The Potential use of Research Networks

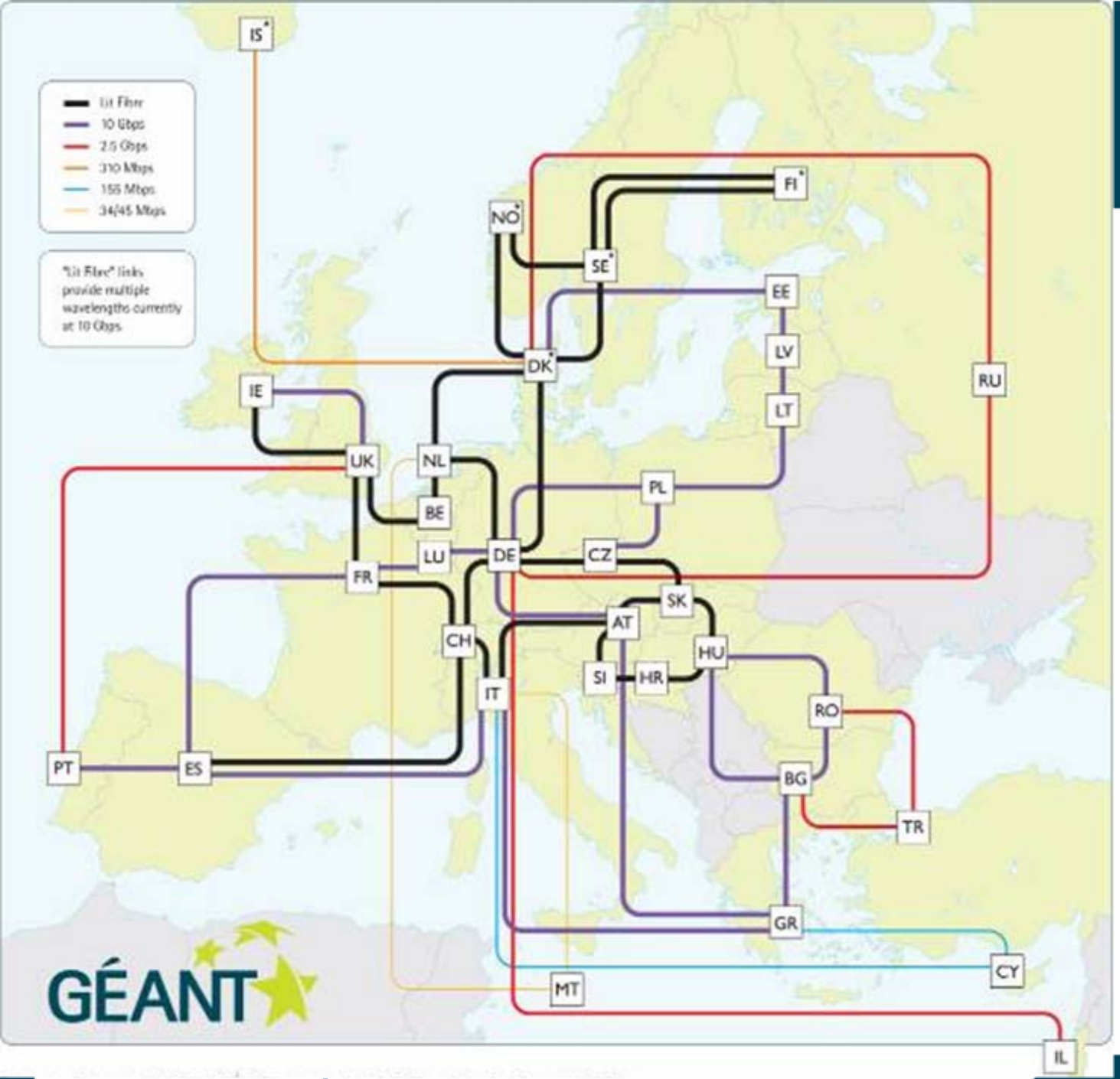
Richard Hughes-Jones
DANTE Delivery of Advanced Network Technology to Europe
WMO Information System Co-ordination Group, Seoul, February 2010

European R&E Networking

- Each country operates it own independent R&E network.
- Depending on the country, this usually connects universities, colleges, research laboratories, schools, libraries, museums, municipal offices, hospitals.
- These national research and education networks (NRENs) may use different technologies and may offer different services.
- The NRENs are interconnected by a pan-European backbone called GÉANT.
- GÉANT provides extensive international connectivity to other world regions and is operated by DANTE.
- The key is close Collaboration & Co-operation.

The GÉANT – NREN Evolution:

- 7th generation of pan-European research network ***federated*** infrastructure:
  - EuropaNET → TEN34 → TEN155 → GÉANT (GN1 →GN2 → GN3)
- Connects 36 European countries through 32 NREN partners.
  - Serves over 3,500 research and education establishments across Europe
  - Over 30 million users
- Provides extensive international connectivity to other world regions.
- Funded jointly by NRENs and the EC.
- Mechanism is the GN3 ***Collaborative*** Project GÉANT:
  - co-ordination by ***DANTE*** via the ***PMT*** (Project Management Team)
  - complemented by ***TERENA***
  - involves > ***400 NREN staff***
- **Collaboration & Co-operation.**
- **A success story spanning over 20 years.**



- 38 European Countries
- Dark Fibre
- Hybrid network:
  - IP Packet routed
  - Switched point-to-point Circuits
  - Dedicated wavelengths Lambdas

GÉANT topology – April 2009

GÉANT Connectivity Services

- GÉANT & NRENs will offer connectivity.
  Hybrid networks built on dark fibre infrastructures lit with DWDM equipment.
- Basic IP access via a GÉANT2 router - GÉANT ip
  - High Bandwidth
  - Multicast
  - IPV6
  - QoS
  - MPLS / Traffic engineering
- Point-to-point Circuit Network - GÉANT plus
  - Dedicated Capacity – typically 1 Gigabit paths – linking data centres
  - Quickly configurable
  - More than 60 dedicated circuits by January 2009
- Wavelengths - GÉANT lambda
  - Full 10Gbps wavelengths across Europe
  - Backup for country IP access links with connection to another router

Key phrase is
Multi-Domain

- Note that not all networks may be able to offer all these facilities.

GÉANT Network Services

- GÉANT & NRENs will offer network services.

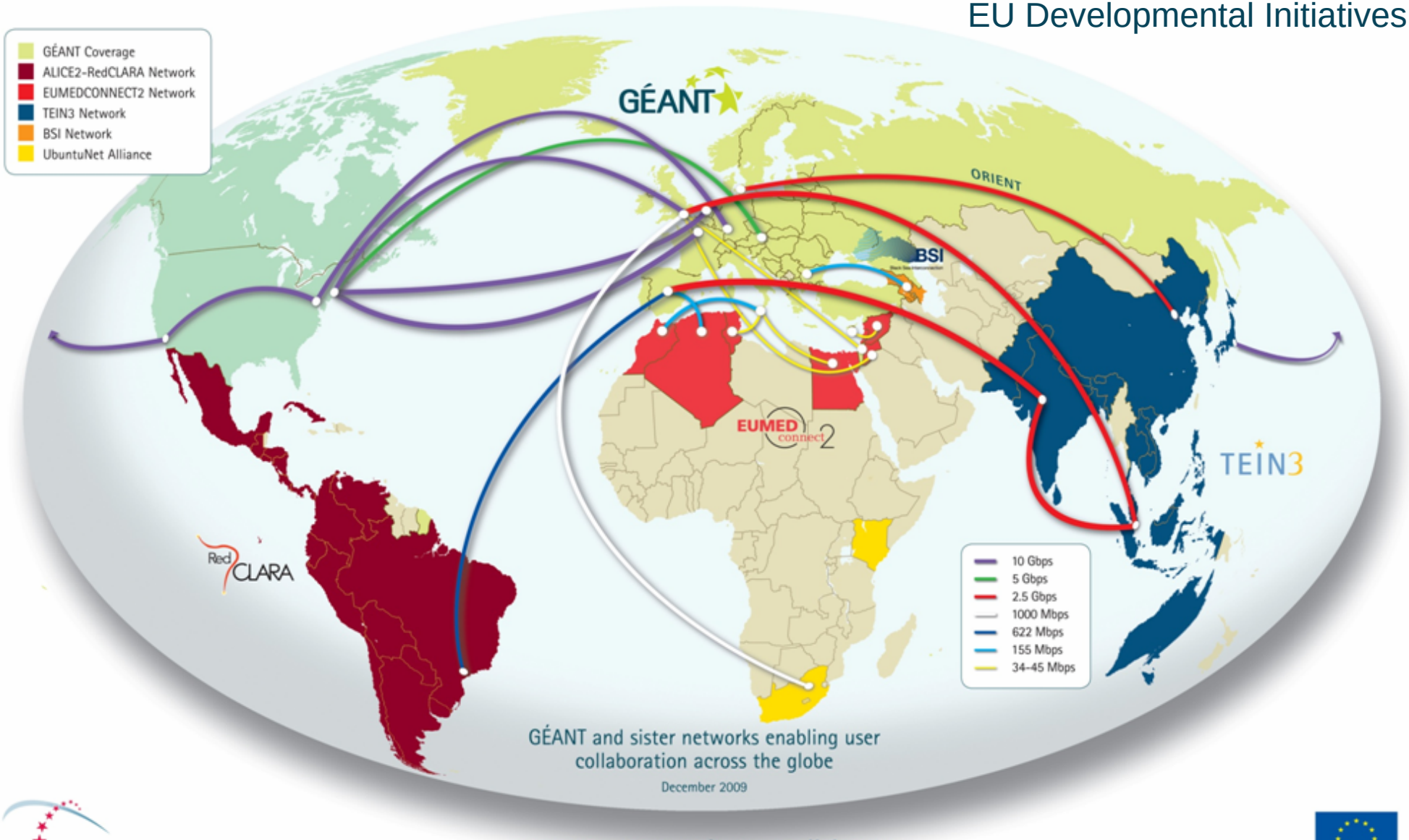
- Network Monitoring
  - perfSONAR – based on OGF Standards
  - e2eMON
  - (Troubleshooting tools)
  - eduPERT
- Network Provisioning “on demand”: Circuits / VPNs / MPLS / QoS
  - autoBAHN tool from GN2
  - World wide interoperation – OGF Standard being developed
  - Quick configuration tool as a minimum
- Security & mobility
  - PKI coordination
  - Roaming Access Service eduROAM
  - eduGAIN Service introduction
- Note that not all networks may be able to offer all these service facilities.

