Cross-Network (Inter-Domain) Interoperability

Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Director, Metropolitan Research and Education Network (www.mren.org)
Partner, StarLight/STAR TAP, PI-OMNINet (www.icair.org/omninet)

US-LHC End-to-End Networking Meeting
Fermi National Accelerator Laboratory

October 25, 2006

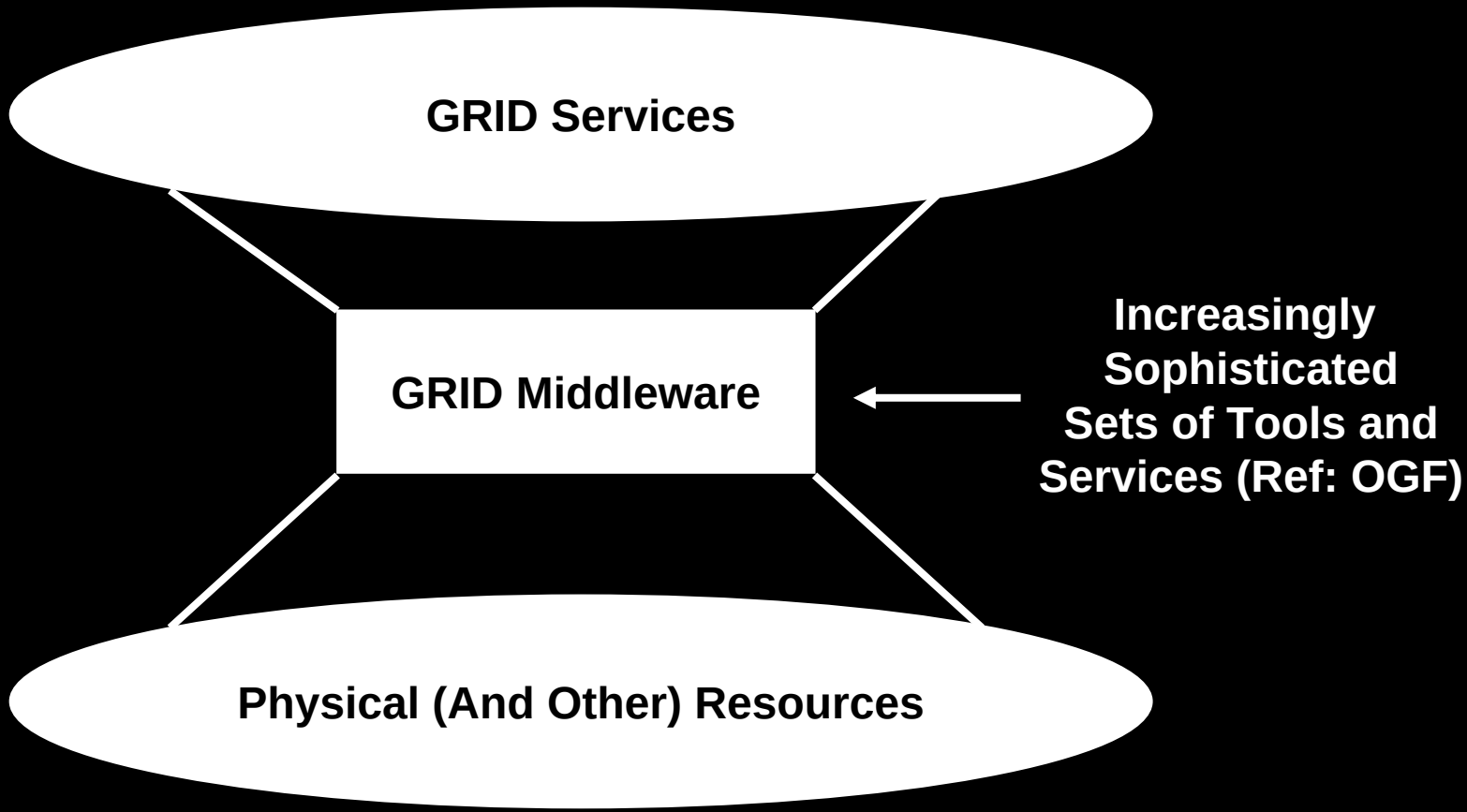
iCAIR

STARLIGHT℠

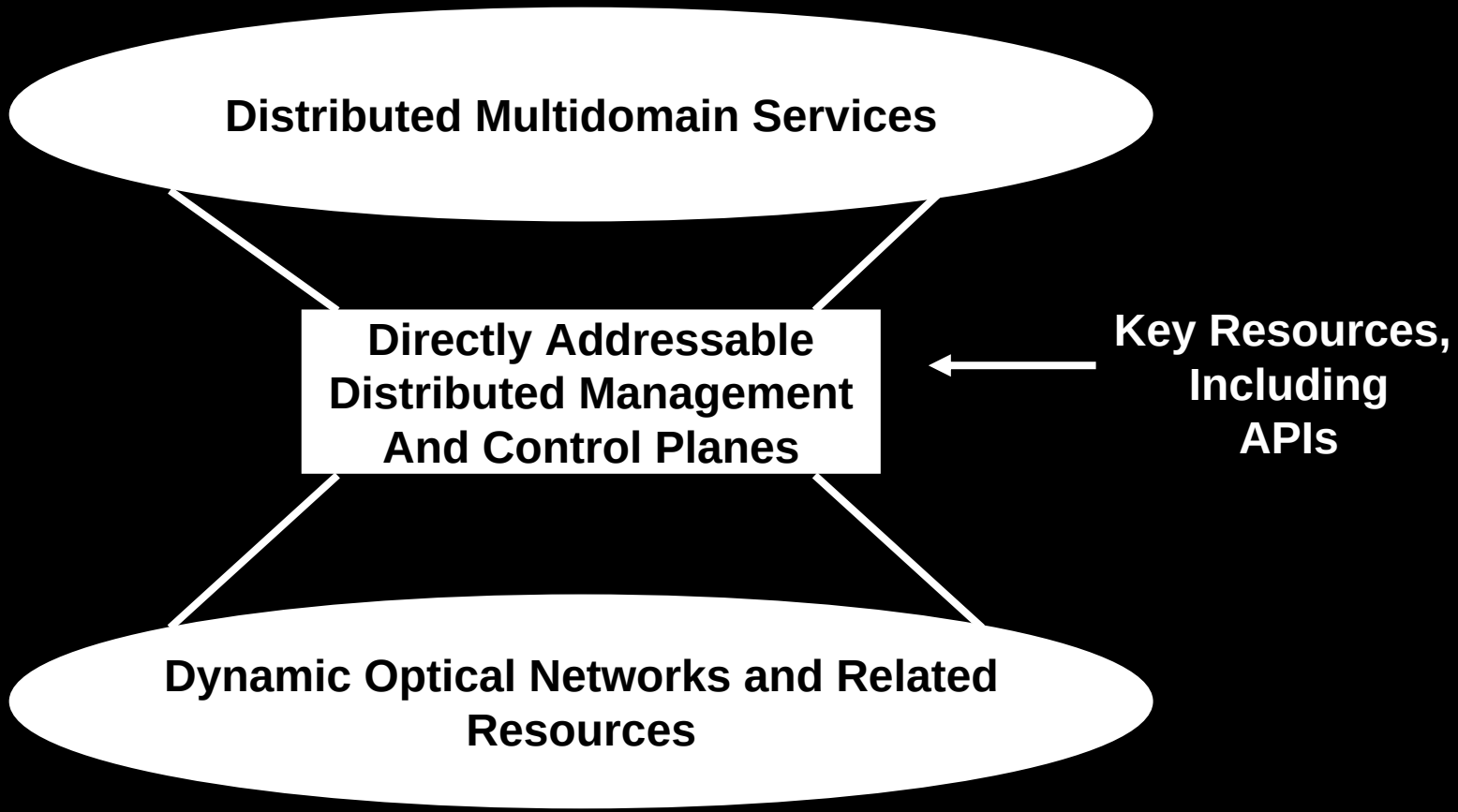
Concepts

- Multilayer Network Virtualization
- L1/L2 Supplements to L3
- Distributed Control and Management – Including To Edge Processes
- Architecture
- Tools and Methods
- Network Description Language
- Implementations

GRID “Hour Glass” Design (Ref Internet Architecture)



Global Lambda Integrated Facility (GLIF)



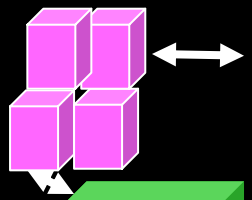
DMCP = “Facility Intelligence”

Standards Organization Activities

- IEEE Developing Hierarchical Architecture
  - Ethernet Architecture = Current Lack of Hierarchy
  - Network Partitioning (802.1q, vLAN tagging)
  - Multiple Spanning Trees (802.1s)
  - Segmentation (802.1ad, “Provider Bridges”)
  - Enables Subnets To be Characterized Differently Than Core
- IETF – Architecture for Closer Integration With Ethernet
  - GMPLS As Uniform Control Plane
