PRACTICE CONSIDERATIONS FOR DELL/EMC CX3 FC/iSCSI STORAGE SYSTEMS
BEST PRACTICES PLANNING

Abstract
This white paper discusses practice considerations for the Dell/EMC CX3 FC/iSCSI storage systems. Included in this paper are considerations for host and network configuration as well as storage replication and performance.

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EXECUTIVE SUMMARY
The Dell/EMC® CX3 UltraScale™ Series is based on a new, breakthrough architecture and extensive technological innovation providing a midrange storage solution that cannot be matched by any competitor. The CX3 UltraScale Series delivers industry-leading application performance, and new levels of scalability, reliability, and affordability. It also includes new levels of ease of use, making the CX3 easy to install, manage, and scale. The CX3 is the third-generation CX Series, and continues EMC’s commitment to maximizing customers’ investments in Dell/EMC technology by ensuring that existing resources and capital assets are optimally utilized as customers adopt new technology.

The CX3’s UltraScale architecture is based on state-of-the-art I/O interconnect PCI Express technology, enabling it to provide high bandwidth and low latency. It is the only midrange storage system in the industry that delivers a full 4 Gb/s throughout the entire system. Since most current SANs are based on 2 Gb/s technologies, CX3 storage systems are designed to recognize and support devices of mixed speeds, which can be operated simultaneously. Furthermore, as the customer’s requirements change, Dell/EMC’s unique Virtual LUN technology can be used to dynamically move data from one tier of storage to a higher or lower tier within the same CX3 storage system.

INTRODUCTION
This white paper discusses practice considerations for planning and deploying the Dell/EMC UltraScale CX3 Fibre Channel/iSCSI systems to best achieve performance and reliability in either a SAN or IP SAN environment.

The paper also discusses the considerations that need to be made with regards to host and network configuration as well as the choices that can be made with regards to storage-system replication and performance.

Audience
This white paper is intended for Dell/EMC employees, partners, IT planners, storage architects, administrators, and any others involved in evaluating, acquiring, managing, operating, or designing an Dell/EMC networked storage environment.

Terminology
- **iSCSI node**: An initiator or target in the IP SAN.
- **Alias**: A user-friendly name associated with an iSCSI node.
- **Session**: A connection between initiator and target.
- **Challenge Handshake Authentication Protocol (CHAP)**: Optional authentication algorithm that provides access control between an iSCSI initiator and target.
- **EUI**: Extended unique identifier. Unique name for iSCSI initiator or target. Similar to a WWN structure in Fibre Channel. Often used when bridging between FC and IP networks.
- **IQN**: iSCSI qualified name. Unique name for iSCSI initiator or target. Based on vendor or organization Internet domain name.
- **TOE**: A NIC with a TCP/IP offload engine. The TOE offloads processing of TCP/IP segments from the host CPU. For systems with high CPU usage, a TOE may provide better performance by providing more CPU cycles for other processes.
- **iSCSI HBA**: iSCSI host bus adapter. A NIC with a TOE plus ability to process iSCSI PDUs.
- **NIC**: Network interface card. Connects the host to the TCP/IP network.
• **Response time**: The interval of time between submitting a request and receiving a response.

• **Bandwidth**: The amount of data the storage system can process over time. Bandwidth is measured in megabytes per second (MB/s).

• **Throughput**: The number of individual I/Os the storage system can process over time. Throughput is measured in I/Os per second (IOPS).

**OVERVIEW**

The Dell/EMC CX3 UltraScale Series storage systems are made up of the following modular components:

- A 4 Gb/s storage processor enclosure (SPE) – houses the storage processors (SPs).
- A 4 Gb/s UltraPoint™ disk array enclosure (DAE) – houses up to 15 drives. Additional DAEs can be added for a maximum of 60 drives for the Model 10, 120 drives for the Model 20, 240 drives for the Model 40, and 480 drives for the Model 80.
- Dual standby power supplies (SPS) – enables proper shutdown of the storage system during power failure by safely moving the data currently in the write cache to a reserved area in the first five drives.