Key phrase is still **Multi-Domain**

WORLD CONNECTIVITY

GÉANT global connectivity

EU Developmental Initiatives



connect • communicate • collaborate

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DANTE
www.dante.net

European Commission
Information Society
and Media

Global Connectivity

Americas

• CANARIE	Canada
• CEDIA	Ecuador
• CUDI	Mexico
• ESNet	USA
• INNOVA|RED	Argentina
• Internet2	USA
• NISN (NASA)	USA
• NLR	USA
• RAAP	Peru
• RAGIE	Guatemala
• RAICES	El Salvador
• RAU2	Uruguay
• REACCIUN2	Venezuela
• RedCyT	Panama
• RENATA	Colombia
• REUNA	Chile
• RNP	Brazil
• USLHCNet	USA

Europe

• ACOnet	Austria
• ARNES	Slovenia
• ASA/INIMA	Albania
• BELNET	Belgium
• BIHARNET	Bosnia & Herzegovina
• CARNet	Croatia
• CESNET	Czech Republic
• CYNET	Cyprus
• DFN	Germany
• EENet	Estonia
• FCCN	Portugal
• GARR	Italy
• GRNET	Greece
• HEAnet	Ireland
• Holy See Internet Office	Vatican City
• ISTF	Bulgaria
• IUCC	Israel
• JANET(UK)	United Kingdom
• JSCC	Russia
• LITNET	Lithuania
• NIIF/ HUNGARNET	Hungary
• NORDUnet	Denmark Finland Iceland Norway Sweden
• PSNC	Poland
• RedIRIS	Spain
• RENATER	France
• RESTENA	Luxembourg
• RoEduNet	Romania

Europe (cont.)

• SigmaNet	Latvia
• SURFnet	The Netherlands
• SWITCH	Switzerland
• UKIM/MARNET	FYR of Macedonia
• ULAKBIM	Turkey
• University of Andorra	Andorra
• University of Malta	Malta
• UoB/AMRES	Serbia & Montenegro
• UoM/MREN	Serbia & Montenegro
• URAN	Ukraine

Middle East & Africa

• ANKABUT	United Arab Emirates
• ARN	Algeria
• Birzeit University/ Al Quds Open University	Palestinian Territories
• EUN	Egypt
• JuNet	Jordan
• MARWAN	Morocco
• Qatar Foundation	Qatar
• RFR	Tunisia
• SHERN	Syria
• TENET	South Africa

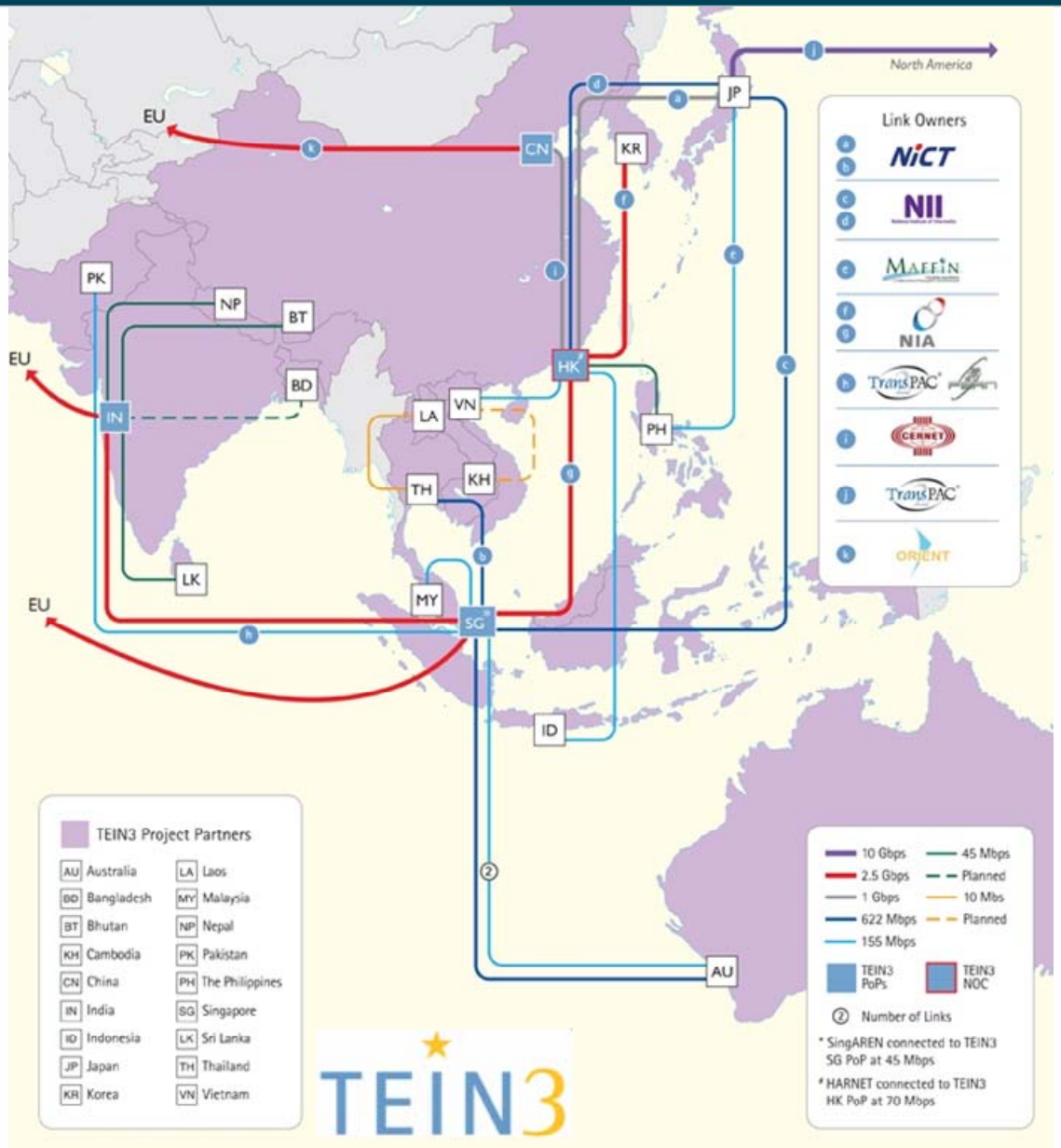
Asia & Oceania

• AARNet	Australia
• CERNET	China
• CSTNET	China
• ERNet	India
• INHERENT/ITB	Indonesia
• JGN2	Japan
• KOREN	Korea
• KREONET2	Korea
• LERNET	Laos
• MAFFIN	Japan
• MYREN	Malaysia
• NCSFNET	China
• PERN	Pakistan
• PREGINET	Philippines
• SINET	Japan
• SingAREN	Singapore
• ThaiSARN	Thailand
• UniNet	Thailand
• VINAREN	Vietnam

