

# EARNEST Study Findings

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« networking the networkers »



**UNI•C**



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# What is EARNEST?

- A foresight study inside the GN2-project
- Acronym for the full title: Education And Research Networking Evolution Study
- Led by TERENA
- Contributions also from DANTE, The European Science Foundation (ESF) and EUNIS, European UNiversity Information Services
- Steered by a panel of study area leaders covering 7 areas



# The 7 study areas of EARNEST



- Researchers' requirements (led by ESF)
- Other users (including primary and secondary education)
- Campus issues (led by EUNIS)
- Geographic issues
- Economic and regulatory issues (led by DANTE)
- Organizational and governance issues
- Technical developments





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# What are the goals?

- To provide inputs for new initiatives keeping Europe at the research and education networking forefront and enhance the competitiveness of the European Research Area
- To provide evidence of the impact on research that advanced networking has had in recent years
- To look at the development of the digital divide issues pointed out in the preceding foresight study, SERENATE
- To prepare the ground for further development after the completion of GÉANT2





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# Researchers' requirements

- In the first stage, the ESF carried out a large-scale survey to collect factual information as well as opinions from active researchers all over Europe
- Over 11500 contacts were provided by the ESF
- 4392 scientists responded
- The second stage was an in-depth investigation with interviewees drawn from the initial total pool based on their expertise, responses in stage 1 and willingness to take part in stage 2. This also focused on new ideas for the use of networks in the coming decade





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# Researchers' requirements

- A broad range of scientific disciplines were represented in the survey
- Access to digital libraries has had a very strong impact – and broadened the research fields of many participants, paving the way for new interdisciplinary collaboration
- Researchers are satisfied with the development in recent years– and also expect the future to bring new possibilities

Research area	Proportion
Social sciences	18%
Physics and related sciences	17%
Life sciences (incl. biology, biotechnology...)	16%
Environmental sciences (incl. earth sciences, marine sciences...)	14%
Humanities	9%
Medical sciences	6%
Chemistry and chemical engineering	6%
Mathematical sciences	6%
IT and computer science	5%
Materials science and mechanical engineering	4%



# Researchers' requirements

## - recommendations

- Europe should promote the virtual provision of services, including computing resources, storage services, data-repository services, collaborative tools and communication services
- Interoperability of services and facilities should be enhanced
- There is a need to upgrade and improve usage policies, security and quality control of data and information management
- There is a need for continuous training in the use of existing and upcoming tools through new media



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# Schools, healthcare, arts

- Primary and secondary schools need very safe, stable and easy-to-use services, including more "content"-services than universities
- The health sector has rigid demands on security and can benefit from the extensive know-how of NRENs in the advanced networking and security area
- University hospitals and health research have very demanding emerging applications like remote high-resolution radiology, bio-informatics linking genomic data to clinical diagnosis and treatment and remote robotic surgery
- The performing arts now experiment with remote interaction in concerts, master classes etc



# Geographic issues – are we REDI?



- The Geographic Issues Study (GIS) had the goal of producing an enhanced, concrete and structured method to measure the research and education networking development status in order to contribute to a deeper understanding of Digital Divide or Digital Inclusion challenges and Digital Opportunities – as well as to suggest ways to address these
- The GIS describes a process and a tool which can help quantify several elements related to the Digital Divide
- A set of computations eventually derives a convoluted Research and Education Development Index (REDI)





