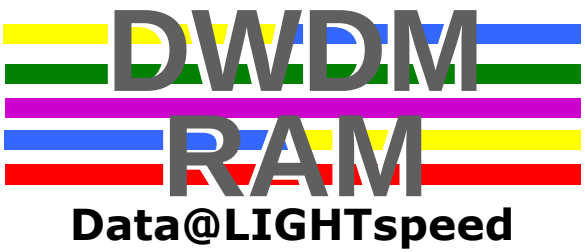

DWDM-RAM: DARPA-Sponsored Research for Data Intensive Service-on-Demand Optical Networks

Tal Lavian, Guo-Qiang Wang, Franco Travostino, David Gutierrez, Doug Cutrell, Howard Cohen, Guoli Yin, Inder Monga, Steve Merrill, Hal Edwards, Paul Daspit; Nortel Networks

Joe Mambretti, Aaron Johnson, Jeremy Weinberger, Fei Yeh, Jim Chen;
International Center for Advanced Internet Research (iCAIR)

Sumit Naiksatam, Silvia Fugueira; Santa Clara University

Doan Hoang; University of Technology, Sydney

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Challenge: Emerging data intensive applications require:

Extremely high performance, long term data flows
Scalability for data volume and global reach
Adjustability to unpredictable traffic behavior
Integration with multiple Grid resources

Response: DWDM-RAM - An architecture for data intensive Grids enabled by next generation dynamic optical networks, incorporating new methods for lightpath provisioning

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DWDM-RAM: An architecture designed to meet the networking challenges of extremely large scale Grid applications. Traditional network infrastructure cannot meet these demands, especially, requirements for intensive data flows

DWDM-RAM Components Include:

Data management services
Intelligent middleware
Dynamic lightpath provisioning
State-of-the-art photonic technologies
Wide-area photonic testbed implementation

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Data Management Services

OGSA/OGSI compliant
Capable of receiving and understanding application requests
Has complete knowledge of network resources
Transmits signals to intelligent middleware
Understands communications from Grid infrastructure
Adjusts to changing requirements
Understands edge resources
On-demand or scheduled processing
Supports various models for scheduling, priority setting, event synchronization

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Intelligent Middleware for Adaptive Optical Networking

OGSA/OGSI compliant
Integrated with Globus
Receives requests from data services
Knowledgeable about Grid resources
Has complete understanding of dynamic lightpath provisioning
Communicates to optical network services layer
Can be integrated with GRAM for co-management
Architecture is flexible and extensible

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Dynamic Lightpath Provisioning Services

Optical Dynamic Intelligent Networking (ODIN)
OGSA/OGSI compliant
Receives requests from middleware services
Knowledgeable about optical network resources
Provides dynamic lightpath provisioning
Communicates to optical network protocol layer
Precise wavelength control
Intradomain as well as interdomain
Contains mechanisms for extending lightpaths through
E-Paths - electronic paths

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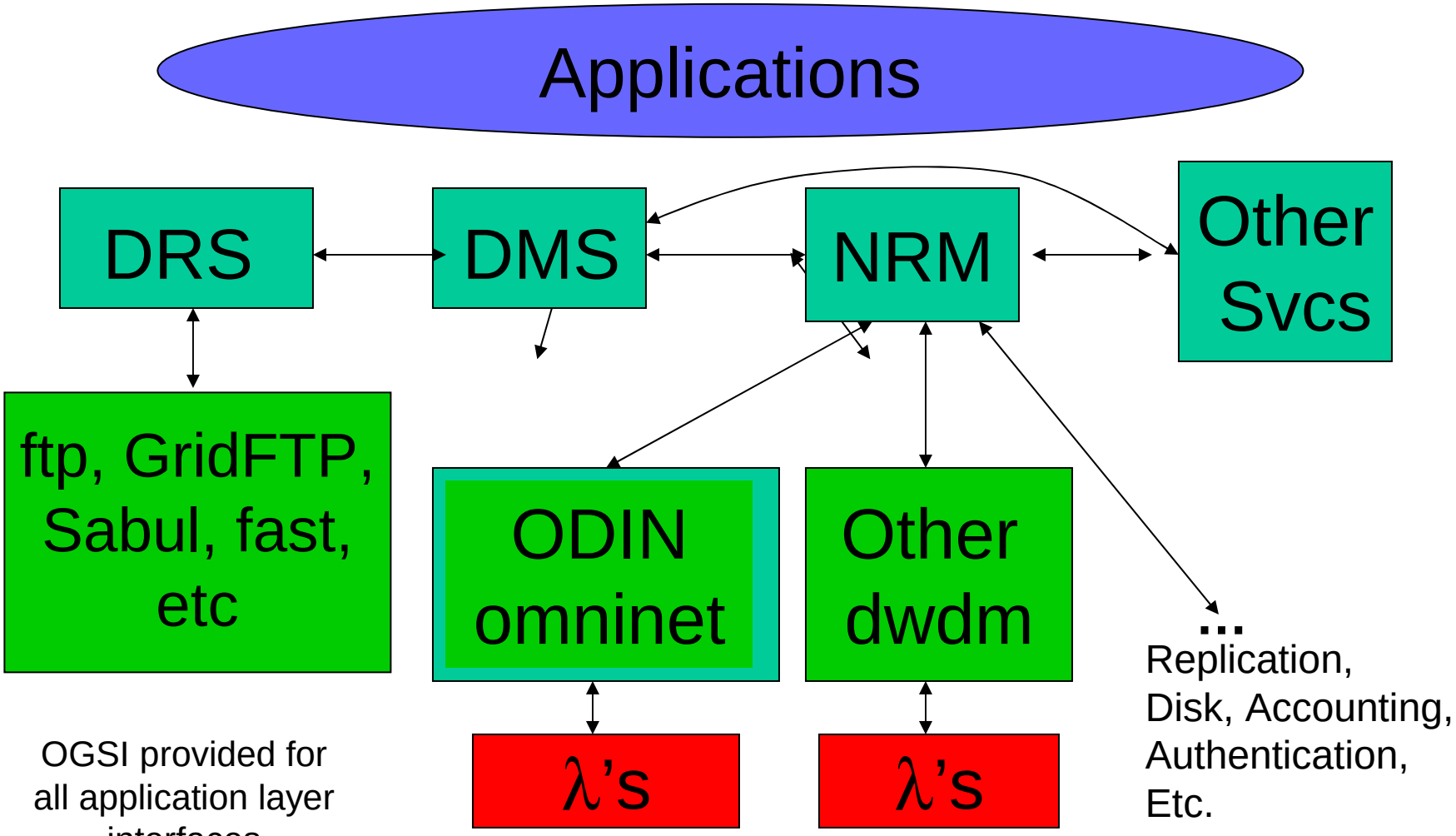
Architecture