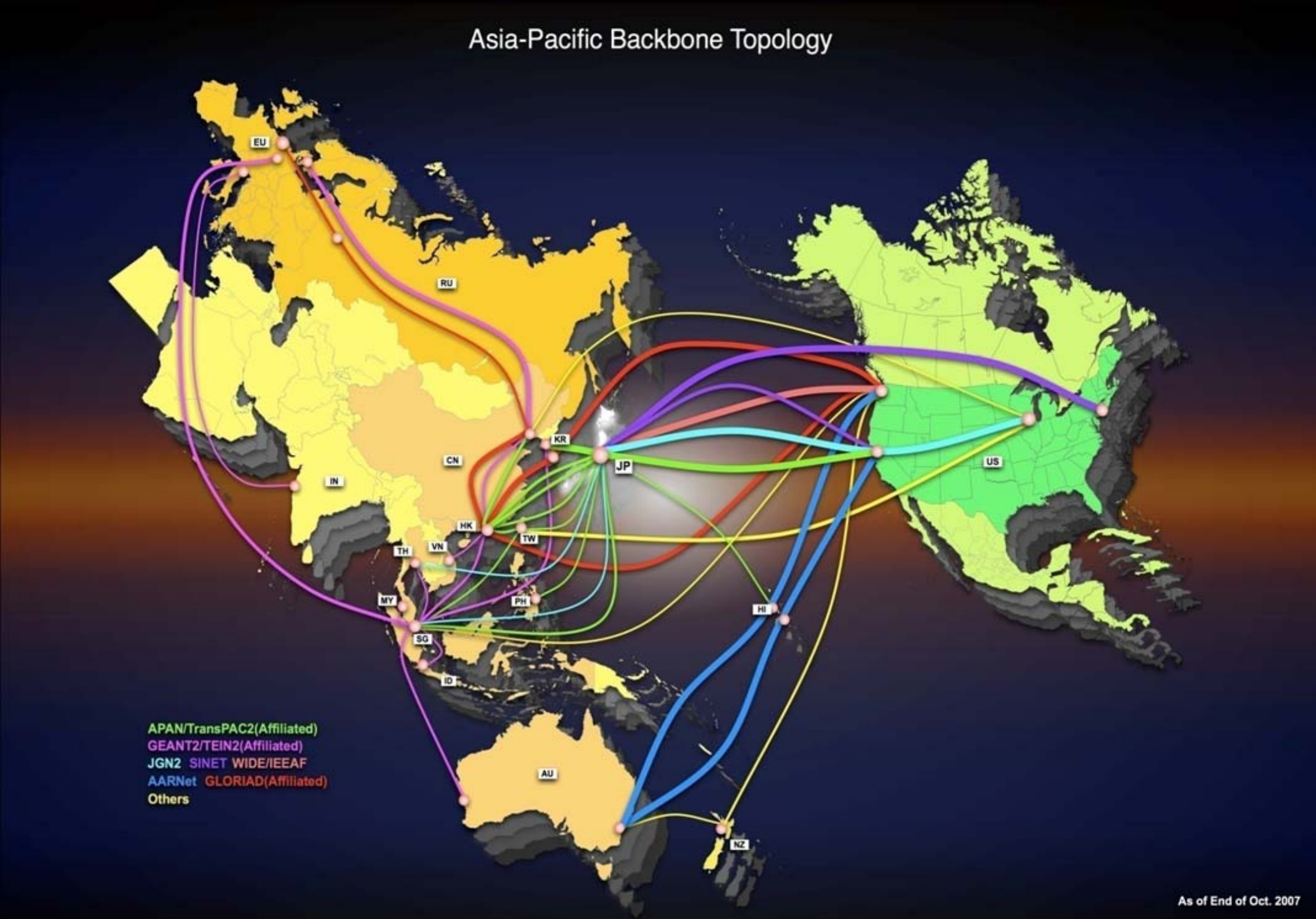
RedCLARA Topology

- EU ALICE Project
- CLARA a Regional Federation of NRENs
- Operate RedCLARA Network
- Varied Capabilities: Brazil, Argentina have dark fibre
- Links to Europe & US

TEIN3 Topology January 2010

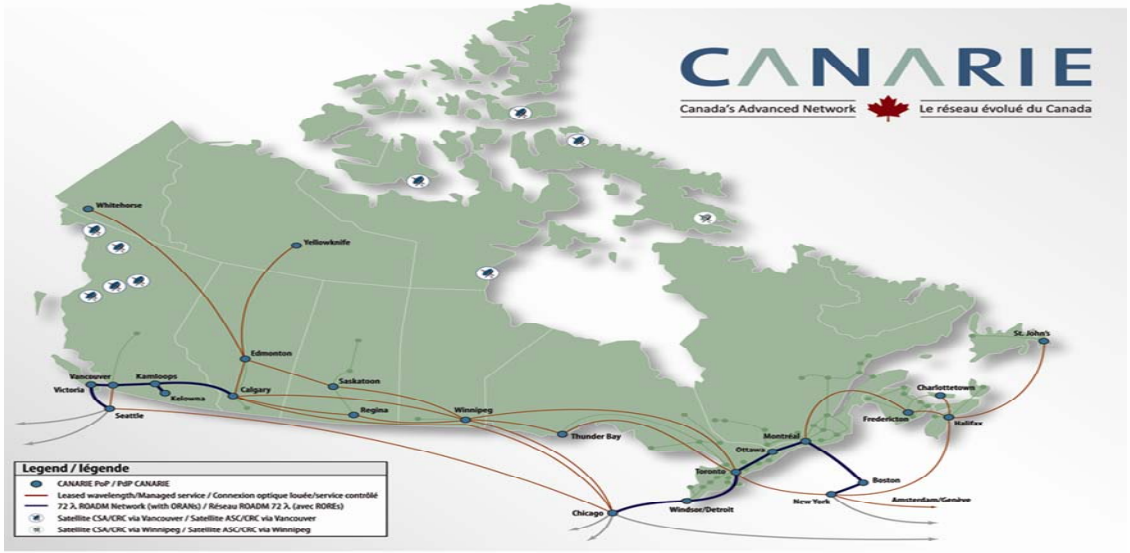


- Trans-Eurasia Information Network
- Federation of NRENs
  - 45 million users
  - 8,000 Institutes
- 2.5 Gbit Links to Europe
- NOC in HC managed by DANTE
- Catalyst for developing regional NRENs
- ORIENT & ORIENT2

