clear leaders in the storage networking industry today and will continue to be well positioned into the future, regardless of the outcome of this debate.

More conservative storage investments.

Companies without any networking preference offer less risk for investors. Among our favorites are: EMC, VERITAS, and Network Appliance.

Focus - Fibre Channel vs. Ethernet

➤ **Recently, there has been quite a stir as to what will be the sole networking technology of the future. We believe Fibre Channel's disruptive technology is the catalyst driving the debate and, therein lies our focus.**

The Reality of a Homogenous Network

Meet George Jetson

The driving focus on the "Fibre Channel versus Ethernet" debate stems from the belief that the world should have a homogenous network that can interconnect all types of voice and data traffic. In fact, this is the goal of many networking companies' current initiatives and has been for many years (note the competition between Cisco and Lucent over who has the ultimate networking technology). However, we believe making it a reality may be as far out as the reality of "The Jetsons" cartoon. Therefore, we believe investors should be focussed on *when* and *how* it might happen in order to put things into perspective.

When

In the end, we believe it will take at least two or three years before Ethernet is ready to go head-to-head with Fibre Channel. Thereafter, we believe the two technologies will overlap.

We have heard many people implying that this concept of "one network" is just around the corner and beginning to emerge today. While we agree it is being *architected* today, we believe the *availability* of a technology that can meet all types of networking demand is in the distant future (more than five or ten years).

It has been our experience that technology shifts of this magnitude take more time — not less — than originally anticipated. Right now, people are talking about Gigabit Ethernet moving to 10 Gbps and 100 Gbps; we note that Ethernet is currently just beginning to ramp transmission speeds of 1 Gbps. At the same time, it must be noted that Fibre Channel is not standing still. Fibre Channel of 2 Gbps should begin rolling out later this year and 10 Gbps Fibre Channel spec is already in the works.

How

The *how* is a bit tougher to explain. We break this explanation into three parts: 1) understanding the difference between various networking medias and protocols; 2) what we believe will unfold in the next three years; and 3) our longer-term vision. We believe investors should focus on points 1 and 2. We believe point 3, while exciting to talk about, is too futuristic and, therefore, should not consume investors' focus today.

Learning From History

Who would have guessed that Cisco's technology — a company that very few people had heard of in the late eighties and early nineties — could have usurped Big Blue's efforts to network the Internet with their technology? The point is, nobody really knows what technologies will survive in the distant future (we believe a more appropriate window to focus on is two or three years out).

We believe when the dust settles in ten years, we will have networking companies with Ethernet roots and ones with Fibre Channel roots. In our view, the key for investors is* not *to pick a technology, rather quality companies which have displayed the ability and willingness to adapt.

Who Wins?

We certainly see many new technological advancements developing from both sides of the debate. For example, we believe Cisco's recent torrid pace of acquisitions is a clear indication that it recognizes networking is constantly changing. We also believe almost every one of the Fibre Channel companies has morphed quite a bit since inception. For example, Ancor, which was focussed on Fibre Channel LANs in the early nineties, has moved into Fibre Channel storage networking, and is now helping define Infiniband with Intel. *Note: we used Ancor as an example because of its long history and dramatic migration, but we could have used any other Fibre Channel company.*

We believe the ultimate winners will be companies from both Ethernet and Fibre Channel networking ancestries that have displayed 1) technology leadership, 2) visionary management leadership, 3) the ability to *react quickly* to changing technologies and changing customer demands, and 4) a willingness to migrate their core competencies to suit customer needs two to three years out by developing fresh technologies in new directions.

Our Thoughts for the Future

- What about SCSI? SCSI will last for a long, long time (five-plus years).
- By the end of this year, SAN versus NAS arguments will cease to exist in favor of discussions of one uniform "Data Centric" architecture (architecture, not network), which will incorporate multiple networking platforms, including Fibre Channel, Ethernet, and ATM.
- Ethernet TCP/IP networking companies will both compete and partner with Fibre Channel networking companies throughout 2000 and well into the future.
- Ethernet TCP/IP will develop into a more robust technology over the next three years, and only then, will it be able to truly compete with Fibre Channel to network storage.
- By the time Ethernet TCP/IP is developed to function similarly to Fibre Channel, it will no longer have a cost advantage. In other words, you get whet you pay for; there are no free lunches.
- Fibre Channel should continue to be the premier storage networking solution for enterprise class data for at least another two or three years.
- Fibre Channel should continue to gain momentum through the end of 2001, no matter how many resources are stacked against it. *Note: it takes a long time between a technology's inception and when its ready for prime time.*
- Storage Networking companies should continue to recognize record growth in the next two years.
- Storage Networking companies will continue to migrate to incorporate Ethernet, ATM, and any other networking technology which presents itself as a viable storage networking alternative for the future.

