



# Is there Life after GÉANT2 ?

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# R&E Networking Model in Europe



- **A 3-tier Federal Architecture**, partially subsidized by National and EU Research & Education funds:
  - The Campus Network (LAN/MAN) > 3,500 Institutions, >30 M Users
  - The 34 NREN's (MAN/WAN)
  - The Pan-European Interconnection: **TEN34 à TEN155 à GÉANT** (GN1 in FP5) **à GÉANT2** (GN2 in FP6): **Hybrid Optical Backbone (+ Cross Border Fibers) à GÉANT3** ( GN3 ? in FP7)
- **Total GN2 Cost: 40 M€/year (co-funded by the EC and NREN's)**

**GN2 EC Subsidy < 10% of total European R&E Networking Cost**

- **GÉANT Governance:** NREN Policy Committee
- **Project Management:** Exec, DANTE



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# European NREN's – GÉANTn: A Growing Success Story - Why?



- Century old Telecom (+ 40 years ARPAnet - Internet) experience: Proven strong *“Network Externalities”* à Sharing tradition
- Industry needs for *Next Generation Network* proofs of concept, synergy with R&E community: The ARPAnet paradigm @ the US of America, inspiring the *“US of Europe”*
- **Foresight** of National + EU funding authorities, triggered by NREN planning – SERENATE, EARNEST Studies
- A decade (+) of success in serving R&E needs of the Continent à Smoothing-out *“digital divides”* & enabling powerful education communities (educators, students, pupils?)
- NREN's as utilities for the R&E communities – extending the *“commons”* principle aka. Open Source S/W, Wikipedia...
- **Solidarity** – human networking within the NREN community
- Stable **Governance**: NREN Policy Committee (NREN PC)



# The NREN Policy Committee



- |   |  |
|---|--|
| <ol style="list-style-type: none"><li>1. Austria (<b>ACOnet</b>)</li><li>2. Belgium (<b>BELNET</b>)</li><li>3. Bulgaria (<b>ISTF</b>)</li><li>4. Croatia (<b>CARNet</b>)</li><li>5. Czech Republic (<b>CESNET</b>)</li><li>6. Cyprus (<b>CYNET</b>)</li><li>7. Germany (<b>DFN</b>)</li><li>8. Estonia (<b>EENet</b>)</li><li>9. France (<b>RENATER</b>)</li><li>10. Greece (<b>GRNET</b>)</li><li>11. Hungary (<b>HUNGARNET</b>)</li><li>12. Ireland (<b>HEANet</b>)</li><li>13. Israel (<b>IUCC</b>)</li><li>14. Italy (<b>GARR</b>)</li><li>15. Latvia (<b>LATNET</b>)</li><li>16. Lithuania (<b>LITNET</b>)</li><li>17. Luxembourg (<b>RESTENA</b>)</li><li>18. Malta (<b>UoM</b>)</li><li>19. Netherlands (<b>SURFNET</b>)</li></ol> | <ol style="list-style-type: none"><li>20. Nordic Countries – Denmark, Finland, Iceland, Norway, Sweden (<b>NORDUNET</b>)</li><li>21. Poland (<b>PSNC</b>)</li><li>22. Portugal (<b>FCCN</b>)</li><li>23. Romania (<b>RoEduNet</b>)</li><li>24. Russia (<b>JSCC</b>)</li><li>25. Slovakia (<b>SANET</b>)</li><li>26. Slovenia (<b>ARNES</b>)</li><li>27. Spain (<b>RedIRIS</b>)</li><li>28. Switzerland (<b>SWITCH</b>)</li><li>29. Turkey (<b>ULAKBIM</b>)</li><li>30. United Kingdom (<b>UKERNA</b>)</li></ol> <p><u>PLUS NON-VOTING MEMBERS:</u><br/>Delivery of Advanced Network Technologies to Europe Ltd. (<b>DANTE</b>)<br/>Trans-European Research &amp; Education Networking Association (<b>TERENA</b>)</p> <p>PERMANENT OBSERVERS: <b>CERN, AMRES, MARNET</b></p> |
|---|--|