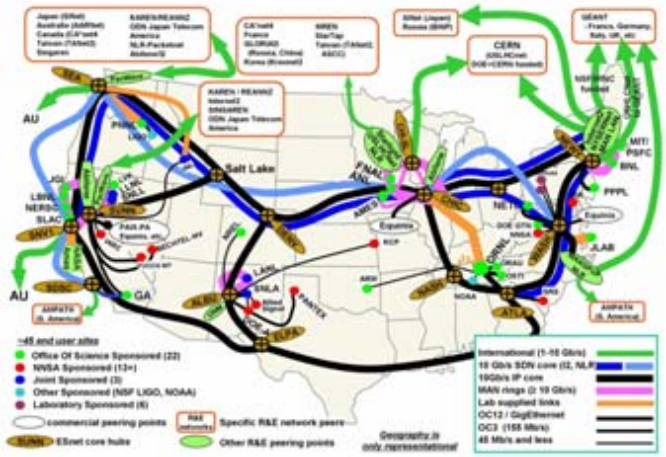


Courtesy of George McLoughlan

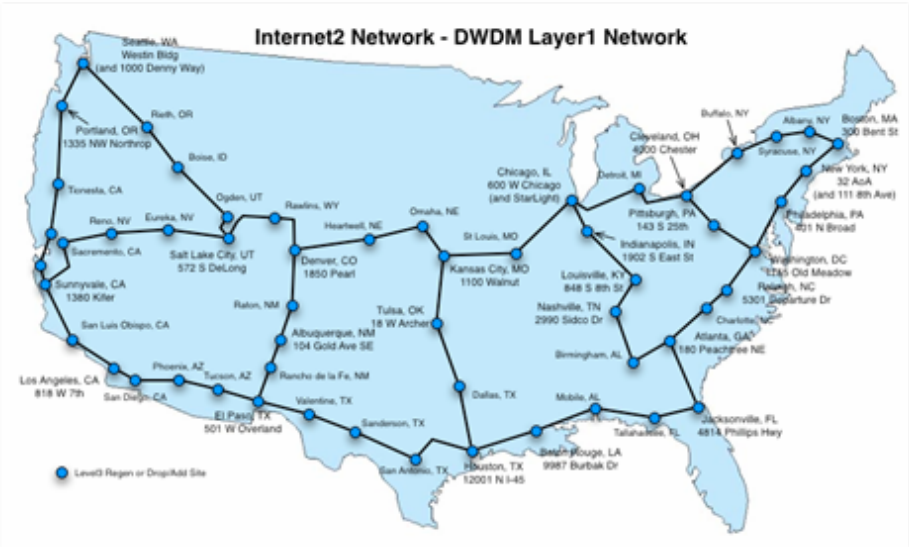
Networks in N. America



Esnet - DoE



Internet2 Infrastructure



NLR Backbone

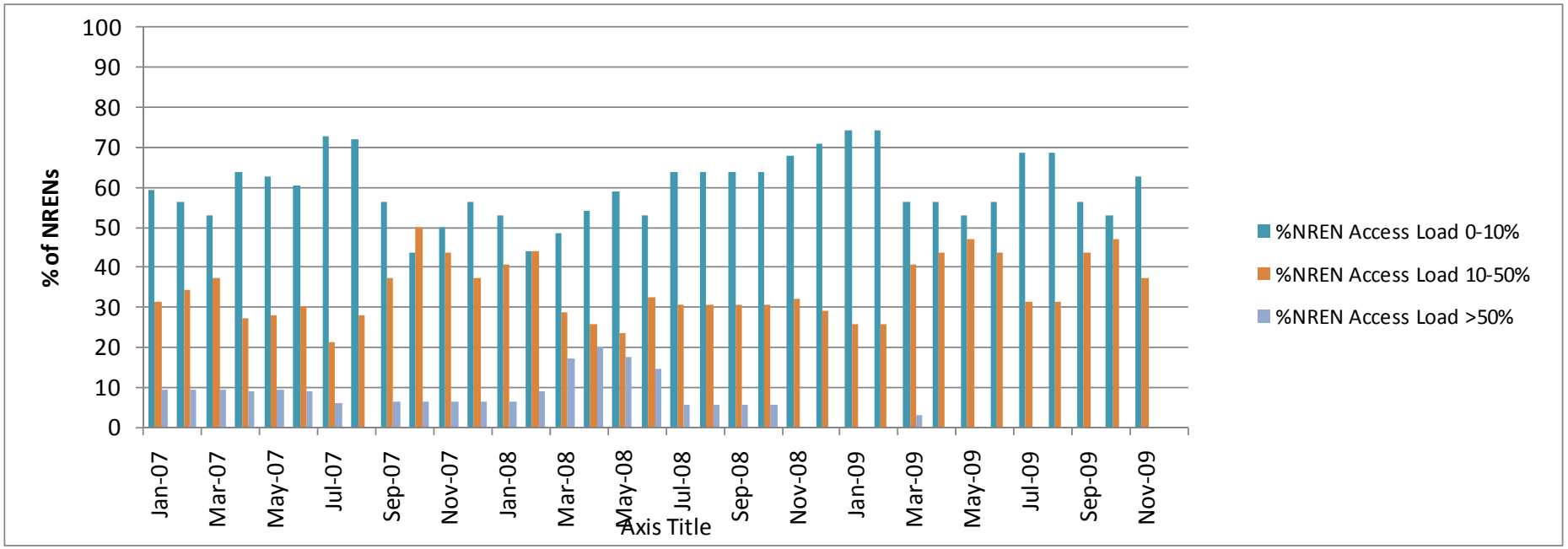
PERFORMANCE, AND SERVICE DELIVERY

Providing Service and Performance

- The network is designed to be robust & deliver 24/7 service to the users.
- Committed to reach specific targets to ensure network performance.
- We set Service Level Targets to ensure that we provide what the user needs:
  - To Fulfil Service Functional Requirements
    - *Ensure the network is fit for purpose*
  - To Fulfil Service Levels Requirements
    - *Ensure the network is fit for use*
- Well structured Network Operations Centres (NOCs) 24/7
  - Well defined multi-domain operational procedures
  - Close collaboration between the NREN's NOCs
- Collaboration with the users to ensure that the performance of the applications and the network meet that required.
- The opportunity to run proof of concept tests in a collaborative manner.

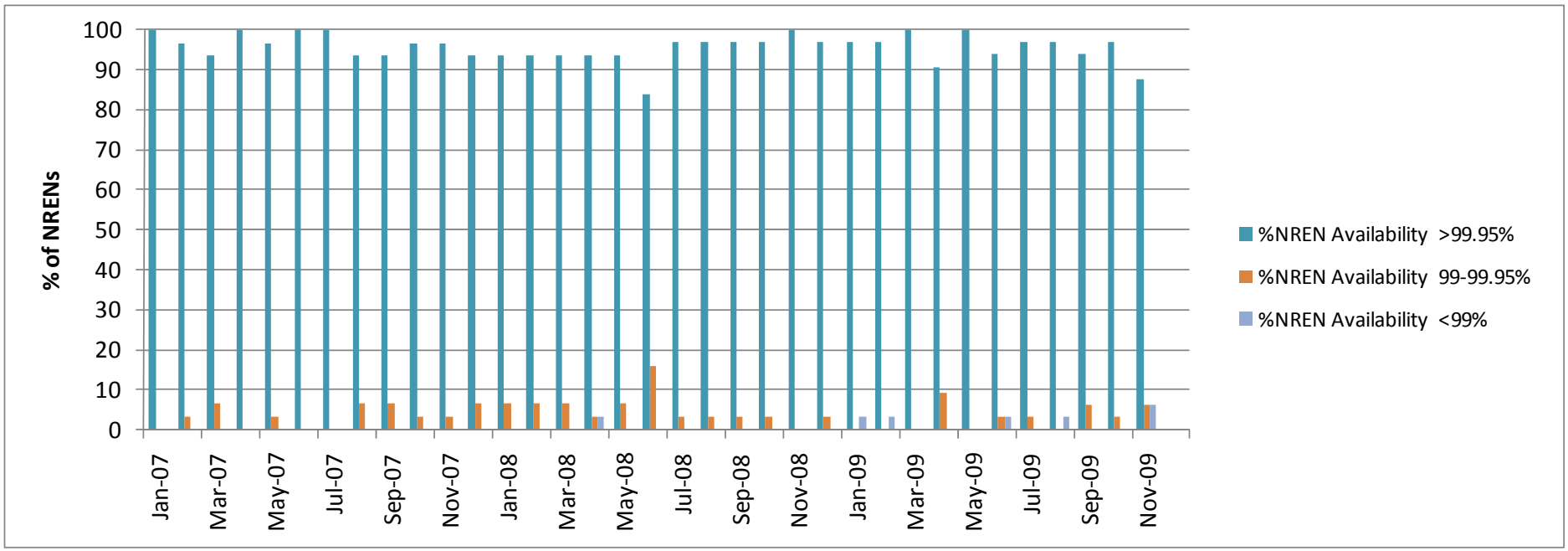
Service Level Targets: Network load

- Our provisioning model aims to provide headroom.
- Percentage of Countries with IP service load < 10% & < 50% per month



Service Level Targets: Availability of the IP service

- Percentage of Countries with IP service availability > 99.95 per month

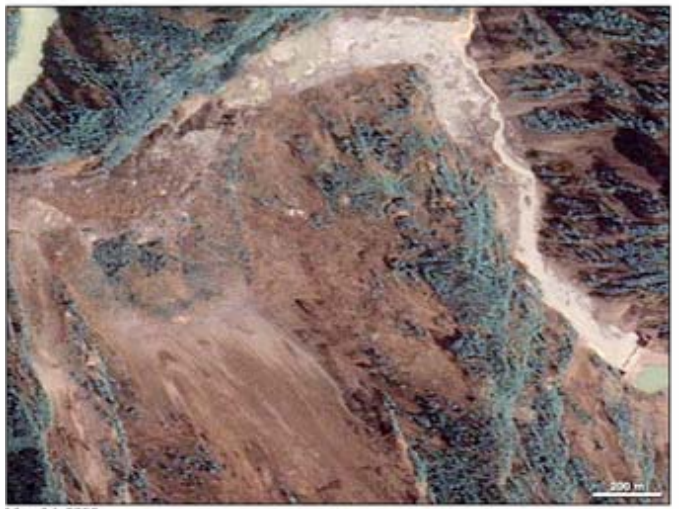


INTERNATIONAL USER COMMUNITIES

Sichuan Earthquake Recovery Efforts

- Sichuan Earthquake on 12th May 2008
- Satellite images of disaster region transferred over the ORIENT link from JRC (Italy) to RSGS (China) with routed IP.
- Tuned TCP throughput.
- Added a second GE link from CSTNET in China.
- Images transferred helped manage the disaster.

