



The SERENATE project

**Strategic studies into the Future of Research
and Education Networking in Europe**

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What is SERENATE?

- **study project: May 2002 – September 2003**
- **budget € 960k**
- **funded by European Union**
- **SERENATE will formulate recommendations for decision makers (governments/funding bodies, research networks, universities etc.) for the development of research networking in 5-10 years' timeframe (at ≥ 100 Gb/s)**
- **SERENATE looks into:**
 - user needs
 - technology
 - market conditions , regulation
 - organisation and finance





SERENATE Steering Committee

- **David Williams** (CERN, former President of TERENA)
- **Dai Davies** (DANTE)
- **Knud Erik Skouby** (CTI)
- **Karel Vietsch** (TERENA)
- **Marko Bonac** (ARNES, member TERENA Executive)
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- **Ian Butterworth** (Academia Europaea)
- **Tony Mayer** (ESF)
- **Fernando Liello** (GN1 project)





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Assumptions

David Williams, CERN

SERENATE Final Workshop, Bad Nauheim

16 June 2003



Not just a market issue

- The availability, quantity and quality of research networking cannot simply be left to market forces. Governments need to accept their overall responsibility in this field
- R&E field is an open international competition for brains (and later economic strength) – the Knowledge Society
- Advanced networking has/can have enormous impact on speed of development (research) and speed and range of delivery (education)
- R&E community accepts (within reason) to work close to bleeding edge
- Advanced services for the R&E community is not a market where ISPs can invest and hope to make lots of money
- Progress in R&E networking feeds through to Internet – both individuals and industry – *e*Europe → next slide
- This is the **politics of national economic progress**
- **Also note the strong complementarity between R&E networking and *e*Europe**

R&E networking is a significant driver

- Research (and Education) networking is an important trigger for the development of the Information Society and eventually economic prosperity
- It introduces students to very advanced Internet concepts which they then will want to use in their professional life – promoting ICT innovation in many different industries
- Some students are well trained for work in ICT companies and start-ups
- NRENs themselves are operating at the leading edge and often work in collaboration with local ICT companies, contributing to innovation and/or industrial and commercial deployment of advanced concepts
- Some governments are wise enough to use “their” NREN as a pool of ICT expertise for the wider “public sector” (including education and government services)



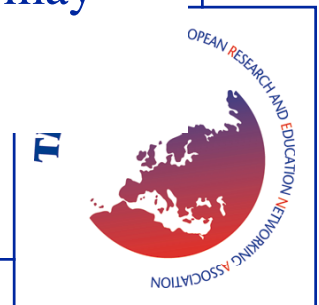
Global cooperation is important

- We must ensure global co-operation in research networking
- Research is global
- Some partners that you want to work with live and work abroad
- Some effects that you want to investigate can only be studied abroad
- In the absence of cooperation we will have cacophony



Europe has a role to play

- Some form of organisation of research networking at the European level is necessary
- Researchers (and citizens) move around the Single Market
- We are trying to create the European Research Area (ERA)
- All European countries – perhaps except for the very biggest - need to cooperate to give weight to their (common?) views and cultural values
- Although distance shrinks in cyberspace, international collaboration is still easiest with close-by neighbours, who may also share some of your overall approach.



Subsidiarity

- The responsibility for the provision of network infrastructure for the Research and Education community *inside* each country belongs to that country
- To who else?
- Can it be afforded?
- Will anyone help the economically less-favoured to provide “equality of opportunity” for their citizens? → next slide
- In the end R&E networking is only sustainable if it is supported (also financially) by your own government



ERA “equality”

- We wish to offer equality of network access to researchers all over the European Research Area
- What do we mean by “equality of network access”?
 - availability, reliability, bandwidth, service quality and availability, affordability
- Is this “equality” at all a realistic aim?
- Is good networking a significant factor for excellent researchers when they decide where they wish to work? Or, is bad networking a factor pushing them to migrate?

We will discuss the next point in more detail later (Digital Divide session)

- How might we try to attain “equality”, and how long will it take?