The Dell/EMC CX3 FC/iSCSI UltraScale storage systems have 4 Gb/s Fibre Channel front-end (FE) ports on each SP. In addition, there is iSCSI connectivity for the Models 10c, 20c, and 40c. The Model 10c has two 1-Gb/s iSCSI FE ports per SP, and Models 20c and 40c have four. These iSCSI ports may be connected to a 10/100/1000 Mb/s port on an Ethernet switch or they may be directly connected to a 10/100/1000 Mb/s NIC or iSCSI HBA on a server/host. Linux, Solaris, Windows, and VMware iSCSI hosts can be attached to these arrays.

For more general information about the Dell/EMC CX3 UltraScale family, please see the *Introduction to Dell/EMC CX3 UltraScale Series* white paper on EMC Powerlink®.

**Flexibility**

The Dell/EMC CX3 FC/iSCSI models offer new levels of tiered storage flexibility. Dell/EMC provides tiered storage (in-a-box) capabilities with its ability to mix and match drive types and non-disruptively move data within a single frame using Virtual LUN technology. Now Dell/EMC CX3 arrays offer even more flexibility by allowing the user to connect hosts over an FC SAN, IP network, or both, depending on the applications’ requirements and infrastructure considerations.

This new low-cost connectivity option allows you to extend the benefits of consolidation to customers whose environment and applications were not previously suited to storage consolidation.

In addition, applications connected via iSCSI can take advantage of all the advanced functionality that Dell/EMC CX3 has to offer such as centralized management, Virtual LUN technology, local replication, and remote replication; remote replication is achieved by replicating iSCSI presented devices over the Fibre Channel ports to a secondary storage system.

Some case examples of when having both iSCSI and Fibre Channel connectivity are useful include:

- Systems that require external storage, but do not warrant the expense of a Fibre Channel infrastructure and therefore can use native iSCSI to obtain the storage
- Test/development systems attached via iSCSI that can use a local replica of a production LUN presented to a Fibre Channel system
- Storage that requires the service level of iSCSI today but could eventually require the level of Fibre Channel in the future
Consolidation
The Dell/EMC CX3 FC/iSCSI models provide customers an advantage whether they currently use iSCSI or Fibre Channel. For customers who are implementing networked storage for the first time and considering iSCSI, the Dell/EMC CX3 Model 10, Model 20, and Model 40 provide scalable iSCSI storage as well as the flexibility and investment protection of integrated FC support as their business and application needs grow.

Choice
For customers with existing FC deployments, the Dell/EMC CX3 FC/iSCSI models offer the opportunity to economically expand the reach of their network storage environment with iSCSI, while maintaining complete flexibility with respect to how the incremental capacity is shared across server platforms and interconnects.

UltraScale architecture
The breakthrough UltraScale architecture integrates extensive and unique intellectual property from EMC—including 45 patent-pending innovations and EMC’s highly scalable hardware design. It delivers cutting-edge performance, including the highest levels of resiliency and availability, tiered storage flexibility, and powerful, easy-to-use interfaces.

UltraScale is the only midrange storage architecture capable of delivering maximum throughput and performance for a wide variety of business applications. The UltraScale’s native PCI Express interconnect delivers high bandwidth and low latency characteristics, and enables the Dell/EMC CX3 Series to deliver the industry’s only full 4 Gb/s capability throughout the entire system.

UltraPoint’s auto-sense speed setting provides the UltraScale architecture with the flexibility to allow customers to use a combination of 2 and 4 Gb/s drives simultaneously. Initial tiered storage configurations are simplified due to the Dell/EMC CX3’s ability to detect the characteristics of drives as they are added. Furthermore, as a customer’s requirements change, Dell/EMC’s unique Virtual LUN technology can move data from one tier of storage to a higher or lower tier without disrupting the host application.

iSCSI technology overview
The Internet Small Computer Systems Interface (iSCSI) is a protocol that transports SCSI commands and data over a TCP/IP network. The iSCSI protocol can be used to transport I/O from a host to the Dell/EMC CX3 FC/iSCSI systems over the IP network, leveraging standard network equipment. Much like Fibre Channel, iSCSI has nodes called initiators or targets. Initiators are typically the hosts, and targets are the front-end iSCSI ports of the storage system. Each initiator and target must have a unique name in one of the following formats:

- iSCSI Qualified Name (IQN): The name is based on a registered domain name, which is usually the name of the iSCSI node provider. For example, an IQN for an EMC-provided storage device could be: iqn.1992-1994.com.emc:cxapm123456789AB.
- EUI: This is a 64-bit unique identifier that is a 24-bit organizational unique identifier (OUI) assigned by the IEEE. One example is eui.5006048212345678.

