Next Generation Networking in Europe: GÉANT3 and FEDERICA

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Contributions to this Talk

- **GN2 Activity Leaders**
  GN2 Coordinator DANTE

- **GN3 Technical Strategy Committee**
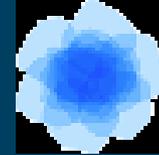 GÉANT2 Consortium

- **EARNEST Foresight Study**,
  GN2/NA5 – Activity Leader TERENA

- **FEDERICA Consortium**
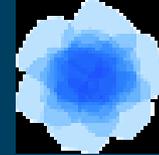 FP7 Project, Research Infrastructures – Coordinator GARR

GÉANT2:
A European Team Effort

- The **GÉANT2 Network Footprint**: Interconnects 30 (34) National Research & Education Networks (NREN's) of the Extended European Research Area

- **GN2 Project**: co-funded by the European Commission (DG INFSO-M) and the Consortium (30 NREN's + DANTE + TERENA)
  - (Human) Networking Activities (NA's)
  - Service Activities (SA's)
  - Joint Research Activities (JRA's)

- **Global Outreach**: Extending the Team Collaborations in all Continents

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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 EC FP5) **→ GÉANT2** (GN2 in EC FP6)**: Hybrid Optical Backbone (+ Cross Border Fibers)**

- **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
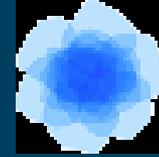- **GN2 Project Management:** ~~DANTE~~ http://www.dante.net/

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European NREN's – GÉANT: A Success Story

- Century old Telecom (+ 40 years ARPAnet - Internet) experience: Proven strong *"Network Externalities"* → Sharing tradition

- Industry needs for *Next Generation Network* proofs of concept: 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

- Success in serving R&E needs of the Continent → Smoothing-out *"digital divides"* & serving powerful communities (educators, students, pupils?)

- NREN's as public utilities for the R&E communities – *"commons"*

- Solidarity – human networking of NREN community

- Stable Governance: NREN Policy Committee (NREN PC)

# Evolution of European NREN Interconnection

- From *2 Mbps* to *155 Mbps*:
  - **EuropaNet → TEN34 → TEN155** (pre-FP5 EC Projects)

- From *155 Mbps* to *Gigabit IP*:
  - **TEN155 → GÉANT** (FP5 EC Project GN1)

- From *Gigabit IP* to *Hybrid Networking over Dark Fibers*:
  - **GÉANT → GÉANT2** (FP6 EC Project GN2)
    - ***Paradigm Shift***, predicted by the *SERENATE* study & made possible by the availability of dark fibers in liberalized markets

e-IRG Recommendation on Hybrid Networking & GÉANT
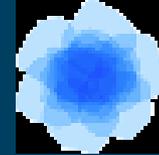
"The e-IRG stresses the importance of flexibly configurable, reliable end-to-end optical provision to European researchers and e-Science projects. This service should co-exist with routed IP connectivity and follow the three tier hierarchical European paradigm: Campus LAN, NREN and Pan-European GÉANT network"
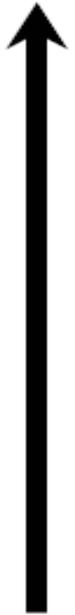
Den Haag, 19/11/2004

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Bandwidth Requirements per User
## SERENATE Study Final Report, 2003
Cees De Laat, David Williams et. al.

