



What should come 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** → **TEN155** → **GÉANT** (GN1 in FP5) → **GÉANT2** (GN2 in FP6): **Hybrid Optical Backbone (+ Cross Border Fibers)** → **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"* → 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 → 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



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1. Austria (**ACOnet**)
2. Belgium (**BELNET**)
3. Bulgaria (**ISTF**)
4. Croatia (**CARNet**)
5. Czech Republic (**CESNET**)
6. Cyprus (**CYNET**)
7. Germany (**DFN**)
8. Estonia (**EENet**)
9. France (**RENATER**)
10. Greece (**GRNET**)
11. Hungary (**HUNGARNET**)
12. Ireland (**HEANet**)
13. Israel (**IUCC**)
14. Italy (**GARR**)
15. Latvia (**LATNET**)
16. Lithuania (**LITNET**)
17. Luxembourg (**RESTENA**)
18. Malta (**UoM**)
19. Netherlands (**SURFNET**)

20. Nordic Countries – Denmark, Finland, Iceland, Norway, Sweden (**NORDUNET**)
21. Poland (**PSNC**)
22. Portugal (**FCCN**)
23. Romania (**RoEduNet**)
24. Russia (**JSCC**)
25. Slovakia (**SANET**)
26. Slovenia (**ARNES**)
27. Spain (**RedIRIS**)
28. Switzerland (**SWITCH**)
29. Turkey (**ULAKBIM**)
30. United Kingdom (**UKERNA**)

PLUS NON-VOTING MEMBERS:

Delivery of Advanced Network Technologies to Europe Ltd. (**DANTE**)
Trans-European Research & Education Networking Association (**TERENA**)

PERMANENT OBSERVERS: **CERN, AMRES, MARNET**

NREN's & GÉANTⁿ: 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



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Bandwidth Requirements per User

SERENATE Study Final Report, 2003

Cees De Laat, David Williams et. al.