  - Generalized UNI for Subnets
  - Link State Routing In Control Plane
  - TTL Capability to Data Plane
  - Pseudo – Wire Capabilities

L1 10 Gbps

- APIs
- Discovery Mechanisms
- Policy-Based Access
- Control Protocols
- GMPLS
- IETF GMPLS UNI (vs ONI UNI, Implications for Restoration Reliability)
- Services
    - Lightpaths with Attributes, Uni-directional, Bi-directional
    - Highly Secure Paths
    - OVPN
    - Optical Multicast
    - Protected Through Associated Groups
- ITU-T SG Generic VPN Architecture (Y.1311), Service Requirements (Y.1312), L1 VPN Architecture (Y.1313)



Intelligent Application/Process Signaling

Multi-Domain L1 Dynamic Provisioning

Multi-Domain Control Plane

IAS Server

UNI

Controller

D1

I-UNI

Controller

D2

Controller

D3

Client Data Plane Server

CI

CI

CI

Client Layer Control Plane: Communications Service Layer Service Layer, Policy Based Access Control, Client Message Receiver, Signal Transmission, Data Plane Controller, Data Plane Monitor

Optical Layer Control Plane

Client Layer Traffic Plane

D1

D2

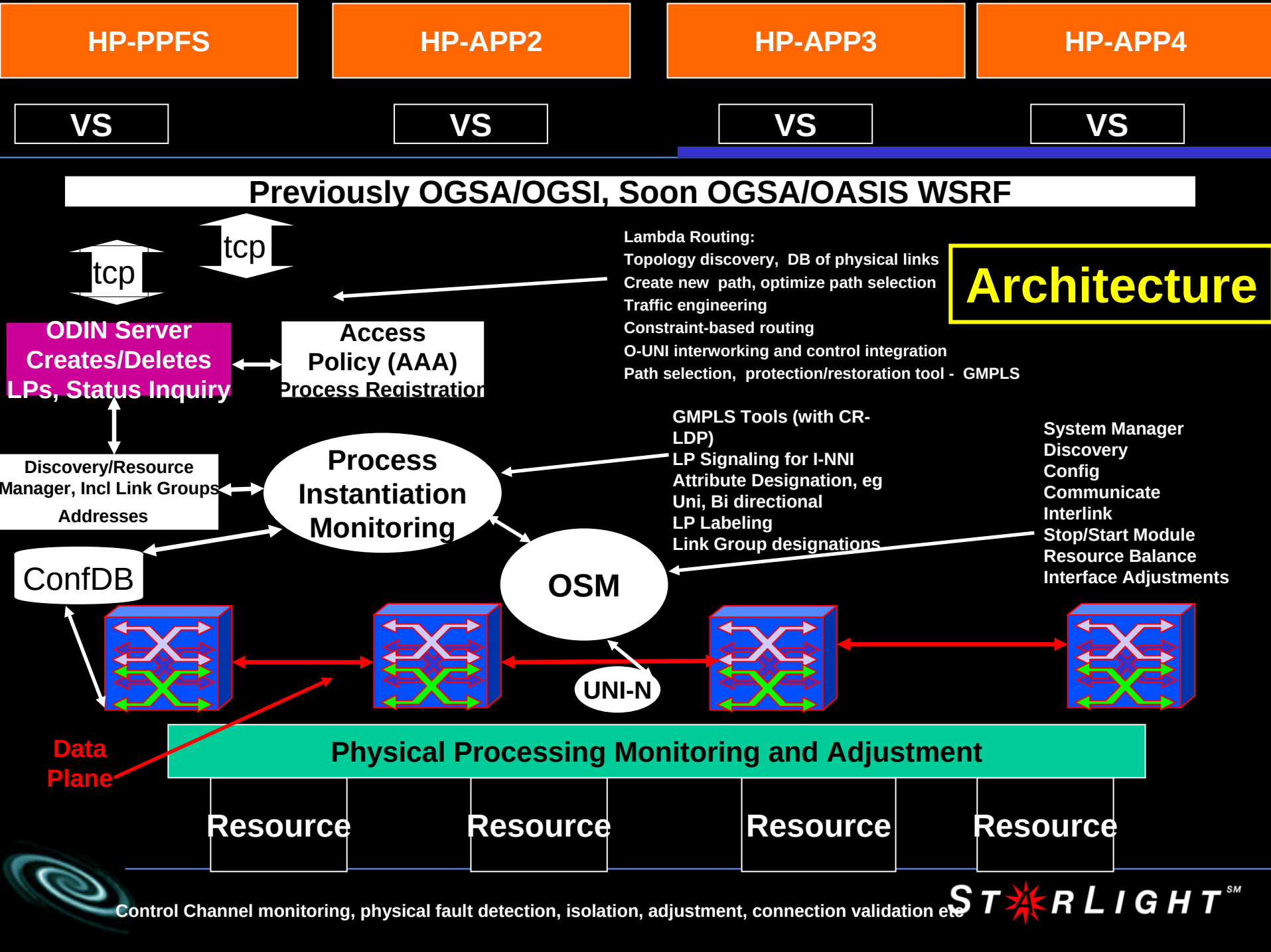
D3

Optical Layer – Switched Traffic (Data) Plane Multiiservice: Unicast, BiDirectional, Multicast, Burst Switching

