Data center interconnects (DCI) are traditionally used for critical data replication to meet corporate compliance and continuity requirements. Recent virtualization technology now allows IT to shift computing pools with DCI for greater resource efficiency and accessibility. With greater reliance on the services running in DCI environments, IT and service providers must have visibility into the performance and events that can impact end-user and business processes. Managing the success of these services, and the critical wide-area network (WAN) links, requires an analysis solution that can identify baseline behavior and isolate performance degradation to avoid disrupting the most important services being carried out across these critical links.

Managing data center interconnect performance for disaster recovery highlights:

- Industry-leading packet analysis and inspection of critical WAN links ensures data compliance and accessibility for business-essential backup and replication services.
- Synchronous-replication environments require packet-level visibility and baseline analysis to maintain application performance.
- Storage network equipment manufacturers (NEMs) trust Xgig® Analyzer to measure storage performance and to isolate communication failures.
- Data backup and replication performance baselines help service managers understand normal behavior and identify slow degradation that can lead to service disruption.
- Packet-level visibility shortens problem isolation and resolution when triaging multivendor issues.
DCI and Synchronous Replication

The use of DCI to enable high availability and continuity replication services is critical. At the same time, the data center industry is embracing DCI to dynamically move and geographically extend virtual computing pools for high performance and low cost. Organizations of all sizes are benefiting from the accessibility of interconnected data centers, but replication and backup are the two used predominantly to protect against catastrophic events like weather and electrical outages, as seen in the news recently. The most resilient form of data integrity and accessibility in DCI environments is facilitated through synchronous replication using fibre channel across wave-division multiplexed (WDM) optical networks, typically supplied by third-party carriers.

Synchronous replication is unnecessary for every application within an organization; rather it is typically reserved for applications that require the most stringent, near instantaneous recovery point objectives and recovery time objectives (RPO and RTO) such as those found in the financial, insurance, and telecom industries. Synchronous replication helps to achieve a near-zero RPO because data is simultaneously written to both local and remote volumes. When this type of replication is used, changes made to the source storage array are immediately visible at and propagated to the target storage array (see Figure 1).

Data cannot be written to the source until the target storage array commits and acknowledges the previously written data. Synchronous replication, also called real-time replication, does not require buffering/delay between data committed to both the source and target elements. As a result, synchronous replication requires high-bandwidth/low-latency WAN connections, typical of WDM optical connections. Note that minimal latency increases across these networks can directly correlate to replication performance and, as a result, application performance, see Figure 2.

Transaction processing without synchronous replication is dependent on:
1. End-user processing time
2. Network transport time
3. Host-server processing time
4. SAN transport time
5. Storage-array processing time

Transaction processing with synchronous replication is dependent on:
1. End-user processing time
2. Network transport time
3. Host-server processing time
4. SAN transport time
5. Storage-array processing time
6. WAN transport time
7. Remote-storage processing time

The greatest bottleneck of application performance are the replication components in steps 6 and 7.

Figure 1. Changes to the source storage array are immediately visible at and propagated to the target storage array.

Figure 2. Applications with synchronous replication enabled are critically impacted by DCI performance.
As Figure 2 shows, improper management can negatively impact application performance in a synchronous replication environment. Every bit of data must be written or modified in two separate data centers before the next transaction can occur. No matter how tuned an application, the network that carries the replication data always causes response time constraints.

The Need for Data Storage Visibility

Enterprise and carrier-class switches support the collection of basic traffic and error data for performance monitoring and troubleshooting. However, using these counters to measure performance and isolate the root cause of issues is challenging and often impossible without deeper analysis. While many organizations use and embrace protocol analysis in IP and Ethernet networks, this investigation is less commonly understood or used in storage networks, even in DCI environments with critical business data.

Data that remains within a data center usually has negligible input/output (I/O) latency as part of overall application/database response times because of limited network congestion. With DCI, WAN performance directly impacts I/O performance and, in turn, application/database performance. While storage networks within a data center commonly operate at 4, 8, 10, or even 16 G, DCI WAN connections often deliver much lower bandwidth rates. Furthermore, because third-party network operators often provide the WAN service, issues can arise within their networks from actions such as fiber-route failures, network failover, or poor maintenance. Data center operators must have analysis capabilities to determine the root cause for bottleneck issues arising from such situations.

Unfortunately, pinpointing the source of issues can be complex. There are virtually no I/O or SCSI statistics in networking equipment and no ability to correlate I/O to disk array volumes. For instance, disk array operating systems typically provide abstract information such “Disk Error” messages that mask things like SCSI completion codes, limiting the ability to debug. DCI further exacerbates the challenge as, for instance, WDM combines many logical unit numbers (LUNs) over a single wavelength, making isolation more complex. Put simply, there is no way to monitor I/O performance issues without equipment built specifically to provide detailed visibility.

