



The SERENATE Project
- strategic choices for
R&E networking in Europe

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OUTLINE

SERENATE has generated lots of material – and I cannot cover everything

This is definitely not all my own work. Almost all from colleagues on the SERENATE Steering Committee, from many NRENs and others



Talk outline

- What SERENATE is all about
- Present situation of R&E networking in Europe
- The evolution of user requirements
- Technical developments
- Economic and regulatory developments – the new complexity
- The “digital divide” inside R&E networking in “Europe”
- Local connectivity
- Future structure and organisation of R&E networking in Europe
- [Other countries and regions]
- Recommendations
- Wrap-up



WHAT IS SERENATE ABOUT?



SERENATE outline

- SERENATE is a strategic study into the evolution of European research and education networking over the next 5-10 years.
- The idea is not to design any specific network, but rather to look at the situation in which all actors involved in R&E networking find themselves today, **to consider the likely technical, commercial and political evolution over the next few years, and to formulate recommendations of general applicability.**
- SERENATE is a project funded under the Information Society Technologies element of the European Union's Fifth Framework Programme, and the project partners are AE, CTI, DANTE, ESF and TERENA
- It has generated a mass of very interesting information, which can be accessed via www.serenate.org
- Our job now is to use this information **to prepare a clear overview and set of recommendations**



Steering Committee

- Bonač - ARNES – “geographic” issues
- Butterworth - AE – “research users”
- Davies - DANTE – “technical”
- Jaume - RENATER – “other users”
- [Liello - chair NREN Consortium]
- Mayer - ESF
- Skouby - CTI – “economics”
- Vietsch - TERENA
- Williams



Working methods

- Five workshops
 - Initial and Final
 - Operators
 - Users
 - NRENs
- Multiple work packages
- Deliverables – several serious reports - on the Web site www.serenate.org



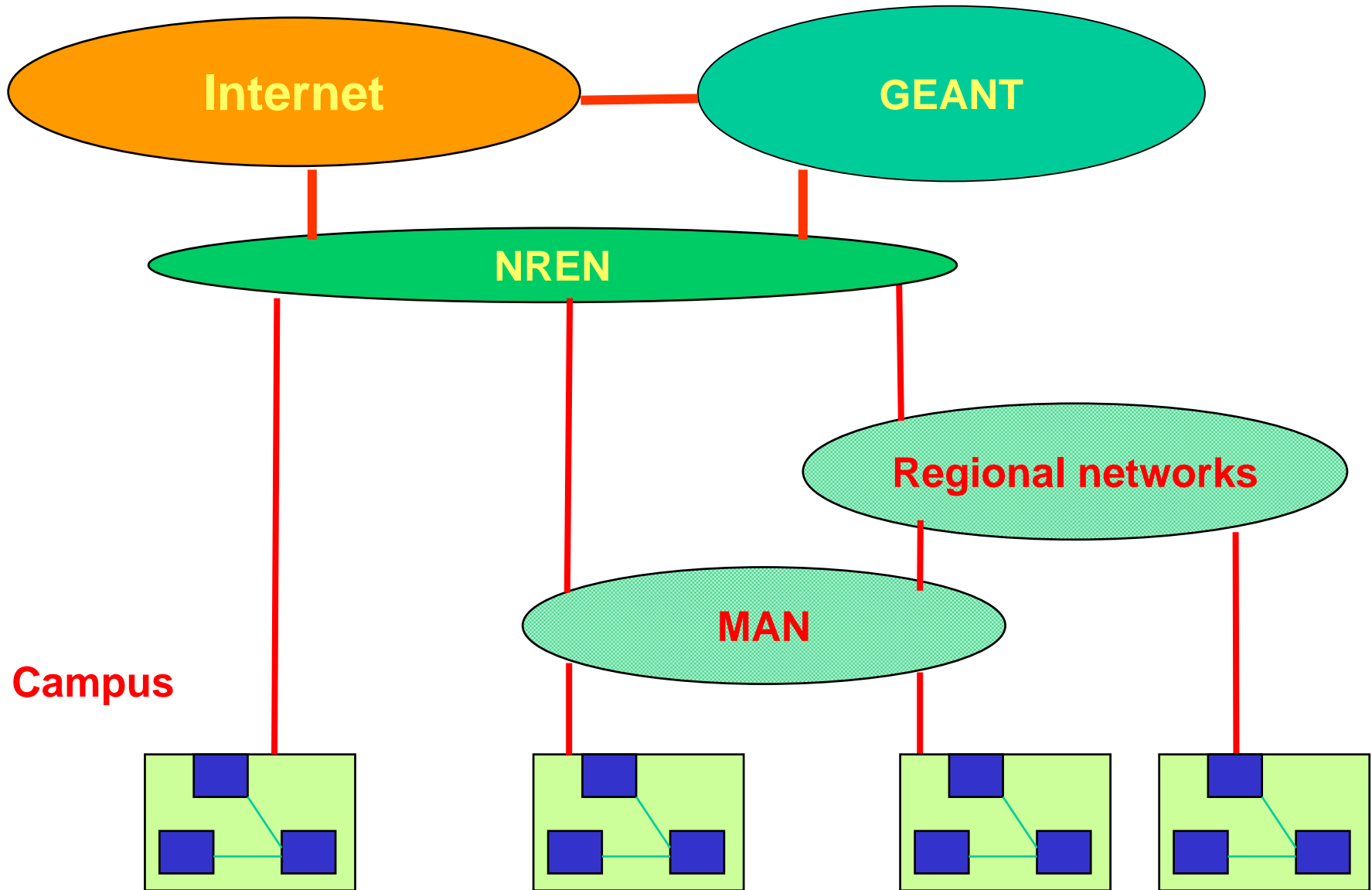
THE PRESENT STRUCTURE AND ORGANISATION OF RESEARCH AND EDUCATION NETWORKING IN EUROPE