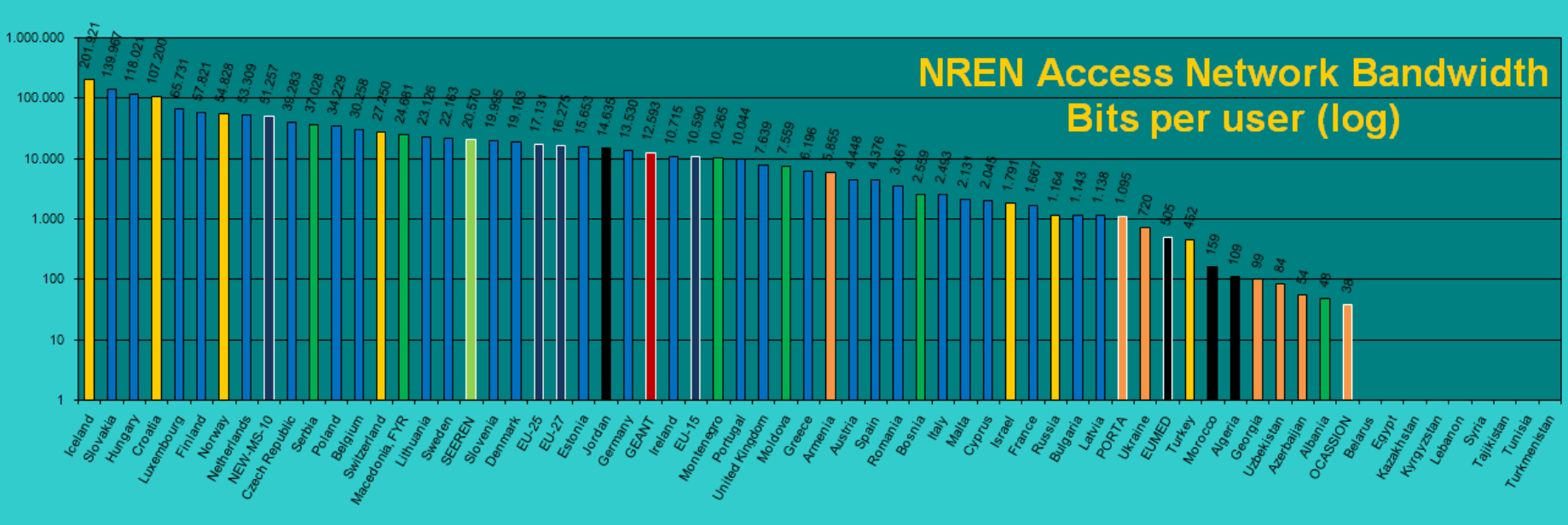
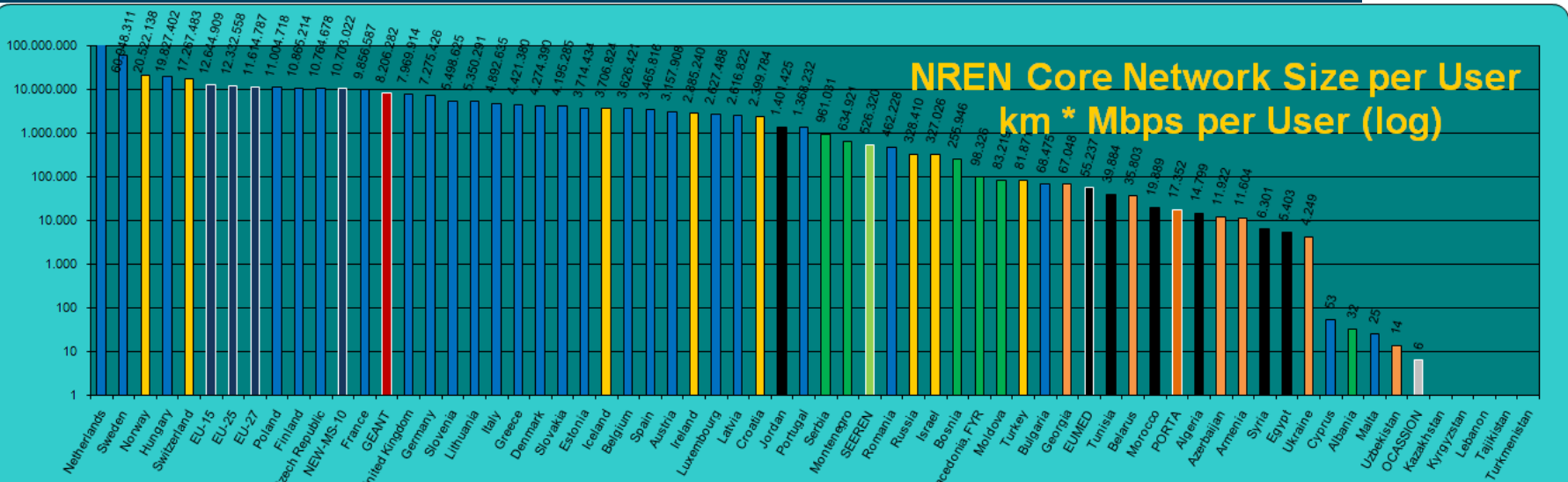
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# Steps for building REDI

- Following international best practice from well-known indices like the Digital Access Index (ITU), Network Readiness Index (WEF/INSEAD/InfoDev), etc, the REDI indicators are related to
  - Infrastructure
  - Usage
  - Affordability
  - Knowledge
  - Quality
- and REDI is then a weighted index based on the corresponding sub-indices