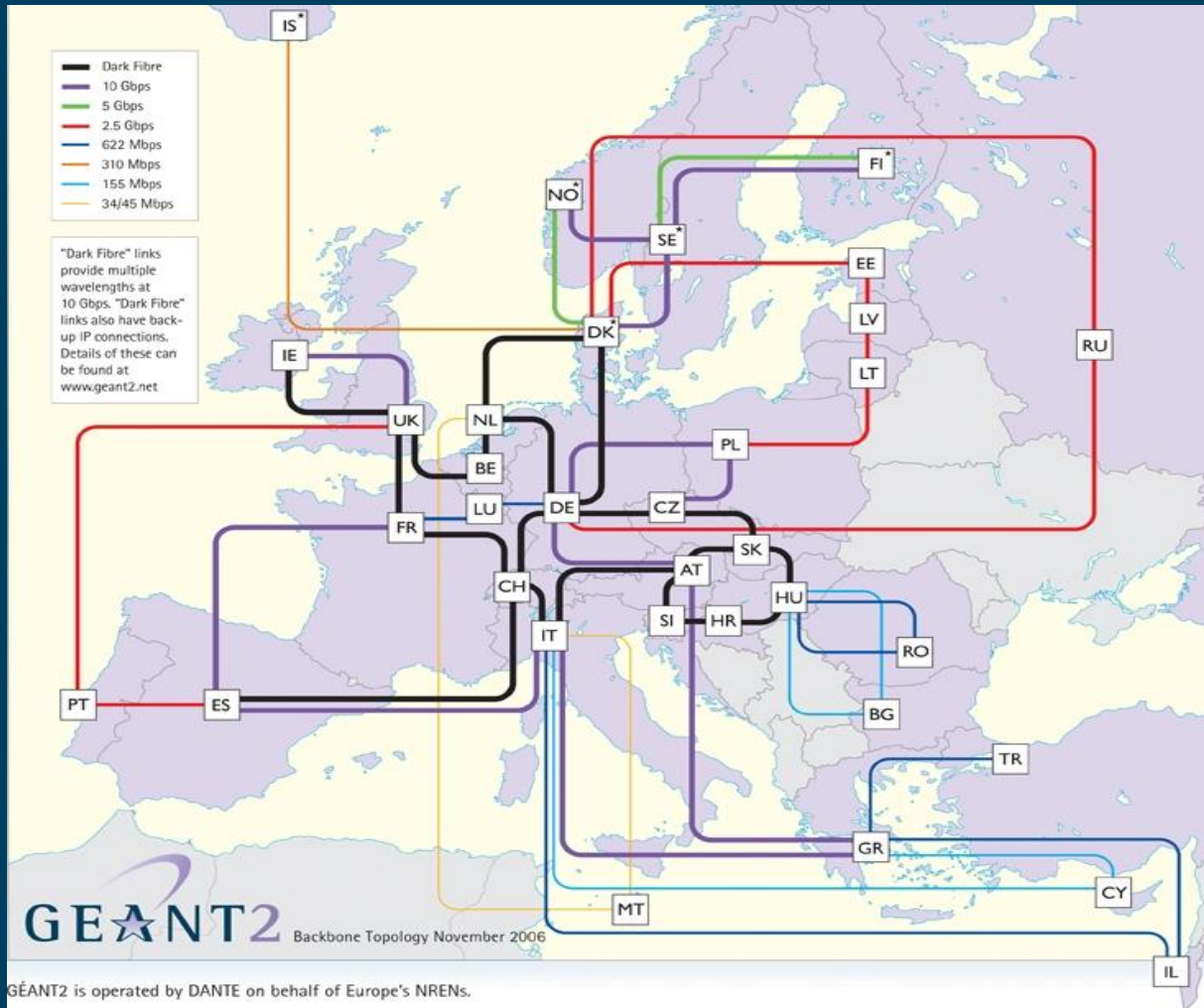
# NREN's & GÉANT<sup>n</sup>: e-Science Enablers + Networking R&D Platforms



- NREN's – GÉANT2/3 provide cost effective **e2e switched & light path connectivity** within the Dark Fiber Cloud (DWDM footprint)
  - + Global **IPv4 – IPv6 coverage** and **Hybrid** networking services
  - + Multi-domain Network management, resiliency & support
- *e-Science* (GRID) Virtual Organizations obtain, production quality hybrid networking, beyond leasing individual circuits, wave-lengths or dark fibers
- *e-Infrastructures* as equalizers, reduce the **DIGITAL DIVIDES** in Europe & globally: **Big Science affordable via virtual e-Science**
- NRENs – GÉANT stimulate **Network Research** & enable novel concept evaluation - **emulations** in a global production environment via virtualization of facilities & services



