Report on the expected evolution of international connectivity in Europe and to other continents over the next five years

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CONTENTS

Executive Summary

SERENATE aims to offer a strategic perspective on the future development of research and education networking in Europe. An important component in the construction of any network is the connectivity provided by the telecommunications infrastructure that interconnects the nodes of the network. The purpose of this SERENATE deliverable is to present forecasts for the evolution over the next five years of the transport infrastructure that is needed for advanced trans-European research networking.

The evolution of the transport infrastructure depends on a wide range of regulatory, organisational, technical and economic parameters. The regulation defines the rules related to various options for ownership and specifies possible special obligations. The organisation or structure of infrastructure providers sets the framework for how their networks are managed and affects the overall design. The technology adopted by providers defines the technical options and specifies characteristics, availability and prices of equipment. Together these factors determine the underlying costs for the operator. Finally, the market conditions in the connectivity market shape the availability of and the prices asked for various types of connections.

The new European Union framework for telecommunications regulation aims to create a competitive market for telecommunications services and was foreseen to be implemented by mid 2003. However, it seems that in several countries the implementation will be delayed. It is therefore expected that inadequate procedures for licensing and interconnection will still hamper the development of real competition in the least developed telecommunications markets. In this respect there is no sharp border between the EU member states and the accession countries; rather there is a sliding scale basically following the ranking from low-income to high-income countries.

Four groups of countries are distinguished:

(i) Liberal markets with transparent pricing: Belgium, France, Germany, Italy, the Netherlands, Switzerland, the United Kingdom and the Nordic region

(ii) Liberal markets with less transparent pricing structure: Austria, the Czech Republic, Hungary, Ireland, Luxembourg, Slovakia and Spain

(iii) Emerging markets without transparent pricing: Croatia, Poland and Slovenia

(iv) Traditional monopolist markets: Bulgaria, Cyprus, Estonia, Greece, Latvia, Lithuania, Malta, Portugal and Romania.

Today there are huge differences between the four groups of countries in the price for high-capacity international connectivity. If the minimum price is set to 1, the prices vary from 1-1.4 on transparent liberal markets, 1.8-3.3 on less transparent liberal markets, 7.5-7.8 on emerging markets, and 18-39 on de-facto monopolistic markets.

Three scenarios have been developed to describe how the markets in these four groups of countries could evolve:

1) An optimistic scenario with annual price reductions of 10% on liberal markets and convergence to the same level in the other groups of countries

2) A neutral scenario with annual price reductions of 10%

3) A pessimistic scenario with slight increases in prices on liberal markets, while emerging and de-facto monopolistic markets remain stable.

The first scenario is considered to be unlikely without significant new policy initiatives. The probability of the other scenarios depends among others on how the demand will develop. Up to now the telecommunications markets have seen dramatic decreases of prices for high-capacity lines, and for some routes the prices are now lower than the underlying costs, in particular for long distances. It is therefore possible that in certain markets

prices will increase. On the other hand, technological developments and increasing demand will lead to cost reductions in the long term.

Regulation will in principle allow national research and education networking organisations to establish their own networks instead of leasing capacity from public network operators. In reality, there may still be problems related to getting a license and to obtaining rights of way. Although these issues may complicate the construction of a national research and education network's own network facilities in some countries, the Do It Yourself approach will become a viable option also in the current de-facto monopolistic markets.

Many different factors will determine whether the option to adopt a Do It Yourself solution will actually strengthen the negotiating position of a research networking organisation when trying to obtain connectivity on the market.

Looking at the three scenarios for market development, a form of ownership of telecommunications facilities will in general not be viable in the first scenario, where prices in all parts of Europe will converge towards cost-based prices. This is because of the substantial economies of scale that can be exploited better by network carriers with high volumes of traffic. In scenario 2), where the markets remain largely as they are today, ownership options should be considered for countries with de-facto monopolistic markets, and as far as national connectivity is concerned also in countries with emerging markets for routes outside the major cities. The same conclusion is valid for scenario 3). It should be noted however that even with a slight price increase prices in liberal markets will still be on a level that is too low to consider laying one's own fibre, thereby making the most far-reaching ownership option – laying fibres and lighting them all on one's own – not viable.

Finally, this also implies that the four groups of countries are likely to change, both in scenario 1) and in scenarios 2) and 3). Scenario 1) implies that there will be a single competitive market in Europe. In scenarios 2) and 3) the actual use or merely the potential use of the Do It Yourself model might push some countries into a more liberal environment. Which of the countries this will affect, will depend on demand and on network strategies adopted by the research and education networking organisations.

1. Introduction

The purpose of this deliverable is to present forecasts for the evolution over the next five years of the transport infrastructure that is needed for advanced trans-European research networking. In this report we study the price dynamics of this competitive field. The evolution of the transport infrastructure depends on a wide range of regulatory, organisational, technical and economic parameters. The regulation defines the rules related to various options for ownership and specifies possible special obligations. The organisation or structure of infrastructure providers sets the framework for how their networks are managed and affects the overall design. The technology adopted by providers defines the technical options and specifies characteristics, availability and prices of equipment. Together these factors determine the underlying costs for the operator. Finally, the market conditions in the connectivity market shape the availability of and the prices asked for various types of connections.

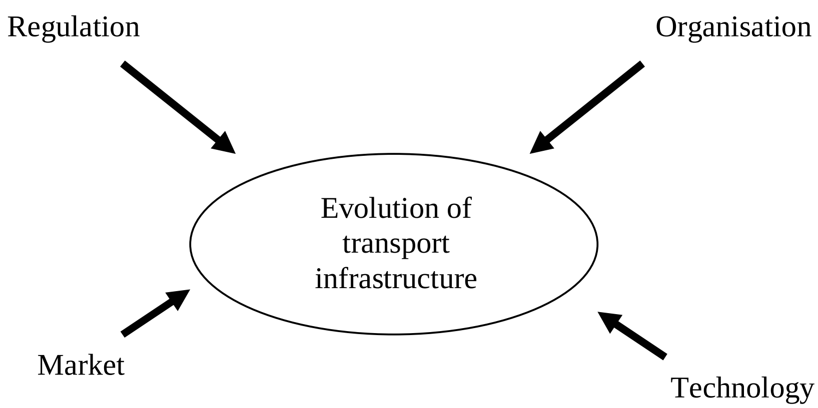

Figure 1. Parameters affecting the evolution in transport infrastructure

Important aspects have been discussed in earlier SERENATE deliverables:

- Deliverable D6 “Report on present status of international connectivity in Europe and to other continents” provides an overview of the current market for international connectivity in Europe.
- Deliverable D7 “Report on the expected development of the regulatory situation in European countries relevant for the SERENATE project” describes the regulatory framework under which the infrastructure market will operate in the future.
- Deliverable D4 “Report on workshop on operators’ views on infrastructure and likely evolution” presents the views of traditional and alternative providers of telecommunications and network services on the status of the pan-European telecommunications and network infrastructures and their likely evolution.

The present deliverable provides an integration on the basis of the work described in those three earlier deliverables. Based on the report on the current situation and the short-term evolution, the report on the likely development of the regulatory situation and studies of traditional and alternative providers of network infrastructure, this report aims to discuss the evolution of transport infrastructure provision over the next five years.