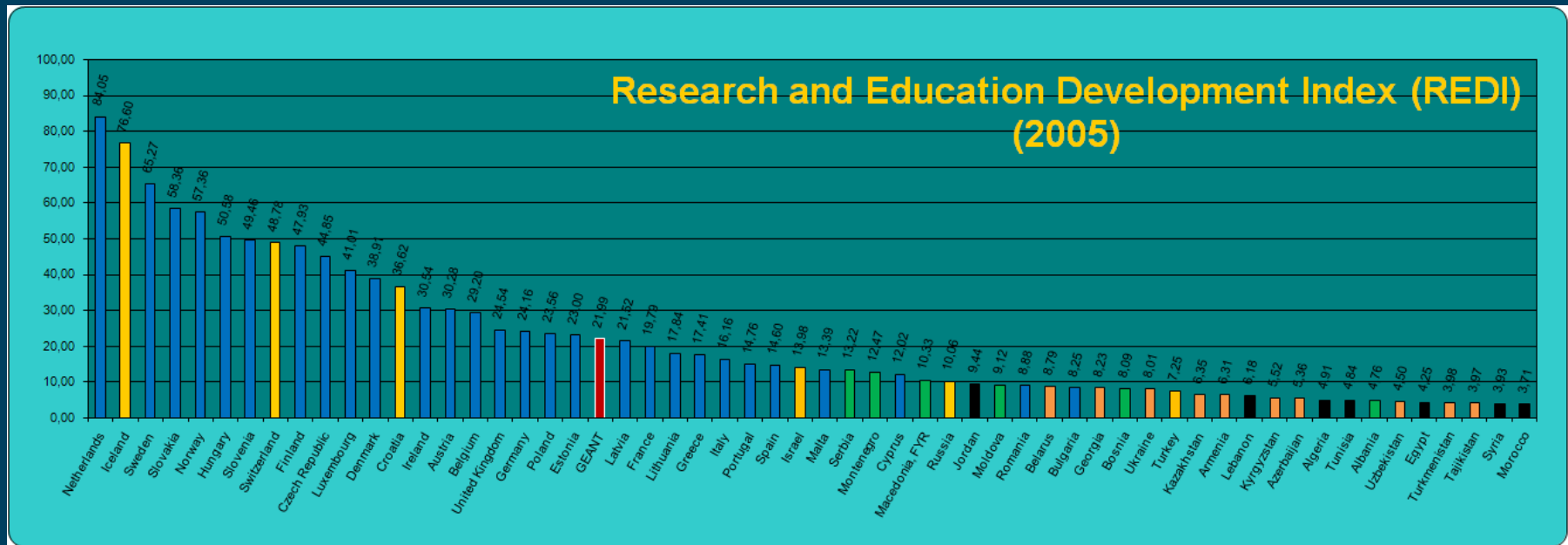
# Geographic issues: Core and access network



# Geographic Issues Study: REDI



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# REDI – a few words

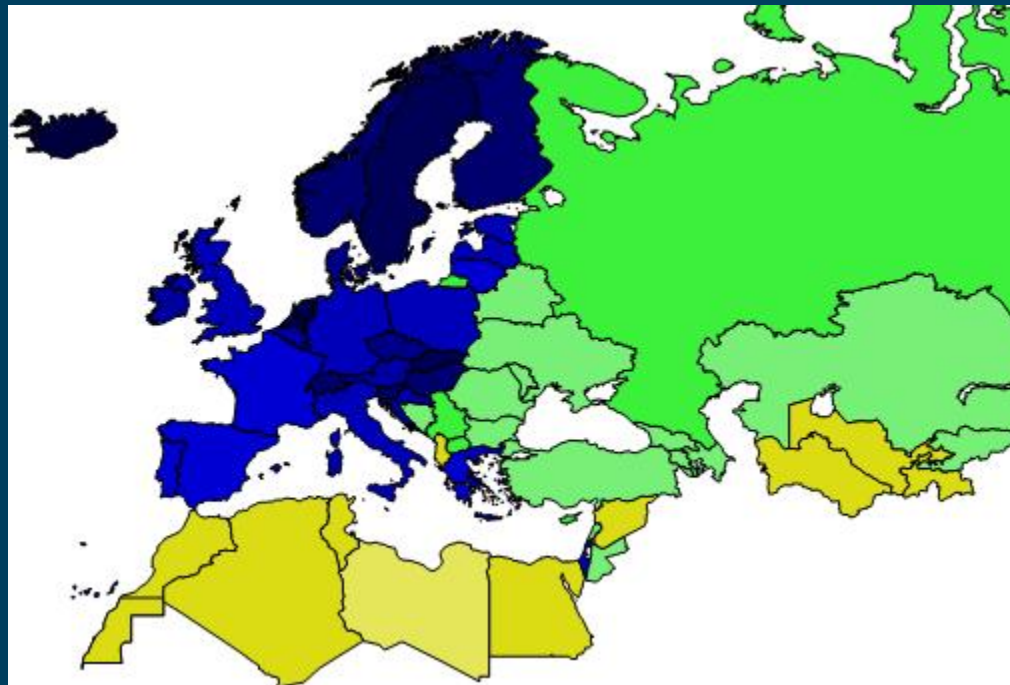
- The REDI convolutes 16 indicators that manifest the digital divide
  - due to infrastructural, social, economic, educational, regulatory and other causes, including but not limited to, unavailability of, difficulty in accessing, unawareness of the availability and/or capabilities of, lack of understanding of how to access and/or use digital resources and technologies
- The “usual suspects” for the digital divide existence and/or widening, include
  - limited budgets, relatively uncompetitive telecommunication markets, uncertainty of subsequent phases of planning and support, ineffective NREN management structure, etc.
- There are certain aspects of the national and regional development plans that if they remain unattended will limit the prospect of digital inclusion for the regions that are still lagging behind.