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of users



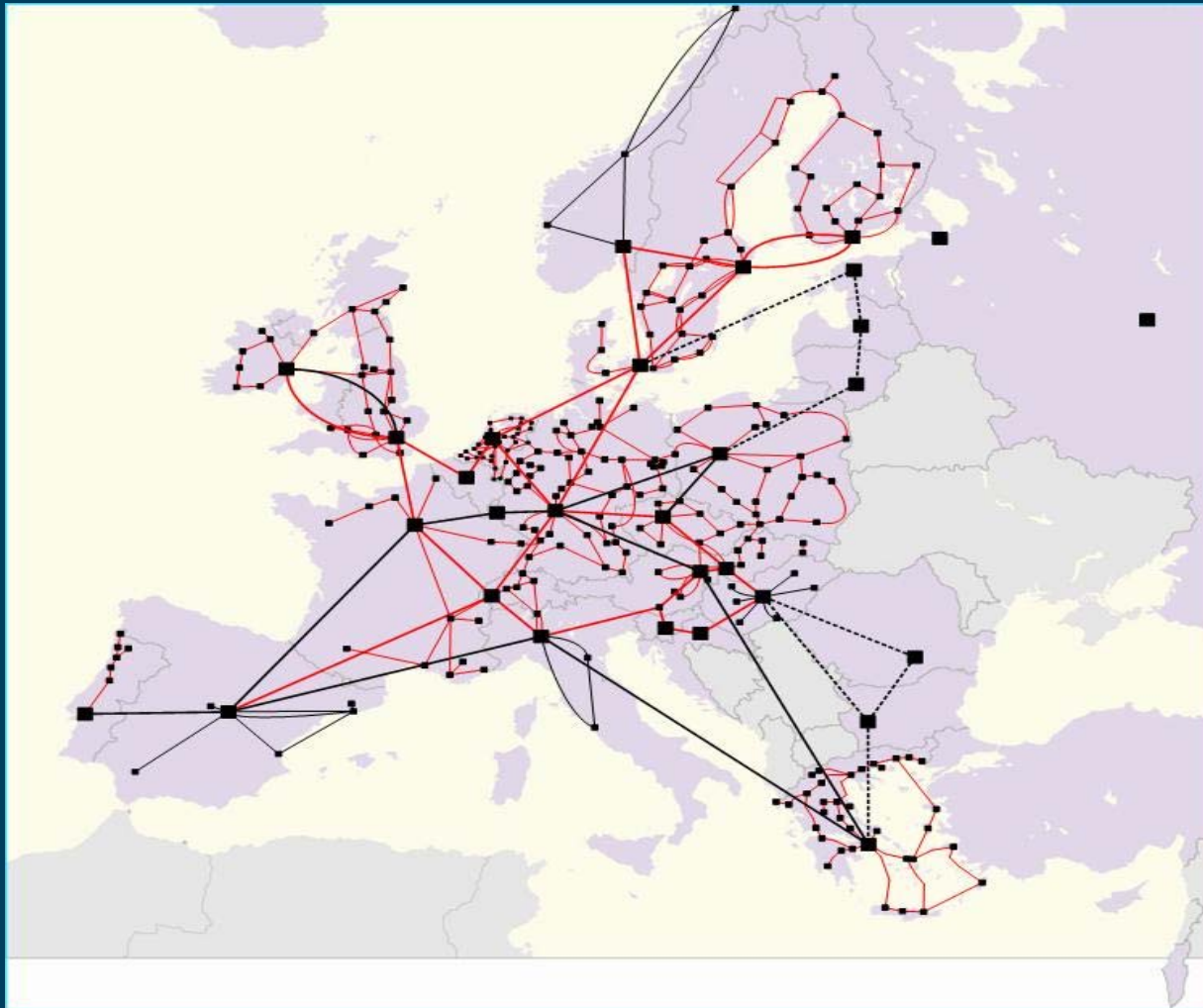
ADSL

GigE

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