Multiple levels

- Campus
 - (MAN and regional)
 - National
 - European and International
-
- ALL RUN BY DIFFERENT ORGANISATIONS!
 - Many different organisations even for a “normal” R&E connection





Typical NRENs

- Structure
 - A separate organisation, more or less at arms-length from government, reporting to appointed management board
 - You can find lots of detailed status information in the annual TERENA Compendium (www.terena.nl/compendium)
- Funding
 - Typically mixed – most from user population, some from government – for special missions
 - No charge to individual at point of user. Typical end-user cost is <25€/yr.
 - GÉANT cost shared according to subscribed bandwidth, but without looking at what local bandwidth costs. Smooths out heavy price variations.
- User communities
 - Originally teachers, students and researchers at universities and research centres. Extended to ~all education in some countries during 1990s.
- AUPs
 - NRENs have a dedicated mission and do not want to compete with ISPs



NREN goals and objectives

- Serve users
 - Deliver “high quality” networking
 - Cost effective; Reliable; Very advanced (when needed);
 - Everywhere to everywhere; Well-supported; Well-integrated with national R&E communities
- [Provide support European Research Area]
 - GEANT directly connects 30+ countries
 - Cutting edge of real ERA
- Network as infrastructure
 - Always working – user doesn’t need to think about it
- [Technical innovation and feed-through to society and industry]
 - The government may not always understand that this is important



THE EVOLUTION OF USER REQUIREMENTS



Basis of the user questionnaire (total = 490+)

Disciplines	Respondents (%)
Mathematical sciences	4
Physics and related sciences	20
Chemistry & Chemical engineering	8
Materials science & Mechanical engineering	4
Environmental sciences	11
Computer sciences & related	6
Life sciences	19
Medical sciences	6
Social sciences	14
Humanities	8



Just some of the usages ...

- *Collaboration tools, remote control of databases / large repositories, interactive multi media projects and distributed Virtual Reality (VR in Design)*
- *Molecular Dynamics and Structural Analysis (Proteomics)*
- *The internet to access structural and sequence databases, as well as remote access tools (Protein Modelling)*
- *Remote control of bioreactors by Active-X internet applications. (Environmental Biotechnology)*
- *Modelling of buildings, including 3D CAD and the effect of fire, CFD. Streaming video of collaborative experiments (Building Research)*
- *The data of the main research project is collected in Kazakhstan, then sent to Italy, where it is processed (Human biology)*
- *Passing around MPEG movies of around 100MB. These movies are transferred to different sites for analysis. (Linguistics)*
- *Setting up an international database for analysis of DNA-fingerprints including submission of data and on-line search and analysis of data. (Epidemiology)*
- *Remote control of instruments. (Forest Ecology)*
- *Computer aided surgery*
- *Art history*



What do the users want (1/2)?

- Networking which is **cheap, reliable, technically up-to-date and easy to use.**
- **Complexity should be hidden** as much as possible.
- **Mobility** – good access from any random stationary location is much more important than access while moving.
- **To handle growing volumes of data.** GEANT long-term trend-line is 2.6x more per year. That's 80x in 5 years, more than 6000x per decade. The implication is that Terabits per second (**Tbps**) networking will be “everywhere” by the end of the decade
- **To gain access** via GE, 10GE interfaces and to send data at those speeds to the ends of the Earth
- Support services are needed to fix any problems of **end-to-end performance.**



What do the users want (2/2)?

- **No charging at point-of-use.** However, it is possible that, after the technology has stabilised, marginal cost charging for infrastructure would be useful for very advanced services (grid links might be one example)
- Support for **video-conferencing services**, and in general for **integrated IP communications**?
- How big is the pressure for **distance learning** via NRENs? We suspect that it should be very large, but we don't see as coherent an interest as we expect.
- **Advanced applications (grids** – allowing communities to share IT resources, **virtual presence, ...)** and **services** which will enable new ways of working. This will require **improved relations between NRENs and academic IT communities** and service providers.
- **Guidance** on likely future developments



Users' dreams - when asked what could they do with 10x, 100x more bandwidth

- *Could really develop proper European Earth System Models.*
- *Online, real-time modelling of ecosystem-atmosphere gas-exchange.*
- *Possibility of ensemble ecosystem simulation by grid. On line collaborative data mining of simulated complex systems (such as ecosystems) using 3D visualization.*
- *Ability to respond to Targets of Opportunity (e.g. supernova)*
- *If we had 100 Gbit/s we would truly be able to interconnect our computing centres around the globe as if they were "tightly connected" resources and our computing paradigm would change.*
- *Slow internet contacts at the moment stop us from having full collaborations with European researchers. An order of magnitude improvement on network speeds would allow a fully interactive research with the whole European network, adding everybody expertise to the experiment. It would be a new way of working all together.*
- *The ability to count marine animals optically and transfer the data, would revolutionize fishery management.*



Further user needs

- Heavy applications
 - Grids are one obvious area, but not just grids. Also immersive VR, transmission of very high quality images, remote collaboration with multiple participants (such as Access Grid)
 - These flows can be 100x, 1000x “traditional”
- Everyone, everywhere needs advanced networking
 - Not just “hard” sciences – all across the board
- End-to-end approach to services
 - The users shouldn’t need to know about the organisational complexity
- Collaboration with more “exotic” locations



User needs - summary

- In **ALL** countries and in **ALL** disciplines researchers are eagerly anticipating improved networking tools. There is **NO DIVIDE** on the **demand** side!