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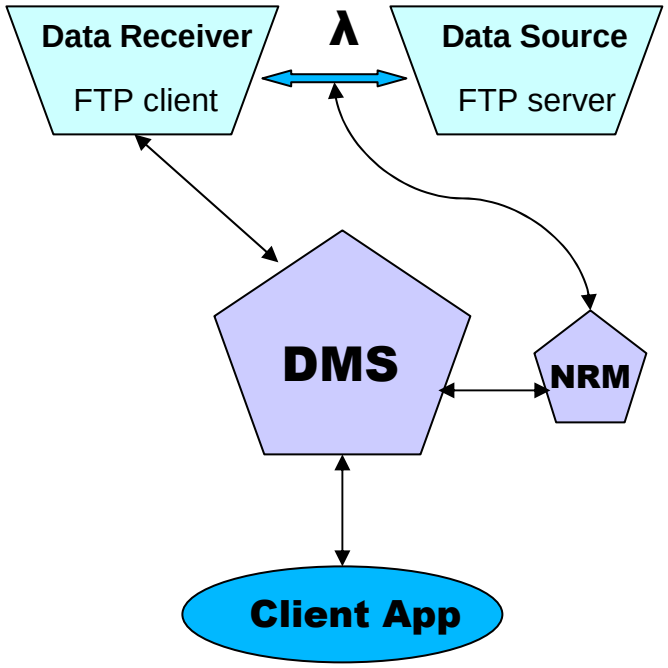
Data Management Service

- Uses standard ftp (jakarta commons ftp client)
- Implemented in Java
- Uses OGSI calls to request network resources
- Currently uses Java RMI for other remote interfaces
- Uses NRM to allocate lambdas
- Designed for future scheduling



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Lightpath Services

Enabling High Performance Support for
Data-Intensive Services With On-Demand Lightpaths Created By Dynamic Lambda Provisioning, Supported by Advanced Photonic Technologies

OGSA/OGSI Compliant Service
Optical Service Layer: Optical Dynamic Intelligent Network (ODIN) Services
Incorporates Specialized Signaling
Utilizes Provisioning Tool: IETF GMPLS
New Photonic Protocols

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ODIN

Optical Dynamic Intelligent Networking Services:
An Architecture Specifically Designed to Support Large Scale, Data Intensive, Extremely High Performance, Long-Term Flows

OGSA/OGSI Compliant Service
Dynamic Lambda Provisioning Based on DWDM
Beyond Traditional Static DWDM Provisioning
Scales to Gbps, Terabits Data Flows with
Flexible, With Fine-Grained Control

Lightpaths: Multiple Integrated Linked Lambdas, Including
One to Many and Many to One, Intradomain/Interdomain

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Lightpath Provisioning Processes

Specialized Signaling

Request Characterization, Resource Characterization, Optimization, Performance, and Survival/Protection, Restoration, Characterization

Basic Processes Are Directed at Lightpath/λ Management:

Create, Delete, Change, Swap, Reserve

And Related Processes:

Discover, Reserve, Bundle, Reallocate, etc.

IETF GMPLS As Wavelength Implementation Tools

Utilizes New Photonic Network Protocols

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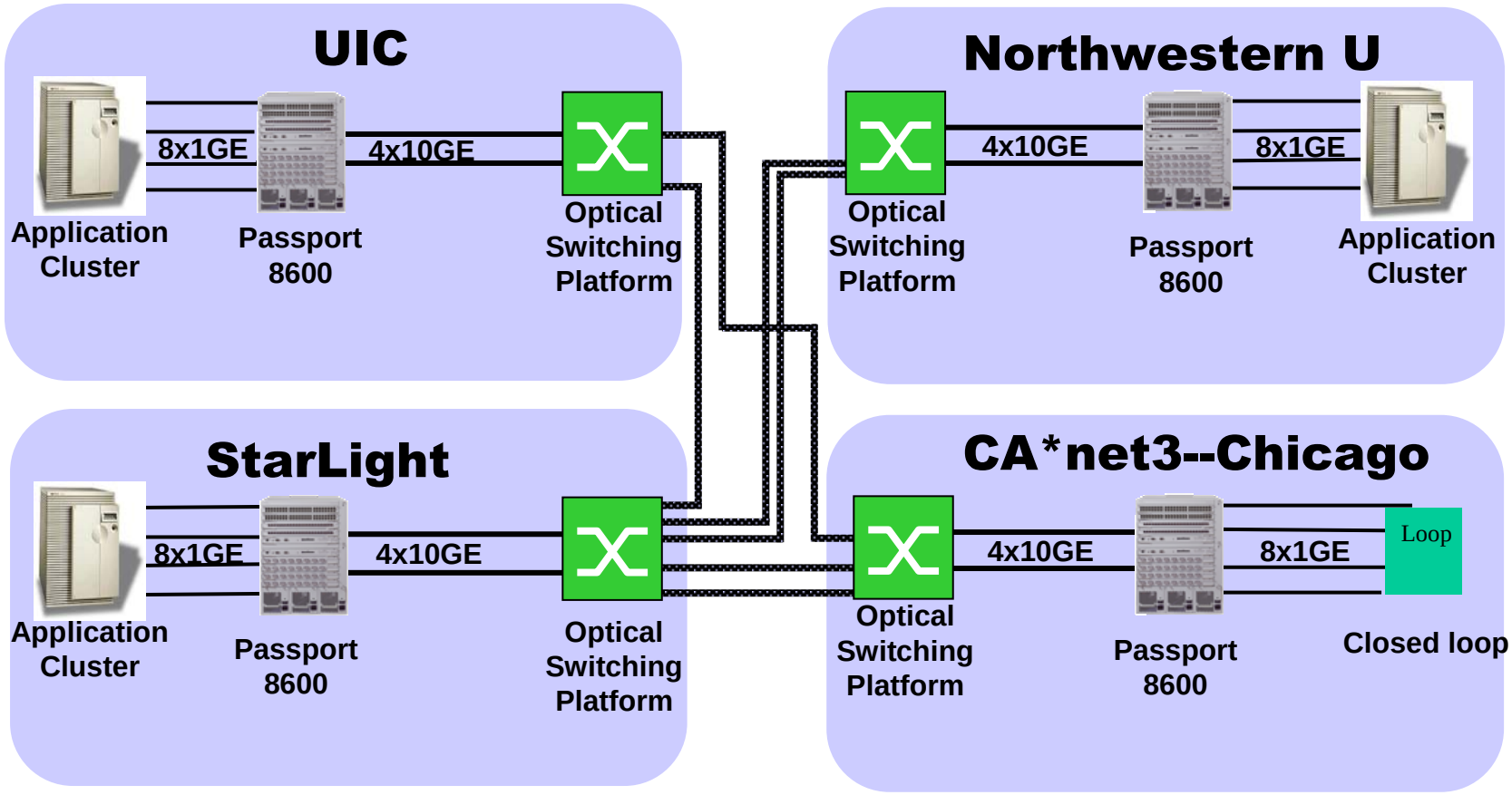
OMNInet Core Nodes



