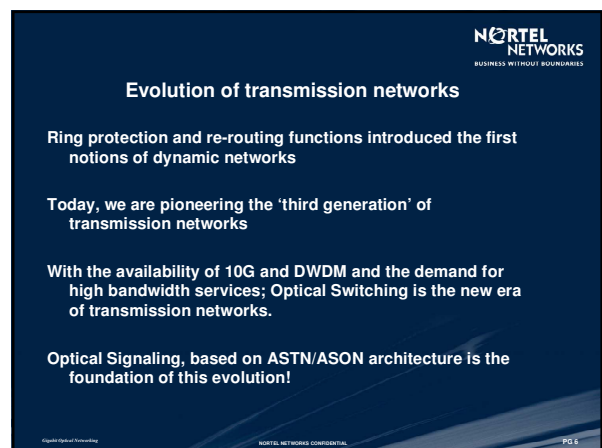
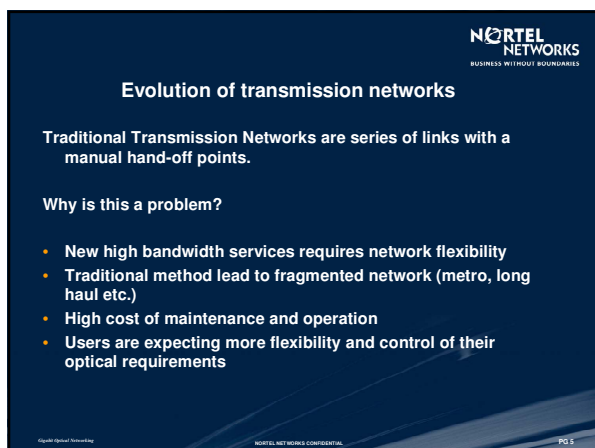
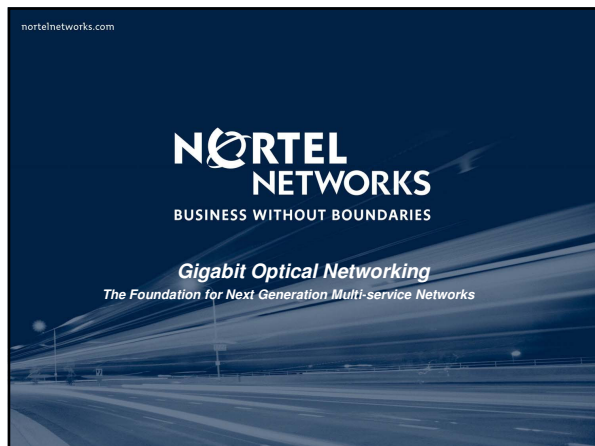
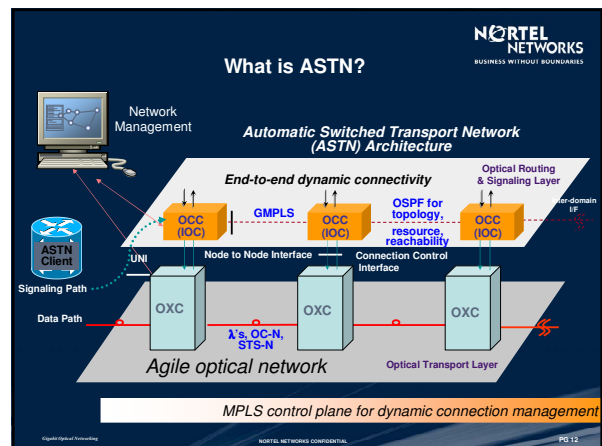
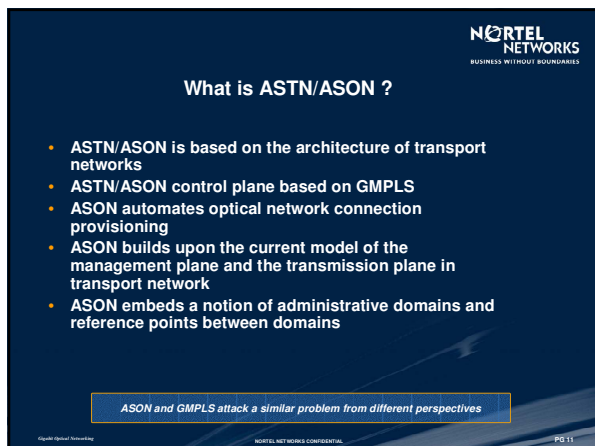