IMPORTANT TECHNICAL DEVELOPMENTS



From electrical to optical transmission

- Is this a fundamental evolution – YES
- Is this situation likely to reverse quickly – NO
- What are the likely impacts?
 - This is a major technical driver (more accurately, enabler) for reducing costs and increasing bandwidth at constant cost (by improving fibres, lasers and receivers)
 - On a multi-year timescale, **move towards optical switching**
 - Evolution towards **hybrid NREN networks (and GÉANT)**, with general Internet use (many-to-many) via classical packet switching and specialised high-speed traffic (few-to-few) via optical paths? Even end-to-end paths??
- **Direct access to fibre** likely to become a critical resource for NRENs



Higher speeds and more powerful routers

- 40 Gbps transmission doesn't seem likely to be coming very soon
- It's ready in the labs but no good business case yet
- Doesn't seem to be a problem for us in the short term
- Maybe linked to more powerful router status
- Implementations for next generation routers seem feasible, but probably more efficient to keep large long-term flows away from routers



Wireless

- Growing usefulness of 802.11b and 802.11g (Wi-Fi)
- Eventual merge with mobile telephony?
- Will increase the importance of AAI (forward reference)



Protocols etc.

- In Europe it is clear that we are about to deploy IPv6 on a broad scale.
- And that multicast protocols should be really supported across the end-to-end spectrum – but that simple statement probably hides a whole can of worms.



AAA services

- Technology evolution concerns more than just hardware
- We need improved techniques (not just password/login) to Authenticate our users, to Authorise them to use various services, and to Account for the resources that they use = AAA
- The ideas have been around for several years, but **deploying them in production needs a lot of coordination**
- First inside a campus, then inside all the campuses in each country
- And then we should worry about pan-European and global inter-working!



ECONOMIC AND REGULATORY DEVELOPMENTS – THE NEW COMPLEXITY



From bundled to unbundled communications services

- Over the past ~5 years we have moved from mainly electrical to mainly optical transmission over the wide area
- That technical change has been accompanied by an unbundling, induced by a combination of regulatory and commercial changes
- That exposes the cost of the components of what used to be a single bundled service
 - Access to optical fibre infrastructure
 - Deployment of transmission equipment (including amplifiers and regenerators)
 - Handling of back-up in case of break of service
 - Operation
- While NRENs have no strong interest to become responsible for these services themselves, they must understand the costs, to make sure that they take a reasonable economic approach



Regulatory “freedom”

- In principle on 25 July 2003 the new (2003) EU regulatory framework for electronic communications infrastructure and associated services entered into force in all countries of the EU-15.
- That replaces prior licensing of operators by registration with the national regulator
- Permits NRENs and any other organisation to operate their own infrastructure, including construction – if that’s what you want to do.



The wide variety of service offerings

- In this new technical and regulatory situation, operators offer a wide variety of services
 - sale of optical fibre
 - long- and short-term lease of optical fibre
 - dark and/or managed fibre
 - leasing wavelengths
 - leasing SDH circuits



Different business models and sustainability

- Traditional telecoms operators
- Alternative infrastructure operators
- Wavelength operator(s)
- Which models will be sustainable over the medium-term??