Fibre Channel: A Little Background

Why Does Storage Need Fibre Channel Today?

Small Computer Systems Interface (SCSI) has been the storage connectivity solution for decades. SCSI differs from IP connectivity solutions in that it enables "block level" data transmissions from servers to storage (see the section "Ethernet Is Cumbersome" for more details). With data doubling every year, SCSI has begun to fall short of meeting computing needs. Therefore, Fibre Channel has emerged to: 1) assist in circumventing the I/O bottleneck, 2) move data more quickly, and 3) enable server and storage connectivity over longer distances.

Fibre Channel Helps Resolve I/O Constraints

The emergence of Fibre Channel is a result of the ever increasing demand for more data, more quickly, i.e the demand for higher I/O bandwidth (I/O refers to Input/Output and represents the rate at which a computer can receive and send information). Also called "bandwidth" solutions, connectivity solutions refer to those technologies that aid in the transfer of data between its storage site and the client or server computer. The connectivity solution can significantly enhance total system performance by increasing data transfer rates between PCs, servers, peripherals and networks. Connectivity is the element that links the user to the data.

Note: when connectivity solutions are switched or routed we refer to them as networking solutions. Traditional SCSI can connect a maximum of 16 nodes while Fibre Channel can connect 126. Fibre Channel can be switched, which has enabled companies such as Brocade to interconnect over 3000 nodes.

Connectivity, especially in the high end of the storage systems market, is undergoing a rapid transition to higher bandwidth technologies. A number of trends are driving the need to increase effective I/O bandwidth between clients, servers, peripherals and networks. These factors have created a rapid increase in the transfer of data between the desktop, servers, peripherals, and networks, resulting in substantial I/O and network bottlenecks. Some of these are as follows:

- The introduction of increasingly powerful processors requires more rapidly accessed and intelligently managed data.
- Advanced operating systems, especially advances in open systems such as UNIX and Windows NT, allow for faster I/O and multitasking.
- The growth of data-intensive software applications, such as graphics and video, require increases in bandwidth.
- The proliferation of client/server networks, the Internet, email and corporate intranets all drive growth in the number of servers clients, all communicating over the same network.
- The growth in high performance peripherals, such as high capacity hard disk drives, scanners, CD-ROMs, digital photography and voice recognition technologies adds to the flow of information over the network.

The existing storage connectivity standard, SCSI, has begun to fall short of the rapidly advancing system I/O demands. Due to the inherent limitations of the SCSI standard, a new storage connectivity standard, Fibre Channel, has emerged to take its place. This new standard has gained strong momentum in the past year as the heir apparent to SCSI and the enabler of Storage Area Networks (SANs); thereby bringing the additional benefits of networking to the storage world.

Note: Fibre Channel is based on SCSI protocol, think of it as supped up SCSI.

Fibre Channel Moves Data More Quickly

Fibre Channel represents the combination of connectivity and networking. While SCSI currently moves data at 40 and 80 Megabytes per second, Fibre Channel currently moves data at one Gigabit per second (referred to as 1 Gbps, also referred to as 100 Megabytes per second or 100 MB/sec or 100 Mbps; its all the same thing).

Another benefit of Fibre Channel is that it is bi-directional, which means that it can send and receive data at the same time. This feature effectively doubles Fibre Channel's band width to 2 Gbps. In contrast, SCSI functions in one direction, either read or write. Fibre Channel overcomes many of the limitations of SCSI.

Figure 1. SCSI And Fibre Channel Comparisons

	Maximum Data Transfer Rate (MB/sec)	Maximun Cabling Length	Maximun Number of Host Device Connections	Appliaction Performance
Wide Ultra SCSI	40 Mbps	1.5 meters	16	Low/Medium
Wide Ultra2 SCSI	80 Mbps	12 meters	16	High
Ultra160 SCSI*	160 Mbps	12 meters	16	High
1 GB Fibre Channel	100 Mbps	10K meters	126	High
2 GB Fibre Channel*	200 Mbps	10K meters	126	High

*Not currently shipping in quantity.

Source: Adaptec

Does this mean that SCSI is dead? We don't think so. In our experience, technological shifts of this magnitude occur over long periods of time and, in many cases, both technologies co-exist for prolonged periods. We would refer to this migration as evolutionary, not revolutionary. We expect both connectivity solutions to co-exist for another five to ten years, albeit at a diminishing rate.

Fibre Channel Traverses Greater Distances

When storage was directly connected to servers, a short SCSI cable did the job. With the expansion of data and the desire to centrally locate and manage storage, SCSI's short distance limitations have given Fibre Channel another leg-up. While SCSI reaches distances of 12 meters, Fibre Channel can span up to 10 kilometers.

The Great Debate

Fibre Channel versus Ethernet

In the mid-1990s, some companies began to realize the benefits of Fibre Channel.