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Summary of findings and recommendations

David Williams, CERN

SERENATE Final Workshop, Bad Nauheim

16 June 2003



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 <http://www.serenate.org>
- Our job now is to use this information to prepare a clear overview and set of recommendations
- We start by considering the **User Requirements**, the **Technology Evolution** and the **Transmission Scenarios** and (related) **Cost Evolution**
- We then pose six strategic questions, and give our answers
- And finally arrive at our strategic recommendations

USER REQUIREMENTS



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.
- 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
- Support services are needed to fix any problems of end-to-end performance.
- 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)

What do the users want(2/2)?

- Support for video-conferencing services, and in general for integrated IP communications?
- How big is the pressure for distance learning via NRENs?
- 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



TECHNOLOGY EVOLUTION



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 heterogeneous 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??



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!



TRANSMISSION SCENARIOS AND COST EVOLUTION



The building blocks (1/2)

1. Dig a trench (or get access to one already dug)
 - Say 40 k€per km
2. Install a cable (or get access to one already in place)
 - Say 4 k€per km for 100 fibre pairs, each of which rents for ~500 €per km
3. Ensure that the trench/cable ends up where you want (PoP), or else arrange a connection!
 - A major issue
4. Install equipment to transmit and receive information across the cable
 - Say 1 k€per km per path (wavelength), for spans up to 200 km. But the cost obviously depends on many details, including the speed required.
5. If the distance is >200 km install amplifiers
 - Traditionally 150 k€per 80 km (~2 k€per km) covers basic amplification for all wavelengths on a fibre, PLUS COST OF TECHNICAL SPACE. Recently amplifiers which are 5x cheaper have become available.

The building blocks (2/2)

6. If the distance is >700 km install regenerators
 - Terminate all wavelengths, OEO conversion, regenerate each wavelength. Say at least 1 M€per 700 km PLUS TECHNICAL SPACE, or roughly another 2 k€per km
7. Install switches and routers to move the information from source to destination
8. And support for all other necessary services – such as DNS, security, and don't forget the personnel!
9. Make sure that the information gets to and from the end user on the campus
 - Wired or wireless
10. And/or to the end user at home
 - Various techniques



The Business as Usual (BAU) scenario

- For the past few years the “usual” approach has been that campuses look after points 9 and 10, that NRENs and campuses together look after points 7 and 8, and that NRENs and DANTE purchase a service covering points 1-6 from telecoms operators.
- This is the “simplest” approach for the NRENs



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



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 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



The Do-it-yourself (DIY) scenario

- If the price offered by the telecoms operators for the service covering points 1-6 is excessive, and seems unlikely to change, then the main (probably only) alternative approach which is open to the purchaser (the NREN or DANTE) is to provide their own transmission system.
- Although the community has some experience in local transmission systems, gained on-campus, between campuses, and across MANs, we believe that it has no over-riding wish to become involved in DIY solutions in the wide-area.
- However, the community does have a reasonable understanding of the economics, and is and will remain unwilling to pay excessive prices.
- If the capital investment required for DIY transmission on a given route is no more than the price quoted for one year's rental then the decision will be clear.
- If the pay-back period extends much beyond two years then the NREN needs to make a very good assessment of the chances of additional operators arriving and bringing the prices down quickly.
- If an NREN (CH, CZ, PL are examples) becomes the “owner” (or long-term leaser) of a national fibre infrastructure then they obtain more direct control of the conditions under which they can increase the transmission capacity of their network
- Provided that the fibres that they “own” are of high enough specification

Regulation

- The EU approach is to implement one regulatory regime per country. That makes for a non-uniform situation, and that might be a strategic issue that SERENATE should comment on. Is it a big issue for implementation of transmission services? – maybe yes if too much diversity
- In the EU-15 a new regulatory regime should come into force on 25 July 2003
- This makes it very clear that NRENs are free to adopt a DIY scenario if they so wish. The only thing that might delay any DIY project undertaken by an NREN is obtaining installation permission from local authorities – should not exceed a few months.
- In the Accession States this new regime comes into force when they accede – 1 May 2004 for the next 10 members.
- Many neighbouring third countries are in a much more traditional regime, with little sign of how quickly things will evolve
- In any case the reality is often much worse than the official situation, and NREN in such countries are little inclined to start law suits