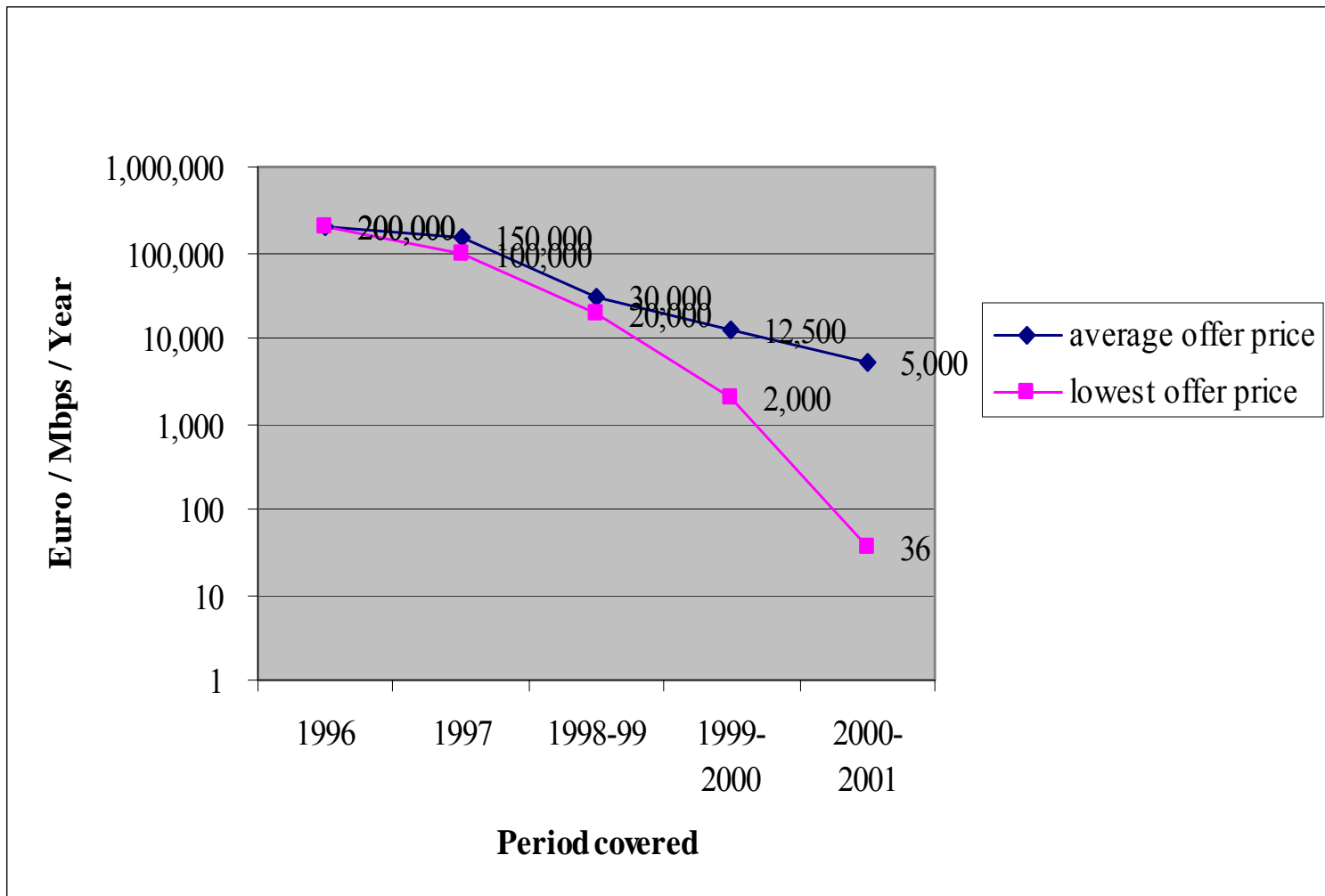
Getting more concrete with costs

- The 1996-2001 precipice
- 6000x cheaper in raw terms
- 300x cheaper after accounting for the larger circuits
- Some component of that was a “one-off” effect
- Introduced a major geographic spread of prices





Evolution of Market Competitiveness : International Intra-European Connectivity



Pricing is far from uniform – between countries

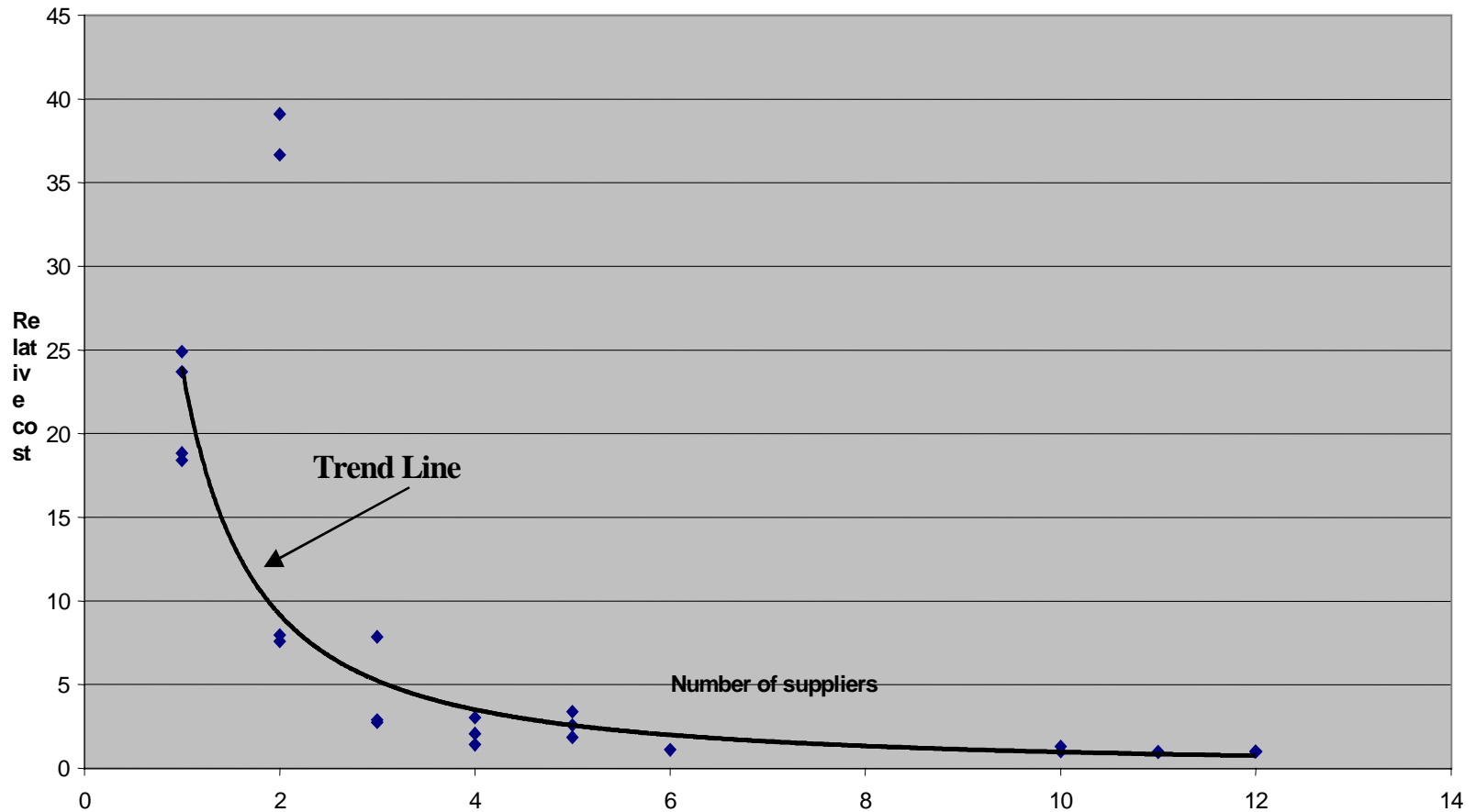


Table 2 International Connectivity Costs in the Differing Market Segments

Market segment	Number of Countries	Cost Range
Liberal Market with transparent pricing	8	1-1.4
Liberal Market with less transparent pricing structure	7	1.8-3.3
Emerging Market without transparent pricing	3	7.5-7.8
Traditional Monopolist market	9	18-39



