Storage over the MAN/WAN: How to Choose the Best Solution

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AGENDA

• Application Overview
  • WAN Networking Options & Considerations
  • Deployment Examples
  • Summary
To achieve the maximum performance at the lowest cost, every component of the solution from end-to-end must be considered in the design of the network.

This presentation will focus on the cost optimization of the MAN/WAN networking component.
Requirements Storage Wide Area Networking

• **Cost**
  - Must meet Budget Constraints
  - Often bandwidth make up >50% of the project cost

• **Security**
  - Guaranteed Isolation of Sensitive Data
  - Guaranteed Data Delivery

• **Performance**
  - Minimal Impact on the Application with a High Throughput, Low Latency, and Rapid Restore Times

• **Capacity**
  - Intelligent utilization of network resources

• **High Availability**
  - Five 9’s, with the Ability to Monitor/Report/Protect to Maximize Performance and Perform Rapid Fault Isolation.

• **Flexibility**
  - Support for all Data Types (Storage, Voice, Data, Video) and Applications
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Choices Connecting Data Centers

Deploy Fiber between buildings
  • build your own network (likely using WDM equipment)

Lease a connection from a carrier or service provider
  • likely a SONET service, wavelength service, or an IP service
  • manage your own network, and the gateways

Lease a Managed Storage Service
  • combination of the gateway solution + the connectivity
  • customized SLAs and service features focused on extension
MAN / WAN Options

Private Build or Leased (Campus / Metro only)

1. WDM / Dark Fiber
   - Multiple services on a fiber, high capacity, campus or metro

2. SONET/SDH
   - Secure bandwidth, ubiquitous service access

3. ATM
   - Used by legacy channel extension technology, costly

4. IP
   - Storage mapped into IP packets, usually through TCP/IP

Leased Bandwidth (Campus / Metro / Long-Haul)
Storage over WDM

Today’s Applications

- Fiber relief
- Native protocol carriage (GbE, Fibre Channel, ESCON)
- Virtual Private Network
- Bandwidth Leasing

Characteristics for Storage

- Large capacity (80G in Metro)
- Reach limited to metro distances
- DWDM is cost effective for large # of services and volumes of data (> 10 Gbps)
- CWDM provides a lower cost solution
- Single channel per service regardless of utilization
Channel extenders represent a legacy approach to storage extension

- Support ESCON/FC only neglecting overall data center extension requirement likely including GbE
- ATM mapping adds significant overhead resulting in bandwidth inefficiency
- Extremely high (starting at $80K) pricing
- Adds significant latency to applications not requiring “host emulation” resulting in decreased application performance
IP Storage over IP Networks

- Storage extension over IP networks (e.g. a leased GbE service) is only feasible if very high QoS SLAs can be guaranteed
  - Latency less than 5 ms
  - Packet Delivery Ratio (PDR) of 99.99% or higher
  - TCP can drive a maximum of 100 Mbps over a network with a latency of 5 ms and PDR of 99.99%
- IP networks must be dedicated to SAN extension in order to maximize PDR and minimize latency and even then, they can not support synchronous applications due to their high latency
- Bandwidth must be over-provisioned by up to 50% to account for dropped packets and retransmissions
Storage over SONET / SDH

• What is SONET / SDH?
  – Self-monitored high performance networking technology
  – Ubiquitous network with over 150,000 installed carrier rings
  – Uses Time Division Multiplexing (TDM) to aggregate multiple signals together
  – Standardized rates from 50Mbps – 40 Gbps

• Why SONET / SDH?
  – Guaranteed, high bandwidth
  – Low latency
  – Deterministic
  – Secure, 99.999% availability network
  – Metro and Long Haul networks
  – National and International

SONET/SDH Based Services Perfectly Match the Requirements of Business Continuance Applications
SONET as the Backbone

- 99% of all data traffic goes across the SONET network, including IP
- Native protocols are mapped directly into SONET as soon as they leave the building or campus where they originated