NREN's & GÉANT2: *e-Science* Enablers and Equalizers

- NREN's - GÉANT2 provided cost effective e2e switched & light path connectivity within the Dark Fiber Cloud (DWDM footprint)
    + Global IPv4 – IPv6 coverage and Hybrid networking services
    + 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, reduced the *DIGITAL DIVIDES* in Europe & globally: Big Science affordable via virtual *e-Science*
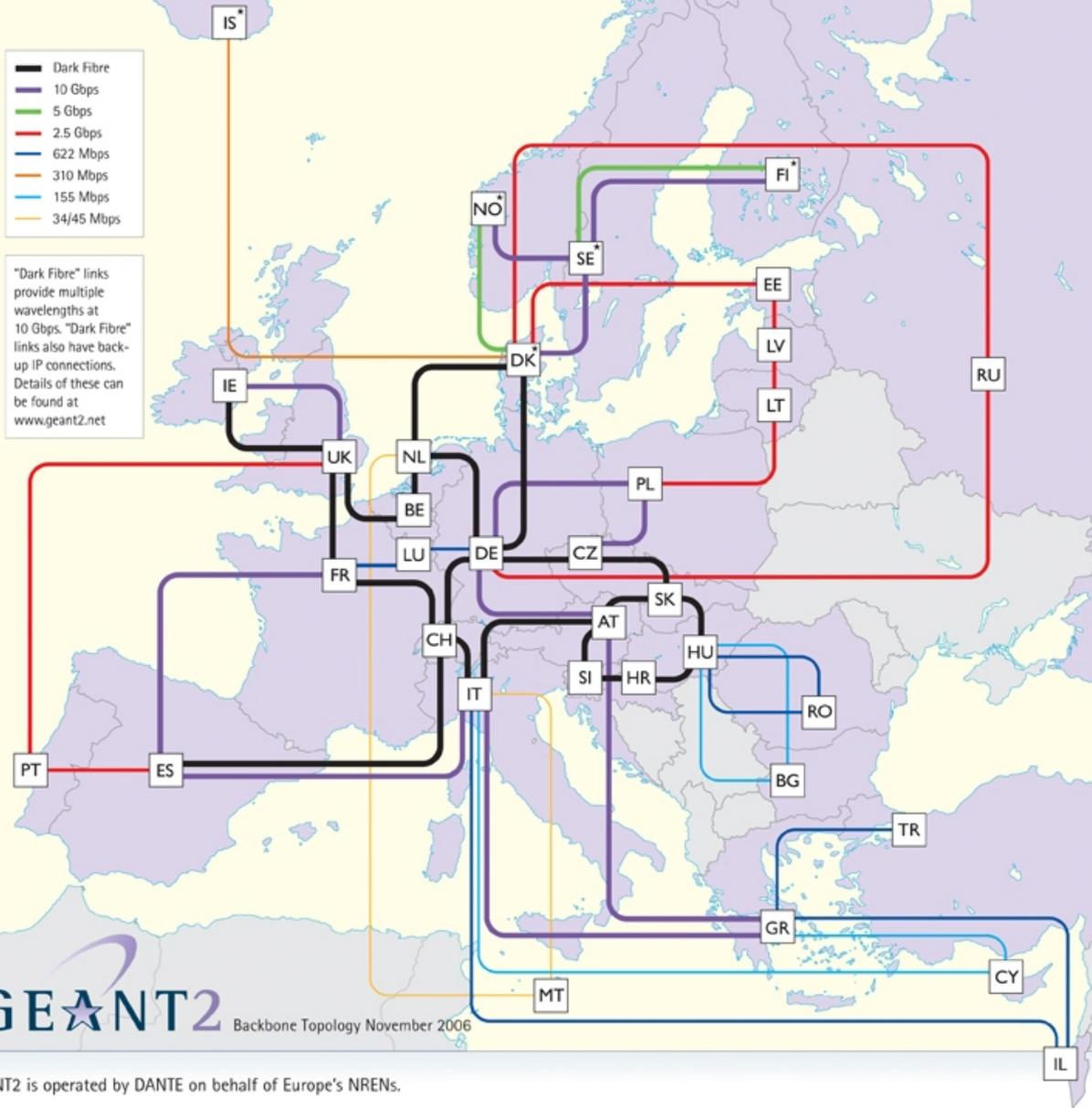
The NREN Policy Committee
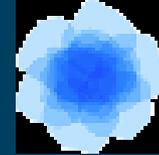
1. Austria (ACOnet)
2. Belgium (BELNET)
3. Bulgaria (ISTF)
4. Croatia (CARNet)
5. Czech Republic (CESNET)
6. Cyprus (CYNET)
7. Germany (DFN)
8. Estonia (EENet)
9. France (RENATER)
10. Greece (GRNET)
11. Hungary (HUNGARNET)
12. Ireland (HEANet)
13. Israel (IUCC)
14. Italy (GARR)
15. Latvia (LATNET)
16. 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