Backing up in time for a moment, Fibre Channel actually came to the market in the late eighties to be a data communications networking technology; in other words, instead of using Ethernet one would use Fibre Channel. In fact, Ancor Communications, one of the current leaders in Fibre Channel networking, was founded in the late eighties as a LAN company.

The benefit of Fibre Channel was that it could transmit larger packets of data effectively (referred to as "block level" data transfers), while Ethernet was more focussed on small packets. In the end, Ethernet won because of its backing by the government and its broad-based support from multiple organizations. *Note; there was no real need at the time to send block level data over the LAN, that was being handled behind the server by SCSI, which at the time did not have a demand to be networked.*

In the mid-1990s, when SCSI began to look like it was running out of gas, companies such as EMC and Brocade began to realized the benefits that Fibre Channel could bring by networking storage.

Fibre Channel Components

Disk drive suppliers and component manufacturers also realized the benefits that Fibre Channel components could offer. Today, Fibre Channel technology is not only used for connectivity between servers and storage, it is also becoming a preferred component technology. The benefit of Fibre Channel components are 1) their ability to provide thinner internal connectivity within systems, thereby enabling smaller systems, 2) that they produce less heat, and 3) that they enable faster transmissions. For example, Network Appliance was able to triple its Filers' capacities to 1.4 terabytes, simply by using Fibre Channel drives instead of SCSI drives.

Ethernet's TCP/IP Started Out Servicing Government

TCP/IP was originally design by the US Department of Defense and largely used in governmental agencies and universities. However, it was the use of TCP/IP to develop the Internet that gave it the ultimate upper hand over competitors such as Novell's SPX/IPX and IBM's SNA protocols.

Ethernet Is Cumbersome

Ethernet uses a TCP/IP stack (Transmission Control Protocol/Internet Protocol). The TCP part is for data transmission (what is being sent) and the IP part is for communication (where to go and how to get there). Ethernet works well for small bits of information, but generates too much overhead and is too unreliable to effectively transmit larger blocks of data.

While TCP/IP does the job for file level data on the LAN, it does not currently meet the performance requirements of block level storage transmissions.

The overhead in TCP/IP is partly a result in its smaller framing size (1.5k frames), relative to Fibre Channel (2.0k frames which can be grouped without interrupting the host). Further, TCP/IP often routes each frame, or packet, differently; whereas Fibre Channel logically groups packets. The result is that TCP/IP often drops and/or loses packets of data when the network becomes congested. Lost data must then be retransmitted. TCP/IP also has a more cumbersome instruction set (over 5000 instructions per stack versus a few hundred in Fibre Channel), which requires the utilization of more CPU cycles than Fibre Channel.

Okay... let's look at this in a way that is easier to understand. Think of a wooden log that you need to transport between point A and point B. The log represents the data. Ethernet takes the log at point A, puts it through a wood chipper, sends the various pieces to point B through multiple paths, loses pieces along the way and reassembles the log at point B. On the other hand, Fibre Channel takes the log at point A, breaks it into a couple of pieces, establishes a dedicated connection to point B, links the pieces together end-to-end, transfers the pieces to point B over the dedicated connection and reassembles the log at point B.

In our view, for Ethernet to match Fibre Channel it must reconfigure its protocol.

Given that imagery, in our opinion there can be no debating the fact that Fibre Channel is a more robust block level data transfer technology! Also note that Gigabit Ethernet, although it raised its data transfer rate 10x by moving to 1 Gbps, only increased its throughput by approximately 3x as a result of its high overhead (one could argue the increase is 2x or 4x, depending on the method of measurement). Therefore, we believe the argument that Ethernet is growing to higher capacities is largely irrelevant.

We believe two solutions have been in the works to make Ethernet TCP/IP more robust: 1) stacking encapsulated SCSI over TCP with IP; and 2) to beef up the current TCP/IP protocol to function more like today's Fibre Channel. It is important to note that we believe either approach would take many years to develop.

The Only Available Solution Ready for Primetime Today Is Fibre Channel

In our estimation, the promise of Ethernet TCP/IP to provide a reliable block level data transport protocol equal to today's Fibre Channel is at least two or three years away.

In the end, IT (Information Technology) professionals need a solution today! IT managers have already begun using Fibre Channel to network servers and storage. In fact, they spent an estimated $478.4 million dollars on Fibre Channel networking equipment alone in 1999 and they are projected to increase that spending almost three fold in 2000 (on networking equipment alone). In our estimation, the promise of Ethernet TCP/IP to provide a reliable block level data transport protocol equal to today's Fibre Channel is at least two or three years away. Many of the industry experts we polled agree that our time frame is conservative.