Nodes are connected to the network via a standard IEEE network interface card (NIC) or an iSCSI host bus adapter (HBA). An iSCSI HBA has a TCP/IP offload engine (TOE) that manages the TCP/IP overhead; as a result CPU cycles are not used for TCP/IP packet processing.

Once the host and storage system have been properly configured for the iSCSI network, the host sees the iSCSI target. The storage provisioning and configuration procedure is then identical to that of a Fibre Channel storage system.
For security-conscious customers, the Challenge Handshake Authentication Protocol (CHAP) can be used. An administrator must configure both the host and storage system for CHAP. CHAP has two types of authentication: initiator and mutual. For Initiator authentication, the storage system is configured to accept a certain “secret” (or password) that is associated to a specific IQN or EUI. When the initiator logs in to a target, the password must be sent with the login request. If the correct password is entered, login continues; however, if the wrong password is sent or no password is configured, the storage system will not allow the initiator to log in. This prevents unauthorized hosts from trying to access the storage system. With mutual authentication, both the initiator and target must supply a password to be authenticated by the other party.

**NETWORK CONSIDERATIONS**

The iSCSI protocol is a network service that runs on the storage processor. Network addressing for the iSCSI target is facilitated through a portal group, which associates the iSCSI target with a defined Dell/EMC TOE interface. The default port number assigned to new portal groups is 3260. It is possible to run this over a public or private Ethernet network, whether it is a dedicated network device or VLAN. While VLAN packet tagging is not supported by the Dell/EMC CX3 UltraScale Fibre Channel/iSCSI systems, Ethernet switch port-based VLANs are supported. This allows for the isolation of the iSCSI traffic within the customer network environment. Some configuration of the network equipment may be required.

Since iSCSI on Dell/EMC is a network service, previous networking knowledge and experience is helpful when planning the iSCSI implementation.

iSCSI is an open network protocol, so any host system running a supported iSCSI initiator can establish an iSCSI network session with a Dell/EMC iSCSI target and access the block storage devices that have been allocated to that target. The same risks and challenges that exist in networking servers, especially public and wide area networks, can also affect the efficiency of an iSCSI session. The impact of the network should be clearly understood when planning to use the network as part of an application requiring explicit service levels.

Before deploying iSCSI, it is very important to understand the network topology between the initiators and targets. A poorly configured or over-utilized network can result in unacceptable iSCSI performance. Evaluating the capabilities of your network (for example, peak throughput capacity and response time) prior to deployment will help to assess your network’s ability to support your application. It will also provide an understanding that is beneficial in your post-implementation assessment. For example, if, based on your planning, you thought you had enough network capacity but your application does not provide the expected result, your technical staff will have the necessary information to isolate the cause of the problem. This is true for both public and private networks when new initiators are added to an IP SAN and particular service levels are required.

Network processing adds some latency or delay each time a packet passes through a network device. There are several forms of latency in the network. There is the natural delay, or propagation delay, measured as round trip time (RTT). RTT is the amount of time it takes for a packet to reach its destination and return to the source. On a clean network, the propagation delay is the result of the velocity and distance that the signal travels across the network. Routing devices can add up to 1 ms in response, while network switches add very little overhead (about 0.1 ms).

The impact of packet loss and RTT can be calculated in the following formula:

\[
\text{Bandwidth} = 0.75 \times \text{MSS} / (\text{RTT} \times \sqrt{\text{Loss}})
\]

where MSS is the message segment size being used on the connection, RTT is the round-trip time, and Loss is the loss rate experienced by the connection.

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1 See the basic formula in *TCP-Friendly Unicast Rate-Based Flow Control* by Jamshid Mahdavi and Sally Floyd at http://www.psc.edu/networking/papers/tcp_friendly.html
Local area networks

In a local area network, or LAN, there is reduced risk of packet loss due to the limited number of devices and proximity of the source and the destination nodes. This should result in reduced round-trip times.

