International High Performance Digital Media With Dynamic Optical Multicast

An Experimental Architecture and Prototype Optical Digital Media Service – Demonstration of Current Research Status at the 7th Annual Global LambdaGrid Workshop

Presentation to Control Plane Working Group

Prague, Czech Republic

September 17-18, 2007

Overview

- A Consortium of Research Centers From Around the World Has Formed a Cooperative Partnership To Explore the Key Issues Related to the Challenges and Opportunities Related to Using Lightpaths for High Performance Digital Media (HPDM)
- At the Annual Global LambdaGrid Workshop in Prague, Demonstrations Have Been Designed to Show the Current Project Status (Not Final Results, Products or Services)
- Multiple Sites Require High Performance/High Volume/High Definition Digital Media Streaming Simultaneously Among All Locations (Multi-Point to Multi-Point)
- Traditional L3 Techniques Cannot Be Used for Many Types of High Definition Media
- These Techniques Were Designed for Many Small Information Flows – Not for Large Scale Flows
- This Consortium Is Designing and Developing New L1/L2 Capabilities That Can Provide Large Scale HPDM Service Solutions

Challenges and Opportunities

- Challenges
  - Digital media standards have been developed independently of WAN/LAN standards
  - Traditional WAN/LAN standards have been developed independently of considerations for many HDDM requirements
  - Consequently, today's communications capabilities do not always meet application requirements
- Opportunities
  - Using existing and emerging technologies several powerful solutions can be designed today
  - However, an optimal approach for meeting unmet current and future requirements has not yet been determined
  - Various options exist for addressing HPDM requirements
  - Current research is exploring these options and experimenting with alternative approaches
  - This demonstration incorporates several promising emerging technological approaches

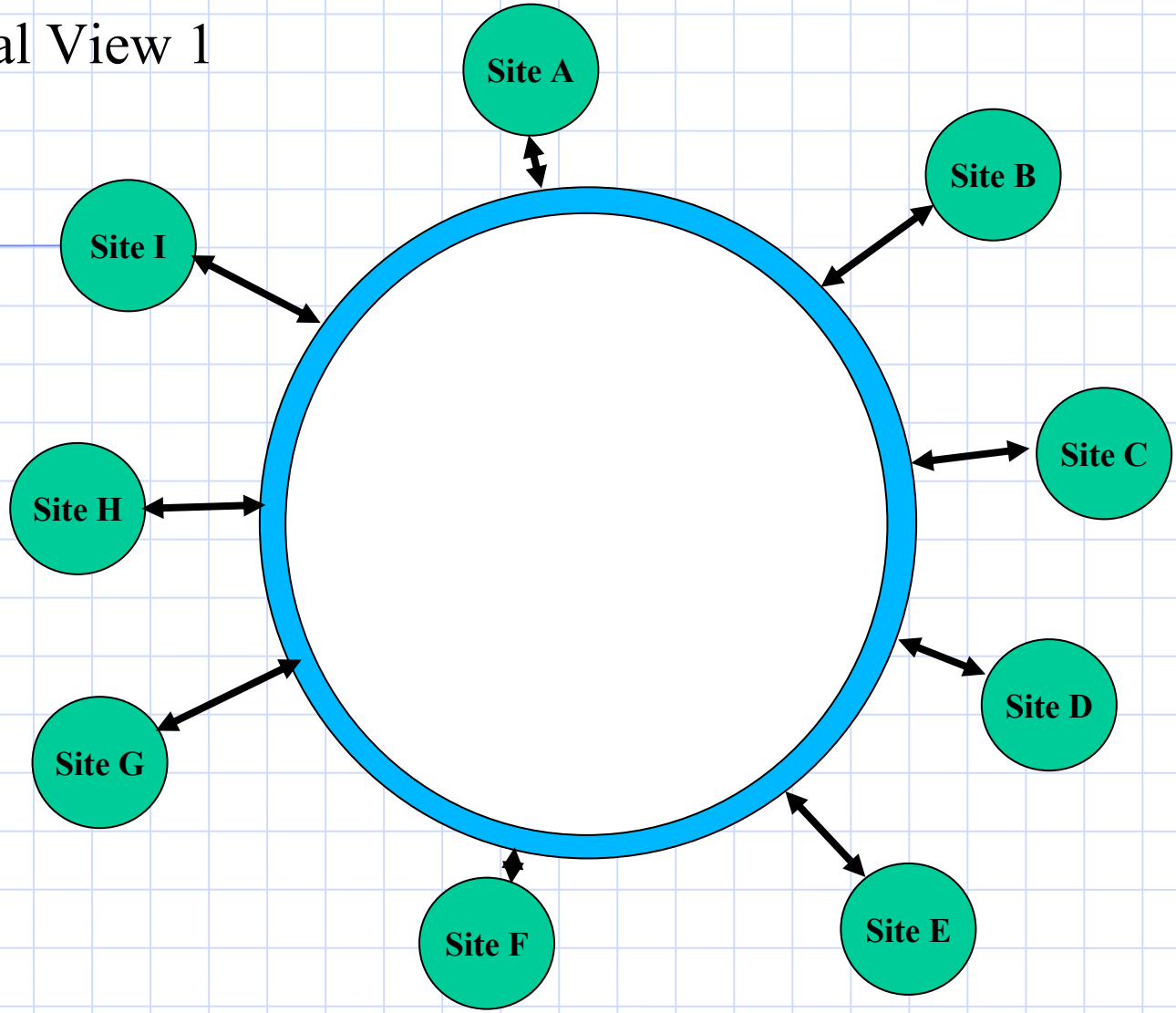
GLIF Demonstrations

- This Research Consortium Has Designed and Implemented an International HPDM Testbed (HPDMnet), and It Is Being Used for Experiments and Demonstrations
- A Specific Instantiation of the HPDMnet Testbed Was Created For the Global LambdaGrid Workshop
- Various Architectural Approaches And Technologies, Including Middleware, Are Being Developed and Investigated On Research Testbeds, Including HPDMnet
- Middleware Component Technologies Being Showcased Include Optical Multicast, UCLP, EnLIGHTened, HARC and G-Lambda
- The Research Will Continue And Further Demonstrations Are Planned

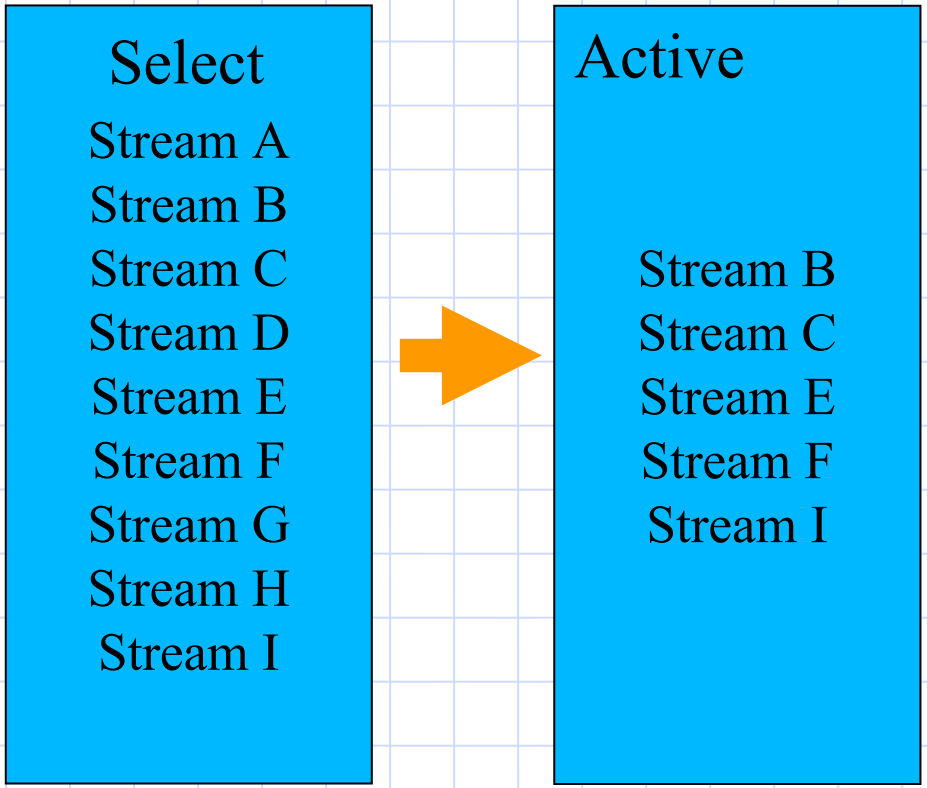
Communications Technologies

- The Demo Technologies Include the Following:
  - Dynamic L2 and L1 (lightpath) allocation and adjustment is an emerging technique
  - Both persistent and dynamic large scale L1/L2 resources can be allocation, depending on requirements
  - Integrated, addressable WAN and LAN paths can be used
  - High level path control capabilities from an application perspective is a key resource
  - To further enable network optimization, HPDM streams can be “branched” by setting parameters through the device control systems
  - Multiple path options can be individually selected to optimize stream flows
  - The Architectural framework being developed assumes an SOA context

Logical View 1

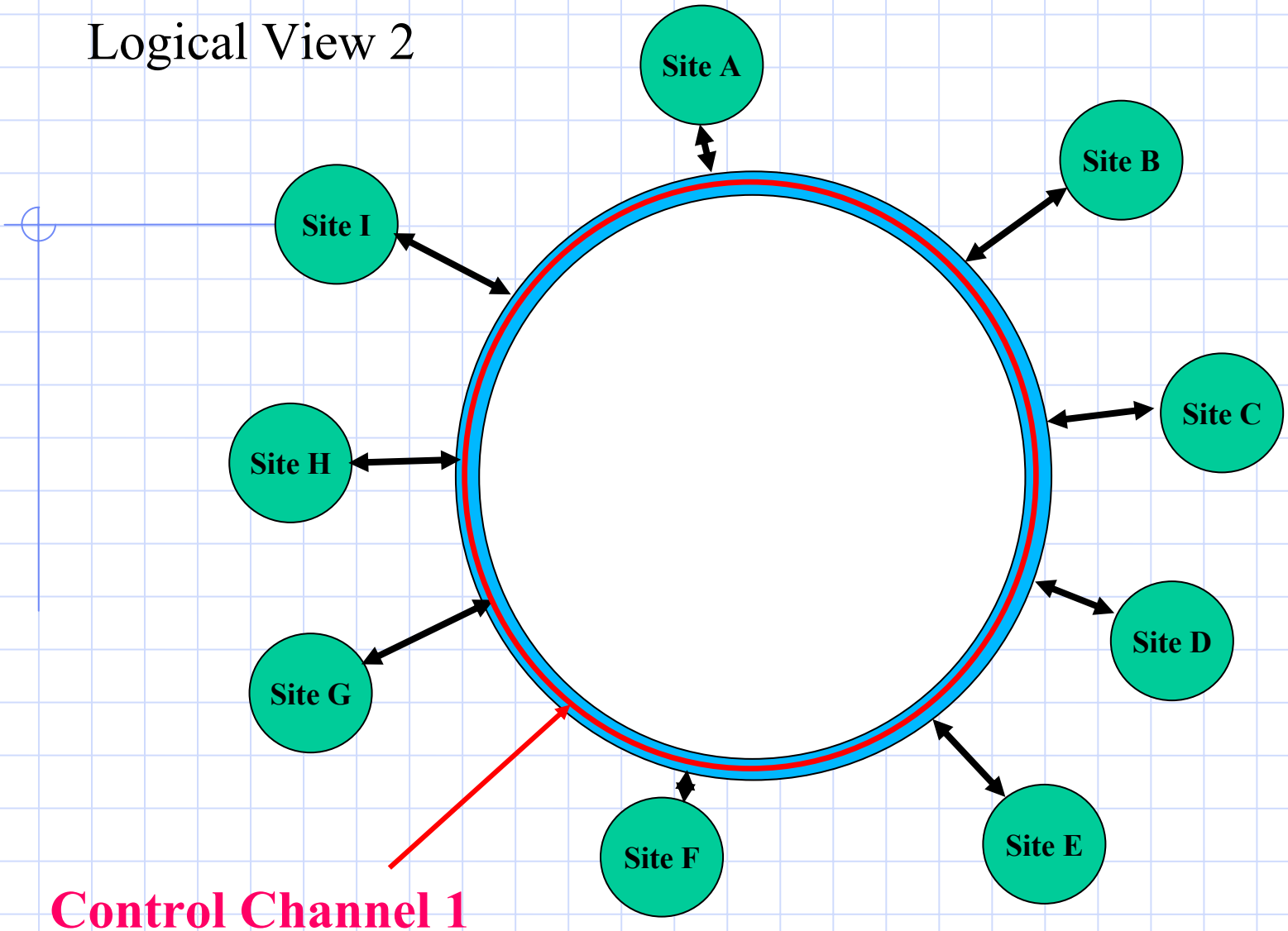


Logical Interface



Note "Stream" – Not Site – Each Site Can Support Many-to-Many

Logical View 2



Overview of Demos

1. Resources Are Discovered
2. Resources Are Selected
3. Resources Are Used In Sequence
4. Resources Are De-Allocated
5. Clients show video/visualizations