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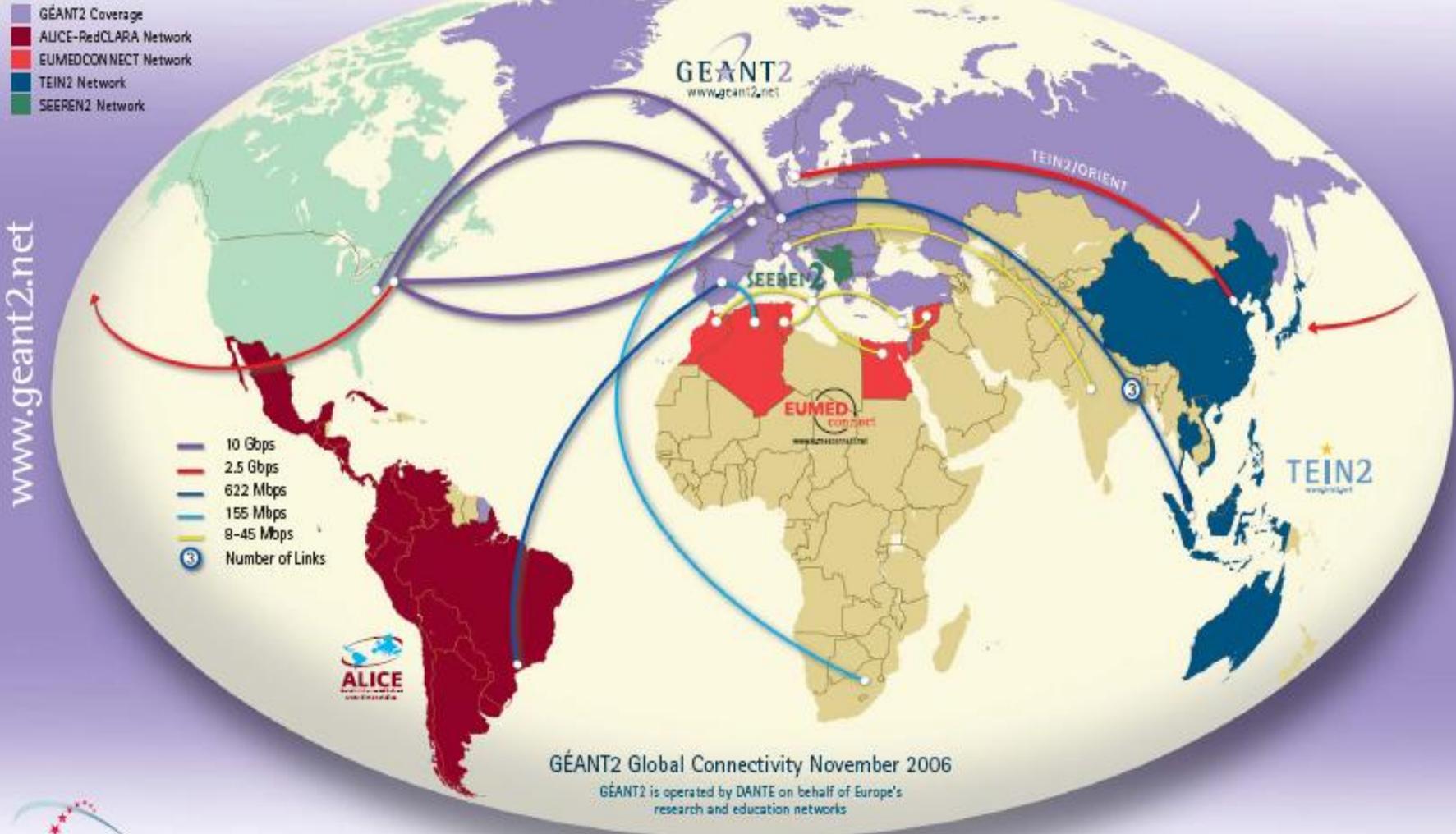
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GÉANT2 Topology

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

Rest, via leased "lambda" and SDH circuits

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GÉANT2 At the Heart of Global Research Networking

GÉANT2 Coverage
ALICE-RedCLARA Network
EUMEDCONNECT Network
TEIN2 Network
SEEREN2 Network

www.geant2.net

GÉANT2
www.geant2.net

TEIN2/ORIENT

SEEREN2

EUMED
connect
www.eumedconnect.net

ALICE

TEIN2

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

GÉANT2 Global Connectivity November 2006
GÉANT2 is operated by DANTE on behalf of Europe's
research and education networks