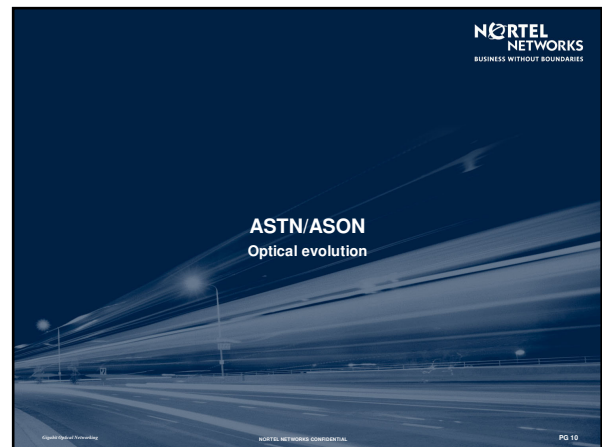
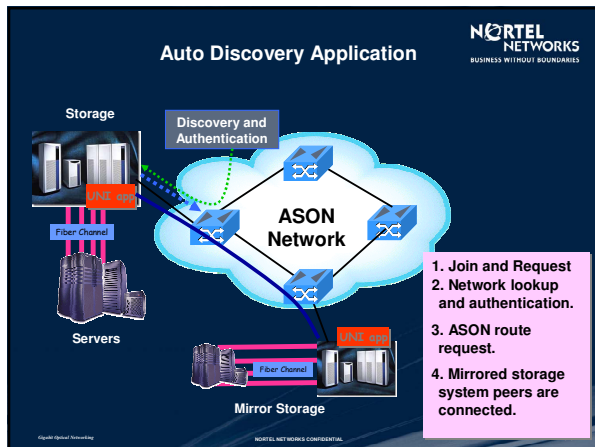
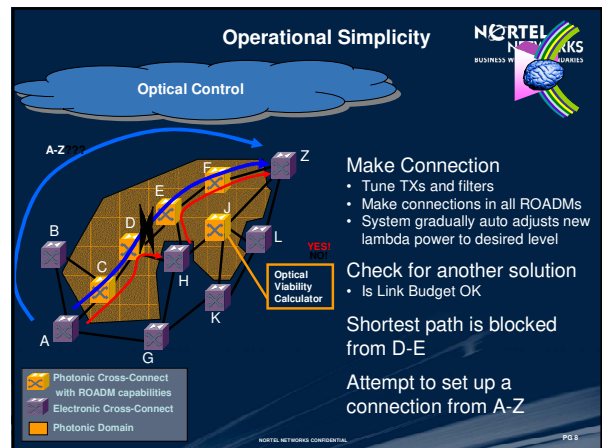
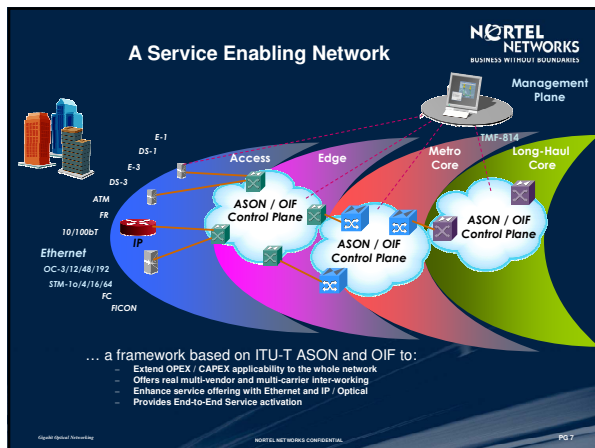
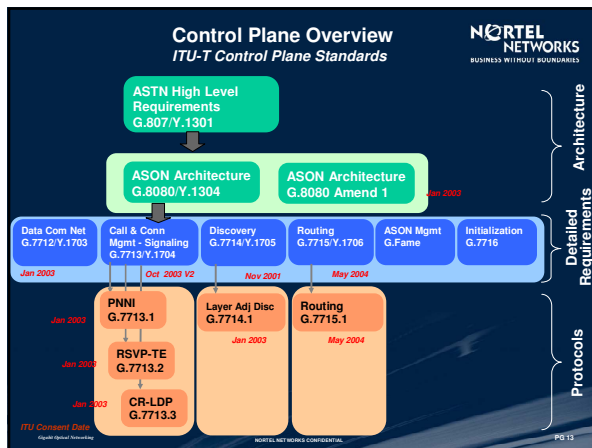