It should be noted that the present report is only an intermediate step in the SERENATE studies. In a subsequent deliverable[1], a synthesis will be provided of the earlier work. Based on the three deliverables

[1] SERENATE deliverable D14 “Report discussing future scenarios for the funding of network infrastructure in the European research networking community, and of related costs”

mentioned above, the present report and case studies of novel acquisition initiatives[2], the synthesis report will attempt to draw conclusions comparing the current approach where the transport infrastructure used by the national research and education networks is provided by (traditional or alternative) telecommunications operators, with various possible alternative approaches.

All these results, together with studies on the characteristics and availability of equipment for next-generation networks[3] and on the networking requirements of European researchers[4], will then lead to overall strategic scenarios for the future evolution of pan-European research and education networking[5].

Historically, within Europe, the telecommunications infrastructure has been the preserve of monopoly telecommunications providers. In this respect, Europe lagged behind, for example, North America, where there was greater competition in the provision of connectivity. By the end of the 1980s competition was introduced by the European Union and began to emerge in the national markets for telecommunications in Europe. Generally this resulted in reduced prices for connectivity and a gradual end to restricted access to high-performance connectivity.

At the international level the development in Europe was slower, but by 1998 the European Union had implemented legislation that facilitated a reasonable degree of competition including international connectivity. Taking advantage of this liberalisation, a number of companies have constructed trans-European networks with a reasonable geographic coverage, certainly in most of Western Europe and, to some extent, also extending to Central and Eastern Europe. However, the picture has not been one of homogeneous development. Most of these trans-European networks have connected major business centres and a limited set of major locations on the routes between those centres. For some Western-European countries, and for certain regions within most countries, there has been very little investment. In Central and Eastern Europe the situation varies from country to country. However, in general, although competition for connectivity is not as advanced as in Western Europe, it has had a significant influence on prices and availability of high-capacity connections.

[2] SERENATE deliverable D3 "Report on the experience of various user communities that have experimented with "alternative" models of acquisition"
[3] SERENATE deliverable D9 "Report on the availability and characteristics of equipment for next-generation networks"
[4] SERENATE deliverable D10 "Report on the networking needs of users in the European research community"
[5] SERENATE deliverable D18 "Report outlining scenarios for the evolution of the pan-European infrastructure for European research and education networking"

2. International Connectivity Models for Research Networking

This report aims to present forecasts for the evolution of the international transport infrastructure as far as it is relevant for the organisations that provide network facilities and services to users in the European research and education community. In this respect it is relevant to consider how these organisations have organised the geographic aspects of the provision of connectivity to this user group at a pan-European level, and how they translate their connectivity requirements into a demand on the infrastructure market. Possible alternative international connectivity models in this community could have an effect on the requirements brought to the connectivity market.

2.1. Types of Research and Education Networks

The research networks in Europe are organised today in a hierarchy of three levels (or even four, if the intercontinental level is also included): trans-European, national and local networks. The three levels of transmission networks reflect the underlying organisational structure. Each research establishment or institution for higher education operates its own internal network, which is connected to other institutions via the national research network, which is operated by the national research and education networking organisation in the country. (In some cases there is an intermediate level of regional or metropolitan networks, which usually are not under the control of the national research and education networking organisation.) In turn, the national research networks are interconnected via the European research and education backbone network infrastructure GÉANT, which is managed by DANTE.

This three-level structure of networks represents a relatively simplified view, as the division between the national research and education networks and the local access networks is not always so clear-cut and overlaps in responsibilities are therefore possible.

The three types of networks have significantly different transmission requirements and network architectures. GÉANT is composed of international links with very high capacities, and the types of services offered are predefined. The essential service to be provided by GÉANT is transport, so the primary concern is capacity. The topology is rather stable, as there is only one point of connection in each country in Europe. However, if and when the amount of traffic grows dramatically, the capacity of the backbone network must be expanded easily in order to cope with the increased traffic load. Today the largest national GÉANT backbone access capacities are 10 Gb/s. However, it is believed that this capacity level will increase significantly over the next five years, and some connections might reach capacities of 50-100 Gb/s or more.

At the national level and one step ‘below’ GÉANT, there are the national research and education networking organisations. Contrary to GÉANT they have to cope with a variety of services and applications. They provide an infrastructure for direct communication between research institutions and in most cases also deliver to the institutions connectivity to the commodity Internet.

Communication services and applications come in different sizes and with different characteristics, which puts continuously changing demands on the networks. In addition, the topologies of the national and local networks are constantly changing as new entities are connected and already connected entities or access networks demand more bandwidth. Still, most of these networks have a relatively stable topology, but they are continuously expanding their capacity. It is believed that with a five-year timeframe these networks will operate with capacities well above 10 Gb/s.

The access networks connecting the end-user are very diverse with respect to network topologies, protocols etc. Access networks include extensive networks connecting end-users from many different locations within the same research institution, but also networks providing access to a limited number of users concentrated at one location.

Moreover, the networks provide a broad variety of data rates to a substantial number of users. The bursty, asymmetric and more or less unpredictable nature of traffic on these networks presents many challenges, especially if the predicted growth of real-time applications and the ever growing number of users are taken into account.

In spite of these differences there are also similarities. The three types of networks must all meet the following challenges[6]:

- Flexibility, enabling significant interchanges to offload traffic in various ways
- Optics must be adapted to distance – in long-haul networks, systems must allow the optical signal to span huge distances without requiring regeneration, whereas cheaper optics may be preferred for shorter distances
- Links with heavy traffic must be able to carry maximum traffic.

These matters can be handled in different ways. The demand for capacity fluctuates and varies from location to location, and user needs may develop across the three levels presented above. One particular application may sometimes generate a very substantial part of the total traffic load and may require special facilities in some routes in all of the three network levels.

An uneven distribution of capacity needs implies that a non-discriminatory approach where the same capacity is provided to all locations might be inefficient. Examples[7] of advanced research networks worldwide show that there is a trend to move away from the former monolithic approach.

2.2. Alternative Models for Research and Education Network Infrastructures

The economic analysis in this report will take the three-level research network model as presented above as a point of departure. However, this current model might be partly changed in the future, in order to improve and simplify the operations and management of the various networks.

Some alternative solutions are described below, together with the benefits and the disadvantages that they would bring. However, these models should not be seen as replacements of the current model, but more as sources of inspiration for future network design. Some of the suggestions are definitely not suitable for a full-scale implementation, but might be used in some regions or parts of a new network structure.

Nevertheless, because the alternative solutions, even when only partially and modestly implemented, would have some impact on the connectivity requirements brought to the infrastructure market by the research and education networking community, it is of interest to consider them in this report.

2.2.1. Regional networks

One of the options would be to create a number of regional networks, which when interconnected would serve as a simpler trans-European network, with less connection points than the current one, because some of the national connection points would be moved to the regional networks. This solution would also make a new trans-European research network backbone network smaller and thereby less complex, by transferring some of its workload, operational management and connection points to the new regional networks. The model is illustrated in Figure 2 below, by a five-node European research network backbone, where each regional network connects three or more national research and education networks.

One example of a regional network already exists in the Nordic countries, where a regional network (NORDUnet) has been in place for several years. NORDUnet is the Nordic Internet highway to research and education networks in Denmark, Finland, Iceland, Norway and Sweden. It provides connection between the Nordic backbones and the global set of research networks, by connecting to other research networks (to GÉANT, to Abilene and to other networks via the STAR TAP / StarLight[8]) and it provides connectivity to the general Internet through connections supplied by Sprint and Level 3 Communications. The topology of NORDUnet is shown in Figure 3 below.