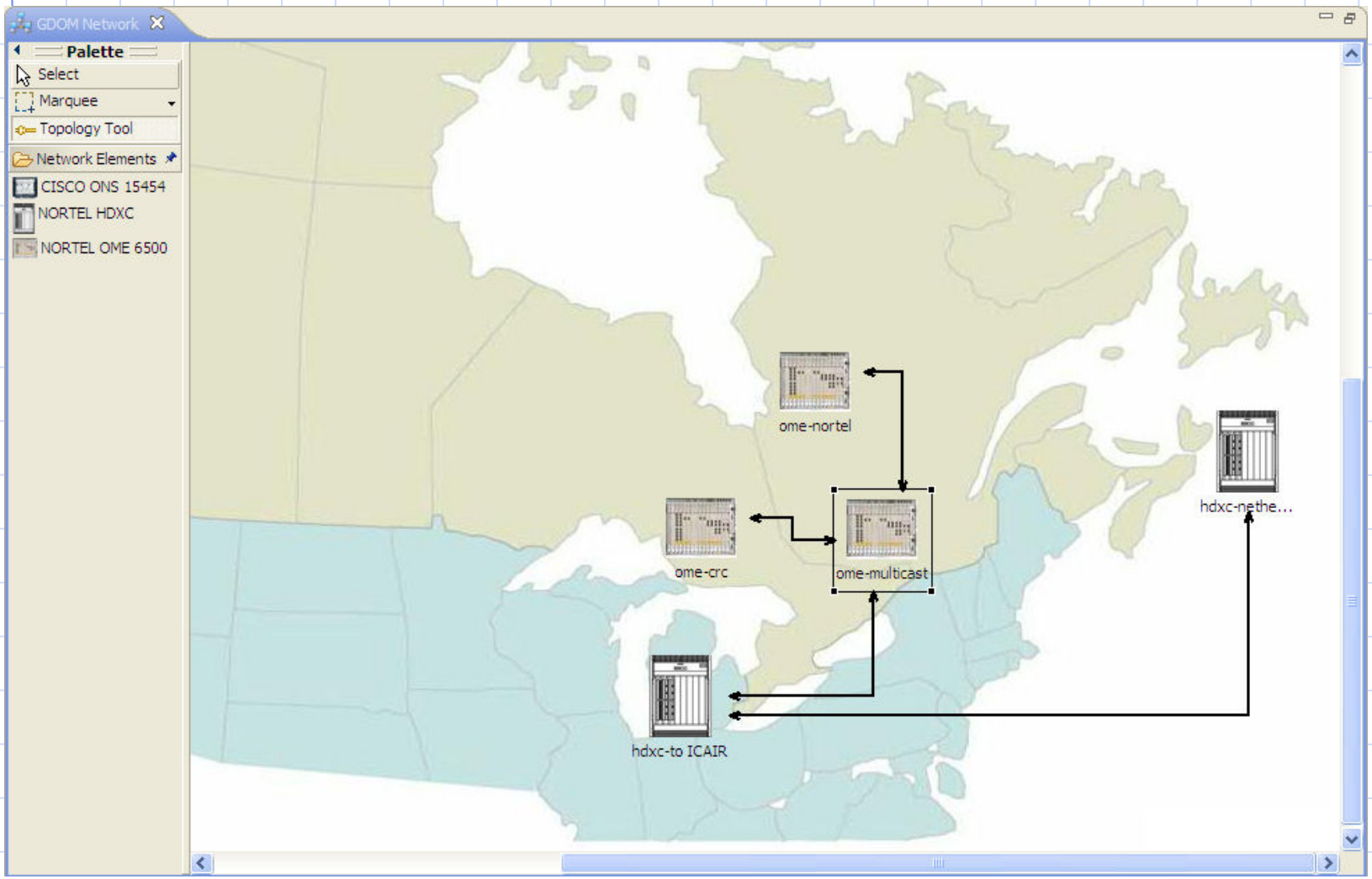
About UCLP / Argia

- Argia is a production grade version of UCLP
- Argia is middleware that allows end-users (people or applications) to treat network resources as software objects and provision and re-configure lightpaths within a single domain or across multiple, independently managed domains
- Users can also join or divide lightpaths and hand off control and management of these private sub-networks to other users or organizations
- Argia enables the virtualization of a network that can be reconfigured by the end-user without any interaction by the optical network manager
- http://www.inocybe.ca

Control Channel: UCLPv2

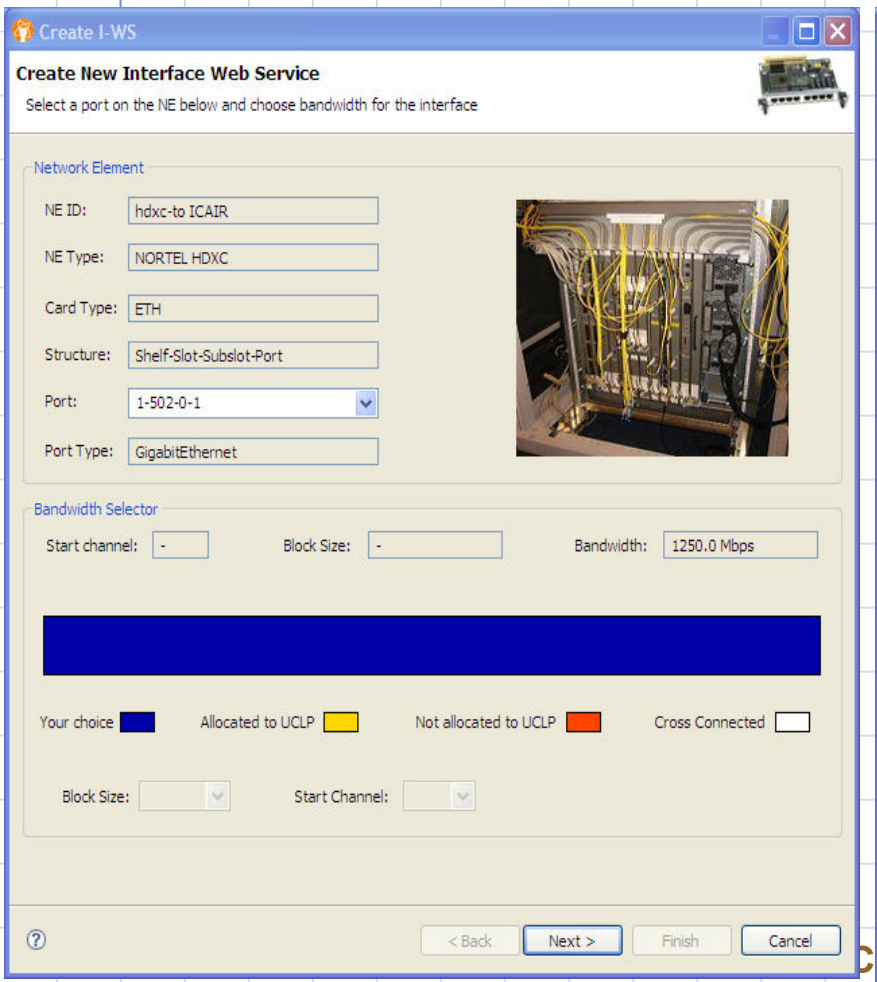
- Initially (Phase 1), UCLPv2 Has Been Implemented on a Server as a Single Point of Control For Multiple Dedicated Channels Within HPDMnet
- For a Particular Instantiation (e.g., a Demonstration), UCLP Can Create A Customized ("Articulated") Network (e.g., An Event or Situation Specific Network)
- Following Is An Example

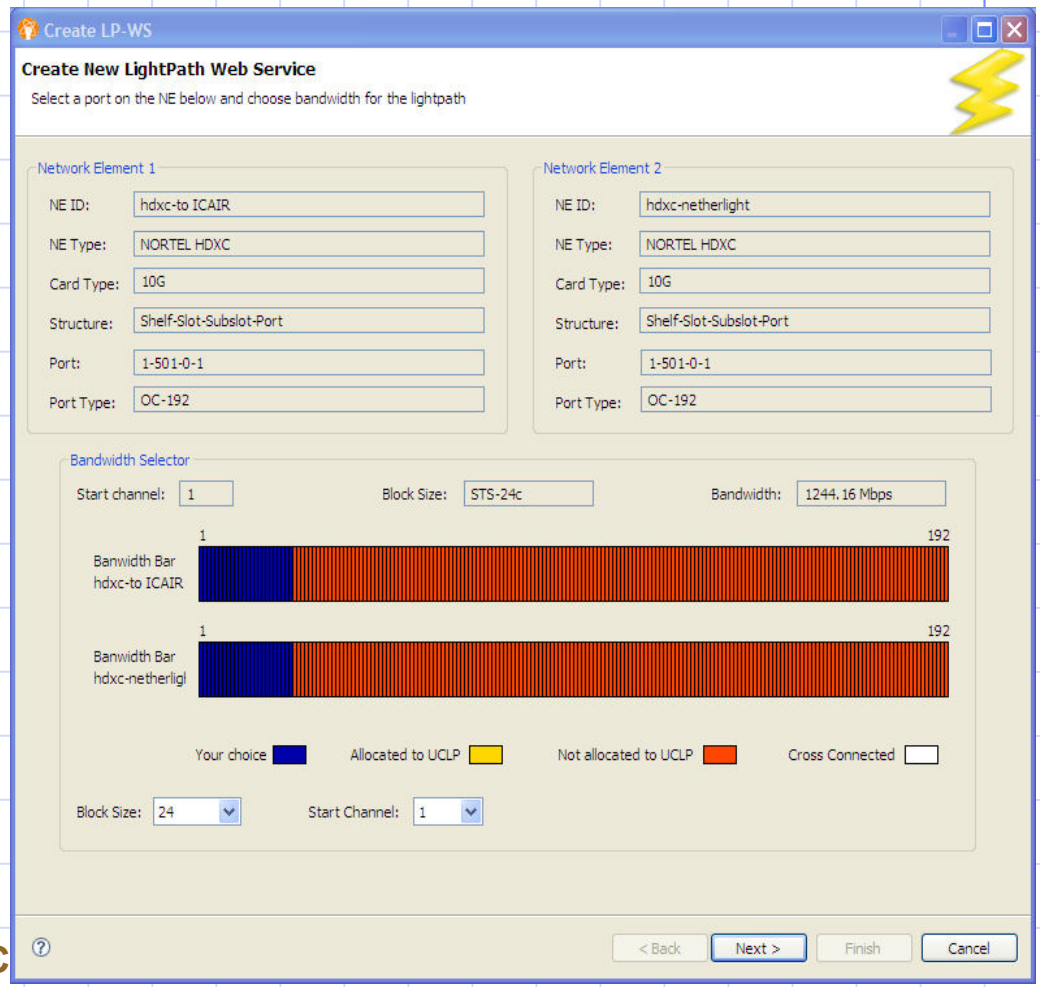
For An Event Requiring the Articulated Network, An Instantiation Need Be Undertaken Only Once. In this example, the Instantiation Is Implemented Across Network Domains, As A Single Network Within A Larger Physical Network, Comprised of Separate Physical Networks of Multiple Partners, Each With Separate Domains