When implemented in a switched environment, the efficiency of the network (and thus the iSCSI deployment) is significantly increased. Since there may be a considerable amount of data transmitted across the switch, the switch should have the receive and transmit flow control option enabled and have sufficient buffer space to accommodate large write applications within the network.

Most network switches today add no more than a few microseconds to the packet RTT, which is why many iSCSI advocates have identified local area switched environments as the desired topology for IP SAN. For best performance, a dedicated 1 Gb/s private LAN should be used for the IP SAN.

Switches are extremely efficient in the number of packets per second (pps) they can process. Increased port speeds will continue to make switches very attractive for IP storage. Therefore, deploying iSCSI into a switched environment can be done with a high degree of certainty that it will not adversely affect throughput. However, deploying iSCSI into a multipoint routed network may result in a noticeable degradation of throughput. Some routers, for example, can add up to 1 ms of propagation delay to each TCP packet. The distance that a packet has to travel is also responsible for 1 ms added for every 100 miles.

Basic system utilities such as ping and trace route (available at both the host and storage-system level) are typically used to verify connectivity and can also be used to provide some crude observations of the latency that exists between the source and the destination network interface. Additionally, there are several open source tools such as Ethereal that can be used to look at the network. Excessive number of Address Resolution Protocol (ARP) requests, for example, can also add to the overhead within the network, as all of the systems on the network must inspect the packet to determine whether it is the intended destination of the request.

In general, most of the networking benefits that are provided to address security can also benefit the performance aspect of an implementation, and vice versa. The key action during the planning stage is to understand the network environment and the application requirements for iSCSI.

Security

Several Dell/EMC iSCSI features can be leveraged to establish a secure environment for iSCSI sessions. Basic Dell/EMC configuration provides methods to authenticate each initiator with the iSCSI target. An authentication is provided through the Challenge Handshake Authentication Protocol (CHAP).

CHAP is a type of authentication in which the authentication agent (initiator) sends the target a random value (that is used only once) and an ID value. Both the initiator and target share a predefined "secret" (or password), which in the case of a Dell/EMC system is the assigned password configured on the iSCSI target. The peer concatenates the random value, the ID, and the secret password to calculate a one-way hash using MD5. The hash value is sent to the authenticator, which in turn builds that same string on its side, calculates the MD5 sum, and compares the result with the value received from the peer. If the values match, the peer is authenticated. By transmitting only the hash, the secret can’t be reverse-engineered. The ID value is increased with each CHAP dialogue to protect against replay attacks.

The default settings do not require that CHAP be enabled; however, there are Dell/EMC parameters that can be configured to force all initiators to use CHAP to authenticate to the Dell/EMC iSCSI targets. The Dell/EMC system offers the option to assign a password for each initiator that accesses the Dell/EMC system. The CHAP secret is assigned at the storage-system level, which means that each time an initiator attempts to establish a new session with a target it will undergo the authentication process. Basic configuration requires the
use of a password that is between 12 and 255 characters in length. Additionally, the system allows for reverse authentication between the target and the initiator, known as Mutual CHAP. The CHAP secret password for the target must also be 12 characters or greater; however there are limits to the number of characters that are supported for reverse authentication by some initiators. The Microsoft iSCSI initiator software version 2.0, for example, has a CHAP secret limit of 16 characters.

Host configuration

Using a NIC versus using an iSCSI HBA

All hosts in an IP SAN can utilize a standard IEEE NIC; however, an iSCSI HBA should be used for overall better performance or if booting from the SAN.

A host can have one or more 10/100/1000 NICs or 1 Gb/s iSCSI HBAs. If the customer has a host application with substantial I/O requirements, then an iSCSI HBA should be considered. As a general rule, the iSCSI HBA will perform better than a standard 10/100/1000 NIC due to the iSCSI HBA’s TOE, which handles the processing of the TCP/IP frames of the iSCSI packets. For hosts that do not have a TOE, the host’s CPU(s) will process these frames, potentially impacting performance. A single NIC or iSCSI HBA is required for the iSCSI solution; however, two NICs or HBAs are strongly recommended with the use of PowerPath® or other host failover software to ensure host connectivity through path failures. PowerPath can also provide load balancing, fine-tuning and balancing the I/O loads across all available paths between the host and the storage system.