- **A four-node multi-site optical metro testbed network in Chicago -- the first 10GE service trial!**
- **A test bed for all-optical switching and advanced high-speed services**
- **OMNInet testbed Partners: SBC, Nortel, iCAIR at Northwestern, EVL, CANARIE, ANL**

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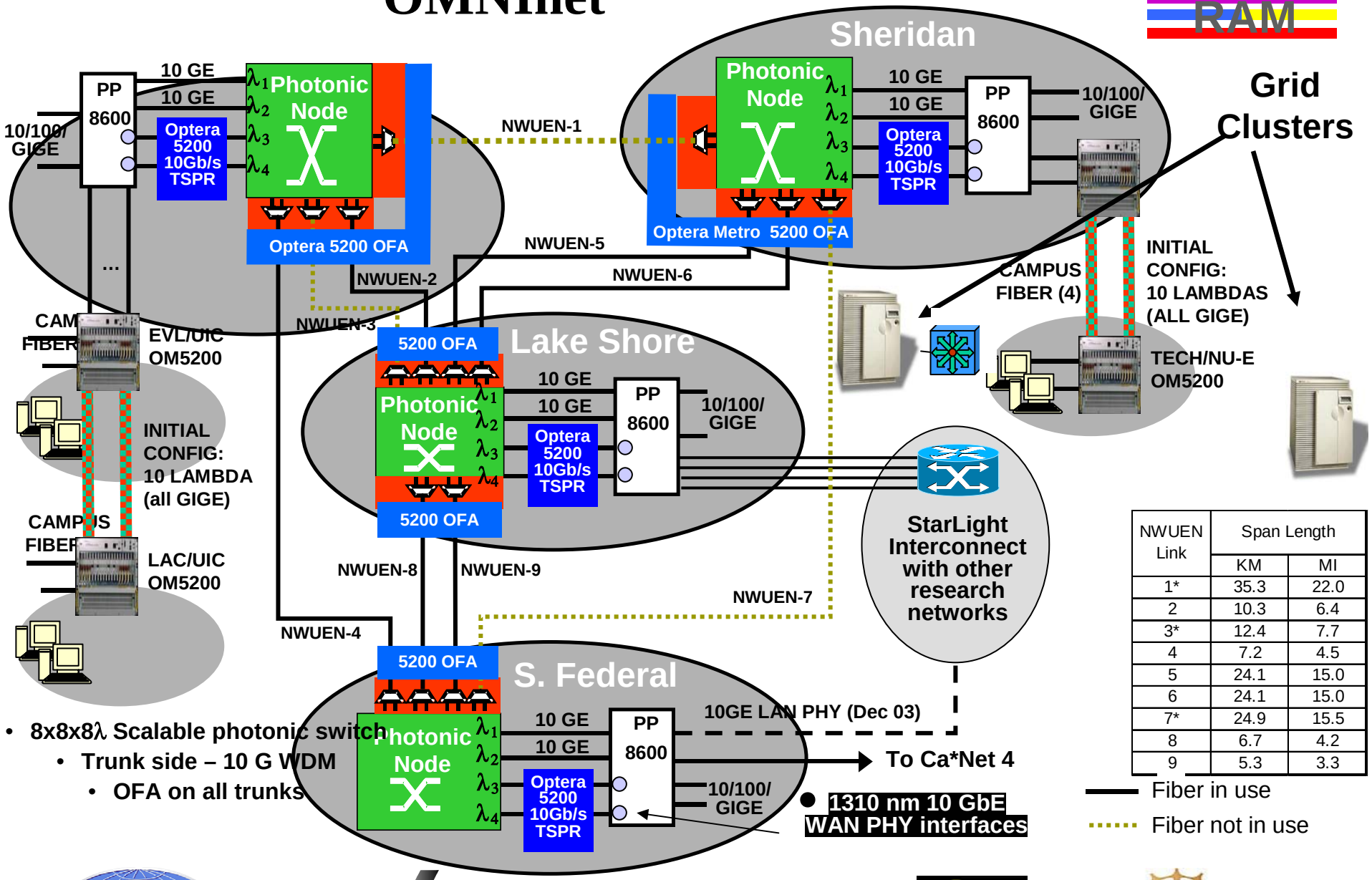
OMNInet