Extensions to the MPLS standard

- Packet-switch capable (PSC) interface
- Time-division-multiplex capable (TDMC) interface
- Lambda switch capable (LSC) interface
- Fibre-switch capable (FSC) interface

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PG 14

Definition 1 (GMPLS)

IP on Optics

- Direct use and visibility of optical transport and photonics for IP carriage.
- Usual interpretation of "optical internet" amongst L3/L2 folks.
- Examples
 - IP on POS links, IP on DWDM, Work in IP over Optics BOF

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PG 15

Definition 2 (ASON)

IP for Optics

- Use of IP control protocols for optical transport and photonic path control (a.k.a. Intelligent Optical Networks).
- Common interpretation of "optical internet" amongst L1/L0 folks.
- G.ASON and OIF O-UNI are examples of work.

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PG 16

Benefits of ASON

ASON supports the separation of transmission and control

- Control plane and management plane have separate views transmission ports
- The control plane can fail without affection transmission

ASON relies on strict separation between transmission, control, and management to maintain existing transport reliability

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PG 17

Separating the customer from the network

- **Calls and connections**
 - ASON supports the separate concepts of call and connection
 - A call is an association between users or between networks and may embody any number of connections
 - A connection is an association between two ports for the transport of user information over a series of links
- **Addressing**
 - ASON assigns a (public) address to a UNI link
 - Customer and network addresses are in different spaces
- **Routing**
 - ASON disallows routing at the UNI reference point

ASON is suitable for public transport connectivity services because of adequate separation between the customer and the network

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PG 18

Control Plane Call Provisioning Overview

Optical Manager EMS

Successful creation of circuit between A & Z points

- 1) Select Call Attributes:
 - Source / Ingress point
 - Dest. / Egress point
 - Bandwidth
 - CoS
 - Cost / Metric2 ...
- 2) Select "Activation"

- Call Management GUI available for control plane call provisioning:
 - Simple point&click operations
 - Supports all Class of Service (CoS)
 - Supports explicit and implicit routing
- Automated route selection, based on constraint-based routing
- Call provisioning request is sent to the source NE (OCC entity)

PG 19

Protection & Restoration (CoS)

APS	Dedicated	Shared	Dynamic	Unprotected
50 msec	50 msec	Up to 200 msec	Secs	N/A
APS Protection	Mesh Protection	Mesh Protection	Mesh Restoration	No Protection
- Standard APS - Linear - Fast switching - Highest Availability (function of network Engineering) - Fit with current PMO - At least half of the network capacity is reserved for protection	- Predetermined and reserved backup for fast switching (no sharing) - Revertive - Fast switching - High availability - At least half of the network capacity is reserved for protection	- Predetermined & configured backup for fast switching - Revertive - Sharing over segments w/o common risks - SONET like performance & behavior - Availability function of network Engineering	- Restoration paths are dynamically created (not predetermined) - Revertive - High sharing - Slower restoration time - Restoration & availability function of network Engineering	- Unable to restore at transmission layer - Lowest cost & availability