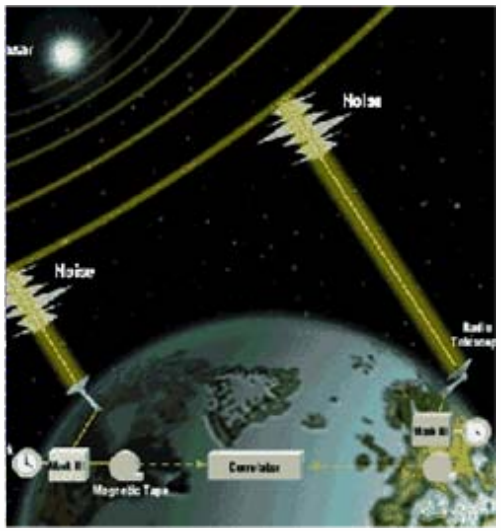
May 14, 2006



May 14, 2008

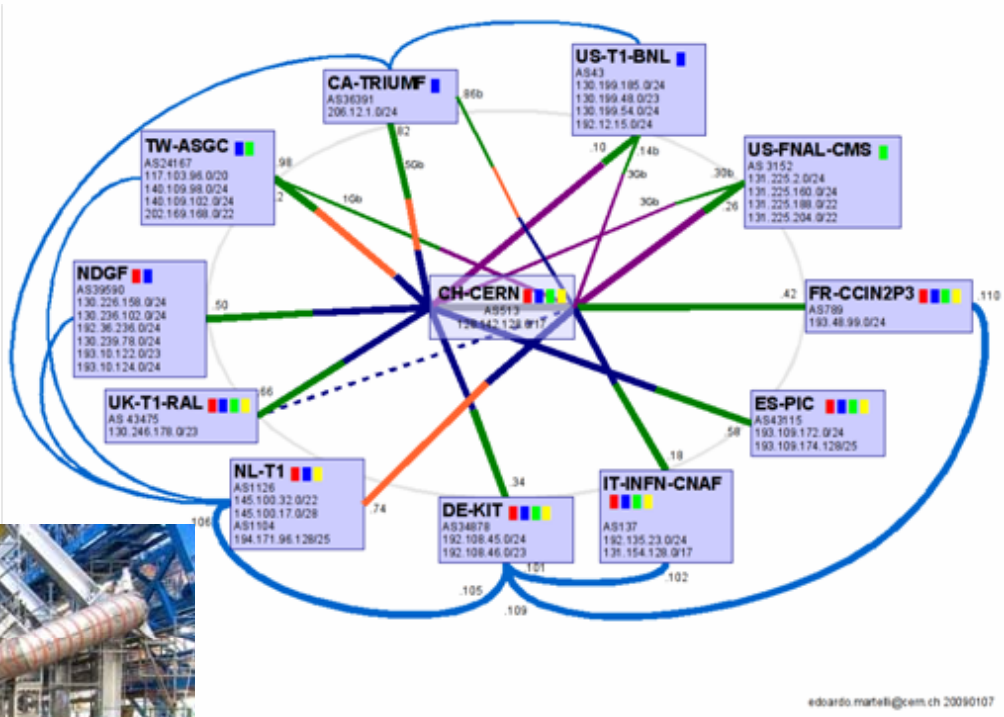
Radio Astronomy VLBI
1GE Circuits & IP connections in 2008

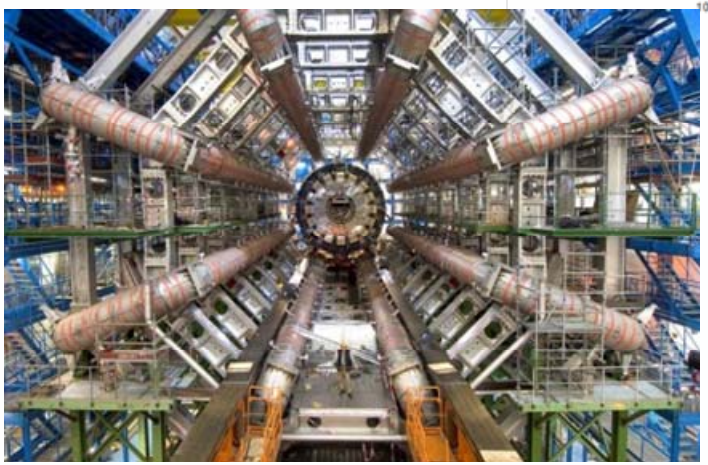
- 1 Gigabit Ethernet point to point circuits to the telescopes in Europe.
- Supplied by NRENs & GÉANT
- Use Routed IP to other telescopes in other world regions
- Timeliness of data important
- Data rates:
  64Mbit/s
  512 Mbit/s
  1 Gbit/s



GÉANT lambdas form the LHC Optical Private Network

- 10 Gigabit Lambdas form a dual star on 2 routers at CERN.
- Designed backup to be on different optical routes from fibre suppliers.
- Used NRENs & GÉANT
- DANTE advised on architecture & resiliency.
- Use Routed IP for other international traffic:
  - China
  - India
  - Japan
  - All Physics users

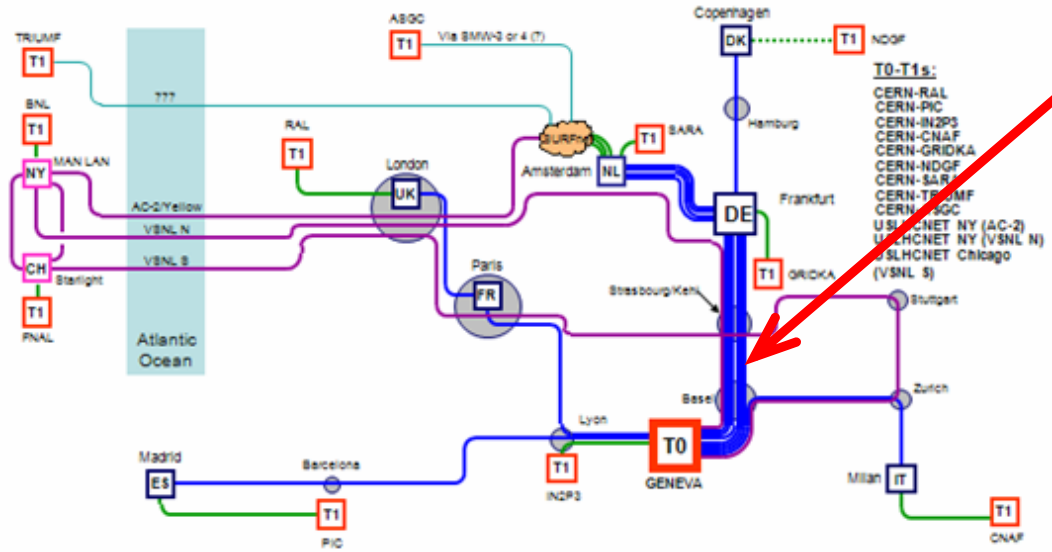




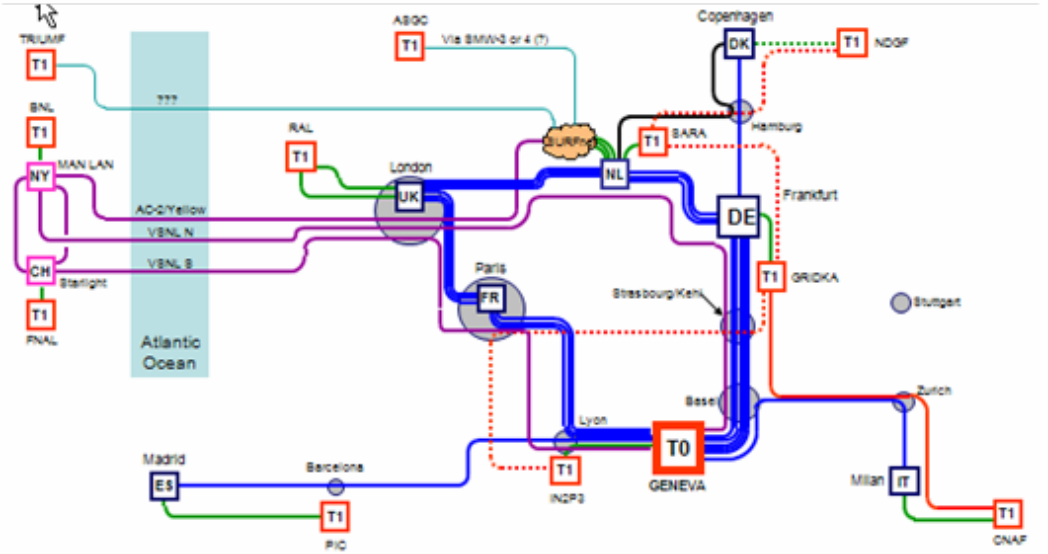
ATLAS @ LHC

WORKING WITH PROJECTS

LHCOPN
T0-T1 Lambda routing-resilience



Many paths on same fibre pair or in the same ducts.

