



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

David Williams, CERN

ENPG Meeting

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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

- Introduction to SERENATE
- Introduction to NRENs
- Optical networking is coming and everyone can and should participate
- A “digital divide” exists inside the European R&E community
- Heavy use applications are coming and will need careful attention
- Users want end-to-end service quality, compatible pan-European Authentication and Authorisation Infrastructure, and value-added services
- The campus is frequently the weakest link in the networking chain
- The extent to which an NREN user community is inclusive is a national issue, but economies of scale are important in smaller countries
- Continued EU and national focus on European R&E education networking will be necessary
- Concluding messages



INTRODUCTION TO SERENATE



David Williams, ENPG at CERN

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
- Now in final editing phase, aiming 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 very serious reports - on the Web site www.serenate.org
- ~6 reports now being printed



INTRODUCTION TO NRENs

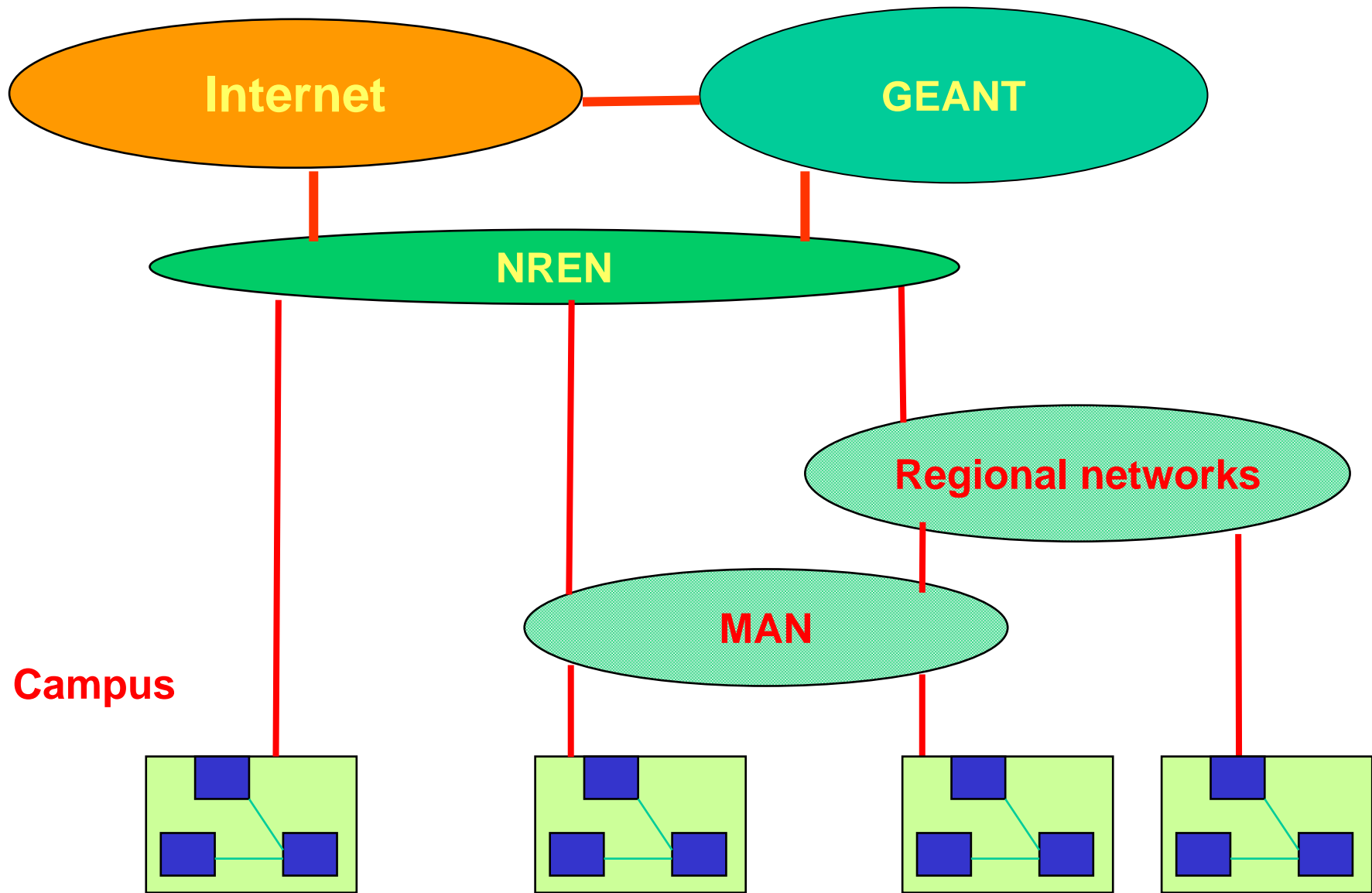


David Williams, ENPG at CERN

Multiple levels of research networking

- 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 ~25-50 €/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



OPTICAL NETWORKING IS COMING: EVERYONE CAN AND SHOULD PARTICIPATE



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



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
- Which commercial models will be sustainable in the longer term??