National scenarios

- The basic choice is between BAU and DIY.
- This is a strategic choice to be made by the NREN.
- The solution might well be mixed, since our data show that while there is usually strong competition and reasonable costs for transmission between major cities, there are often regions where there is little competition and excessive pricing.
- As we indicated before, pay-back periods below two years are very desirable before getting involved in DIY solutions



Pan-European scenarios

- While there is, in principle, the same choice (as nationally) between the BAU and DIY scenarios, there is an additional technical complexity for the pan-European situation over and above the national situation.
- As the span to be connected starts to exceed 150-200 km the equipment which is needed to transmit and receive information along the fibre changes. At the present time “Nothing in line” (NIL) solutions do not work beyond these distances, though that might change over time? So transmission beyond 150-200 km depends on fibre routes where amplification and regeneration is carried out on a regular basis.
- The idea of an NREN needing to become responsible for such infrastructure services is not attractive.



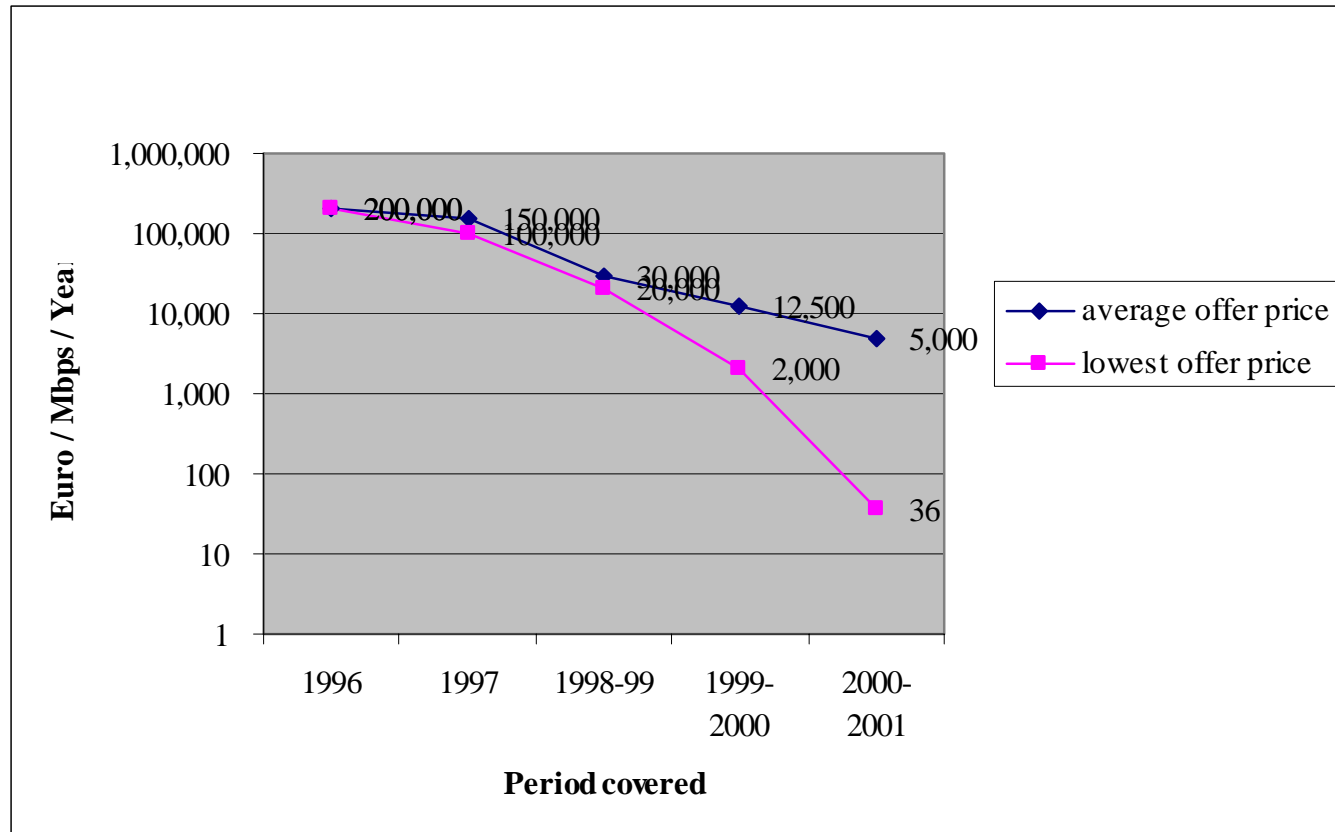
Cost evolution (1/2)