# The GÉANT2 Network



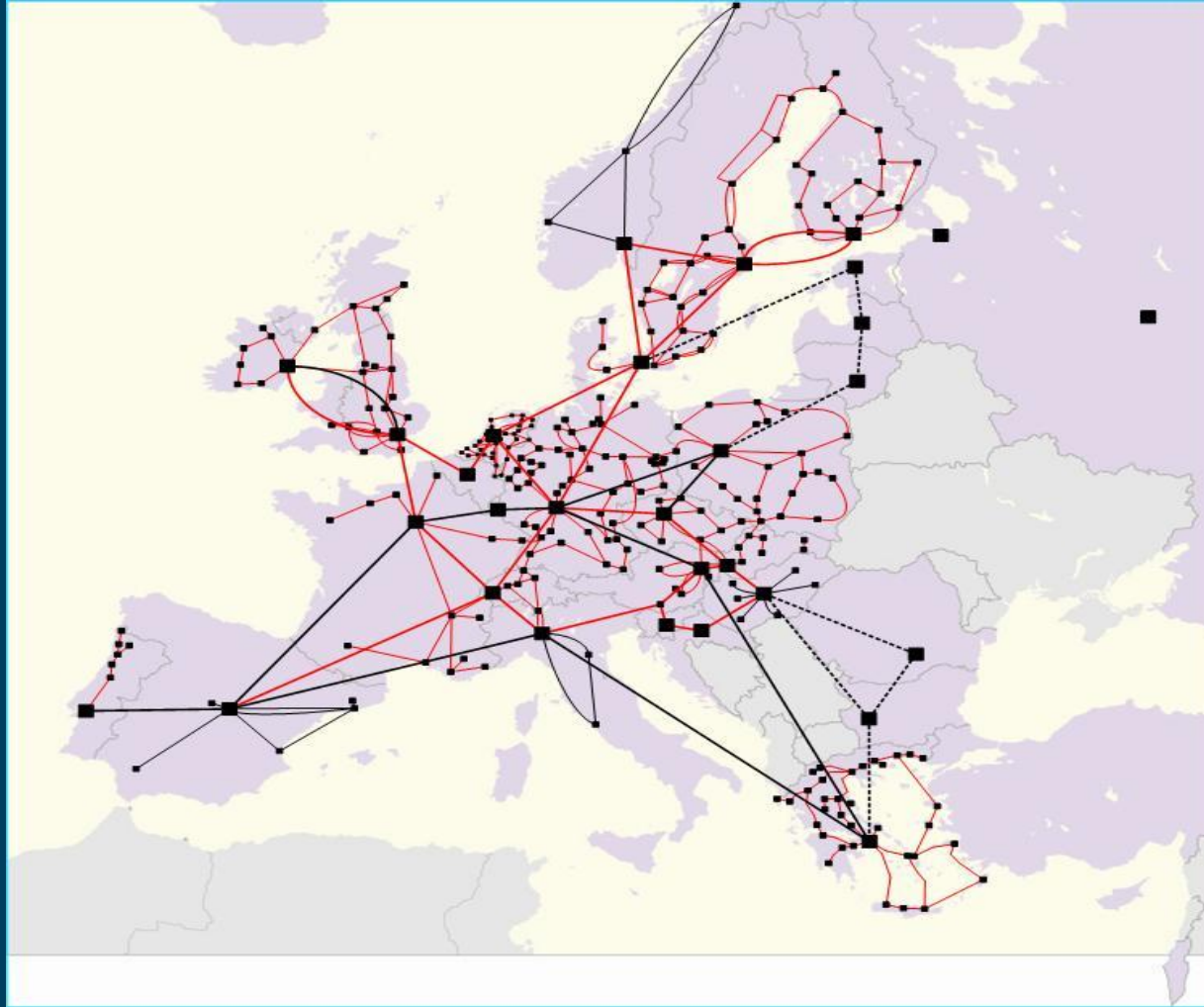
## GÉANT2 Topology

15+ NRENs interconnected within the Dark Fibre (DF) "cloud"