DANTE
www.dante.net

★ Connect ★ Communicate ★ Collaborate

European Commission
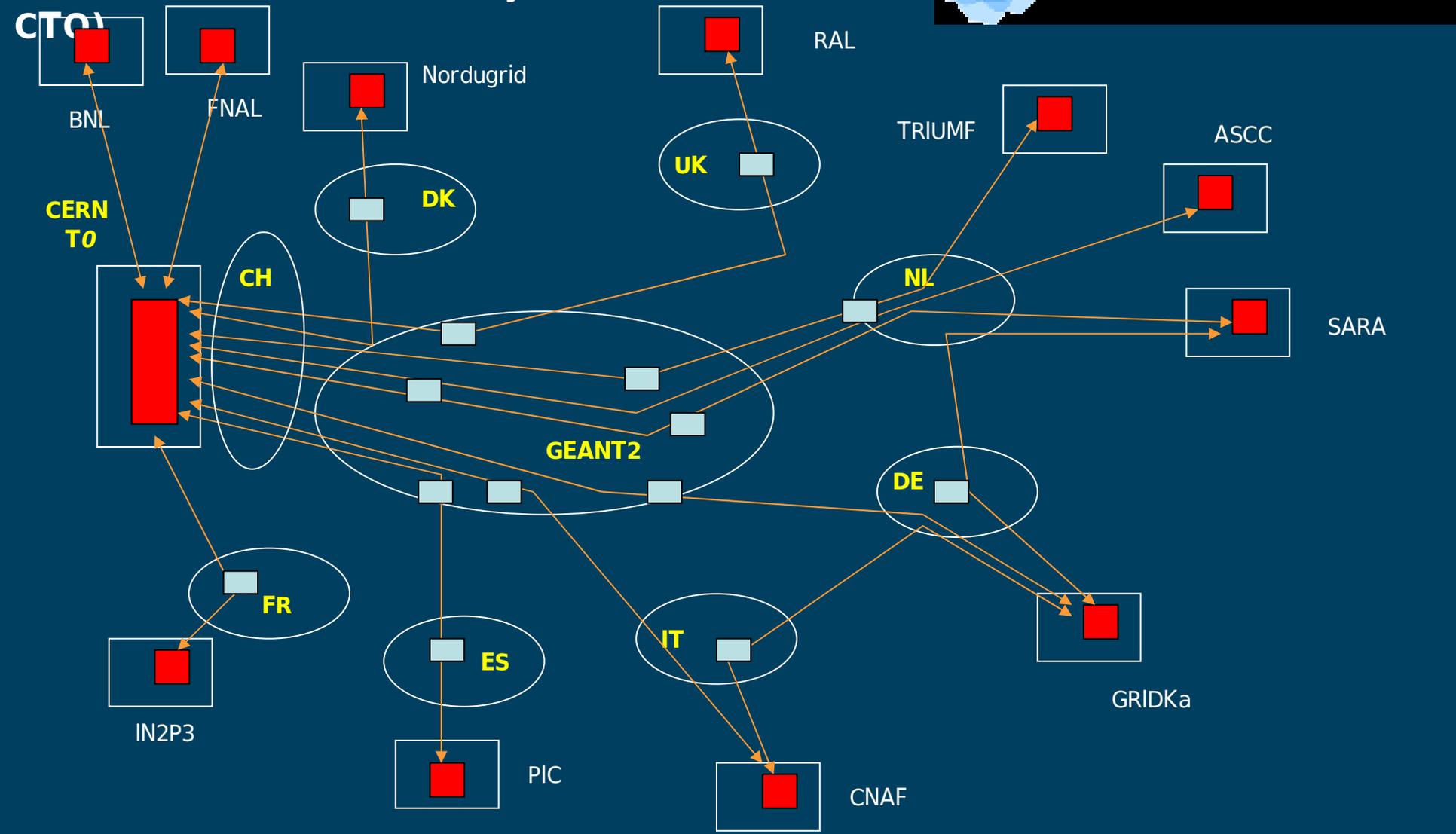Information Society and Media
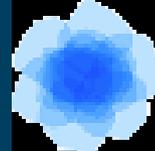
GÉANT2 NOC Functionality

- IP NOC
- Transmission NOC
- Switching NOC
- E2ECU (end-to-end co-ordination unit)

e2e circuits typically span campuses, NREN's and GÉANT **multiple domains** of heterogeneous data & control planes (e.g. GigE's, SDH/GFP, 10 Gig LAN/WAN PHY)

LHC TIER*0* – TIER*1* Optical Private Network - OPN,
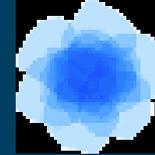## (Scenario based on work by *Roberto Sabatino* DANTE CTO)