- We should say that the price reductions seen in the last five years are not likely to be repeated.
- Best guess is not much movement in 2003, and maybe even 2004, then perhaps back to more standard situation
- Depends on how much real effective competition there will be
- Three scenarios G,B,U or G,N,P (more PC)



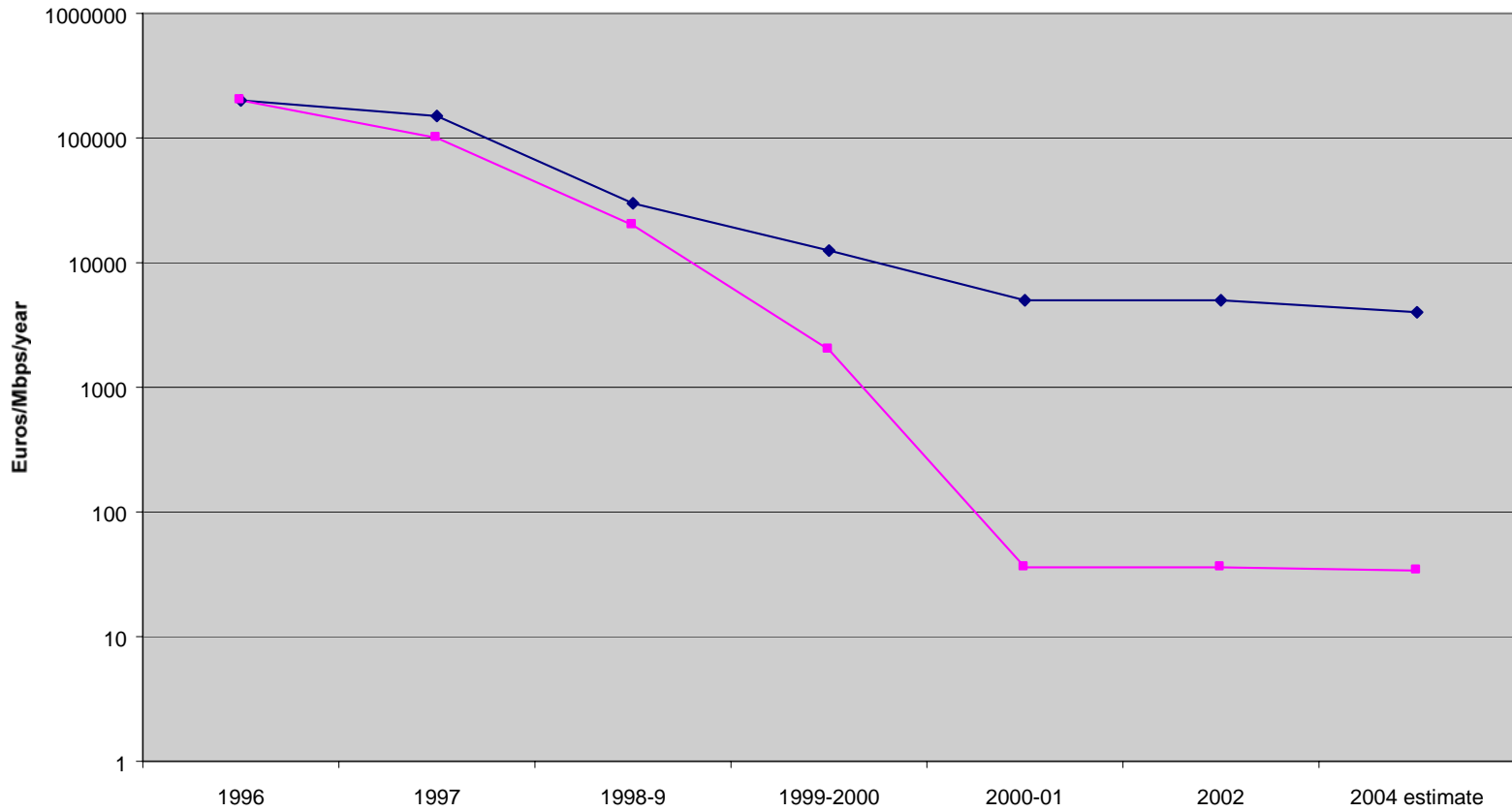
Transport infrastructure

Evolution of Market Competitiveness : International Intra-European Connectivity





Price trends extrapolation



Cost evolution (2/2)

- **GOOD (GOOD)**
 - Price reduction of 10% p.a. in liberal markets and rather rapid convergence of everyone to those levels
 - Removes source of inter-European Digital Divide
- **BAD (NEUTRAL)**
 - Price reduction of 10% p.a. in all markets, maintaining Digital Divide largely “as is”.
- **UGLY (POOR)**
 - Small price increases in the liberal markets, with stability in emerging and quasi-monopoly markets
- **What will happen?**
 - GOOD seems unlikely and would need very strong political push
 - B/N probably the most likely?



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.
- Overall costs are in the range of 80-110 €/per port, of which some 25 €covers the necessary off-site connectivity.
- The general feeling 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.
- Careful attention is needed to the integration of regional networks into the chain NREN-regional-campus.

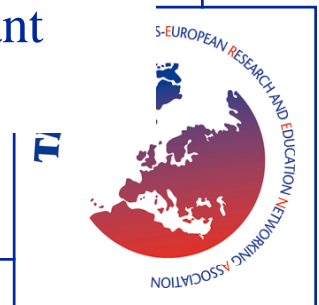


SIX STRATEGIC QUESTIONS



The questions

1. What action, if any, do the NRENs need to take concerning the move from electrical transmission to optical transmission and fibres?
2. What, if anything, should be done about Europe's Digital Divide?
3. Does R&E networking have any political role to play in Europe's relations with the developing world?
4. Should NRENs become more inclusive towards other user communities?
5. What action, if any, should be taken by the R&E community as IT and network technologies assume an ever more important role in the whole process of delivering R&E?
