

# Federated Testbeds for Future Internet Research

## The **NOVI Experience & NREN/GÉANT Potential**

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Boston, Massachusetts - USA



- **Data plane stitching across continents**
  - Multi-technology, multi-vendor, multi-domain
- **Control & Management (C&M) plane federation**
  - Compatible with NREN & PlanetLab experience, building on GENI, NOVI... C&M Frameworks
  - (Loosely) Coupled Aggregate Managers (AM)
    - MyPLC
    - OpenFlow/SDN AMs, the NREN experience – US NDDI, EU GN3 OF Testbed
    - Bandwidth on Demand Brokers, OSCARS (Internet2/ESNet), AutoBAHN (GÉANT)
  - Federated AAI: SFA, EduGAIN... → Slice management, generic SFA wrappers
- **Some areas of concerted experiments**
  - Interoperability across continents (AAA, orchestration of SDN & BoD AMs)
  - Monitoring across virtualized domains (tools, views), perfSONAR extensions
  - Global roaming, VM mobility, data-center backup, green issues
  - CDNs, HD video multicasting
  - Hierarchical wired/wireless platforms, autonomic architectures...



- **Role of NRENs in FI R&D**

- Capacity providers & technology brokers
- US: Internet2/NLR + Indiana University + Stanford → NDDI
- Europe: FEDERICA, GÉANT Network Factory + OpenFlow Testbed
- APAN: NICT/JGN2, KOREN, CERNET etc.
- Latin America: RedCLARA, RNP....
- Inter-domain Control Protocols (IDC) → OF/SDN?
- Aggregate Managers to complement e2e SDNs (AMs for OSCARS, AutoBAHN...)
- Use OpenFlow controllers and AMs for user-programmable SDNs; and special purpose (layer 2++) closed network (cyber) communities?

- **Synergy with PPP's?**

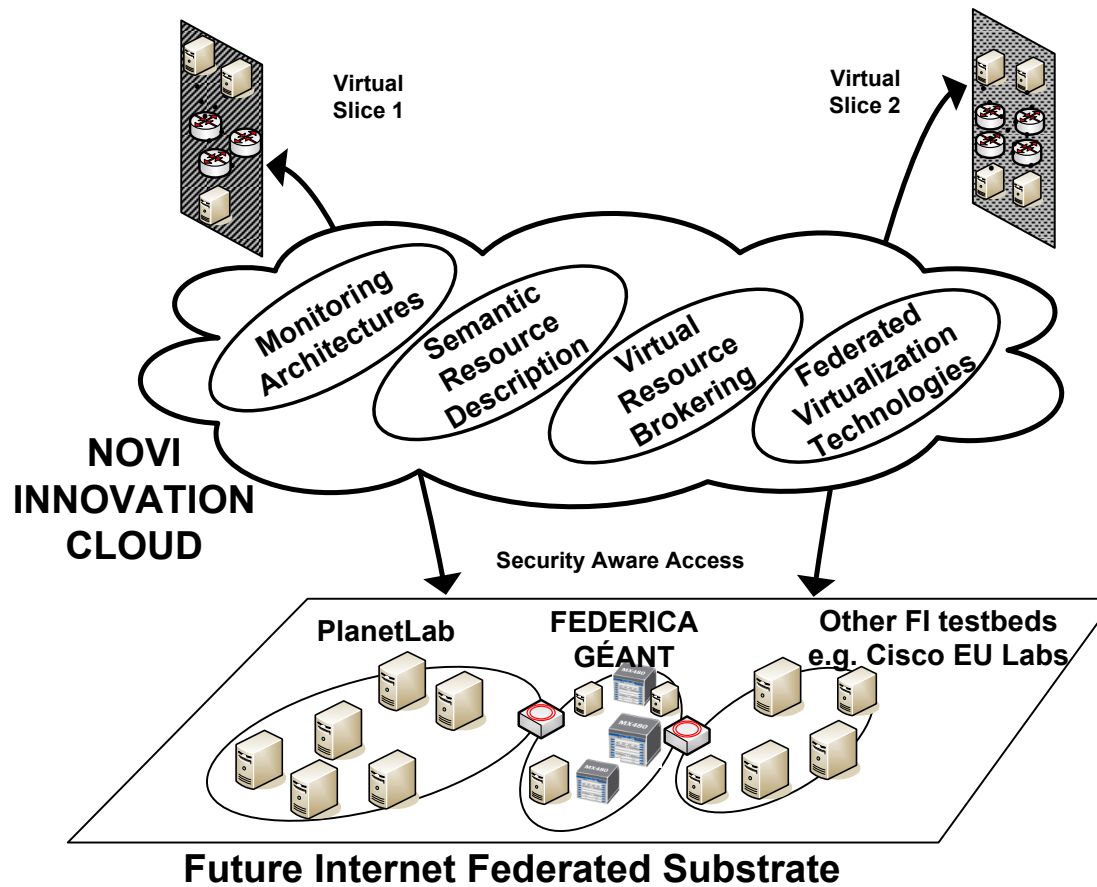
- US Ignite, EU FI PPP & Connecting Europe Facility, Smart Cities....
- Towards a FI globalization (or **blocked** by national interests and conflicting IPR/ownership legal mess across borders?)
- Pressure on all due to worsening economic conditions