PORTUGAL 2007

BNL

FNAL

Nordugrid

RAL

TRIUMF

ASCC

CERN T*0*

UK

DK

CH

NL

SARA

GEANT2

DE

FR

ES

IT

GRIDKa

IN2P3

PIC

CNAF

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LHC OPN T1-T1 Schema

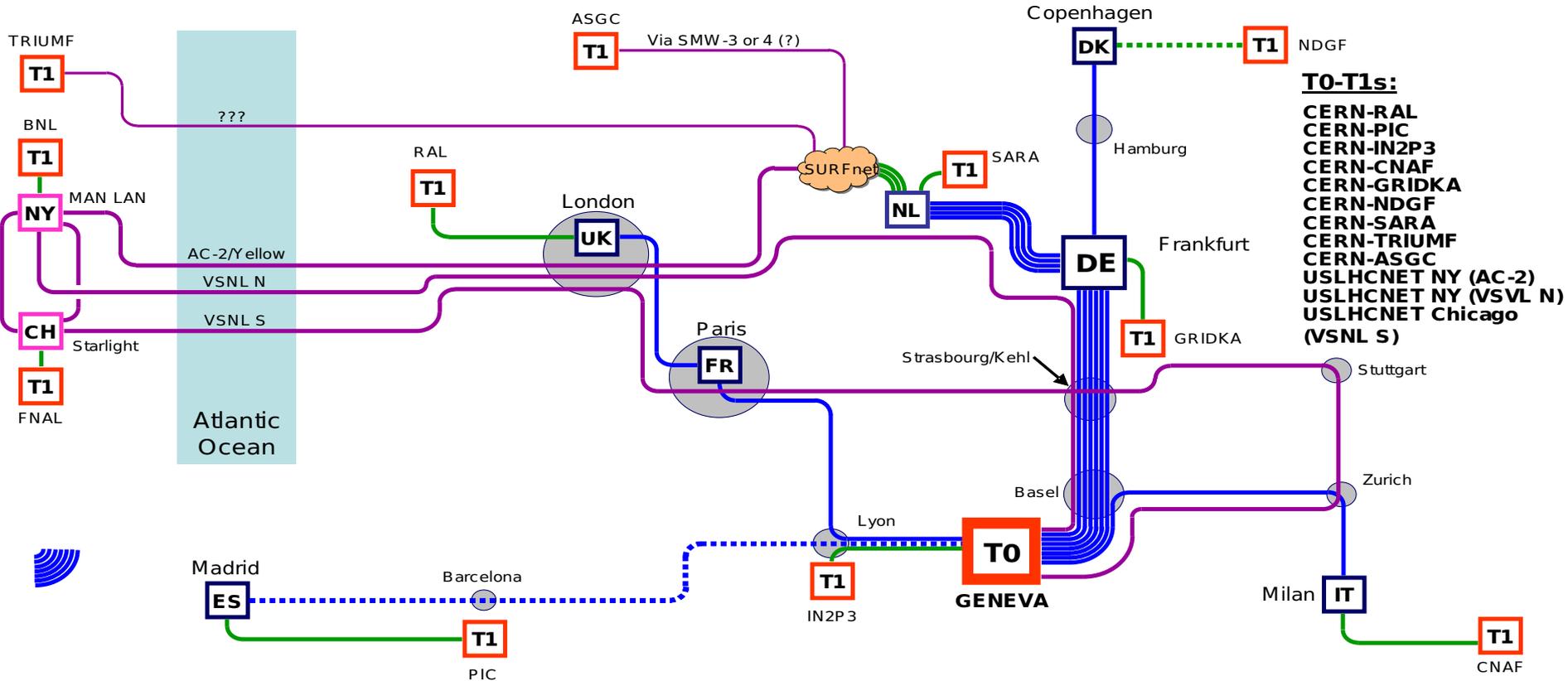**as presented by *Hans Döbbeling*, DANTE GM (Based on material by *Michael Enrico*, DANTE & GN2/JRA4 Activity Leader)**

PORTUGAL 2007

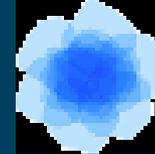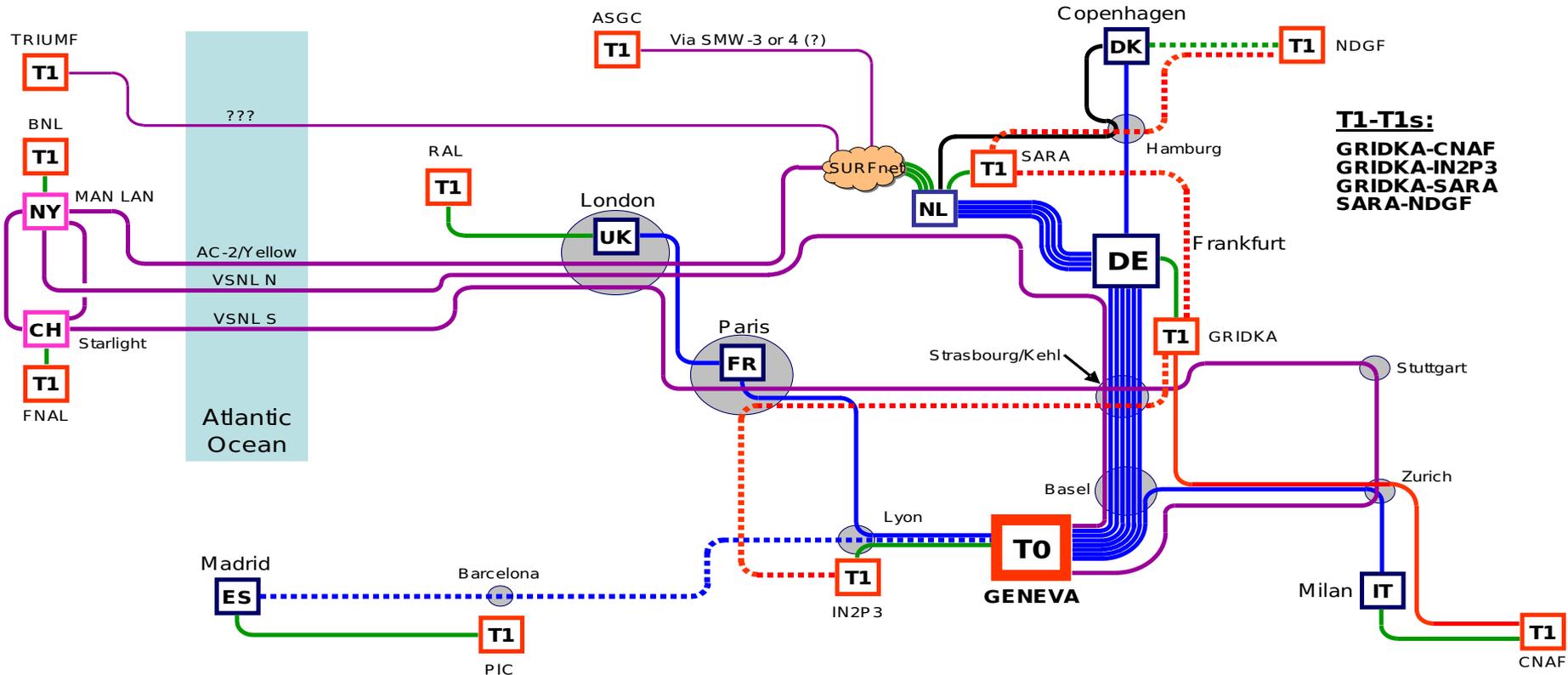## T1-T1 Lambda routing (schematic) [v6]