NWUEN Link	Span Length	
	KM	MI
1*	35.3	22.0
2	10.3	6.4
3*	12.4	7.7
4	7.2	4.5
5	24.1	15.0
6	24.1	15.0
7*	24.9	15.5
8	6.7	4.2
9	5.3	3.3

- 8x8x8λ Scalable photonic switch
  - Trunk side – 10 G WDM
    - OFA on all trunks

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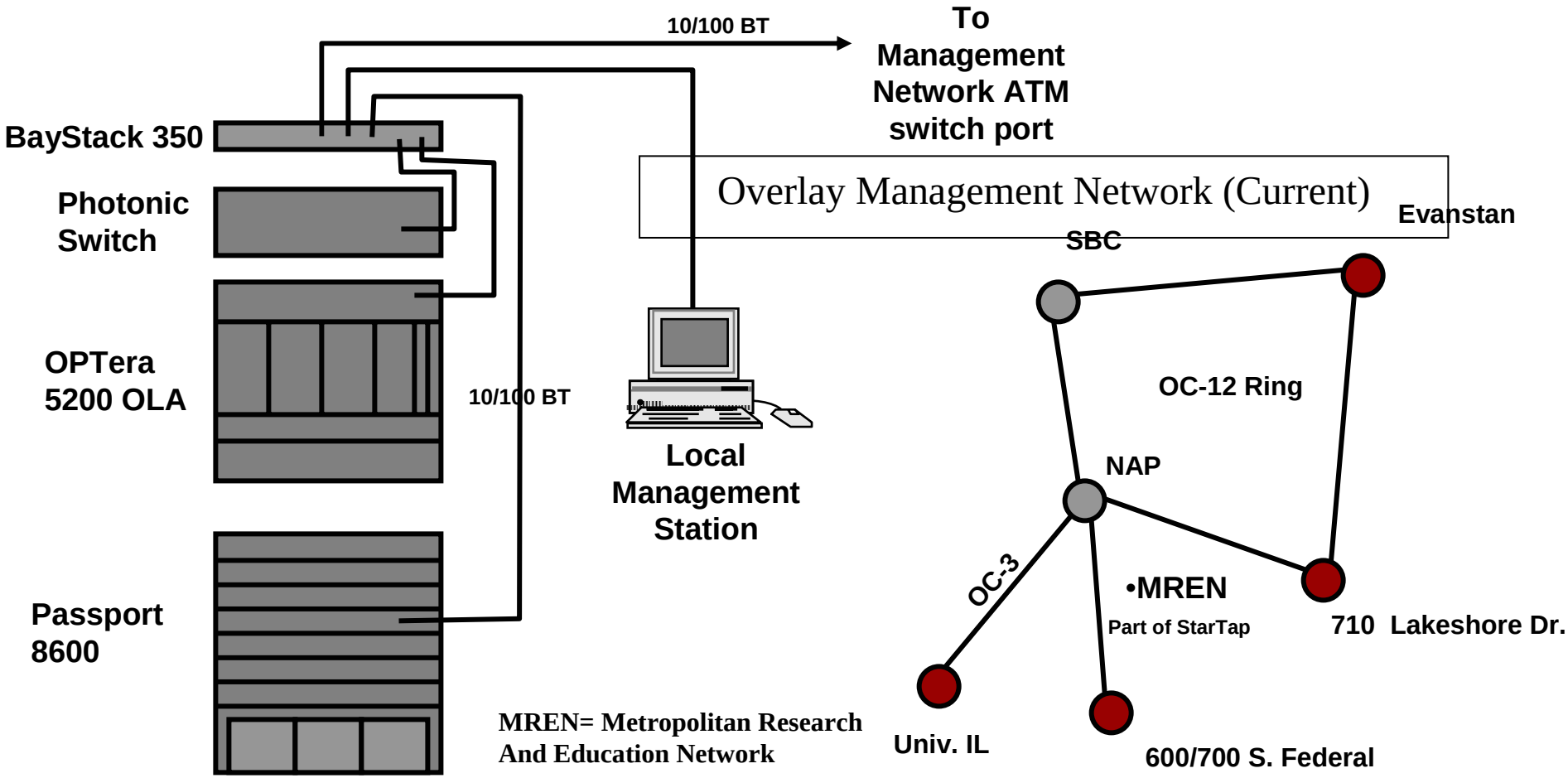
NTONC National Transparent Optical Network Consortium

NORTEL NETWORKS

iCAIR

NSF

OMNInet Control Plane Overlay Network



- Uses ATM PVC with 2 Mb/s CIR from existing network (MREN + OC12)
- Hub and spoke network from 710 Lakeshore Dr.