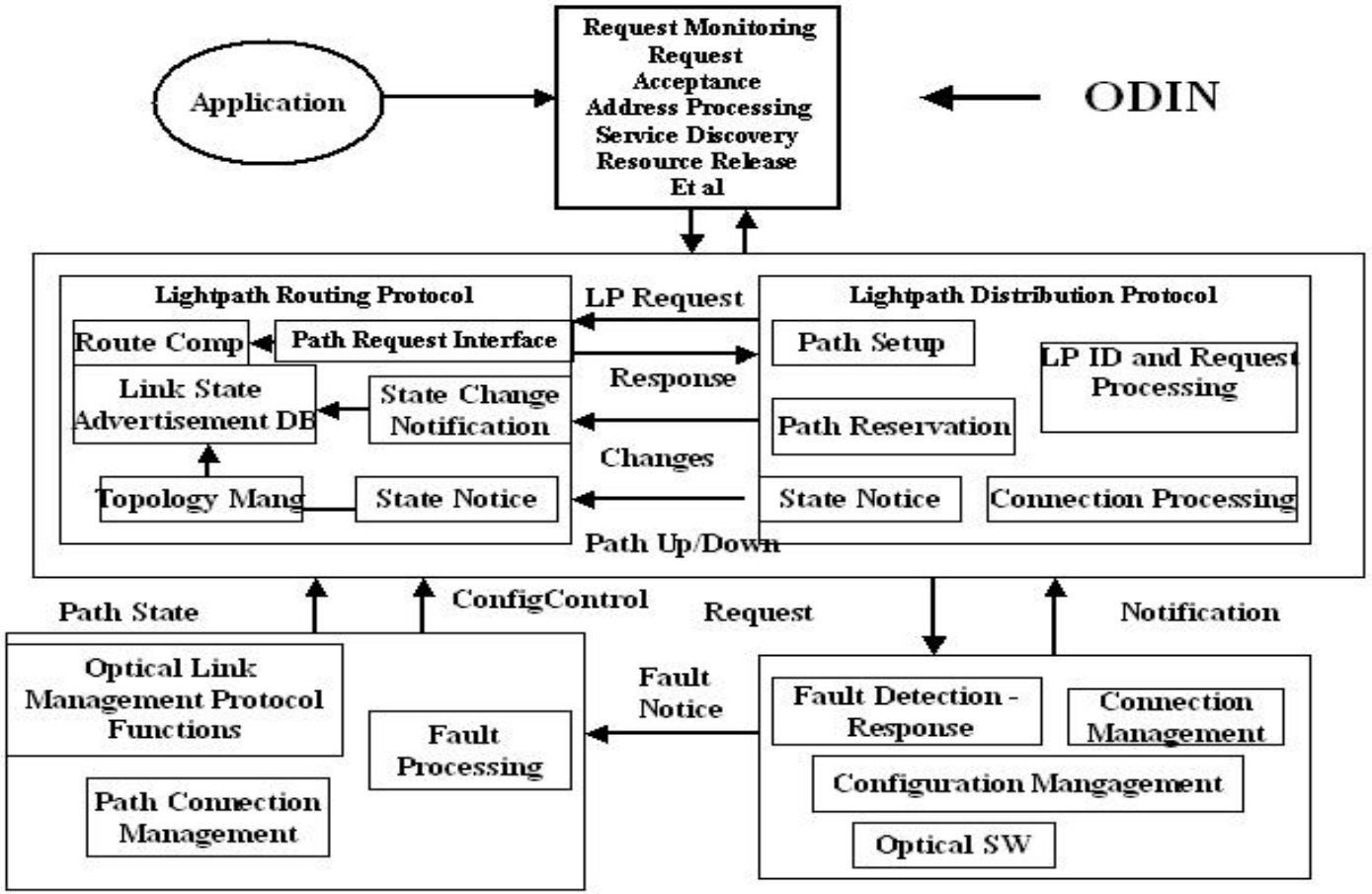
Multi-Domain Data Plane

iCAIR

STARLIGHT SM

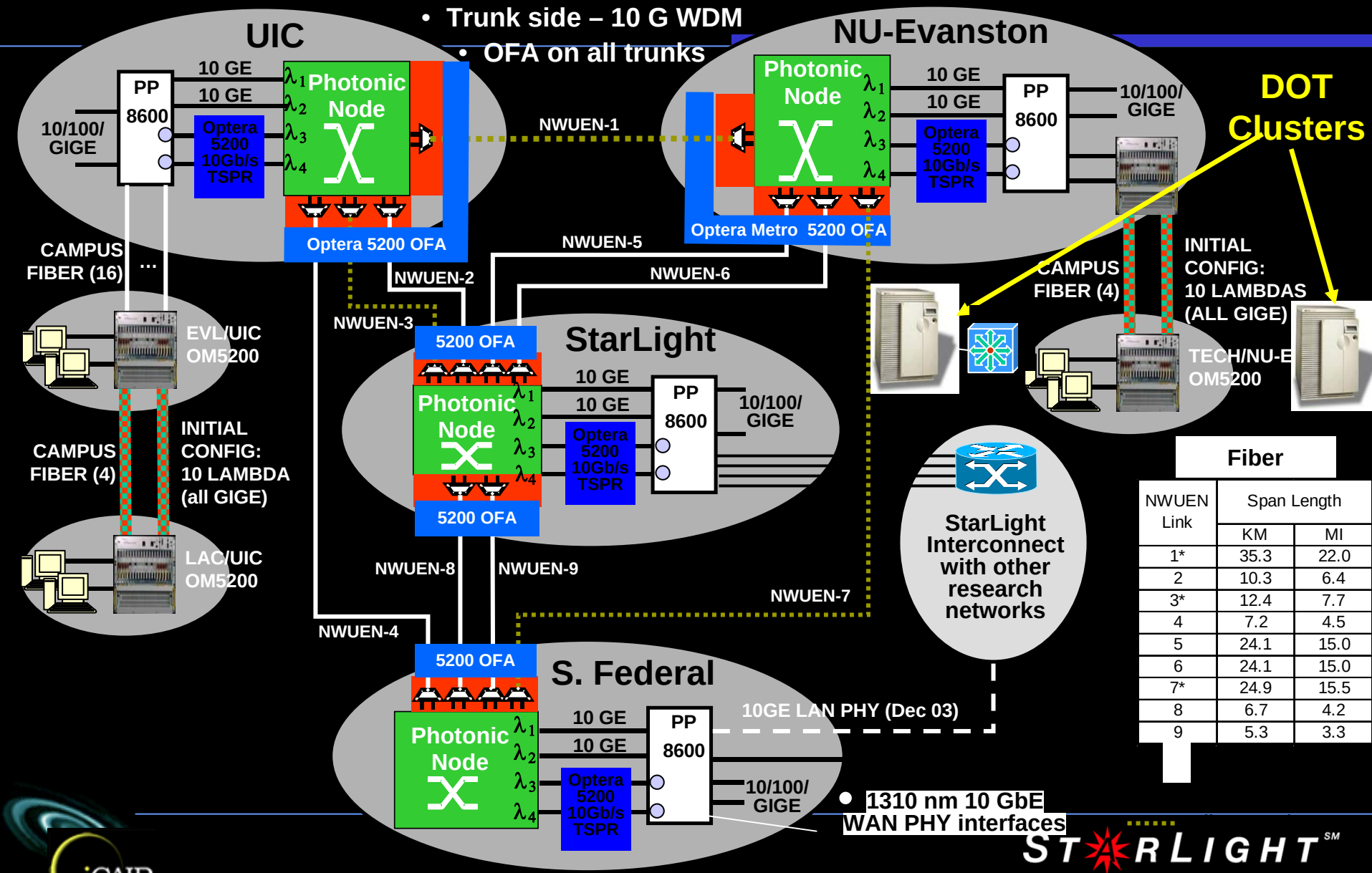

HP-PPFS
HP-APP2
HP-APP3
HP-APP4
VS
VS
VS
VS
Previously OGSA/OGSI, Soon OGSA/OASIS WSRF
tcp
tcp
Lambda Routing:
Topology discovery, DB of physical links
Create new path, optimize path selection
Traffic engineering
Constraint-based routing
O-UNI interworking and control integration
Path selection, protection/restoration tool - GMPLS
Architecture
ODIN Server
Creates/Deletes
LPs, Status Inquiry
Access
Policy (AAA)
Process Registration
GMPLS Tools (with CR-LDP)
LP Signaling for I-NNI
Attribute Designation, eg
Uni, Bi directional
LP Labeling
Link Group designations
System Manager
Discovery
Config
Communicate
Interlink
Stop/Start Module
Resource Balance
Interface Adjustments
Discovery/Resource
Manager, Incl Link Groups
Addresses
Process
Instantiation
Monitoring
ConfDB
OSM
UNI-N
Data
Plane
Physical Processing Monitoring and Adjustment
Resource
Resource
Resource
Resource
Control Channel monitoring, physical fault detection, isolation, adjustment, connection validation etc
STARLIGHT SM

Optical Dynamic Intelligent Network (ODIN)



OMNInet Network Configuration Phase 2 (Extended Via Demonstrations Nationally and Internationally)