[6] Introduction to optical transmission in a communication network – http://www.iec.org/
[7] see SERENATE deliverable D3 "Report on the experience of various user communities that have experimented with "alternative" models of acquisition"
[8] http://www.startap.net/

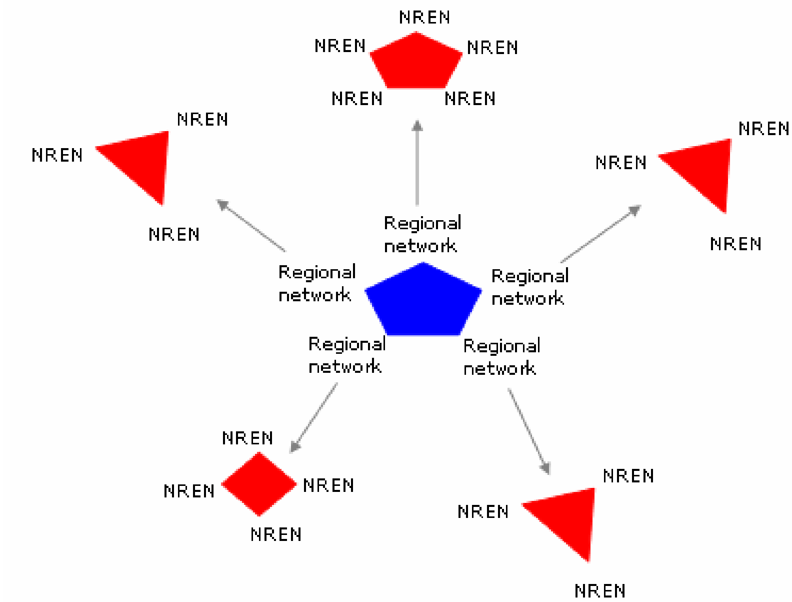

Figure 2. Topology based on regional networks

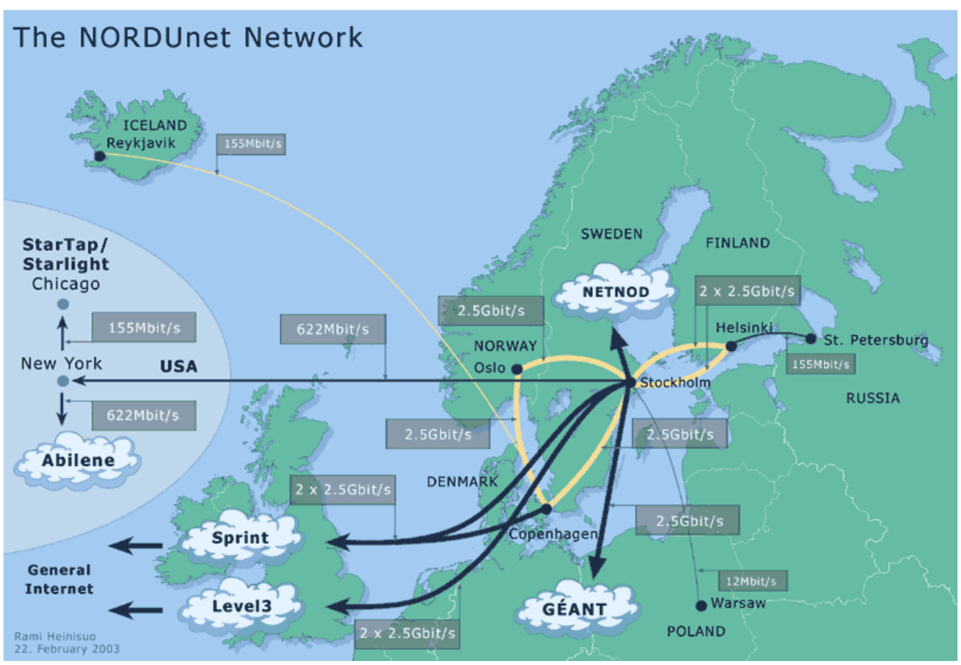

Figure 3. The NORDUnet network

It can be seen in this figure that NORDUnet is connected to GÉANT through a single node located in Stockholm. However, NORDUnet is also connected to the outside world via other connections from Stockholm, Copenhagen and Helsinki.

2.2.2. Border crossing and border hopping

Another alternative approach for building a future pan-European research and education networking infrastructure could be to replace the trans-European backbone network by direct interconnections between national research and education networks in neighbouring countries. Such an interconnection model could either follow the present GÉANT topology with one international node in each country, or it could have a more decentralised approach with the creation of direct links between research institutions on both sides of a border. This approach would eliminate the trans-European level, by interconnecting the various national networks directly and thereby creating a virtual pan-European network. Potentially this approach could lead to cost savings, because the international traffic would in part be channelled through national links and the need for long international links would be limited.

However, such an approach will also create significant management problems with respect to operations and maintenance of the border-crossing links. Different national research and education networks may use different types of equipment and network design; they may also have different approaches towards operations and maintenance, and have different strategies for network expansion. These problems will extend beyond the border-crossing links, since no single organisation will have the entire responsibility for international communications. If, for example, communication fails between London and Milan then several national research and education networking organisations must be involved in identifying and correcting the problem.

Border hopping, i.e. combining the border-crossing concept as described above with some form of ownership of the international fibre/wavelength/capacity, will be most attractive for countries where market prices for international connectivity are very high, and in situations where the distance between nodes connected to two different national research networks is relatively short. In the latter situation border hopping would be particularly attractive for stretches (e.g. Berlin-Poznań) where it is possible to establish a direct NIL[9] connection, which could be operated by the national research networking organisations without involvement of a public network operator.

If one would want to use the opportunities offered by border hopping, then it is important to give careful consideration to the location of the trans-European research networking infrastructure's Point(s) of Presence in each country: a location close to the borders of neighbouring countries would make it possible to construct a NIL connection between two or more countries.

Border hopping will not necessarily replace the three-level structure of European research networks completely. However, border hopping might be a suitable solution to establish direct interconnection between research institutions in neighbouring countries with special communication needs, as a complement to the trans-European network. Examples could be between Poland, Germany and the Czech Republic, or between Austria, Slovakia, Hungary and Slovenia.

2.3. Ownership Options

The liberalisation of the European telecommunications market allows organisations that provide network services to users in the research and education communities – for example, national research and education networking organisations or DANTE – to invest in their own telecommunications facilities. These organisations may therefore consider various models for ownership of the telecommunications facilities that they are using, such as full ownership of fibres (laying fibres and lighting them), dark fibres (buying dark fibres from operators or carriers on a time-limited contract and lighting them by deployment of own transmission equipment and end-equipment), managed dark fibres (buying dark fibres from operators or carriers but giving them the responsibility for amplification and possibly regeneration of signals), direct access to fibres (buying wavelength connections from public operators or network carriers) or buying of capacity (buying specific levels of capacities from operators and carriers between two or more points). Forms of ownership may be preferred either for purely economic reasons – for example, if prices charged for leased lines exceed the costs of ownership with a considerable margin – or because direct ownership enables more control over the network.

[9] Nothing In Line – see for an explanation of this technical concept SERENATE deliverable D9 "Report on the availability and characteristics of equipment for next-generation networks"

A description of the various forms of ownership and the associated costs is outside the scope of this report[10]. For the context of the present report it is important to realise that the (potential) availability of different Do It Yourself approaches as an alternative to leasing lines from public operators may strengthen the position of research networking organisations as parties on the demand side in the international connectivity market.