Creating Logical Resources (Interfaces, Lightpaths)

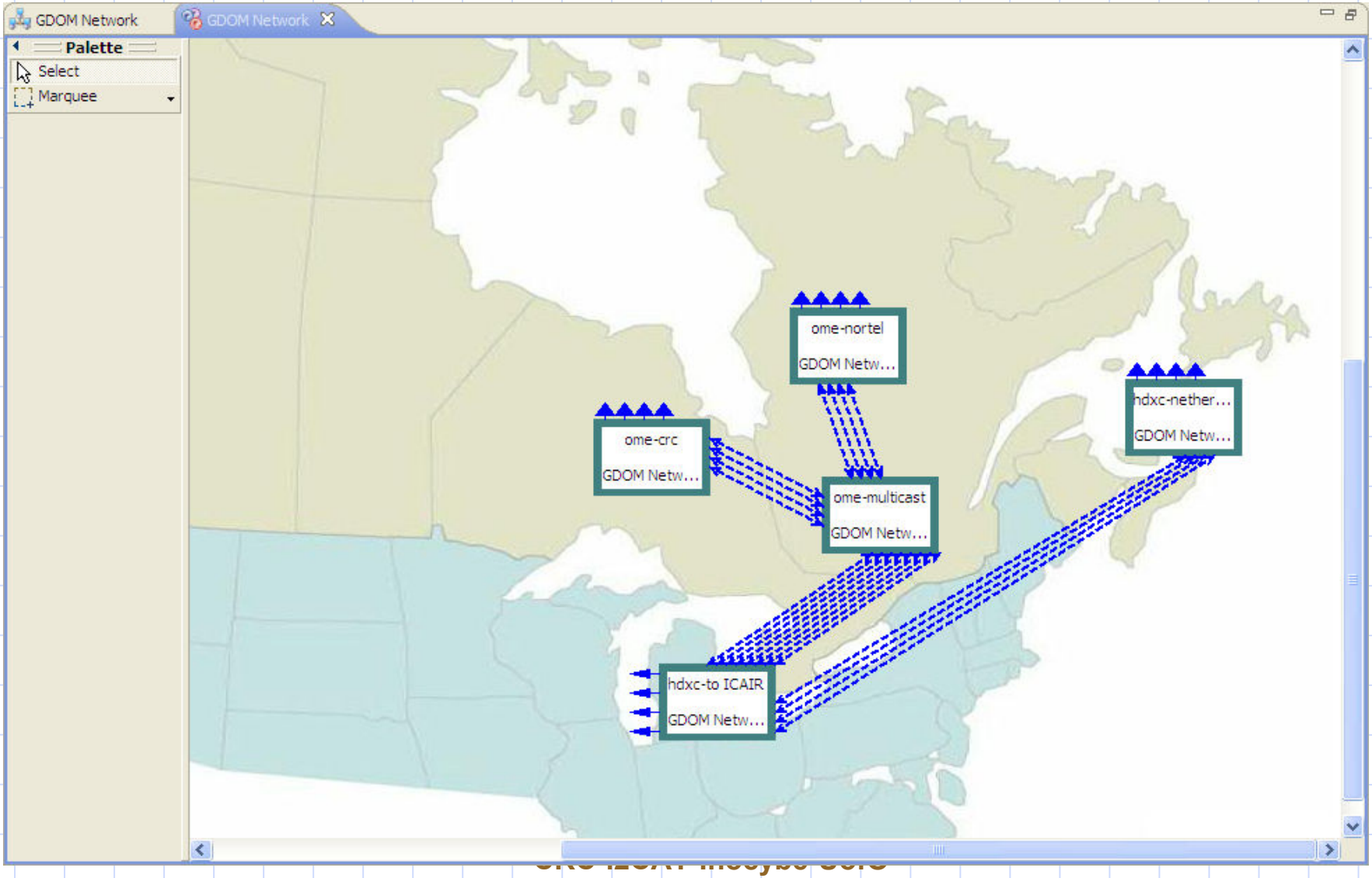
- Before Physical Connections Are Made, Logical Resources Must Be Selected and Integrated. Below Is an Example of Selecting and Allocating The Resources Required for multicast connections, which will result in the interface and lightpath resources creation,





Creating Logical Resources: The Logical Network

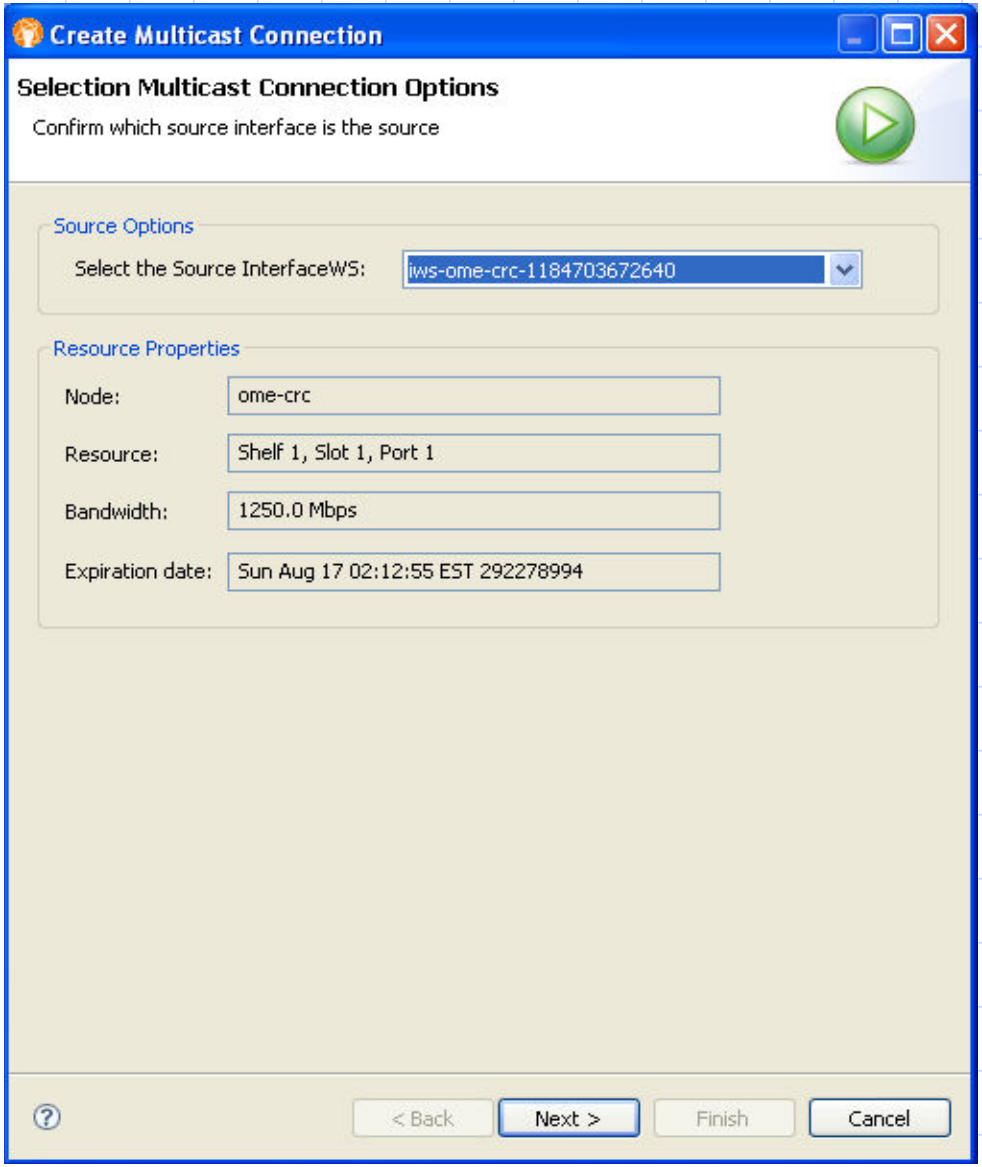
- All Created Logical Resources Are Shown By the Logical Network Editor
  Note that At This Point – There Are Still No Connections



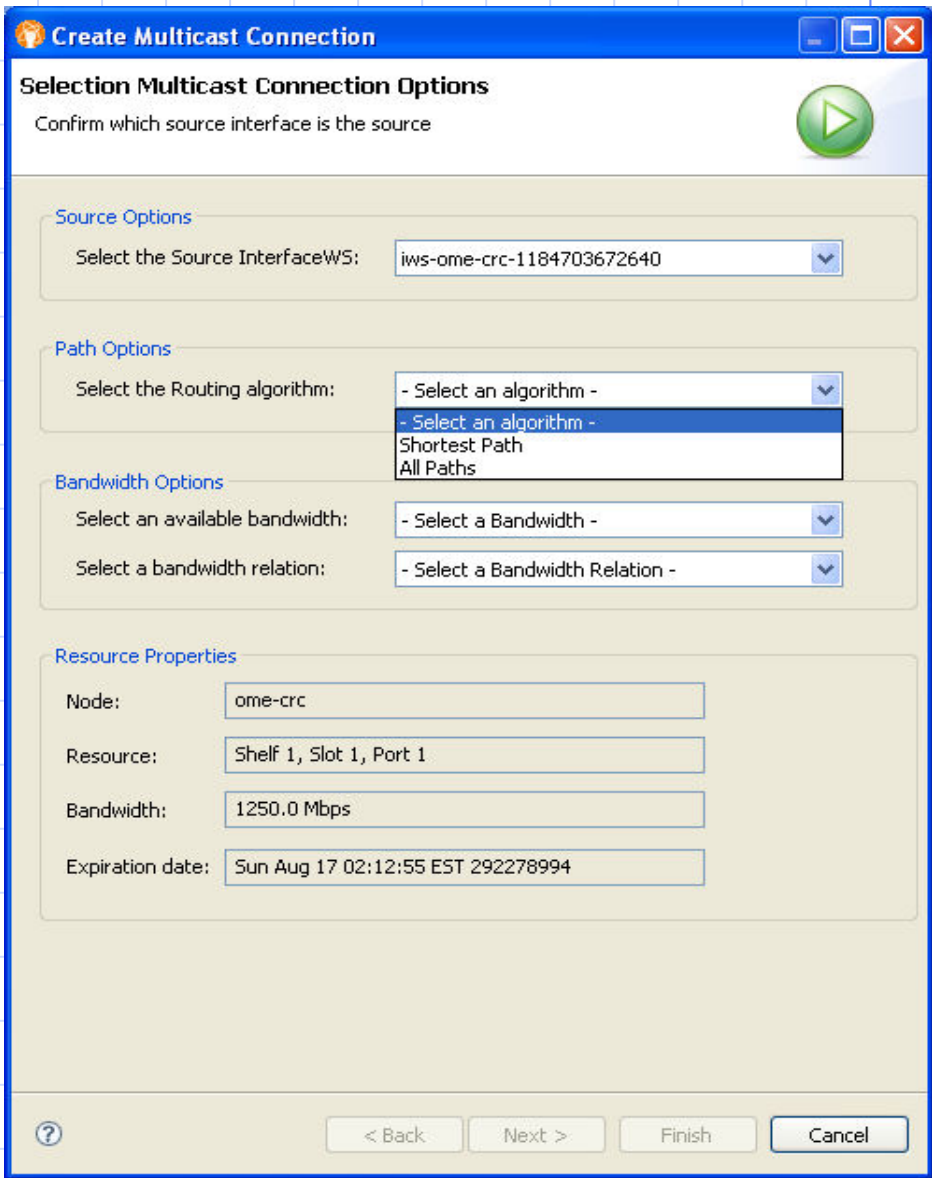
Creating the Multicast Connection(s)