- Additionally, Mesh Restoration can be applied over any protection as a 2nd level
- Link Protection Mechanism offers the flexibility & simplicity to engineer Availability

PG 20

APS SONET/SDH Protection

Linear / Ring + Mesh Restoration

- Standard based Linear, 2-F/4-F BLSR / MS-SPRing, UPSR / SNCP Protection for fast switching (< 50 msec)
- Optionally, mesh restoration can be applied at the connection level (2nd level)
 - Mesh restoration is independent for the APS SONET/SDH Protection
 - Upon path failure, control plane re-route connection on any "spare"/available capacity
 - Restoration works like a dynamically Mesh restored service (revertive behavior)

PG 21

Shared Mesh Protection

- Mesh Protection defined on a Tunnel / logical facility (bundling)
- Protection Tunnel is pre-determined and shared (on a per link basis)
- W & P build by control plane, however protection switch doesn't require any control plane assistance

Delivering a High Performance Mesh Network!

PG 22

Mesh Restoration

- Rapid Failure Detection
- Dynamic restoration for best survivability and efficiency
- Simple & Robust Restoration Algorithm
- Higher Availability & Robustness could be achieved by using mesh restoration or protection & restoration with proper spare capacity to survive multiple failures

PG 23

GMPLS clients: Embedding GMPLS-overlay in ASON

For GMPLS clients, GMPLS-overlay per IETF draft can be implemented on top of ASON

PG 24

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Trend in advanced optical networks (servicing the R&D community)

PG 25

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Trends in optical R&D networks

- CANARIE – CA*net4
- CANARIE supports research in such fields as astronomy, bioinformatics and high energy physics
- As part of a recent network upgrade, Nortel Networks Optical Multiservice Edge 6500 was chosen for CA*net4
- CANARIE's User Controlled Lightpath software, a feature of CA*net 4 gives end users the ability to provision, partition and allocate network links to other users without involving a central management organization

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Trends in optical R&D networks

- SURFnet - a world leading educational and research network organization in The Netherlands
- Operates the national research network, to which over 150 institutions in higher education and research in the Netherlands are connected.
- Delivering hybrid IP-Optical technologies for the high-speed networking requirements of academic and scientific member organizations
- SURFnet will utilize the latest optical technology from Nortel Networks, including Optical Multiservice Edge 6500, as well as a next generation Common Photonic layer

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Trends in optical R&D networks

- OMNInet - a collaborative experimental network designed to assess and validate next generation optical technologies.
- OMNInet is based on leading-edge photonic technology, including lambda switching.
- Focus on:-
 - Trials of highly reliable, scalable 10GE in metropolitan and wide area networks
 - Trials of new technologies for applications that require extremely high levels of bandwidth (computational science and ultra-high resolution digital imaging) – "DWDM-RAM"
 - Development and trial of optical switching

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Enabling technology

PG 29

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Three major components

- Flexible Optical Layer.
- Edge device to provide multiple services and allow efficient capacity management.
- Flexibility points in the network to service lambda switching and cross connection requirements.

PG 30

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Enabling technology
Common photonic layer

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Scalability

- Metro, Regional, Long Haul support
- Foreign wavelength support (Non Nortel)
- Hitless Expansion
- Lowest IFC, modular growth

Challenges

Major/HQ Site Domain

Operational Simplicity

- Automatic λ Activation
- Dynamic Continuous System Optimization
- SLAT and Planning Automation
- Remote Configurability

Flexibility

- Single λ granularity
- OADM Modularity (Any λ , Anywhere)
- Optical Branching
- Remote Reconfigurable OADM