[10] These issues will be described in detail in the subsequent SERENATE deliverables D14 “Report discussing future scenarios for the funding of network infrastructure in the European research networking community, and of related costs” and D18 “Report outlining scenarios for the evolution of the pan-European infrastructure for European research and education networking”

3. Regulatory Aspects

There are two reasons why telecommunications regulation is important for research and education networks:

1. Regulation affects the market for the provision of telecommunications services and thereby the conditions under which the research and education networks can lease lines etc.

2. Regulation affects the conditions for how research and education networks can construct and operate their own networks.

Both the current European Union member states and the accession countries aim to implement the EU framework for telecommunications regulation. All the member states are requested to implement the new communications regulatory package by July 2003. However, it seems that the implementation will be delayed in several countries, and a few countries may not be able to implement the package before 2004.

3.1. Market Issues

In regulation and market conditions there is no sharp border between the EU member states and the accession countries; rather there is a sliding scale, basically following the ranking from low-income to high-income countries.

The most important problems for competition that have been encountered in some countries under the existing regulation are:

- Apparently unreasonable refusal of licenses, or licenses being granted for a short period, with high fees or on very difficult conditions

- Lack of co-operation or even outright opposition from an obstructive incumbent operator, delaying interconnection or provision of other facilities.[11]

These problems can be related to, among others, the governments having a financial interest in the incumbent operator, inadequate separation between the branches of government responsible for regulation and the branches responsible for the financial interests in the telecommunications sector, a long history of bureaucratic traditions, and vulnerability to improper interference from politicians and public officials. Such issues cannot be resolved from one day to the next, and they may even not be resolved entirely by the full implementation of the new telecommunications regulatory package, which has the introduction of real competition as its major objective.

Furthermore, it must be noted that regulation can only facilitate competition. Basically, for real competition to be created new suppliers must enter the market, and that is only attractive for them in areas with a sufficient level of demand. In low-income areas or areas with a low density of population, only limited competition can be expected on the type of services that are demanded by the research and education networks. This implies that excessive levels of charging can be maintained more easily. In turn, this will make it more attractive to (national) research and education networking organisations to establish their own network facilities.

3.2. Regulatory Issues Affecting Ownership Options

A monopoly in the provision of fixed-line telephony infrastructure, as existed in a number of accession states until January 2003 and as still exists in Turkey and a large number of countries that are not candidates for EU membership, typically prevents that national research and education networking organisations deploy their own networks and forces them to lease capacity or rely on data transmission services from the monopoly provider.

[11] see SERENATE deliverable D7 "Report on the expected development of the regulatory situation in European countries relevant for the SERENATE project"

In a liberalised market, research and education networking organisations have the possibility to choose between leasing capacity from operators and building their own physical infrastructure. If networking organisations deploy their own infrastructure there are additional questions of access to scarce resources, in particular rights of way (RoW) and radio frequencies. In this situation research and education networking organisations must have RoW in order to lay cables. When using radio links or radio access facilities they need rights to mount their radio transmission equipment on masts and they need access to radio frequencies.

In a liberal regime without special rights of any operators to build and operate communications infrastructures, there should be no overall impediments of a communications regulatory character for national research and education networks to establish self-owned infrastructures. Furthermore, no matter which kind of infrastructure research and education networks choose to implement, there will be technology-neutrality under the new EU regulation, meaning that different kinds of infrastructures will be regulated in the same, neutral manner.

Under the old EU regulation, obligations to obtain licenses and the conditions under which such licenses are granted could constitute limitations on the establishment and operation of networks in various countries. However, with the 'light-handed' type of authorisation in the new EU regulatory package, research and education networks and other entities operating communications networks are not required to obtain permission but only to notify national regulatory authorities. This definitely makes it easier for national research and education networks to choose the network solutions that are best fitted to their needs.

However, the question of RoW still has to be taken into consideration. If one wants to lay one's own cables, it is necessary to obtain RoW and accompanying permissions, for example, to dig up streets or put down cables on private properties. These kinds of rights used to be available normally only to public network operators. However, in a liberalised regime anyone can apply for RoW and should receive fair treatment based on objectively justifiable grounds.

Authorities responsible for granting RoW in the different countries vary. In some countries RoW are granted by local authorities, while in other countries such rights are awarded in a more co-ordinated manner at the national level. Or a combination of local and central authorities is involved. RoW may be a real hurdle and this is an important issue for national research and education networks to be aware of.

In addition to the RoW question, there may be other hindrances for research networks that wish to deploy their own infrastructure. As publicly owned or at least publicly supported entities, national research and education networking organisations may be subject to certain political priorities and decisions, or there may be provisions in the statutes of these organisations that make it difficult for them to own proprietary infrastructure. However, these kinds of limitations on national research and education networks are specific to a national situation, and they are not determined by telecommunications regulation.

Besides these basic issues, there is also the question related to the status as public or private network, and the conditions attached to these designations. If a network is private, meaning for a closed user group and not open to the public in general, then it cannot be made subject to the same obligations as public networks with respect to, for example, interconnection and quality of service and security. A private network does not have the same rights to negotiate interconnection agreements with public networks and to obtain cost-based interconnection process (which should be lower than end-user prices) for the use of transmission capacity. However, big customers like national research and education networks will in most cases have the possibility to negotiate special discount rates with the providers of capacity anyway.

If national research and education networks obtain the status of public network providers, they will not only have rights but also obligations, for example to interconnect to other networks.

In the current situation, the public or private status of national research and education networks is not always clear. This applies both to such networks in the existing EU members states and in the candidate countries. The, at times, unclear status stems from the fact that some national research and education networks not only provide services to public research and higher-education institutions, but also to schools[12], to private research

[12] A number of case studies of user communities outside research and higher education using the facilities of national research and education networks will be published in SERENATE deliverable D15 "Report on examples of extension of research networks to education and other user communities"

organisations, and even to the broader public as is the case with, for example, LATNET in Latvia. In cases where national research and education networks provide services outside the relatively closed user group of public research and education institutions, they may be categorised as public networks, which entails regulatory obligations and rights that are different from those in a private-network situation.

The Authorisation Directive[13] in the new EU communications package covers both public and private networks. In the directive it is stated that it “covers authorisation of all electronic communications networks and services whether they are provided to the public or not”. It is further stated that this “is important to ensure that both categories of providers may benefit from objective, transparent, non-discriminatory and proportionate rights, conditions and procedures”. The authorisation regime of the Authorisation Directive is light and the provision of electronic communications networks and services may only be subject to a general authorisation, meaning that “the undertaking concerned may be required to submit a notification but may not be required to obtain an explicit decision or any other administrative act by the national regulatory authority before exercising the rights stemming from the authorisation”.

Consequently, the authorisation regime itself should not present any difficulty for national research and education networks. A notification to the regulatory authorities is sufficient. However, a clarification of the status of the national research and education networks as public or private providers is necessary.

In addition to allowing also research and education networks to build their own infrastructures, the telecommunications regulation affects the viability of different options for ownership through its impact on the structure of the telecommunications market.