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

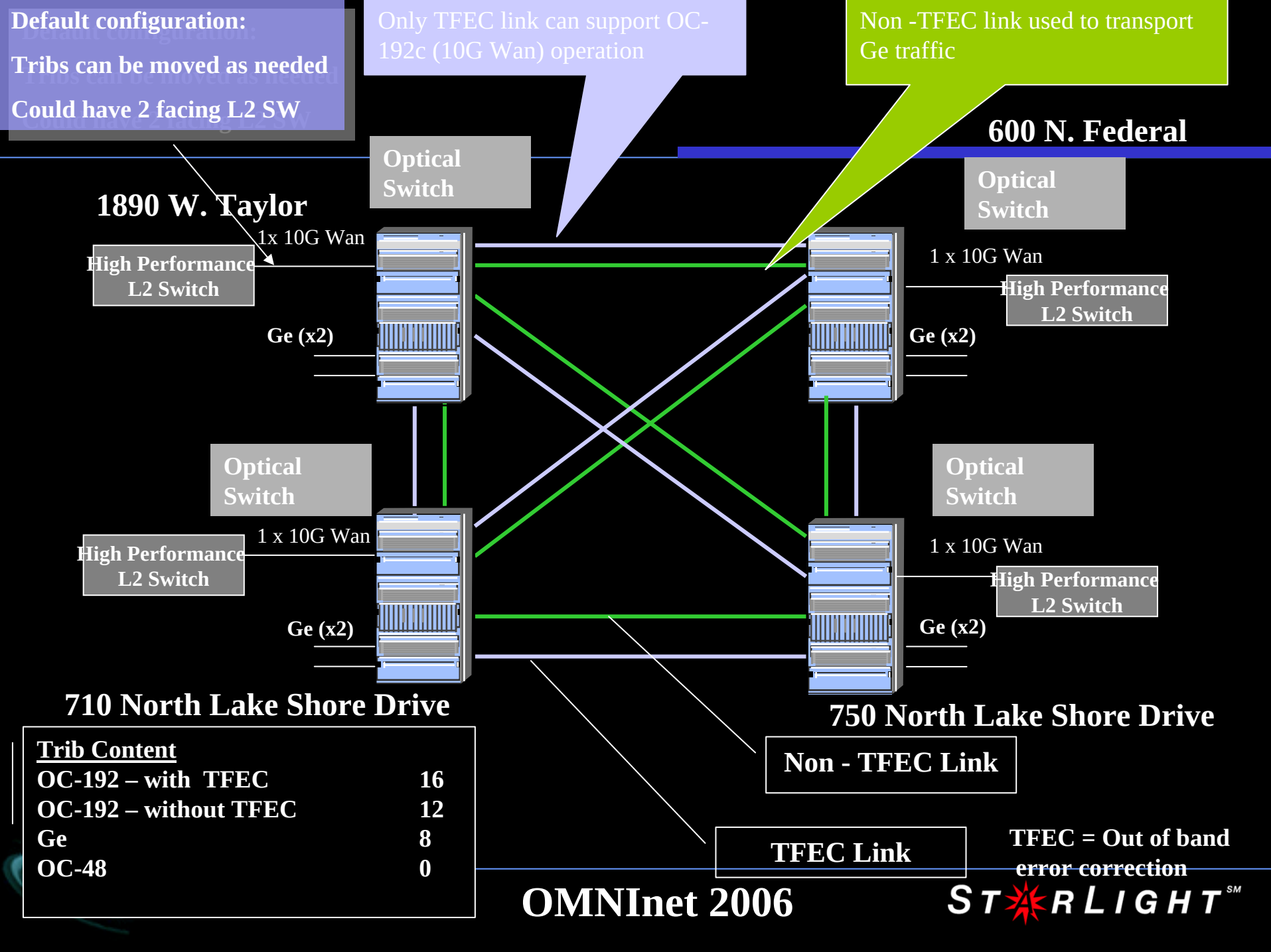


Fiber

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

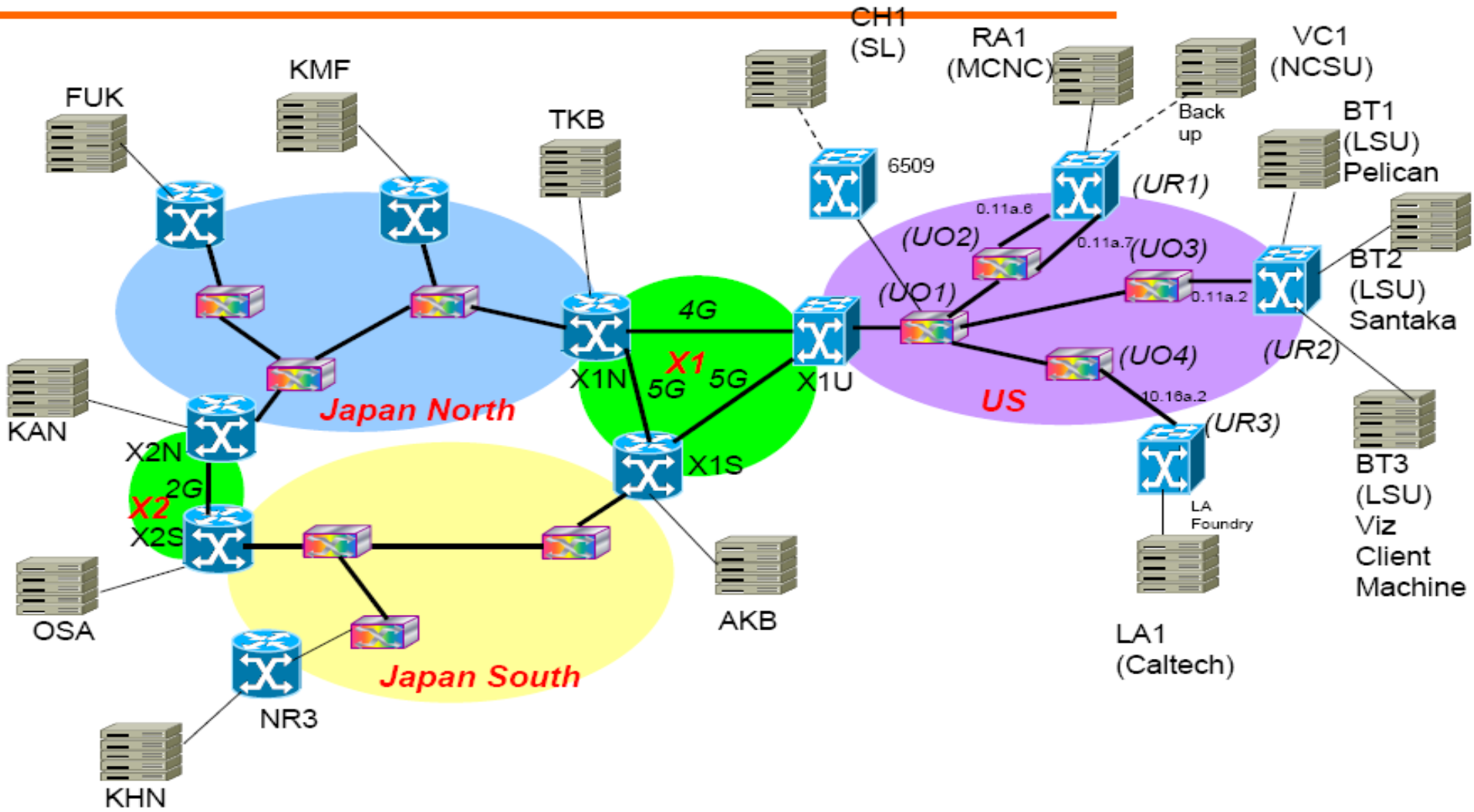
iCAIR

STARLIGHT℠


Default configuration:
Tribs can be moved as needed
Could have 2 facing L2 SW
Only TFEC link can support OC-192c (10G Wan) operation
Non -TFEC link used to transport Ge traffic
600 N. Federal
Optical Switch
1890 W. Taylor
1x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
Optical Switch
1 x 10G Wan
High Performance L2 Switch
Ge (x2)
710 North Lake Shore Drive
750 North Lake Shore Drive
Trib Content
OC-192 – with TFEC 16
OC-192 – without TFEC 12
Ge 8
OC-48 0
Non - TFEC Link
TFEC Link
TFEC = Out of band error correction
OMNInet 2006
STARLIGHT SM