# NOVI @ a glance

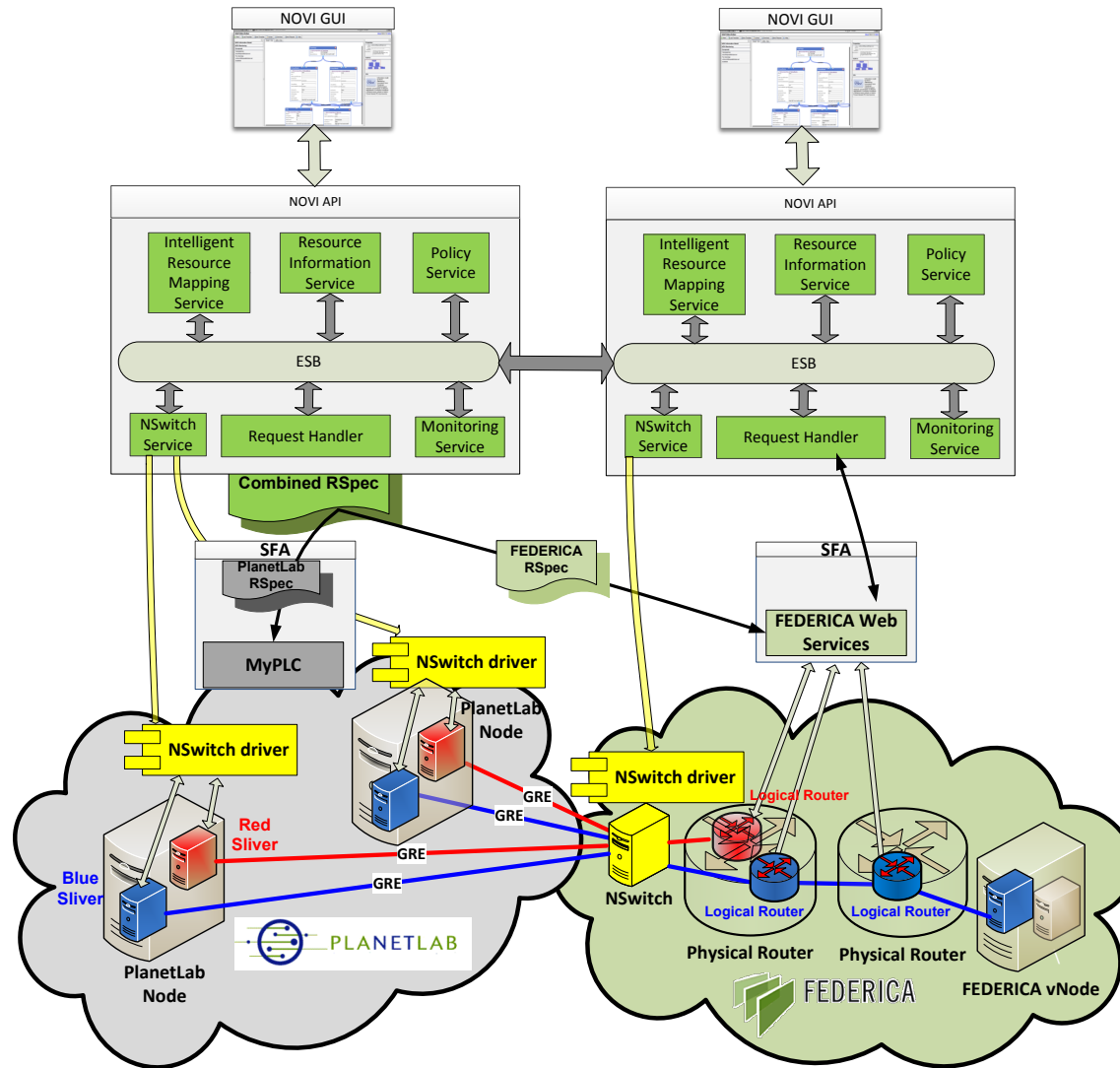
- **FIRE STREP Contract Number:** 257867
- **Start Date:** September 1<sup>st</sup> 2010
- **Duration:** 30 Months
- **Coordinator:** National Technical University of Athens (NTUA), Athens, Greece