Unbundling of the local loop may be an important case. The European Union framework does not require general unbundling of the local loop, but only for copper-based networks. Therefore telecommunications operators do not need to offer dark-fibre facilities to their customers. National regulators are allowed to extend the requirement for unbundling to optical network facilities. This has been done in Denmark, for example, and public network operators in that country are therefore requested to provide dark-fibre facilities to other operators, for instance research networks. However, this is not generally the case in Europe, resulting in an additional obstacle for research and education networks in a number of countries.

Besides the telecommunications regulation, the decision on ownership is also affected by a number of other rules and regulations, for example taxation. One example is that some network facilities such as ducts may be subject to property tax, as is the case in the United Kingdom. This type of expenses must be taken into consideration when deciding about building one’s own physical infrastructure.

[13] ‘Directive 2002/20/EC of the European Parliament and the Council of 7 March 2002 on the authorisation of electronic communications networks and services’, Official Journal of the European Communities, 24.04.2002

4. Trends in Bandwidth Demands

This chapter analyses and forecasts the future demand for bandwidth in the European research and education community, based on historic data and current trends in usage. Furthermore, the implications are discussed of the present structure of demand with a small minority of users demanding very high levels of capacity and the majority of users requesting much lower levels of capacity.

4.1. Bandwidth Demands

The capacities of fibres that were installed more than ten years ago are being depleted by the ever increasing bandwidth demand, requirements for high availability and higher usage rates, coupled with a deregulated telecommunications environment and very sophisticated and sensitive transmission equipment. The depletion is mainly due to the fact that these 'old' fibres cannot serve state-of-the-art transmission equipment and their very high transmission rates. On the other hand, only a fraction of the fibres laid out in Europe is actually used today.

On the user side, different groups are demanding very different network capacities. This implies that different solutions should be established to meet different requirements, moving away from the even, non-discriminatory and monolithic structure of research networks[14]. It is a clear trend that a few large-capacity users are generating the majority of network traffic and that the normal- or average-capacity users only generate a fraction of the overall traffic load, as illustrated in Figure 4 below.

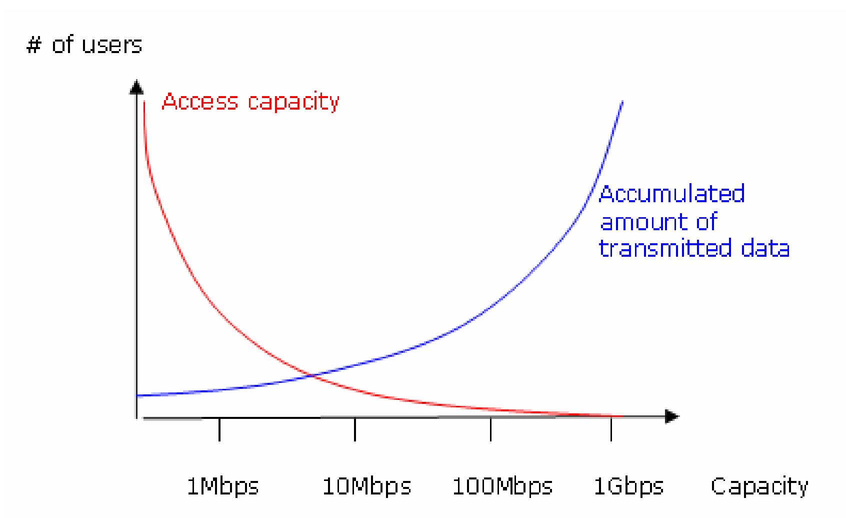

Figure 4. Structure of demand

These very different usage patterns among European researchers suggest that other approaches might be more efficient than the current European research network model, where all users are connected to the same network on an equal basis. One solution would be to create two or three levels within the same network, where the different levels offer different services and most importantly: differentiated network capacities. Another solution would be to construct the next generation of research networks by using different 'building blocks', allowing the various connected entities to configure their own connection services and capacity, based on these building blocks for services and capacities.

Together with the increased demand for bandwidth, reliability and availability also become increasingly important for many users. Network communications is becoming more critical to the users and therefore the

[14] see SERENATE deliverable D3 "Report on the experience of various user communities that have experimented with "alternative" models of acquisition", page 3

'operators' have to ensure that their networks are fault tolerant. This is generally solved by providing backup routes introducing simple one-to-one redundancy in ring or point-to-point configurations.

4.2. Backbone Capacity and Traffic Trends

The historic capacity levels of the different generations of the European backbone networks interconnecting the national research and education networks are shown in Figure 5 below. It illustrates a more than exponential growth in the backbone capacity. Furthermore, the lifetime of the different generations is decreasing. The first two generations were in operation for approximately four years, the last three (excluding GÉANT) were in operation for two to four years. This declining trend for operation time or lifetime of backbone networks reflects the very high growth rates in backbone capacity over the last decade.

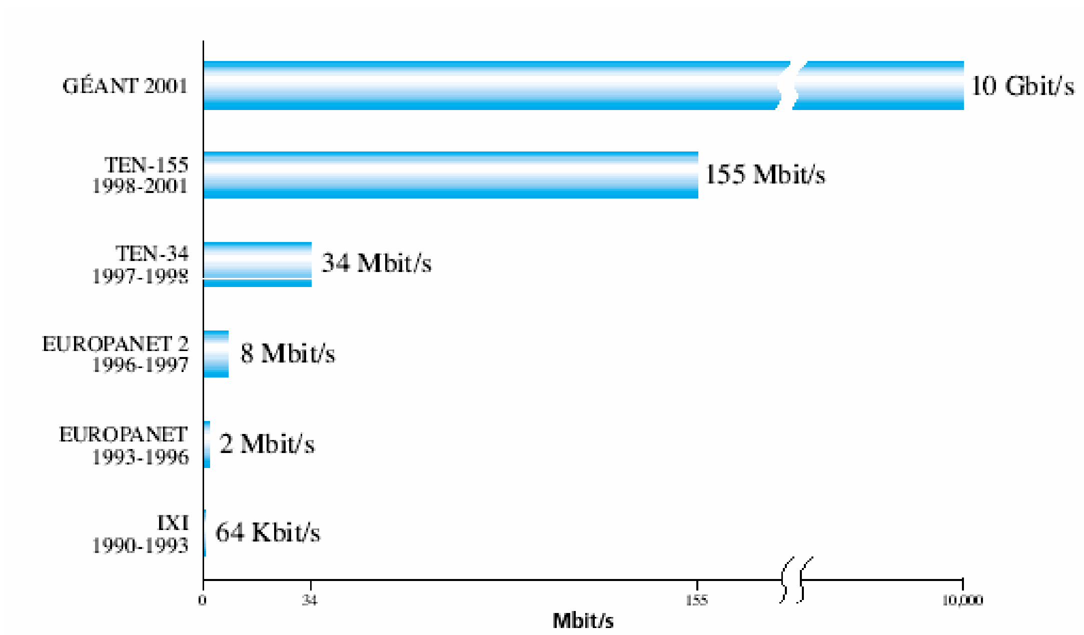

Figure 5. Development in backbone capacity levels

Looking at the development in traffic volume, the picture is more or less the same. During the last six years, the annual growth factor for the pan-European traffic volume has been 2.4 on average. The monthly traffic volume and the year-to-year traffic growth are shown in Figure 6 below.

The gap between transmitted and received traffic in September 2002 was approximately 22%, which more or less represents the average monthly percentage gap between transmitted and received traffic. For the whole of 2002, 1.5 Terabytes (1,500,000,000,000 bytes) of data were received more than were transmitted, which represents a difference equalling 27% on a full-year basis.