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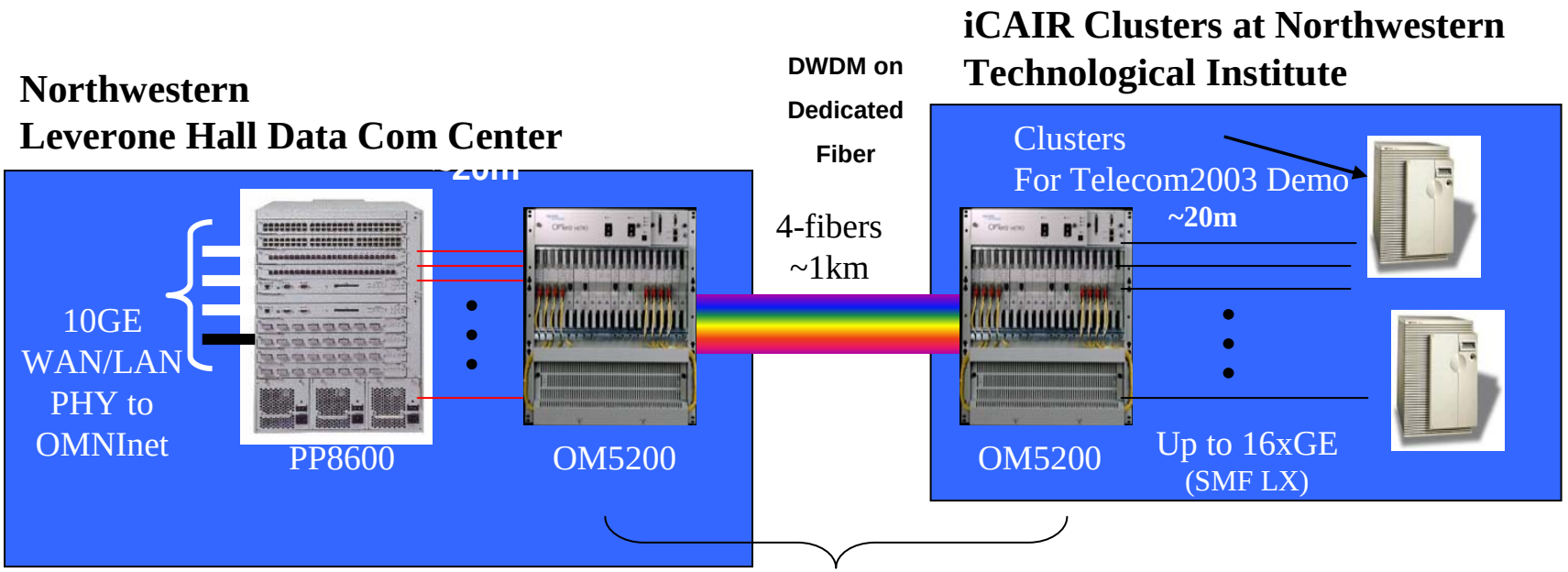
OMNInet Optical Grid Clusters



DWDM Between Cluster Site and OMNInet Core Node at iCAIR sites at Northwestern in Evanston

- The implementation is lambdas (unprotected).
- Installed shelf capacity and common equipment permits expansion of up to 16 lambdas through deployment of additional OCLD, and OCI modules.
- A fully expanded OM5200 system is capable of supporting 64 lambdas (unprotected) over the same 4-fiber span.