Rest, via leased "lambda" and SDH circuits

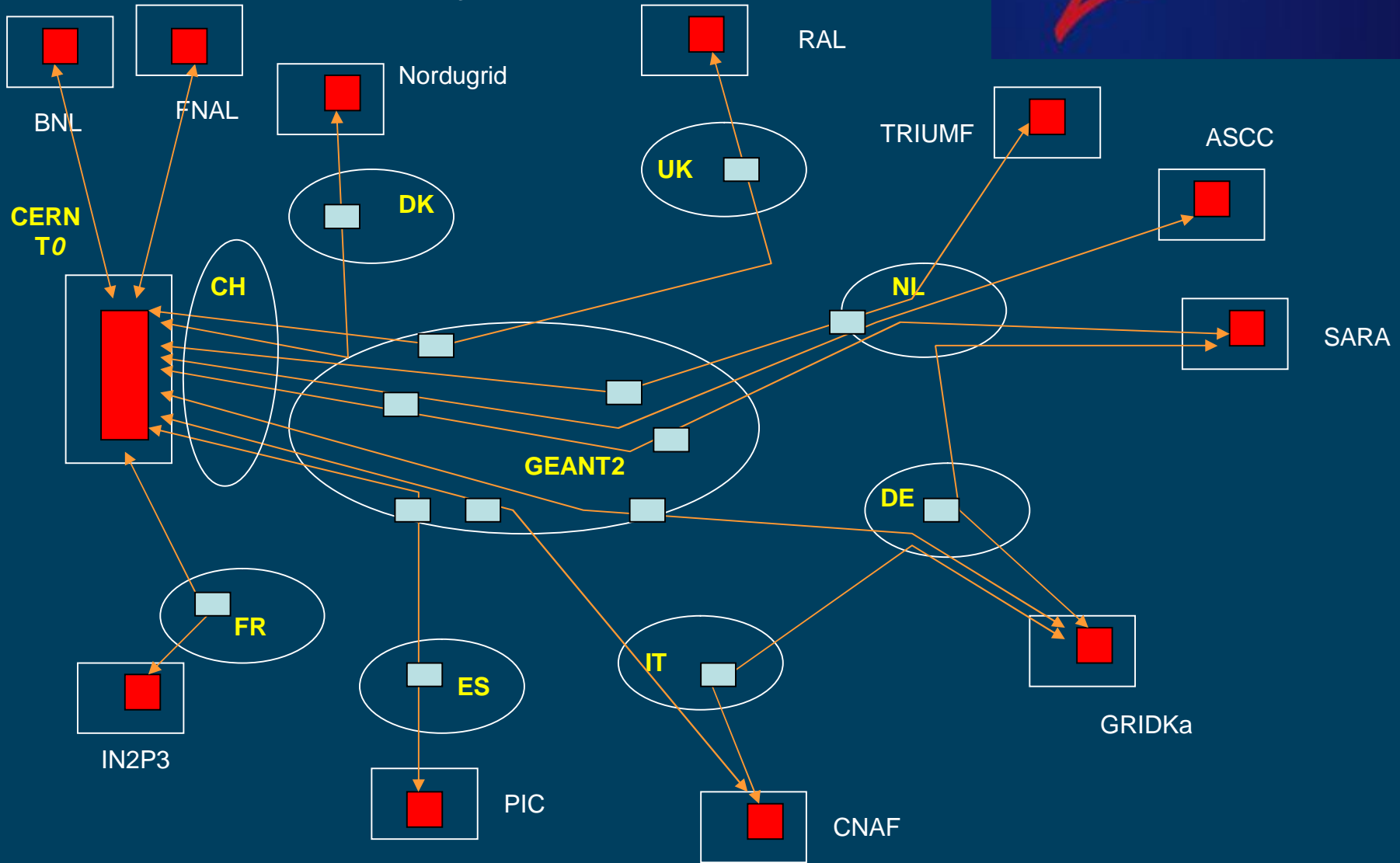


European R&E 10 Gig+ Footprint, March 2008  
(based on data by **DANTE** & **NRENs**)



Enables  
end-to-end  
**Hybrid Networking** &  
Optical Private  
Networking (**OPNs**) for  
**e-Science Projects**

# LHC TIER0 – TIER1 Optical Private Network - OPN, (Scenario based on work by *Roberto Sabatino DANTE*)

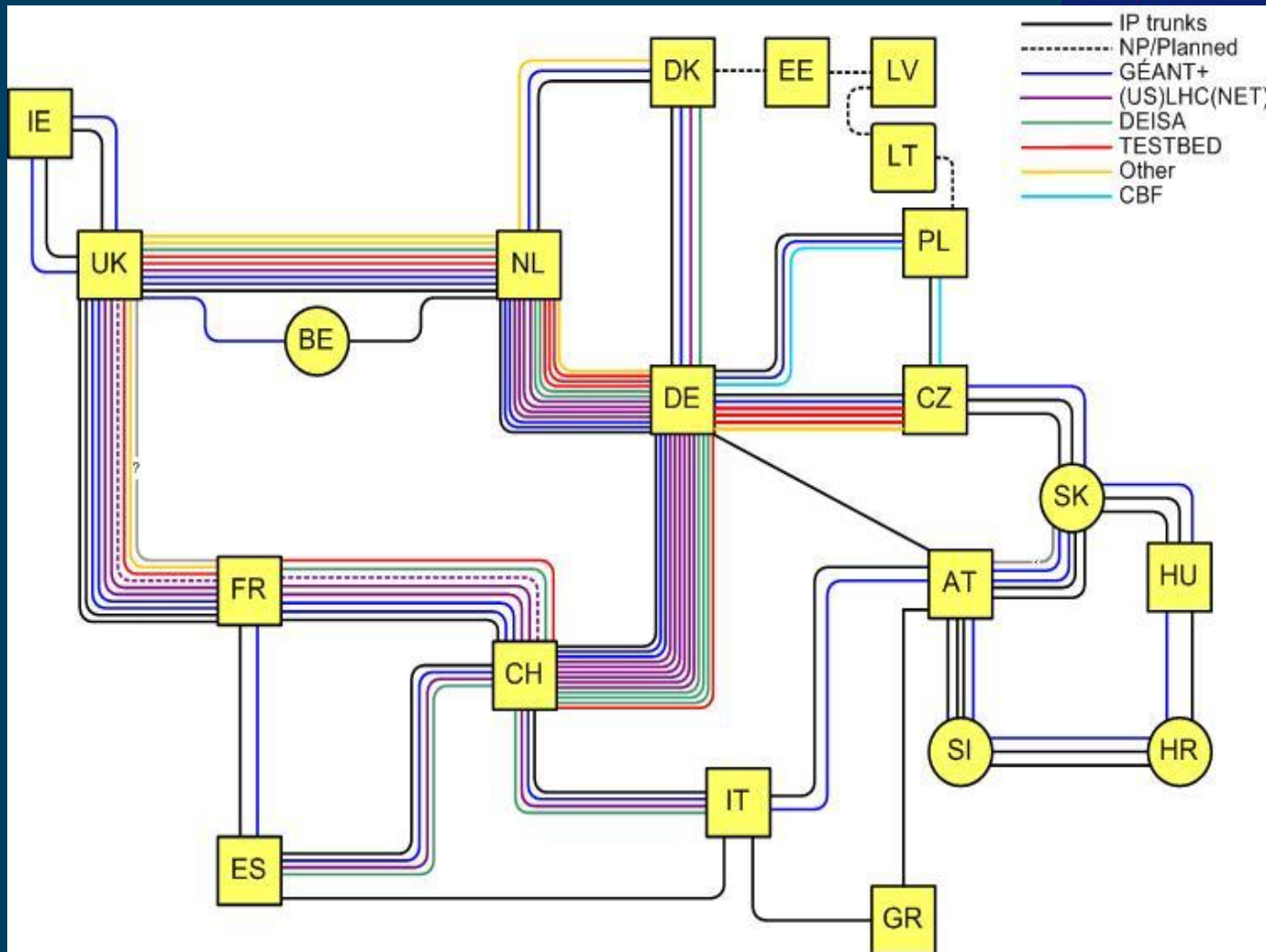


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# Wavelengths on GÉANT2 - February 2008 (Presentation by *Hans Döbbling* DANTE)