Introducing the Xgig Analyzer

The Xgig is the industry’s leading solution for storage analysis on fibre channel and Ethernet and networks. Used by most in the storage equipment industry, the Xgig Analyzer is recognized as the gold standard for performance insight with these key capabilities:

- Fibre channel, fibre channel over IP, fibre channel over Ethernet, and Ethernet analysis
- Industry’s best storage analytics
- Redundant link analysis
- Highly accurate timing clock for precise latency measurements
- Simple access to performance metrics like:
  - IOPS by LUN
  - Min/Max/Avg exchange completion time
  - Read and write MB/Sec by LUN
  - Frames/sec by LUN
  - Errors by LUN
- Protocol visibility, including all errors and primitives
- Nonintrusive, 24x7 analysis provided via optical network taps.

Figure 3 shows the various options for the Xgig Analyzer platform.
Viewing DCI Traffic

One of the first things to consider when planning analysis of data storage traffic is placement of the equipment. The best location for DCI environments is close to the carrier demark, typically between the primary data center fibre channel switch and the carrier’s WAN equipment. Placing the Xgig Analyzer in this location provides optimal investigation of I/O exchange latency, carrier throughput, and performance, as shown in Figure 4.

Many metrics are available once you have packet-level visibility in a DCI environment. First, it is best to measure baseline performance for use future when analyzing increases or decreases in service performance. Dozens of metrics can be monitored from this location, three of the top statistics to monitor are:

- Exchanges completed/Sec
- Exchange completion time
- Fibre channel MB/Sec.
Exchanges completed/s

Exchanges completed/s is a metric that represents the exchange completion time for all (as shown in Figure 5) or selected initiator/target pairs. This counter is also commonly referred to as “IO/Sec”. While this does not reflect the potential exchange completion times, it accurately represents the actual performance between data centers. For an even more detailed view, look at the IO/Sec times for different targets to see if variations exist for individual disks.

Exchange completion time

Exchange completion time is measured beginning with the start time of the first frame in the exchange and ends with the time of the last frame in the exchange. The exchange completion time includes latencies for components, fabric, transmission, and fabric congestion. It can be used to indicate how well the infrastructure is operating for similar types of exchanges. Since replication is one type of operation, there should not be a wide variation; however, variations may occur depending on the operations being carried out.

MB/Sec

MB/Sec is a counter calculated from the transfer rate of a frame type. This calculation does not consider unsuccessful or inefficient data transfer; however, it does give a good indication of the actual data rate the link is providing.

Once you obtain a baseline sample of DCI performance, use it to compare samples taken at later dates/times. Figure 6 provides an example of how the baseline on the left can be used to uncover a performance degradation issue later. Users may not recognize the degradation during daily tasks, however, the data center team should know to investigate this type of performance decrease to prevent impactful degradation.
DCI Error Condition

Errored frames preset on the link can have the greatest impact on DCI performance. If they originate from the service provider supplying the WAN connection(s), a follow-up is required to resolve the issue and for possible restitution against service-level agreements (SLAs).

Unlike Ethernet connections, fibre channel errors can provide great detail about the type of issues experienced on the link. The Xgig Analyzer is very easy to set up for the capture of these events when investigating the causes and origination of such problems. Figure 7 shows how to uncover the details of a Loss of Synch event on the service provider’s side.

![Figure 7. Viewing errors and their source](image)

When opening an event with Xgig software, the first indicator of an issue is the histogram at the bottom of the screen showing dropped traffic levels. On a good note, the event seems to have resolved itself over time; however, note the disruption even though it reset itself. The Xgig traffic summary then points out that the link experienced a Loss-of-Sync event that captured a large number of Link Reset frames, originating from the carrier’s side. The event captured by Xgig was a physical connection problem on the service provider’s optical ring. When the problem occurred, the switching fabric reset over to the redundant path for traffic to resume. This is how the carrier’s architecture should handle such an event; however, without the visibility the Xgig Analyzer provides, data center operators would not have known the event occurred. Also, after this type of event, the baseline performance could be reviewed again to see if the secondary path is providing the same level of service that the primary path used originally.

Conclusion

DCI design and implementation is growing and impacting both cloud providers and enterprise organizations. The data transmitted across the WAN links enabling DCI also is increasing due to the growing volume of information that organizations gather and the need to move it continuously between storage systems. Given the expense of provisioning WAN connections for DCI, it is recommended that Enterprise and Cloud data center organizations implement dedicated analysis equipment to deliver storage performance and service as expected. It is also recommended that service providers who deliver network connectivity between data centers use analysis equipment to troubleshoot their infrastructure more effectively and to measure baseline performance against contracted obligations. The Xgig Analyzer is the only equipment on the market that provides this type of visibility, especially when storage systems connected in the DCI are transmitting data using fibre channel or fibre channel over IP across long-distance links.