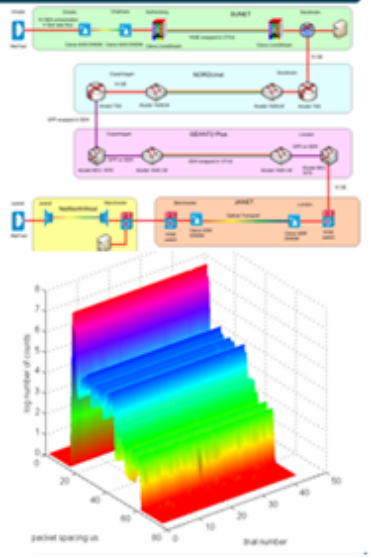


Re-route paths to reduce the risk.

Collaborating with Users: Tests and Proof of Concepts

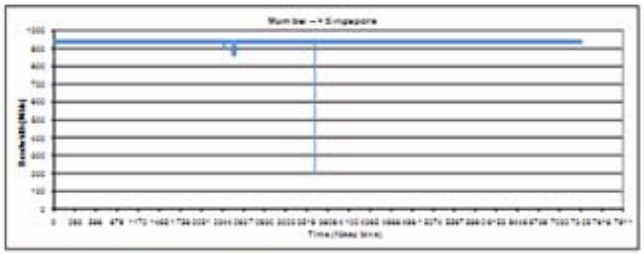
Collaborating with Users: VLBI Long Term Stability 4 Gigabit flow

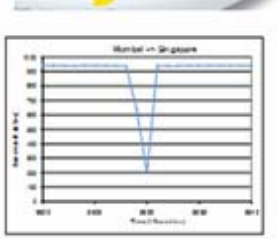
- True multi-domain 4 Gigabit circuit Onsala, Sweden and Jodrell Bank, UK.
- Radio Astronomy require real-time data.
- 24 hr of trials sending 100M packets trials take ~27 min.
- Measure:
  - Throughput = 4.094 Gbit/s
  - **Packet loss Zero**
  - Inter-packet arrival times
- Configured path to meet requirements.
- Very stable
  - Peak at 16 µs, tail extends to ~70 µs
  - Tail ~ 10^{-3} smaller



Reliable Infrastructure: Testing SDH Protection

- Part of acceptance testing for the European-India-Singapore links.
- The low level network layer will switch to an alternate data path when an error is detected e.g. a fibre cut.
- Measure the effect with a 24 hr. user TCP flow:

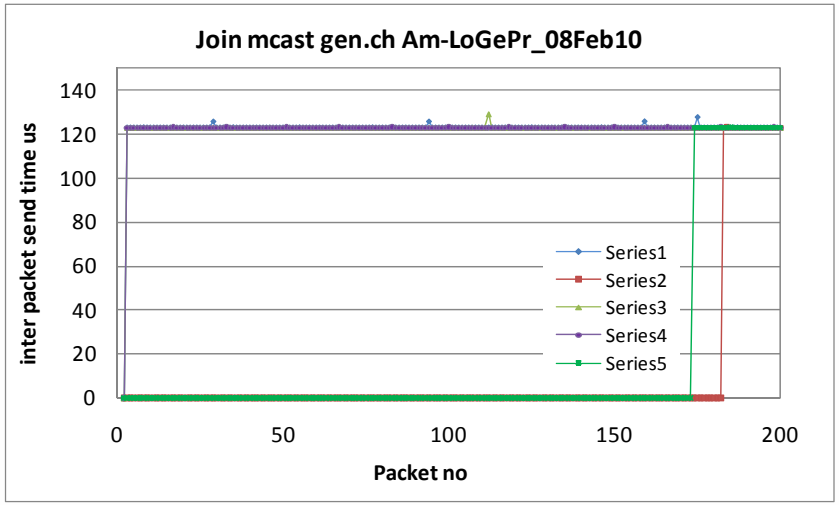


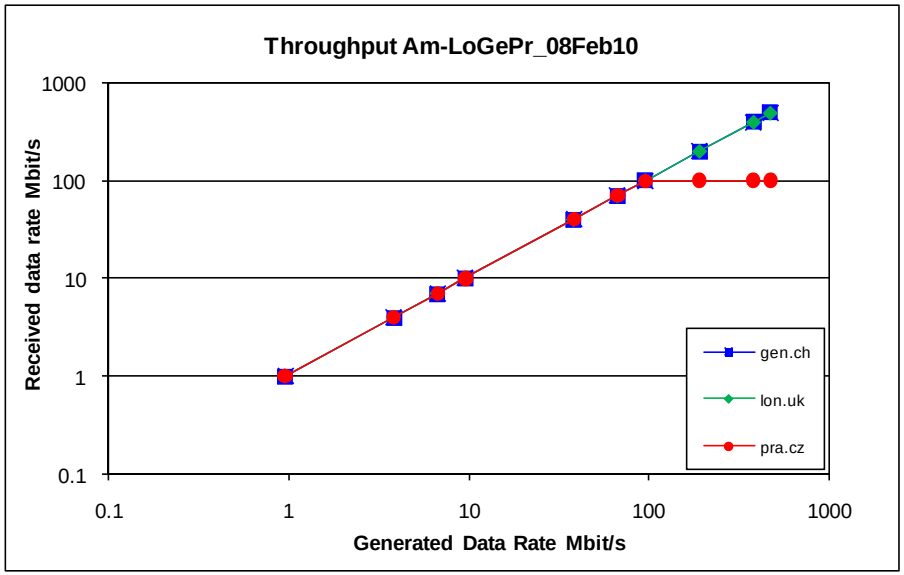


- TCP link remains up. Throughput recovers in ~20s.

Proof of Concept Test: High Bandwidth Multicast

- Collaborative project with the end user.
- Emulated the project data flows over the backbone using multicast.
- At each site measured:
  - Throughput
  - Packet loss
  - Inter-packet arrival times





- Throughput stable to 500 Mbit/s
- No packet loss once the multicast tree is formed.
- Take care with switches !

- Next steps
  - To test with the user kit and applications.
  - Perform multi-domain tests.

WIS & ACADEMIC NETWORKING

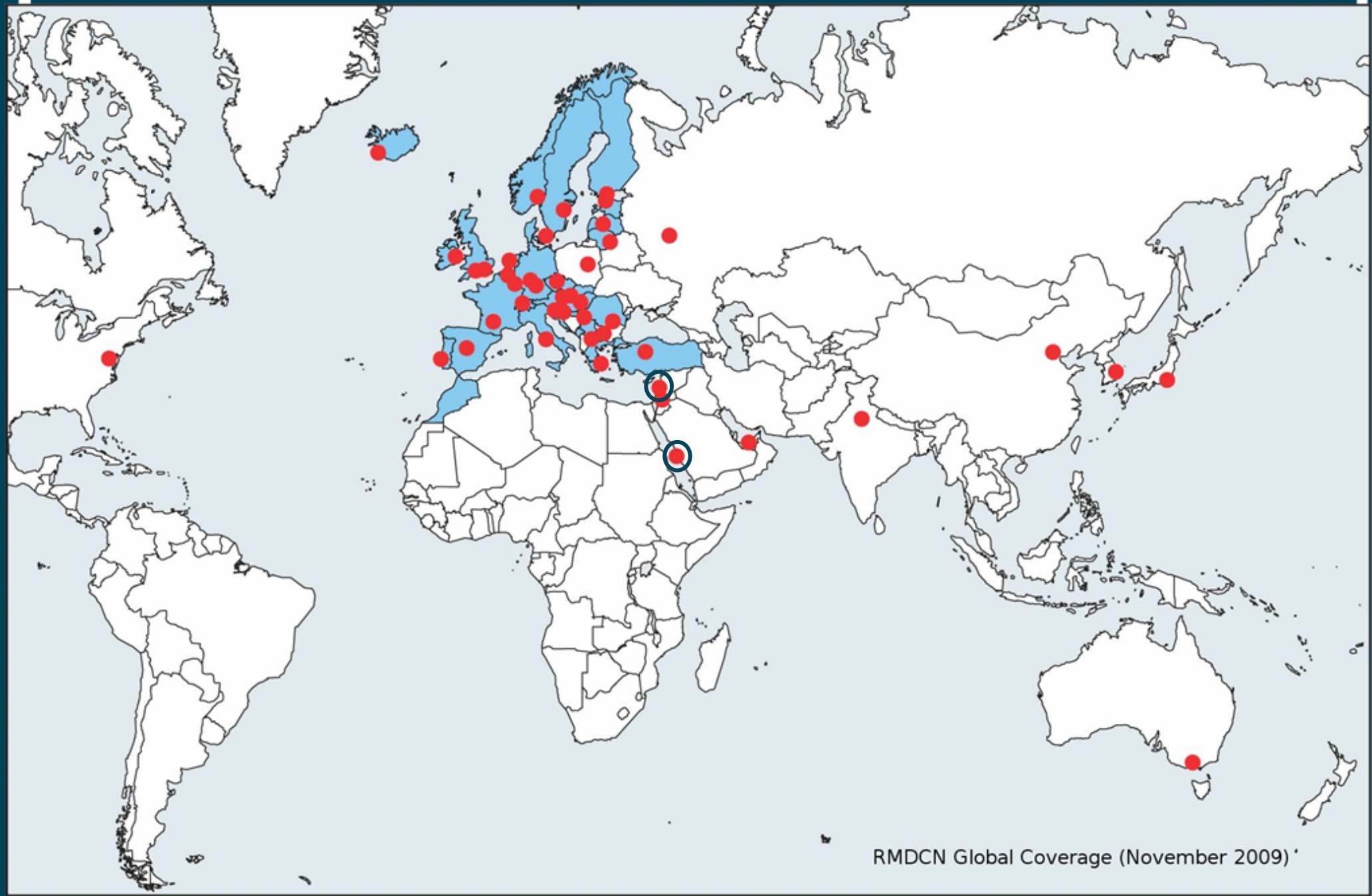
Meeting the Technical Requirements of WIS