Connect. Communicate. Collaborate

T1-T1s:
GRIDKA-CNAF
**GRIDKA-IN2P3**
GRIDKA-SARA
SARA-NDGF

The future: Do we face a paradigm shift?

- Not as clear as the introduction of **hybrid dark fiber backbones** (GÉANT→GÉANT2)
- Backbone speed/wavelength (40 -100 Gig) & DWDM wavelengths/fiber **limited by quality of deployed fiber mix**
- Need to **consolidate current advances** into **robust services**
- Emphasis on **multi-domain** aspects & **end-user** support via NRENs and Campuses
- Campus – NREN – GÉANT3 hierarchy: Required for **scalable management** of vast resources
- Promote e2e paradigm - **network neutrality**: Enable end-user services, from simple **IP(v6)** connectivity to elaborate multi-domain VPN/OPN management tools

The GÉANT2 αlphaβet Soup
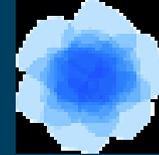
- End-to-end (e2e) provisioning: Technically accomplished for *homogeneous* (Premium IP/DiffServ or MPLS/TE) domains
- Need to establish trust/coordination across domains:
  - Mobile user support (GN2 SA5 *eduROAM*)
  - Federated AAI, Global ID management (GN2 JRA5 - *eduGAIN*)
  - Coordination of Anomaly/Intrusion Detection & CERT's (GN2 JRA2)
  - Monitoring (active/passive measurements, GN2 JRA1 - *perfSONAR*)
  - Bandwidth allocation/scheduling for IP networks (GN2 SA3 - *AMPS*)
  - Bandwidth on Demand in hybrid networks (GN2 JRA3 - *AutoBAHN*)

Multi-Domain Hybrid Networks: Building on NREN/GÉANT2 (2/4)

- Interoperability - stitching of data & control plane domains: GMPLS, ASON...

  CAUTION: Multi-Domain MPLS failure – yet

  The only two (2) success stories in multi-domain control plane standardization:
  - **SS7** (Telephony)
  - **BGP** (Internet)

- Multi-domain extensions of *common Network Information Service cNIS* (GN2 SA3)
  - cNIS is single domain network abstraction
  - Extend its functionality to multi-domain networks and require standard (WS) Northbound Interfaces from domains (NRENs)
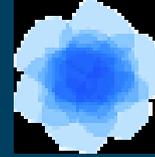
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- Integrated business model for hierarchical (tier) & cross-border fiber (peer) topologies (GN2 JRA4)

- Monitoring across **heterogeneous** data & control plane domains at multiple protocol layers (GN2 JRA1 – *perfSONAR*)

- Deployment of passive – active monitors (including end-user campuses)

- Addressing of Layer 1 & 2 Network Elements at the Control Plane **(IPv6?)**

- Backbone VLAN routing and TE/QoS provisioning for Layer 2 - IEEE 802.1 ah - 802.1 ad (vendor dependent?)