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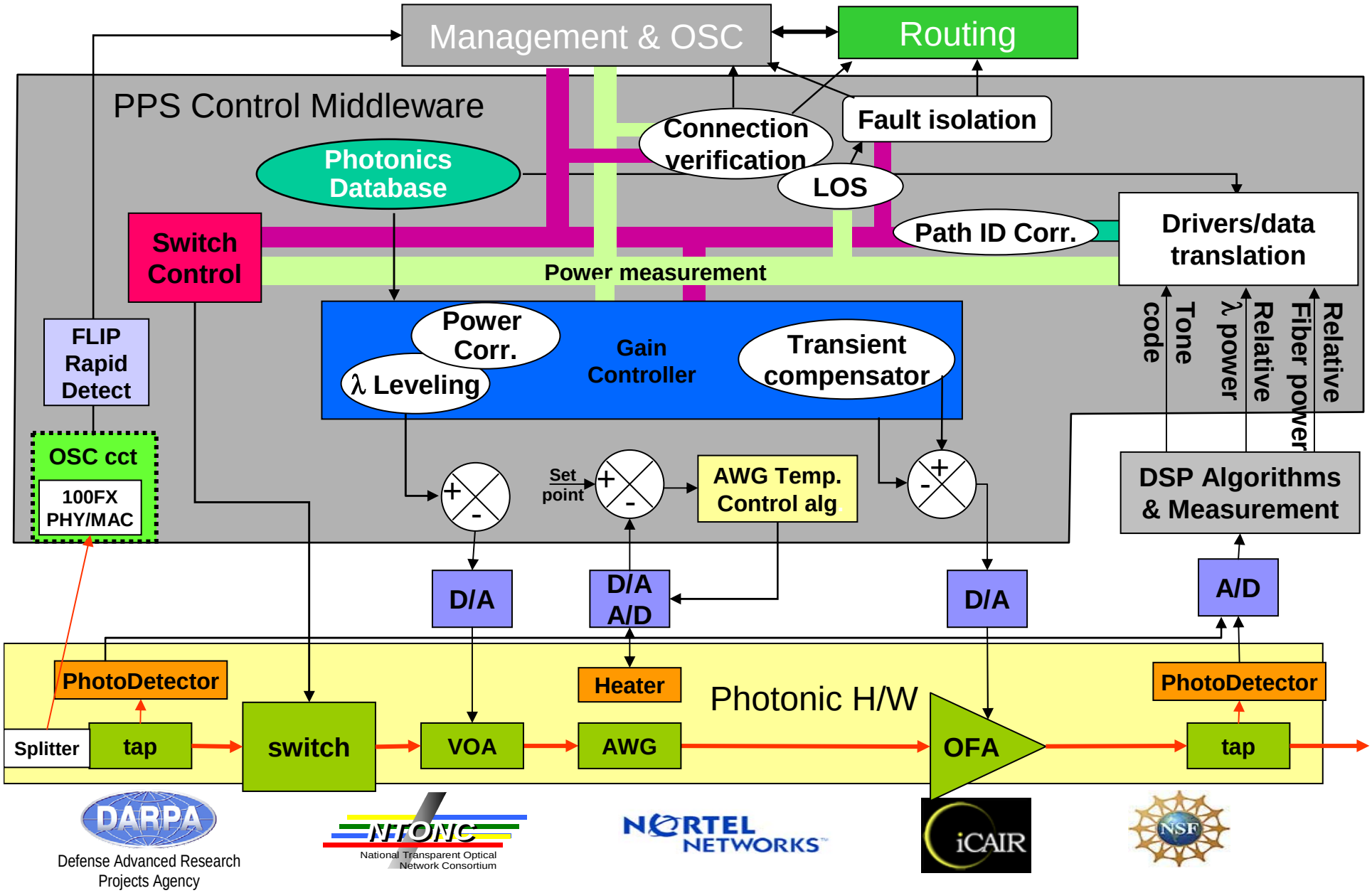
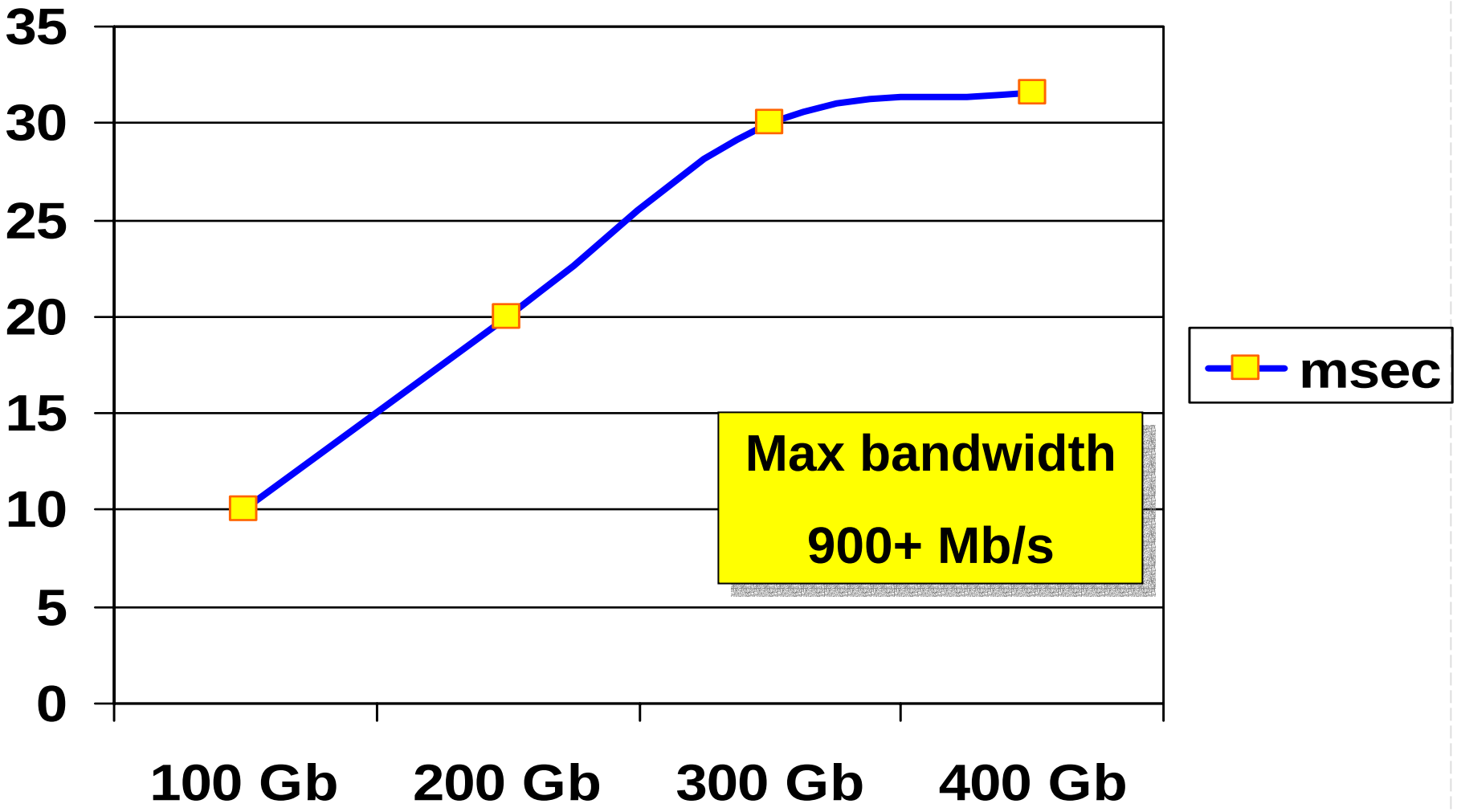
Physical Layer Optical Monitoring and Adjustment