EnLightened/G-Lambda Demo at GLIF

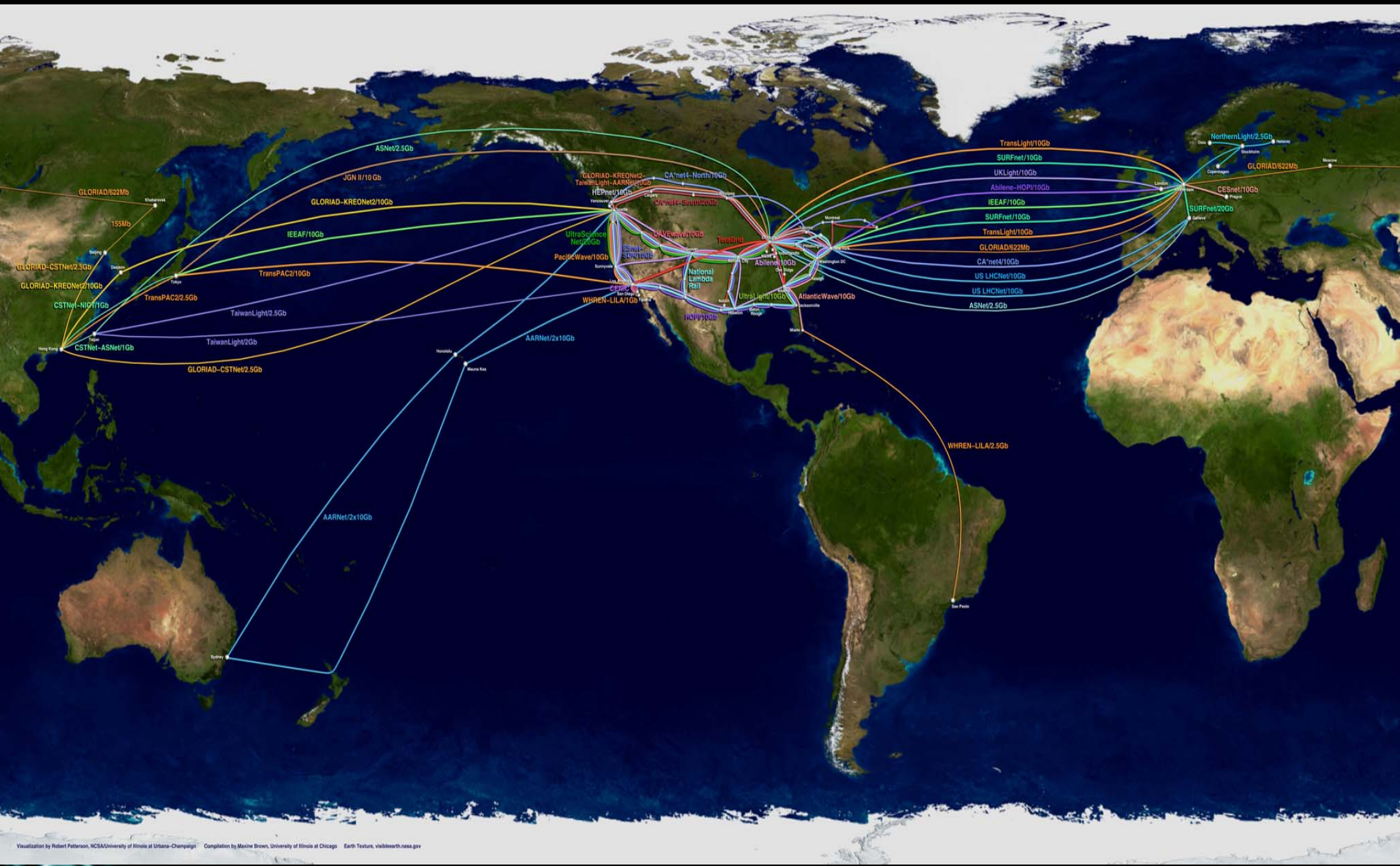
Resource map of the demo



Source: EnLightened;G-Lambda

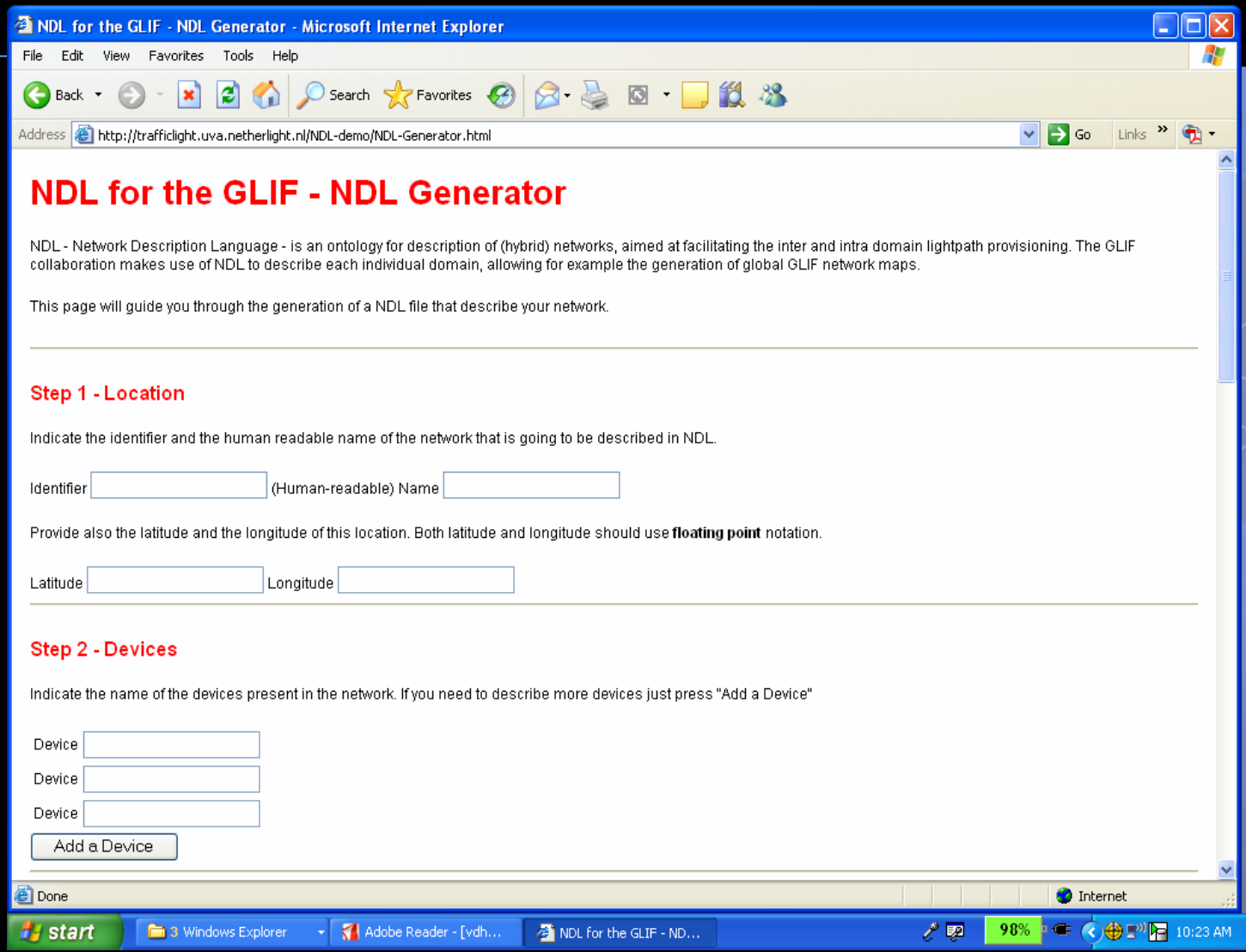