# REDI -map



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# Geographic Issues Study - selected recommendations



- Energetic measures should be taken to reduce the digital divide in Europe, both inside countries and between them
- The European Commission should monitor annually the state of the digital divide between the EU's research and education communities, also including the neighbouring countries. The monitoring should cover the availability and cost of Gigabit communication services and the functionality and performance offered by the various national research and education networks
- Structural funds should be seen as a possible source of finance for investments in research and education networks





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# Economic issues

- The cost of connectivity remains the most significant cost in the operation of the pan-European research network GÉANT2. Unlike other costs (hardware investment and operations), connectivity costs have a significant geographic element
- Historically, when international connectivity in Europe was monopolistic, there was no geographic element to the cost
- Today, both leased connections and "lit fibres" give pricing differences between those countries placed in the centre of the GÉANT2 network and those placed at the "edges".
- This "geographic divide" demands attention. Countries should be encouraged to facilitate investments in international fibres which can be made available to public sector users





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# Technical Issues

- Four main areas of study:
- Transmission technologies
- Control Plane and Routing Technologies
- Operation and performance issues
- Middleware



# Technical challenges - "faster or fatter 1"



- R&E networks have traditionally run best-effort IP service, but dark fibre is becoming increasingly available.
- WDM techniques allow multiple channels to be broadcast over single fibre.
  - Up to 160 channels at 10 Gbps per fibre.
  - 40 Gbps over more limited number of channels, with 100 Gbps promised by 2011.
- Problems with WDM:
  - More complex to manage, especially as more wavelengths added.
  - Trade-off between line rates and number of channels due to interference.
  - Higher line rates are more susceptible to signal degradation over longer distances.
  - Typically premiums charged for highest speed interfaces, so multiple lower-speed interfaces may be more cost-effective.
  - Lower capacity channels cause problems for very large data flows, and concatenating several channels is limited by capabilities of transmission equipment. Also problematic to split time-sensitive applications over more channels.



# Faster or fatter 2: how to provide increased bandwidth?



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- Vendors see much less scope in increasing number of wavelengths that can be supported on single fibre (~80), and now focusing on faster line speeds.
- Most R&E networks have yet to fully exploit WDM, and tend to prefer to upgrade line speeds.
- Are WDM systems cost-effective for needs of R&E networks?
- Is WDM needed for running IP-only services?
- With uncertainty of availability of 100 Gbps, will  $n \times 10$  or 40 Gbps be sufficient until 2011 or so?



# Improved management and monitoring at layers 1 and 2



- R&E networks have lot of experience working with Layers 3 and above as they have run IP services for years..
- With availability of dark fibre, R&E networks increasingly become responsible for Layers 0-2.
- SDH complex to manage, whilst Ethernet currently lacks many OAM&P features that makes fault tracing and circuit restoration difficult.
- Fewer tools available for configuration and operation of lower layers.
- EARNEST study revealed general lack of knowledge of Layer 1 and 2 management and monitoring techniques.
- Recommendations:
  - Improve knowledge transfer.
  - Organise training.
  - Support development of easy-to-use and affordable tools (e.g. TL1 Toolkit, NDL)



## Security policies that facilitate end-to-end connectivity and do not hinder innovative use



- Experience of end-users does not always live-up to potential of gigabit networks.
  - Impaired performance, things just don't work, or other problems
  - Backbone operator often blamed, even though operational experience shows majority of problems can be traced to end-sites.
- Middleboxes (e.g. firewalls, NATs, caching devices) have become increasingly common as convenient solutions to network management problems
  - Can introduce problems though – because of intrinsic architecture (e.g NATs), intended behaviour (e.g. firewalls blocking certain traffic), or misconfiguration.
  - Time needs to be spent troubleshooting problems.
  - Measures can prevent innovative use of network by new applications or protocols.
  - Can encourage circumvention of policies by encapsulation of prohibited or restricted traffic.
  - Devices that are supposed to help manage and secure network, can often end-up making things more complicated and insecure.