Based on the average growth rate, the projected traffic volume is going to be approximately 33 times bigger in 2006, compared to the 2002 figures. Following these numbers, the traffic volume in September 2006 will equal 20 Petabytes (20 million Gigabytes). See Figure 7 below.

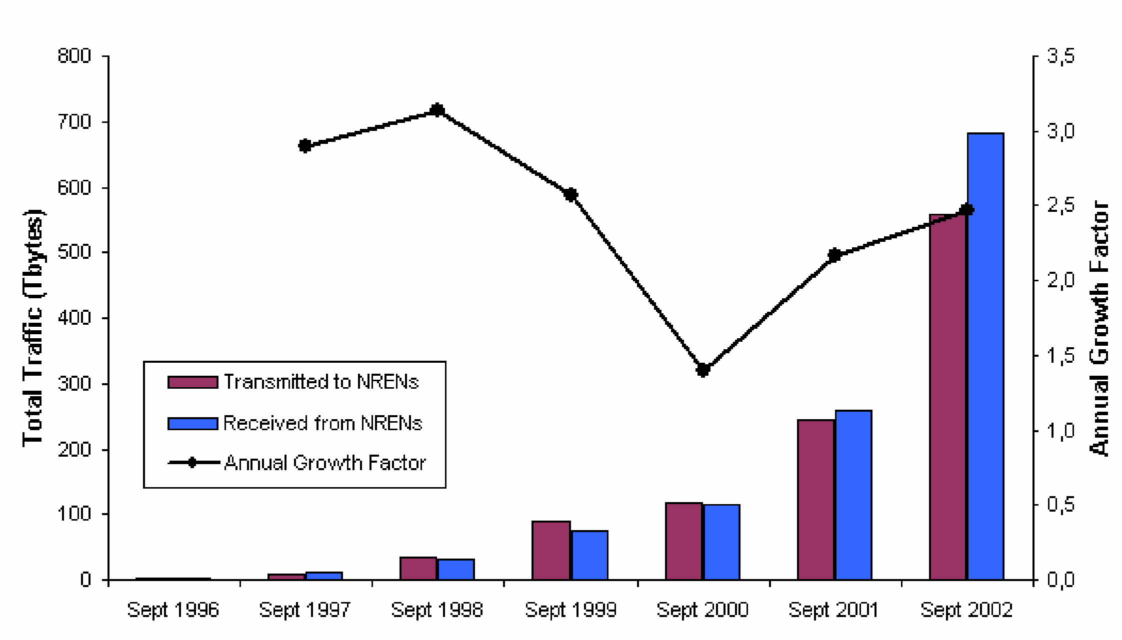

Figure 6. Monthly traffic volume and year-on-year volume growth

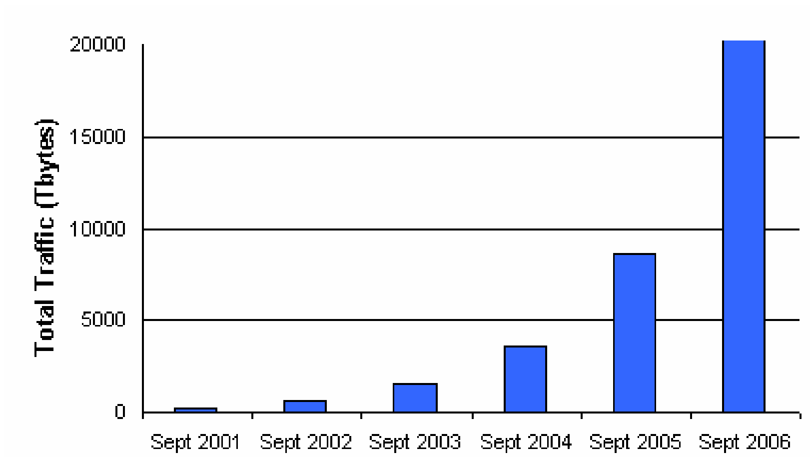

Figure 7. Predicted incremental monthly traffic volume (transmitted and received)

These figures are based on expected incremental growth and do not include an expected increase in the deployment of Grids, which will demand very high bandwidth for special locations and tasks. It is believed that the demand from Grids and the related traffic volume will double the traffic in 2006, which means that the average traffic volume in September 2006 is estimated to be 40 Petabytes (40 million Gigabytes).

However, in line with the trends indicated above, it is believed that the Grid applications will be used only by a limited number of entities generating the majority of the traffic, whereas the majority of the users have relatively 'normal' bandwidth demands. In addition to pure bandwidth, the future usage of Grid applications is also believed to be influenced by geographic considerations and the cost structure of getting connected. The geographic considerations are mainly related to the number of entities that a single Grid network will consist of and where these are located, which is also related to the cost structure of providing Grid capacity levels.

The unknown factors that influence the deployment of Grid applications, for example geographic considerations, the bandwidth required and the price and cost structure, make it very difficult to predict that deployment.

Today there are no serious bottlenecks in the GÉANT network, and almost all users have the bandwidth that they need. However, the expected demand for Grid applications and their high bandwidth requirements could prove to be a major challenge in the near future. These applications will demand delivery of extreme capacity levels at specific locations for a limited time period.

5. Trends in the Telecommunications Markets

5.1. Trends in the European Markets for Telecommunications Infrastructure Services

The trend in the pricing of telecommunications services has been a decreasing one over the period 1998-2002, with large reductions in the prices on the most competitive international connections. The reasons for the dramatic reductions are:

- Deregulation and a subsequent competition in key markets
- New network technology enabling huge capacity per fibre strand
- Unprecedented availability of very low cost capital.

While network technology will continue to develop, deregulation in itself will not lead to further price reductions in markets where competition has been established already. However, deregulation can be expected to have a significant impact in countries where real competition still has to be seen, mainly in Eastern Europe.

The worldwide bandwidth pricing index has shown a drop of 55.5% in 2001-2002 with the European index dropping 64.8% over the same period. But it is expected that the market will stabilise, because bankruptcies have reduced the number of providers, leaving the survivors with less competition.

In addition, more companies see the benefits of service provision over network acquisition. Transactions for dark fibre are still being made but largely to meet specific demands and, therefore, smaller in scale geographically and very location-specific[15].

In parallel, however, the divergence of connectivity prices has increased greatly in this period.

Country	1998	2002
Austria	48,691	33,000
Belgium	126,095	24,529
Denmark	38,794	34,794
Germany	59,244	10,085
France	56,939	46,650
Italy	98,788	66,324
Luxembourg	-	8,671
Sweden	15,151	15,151
UK	117,968	100,363

Table 1. Prices for national connections: 140/155 Mb/s, 200 km (euro per month)[16]

Also prices for leased lines have fallen in the last years, but these price reductions are less dramatic. The EU average prices for high-capacity leased lines have been reduced by 25-45% in 1998-2002, mostly for long distances. The EU average price for a national line of 200 km at 140/155 Mb/s is now 400,000 euro per year, while international connections are more expensive[17]. Price differences between the cheapest and the most expensive locations are also very significant here. SERENATE deliverable D6 reports differences in prices for international connectivity to be up to a factor of 39 if the accession countries are included[18].

