GÉANT Network: Services & Operations
Brook Schofield, GÉANT

APAN48, Putrajaya, Malaysia
Thursday 25th July 2019
What is GÉANT?

- **Runs a membership association for Europe's National Research & Education Networks (NRENs)**
  GÉANT Association

- **Coordinates and participates in EC-funded projects**
  Under Horizon 2020 the financial instrument for implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness

- **Operates a pan-European e-infrastructure**
  GÉANT network

- **Manages a portfolio of services for research & education**
  eduroam, eduGAIN, eduTEAMs, InAcademia

- **Organises and runs community events & working groups**
  TNC, task forces & special interest groups
I’m not Mian, Guy or Sebastiano

Mian Usman  Guy Roberts  Sebastiano Buscaglione
A family of services

eduroam

eduGAIN
Free secure Wifi provided by NRENs between campuses.

A global network of users across over 100 territories. More than 2 billion international authentications and counting.

A worldwide success story
From its early beginnings as a joint venture between a few European universities to today – with millions of users in more than 100 territories worldwide, eduroam has been an amazing success story and an example of research and education collaboration.

www.eduroam.org
eduGAIN

- 60 eduGAIN Participants
- 4 eduGAIN Members
- 11 Candidate Federations
- 5 Known Federations
The GÉANT network interconnects research, education and innovation communities worldwide, with secure, high-capacity networks.

We design, plan, build and operate the large-scale, high-performance GÉANT network that connects European NRENs to each other and the rest of the world for sharing, accessing and processing the high data volumes generated by research and education communities and for testing innovative technologies and concepts.

Interconnecting Europe’s NRENs over a 500Gb highly-resilient pan-European backbone.
NRENs serve 50 million users at 10,000 institutions across Europe.
Network services: IP, Point-to-Point Services, VPN, Testbeds, performance monitoring

Data transfer tests in 2017 between 10G servers in GÉANT and AARNET achieved 9.73Gbps over 48h through R&E networks, whereas over commercial links this was only 1.77Gbps.
R&E Networks Optimised for research data

- Route GÉANT, ANA300, Internet2 & AARNet: RTT 304 ms.

- Throughput:
  - Average including slow start 9.09 Gbit/s
  - Plateau from 5s onwards 9.73 Gbit/s.

- NO TCP re-transmitted segments
GÉANT – Optimised for research data transfers

Public Internet
Geneva to Canberra

GEANT and R&E partners
Geneva to Canberra GEANT + R&E networks US to Australia

R&E networks are designed for different goals than Internet

Comparative Times for a 100TByte data transfer.

<table>
<thead>
<tr>
<th>File Size (TB)</th>
<th>Data rate (Gbit/s)</th>
<th>Time taken (Hours)</th>
<th>Time Taken (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NREN 100</td>
<td>9.27</td>
<td>34.0</td>
<td>1.4</td>
</tr>
<tr>
<td>ISP A 100</td>
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</tr>
<tr>
<td>ISP B 100</td>
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Fiber Renewal Plan Starting Point – *Last time we met!*

- **Current Fiber Network:**
  - Short term leases
  - 14 countries connected on fiber
    - UK, BE, FR, CH, DE, AT, NL, HU, HR, IT, SI, SK, CZ, ES (spur)

- Other countries on leased lines
  - Typical capacity multiple 10Gs
**Fiber Renewal Plan Starting Point – Current Network**

- **Current Fiber Network:**
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In the beginning: 2015 Ams to Ham

- R&E community had two parallel fibre systems between Amsterdam and Hamburg.
- Yellow cable is SURFnet.
- Green cable is GÉANT.
- Duplication of infrastructure diluted utilization.
- Objective 1: remove one fibre system and share remaining fibre
- Objective 2: retain GMPLS control plane
- Solution: alien waves
What is Spectrum Sharing?

• Spectrum sharing is the ability to share available optical spectrum between different organizations.

• Spectrum customers (cooperators) will have access to inject light directly into the host line system (DWDM).
  • Alien Wavelength: Is the simplest form of spectrum services where the spectrum is limited to a single light source over a limited spectrum (<100GHz).
  • Spectrum Service: Multiple light sources over a broader portion of optical spectrum.
What is Spectrum Sharing?

**Alien Wavelength**
- Third party device connected to the ROADM through a filter
- Single source transmitter
- Limited spectrum <100GHz

**Spectrum service**
- Third party device connected to a WSS port in the ROADM
- Supports multiple light sources
- The user stands free to use the dedicated spectrum as they want to
- Spectrum size could be several hundreds of GHz but should be limited to a certain value
Motivation

• Spectrum sharing fully utilizes the line system capacity and saves cost
  • Deployed line system enables enormous amount of capacity: several Tbit/s
  • No single NREN needs all this capacity
  • Sharing will save unnecessary deployments
  • Gives better redundancy since different partners can focus on deployments in different geographical areas

• Different part of the optical delivery chain have different lifecycles
  • Separation of line system from adaption function(transponders) gives the freedom to choose the best cost efficient solution at any given time

• Avoids vendor lock-in
Challenges with spectrum sharing

- Commodity DWDM pluggables
- Data centre interconnects
- Open line systems/ Alien waves maturity
- Disaggregation requires APIs
- Two-speeds of development cycles:
  - WSS/amplifiers 8 years
  - Transponders 3 years
Host Line System should:
- Provide the customer with OSNR/GSNR values between different edge nodes
  - (OSNR & GSNR) can be used to predict the performance of source modem used by the customer
  - EOL Margin considerations
  - These parameters could be used to define the right price for the spectrum service we buy/deliver