Even if/when the revised protocol is available, it must still gain the support of broader industry groups to work in a unified direction to create hardware and software support. Also, the resulting Ethernet stack will not be compatible with today's Ethernet, so significant additional customer investments must be made to effect the migration. We believe there are going to be an increasing number of Fibre Channel networks deployed between then and now and we have yet to met an IT professional who is in favor of a wholesale abandonment of a technology that they have spent years installing. Therefore, we have to conclude that Fibre Channel will be around for some time.

While we have heard some very good arguments that IP is a preferred protocol as a result of its broad acceptance and use on the Internet, we believe it is many years away from being able to service block level storage data traffic reliably.

Recent Company Developments

What Has EMC Said and Done on the Subject?

We believe EMC helped start this whole debate back in December of 1995 when it bought McDATA Corp., which was one of the first Fibre Channel networking companies. Since then EMC has generated over $2 billion of Fibre Channel revenues. Although these revenues are not all Fibre Channel networking per se, we believe it is an interesting statistic in light of today's debate.

EMC's Recent Announcement of SRDF Over IP Has Ignited Today's Debate

One of EMC's most recognized developments has been its ability to remotely mirror multiple Symmetrix storage subsystems in multiple locations real-time. The benefit of this is the ability to recover from a Disaster in which all systems in one location fail; this is why its referred to as Disaster Recovery (DR). The lack of being able to recover data can cost companies millions of dollars in past, current, and future business.

Historically, remote mirroring has gone over leased T1 lines in order to interconnect multiple sites; remember, IP is not robust enough to handle block level storage traffic effectively. Recently, EMC announced that its Symmetrix Remote Data Facility (SRDF) is available over IP. So now IT managers can take advantage of the Internet and cut costs be using SRDF over less expensive IP instead of having to lease expensive T1 lines? Not quite.

Yes, SRDF can go over IP, but not for Disaster Recovery as a result of the high latencies associated with IP. EMC's SRDF over IP only supports asynchronous applications. In other words, you can only use SRDF over IP for static applications such as Internet content. We believe this actually opens up new opportunities for EMC, which complement SRDF's DR functions.

EMC Has Entered the NAS Market To Offer Direct File Access Over IP

A second application EMC is using IP for is to attach storage directly onto Ethernet LANs in order to serve up file data, not block level data, directly to clients, this is usually referred to as Network Attached Storage or NAS. EMC's NAS solution connects a Symmetrix directly to the LAN through its Celerra File Server. EMC can also connect that same Symmetrix to a Fibre Channel based storage network behind the server to keep block level data transfers separate. Notice the convergence of storage networking behind the server (SANs) and storage access directly on the LAN (NAS).

EMC Is Agnostic To the Debate Between Ethernet And Fibre Channel

We believe EMC is anticipating a third application, Ethernet connectivity between servers and storage. At the same time, it is our understanding that EMC sees storage networking traffic remaining separate from file data traffic. In other words, even if

Ethernet TCP/IP were just as robust as Fibre Channel, storage and datacom networks would continue to be separate.

If the networks do, in fact, remain separate, we believe this will benefit Fibre Channel storage networking, which is continually gaining momentum. We believe Fibre Channel and Ethernet networking technologies will begin to overlap in the three- to five-year time frame.

EMC has told us that they do not foresee any precipitous change in the storage networking landscape in the next two years. In other words, Fibre Channel will continue to be the most robust block level data storage networking technology for the next two years. Furthermore, the company does not have any preference as to which technology customers will ultimately favor.

Brocade's Move to Partner Up with ONI

We believe Brocade's recent ONI (Optical Networks Inc.) partnership represents a significant shift in the dynamics of networking. The agreement promotes Fibre Channel to fiber-optic connectivity across Metropolitan Area Networks (MANs). We believe partnerships between voice networking, datacom networking and storage networking companies has been imminent. We believe Brocade has been strategizing with most major networking companies in an effort to create synergies between various networking platforms. We believe Brocade will continue its efforts to leverage its core competencies across other networking platforms, including Ethernet and ATM. In the end, we believe Brocade is a *storage* networking company, not a *Fibre Channel* networking company.

It is important to note that the most robust storage networking platform available today is Fibre Channel. Therefore, companies such as Brocade use Fibre Channel. Many Fibre Channel networking companies are working to develop networking capabilities across a wide variety of networking platforms. Evidence of this can be seen in Gadzoox recent acquisition of SmartSAN. SmartSAN has been developing Fibre Channel to ATM and Ethernet connectivity. *Note: We believe any competing storage networking platform is at least two or three your away and will take much longer to gain broad based adoption.*

We expect many announcements similar to Brocade's ONI partnership throughout this year and well into the future.

Companies mentioned in this report:

BROCADE Communications (BRCD-$331.00; 2H)
EMC Corp. (EMC-$126.06; 1M)
Gadzoox Networks (ZOOX-$54.56; 3H)
Network Appliance (NTAP-$197.06; 2H)
VERITAS Software (VRTS-$154.75; 2H)