- Within Europe GÉANT & NRENs Provide Basic IP connectivity services that can meet the requirements:
  - High Bandwidth – most backbones are 10 or multiple 10 Gbit/s
  - Multicast – Sparse mode PIM
  - IPV6 – the routers implement native dual stack IPv4 & IPv6
  - QoS – Available but little used as there are few bottlenecks.
  - Virtual Private Networks
  - MPLS / Traffic engineering (may not be possible on all NRENs)
- The world-wide links provide connectivity to other NRENs. Who also provide the above IP services.
- Requirements may also be met by using:
  - Dedicated point to point circuits at 1 Gigabit
  - Dedicated full 10 Gigabit lambda

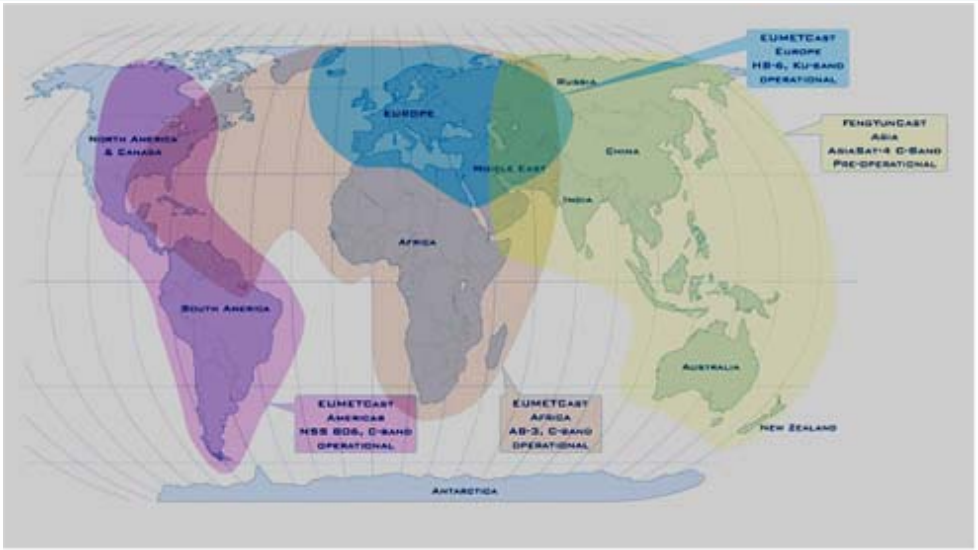
Connectivity to (European) Countries of Interest to WMO

- Blue denotes Members of GÉANT Collaboration.
  Underline know to be already connected to an R&E Network.
- A ECMWF Member States:
  Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Austria, Portugal, Switzerland, Finland, Sweden, Turkey and United Kingdom
- ECMWF Cooperating States:
  Czech Republic, Montenegro, Estonia, Croatia, Iceland, Latvia, Lithuania, Hungary, Morocco, Romania, Serbia, Slovenia and Slovakia
- Others:
  Australia, Brazil, Canada, India, Japan, USA, UAE, Saudi-Arabia, Lebanon, China, Russia, Korea, Bulgaria, Jordan, FYR Macedonia, Poland, South-Africa
- International organisations: ECMWF, EUMETSAT

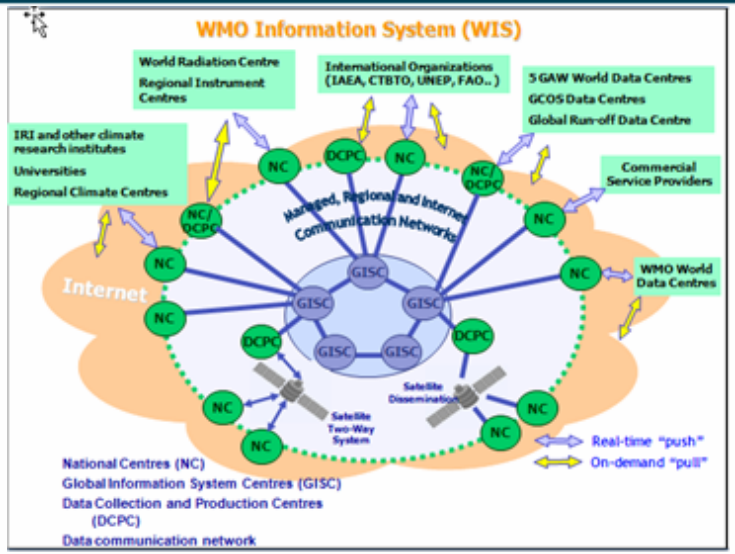
The Geographical view



Academic Terrestrial Links



GEONETCast



WIS

- The Academic Networks are complementary to existing infrastructure.
  - Satellites
  - Mobile phone
  - Commercial connections
- Areas where Academic Terrestrial networks might be able to help include:
  - Higher bandwidth between Data Centers (GISC).
  - Provide access to more data providers & users.
  - Independent backup links

Summary:

- The Academic Internet is a reliable, innovative, responsive multi-domain hybrid network.
- Built using advanced transmission & switching technologies.
- R&E Networks support all network activities including GRID, Cloud, HPC computing, and data-centric knowledge acquisition world wide and not just science.