STARLIGHT℠

Global Lambda Integrated Facility (GLIF)



STARLIGHT℠

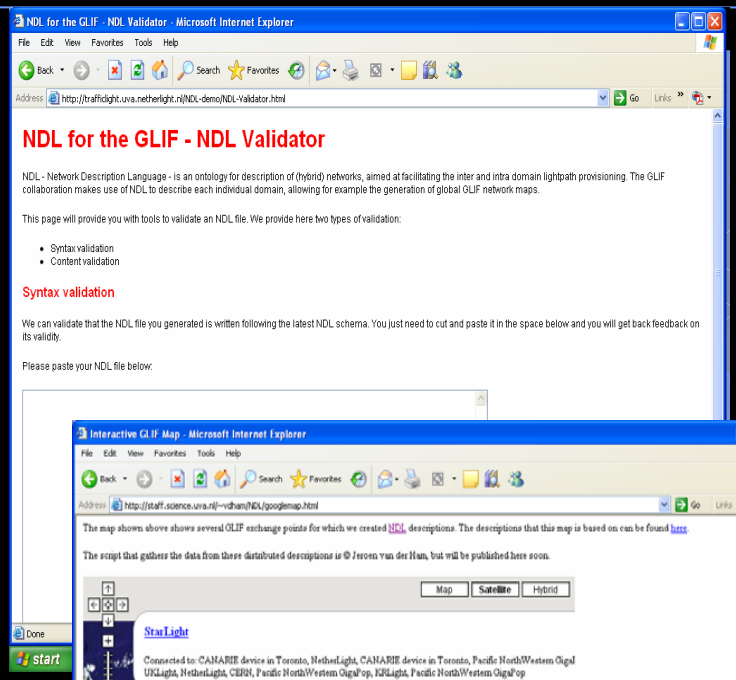
Network Description Language for the GLIF