The key parameter here seems to be the level of competition. In markets with limited competition, the

[15] Total Telecom, 25 June 2002.
[16] Source: Teligen: Report on Telecom Price Developments from 1998 to 2002. Produced for: European Commission Directorate General for Information Society.
[17] Commission staff working paper: Technical Annexes of the Eighth Report on the Implementation of the Telecommunications Regulatory Package. SEC(2002) 1329 Brussels, 3.12.2002.
[18] SERENATE deliverable D6 “Report on present status of international connectivity in Europe and to other continents”

responses from each operator are crucial for pricing and availability of services. Of the European countries currently connected to GÉANT, around half can be considered to have competitive internationalised markets for telecommunications. In the remaining countries, prices remain high and, in some countries, the availability of advanced building blocks is very restricted.

The strong correlation between the number of suppliers and the price levels is analysed in SERENATE deliverable D6. From analysis of the GÉANT tender data, it is apparent that at least four international suppliers are necessary to create a reasonably competitive market. Operators expect that competition in Eastern Europe will increase during the next five years. But in spite of the extension of the EU regulatory framework to the accession countries, most operators do not envisage a further build-out of their fibre-optic networks in the short to medium term. The number of suppliers will therefore remain limited at least in some of the countries connected to the GÉANT network.

One problem is that GÉANT demands services for which there is a very limited market both in terms of suppliers and in terms of the number of customers. While research networks may want 80 Gb/s as the building blocks for the future infrastructure, operators see no serious demand for 40 Gb/s connectivity, and none of them have it as part of their portfolio.

One solution to this problem is to lease dark fibres directly from operators, but this may not be an option everywhere. Unbundling of fibre facilities is not part of the EU regulation and is only required in a few countries. International telecommunications operators are divided on the issue of dark fibres. Some refuse to sell or lease dark-fibre facilities as this will harm their core business, while others offer dark fibres as part of their product portfolio[19]. Most operators offer wavelength solutions and recommend this to their customers, as this gives the benefits of a dark fibre without the associated capital investment.

5.2. Market Scenarios for Telecommunications Infrastructure Services in Europe

It is not possible to predict with any accuracy the way that the market for international telecommunications in Europe will develop in the next five years. Today the European countries can be categorised in four groups of markets:

- Liberal markets with transparent pricing: Belgium, France, Germany, Italy, the Netherlands, Switzerland, the United Kingdom and the Nordic region
- Liberal markets with less transparent pricing structure: Austria, the Czech Republic, Hungary, Ireland, Luxembourg, Slovakia and Spain
- Emerging markets without transparent pricing: Croatia, Poland and Slovenia
- Traditional monopolist markets: Bulgaria, Cyprus, Estonia, Greece, Latvia, Lithuania, Malta, Portugal and Romania

Three scenarios are constructed to show how the markets in the four groups could develop:

1. An optimistic scenario with annual price reductions of 10% in the liberal markets and convergence towards the same level in the other groups of countries, resulting in a uniform market price
2. A neutral scenario with annual price reductions of 10% within each group of countries
3. A pessimistic scenario with slight increases in prices on liberal markets, while emerging and de-facto monopolistic markets remain stable.

Market developments in the four groups corresponding to the three scenarios are discussed below.

[19] see SERENATE deliverable D4 "Report on workshop on operators' views on infrastructure and likely evolution"

Scenario 1: An optimistic scenario

In this scenario there is growing competition, particularly in the accession states and in the less liberalised parts of the European market. The very large difference of prices between inexpensive and expensive locations essentially disappears. Direct access to infrastructure or to very high speed data links becomes ubiquitously available internationally at prices that relate directly to the cost of provision of service. In the GÉANT environment this will make the issue of cost sharing between national research and education networks significantly easier.

This scenario is unlikely without significant political initiatives to foster and develop a competitive and transparent market in telecommunications.

There are a number of factors to be taken into account. Firstly, some of the companies that invested heavily in trans-European networks following liberalisation – notably KPN Qwest, Global Crossing and Teleglobe – have either left the market, failed or sought protection under the Chapter-11 status. The entry on the market of these new players was the catalyst for very significant investment and large reductions in price. The remaining players who offer trans-European connectivity are either not yet profitable "in the strict sense of the word", e.g. COLT, Level 3 Communications and Telia International Carrier, or are 'old incumbents' such as Deutsche Telekom, British Telecom and France Télécom, where the international networking business is adjunct to their domestic business. The domestic business is typically suffering from very large levels of debt related to the auctions for Third Generation mobile licenses. As a result, there is currently very limited free capital available for investment. In the absence of significantly rising demand, it will be impossible to make the case for large-scale investment in a difficult economic environment.

For some of the countries with a less liberalised market it is possible that competition will increase. This will give rise to reductions in prices from their current high levels, although much will depend on the extent to which alternative network operators emerge. As prices are much higher than the underlying costs, there is scope for profitable business in this marketplace. It is likely that other infrastructure providers, e.g. electricity and gas companies, have also invested in fibre-optic capacity without exploiting the investment as telecommunications operators. A successful development of the telecommunications market will depend on owners of fibre-optic capacity recognising that there is a business case to be made exploiting such capacity, rather than on the incumbent providers.

Scenario 2: A neutral scenario

In this scenario there is more limited development of the market with little, if any, changes in the regulatory intervention to encourage a competitive international marketplace. As a consequence, the price differences between inexpensive and expensive countries will remain. In parts of Europe, the availability of direct access to infrastructure or to very high capacity connectivity services will be seriously limited. As market liberalisation gradually develops, it is likely that there will be some modest reduction in prices of connectivity, together with an increase in the availability of direct access to high-capacity wavelength connectivity. As a result, the commercial and technical distortions apparent in GÉANT today will continue for the foreseeable future. The overall picture is one of stability, in terms of the infrastructure providing pan-European connectivity.

Today, the liberalised market covers the major financial and economic centres in Europe. It is likely that demand between these locations will be maintained and further developed. Prices will decline at a moderate rate. However, one exception will be that prices and costs will become more closely aligned than is the case today. The cost of DWDM capacity is heavily distance-dependent, with break points for spans over 200 km and over 600 km. The underlying investment required to implement a span of 2,000 km is approximately three times the investment that is required for a span of 600 km. This is not reflected in pricing today. As the market rationalises, it is likely that shorter-distance routes will see bigger reductions in price than longer-distance routes, which are more competitive today relative to costs.

For the de-facto monopoly markets and emerging markets, some incremental investment will occur, which will improve the competitiveness of international routes to and from these countries. This could lead to quite significant reductions in prices, in the order of multiples of 10% per year. However, there is no driving force or political initiative likely to make this happen. There are some signs that owners of fibres outside the telecommunications sector are prepared to make them available to third-party operators. This will give rise to some investment for certain routes.

Scenario 3: A pessimistic scenario

In this scenario further market failures occur among the alternative operators. As a consequence, the market will revert to its former structure, where dominant national operators are the major providers of international services. They may well extend their networks with a limited footprint to meet the basic requirements for international connectivity, but the majority of connectivity is provided via interconnection agreements similar to the old ‘half-circuit’ arrangements for the provision of international connectivity prior to deregulation.

In this scenario there will be very considerable divergence of price, with a reasonably competitive market between those countries where there is maximum investment today – namely France, Germany, the Netherlands, the United Kingdom and Belgium –, and much more limited competition in other regions. This scenario will lead to greater divergence of price to the extent where it will be difficult to organise effective cost sharing in the GÉANT environment and where access to infrastructure will vary significantly between countries. It is likely that for the research and education community this will lead to limited pan-European interconnection with relatively low capacity. It could lead to a complete fragmentation of the provision of research networking.