Relative Cost of Connectivity Compared with Number of Suppliers



Pricing is far from uniform – inside countries

- Away from the big cities and the obvious main routes you can find “fibre deserts” even inside big well-served countries
- Gives very high pricing for high bandwidth (and sometimes, simple unavailability)
- It just depends where operators expect good returns on investment
- Brittany, Kent and Lancashire are all examples



More for equipment

- ~5 years ago NRENs typically spent <10% of their budgets on transmission equipment, routers and switches.
- Fraction going up steadily – now typically ~33%
- 10 Gbps routers have infrastructure measured in M€ and adding a new 10 Gbps connection measured in 100s of k€
- Another element of the push for hybrid architectures (move heavy traffic to switched optical routes)



Some typical European market prices [€/km/year]

PRELIMINARY DATA	
"Buying" 500 km dark fibre pair on a 15- or 20-year IRU	3000-7000 €/km is commonly quoted range. This corresponds to 200-500 €/km/year when amortised linearly over 15 years
Leasing 500 km dark fibre pair for 12 months	500-1000
Leasing 500 km 10 Gbps wavelength for 12 months	200 (very competitive) through 500 (more typical) to ??
Leasing 500 km 2.5 Gbps wavelength for 12 months	
Leasing 500 km 155 kbps SDH circuit for 12 months	



The GÉANT scenario

- At present GÉANT pays ~30 M€/year for all of its connectivity
- Of which roughly 14 M€ for 140 Gbps of wavelengths and 16 M€ for 3 Gbps of SDH capacity
- If it could buy all this connectivity at the price of the cheapest, the total connectivity bill would be less than 5 M€ per year

- SO – STILL A FACTOR 6 AVAILABLE
- THE IMPORTANCE OF INFRASTRUCTURE COMPETITION



Fair shares for fibre costs? OR

The transmission services market is very special

- An unusual market, and very hard to predict its evolution
- Huge boom in 2000 and 2001, many failures in 2002 – some now arising from the ashes.
- High capital expense (the first mover pays for the trenching!)
- Builders can adjust their capacity at trivial cost (installing extra fibre pairs is very cheap)
- If they build well (good access to the ducts) “owners” can increase their capacity at low cost.
- Poor understanding of the demand – which is very price sensitive.
- Unclear what “cost-related pricing” might mean – how many fibre pairs should the builder sell/lease before recuperating their investment? Depends on how competitive the route is. On highly specialised routes no sharing is possible. On very competitive routes – assumption of 10-15 users is standard.
- Risk that the trench owner becomes the new monopolist



ECONOMIC AND REGULATORY DEVELOPMENTS – THE NEW COMPLEXITY

The end of a long section

It is a complex issue to understand, and to try to explain



THE “DIGITAL DIVIDE” INSIDE EUROPEAN ACADEMIC AND RESEARCH NETWORKING

We are convinced that Europe does have a rather serious
internal Digital Divide →