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Multi-Domain Hybrid Networks: Building on NREN/GÉANT2 (4/4)

Multi-Domain Provisioning: The *AutoBAHN* Concept (GN2 JRA3)
(Based on material by *Afrodite Sevasti*, GRNET & GN2/JRA3 Activity Leader)

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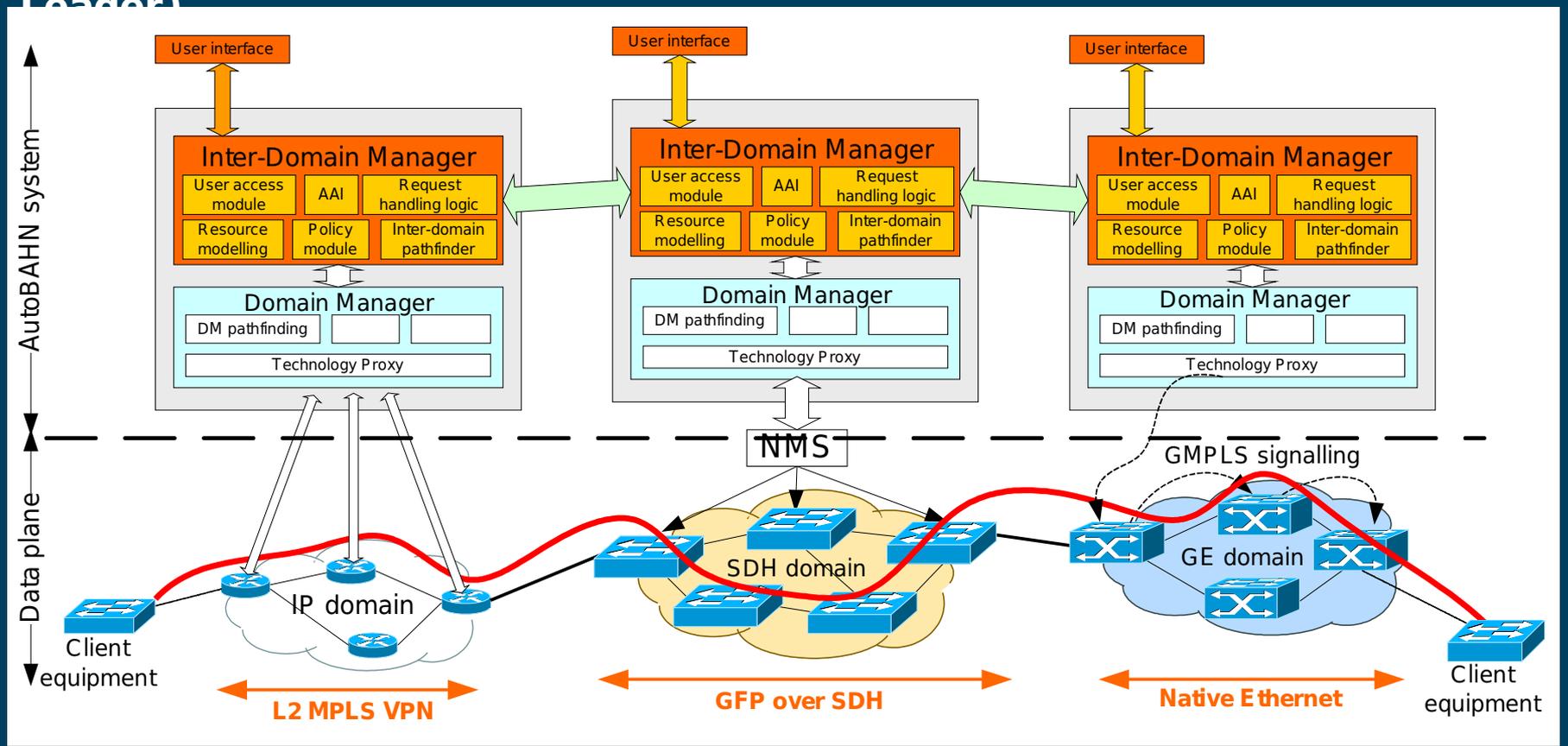
Some Open Issues on GÉANT3 Planning (1/2)

- Support coordination of NREN supplied *Data Storage Area Networks*: An opportunity but an issue to debate

    - Up to what degree is convergence of *e-Infrastructures* affect our future?
    - Is this an NREN – GÉANT3 task?
    - Is there a conflict with distributed GRID – Super Computing infrastructures?
    - Can we compete with advanced commercial offerings e.g. Google, Amazon?
    - Are NRENs/GEANT3 *third trusted parties* for data repositories?
    - ....

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- Innovation & Research on the *Network of the Future*

  - Isolated slices & virtual instances can be allocated to University & Research Lab groups experimenting on disruptive network research to *provide a realistic platform for emulations, within a production network*

  - Advantage of Europe: Existence of the vastest hybrid optical footprint, GÉANT2 & NRENs, *no need for expensive clean slate approaches*

  - The NREN community & GÉANT3 is capable to:
    - Support demands by EC Projects on the Network of the Future (e.g. *FEDERICA, FIRE projects*)
    - Engage in research on *virtualization of network elements* (open source routers, programmable routers & protocol agnostic switches with open APIs), extending its testbed activity (GN2 JRA4)
    - Collaborate with similar international initiatives, e.g. *PlanetLab, GENI*

Few words on FEDERICA (1/2)