***NOVI concentrates on methods, algorithms and information models that will enable users to compose and manage isolated concurrent slices, baskets of virtual resources and services provided by diverse yet federated Future Internet (FI) platforms.***

# The NOVI Innovation Cloud



# NOVI Federation Overview



# NOVI Services

Users (slice owners) of each testbed participating in a NOVI federation have access to the **NOVI Service Layer** consisting of:

- The **NOVI Application Programming Interface (API)**, the northbound interface to the NOVI Service Layer accepting user requests.
- The **Request Handler Service**, the southbound interface communicating with the virtualized testbeds via the GENI Slice-based Federation Architecture (SFA).
- The **Resource Information Service (RIS)**, used by all NOVI services to obtain information on resources described by ontologies of the NOVI Information and Data Models.
- The **Intelligent Resource Mapping (IRM)** Service, mapping user requests for virtual resources to the federated physical substrate topologies.
- The **Policy Service (PS)**, used to implement a role-based management system.
- The **NSwitch** enabling data plane connectivity between virtual resources belonging to different testbeds.
- The **Monitoring Service (MS)**, providing monitoring information for reserved slices or physical devices.

# The NOVI Consortium



UNIVERSITY OF AMSTERDAM

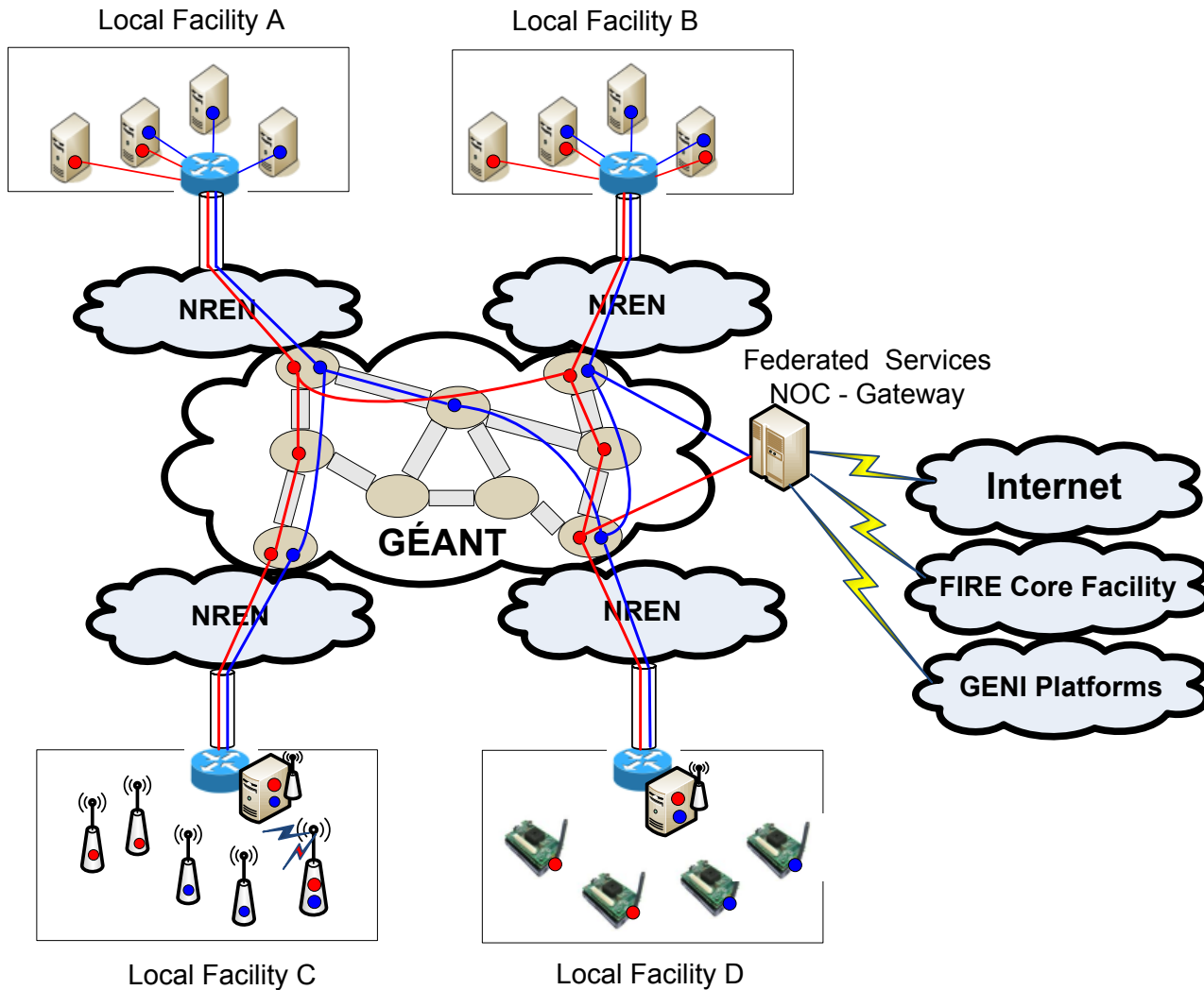




# NOVI Collaborations

- **EU:**
  - FIRE projects (FireStation, Fed4FIRE...)
  - e Infrastructures (GÉANT, FEDERICA, Mantychore...)
- **US:**
  - GENI (Renci)
  - Internet2, Indiana University (NDDI)
- **Korea:**
  - ETRI

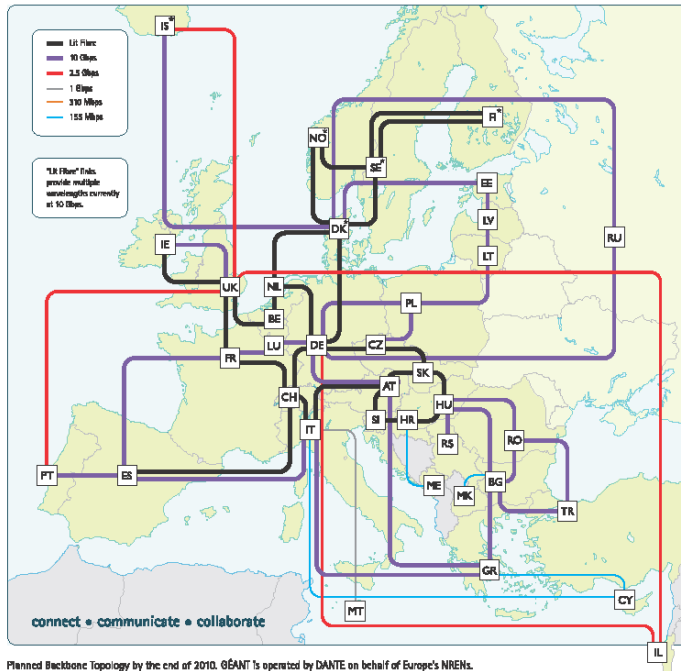
# Virtualization over GÉANT - NRENs



# The GÉANT Service Area



**GÉANT** the pan-European research and education network  
 Transforming the way users collaborate



DANTE  
 www.dante.net

GÉANT is co-funded by the European Commission within its 7th REID Framework Programme.

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European Commission  
 Information Society and Media