- Two Options Exist:
  1. Manually select all the resources that will be part of the multicast connection.
  2. Select the interfaces to connect and the required lightpaths will be automatically computed.
- In Both Cases the Source Interface for the Connection Is Specified
  - This specification provides the GUI with a starting point for verification calculations and creates the correct data structure to represent the muilt-cast connection (Tree data structure)

Manually Selecting All Resources for Connection

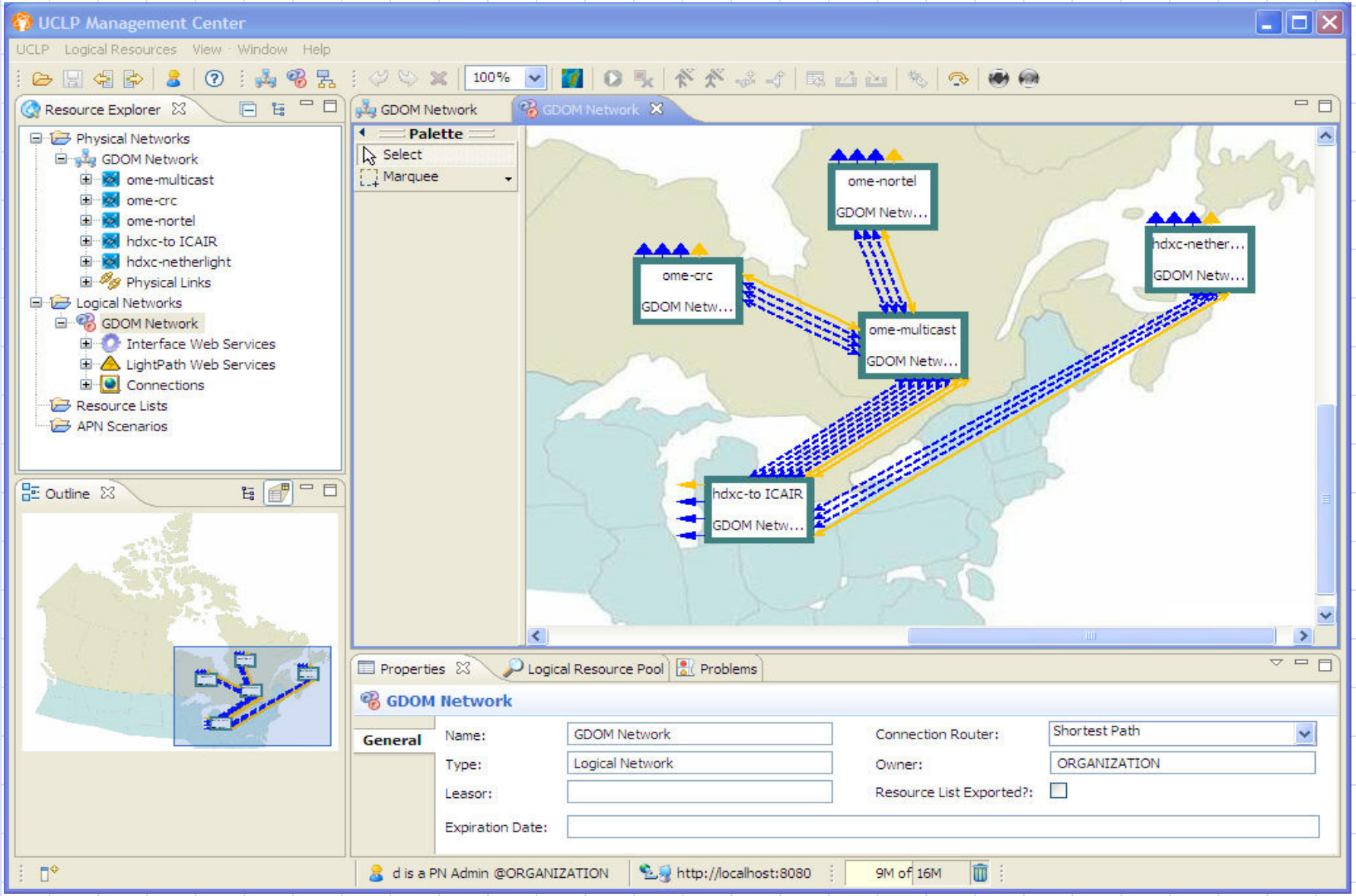


Letting UCLP Calculate Possible Routes



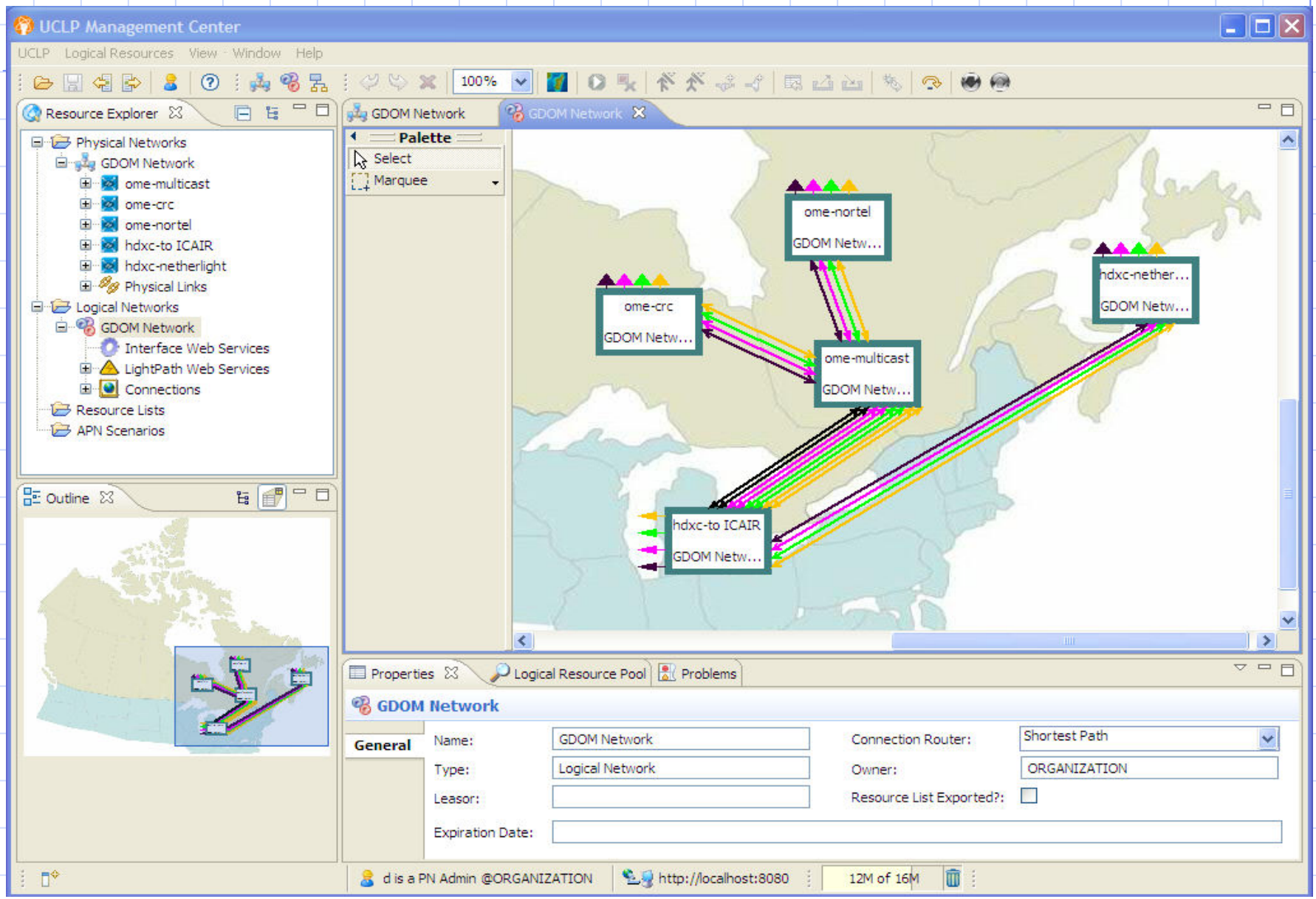
Creating the Multicast Connection(s) - II

- When the Connection Is Created, It Will Be Seen Graphically in the GUI



Creating the Multicast Connection(s) - III

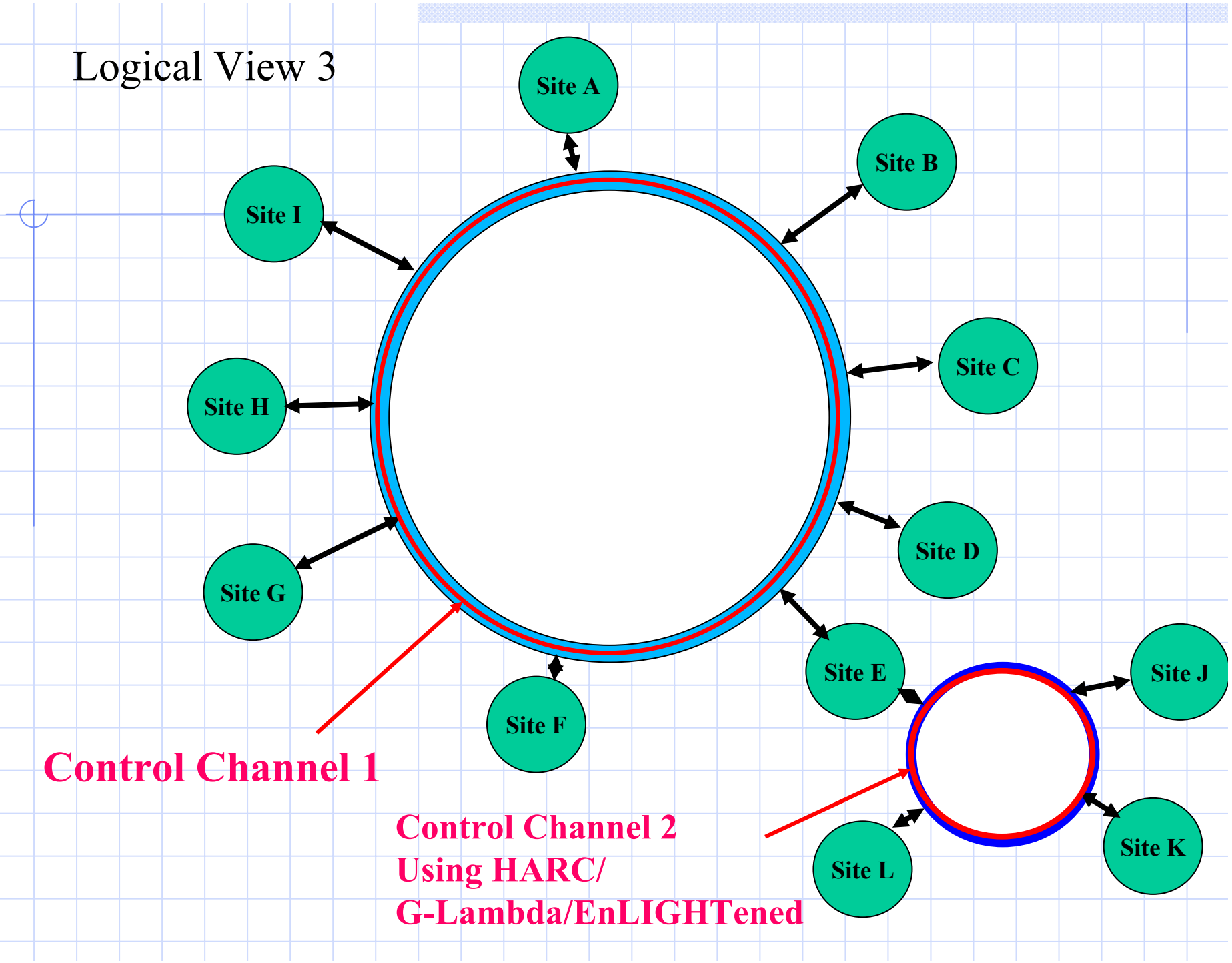
- Continue to Add Connections Until All Are Completed