Native Services Are Transported Worldwide Over SONET

<table>
<thead>
<tr>
<th>Bit Rate (Mbits/sec)</th>
<th>Electrical SONET</th>
<th>Optical SONET</th>
<th>SDH Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.84</td>
<td>STS-1</td>
<td>OC-1</td>
<td></td>
</tr>
<tr>
<td>155.52</td>
<td>STS-3</td>
<td>OC-3</td>
<td>STM-1</td>
</tr>
<tr>
<td>622.08</td>
<td>STS-12</td>
<td>OC-12</td>
<td>STM-4</td>
</tr>
<tr>
<td>2488.32</td>
<td>STS-48</td>
<td>OC-48</td>
<td>STM-16</td>
</tr>
<tr>
<td>9953.28</td>
<td>STS-192</td>
<td>OC-192</td>
<td>STM-64</td>
</tr>
</tbody>
</table>
Performance Considerations

- **Latency**
  - Delay introduced by the intermediate equipment (i.e. switches, transport, speed of light in fiber) which slows down the response time of applications

- **Bandwidth**
  - Dedicate enough bandwidth to ensure optimum application performance, but only allocate the required to bandwidth to minimize MAN/WAN costs
  - Choose a storage networking technology that efficiently makes use of expensive MAN / WAN resources

- **Protocol Flow Control**
  - Not have sufficient protocol extension capabilities will leave the application waiting

Latency, Bandwidth and Protocol Flow Control can significantly impact application performance
Latency Sources

1. **Storage Infrastructure**
   - Very small compared with other sources; can be ignored

2. **MAN / WAN Gateway**
   - The time it takes for the gateway to process the frame and send in into the MAN / WAN
   - Can be very significant; varies by vendor
   - With IP, is increased significantly whenever MAN / WAN is shared with other applications

3. **Network Latency**
   - Can dominate overall latency
   - More detail on next slide
## Performance Considerations: Network Latency

### Time of Flight
- Time it takes light to traverse the network
- 5 μsec per km
- 1 ms per 125 miles

<table>
<thead>
<tr>
<th>Technology</th>
<th>Switching Latency</th>
<th>Notes</th>
<th>Impact on Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWDM</td>
<td>&lt;5 μsec</td>
<td>Lowest latency</td>
<td>None</td>
</tr>
<tr>
<td>SONET/SDH</td>
<td>&lt;20 μsec</td>
<td>Low latency</td>
<td>None</td>
</tr>
<tr>
<td>ATM</td>
<td>100s of μsec</td>
<td></td>
<td>Significant</td>
</tr>
<tr>
<td>IP</td>
<td>1000s of μsec</td>
<td>Varies heavily on traffic load, quality of IP service, bandwidth contention</td>
<td>High</td>
</tr>
</tbody>
</table>

Element Switching

Data Center → Data Center

**Notes**
- **Switching Latency**
- **Time of Flight**
- 5 μsec per km
- 1 ms per 125 miles

**Technology**
- DWDM
- SONET/SDH
- ATM
- IP
Performance Considerations: Bandwidth

• Bandwidth tradeoff between cost and application performance:
  – Cost:
    • MAN/WAN networking can be up to 50% of the BC/DR application cost
    • Minimize the bandwidth used through:
      – Data Compression
      – Efficient Mapping
      – Application Consolidation over a single WAN
  – Performance
    • Need to consider the actual throughput of data
    • Need to guarantee application isolation and efficient delivery of data
    • If not enough bandwidth is allocated, or too much contention in the network, a bottleneck to the application will occur

Optimum Solution:
Bandwidth Allocated = Application Requirement
Performance Considerations: Packet / Cell Loss

- Lost packet results in cutting throughput in half
- Throughput slowly recovers over time
- Similar effects with other IP and ATM Storage Solutions