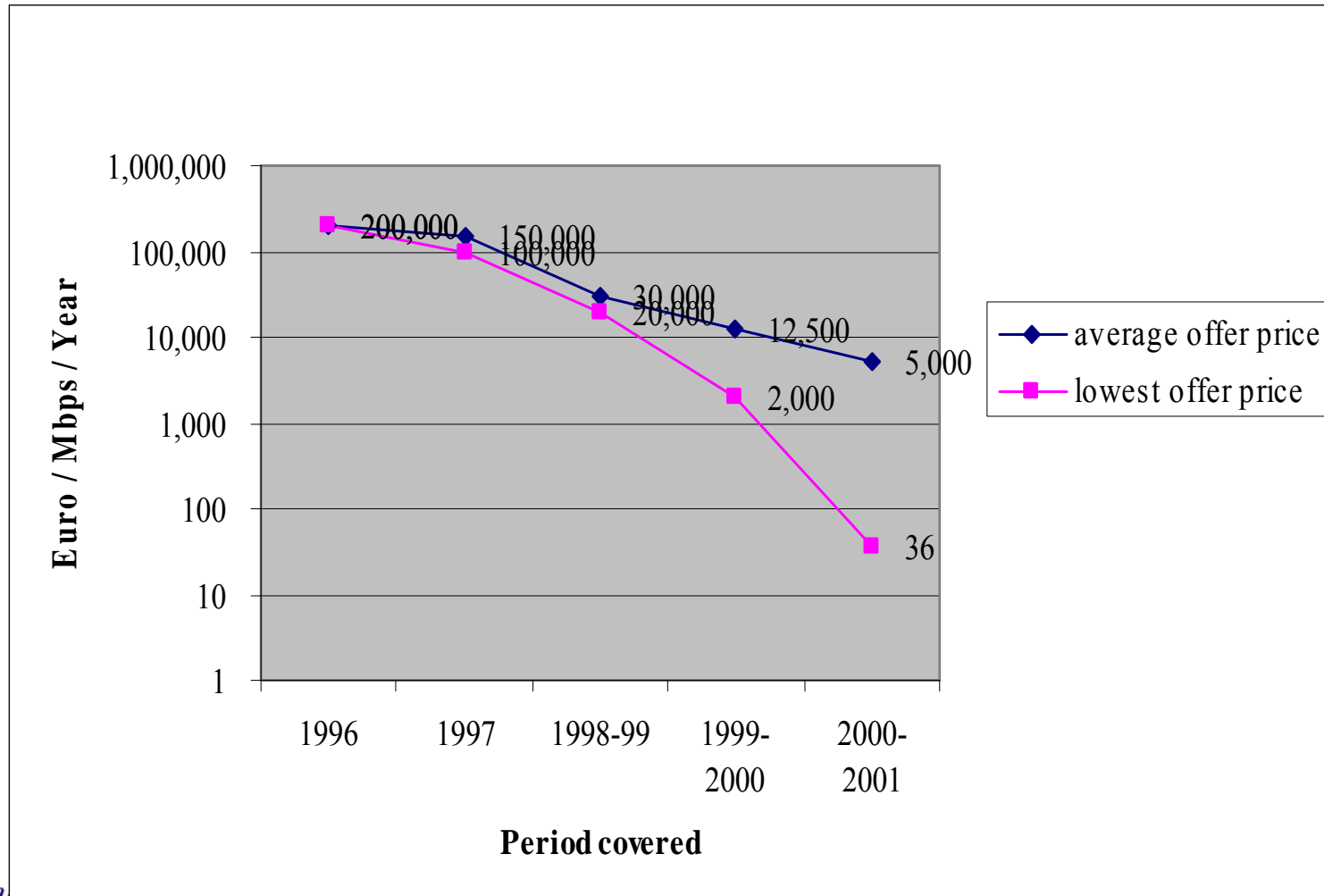
Getting more concrete with costs

- 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

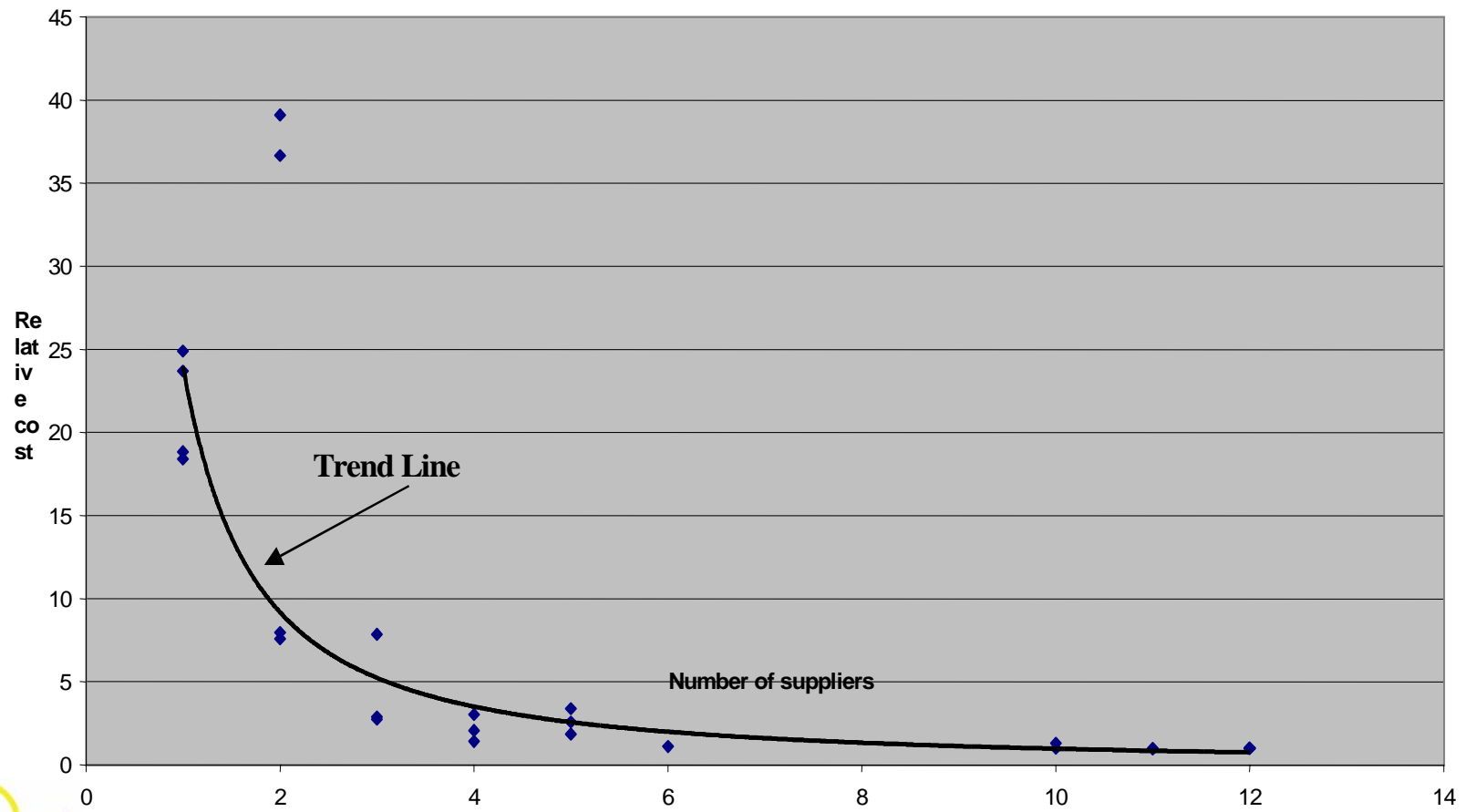
Table 2 International Connectivity Costs in the Differing Market Segments

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 basic costs 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)



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



Fibre and competition (1/2)

- It is very important that **governments across the whole region**, even beyond the formal borders of the European Union, ensure that their NREN, should it so wish, is empowered to install or lease its own optical fibre transmission infrastructure
- 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!
- The European Commission and the national regulatory authorities should establish an annual census of installed optical fibre and ducting, which should be made publicly available.
- The European Commission should, by the end of 2004, consider under what conditions and for which parties it would be reasonable to introduce a right of non-discriminatory access to optical fibre infrastructure at equitably-negotiated pricing.