Capability Extensions

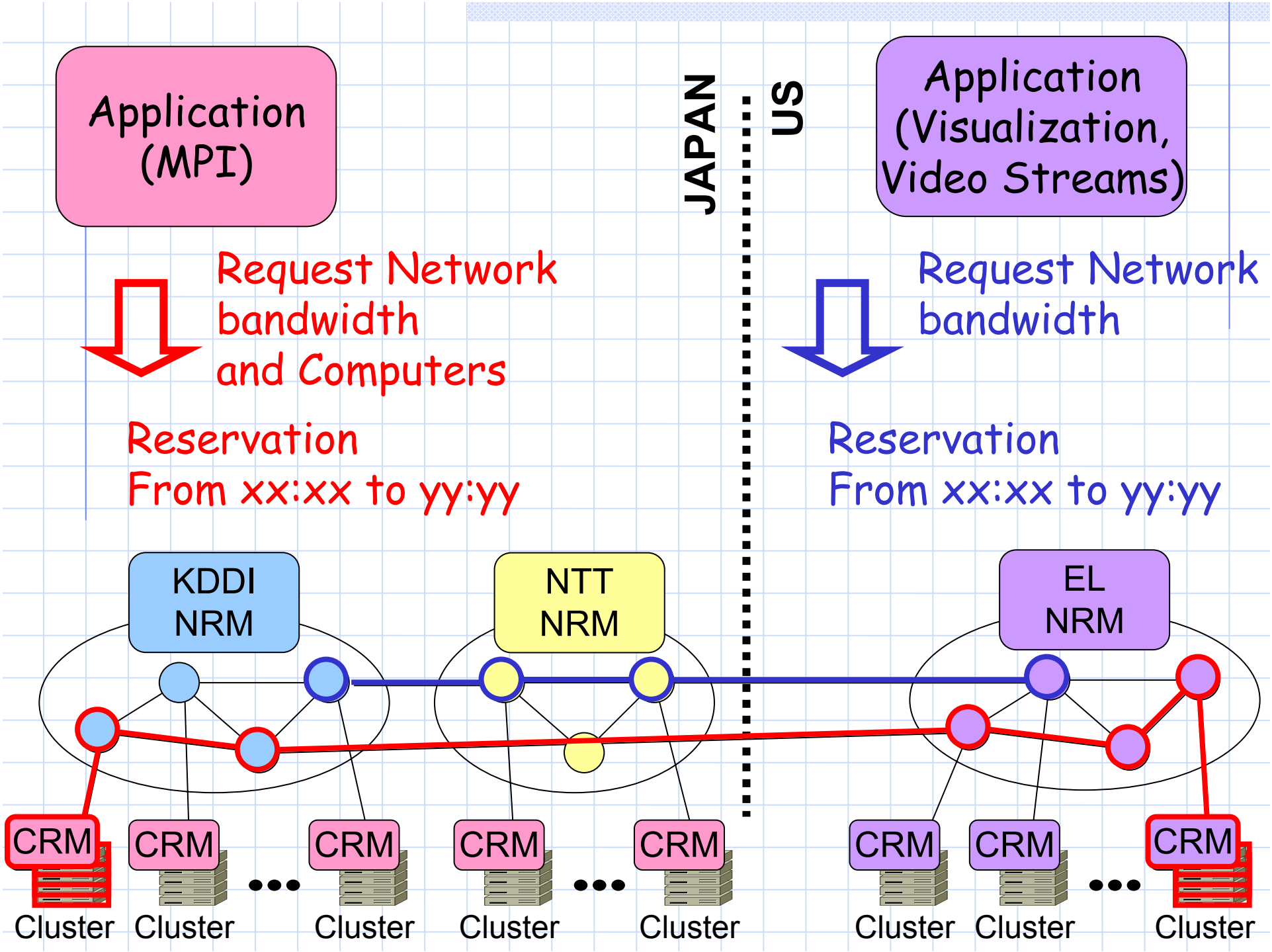
- The Capabilities Demonstrated Can Accommodate Integration With Additional Resources Controlled By Other Signaling Methods
- A Particular Instantiation May Incorporate Resources Controlled By Edge Domain Signaling for Dynamic Resource Switching External to the Core Articulated Network
- Following Is An Example