Due to lost packets and retransmissions, goodput is artificially limited

Performance of Storage Across IP and ATM Infrastructures is Significantly Affected by Loss
## Performance Considerations: Protocol Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Storage over ATM</th>
<th>Storage over IP</th>
<th>Storage over SONET/SDH</th>
<th>DWDM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mapping</strong></td>
<td>Multiple Layers</td>
<td>Multiple Layers</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td><strong>Mapping Efficiency</strong></td>
<td>80%</td>
<td>90%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Protocol Support</strong></td>
<td>FC, ESCON, GbE</td>
<td>no ESCON Support</td>
<td>FC, ESCON, GbE</td>
<td>FC, ESCON, GbE</td>
</tr>
<tr>
<td><strong>Retransmission due to loss</strong></td>
<td>Limits performance</td>
<td>Severely impacts performance</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Isolated</td>
<td>Shared</td>
<td>Secure Layer 1 Isolation</td>
<td>Secure Layer 0 Isolation</td>
</tr>
</tbody>
</table>
Performance Considerations: Protocol Flow Control

- Each credit(r_rdy) carries one FC/FICON frame
- A FC/FICON frame cannot be sent until an r_rdy is received
- The receiving device allocates the credits to the sending device

As the distance is increased, a set number of credits can’t fill the pipe
Throughput degrades significantly as distance is increased

Rule of Thumb:
For every credit you get approx 2 km of max throughput
## Performance Considerations: Cost vs. Performance

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cost of Equipment</th>
<th>Cost of Service</th>
<th>Bandwidth</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>WDM</td>
<td>$$</td>
<td>$$</td>
<td>Gbps</td>
<td><strong>High</strong> - Guaranteed, never changes</td>
</tr>
<tr>
<td>SONET/SDH</td>
<td>$</td>
<td>$$</td>
<td>Mbps to Gbps</td>
<td><strong>High</strong> - Guaranteed, never changes</td>
</tr>
<tr>
<td>ATM</td>
<td>$$$</td>
<td>$$</td>
<td>&lt;= 150 Mbps</td>
<td><strong>Med</strong> : Varies based on ATM service type (CBR, VBR)</td>
</tr>
<tr>
<td>IP – Native IP Service</td>
<td>$</td>
<td>$</td>
<td>No guarantees</td>
<td><strong>Low</strong>: Varies over time, bandwidth contention of the entire IP network</td>
</tr>
<tr>
<td>IP – Router with PoS interface</td>
<td>$$</td>
<td>$$</td>
<td></td>
<td><strong>Med</strong>: Varies over time, bandwidth contention with other services on the same router</td>
</tr>
</tbody>
</table>

Storage over SONET/SDH and WDM are the Best Options for Extending Business Continuance Applications
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Deployment Example: DWDM and Storage over SONET

- **Applications:**
  - Geo-Clustering, Disk Mirroring and Remote Tape via Fibre Channel and Gigabit Ethernet
  - Enterprise has access to one pair of fiber

- **Why the customer choose DWDM & Storage over SONET:**
  - DWDM provided extremely low latency and significant capacity
  - 2.5 Gbps today scaling to 80 Gbps
  - Leased a SONET OC-3 service as a backup
Deployment Example: Storage over SONET

Storage over IP over Router with PoS (Packet over SONET)

Storage over SONET

• Applications:
  – HP Continuous Access via Fibre Channel, LAN via GbE
• Why the customer choose Storage over SONET:
  – > 50 % capital cost savings
  – 2X improvement in WAN utilization
  – Detailed performance monitoring of services and WAN
Deployment Example: Data Migration with Storage over IP

- Applications:
  - Remote Storage via Fibre Channel
- Why did the customer select Storage over IP:
  - LAN connectivity existed between these two locations
  - No significant time restrictions for the migration
  - Storage over IP allowed the migration to use the WAN when bandwidth is available
Deployment Example: Aggregation over Carrier Managed Service

- **Applications:**
  - Enterprise is planning on leasing wavelengths from a service provider
  - Utilize Storage over SONET to aggregate multiple services over each DWDM wavelength

- **Values to the Enterprise:**
  - Cut down reoccurring bandwidth costs by >60%
  - Improve performance monitoring and fault isolation
  - Augment the DWDM with buffer credit extension
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Summary

• Costs due to WAN extension dominate the business case for BC/DR solutions

• Solutions vary greatly based on cost, performance, security and data availability targets – there is no single answer

• Carriers and Service providers must be leveraged for solutions beyond fiber only

• New products are available that both simplify the deployment of, and help drive down the costs associated with distance solutions for storage extension