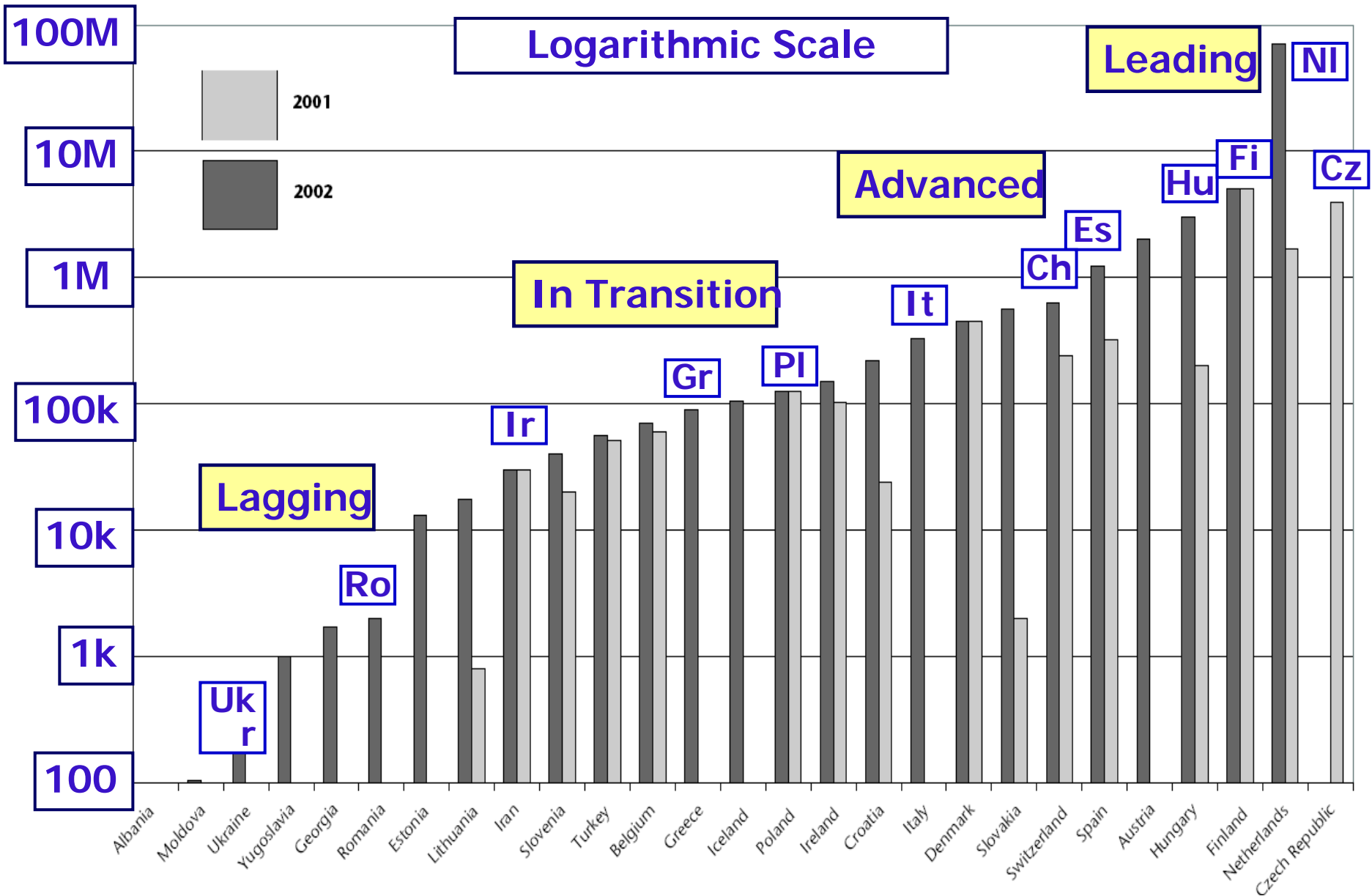


How can we be so sure?

- **ON AVERAGE** the 10 accession countries have NRENs with **4-6 times less backbone capacity** than NRENs in the EU-15 countries
- If we look at the NRENs in the EU-15 and compare their networks with those of the “next band” of countries (beyond the EU-25 plus BG plus RO plus TR) then we see that **ON AVERAGE** the “next band” have **20-30 times less capacity** than the EU-15
- In the most extreme case, Bosnia-Herzegovina and FYROM have **5,000 times less capacity than** each of the four most advanced countries (soon to be joined by several more).
- And Albania *de facto* does not yet have a research network



NREN Core Network Size (Mbps-km)



Tackling the DD will not be easy

- The best tell-tale indicator for DD problems is **excessively high pricing for connectivity**
- The fundamental cause is **lack of competition**, which in many cases is due either to an **out-of-date regulatory regime**, or to the **lack of political will to implement the (legislated) changes**. Especially this latter situation can be extremely frustrating for the NREN involved
- However lack of competition can sometimes be due to **essentially economic factors alone**. Infrastructure operators wish to make a profit in some reasonable period, and look to invest in locations where they think that there is a strong market. We have seen evidence of reluctance to invest in fibre infrastructure both in **small(ish) peripheral countries** without strong high-tech industry, but also in **remote regions of the most prosperous European countries**.



Actions required

- The Digital Divide inside Europe must be better measured and monitored
 - Availability + price of transmission & fibre infrastructure (~EU tracking)
 - What the NRENs are doing with it (~TERENA compendium)
 - Performance as seen by end-users (~SLAC/ICTP efforts)
 - A political discussion is needed concerning what we mean by “Europe” in this context
- This all appears to us to be the responsibility of the EC

Digital divide recommendations

- to the European Union, represented in this context principally by the European Commission and the European Parliament, that it needs to:-
- recognise that at the present time a “digital divide” exists among the research and education communities inside Europe
- take energetic measures to reduce and preferably eliminate this “digital divide”
- have various aspects of progress in that regard monitored on a regular basis until that is no longer necessary
- determine the approach to be adopted in the case of “neighbouring European” countries, those countries beyond the EU-25 plus candidate countries, where, even if they are neither EU members nor likely to be in the short term, EU policies and advice carry significant weight, and where the EU has political interests to ensure stability and to strengthen democracy. [T6]



DD (2)

- to the European Commission
- that it should accept to monitor annually the state of the “digital divide” among the EU member states, and hopefully also among the “neighbouring European” countries, and to report on progress. The main metrics must be (a) the availability and cost of key communications services and (b) the functionality and performance offered by the various NRENs. [S4]
- to the European Union, as represented by the European Commission and European Parliament,
- that the Annual Reports for accession countries should include a section dealing with the overall status of the NREN in that country, and the extent to which it meets the standards of NRENs in EU member states. [S5]



DD (3)

- to the European Union on the one hand and to the governments and NRENS of recently joined members of the Union and Accession States on the other hand
- that they should facilitate the use of Structural Funds to finance investments which could be used by NRENS, especially investments in communications infrastructure, such as optical fibre. [S6]
- to national governments, and particularly to the governments of small countries and of countries that may find themselves temporarily on the “wrong” side of the “digital divide”,
- that they must pay particular attention to the need to establish a really effective national regulator as an important element in ensuring that a competitive national market in communications and network services can be created. [S7]



Second Open Round Table on

Developing Countries Access to Scientific Knowledge:

Quantifying the Digital Divide

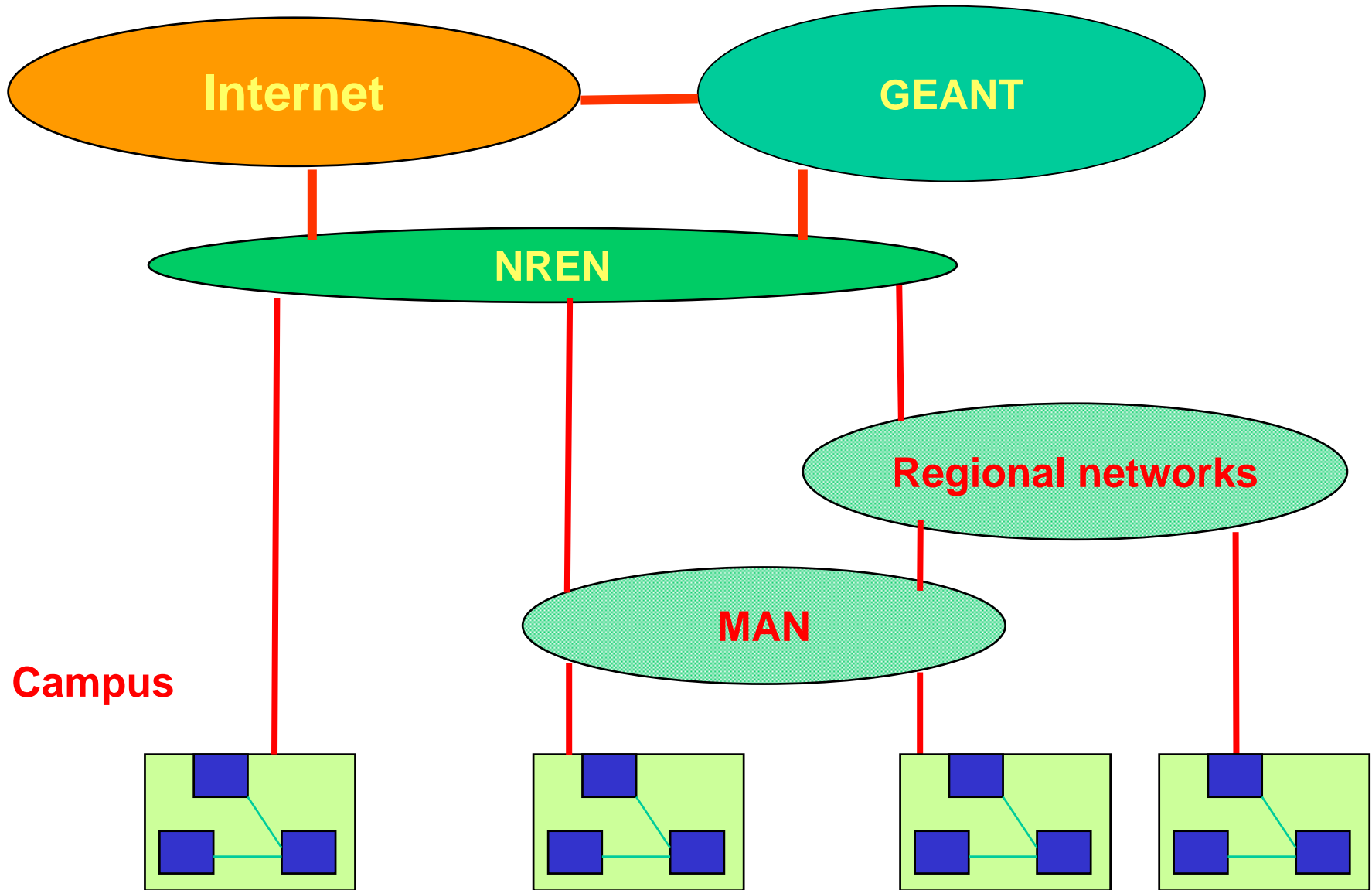
23 - 24 October 2003, Trieste, Italy

<http://www.ejds.org/meeting2003/>



LOCAL CONNECTIVITY





Campus networks

- Deliverable 18a concentrates on the situation of the LAN networks at the sites of universities and research centres. It provides an overview of the costs and makes recommendations concerning planning for adequate service levels.
- The consensus is that **campus networks have not evolved sufficiently rapidly over the past ~5 years and in many places now form the weakest link in R&E networking.**
- I know that this is true from personal experience



MANs

- Normally good things – strategic building blocks – broad participation of all network actors in a city
- They help NRENs and campuses acquire very useful up-to-date experience in transmission technology and fibre infrastructure



Regional networks

- They feel as though they should be “bigger MANs” but are often much more like “little NRENs”
- Not just infrastructure – many “services”
- In some countries the last hideout of the ex-dominant telecom operator
- Technical choices made by multiple regional networks can make the technical evolution of NREN hard
- Careful attention is needed to the **integration of regional networks into the chain NREN-regional-campus.**



THE FUTURE STRUCTURE AND ORGANISATION OF RESEARCH AND EDUCATION NETWORKING IN EUROPE



NRENs and “heavy” user communities

- To the NRENs, both acting nationally and acting internationally through DANTE in the development of GÉANT,
- that they should welcome such heavy use applications, and plan to meet their requirements on an equitable basis.

- We further recommend to groups generating such heavy use applications
- that they should collaborate with their NRENs and GÉANT in order to obtain the services which they require under reasonable conditions, including financial conditions.