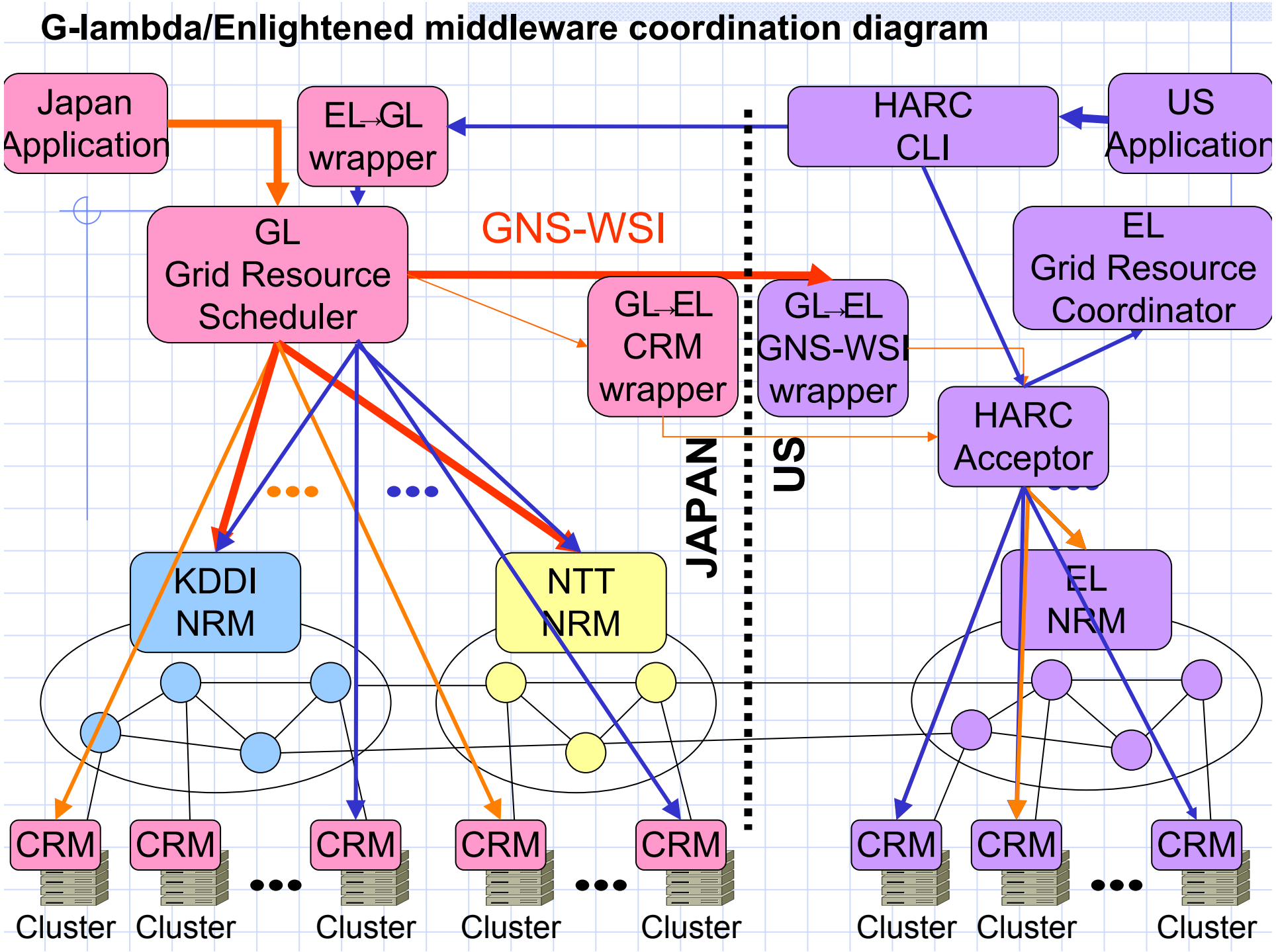
Logical View 3



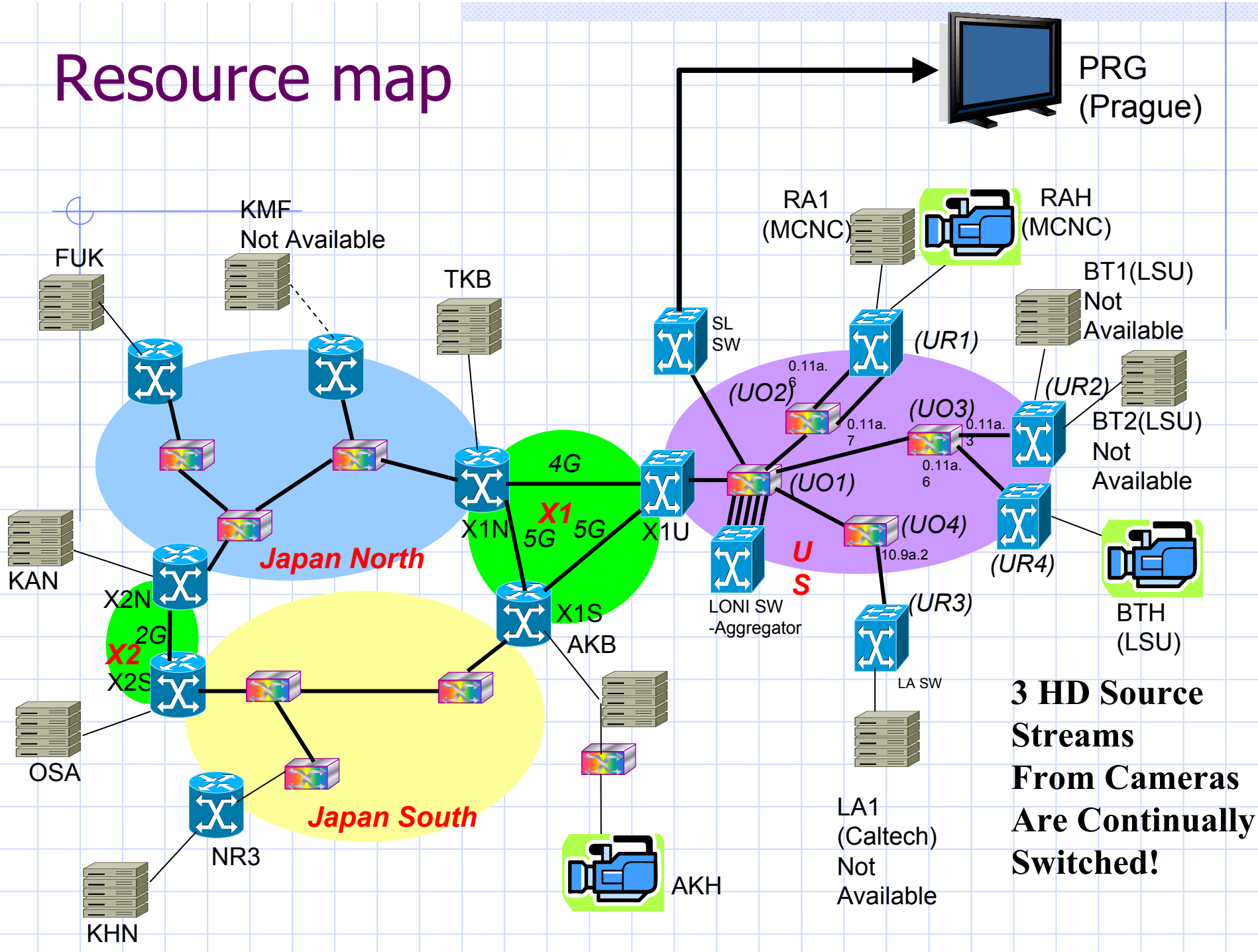
Demo overview

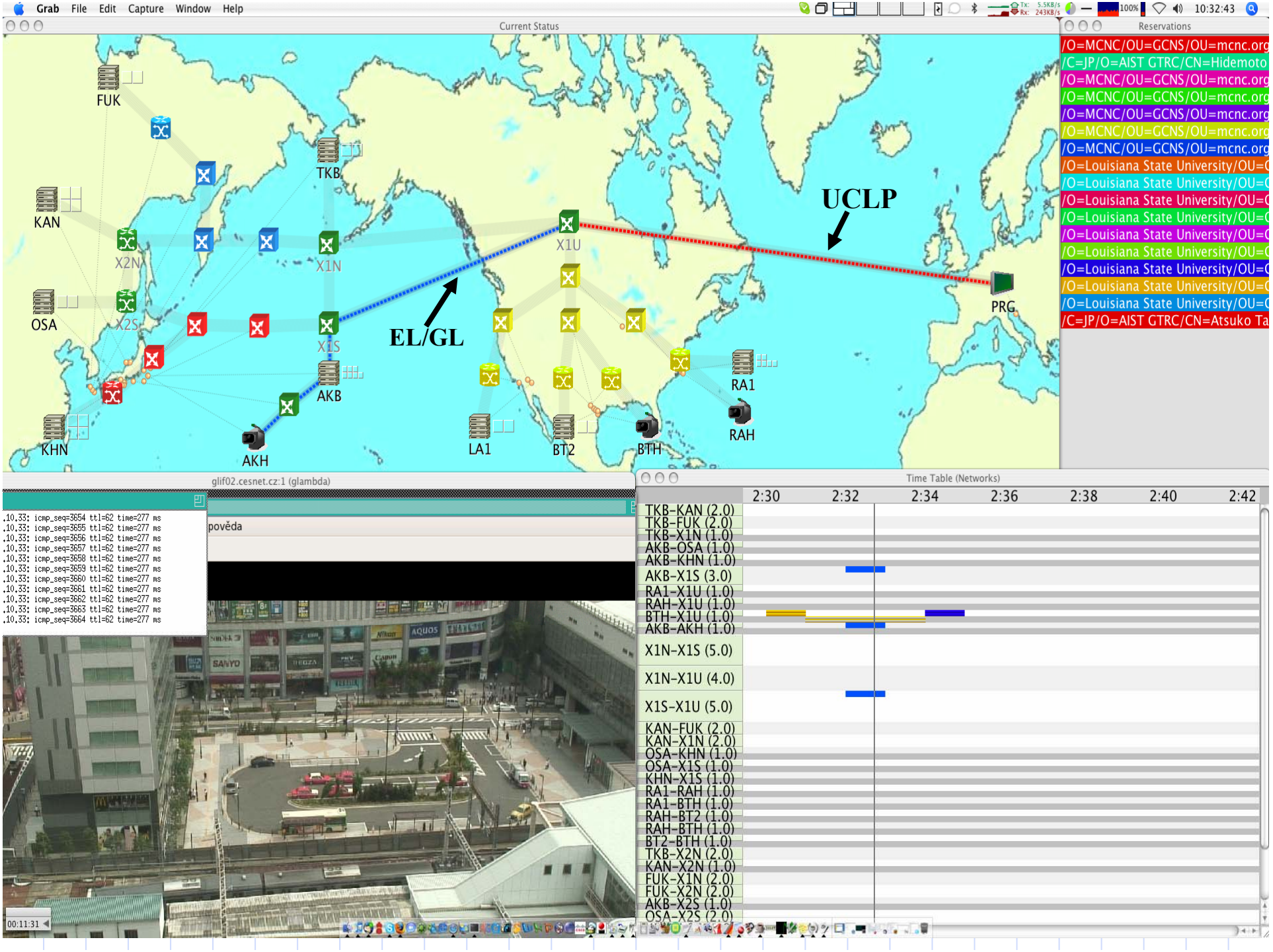
1. Reservations requested by Enlightened side.
2. Video streams begin alternating from multiple sites over dynamically requested / allocated US and Japan paths then to Prague. G-lambda makes a reservation.
3. Reservation statuses will be shown in G-lambda team's Reservation Resource Monitor (RRM) viewer
4. G-lambda team requests compute and network reservations in US and Japan. Reservation status will be shown.
5. Continued video streams are alternated, as per Enlightened reservations
6. When the reserved time arrives, applications start running, and statuses are updated in RRM viewer.


Application (MPI)
JAPAN
US
Application (Visualization, Video Streams)
Request Network bandwidth and Computers
Request Network bandwidth
Reservation From xx:xx to yy:yy
Reservation From xx:xx to yy:yy
KDDI NRM
NTT NRM
EL NRM
CRM
Cluster

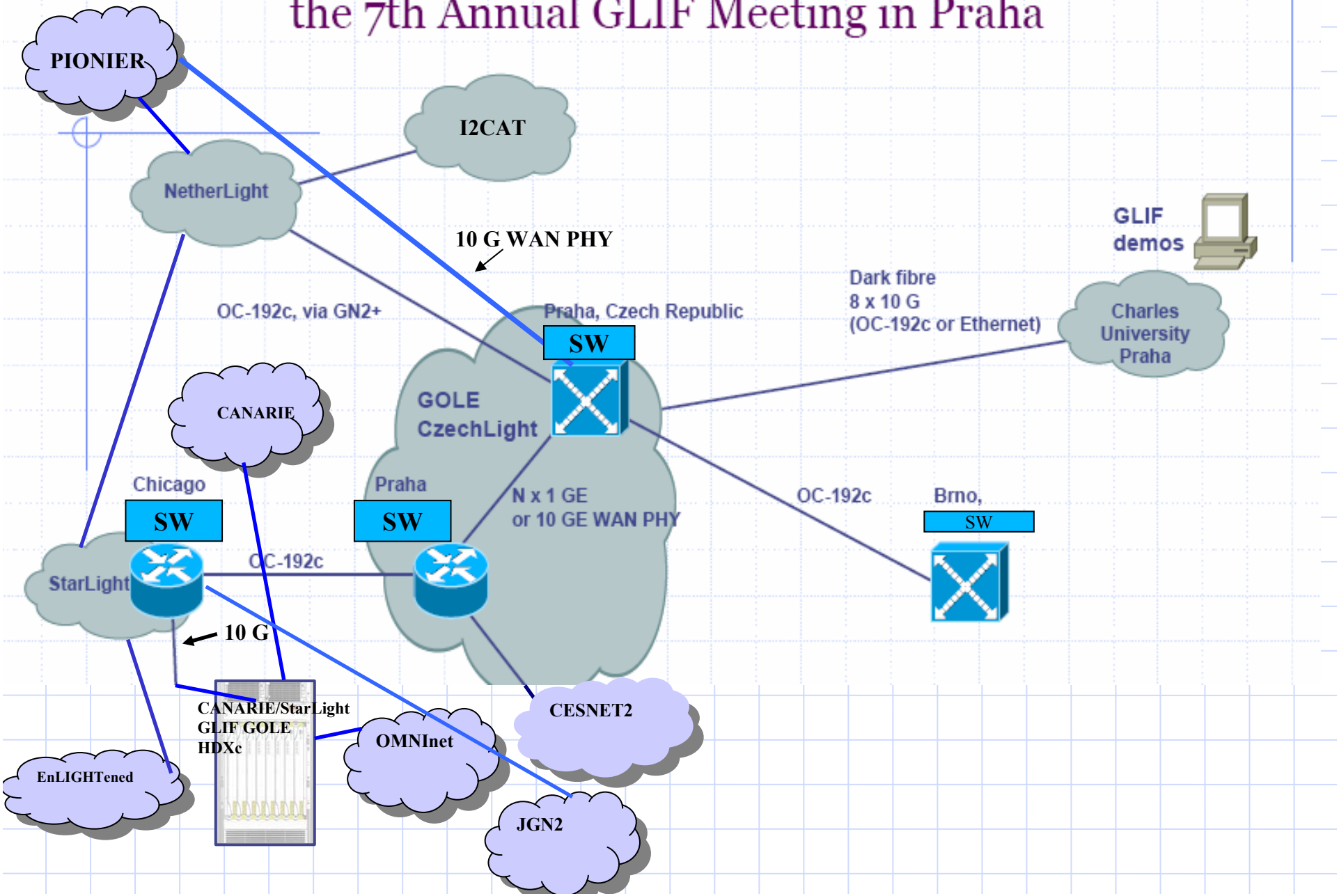

G-lambda/Enlightened middleware coordination diagram
Japan Application
EL→GL wrapper
HARC CLI
US Application
GL Grid Resource Scheduler
GNS-WSI
EL Grid Resource Coordinator
GL→EL CRM wrapper
GL→EL GNS-WSI wrapper
HARC Acceptor
JAPAN
US
KDDI NRM
NTT NRM
EL NRM
CRM
Cluster