## Security policies that facilitate end-to-end connectivity and do not hinder innovative use of the network (cont...)



- Unrealistic to expect certain types of middleboxes and software configurations (particularly firewalls) to disappear anytime soon, as they can be good solution when carefully managed.
- But.. some consideration should be given to improving network transparency between core and edge/campus networks.
  - Use of protocols that better support NAT traversal (e.g. STUN and ICE).
  - Establishing secure connections between trusted hosts.
  - Dynamic management of middleboxes by trusted third-parties (e.g. using MIDCOM or SIMCO).
  - Designating certain hosts within institutions as 'sandboxes' for experimentation.
  - Moving middleboxes closer to end-hosts.
  - Undertaking middlebox functionality on end-hosts themselves.
- Must be recognised that networks themselves cannot ensure security.
  - Enforcement of security of traffic policies must happen at campus level.
  - R&E networks should aim to transparently transport traffic originating from directly connected sites or peered networks with similar AUPs.
  - May be necessary or desirable to prioritise certain classes of traffic, but only for engineering reasons.
  - Higher levels of filtering and firewalling that aim to enhance security must be weighted against resulting reduction in innovation capabilities.





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## Further evolution of PERT service for improving end-to-end services

- R&E networks offering ever-increasing amounts of bandwidth, but users sometimes unable to exploit this due to problems in network or end-hosts.
  - Difficult for users to identify and resolve themselves.
  - Sometimes accept degraded performance as being 'normal'.
- Vast majority of cases attributable to end-sites.
  - Non-optimised hardware or software.
  - Misconfiguration.
  - Enforcement of security or traffic policies.
- Other known issues.
  - TCP transmission problems over long-distance links.
  - Bottlenecks in network due to routing.
- To trace problems, often necessary to liaise with two or more organisations.



## Further evolution of PERT service for improving end-to-end services (continued)

- PERT team established within GN2 project to investigate reports from end-users.
  - Uses variety of diagnostic tools to trace problems.
  - Contacts responsible organisations to try to resolve problems.
  - Has resolved most reported problems.
  - Demonstrated that few problems actually attributable to backbone networks.
- Current PERT limited in scope and effort.
  - Lacks well established relationships with end-sites or users.
  - Cases tend to reach PERT through lengthy chains-of-referral, if at all.
  - Multi-domain nature of most end-to-end problems requires access to systems at end-sites, and/or information from intermediate networks.
- Consideration should be given to extending PERT concept to NRENs, and possibly to the regional and campus level as well.
  - Initially a nominated contact in existing NOC.
  - Establishment of standard operating procedures, knowledge base, and central ticketing system.

## Authorisation and Authentication Infrastructures to be better integrated and more widely utilised



- Researchers increasingly work on joint activities in different places, forming virtual organisations to share resources.
- Needs to be mechanisms to authenticate users and assign access privileges.
- Difficult for users to remember multiple credentials.
- AAls establish trust relationships between institutions, and allow users to use resources at other institutions after being authenticated by their parent institute.
- Recommendations:
  - NRENs should put AAls in place if they have not already done so.
  - R&E community should focus on harmonisation of AAI standards to improve interoperability and management.
  - Also look at mechanisms for communicating identity data to applications, as no well-established standard yet.



# Campus issues - selected recommendations



- Provision for a well-resourced network support team
- Rules for network security
- Aggressive replacement policies
- Provide support and training for performance optimisation
- Adopt security measures appropriate for purpose – that do not hinder effective use of the network
- Establish formal procedures to identify end-user requirements
- Circulate very clear AUP to all end-users
- Establish strong, formalized arrangements for collaboration with NRENs and other relevant institutions



# Organisational and governance issues



- NRENs have very different structures – there is no “one size fits all” – but key stakeholders should always be represented in the governance bodies
- NRENs should have multi-annual budgets, since they have to make long-term investments
- End-users should be kept aware of the infrastructure possibilities, so that plans for separate dedicated networks for special purposes are avoided
- The European Commission should continue to provide funding for GÉANT and provide further support to develop policies for the development of end-to-end services
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