

Some Future Perspectives (Europe)

(Technical and Organizational)

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Network Technology

- **Bandwidth**
 - Bandwidth is not the major problem (within X-WIN up to $160 * 10$ Gb available), at least within the limited NREN-community
 - Probably 40 Gb per Lambda, but more (granularity)?
 - Bandwidth aggregation easier/cheaper with multiple Lambdas
 - Multi-casting
- **Hybrid Networks: Already now in use, increasing in future**
 - General Purpose Networking still with IP (IPv6 ??, since mid 90th)
 - VPNs for communities
 - Relative traffic in VPNs is increasing (especially due to GRIDs)
 - VPN-technology: Lambdas, not SDH etc.,
 - NRENs: Only Lambdas, Ethernet, IP - No ATM, SDH, etc
(Mass Market: Sub-Lambda Granularity)
 - Ubiquitous addressing at lower protocol levels + IPv6

- Need for network intelligence in Lambda-based VPN
 - Monitoring, Network Control, Control Plane
 - From NM to Signalling (static to dynamic)? GMPLS etc.?
 - Few dynamics in connectivity within NRENs? E.g. CERN-LHC-Grid
 - Problem of costs and complexity (Think of ATM).
 - Hybrid situation with NM and Signalling on e2e

- **Wireless Networking**
 - Only one technology, instead of WLAN, UMTS, etc.
 - Wireless instead of fixed line networks in many areas, maybe minor important for NRENs
- **Multi-Domain (a MUST in Europe)**
 - Multi-domain **Management** - e2e Provisioning (NM/Signalling ?), L1-Switching across domains
 - Scheduling, automated e2e set-up in near real-time
 - Coordination across domains with high-end user feedback
 - Coordination of Grid Resource Allocation, Monitoring & Control: NRENs, GÉANT2, Grids, Supercomputing Centers

User Perspective

- Expanding Grid communities. But: Needs more time than expected (not as easy as WWW). Integrate Distributed Computing (Grid) middleware functionality (robustness, simplicity, but (high) functionality)
- Increasing Issue: Security, PKI environments
 - Consolidate AAI (AAA) Architectures into federated schemes for global *e-Infrastructures*
- Virtualization at all levels
 - Network: L1 / L2 / L3 VPNs , Slices
 - Application level Overlays
 - Also in the Commercial and Mass Market (games)

- Raw Physics is not the major problem (Bw, Opto-Electronic, Switching, ...)

Faster solved than Problems in

- Control Plane, Middleware, User Environment

A European R&E Networking Model

- Interconnects **34 National Research & Education Networks-NRENs** of the extended European Research Area (ERA)
- Connects more than **3500 Research & Education (R&E) Institutions**
- Serves millions of end-users + **e-Science Projects** (e.g. GRIDs) under *Accepted Usage Policy (AUP)* rules
- The model: **A 3-tier Federal Architecture**, partially subsidized by National and EU Research & Education funds:
 - The Campus Network (LAN/MAN)
 - The NREN (MAN/WAN)
 - The Pan-European Interconnection: **GÉANT2** (GN2 in FP6): **Hybrid Optical Backbone (+ Cross Border Fibers)**
GN2 EC Subsidy < 10% of total European R&E Networking Cost
- **Governance:** NREN Policy Committee
- **Project Management:** GN2 Exec, DANTE

Business Model Issues for NRENs/GEANT

- *Long-term investment*, e.g. Dark Fiber leasing vs. IRUs ?
- From a hierarchical Pack.Swit. provision (aka. ISP tier1 → tier2) to a PS/CS Hybrid network with cross border fiber provisions (more meshing): *Management, Control, Cost Sharing*
- User community: Inclusion of schools, public libraries ... e-Government. Market competition & regulatory issues ? (*SERENATE study*)
- Security & AAA harmonization – *legal issues Europe*
- *Governance structure in Europe*
 - NREN PC sets policy & forges unity of 34+ NRENs
 - Executive Committee guides detailed project roll-out
 - Roles of DANTE & TERENA