Resource map

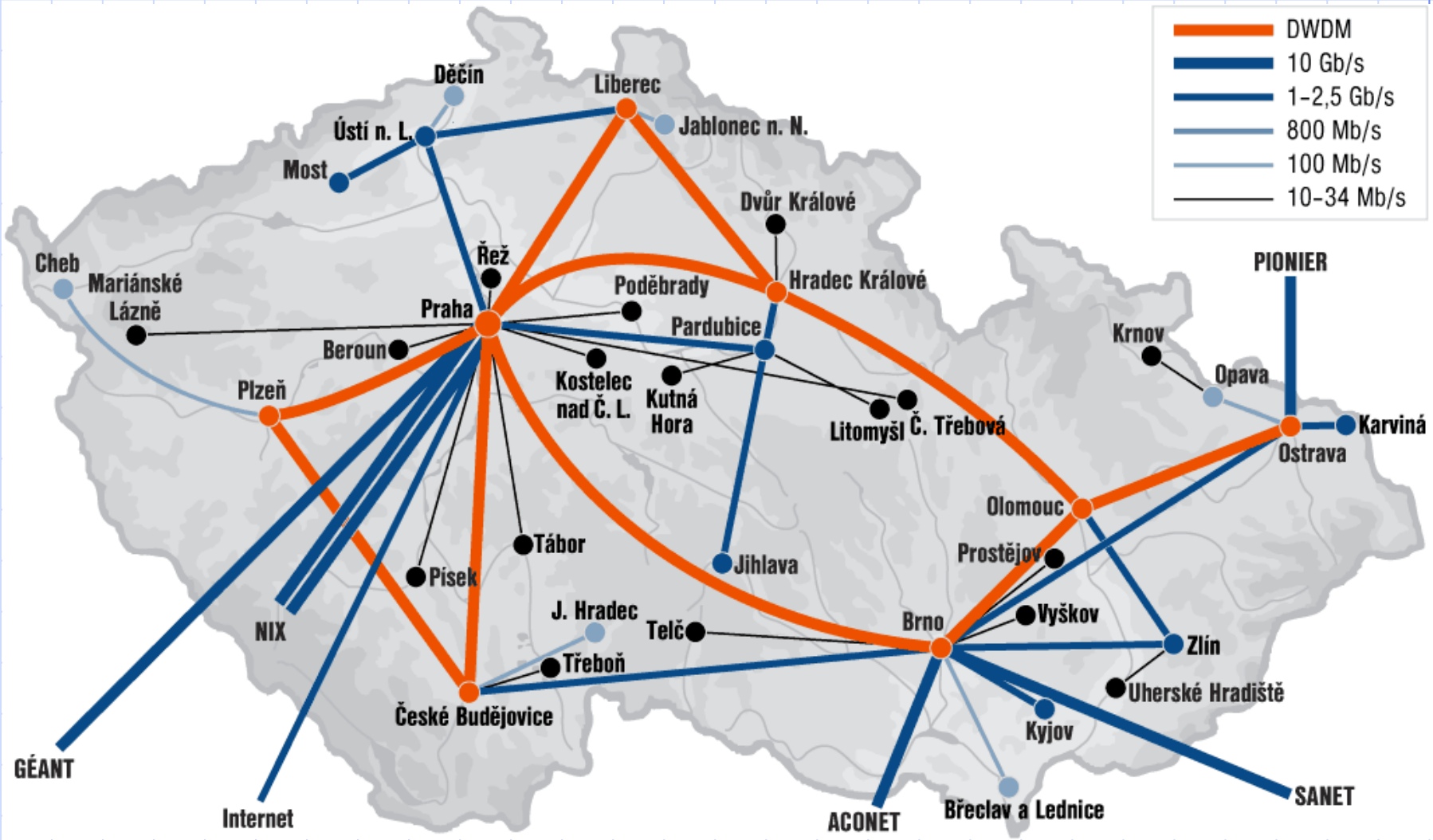



Grab File Edit Capture Window Help
10:32:43
Current Status
Reservations
FUK
TKB
KAN
X2N
X1N
X1U
UCLP
OSA
X2S
X1S
EL/GL
PRG
AKB
RA1
RAH
KHN
AKH
LA1
BT2
BTH
/O=MCNC/OU=GCNS/OU=mcnc.org
/C=JP/O=AIST GTRC/CN=Hidemoto
/O=Louisiana State University/OU=
/C=JP/O=AIST GTRC/CN=Atsuko Ta
glif02.cesnet.cz:1 (glambda)
.10.33: icmp_seq=3654 ttl=62 time=277 ms
.10.33: icmp_seq=3655 ttl=62 time=277 ms
.10.33: icmp_seq=3656 ttl=62 time=277 ms
.10.33: icmp_seq=3657 ttl=62 time=277 ms
.10.33: icmp_seq=3658 ttl=62 time=277 ms
.10.33: icmp_seq=3659 ttl=62 time=277 ms
.10.33: icmp_seq=3660 ttl=62 time=277 ms
.10.33: icmp_seq=3661 ttl=62 time=277 ms
.10.33: icmp_seq=3662 ttl=62 time=277 ms
.10.33: icmp_seq=3663 ttl=62 time=277 ms
.10.33: icmp_seq=3664 ttl=62 time=277 ms
pověda
00:11:31
Time Table (Networks)
2:30
2:32
2:34
2:36
2:38
2:40
2:42
TKB-KAN (2.0)
TKB-FUK (2.0)
TKB-X1N (1.0)
AKB-OSA (1.0)
AKB-KHN (1.0)
AKB-X1S (3.0)
RA1-X1U (1.0)
RAH-X1U (1.0)
BTH-X1U (1.0)
AKB-AKH (1.0)
X1N-X1S (5.0)
X1N-X1U (4.0)
X1S-X1U (5.0)
KAN-FUK (2.0)
KAN-X1N (2.0)
OSA-KHN (1.0)
OSA-X1S (1.0)
KHN-X1S (1.0)
RA1-RAH (1.0)
RA1-BTH (1.0)
RAH-BT2 (1.0)
RAH-BTH (1.0)
BT2-BTH (1.0)
TKB-X2N (2.0)
KAN-X2N (1.0)
FUK-X1N (2.0)
FUK-X2N (2.0)
AKB-X2S (1.0)
OSA-X2S (2.0)

Infrastructure and Connectivity for the 7th Annual GLIF Meeting in Praha

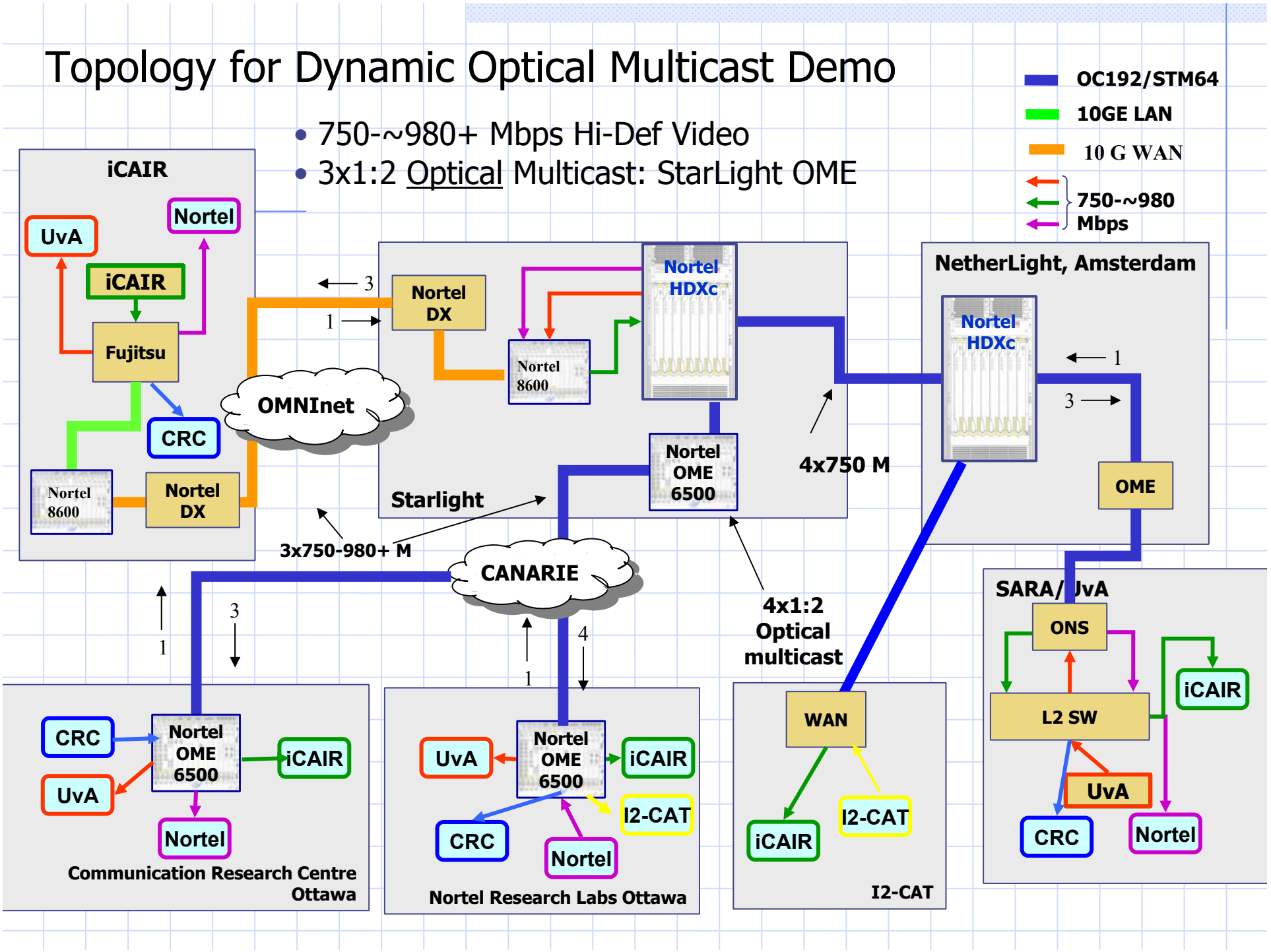


CESNET


DWDM
10 Gb/s
1-2,5 Gb/s
800 Mb/s
100 Mb/s
10-34 Mb/s
Děčín
Liberec
Jablonec n. N.
Ústí n. L.
Most
Dvůr Králové
Řež
Cheb
Mariánské Lázně
Poděbrady
Hradec Králové
PIONIER
Praha
Pardubice
Krnov
Beroun
Opava
Kostelec nad Č. L.
Kutná Hora
Plzeň
Litomyšl
Č. Třebová
Karviná
Ostrava
Olomouc
Tábor
Prostějov
Jihlava
Písek
J. Hradec
Vyškov
Brno
Telč
Zlín
NIX
Třeboň
Uherské Hradiště
České Budějovice
Kyjov
GÉANT
SANET
Internet
ACONET
Břeclav a Lednice

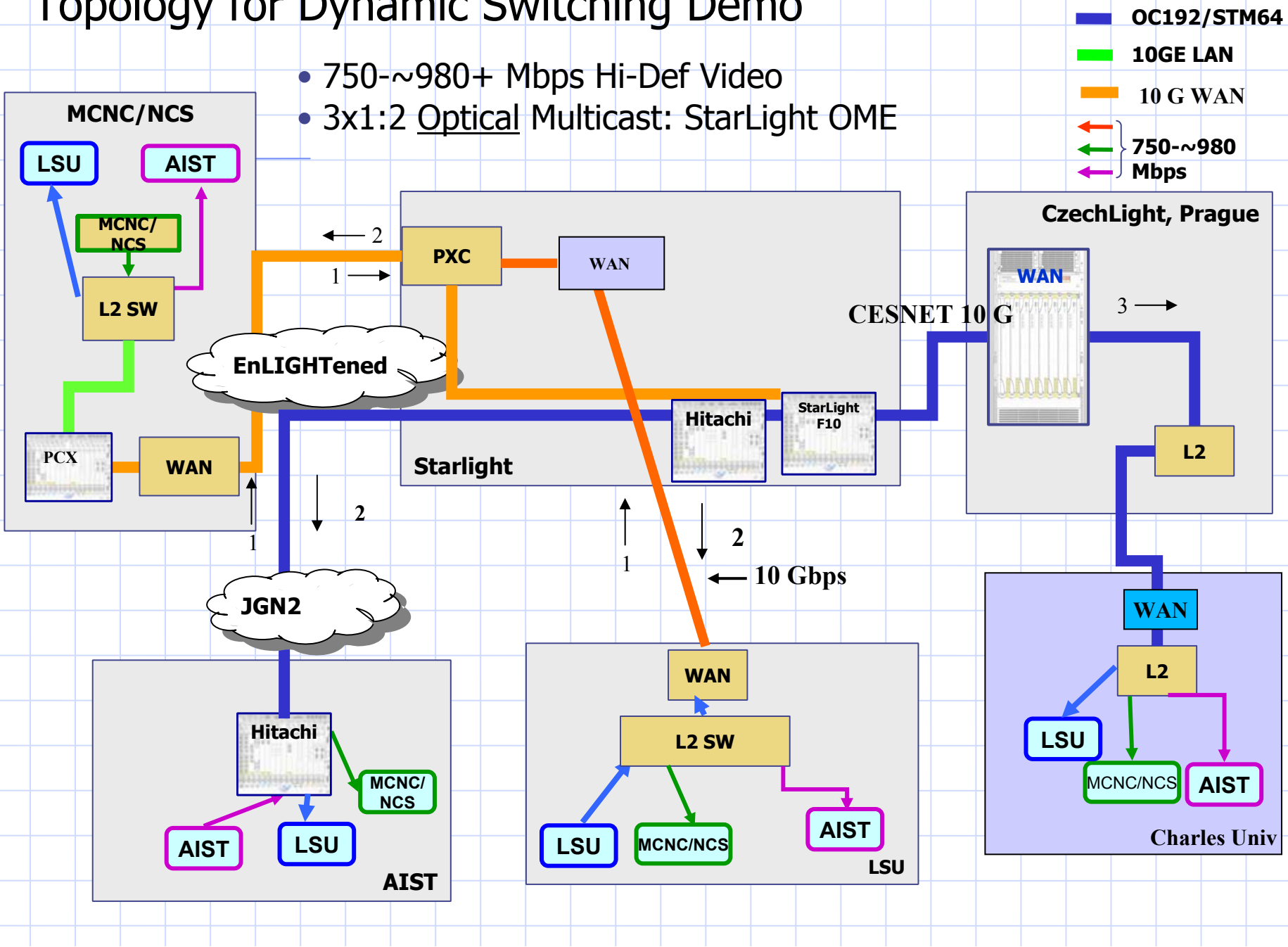
Topology for Dynamic Optical Multicast Demo