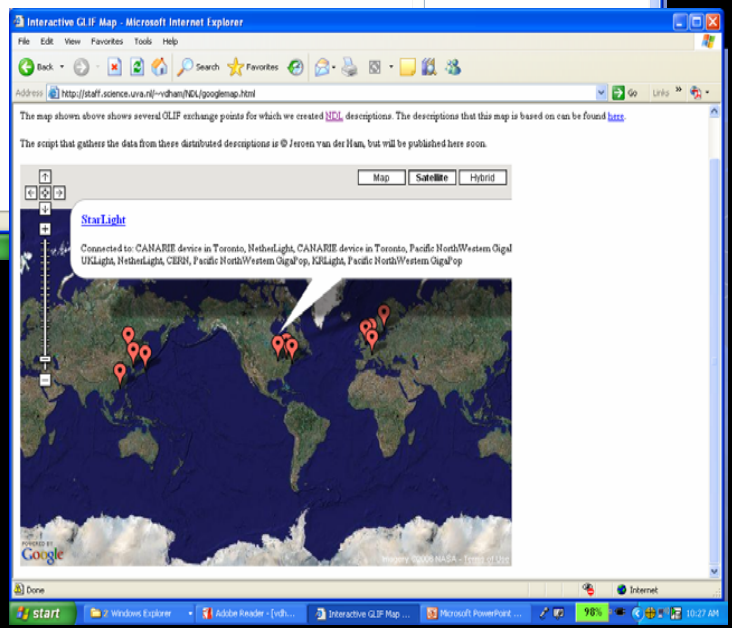


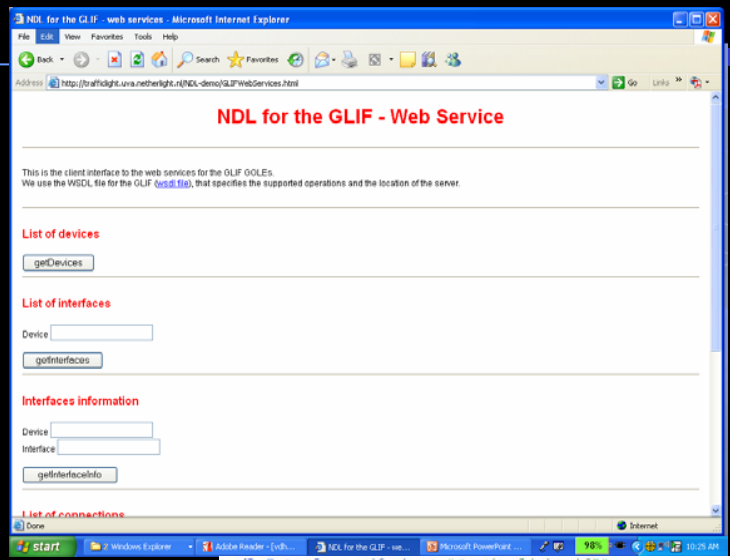
Source: GLIF/SURFnet/GigaPORT

STARLIGHT℠

NDL WS, Validator, Maps, GOLE Description





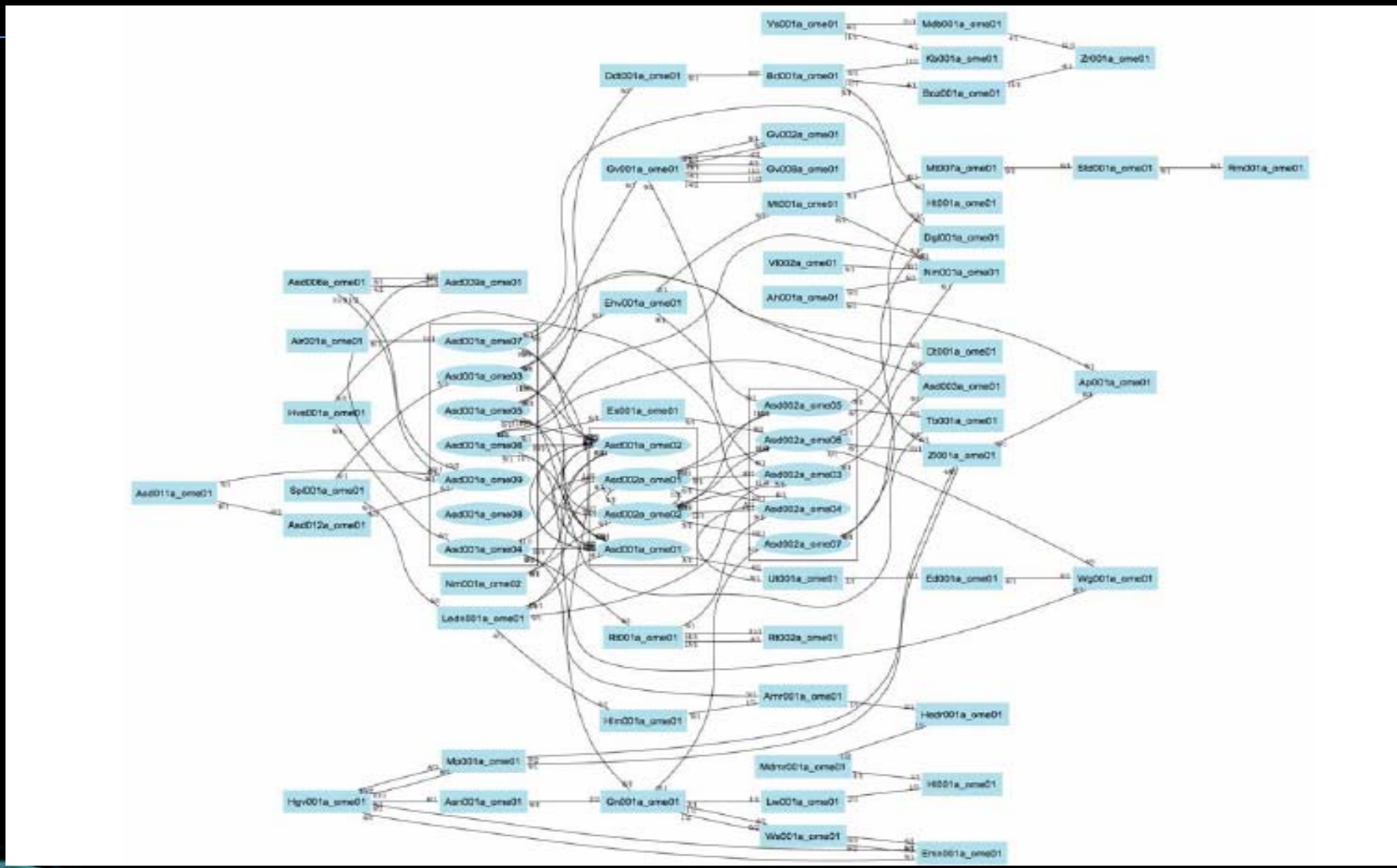



```
<ndl:Interface rdf:about="#netherlight:if5">
    <ndl:name>netherlight:if5</ndl:name>
    <ndl:connectedTo
rdf:resource="http://trafficlight.uva.netherlight.nl/JointDemo/GOLEs/starlight
/starlight.rdf#starlight:if3"/>
</ndl:Interface>

<!--http://trafficlight.uva.netherlight.nl/JointDemo/GOLEs/starlight/starlight
.rdf#starlight:if3-->
<ndl:Interface
rdf:about="http://trafficlight.uva.netherlight.nl/JointDemo/GOLEs/starlight/st
arlight.rdf#starlight:if3">
    <rdfs:seeAlso
rdf:resource="http://trafficlight.uva.netherlight.nl/JointDemo/GOLEs/starlight
/starlight.rdf"/>
</ndl:Interface>

<!--netherlight:if6-->
<ndl:Interface rdf:about="#netherlight:if6">
    <ndl:name>netherlight:if6</ndl:name>
    <ndl:connectedTo
rdf:resource="http://trafficlight.uva.netherlight.nl/JointDemo/GOLEs/starlight
/starlight.rdf#starlight:if4"/>
</ndl:Interface>
```