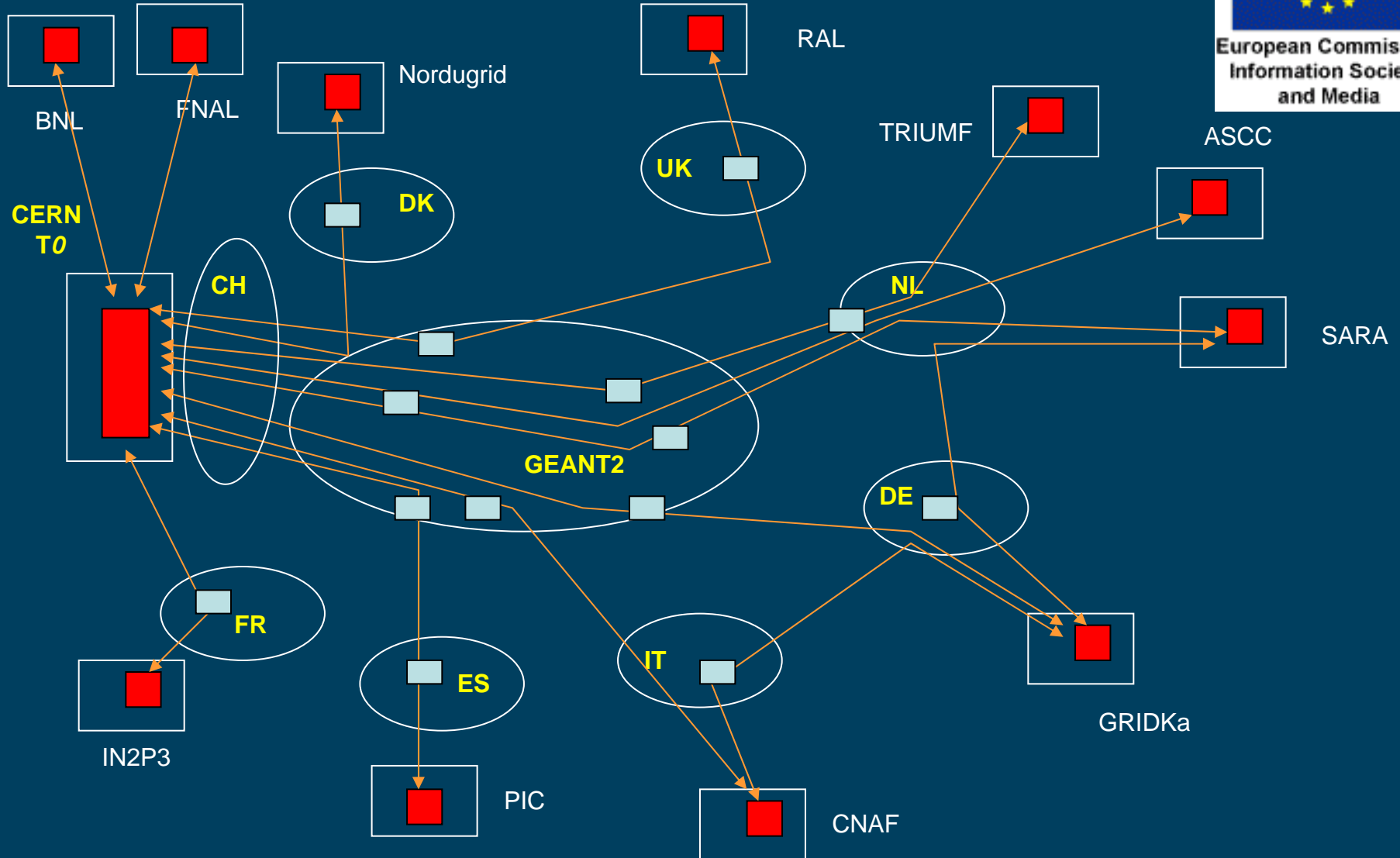
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Enables
end-to-end
Hybrid Networking &
Optical Private
Networking (**OPNs**) for
e-Science Projects