6. What future for the NRENs?



OPTICAL TRANSMISSION AND FIBRES



Optical transmission (repeat)

- 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)
 - Possible/probable move towards optical switching
 - Hence likely move to a heterogeneous network, with general Internet use still via packet switching and specialised high-speed traffic via optical paths? Even end-to-end paths??



NREN response?

- Investigate heterogeneous networks
 - Participate in grid projects to better understand their needs
 - Experiment with traffic segregation of heavy flows onto switched paths
- When there are signs that prices in the (national) transmission market are excessive then experiment with DIY transmission. If the market situation does not evolve then move to production DIY solutions.
- It could be useful for a few NRENs (say 2-3) and DANTE to explore the extent to which a highly reliable and high-performance long-distance path can be created by joining shorter segments of national fibres. Is this an operation which can be put out to tender?
- In time advanced users might want to be able to acquire their own heavy-use infrastructure at marginal cost



EUROPE'S DIGITAL DIVIDE

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 has 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.



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 appears to us to be the responsibility of the EC
- In the absence of progress towards competitive transmission costs, the national, regional or local governments concerned (or the EU) should take action to stimulate open access (and hence competitive) ducting and fibre supply.
- The EC should consider whether the regulatory regime should be adapted to ensure wide access to fibre infrastructure at cost-based pricing.



INCLUDING MORE COMMUNITIES



Including more 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
- 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 interest