# Is there Life after GÉANT2 ?



- Advances in networking technologies: **Terabit** optical networking (enabling the *GTRN – Global Terabit Research Networking* vision), collapsed backbone topology trends (*carrier Ethernet...*), **virtualization** (*logical routers, service oriented middleware, cloud computing...*)
- **Time is ripe to profit from long-term global investment on R&E Networking**
- GÉANT contribution to global initiatives on advanced networking:
  - Internet2: Accelerated hybrid networking development (HOPI à DCN, Dynamic Circuit Network)
  - DICE Group (GÉANT2/3 via *DANTE, Internet2, Canary, ESnet*)
- Growing **global role & commitments** of the GÉANT community

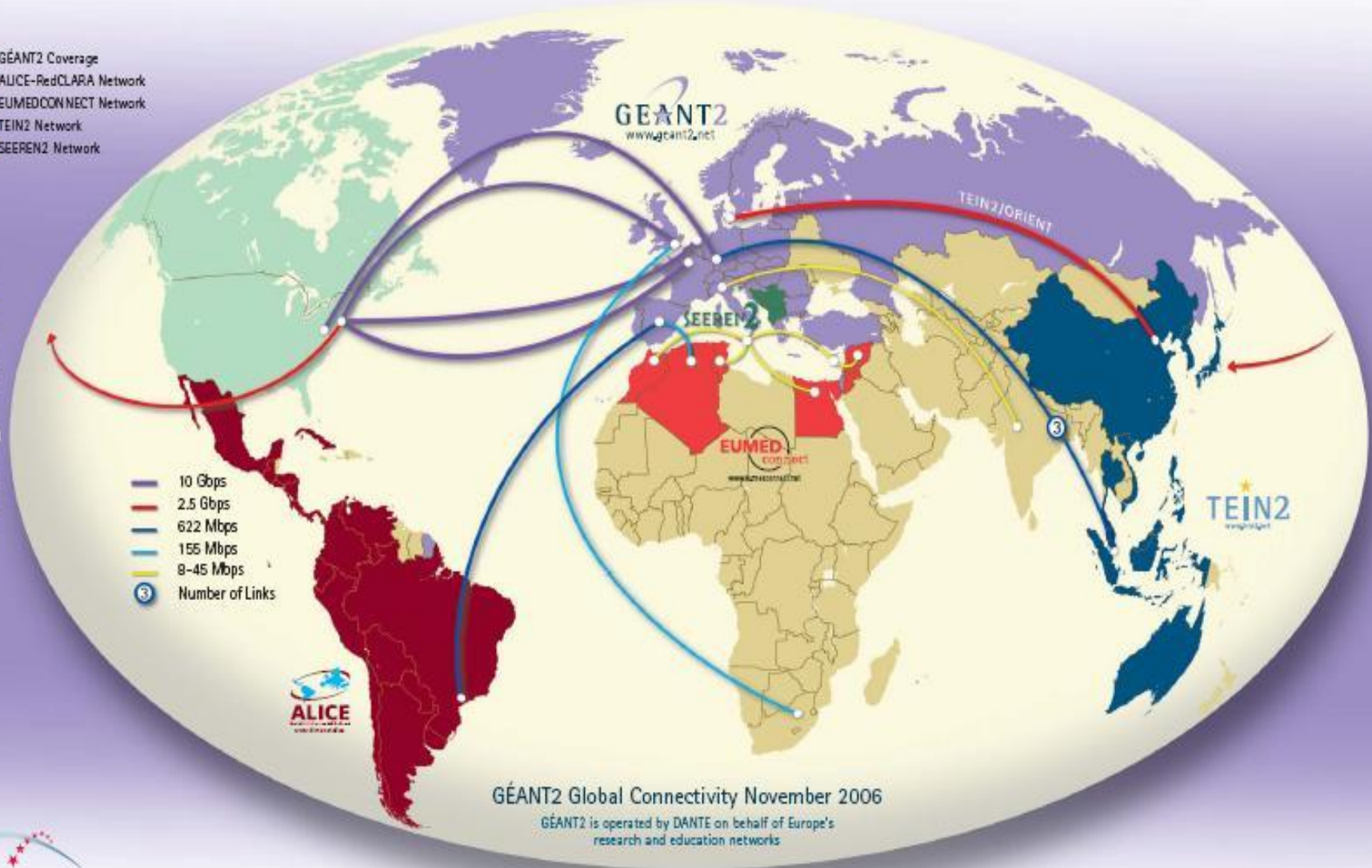


# GEANT2 At the Heart of Global Research Networking

- GEANT2 Coverage
- ALICE-RedCLARA Network
- EUMEDCONNECT Network
- TEIN2 Network
- SEEREN2 Network

www.geant2.net

- 10 Gbps
- 2.5 Gbps
- 622 Mbps
- 155 Mbps
- 8-45 Mbps
- Number of Links



GEANT2 Global Connectivity November 2006

GEANT2 is operated by DANTE on behalf of Europe's research and education networks



★ Connect ★ Communicate ★ Collaborate



# GÉANT3: A factory of (virtualized) networking resources & services (1/3)



- Extending the service portfolio to production quality multi-domain hybrid networking
  - Campus, NRENs, GÉANT3...
  - Innovate to resolve the multi-domain impasse:

*Note that there are up to now only TWO inter-domain control plane (signaling) success stories: SS7 (telephony) & BGP (Internet)*

- Integrating Control Plane Functionality within Distributed Computing (GRID, SOA) Middleware
- Translating into a common view an enriched set of per-domain information, feedback to standardization bodies (IETF, OIF, OGF)



# GÉANT3: A factory of (virtualized) networking resources & services (2/3)

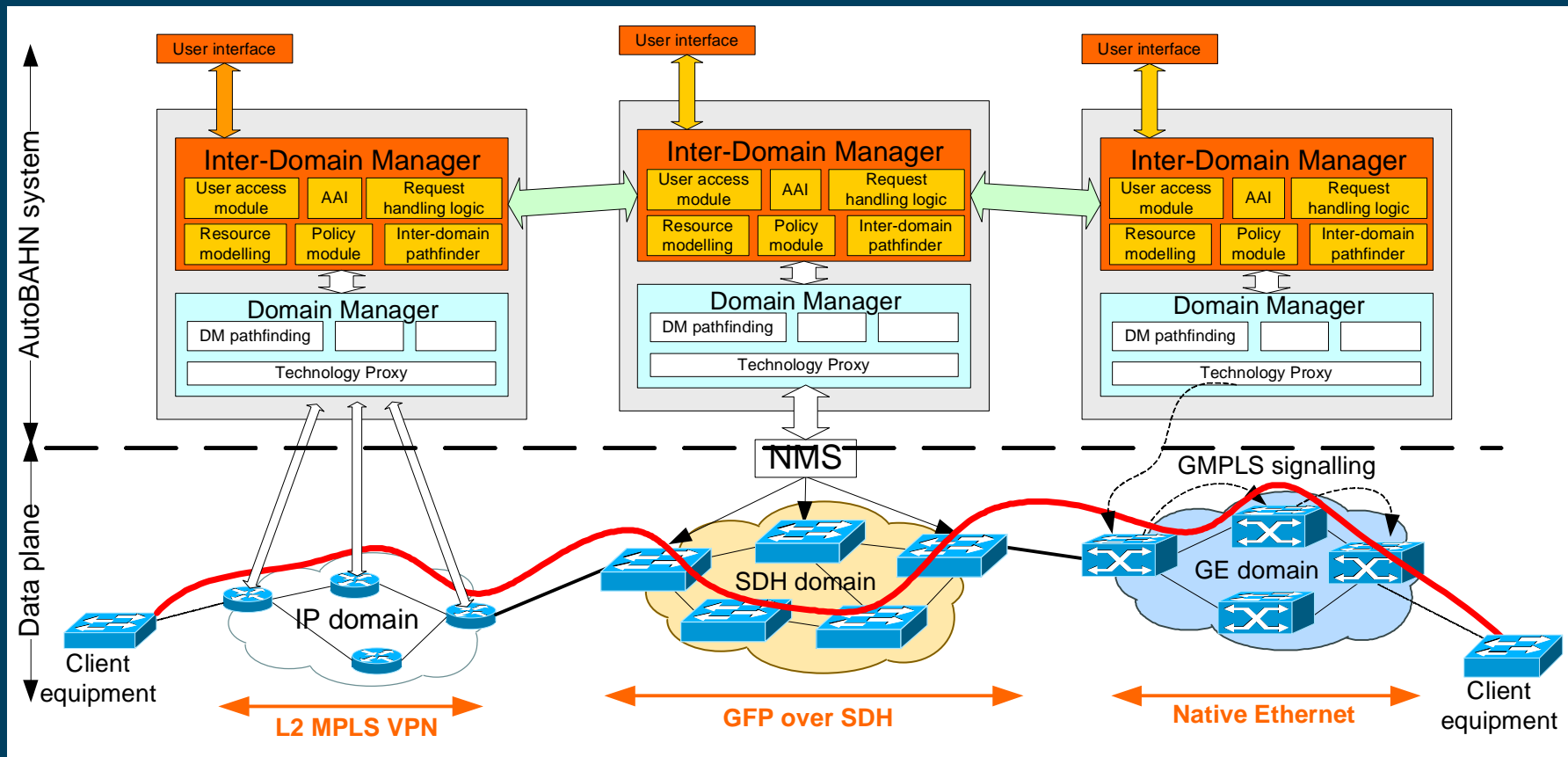


- Multi-domain services focus on management services to NRENs enabling:
  - Distributed ticketing workflows, performance monitoring (*PERT+*)
  - Security (incident reporting, anomaly detection)
  - Confederated Roaming (*Eduroam*), PKI & ID management (*eduGAIN*)
  - Multi-protocol monitoring at 10-100 Gig speeds (*perfSONAR+*)
  - End-to-end Provisioning (*E2ECU*)
  - Automated multi-domain provisioning (*AutoBAHN*)

# Automatic Bandwidth Provisioning: The AutoBAHN Concept



(based on a presentation by *Afrodite Sevasti*, GRNET)



# GÉANT3: A factory of virtualized networking resources & services (3/3)

INTERNET<sup>2</sup>

- Extend the NREN – GÉANT Services to provision of integrated IT services that include:
  - Multi-domain hybrid networking services
  - Storage (?)
  - Computing (?)
- Converging e-Infrastructures
  - Relationship with Grid – Supercomputing
  - Towards **cloud** computing aka. Google, Amazon, IBM...?
  - Now more than ever the **NETWORK IS THE COMPUTER**