Competition more generally

- In general terms all European governments, politicians and national regulatory authorities should strive hard to introduce a truly competitive environment for the provision of gigabit communications services.



A “DIGITAL DIVIDE” EXISTS INSIDE THE EUROPEAN RESEARCH AND EDUCATION COMMUNITY

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



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**.



User needs –geography

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



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



DD recommendations (1/2)

- **The institutions of the European Union** should recognise that at the present time a “digital divide” exists inside the European research and education community, and take energetic measures to reduce and preferably eliminate this “digital divide”
- **The institutions of the European Union** should determine the approach to be adopted by the Union with respect to the “digital divide” which exists between its research and education community and that same community in the “neighbouring European” countries (those countries beyond the EU-25 and candidate countries).

Even if those countries are neither EU members nor likely to be in the short term, EU policies and advice carry significant weight there, and the EU also has political interests in ensuring stability and in strengthening democracy in those countries.



DD (2/2)

- **The European Commission** should monitor annually the state of the “digital divide” inside the Union’s research and education community, ideally also including the “neighbouring European” countries, and publish the results. This should cover (a) the availability and cost of gigabit communications services and (b) the functionality and performance offered by the various NRENs.
- **The European Union and the governments of the EU members and Accession States** should encourage the use of Structural Funds to finance investments in the field of research and education networking, including investments in communications infrastructure, such as optical fibre.
- **Governments of countries with no access to EU Structural Funds** should actively seek alternative sources of finance for such investments.



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/>



David Williams, ENPG at CERN

HEAVY USE APPLICATIONS ARE COMING AND WILL NEED CAREFUL ATTENTION



Heavy use applications

- What they are
 - 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)
- Why they are important
 - These flows can be 100x, 1000x “traditional”



NRENs and “heavy” user communities

- **The NRENs**, both acting nationally and acting internationally through DANTE in the development of GÉANT, should support the new heavy use applications and encourage them to use the common infrastructure.
- **The groups generating such heavy use applications** should collaborate with their NRENs and GÉANT in order to obtain the services which they require under reasonable conditions, including financial conditions.
- **National and European funding authorities** should work to integrate these new heavy use groups with the rest of the NREN user community.



NRENs and hybrid architectures

- In order to better support new heavy use applications, **the NRENs and DANTE** should explore the use of hybrid network architectures, in which switched optical paths are introduced alongside the traditional general-purpose routed network.



USERS WANT:

END-TO-END SERVICE QUALITY;

COMPATIBLE PAN-EUROPEAN
AUTHENTICATION AND AUTHORISATION
INFRASTRUCTURE;

VALUE-ADDED SERVICES



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



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



Other general user needs

- Heavy applications
 - Already discussed
- 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



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!
- **The European Commission and the many other stakeholders involved (universities, academic authorities, governments, funding agencies, hardware and software suppliers) should set up a major project with the objective of implementing and validating a coherent pan-European Authentication and Authorisation Infrastructure (AAI).**