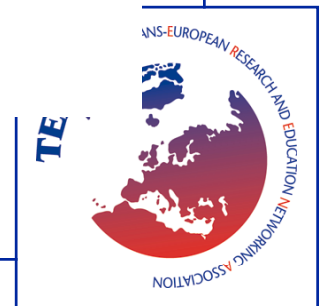


INTEGRATION OF IT AND NETWORKING TECHNOLOGIES IN THE R&E WORLD



The R&E community's use of IT and networking technologies

- We believe that the time is fast approaching when it will become unhealthy for NRENs and academic computing organisations to co-exist in glorious ignorance of each other. In this context both Geographic and Disciplinary coordination will be important
- Strong discussion is needed nationally, and on a pan-European (and probably global) basis to ensure that all solutions which are adopted for Authentication and Authorization allow as easy and as automatic as possible mobility for students, faculty and researchers.
- As grid technologies emerge, decisions will needed inside each (sub)discipline on a range of IT “standards”, such as data storage conventions, metadata definitions, ontology definitions, recommendations for software libraries and tools, and community conventions for sharing data and computing resources. As always, it will be important to avoid taking incompatible decisions on these “standards” in different geographic areas.



THE FUTURE OF THE NRENs



The future of the NRENs

- The arguments to create an NREN include:-
 - Research and Education forms a community which is engaged in a very competitive and rather border-less field (preparing people for the Knowledge Society)
 - The community has the expertise and interest to explore leading-edge products
 - It is willing to accept that such products will sometimes be less than 99.999% reliable
 - It has a track record of having helped move these technologies into widespread use, thereby benefiting the economy and society as a whole
- There are no signs that over the next 5-10 years the need for NRENs will go away. Rather the opposite.



STRATEGIC RECOMENDATIONS



For the NRENs

- Careful attention is needed to the integration of regional networks into the chain NREN-regional-campus
- Need to decide on policy with respect to new EU regulations (public/private network)
- Investigate heterogeneous networks
 - Participate in grid projects to better understand their needs
 - Experiment with segregation of specialised high-speed traffic onto switched paths
- When there are signs that prices in the (national) transmission market are excessive then experiment with DIY transmission. If the market situation does not evolve then move to production DIY solutions.
- It could be useful for a few NRENs (say 2-3) and DANTE to explore the extent to which a highly reliable and high-performance long-distance path can be created by joining shorter segments of national fibres. Can that sort of approach be put out to tender?
- If there is a political mandate to engage with the developing countries, obvious tasks are to help build up their NREN expertise, to help build regional groupings of NRENs, and to help such groupings to connect to GEANT
- Simulating traffic flows



For universities and other research centres

- Campus networks need attention and serious ongoing investment of resources, including personnel.
- *Out-of-scope.* Universities need well-developed and sufficiently funded IT policies.



For multiple academic actors

- Coordination for AAA
- Coordination of the whole IT “approach” across (sub-)disciplines



For the EC

- The EC should assume responsibility for measuring our internal Digital Divide and monitoring progress in reducing it.
- It should trigger a political discussion concerning what we mean by “Europe” in this context
- It should trigger a political discussion on the strategy to be adopted concerning the relation between European networking and the developing world
- It should continue to play the federative role which it has assumed over the past 6 years in enabling the interconnection of Europe’s NRENs.



For politicians

- *See also the previous slide (for the EC) and the next (for governments)*
- A political discussion is needed concerning what we want to do about the Digital Divide inside Europe, and what we mean by “Europe” in that context
- A political discussion is needed on the strategy to be adopted concerning the relation between European networking and the developing world



For governments

- In the ongoing presence of excessively high prices for transmission the national, regional or local governments concerned should take action to stimulate open access (and hence competitive) ducting and fibre supply
- Careful attention is needed to the integration of regional networks into the chain NREN-regional-campus
 - Risk of complicating NREN's technical evolution
 - Risk of becoming last stronghold of ex-monopolists
- Keep supporting your NREN!



For multiple actors, including regulators

- Following discussions with all parties it would be desirable to regulate access conditions to installed fibre.
- Basic census – where, how many fibres, what type, how many lit? – could be very useful and should be made public
- Guidance (at least open discussion) on the share of the investment that the first few purchasers/leasers should cover would be very valuable.



For operators

- Recognise that the NRENs have no particular desire to build and operate their own transmission systems.
- But that they do have a reasonable understanding of the costs involved.
- So take account more of the possibilities of DIY solutions based on optics, and use those as check-points when setting pricing?
- Remember that NRENs are potentially interested in various small and large collaborative projects, which have the potential to bring major mutual benefits





SERENATE

More information, including all reports, is available from the SERENATE website at

www.serenate.org