# Summarizing the GÉANT3 Vision

- To create an innovative **multi-domain hybrid networking** environment, using advanced transmission & switching technologies
- To enable R&E users through their Organizations with **flexible and scalable production quality services** via their constituent NRENs
- To be an enabler for Global R&E networking supporting international e-Science initiatives, creating a **Global Virtual Village** to house researchers & educators around the world
- To contribute to standards as a key participant in European & Global efforts towards the **Network of the Future**



# GÉANT3 & its Global Peers: Help shaping the Internet of the future



- GÉANT3 will be a key player in Global initiatives on the **Network of the Future**
  - US Initiatives
    - GENI <http://www.geni.net/> (clean slate)
    - VINI <http://www.vini-veritas.net/> (on Internet2, NLR)
  - Japanese Initiatives
    - AKARI <http://akari-project.nict.go.jp/eng/index2.htm>
  - European Initiatives
    - FEDERICA <http://www.fp7-federica.eu/> (on GÉANT2, NRENs)
    - FIRE ICT Projects <http://cordis.europa.eu/fp7/ict/fire/>



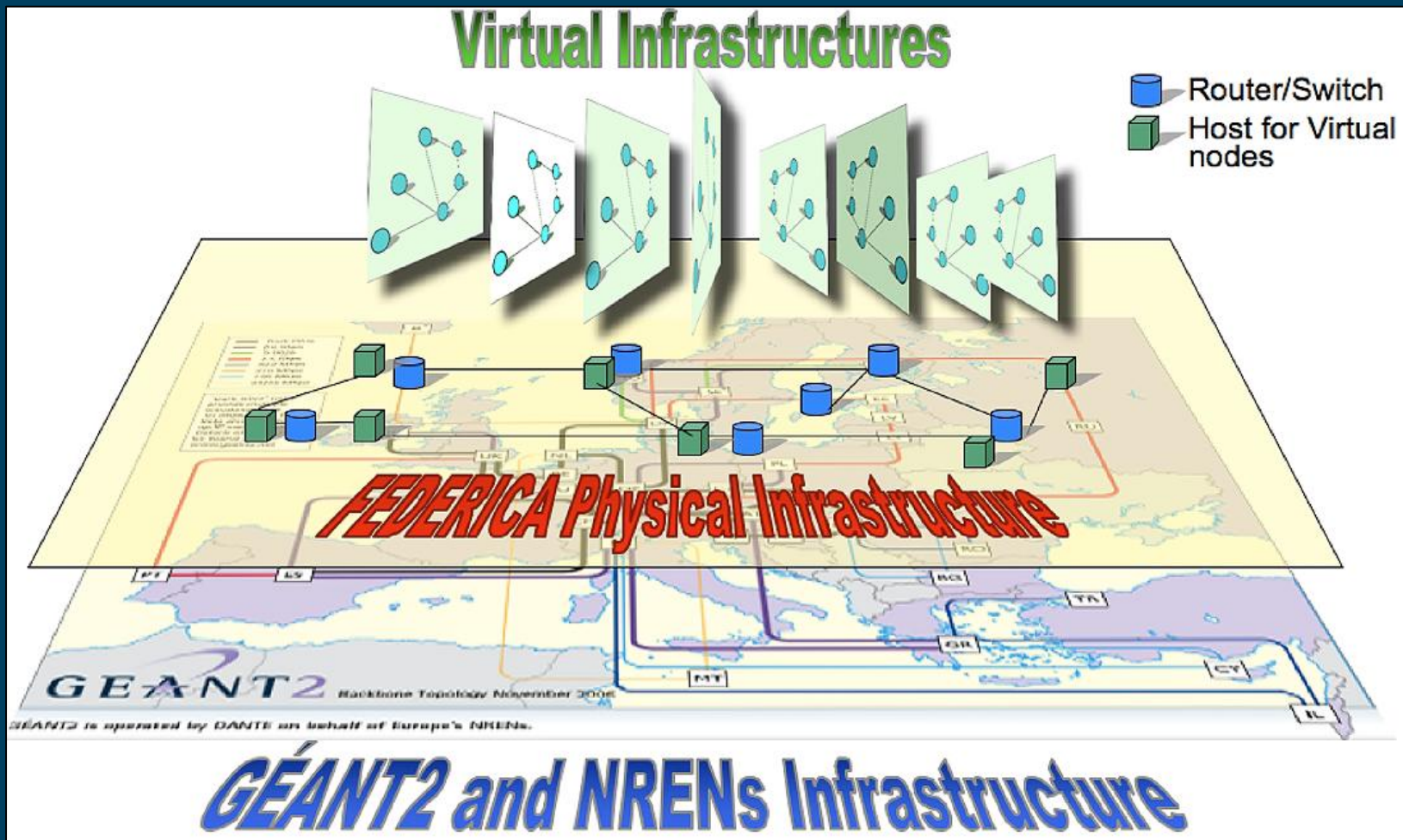
# FEDERICA @ a Glance



- Federated **E**-infrastructures **D**edicated to **E**uropean **R**esearchers  
**I**nnovating in **C**omputing network **A**rchitectures
- RI FP7 Project, based on *stakeholders on network research*:
  - NRENs, GEANT2, end-users and vendors
  - Coordinator: GARR (the Italian NREN)
- Aims to:
  - Employ initially up to 1 Gbps MPLS & GigE circuits from NRENs and GEANT2 (GEANT+ service)
  - Install open source routers, programmable routers and open API switches in selected NREN PoPs
  - Develop a *tool-bench* for managing virtual e2e facilities
  - Provide virtualized facilities to end-users: Research groups on the network of the future, requiring *disruptive emulations*
  - Pave the way for eventual GN3 involvement