Enabling Profitable Broadband Services Delivery

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Scalability

Build Out metro and regional builds on same fiber

Hitless Expansion

- Auto Discovery
- Auto Tuning
- Auto Inservice
- Dynamic System Optimization

Add new Lambda Inservice

- Auto Discovery
- Auto Tuning
- Auto Inservice
- Dynamic System Optimization

Deploy Line

Support Non Nortel Sources – Foreign Wavelength
Maintain Hitless Expansion
Link Budget integrity preserved

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Innovation Roadmap... continuing leadership

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ASTN

Next Generation Modulation

Remotely Configurable OADM

Foreign λ support

- Multi-vendor
- Guaranteed Link budgets

- All Optical Dynamic lambda access
- Reduction in optical patch cords

- Per Lambda Dispersion Compensation
- Compensate when necessary

- Fast end to end provisioning
- Intelligent restoration

- Future proof
- 4 times Spectral Efficiency improvement
- Fiber quality agnostic

Investment in the Future

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Enabling technology
Multi-service provisioning platforms

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Optical Connectivity Services

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Business Continuity

Storage Services

Voice Services

IP-VPN

LAN Extension

Internet Access

Enabled Services

Optical Broadband Services				
Traditional Private Line	Managed Wavelength Service	Storage Connectivity	Optical Ethernet	FR / ATM

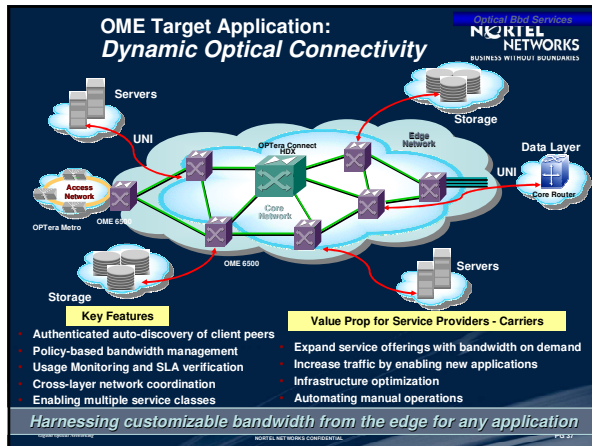
Connectivity Services

DWDM/CWDM	SONET/SDH	Layer 2 Switching
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Infrastructure

Filling the Gap with Optical, Storage, and Ethernet Connectivity

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Nortel Networks Optical Multiservice Edge 6500

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Global Services Platform

SDH/SONET & DWDM
Single depth (12"/), 19" wide
4 shelves per Std. 7' bay/2.2m rack
Front, rear or top cooling
Front or Rear access

Product Flexibility

BLSR/MS-SPRing, UPSR/SNCP, 1+1, Mesh
ASTN, GFP, VCAT, LCAS, RPR, L2 Switching
Service head-end, Fiber relief
Central office consolidation
Large CLE/CPE

Service Diversity

High density mixed service
OBS: OTR/GE/FE/10BT/FC/FICON
Protocol Independent Transport
STM-64/16/4/10, OC-192/48/12/3,
E-3/E-1 & STM1e, DS-3/DS-1, 1+1, 0:1, 1:1

Product Scalability

Line rate scalable –nx2.5G-10G
32 λ scaleable to 64 λ
Scaleable to 160/320G switch capacity
Non-blocking VC-12/VC-4/3 or VT-1.5/STS
Switching architecture

Optical Convergence Platform

Delivering Service Versatility and Richness

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Enabling technology

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Connect HDX

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Connect HDX/HDXc Optical Switch Description