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



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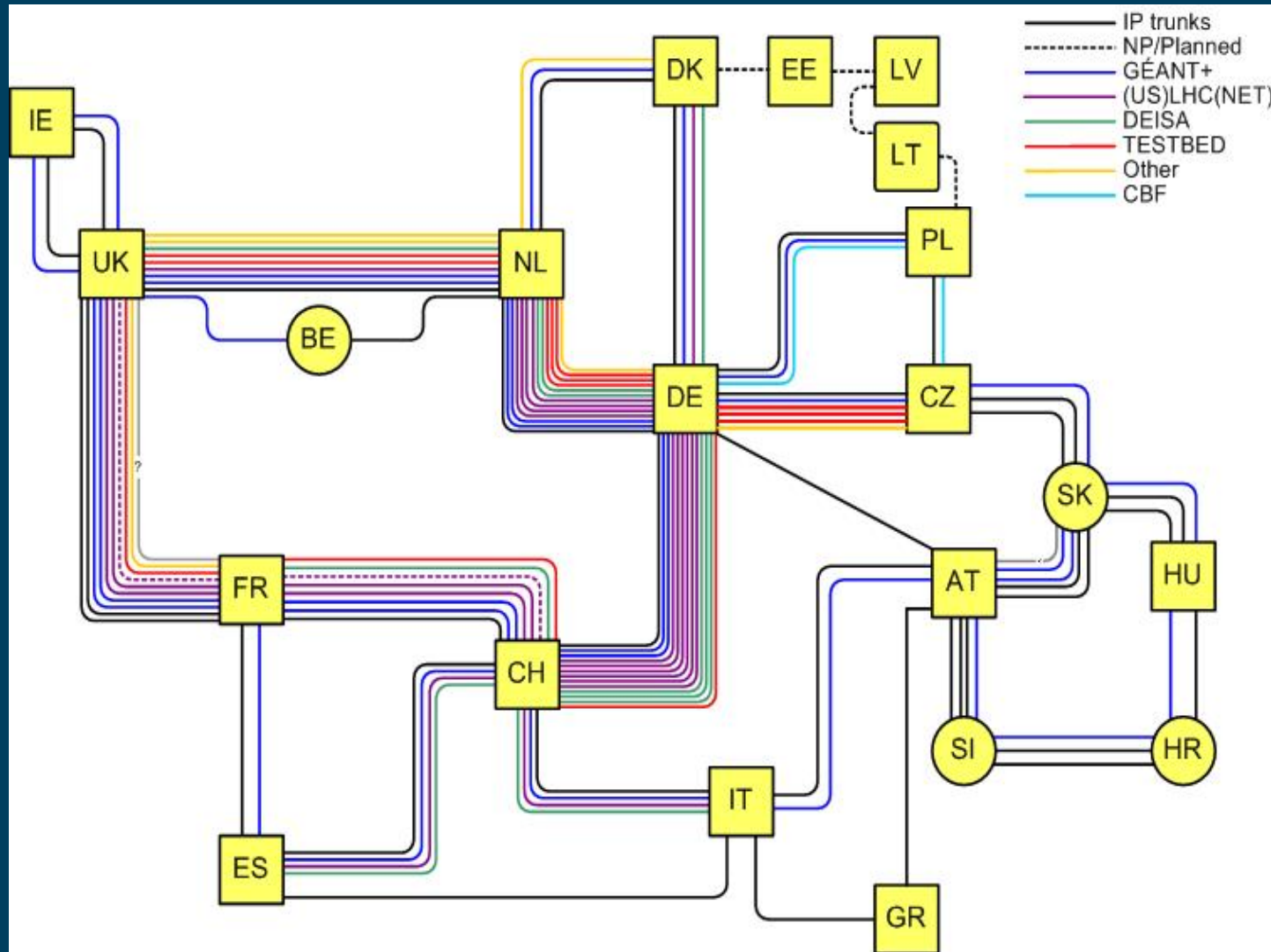


Wavelengths on GÉANT2 - February 2008

(based on presentation by *Hans Döbbling* DANTE G.M.)