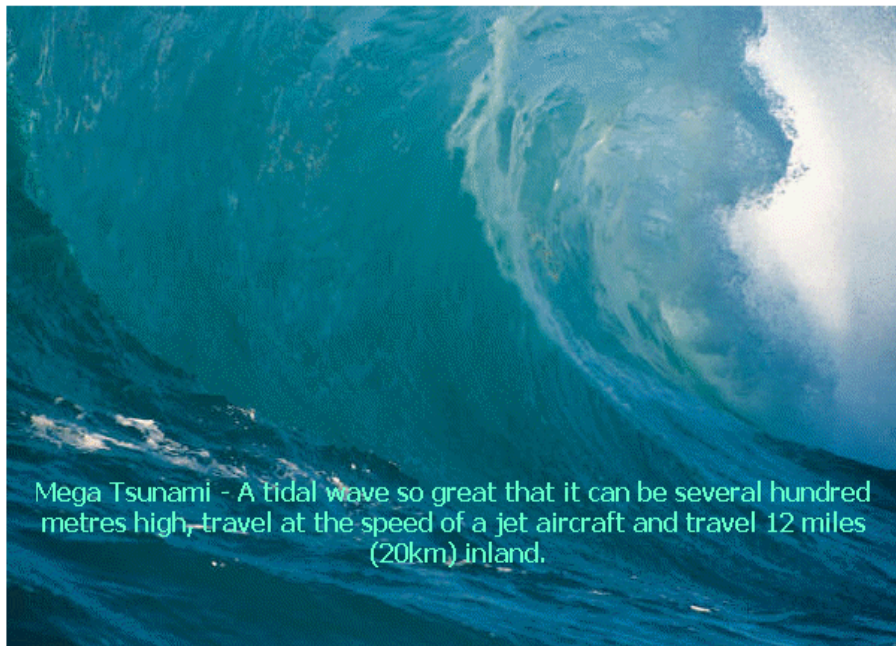


**GÉANT COST: 40 M€/year (equally shared by EC and NRENs)**

- Not just the GÉANT backbone
- Federated services via **37 NRENs** and **4000+ Campuses** to **50 M+ users**

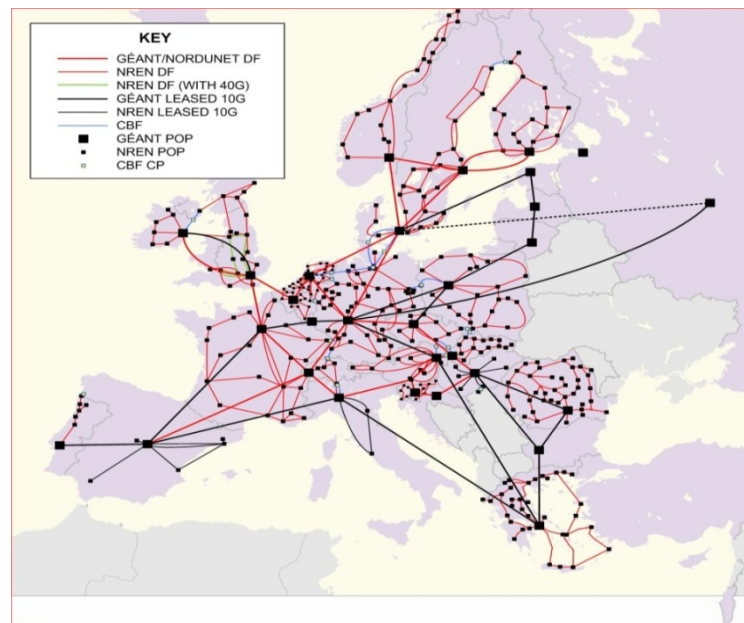
**Total European R&E Networking Cost: International (GÉANT) / National (NREN) / Campus Costs follow the 1/10/100 rule**

# The Key Challenge for NRENs - GÉANT: A Tsunami of Global High-End Requirements



Mega Tsunami - A tidal wave so great that it can be several hundred metres high, travel at the speed of a jet aircraft and travel 12 miles (20km) inland.