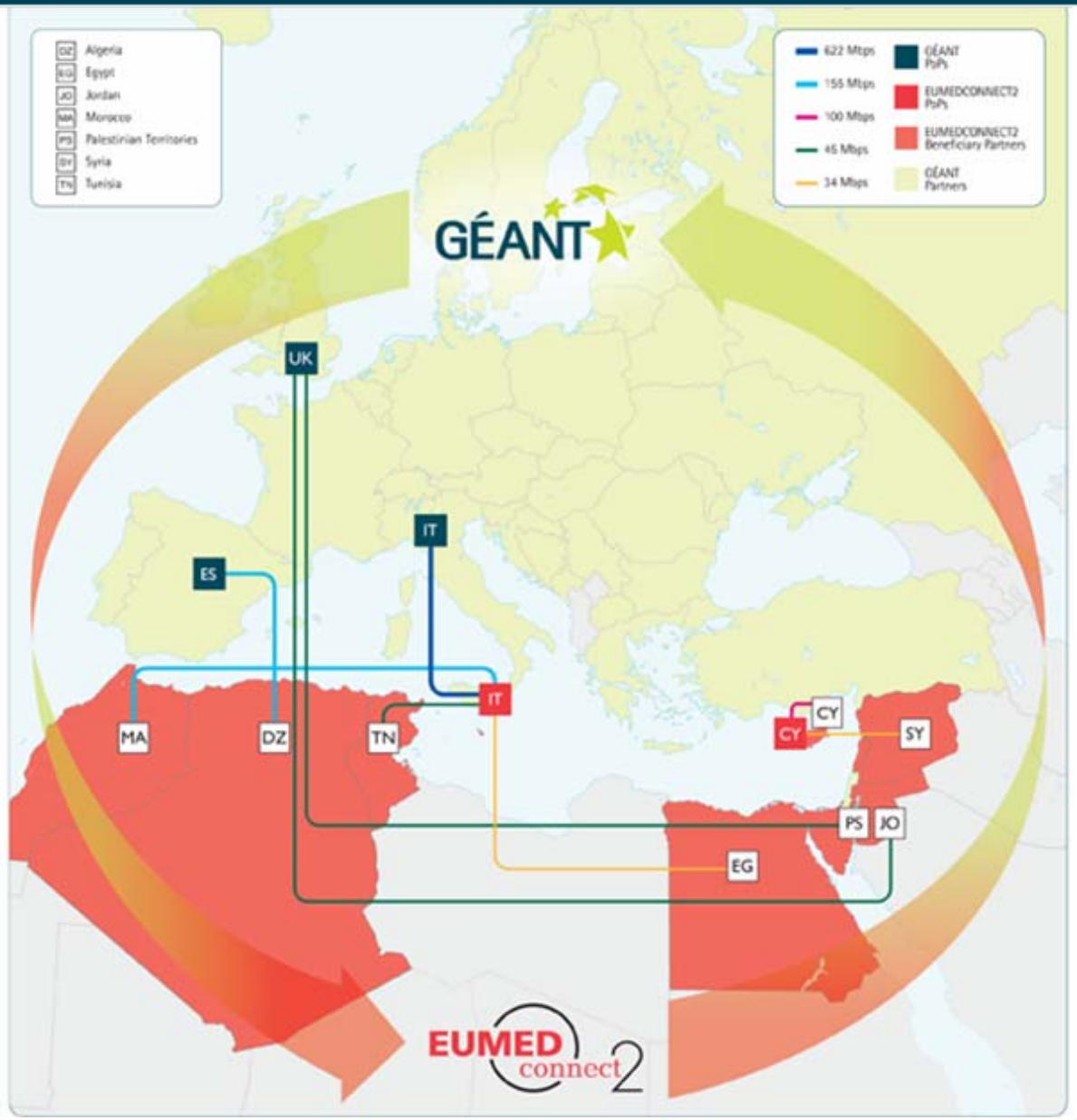
- Many of the Meteo. sites are already connected to the NREN in that country.
- R&E Networks would be supportive and complementary to other techniques – satellite, mobile phone, commercial networks.

- DANTE could act as a facilitator for contacting NRENs
- Collaborate to help with multi-domain performance issues – the interactions between: the application, protocol, end host, & the network.
- Work with NRENs to offer links for proof of concept experiments.

ANY QUESTIONS ?

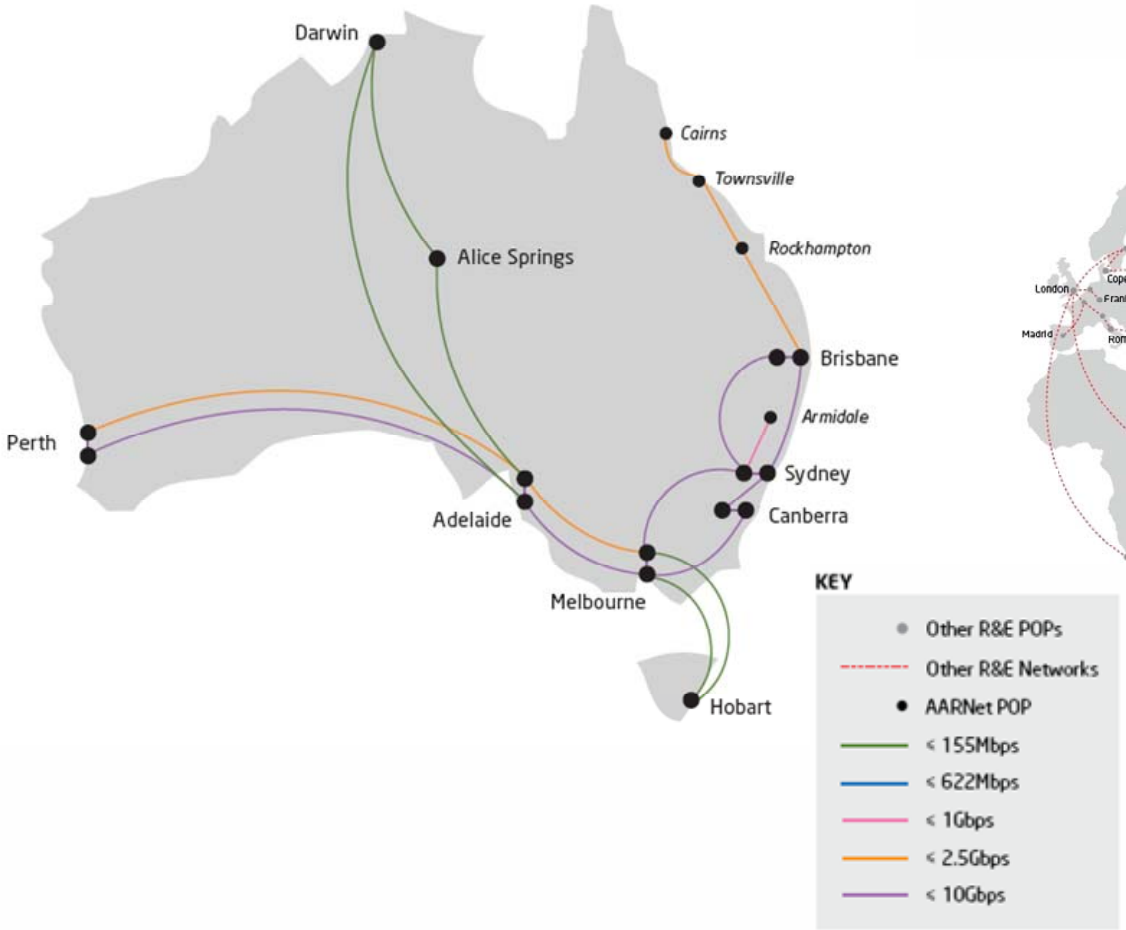
Gyeingju

EUMEDCONNECT2 Topology
June 2009

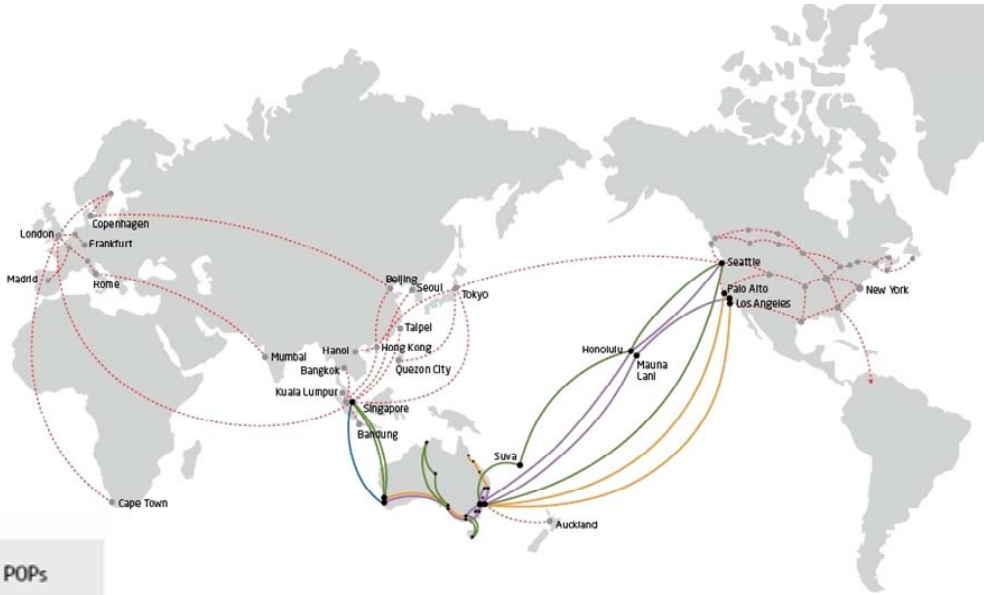


AARNet in Australia

National Network



International Connections



GLORIAD


10G/US-NORDUnet
10G/glo-nl
10G/glo-nl
Stockholm
1G/glo-nord
10G/glo-nord
Moscow
Novosibirsk
155Mb/glo-ru
155Mb/glo-ru
Khabarovsk
10G/glo-ru
Amsterdam
155Mb/glo-cn-ru
Beijing
10G/glo-kr
Daejeon
2.5G/glo-ca
Winnipeg
Seattle
Toronto
NLR-glo
2.5G/glo-ca
10G/glo-kr
Chicago
New York
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Atlanta
3G/TransLight-glo
10G/glo-cn
Cairo
2.5G/glo-cn
10G/glo-kr
Mumbai
Hong Kong
10G/glo-cn
Singapore
Global Ring Network for Advanced Applications Development
Based on Illustration (2007) by Natasha Bulashova, GLORIAD Russia