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- ✓ **Multi-Terabit Switching Capability**
 - Non-blocking STS-1/VC-4 Switch Core
 - HDX: 640G to 1.28T Single shelf model
 - HDXc: 320G Single Shelf model
 - 3.84Tbps Multi-Shelf
 - High Density Optical Interfaces (including integrated DWDM)
 - Smart OXC enabling Next Generation Networking
 - Autodiscovery Resources, Topology & Services
 - ITU-T G.807/ASTN and G.8080/ASON - based
 - Distributed & Integrated Control Plane, Signalling
- ✓ **Multi-Services Management**
 - Any port to any port connections
 - STS-1/VC-4 to STS-192c/VC-4-64c
 - 40G Ready
 - Transparent services
 - Rapid Service Delivery
 - Smart OS/control plane for automated provisioning
- ✓ **Flexible service restoration capabilities and topologies**
 - Mesh, Ring, Linear
 - Restoration based on service attributes
- ✓ **Global Platform**

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Summary

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- Traditional method lead to fragmented network (metro, long haul etc.)
- Users are expecting more flexibility and control of their optical requirements
- Traditional operation of Transmission Networks are unable to handle new demands placed on them
- New high bandwidth services that require network flexibility are becoming essential
- High cost of maintenance and operation is unacceptable and unsustainable

ASON separates the user from the network but allows control of their optical network requirements

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Summary

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- ASON Enabling technologies unify the transmission network
- ASTN/ASON delivers the provision power to the customer
- ASTN/ASON uses the best of layer 0 with the best of layer3
- ASON complements existing optical network architectures and adds flexibility
- ASON provides operational simplicity

ASON separates the user from the network but allows control of their optical network requirements

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Applications

Grid computing

PG 43

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DWDM-RAM for Grid Computing

"Advances in Grid technology enable the deployment of data-intensive distributed applications, which require moving Terabytes or even Petabytes of data between data banks. The current underlying networks cannot provide dedicated links with adequate end-to-end sustained bandwidth to support the requirements of these Grid applications."

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Grid Computing

Bulk data transfer oriented grid computing requires quality of service

- Guaranteed minimum bandwidth
- minimized packet loss

Grid developers have been using IntServ and DiffServ approaches to obtain QoS in packet switching networks – not perfect

Wavelength switching Optical networks have the potential change the way networks are used in Grid computing.

PG 45

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Time (s)	Packet switched (300 Mbps)	Lambda switched (500 Mbps)	Lambda switched (750 Mbps)	Lambda switched (1 Gbps)	Lambda switched (10Gbps)
0	0	0	0	0	0
20	~500	~1000	~1500	~2000	~2500
40	~1000	~2000	~3000	~4000	~4500
60	~1500	~3000	~4500	~5500	~6000
80	~2000	~4000	~6000	~7000	~7500
100	~2500	~5000	~7500	~8500	~9000
120	~3000	~6000	~9000	~10000	~10500

Packed Switched vs. Lambda Network --Setup time tradeoffs.

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Grid Computing

A main concern about wavelength switched optical networks is the overhead incurred during the end-to-end path setup.

Since Grid applications usually transfer huge data sets, it is clear that the time for the path setup is negligible in Grid computing.

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Large File Transfer

File Size (MB)	Setup time / Total Transfer Time (%)
100	~95%
1000	~85%
10000	~40%
100000	~10%
1000000	~5%
10000000	~2%

Assuming a setup time of 48 sec and a bandwidth of 920 Mbps the threshold is 500 GB

PG 48



Reference

- **DWDM-RAM: Enabling Grid Services with Dynamic Optical Networks.** – Figueira(1), S. Naiksatam(1), H. Cohen(2), D. Cutrell(2), P. Daspi(2), D. Gutierrez(3), D. B. Hoang(4), T. Lavian(2), J. Mambretti(5), S. Merrill(2), F. Travostino(2).
- (1)Santa Clara University, (2)Nortel Networks Labs, (3)Stanford University, (4)University of Technology, Sydney, (5)CAIR and Northwestern University.

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- **MPLS and ASTN(Extending multiprotocol label switching for automatically switched transport networking)** - Published by: Nortel Networks-Marketing Publications Dept. 0526 P.O. Box 13010
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- **ASTN Overview** - Dr. Bilel Jamoussi

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Questions?

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