Some general host NIC/iSCSI configuration rules follow:

1. A single host/VM cannot mix HBAs and NICs to connect to the same or different arrays.
2. A single host/VM cannot attach via Fibre Channel and iSCSI protocols at the same time.
3. A single host/VM cannot attach to a Dell/EMC CX/CX3 iSCSI storage system and a Dell/EMC AX iSCSI storage system at the same time.
4. A single host/VM can attach to a Dell/EMC CX/CX3 iSCSI storage system and a Symmetrix® iSCSI storage system when there is common network configuration, failover software, and driver support for both platforms.
5. Hosts using NICs must be configured using the Microsoft iSCSI Initiator for Windows operating systems or the native iSCSI driver found in Linux or VMware operating systems.
6. If a customer requires CHAP, it must be set up prior to the assigning of Storage Groups and LUNs to avoided interruption in I/O.

PowerPath and high availability

PowerPath is recommended and should be installed on all hosts attached to the Dell/EMC CX3 FC/iSCSI storage systems. PowerPath software provides failover and load balancing across all configured and available paths between the host and the storage system.

PowerPath monitors and removes any failed paths from the configuration, and reroutes data to the remaining live paths. Also, if multiple paths are configured from the host to a particular storage system SP and its LUNs, PowerPath will balance the I/O load across the ports on the SP and determine which path will yield the fastest response time for the I/O request. PowerPath
optimizes multi-path LUNs with load-balancing algorithms. PowerPath offers several load-balancing algorithms that are based on access patterns.

PowerPath handles the failover (or trespass) of a LUN from one SP to its peer. A trespass occurs if a host can no longer access its LUN through the SP that "owns" the LUN. PowerPath offers several load-balancing algorithms, but the default algorithm (ClarOpt) is recommended. ClarOpt dynamically adjusts its load-balancing algorithm if an SP fails or the SP itself is rebooting. PowerPath handles the trespass of that SP’s devices to its peer SP without the host seeing an interruption in I/O, provided paths are configured from the host to both SPs.

Given this information, it is best to configure your environment for high availability and to make use of the features of PowerPath. For true high availability, redundancy at all points of the environment is important.

For high availability, install at least two NICs/HBAs in the host. Each of these NICs/HBAs can be configured to see an SP (if direct connected) or zoned to see both SPs. With this configuration, you are protected against the loss of a NIC/HBA, or paths from that NIC/HBA, and configured to take advantage of the failover capabilities of PowerPath.

REPLICATION CONSIDERATIONS
The Dell/EMC CX3 FC/iSCSI models support the full suite of replication products, including SnapView™ for local replication, and SAN Copy™, MirrorView”/S, MirrorView/A, and RecoverPoint/SE (via the arrays’ Fibre Channel ports) for remote replication. With these applications, long-distance replication over IP can be achieved by using FC/IP bridges such as the Connectrix® MP-series multiprotocol switches.

With either of the Dell/EMC CX3 FC/iSCSI models, additional flexibility exists for both local and remote replication products. For example, using local replication, a host that is attached via Fibre Channel can have snapshots or clones of its source LUN. Those snapshots or clones can then be presented to a host that is attached via iSCSI, if so desired, and vice versa. The same rules apply for both SAN Copy and MirrorView. A host that is attached via iSCSI or Fibre Channel can replicate that LUN over the Fibre Channel ports to a remote storage system where the user then has the choice of either presenting that LUN on the remote system to a host that is attached via iSCSI or Fibre Channel.

PERFORMANCE CONSIDERATIONS
Considerations for performance go beyond the storage system itself. Whether you are using the Fibre Channel or iSCSI protocol to attach to the storage system, several aspects of the SAN environment affect application performance, including the servers that run the application, the HBAs within those servers, and the speed of the switches that are used.

For iSCSI environments, the following should be taken into account when trying to optimize the IP SAN environment for best performance:

- Attached hosts should use supported 1 Gb/s iSCSI HBAs to offload the processing of TCP/IP and iSCSI processing.
- A dedicated 1 Gb/s private network should be used for all iSCSI traffic between the host and the storage system.

For Fibre Channel environments, the following should be taken into account when trying to optimize the SAN environment for best performance:

- Attached hosts should use supported 4 Gb/s components (HBAs and Fibre Channel switches) to realize the full benefit of having end-to-end 4 Gb/s technology.