- Finally we recommend to all national and European funding authorities
- that they should work hard to avoid this risk of “fragmentation” of the present rather uniform coverage of the NRENs and GÉANT. [T7]



NRENs and hybrid architectures

- To the NRENs, both acting nationally and acting internationally through DANTE in the development of GÉANT,
- that they should explore the use of hybrid network architectures, to see to what extent switched optical techniques can be introduced for heavy use applications alongside the more traditional approach



Campuses, IT services and AAI

- to European universities and their supervisory and funding authorities
- that they need to review their level of expenditure on their campus LANs, and take appropriate action. [T3]
- to the NRENs and to those responsible for the coordination of academic IT services at the national and campus levels
- that they should rather urgently make plans for much closer cooperation. [T4]
- to the European Commission and to the multiple other actors involved (universities, academic authorities, governments, funding agencies, hardware and software suppliers)
- that a major Sixth Framework Programme project should be set up with the objective of implementing and validating a coherent pan-European Authentication and Authorisation Infrastructure (AAI). [T5]



The role of the NRENs in their country

- A few people have sometimes suggested that NRENs should by now be superfluous, but, IMO, a little thought shows that this is very unlikely to be true
- The “knowledge society” or “knowledge economy” is real and very competitive
- Researchers and educationalists from each country have to do battle in this world every day
- And it’s not just about economics, it’s about culture and language too. Give up the “knowledge” battle and you find only too quickly that you have given up on your culture too.
- The technologies behind the “knowledge economy” or the “Internet society” have only just started
- Most countries have found that their research and education communities are excellent vectors for spreading really advanced Internet technologies into industry and commerce as a whole



Just one NREN for Europe?

- At our Final Workshop someone asked whether in the era of ERA we should not move to a single NREN for the whole of Europe
- Some thought convinces us that this is not a good idea (now, and probably never)
- There are no signs that national governments are willing to give up control over research and (even more) education, it seems inevitable that we will have national NRENs for many years to come

- But the European NRENs obviously need to cooperate well (inside regions, across Europe, and hopefully even further afield)
- DANTE and TERENA have an important role to play in this area



NRENs and broader Internet use

- There is no conflict between the need for an NREN to push the most advanced networking concepts for the R&E community, and the need for a government to push – by many approaches – the take-up of Internet in the community as a whole. (*eEurope*)
- Those are two complementary development – neither makes sense without the other
- The NREN should always be seeking to deploy some of the most advanced services – hardware and software and applications



The importance of government support

- NRENs are most effective when they have good relations with their user community and are recognised by their national governments as an important and effective tool for advancing in the pursuit of the “knowledge society”
- Not an easy job to be an NREN, since you are the focal point for multiple tensions



Greater inclusiveness - Including more user communities?

- We have seen that in many?/most? European countries the use of the NREN is no longer limited to the “traditional” communities of the universities and research institutes.
- But that the exact communities which are included in this extension of the NREN mandate varies a lot from country to country. They can include education at various ages (K through senior citizens), museums, arts and culture, libraries, government institutions. But not healthcare or hospitals,
- The approach varied immensely from country to country ...
- Depending partly on size
 - When you are below say 5-10M inhabitants governments want to apply the expertise that is present at the NREN to a broader range of users
- And partly on the national perception of their interests
- Good consistent backing always delivered well-appreciated services
- Seems impossible to define any simple “pan-European” approach.



[OTHER COUNTRIES AND REGIONS]



RECOMMENDATIONS

Areas which I have not already covered



Fibre and competition (1/2)

- that governments across the whole region
- should ensure that their NREN, should it so wish, is empowered to install or lease its own optical fibre transmission infrastructure. [T1]
- This **should** be mainly applicable outside the EU-25 (since the regulatory regime in the EU-25 permits this anyway)
- Needed to ensure that NRENs (outside the EU-25) have a credible threat with respect to their (quasi-monopoly) telecoms operator
- Serbia

Fibre and competition (2/2)

- SMALL CUSTOMERS NEED TRANSPARENCY AND REASONABLE COSTING!
- to the European Commission and to the national governments, and especially to their agencies handling communications regulations and competition,
- that they should establish an annual census of installed optical fibre and ducting, which should be made publicly available. [S1]
- that the European Commission
- should urgently (say by the end of 2004) review the present (2003) EU regulatory framework and consider under what conditions it would be reasonable to introduce a right of non-discriminatory access to optical fibre infrastructure at equitably-negotiated pricing. [S2]



Competition more generally

- to the EC and to all of the national governments in Europe, and to their politicians and regulatory authorities:-
 - that they should strive hard to introduce a truly competitive regime for the provision of ultra-high bandwidth services



Schools

- to the national governments (and their NRENs) that:-
 - the provision of high-quality networking for primary and secondary education is a vitally important goal
 - That governments should clearly define their national approach to the provision of support for such networking
 - if such support is to be provided through the NREN then adequate resources, additional to those needed to support the traditional research and higher education communities, must be identified and allocated.
 - independently of the detailed organisation and funding arrangements which are made, excellent cooperation is essential between the organisations providing networking for all of these communities – research, higher, secondary and primary education. [T8]



The role of the EC

- It is very important that the EC should continue to play the federating role that it has so effectively assumed over the past six years in enabling the interconnection of Europe's NRENs
- The money helps but these are the only people with the political authority to guide people to decisions
- They also will have an important role in extending the borders of "European" networking



WRAP-UP



Six top messages?

- Always dangerous to make selections!
- Network transmission is going optical – and we must be attentive to some profound implications of that
 - Access to optical fibre
 - Hybrid architectures
- National networks and academic IT services need to rather closely integrate their activities
 - AAI
 - Content delivery & distance learning
- NRENs are important national assets
 - Look after them
 - NRENs need to maintain excellent relations with their users and with their government
- There is a “digital divide” inside Europe’s R&E networking
- Effective competition for the supply of infrastructure and services is crucial in determining the speed of progress in European networking
- Keep your users engaged and supportive!





The SERENATE Project
- strategic choices for
R&E networking in Europe

Takk för uppmärksamheten