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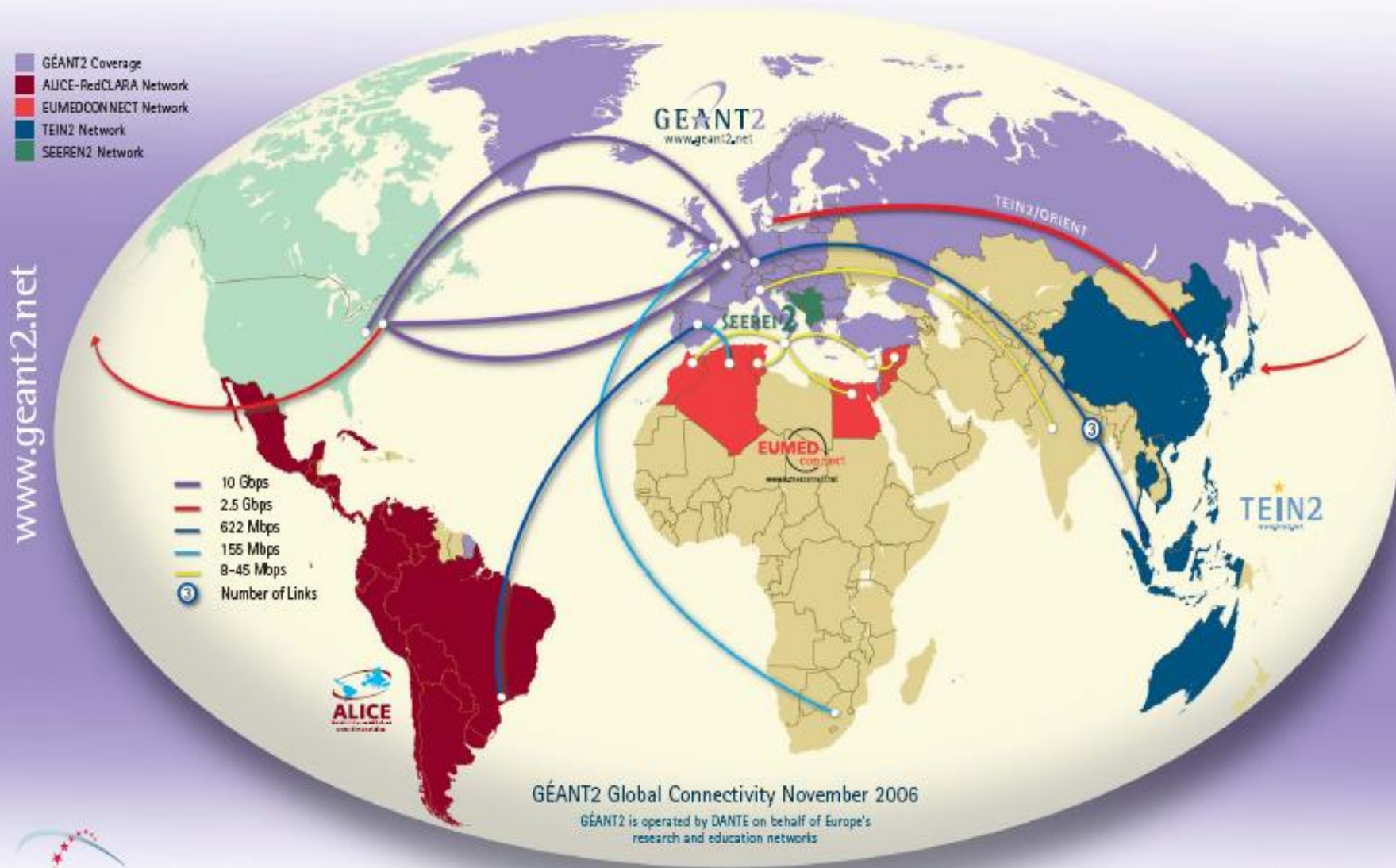
Is there Life after GÉANT2 ?



- 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 for Europe to profit from its long-term investment on R&E Networking**
- GÉANT is a yardstick for global initiatives
 - Internet²: Accelerated hybrid networking development (HOPI → 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



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)

- Translating into a common view an enriched set of per-domain information, feedback to standardization bodies (IETF, OIF, OGF)