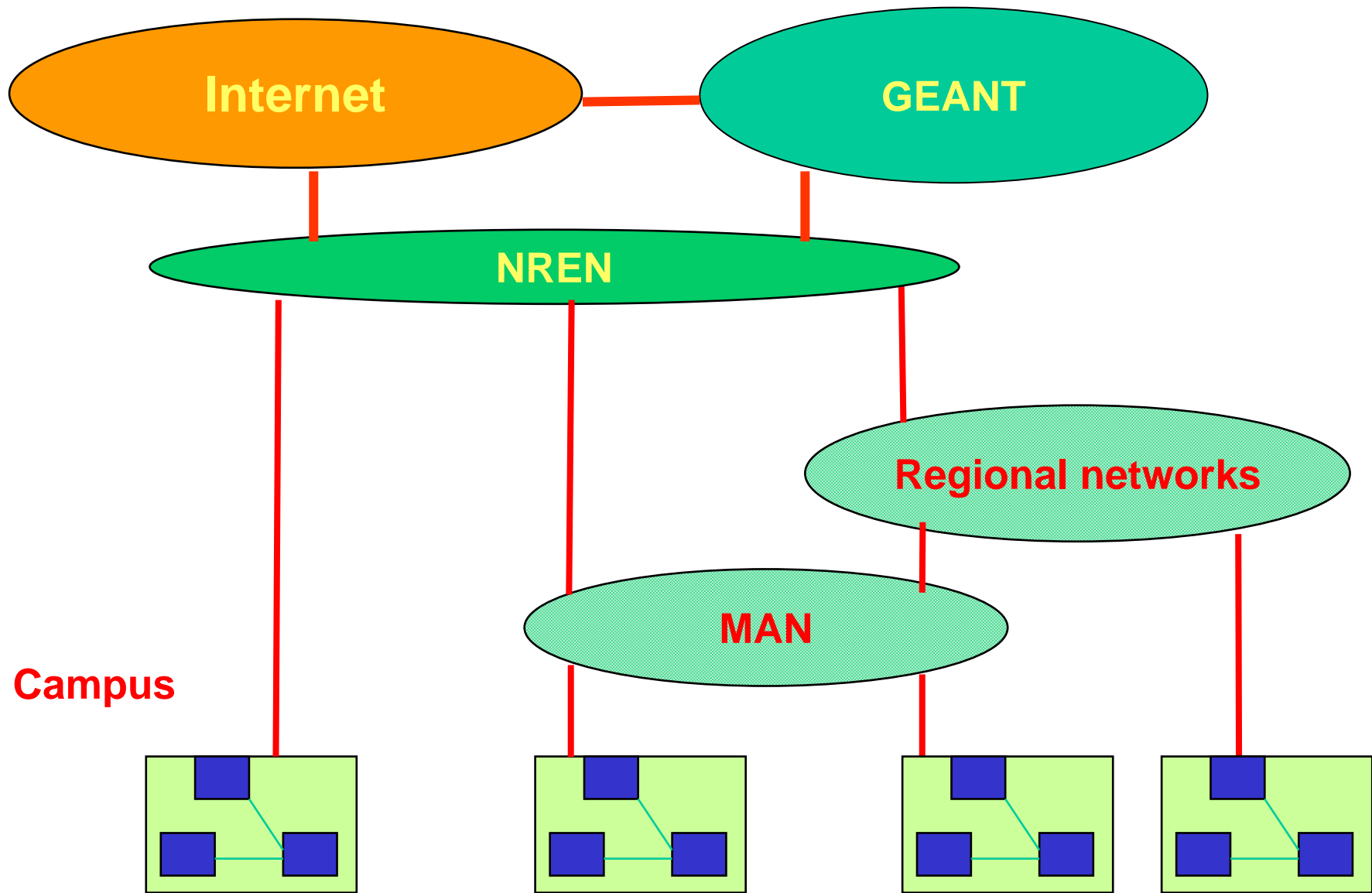
R&E IT services

- All providers of research and education network services, including the NRENs, DANTE and the campuses, need to select and develop tools and to provide “single-stop” facilities for the rapid diagnosis of issues of end-to-end performance and/or reliability. In view of the number of organisations involved in the provision of such services, the coordination will be a significant management challenge.
- The NRENs and to those responsible for the coordination of academic IT services at the national and campus levels need to develop much closer cooperation in order to ensure that services in several areas, especially authentication and authorisation, but also access to content, including distance education material and commercial databases, are delivered in a coherent fashion to their users.



THE CAMPUS IS FREQUENTLY
THE WEAKEST LINK IN THE
NETWORKING CHAIN





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



Campus recommendations

- Campus networks are now frequently the weakest link in the chain of the end-to-end services needed for research and education networking. Therefore **European universities and their supervisory and funding authorities** need to ensure that their campus networks are appropriately resourced. Investment in campus networks is best planned as a regular budget expense, thereby allowing for ongoing technical updates.
- **Research and education institutions** should consider acquiring their own fibre infrastructure between their local area network(s) and the point(s) of presence of key service and/or infrastructure operators, including their NREN, if necessary by commissioning the construction.



NREN USER COMMUNITY INCLUSIVENESS



David Williams, ENPG at CERN

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.



Recommendations

- If networking for primary and secondary education is to be provided through the NREN in a given country, 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 all organisations providing networking for the primary and secondary education communities, the higher education community and the research community.



CONTINUED EU AND NATIONAL
FOCUS ON EUROPEAN R&E
NETWORKING WILL BE NECESSARY



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
- **The European Council and the European Parliament should ensure that the European Commission** continues to play a significant role in ensuring that Europe's research and education networking remains competitive at the global level. There will be no successful European Research Area without an ongoing commitment of sufficient resources to the evolution of Europe's research and education networking.



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



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



David Williams, ENPG at CERN

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