Source: GLIF/SURFnet/GigaPORT

STARLIGHT℠

NDL Resource Visualization



Source: GLIF/SURFnet/GigaPORT

STARLIGHT℠

Further Information

- www.glif.is

- Optical Network Testbeds Workshops (ONT)
- The ONT Workshop Presentations Are on the Site
- www.nren.nasa.gov/workshop9
- (ONT3)
- www.nren.nasa.gov/workshop8
- (ONT2)
- www.nren.nasa.gov/workshop7
- (ONT1)

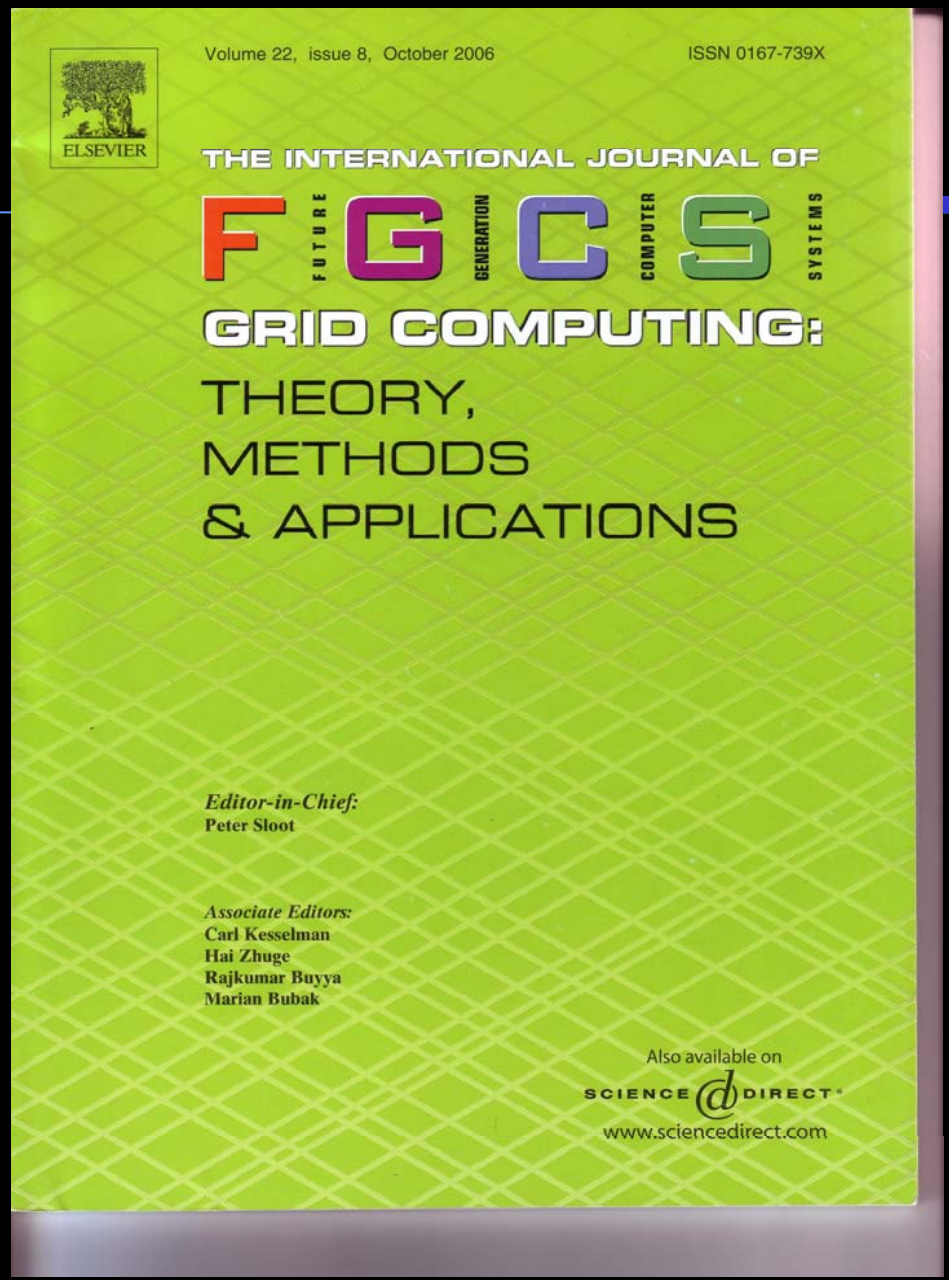
IEEE Communications March 2006 Special Issue on "An Optical Control Plane for the Grid Community"

FGCS Oct 2006

- Special issue on iGrid 2005: The Global Lambda Integrated Facility
- 27 referred papers!

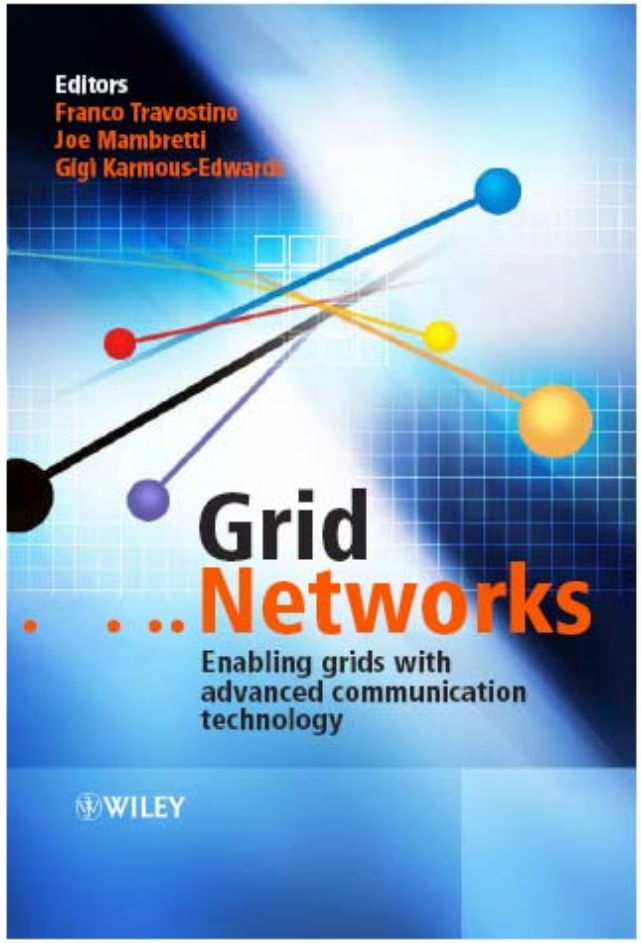
- Smarr, Larry, Maxine Brown, Tom DeFanti and Cees de Laat (guest editors)

- Future Generation Computer Systems, Volume 22, Issue 8, Elsevier, October 2006, pp. 849-1054



Grid Networks

Themes: Network Resources at All Levels As "First Class" Grid Resources



www.startap.net/starlight