DWDM RAM



File Transfer Times



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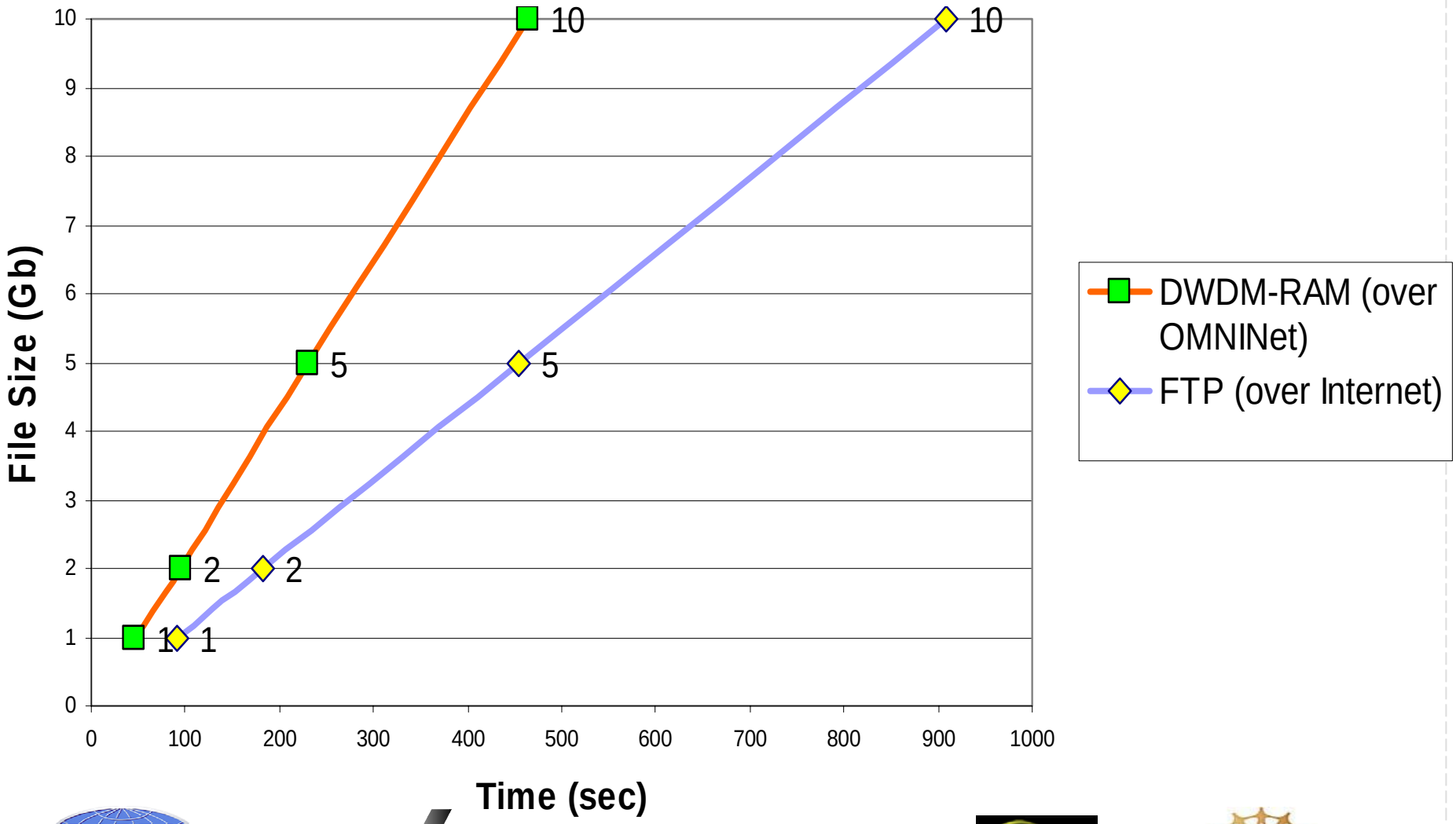
File transfer times



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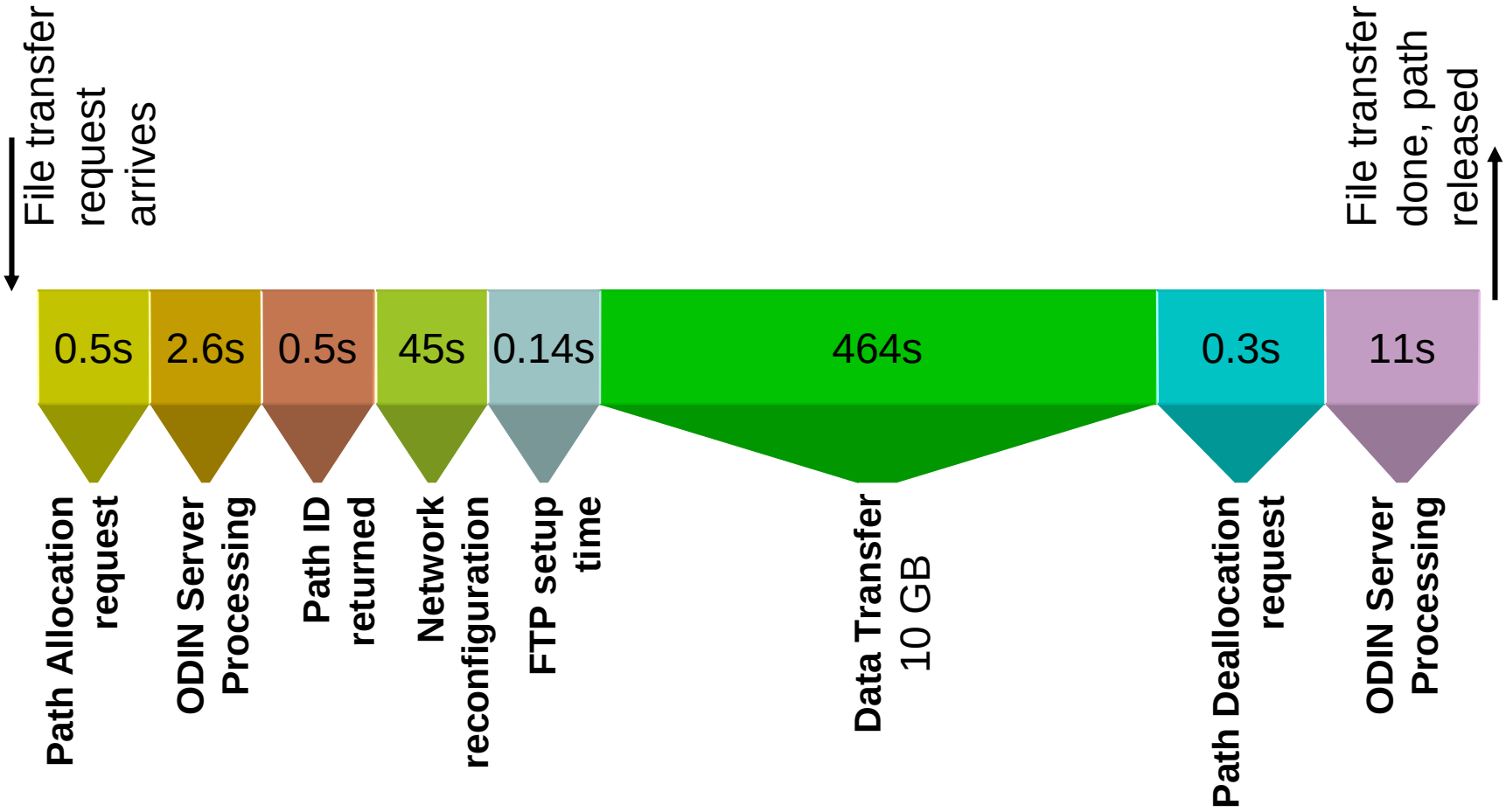
End-to-end Transfer time



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Application level measurements