- 750-~980+ Mbps Hi-Def Video
- 3x1:2 Optical Multicast: StarLight OME



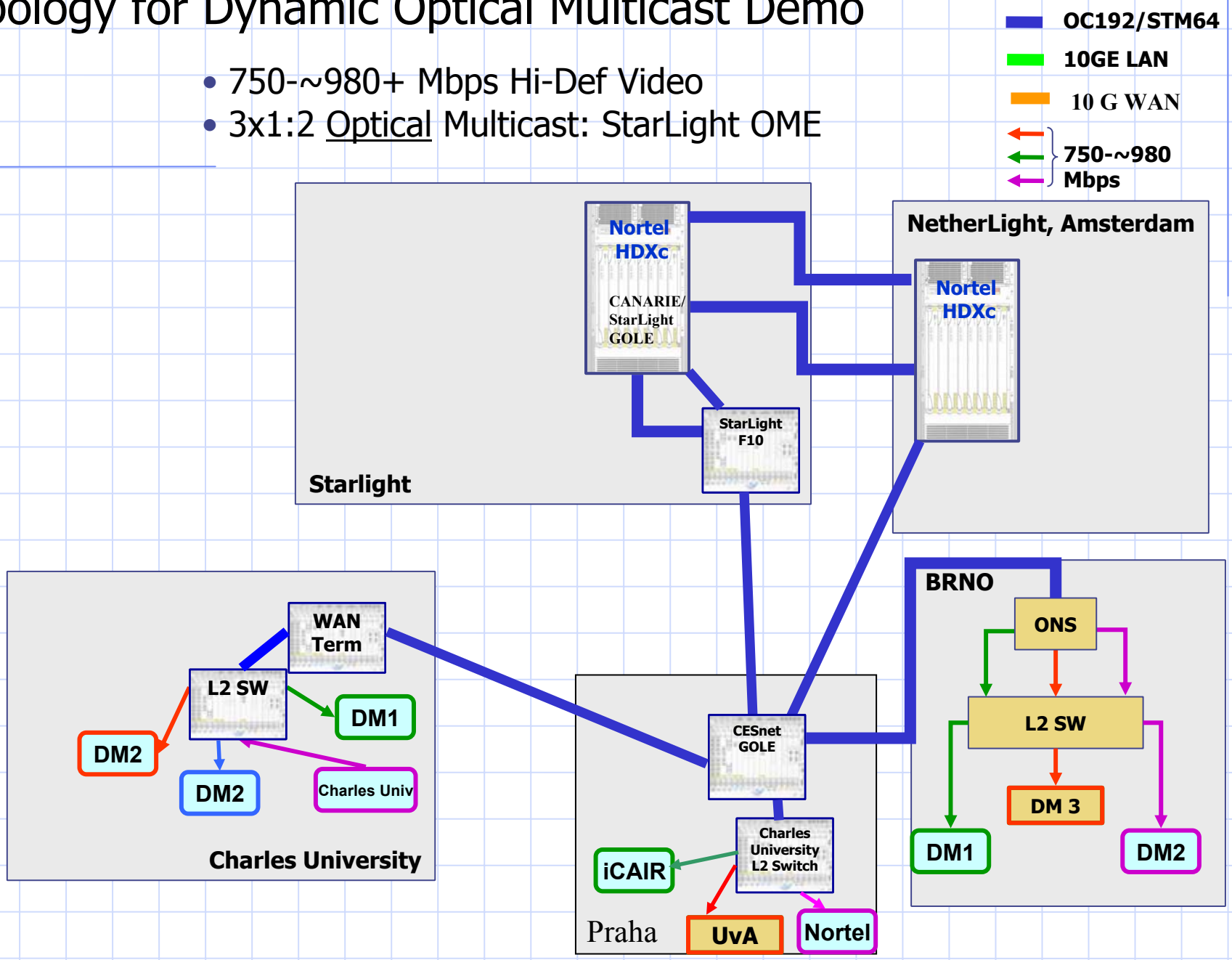
Topology for Dynamic Switching Demo

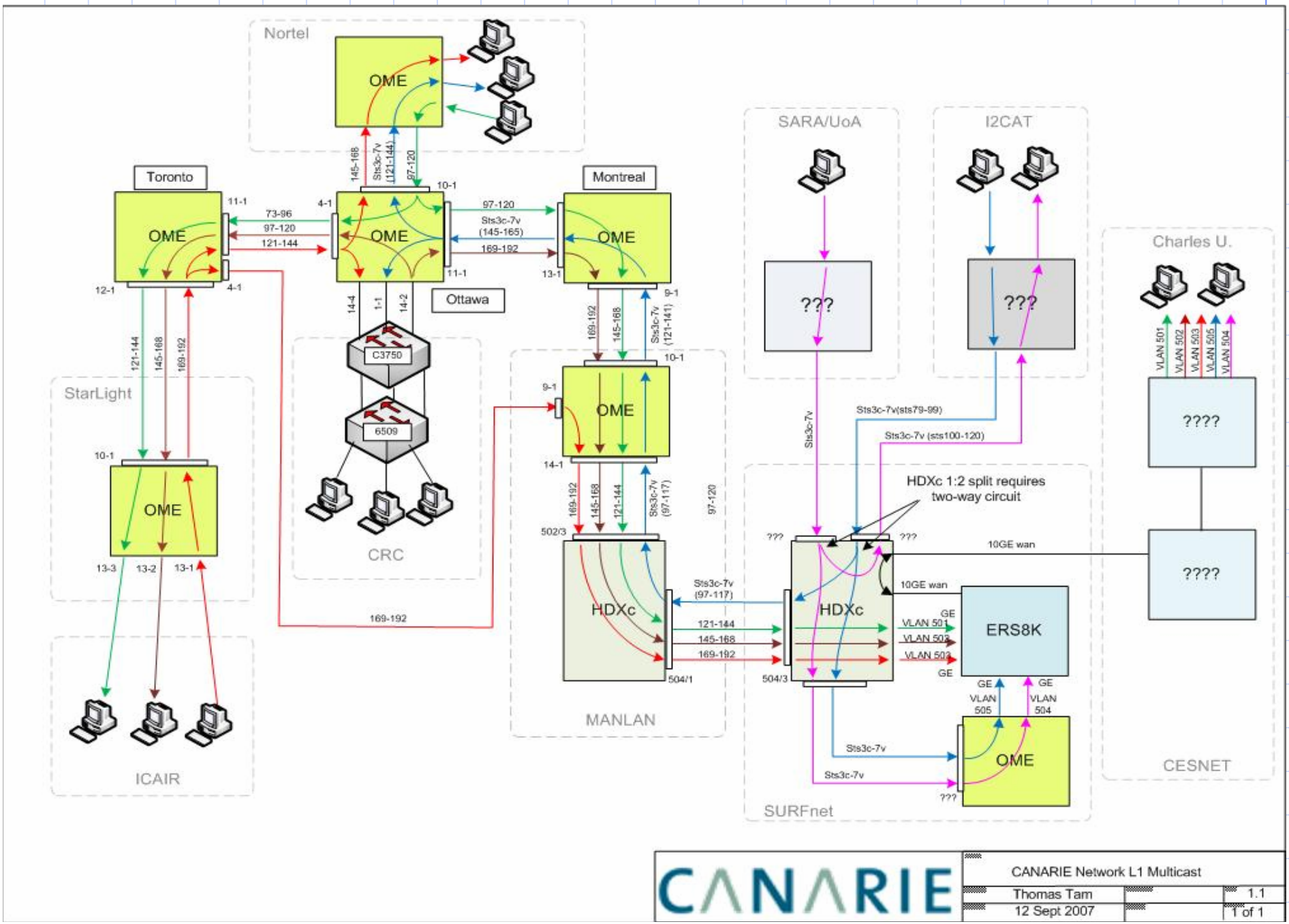
- 750-~980+ Mbps Hi-Def Video
- 3x1:2 Optical Multicast: StarLight OME



Topology for Dynamic Optical Multicast Demo

- 750-~980+ Mbps Hi-Def Video
- 3x1:2 Optical Multicast: StarLight OME




Nortel
OME
145-168
Sts3c-7v (121-144)
97-120
10-1
Toronto
11-1
OME
12-1
4-1
73-96
97-120
121-144
4-1
OME
11-1
Ottawa
97-120
Sts3c-7v (145-165)
169-192
Montreal
OME
13-1
9-1
14-4
1-1
14-2
C3750
6509
CRC
169-192
145-168
Sts3c-7v (121-141)
10-1
9-1
OME
14-1
169-192
145-168
121-144
Sts3c-7v (97-117)
502/3
HDXc
504/1
MANLAN
97-120
Sts3c-7v (97-117)
121-144
145-168
169-192
StarLight
121-144
145-168
169-192
10-1
OME
13-3
13-2
13-1
ICAIR
169-192
SARA/UoA
???
I2CAT
???
Sts3c-7v
Sts3c-7v(sts79-99)
Sts3c-7v (sts100-120)
HDXc 1:2 split requires two-way circuit
??? ???
HDXc
504/3
10GE wan
10GE wan
GE
VLAN 501
VLAN 502
VLAN 503
GE
ERS8K
GE
GE
VLAN 505
VLAN 504
Sts3c-7v
Sts3c-7v
???
OME
SURFnet
Charles U.
VLAN 501
VLAN 502
VLAN 503
VLAN 505
VLAN 504
????
????
CESNET
CANARIE
CANARIE Network L1 Multicast
Thomas Tam
1.1
12 Sept 2007
1 of 1

Demonstration Participants

- **CESNET**
  - Jan Radil
  - Vladimir Trestik
  - Jan Furman
  - Jan Nejman
  - Stanislav Sima
  - Michal Krsek
  - Michal Martin
  - Lada Altmanov
- **Communications Research Centre**
  - Michel Savoie
  - Bobby Ho
  - Hanxi Zhang
  - Scott Campbell

Demonstration Participants (Cont.)

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  - Herve Guy
  - Darcy Quesnel
  - Jun Jian
  - Thomas Tam
- **i2CAT**
  - Artur Serra
  - Sergi Figuerola
  - Berenguer Vilajoliu
  - Eduard Grasa
  - Francisco Iglesias
- **Inocybe**
  - Mathieu Lemay
- **LONI**
  - Lonnie Leger
  - Ben Blundell
  - Charles McMahon

Demonstration Participants (Cont.)

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  - Andrei Hutanu
  - Jon MacLaren
  - Dan Katz
  - Gabrielle Allen
  - Ed Seidel

- **National Institute of Industrial Science and Technology (AIST)**
  - Tomohiro Kudoh
  - Atsuko Takefusa
  - Hidemoto Nakada

- **Nortel**
  - Rodney Wilson
  - Éric Bernier
  - Dave Yeung
  - Wai-Chau Hui
  - Michael Ward
  - Ted Swinwood
  - Inder Monga

Demonstration Participants (Cont)

- **Masaryk University**
- Petr Holub

- **MCNC**
- Lina Battestilli
- Gigi Karmous-Edwards
- John Moore
- Yufeng Xin
- Steve Thorpe
- Syam Sundar

- **Northwestern University**
- Joe Mambretti
- Jim Chen
- Fei Yeh

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- **SARA**
  - Pieter de Boer
  - Ronald van der Pol
  - Jorrit Adriaanse
  - Paul Wielinga
- **StarLight**
  - Linda Winkler
  - Alan Verlo
- **SURFnet**
  - Kees Negers
  - Erik-Jan Bos
  - Bram Peeters
  - Mark Meijerink
- **University van Amsterdam**
  - Cees de Laat
  - J.P. Velders
  - Paola Grosso
  - Jeroen Roodhart

International High Performance Digital Media With Dynamic Optical Multicast: Demonstration Contributors