Selecting which protocol to use for a given application depends on several factors, including a customer’s existing infrastructure, budget, and staff skill-sets. Performance is also a consideration that requires some thought. The I/O profile of that application as well as your tolerance and...
expectation for the performance of that application are critical factors. When considering the performance differences between iSCSI and Fibre Channel attaches, there are two major considerations:

- 1 Gb/s iSCSI ports can only support one-fourth of the total bandwidth of a 4 Gb/s Fibre Channel port (that is, 100 MB/s vs. 400 MB/s)
- In the Dell/EMC architecture, iSCSI I/Os into the storage system require approximately 25 percent more CPU (SP) cycles per I/O than their Fibre Channel counterparts; however, the additional iSCSI storage processor demand is greatly diminished by the TOE included on each of the iSCSI FE ports.

These two considerations have several implications:

- The first consideration is fairly straightforward. If the application requires more than 100 MB/s out of a port, then currently Fibre Channel is your only option. This could possibly apply when considering streaming media types of applications, including backup-to-disk, along with many DSS loads. These loads typically consist of large sequential I/Os. Even though CPU utilization for each iSCSI I/O is inherently higher, because there are not as many I/Os as there are in a small I/O applications (such as OLTP and Exchange), the actual CPU utilization for these loads is minimal.

- The second consideration directly relates to the amount of SP processing power available to process I/Os for the entire system. Because this consideration is dependent on the available processing power on a system level, rather than fixed port speeds, the impact is more complex to determine. This applies to loads that are typically smaller random I/Os, such as OLTP and Exchange. If the OLTP/Exchange environment is not SP-bound, then iSCSI should work in this space just as well as Fibre Channel. On most OLTP/Exchange workloads, the disk drives are the bottleneck, not the SP or I/O ports. This is especially true in smaller environments such as mid-size enterprises or at larger enterprises where iSCSI will be deployed to support applications running outside the data center to support departmental type applications. On these types of workloads, the number of disk drives is directly applied to user counts. On these types of workloads, the number of disk drives is directly applied to user counts. In the white paper EMC Dell/EMC Storage Solutions Microsoft Exchange 2003 Best Practices: Storage Configuration Guidelines (on EMC Powerlink), a drive equates to approximately X users.

These are the calculated for typical user loads: 0.5 IOPS

- o X ~ 130 users per drive for 10k rpm on RAID 1/0 groups.
- o X ~ 187 users per drive for 15k rpm on RAID 1/0 groups.
- o X ~ 88 users per drive for 10k rpm on RAID 5 groups.
- o X ~ 125 users per drive for 15k rpm on RAID 5 groups.

The following are three guides that should assist in determining which attach to employ (assuming industry standard best practices are applied):

- On the Dell/EMC CX3-10 system, an OLTP/Exchange system with 30 drives or less should be able to take advantage of either iSCSI or Fibre Channel. On systems with 30 drives or more, consult an EMC professional.
- On the Dell/EMC CX3-20 system, an OLTP/Exchange system with 40 drives or less should be able to take advantage of either iSCSI or Fibre Channel. On systems with 40 drives or more, consult an EMC professional.
- On the Dell/EMC CX3-40 system, an OLTP/Exchange system with 80 drives or less should be able to take advantage of either iSCSI or Fibre Channel. On systems with 80 drives or more, consult an EMC professional.
CONCLUSION

The Dell/EMC CX3 is the third generation of the CX Series and continues EMC’s commitment to maximizing customers’ investments in Dell/EMC technology by ensuring that existing resources and capital assets are optimally utilized as customers adopt new technology. The addition of the Dell/EMC CX3 FC/iSCSI storage systems continues that commitment by adding the flexibility; at the host attach level, of using either iSCSI or Fibre Channel protocols.

The Dell/EMC CX3 UltraScale Series is now the preferred choice that provides maximum capabilities for a midrange storage platform. The unique combination of a breakthrough architecture design and advanced software capabilities enables the Dell/EMC CX3 Series to meet the growing IT challenges of today’s midsize and large enterprises by scaling system capacity and performance, simplifying management in complex environments, and delivering increasing levels of information availability and protection for critical applications and data.

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