Path allocation:	48.7 secs
Data transfer setup time:	0.141 secs
FTP transfer time:	464.624 secs
Effective transfer rate:	156 Mbits/sec
Path tear down time:	11.3 secs
File size:	10 GB

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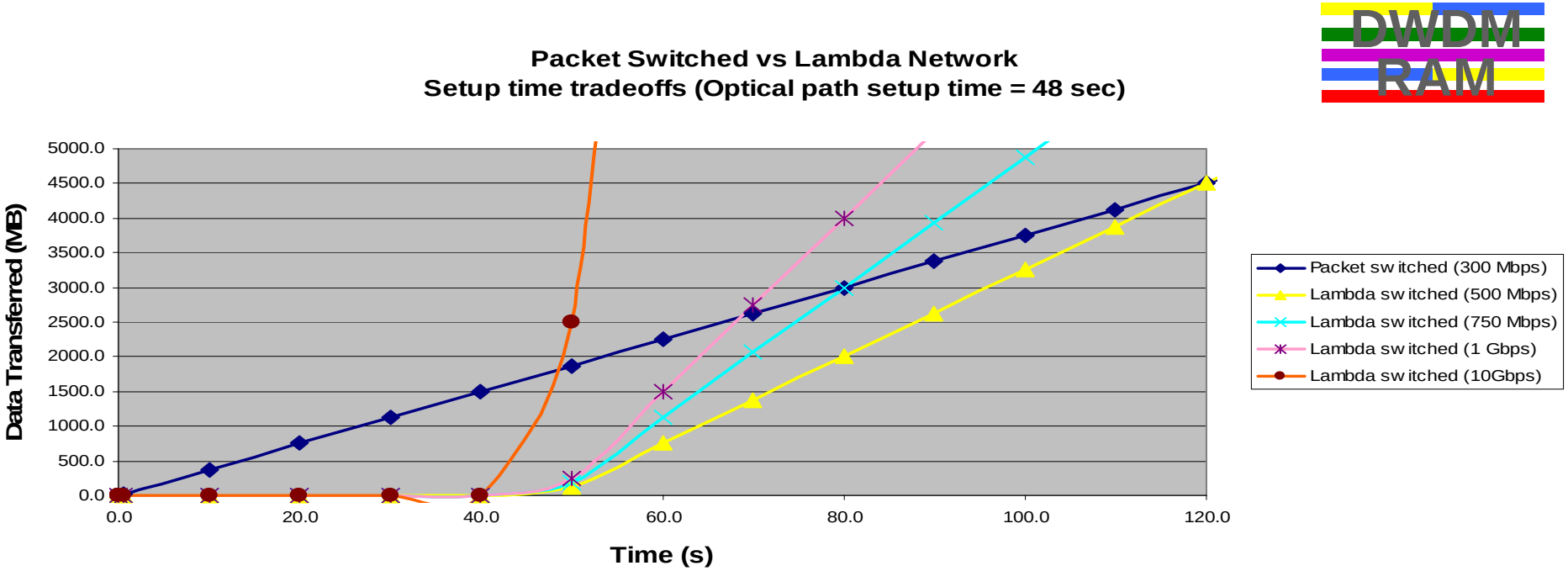

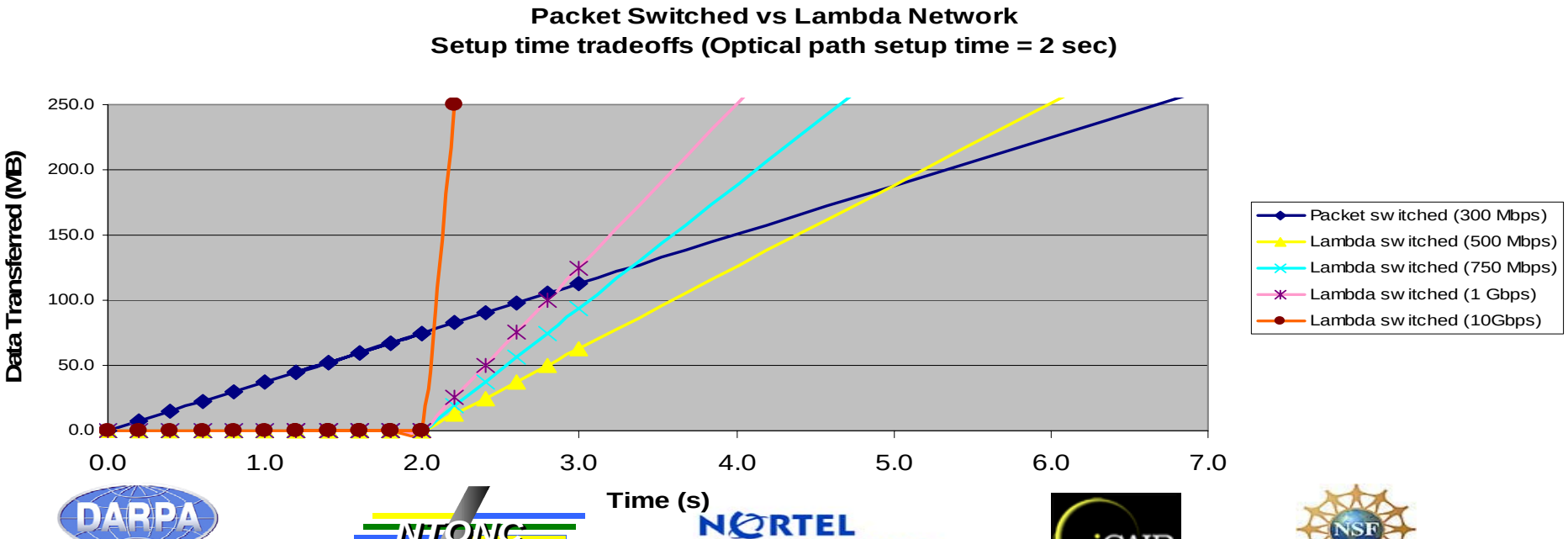

DWDM RAM

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