The customer **must** to commit to:
- Coherent light, waveform that has been agreed
- Power levels that are constant
- Spectrum quality: make the QoS data available to the host OLS operator
- Participate in a joint engineering team with OLS operator to discuss planning and operational issues (there will be a closer relationship between the service provider and user)

Lab-testing and verification should be done in partnership with customer before connecting third part equipment to the line system

You need to have a trust with the organization you share spectrum with.
• Current network is built on Infinera DTN-X
• GÉANT ran Voyager field trial in 2017 and decided to take a risk on adding DCI overlay to DTN-X
• Significant costs savings convinced us of benefit of OLS
• We purchased the Infinera Groove equipment last year
• We have committed to Open Line System (OLS) in new network
• GEANT have automated our network model in Cambridge lab
• Automated tests can cycle through hundreds of power/gain/modulation/noise/FEC parameters
Network Test Automation – JUNOS code certification, benchmarking and qualification

1. MPLS
   - IS-IS
   - Multicast
   - IPv4 & IPv6
   - Netflow v9
   - MDVPN

2. Traffic generation and full routing table
   - RSVP
   - QoS
   - Elephant flows
   - MBGP
   - Logical systems
   - BFD

3. Check for expected behaviour through a series of tests
   - L2 circuits
   - EVVPN
   - NSR/GRES
   - DWDM
   - 1/10/100G links & LAGs
   - LDP

200+ tests
   - Physical flapping
   - Protocol behaviours
   - Route propagation
   - Interoperability
   - Stability
   - Memory leaks

4. Troubleshoot exceptions – report to vendor

5. Repeat test until all pass

6. Certify code for release into network

Testing can also be used to verify that new services/features do not interfere with existing services on GÉANT network.

Outcome: No service-affecting bugs have been introduced into the network for the last four years
Network Test Automation – *Optical Lab Automation*

- Scripting allows to set/read all parameters
- Dozens of optical settings for new transponders
- Automation allows hundreds of tests to be run overnight
Modelling spectrum sharing

- This is the Groove G30 receive sensitivity when launched over a DTN-X line system with an existing Infinera OCG.
- Tx power is varied and the Rx pre-FEC BER as a function of Rx power.
- The Bathtub curve shows the optimal power for launching the AW.
- Nested loop is used to add and repeat tests.
How is cost reduction achieved?

Cost per meter of Fibre

2019 reference
NREN spectrum vs. commercial DF

- Analysis carried out in 2018
- 20 links are candidates for using NREN spectrum
- Costs have been compared with commercial DF
- For 7 we have both NREN and commercial prices, further 5 with estimated commercial prices
- 5 NREN offers have confirmed reduction of the cost share (√)

<table>
<thead>
<tr>
<th>Link</th>
<th>Commercial DF cost-share 8 years</th>
<th>NREN spectrum cost-share 8 years</th>
<th>Saving</th>
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<td>61,492 √</td>
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</table>
The GÉANT Network today

- Dark Fibre in central Europe
- Lease capacity to most countries
- Hub and Spoke
- Based on short procurement cycles
- Short term requirements
- Cost inefficiency

Blue – Dark fibre
Black – Lease capacity
Orange - Spectrum
Regional Studies - to Agree Topology

**UK/Ireland**
Led by Guy Roberts

- **UK**
- **Ireland**

**Iberian Peninsula**
Led by Emanuel Massano (GARR)

- **Portugal**
- **Spain**
- **France**

**Central Europe region**
Led by Sebastiano Buscaglione

- **Austria**
- **Czech Republic**
- **Italy**
- **Malta**
- **Holland**
- **Belgium**
- **UK**
- **Hungary**
- **France**
- **Germany**
- **Poland**
- **Switzerland**
- **Slovenia**
- **Croatia**
- **Spain**
- **Luxembourg**

**South East Europe**
Led by Pavel Skoda (CESNET)

- **Greece**
- **Hungary**
- **Bulgaria**
- **Albania**
- **Israel**
- **Macedonia**
- **Croatia**
- **Romania**
- **Cyprus**
- **Serbia**
- **Slovakia**
- **Turkey**
- **Montenegro**
- **Italy**

**Baltic**
Led by Ieva Muraškienė (LITNET)

- **Belarus**
- **Latvia**
- **Estonia**
- **Lithuania**
- **Finland**
- **Denmark**
- **Sweden**
- **Norway**
- **Russia**
- **Poland**

APAN48, Putrajaya, Malaysia
GÉANT topology
Today

- 2012 design in place since... with very little change
- DF and lease capacity on short procurement cycles and driven by short term requirements
- Regional connectivity hub and spoke with central part of the network

Fibre ‘core’ in green
Leased capacity in black
Spectrum in orange
PoPs blue circle
New GÉANT network

• Spectrum sharing is key to making the new network economic

• We will use spectrum from commercial providers and NRENs

• We also plan to offer spectrum as a service to our customers

• Coordination with NRENs will be achieved via the Spectrum sharing task in GÉANT
Phase A procurement to start in Q3/Q4 2019
GÉANT topology
where next

- This is an evolving map and a number of options are being considered
- .. including countries not on the footprint and synergies with the other international projects such as EAP
Thank you
Any Questions?
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