# The FEDERICA Concept



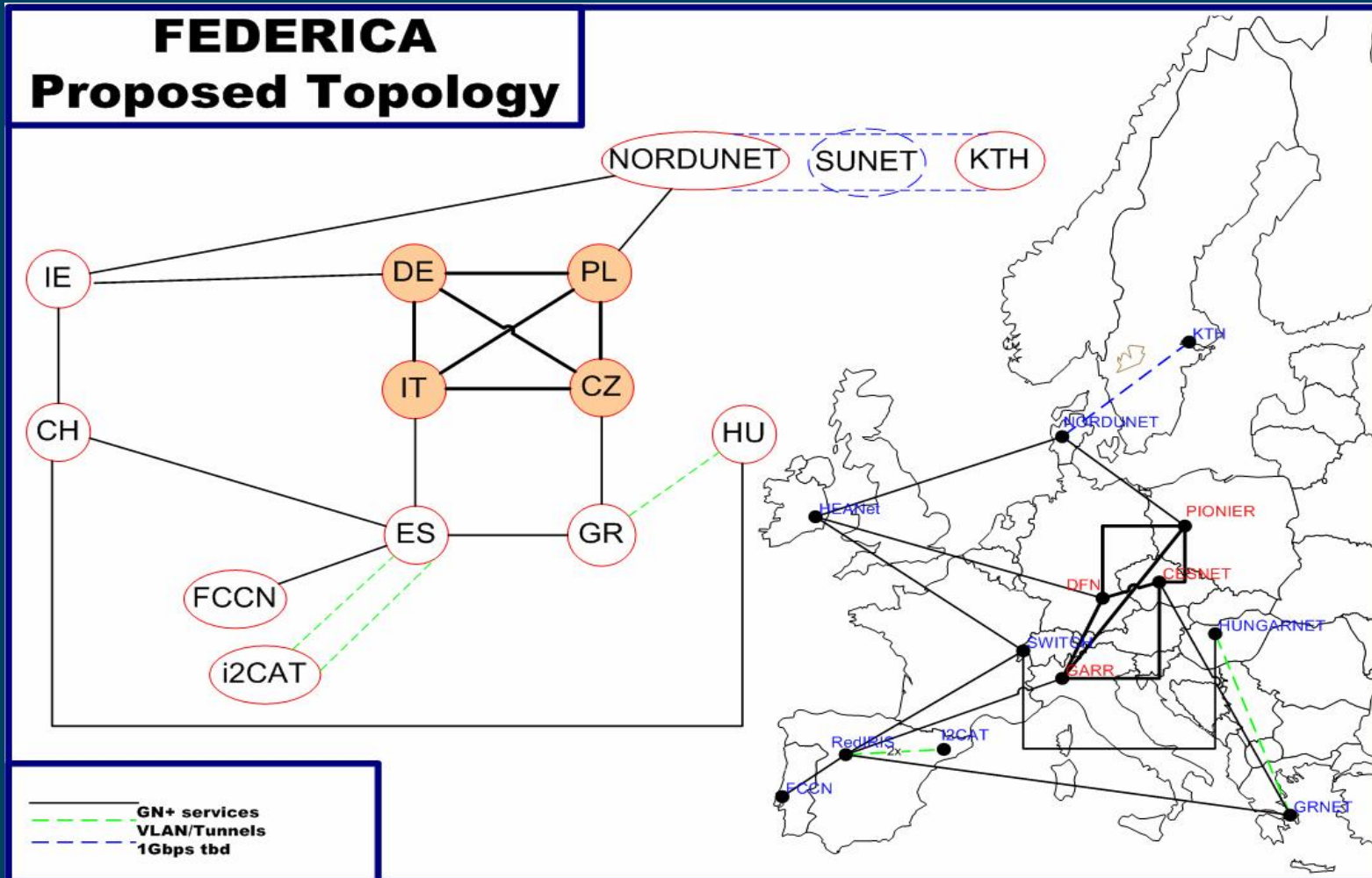
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# FEDERICA Partners

- GARR (coordinator)
- CESNET
- DFN
- FCCN
- GRNET
- HUNGARNET
- PSNC
- RedIRIS
- SWITCH
- TERENA
- i2CAT
- KTH
- ICCS
- UPC
- Juniper
- Martel Consulting
- HEANet
- DANTE
- Politecnico di Torino
- NORDUNET

# The FEDERICA Network Slice



# Converging e-Infrastructures (Cyber-Infrastructures)



Research Networking & HPC/GRID communities common mission

Provision of leading edge *e-Infrastructures* for  
Research & Advancement of HPCN technologies:  
**A Concerted Global Effort**



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