10 Gig+ NREN – GÉANT Footprint

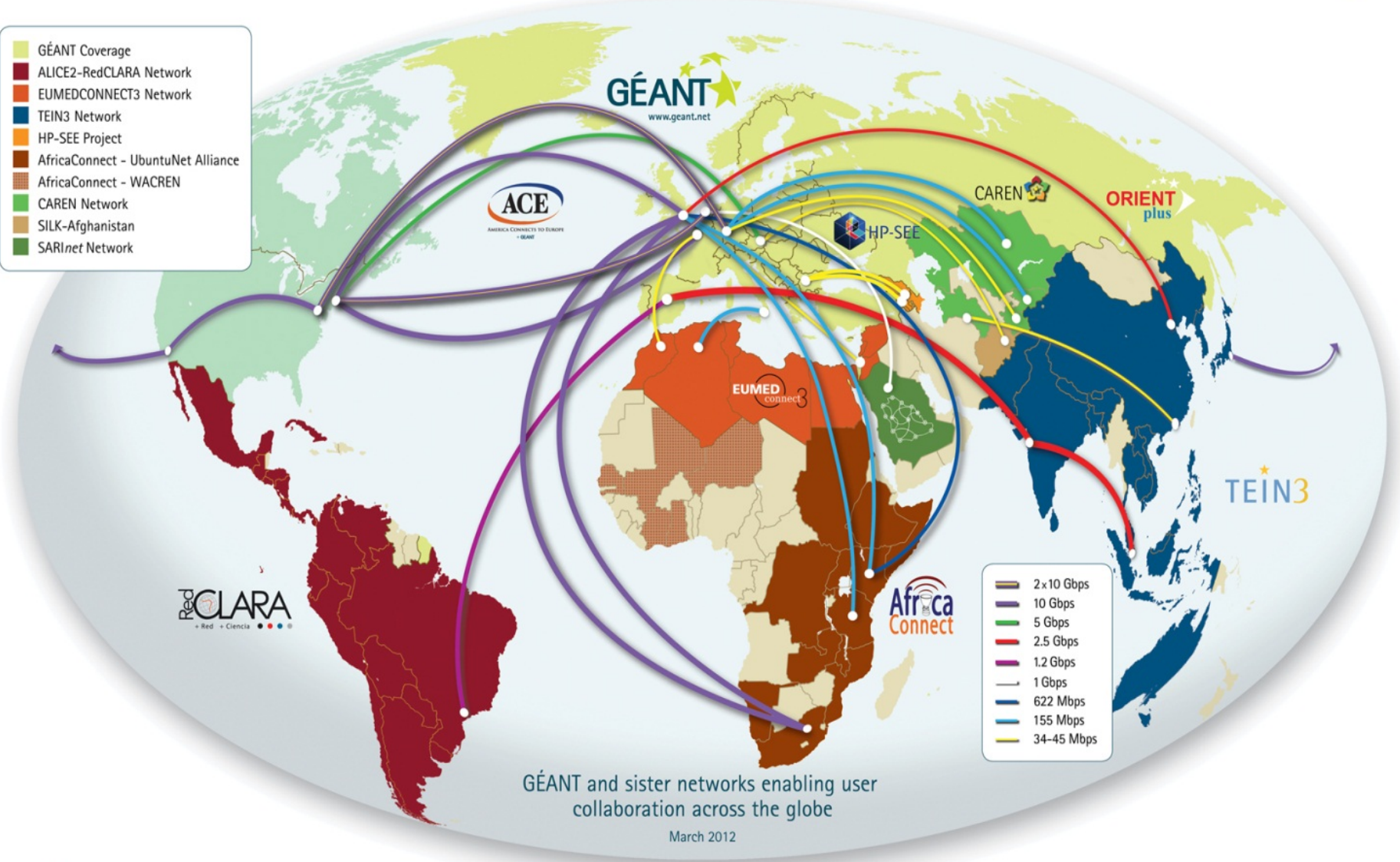











## High-End Users (HPC, CERN, ITER,...) require stable production services:

- Provisioning 10-40-100 Gbps networks (DWDM over dark fiber, leased  $\lambda$ )
- Meeting robustness, reliability, security requirements
- Enabling multi-domain e2e monitoring & on-demand hybrid resource allocation
- Managing converging e-infrastructures as a High Performance Computing & Networking (HPCN) Cloud → **Future Internet (FI) Services & Applications**

# GÉANT At the Heart of Global Research Networking

-  GÉANT Coverage
-  ALICE2-RedCLARA Network
-  EUMEDCONNECT3 Network
-  TEIN3 Network
-  HP-SEE Project
-  AfricaConnect - UbuntuNet Alliance
-  AfricaConnect - WACREN
-  CAREN Network
-  SILK-Afghanistan
-  SARInet Network



-  2x10 Gbps
-  10 Gbps
-  5 Gbps
-  2.5 Gbps
-  1.2 Gbps
-  1 Gbps
-  622 Mbps
-  155 Mbps
-  34-45 Mbps

connect • communicate • collaborate

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## Some Related Links

- **NOVI** (*N*etworking innovations *O*ver *V*irtualized *I*nfrastructures): <http://www.fp7-novi.eu/>
- **GÉANT**: <http://www.geant.net/pages/home.aspx>
- **FEDERICA** (*F*ederated *E*-infrastructures *D*edicated to *E*uropean *R*esearchers *I*nnovating on *C*omputing networking *A*rchitectures):  
<http://www.fp7-federica.eu/>
- **FIRE** (*F*uture *I*nternet *R*esearch & *E*xperimentation):  
<http://www.ict-fire.eu/home.html>