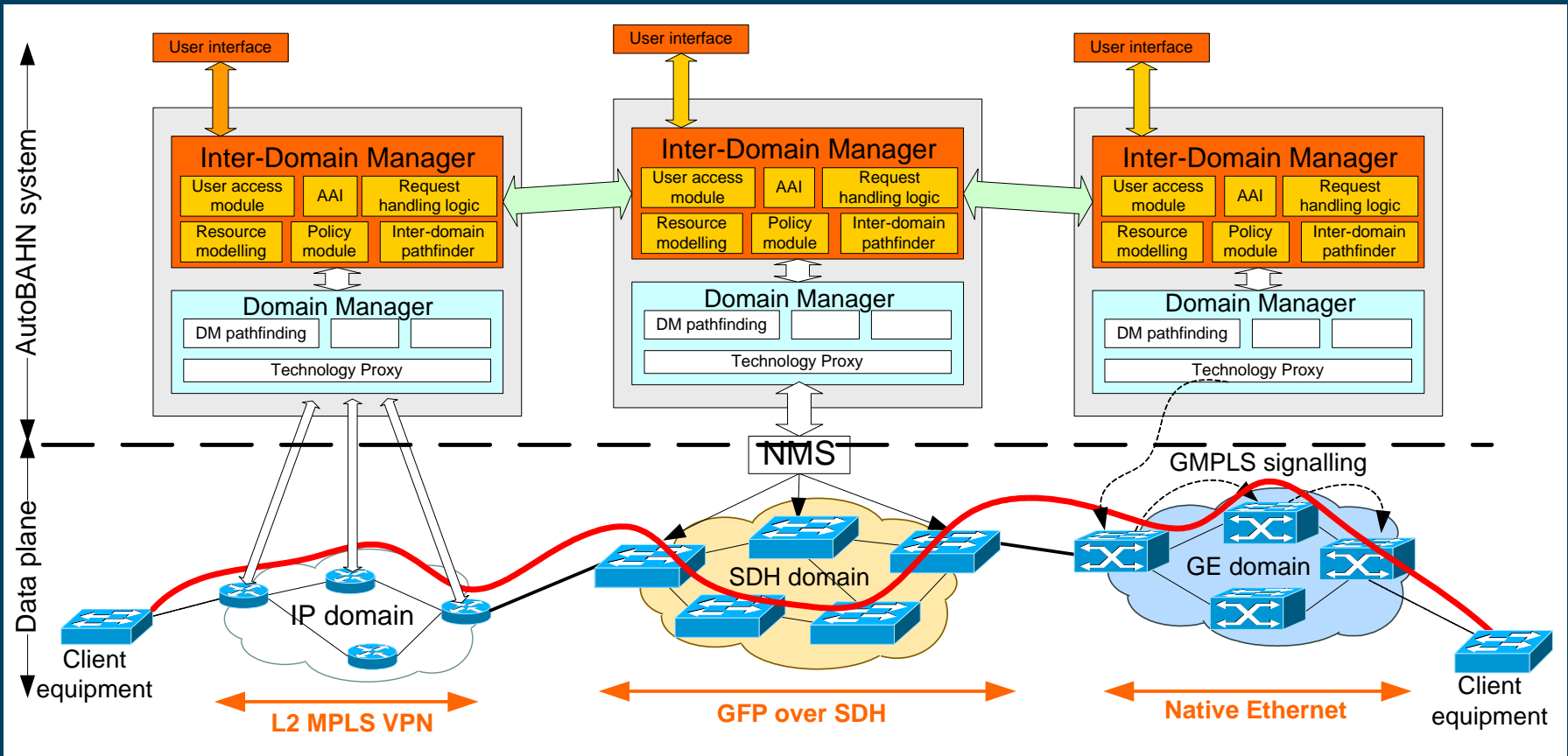
GÉANT3: A factory of (virtualized) networking resources & services (2/3)



- 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)



- 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**

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



- GÉANT3 will be a key player in European & 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/>

Preparations for a GN3 Proposal



- Two task forces established by the NREN PC (**September 2007**):
 - **GN3 Membership Committee:** Artur Binczewski (*PSNC*), Thomas Brunner (*SWITCH*), Dai Davies (*DANTE*), Jan Gruntorad (*CESNET, Chair*), SabineJaume-Rajaonia (*RENATER*), Karel Vietsch (*TERENA*)
 - Rules of membership, categories (**December 2007**)
 - **GN3 High Level Technical Strategy:** Erik-Jan Bos (*SURFNet*), Mauro Campanella (*GARR*), Hans Döbbeling (*DANTE*), Lars Fischer (*NORDUNet*), David Foster (*CERN*), Vasilis Maglaris (*NREN PC, Chair*), Dorte Olesen (*TERENA*), Roberto Sabatino (*DANTE*), Afrodite Sevasti (*GRNET*)
 - Preliminary report (**October 2007**)
 - Green paper (consultation phase amongst NRENs, completed by the **end of March 2008**)
 - White paper (**end of April 2008**)
- Governance, management issues, role of DANTE

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**



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ICT e-Infrastructures: A CONCERTED EUROPEAN EFFORT



Research Networking & HPC/GRID communities common mission:

Provision of leading edge *e-Infrastructures* for Research & Advancement of HPCN technologies as **European added value**



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