*F*ederated *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, GEANT*2*, end-users and vendors
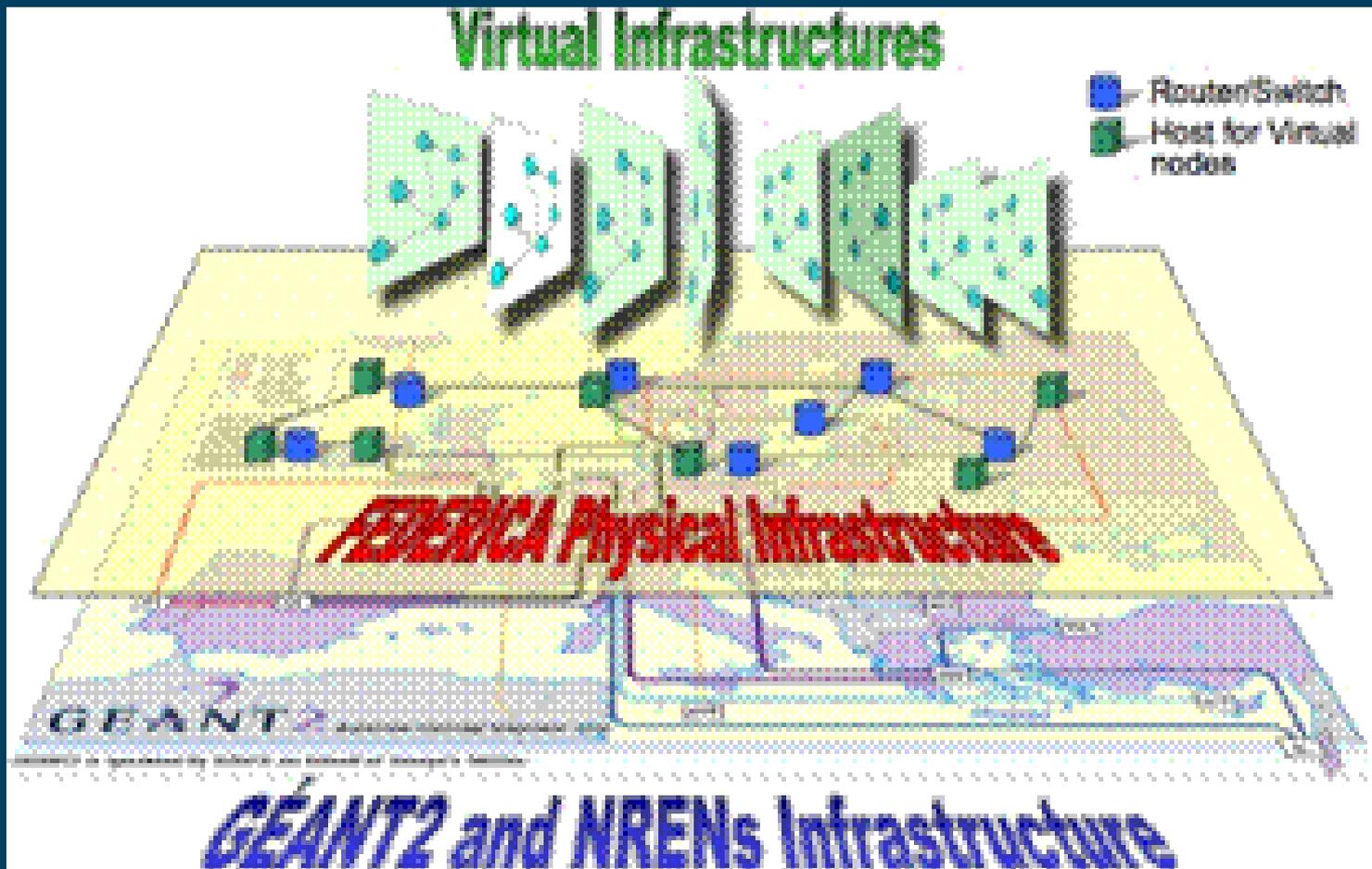- Coordinator: GARR (the Italian NREN)

Aims to:

- Employ initially up to 1 Gbps MPLS & GigE circuits from NRENs and GEANT2 (GÉANT+ 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

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Based on material by *Mauro Campanella*, GARR & FEDERICA Coordinator)
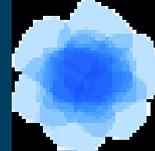
ICT e-Infrastructures: A CONCERTED EUROPEAN EFFORT

Research Networking & HPC/GRID communities common mission:

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

Related Links

- www.geant2.net
- www.dante.net

- For GÉANT2 latest news & fact-sheets
  http://www.geant2.net/media

- For GÉANT2 research activities
  http://www.geant2.net/research

- For FEDERICA
  www.**terena.org/activities/efniw/slides/maglaris-federica.ppt**