The alternative operators have invested significantly in building trans-European networks. However, as a consequence of the fact that the national bankruptcy legislation in Europe does not have an equivalent to the US ‘Chapter 11’, whenever one of these operators failed, its infrastructure was disposed of in a piecemeal way and the coherent network was destroyed. None of the current alternative operators are profitable yet, and it is likely that they will see the pan-European market demand as being significantly overstated. Even growth factors of 2 to 2.5 per year in Internet traffic are unable to fill the installed capacity internationally across Europe within a period of five years. A further complication is that Internet traffic is not especially profitable. The major current source of revenue, i.e. switched voice services for mobile operators, is a very competitive market with large-scale purchasers and it does not generate significant profitability either. Further company failures will result in unconnected infrastructure across major parts of Europe. As a consequences of these failures, there will be no incentive whatsoever for investment in the markets emerging from the traditional monopolist environment. The absence of any emerging competition will entrench current prices. The reduction of competition in the more liberal parts of the market will lead to general price increases.

Implications

The three scenarios have very different implications for how service cost and prices will develop in different parts of Europe. This can be illustrated by the table below, where the forecasted price ranges according to each of the four different categories of countries are depicted.

	Initial cost range	Annual change in prices	Cost range after 5 years
Scenario 1			
Liberal markets I	1-1.4	-10%	0.6-0.8
Liberal markets II	1.8-3.3	-20%	0.6-1.1
Emerging markets	7.5-7.8	-40%	1.2-1.3
De-facto monopolistic markets	18-39	-50%	0.6-1.2
Scenario 2			
Liberal markets I	1-1.4	-10%	0.6-0.8
Liberal markets II	1.8-3.3	-10%	1.1-1.9
Emerging markets	7.5-7.8	-10%	4.4-4.6
De-facto monopolistic markets	18-39	-10%	10.6-23
Scenario 3			
Liberal markets I	1-1.4	10%	1.6-2.2
Liberal markets II	1.8-3.3	5%	2.3-4.2
Emerging markets	7.5-7.8	0%	7.5-7.8
De-facto monopolistic markets	18-39	0%	18-39

Table 2. Forecasting of telecommunications service prices by group of countries in the three scenarios

5.3. Connectivity to Other Continents

Currently, the primary intercontinental route from Europe is that between Europe and the United States. It is characterised by multiple, modern, DWDM based, cable systems. As a consequence, when considering the much greater distances involved, prices for wavelengths on these systems, although higher by a factor of 2-3 than equivalent intra-European wavelengths in the liberalised market sector, are comparable with the most competitive intra-European prices. In absolute terms, they are competitive when compared with the non-liberalised markets in Europe. This implies that it is relevant and sensible for Europe to interconnect as a region with North America as a region.

Today, there are five modern transatlantic cable systems. All of these systems terminate on the East Coast of the United States. In Europe, the systems terminate in countries with an Atlantic seaboard. The main cables land in Ireland, the United Kingdom, France, the Netherlands, Denmark and Germany. Although it is possible to obtain transatlantic connections between the principal cities of Europe and the United States, the cables generally terminate at a limited number of locations and the most cost-effective connectivity is available between these limited landing points. The price evolution of transatlantic connectivity has been very similar to that for intra-European connectivity. Figure 8 shows the way this has evolved in recent years, as perceived by DANTE from the offers that it has received. As the market for connectivity to North America is comparable to the fully liberalised markets in Europe, what has been said in the previous section about those markets can be expected to apply as well to connectivity across the North Atlantic.

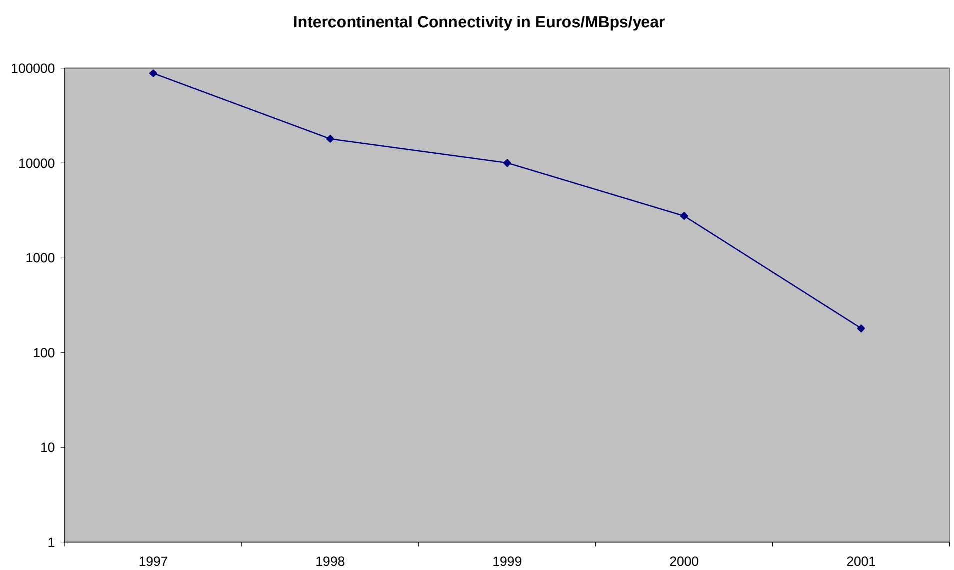

Figure 8. Intercontinental connectivity price evolution Europe-USA route[20]

The situation is very different for connectivity between Europe and other world regions – Africa, Latin America and Asia-Pacific –, where the market is much more fragmented and expensive. As to Latin America, some experience has been gained very recently in the context of the ALICE project[21], which implements the recommendations of the CAESAR study[22]. The EC funded CAESAR study was carried out by DANTE between March and October 2002 and investigated the feasibility of a Latin-American regional research network connecting the Latin-American national research and education networks with each other and to GÉANT. It is expected that the intra-regional Latin-American research network and its direct connection to GÉANT will be operational in the beginning of 2004. A first test of the market for connectivity between Europe and Latin America has shown that it is indeed possible today to obtain connectivity with reasonable

[20] The figure plots the development of normalised intercontinental connectivity prices between Europe and North America. The more recent data represents much higher speed connections taken up by the research and education networks. The connectivity taken up by DANTE has evolved from 34 Mb/s connections in 1997 to 2.5 Gb/s in 2001.
[21] see http://www.dante.net/alice/
[22] see http://www.dante.net/caesar/

capacity at affordable prices, although competition is limited. It is very difficult to predict how this market will develop in the next five years. The situation is far less positive as regards connectivity between Europe and countries in North Africa and the Middle East. The EUMEDCONNECT project[23] is to a certain extent similar to ALICE; it aims to establish interconnection for research networking between Mediterranean countries as well as between those countries and GÉANT. Here DANTE's recent exploration of the connectivity market has produced very disappointing results. Connectivity between countries to the south and east of the Mediterranean is hardly available at all, and for some of these countries connectivity to the countries currently connected to GÉANT is simply not being offered with a reasonable capacity at an affordable price. Strong political pressure will be needed in order to make it possible to connect those countries to GÉANT in the near future. Basically the market for connectivity in those countries is still that of a traditional monopoly. In some of the countries there is no perspective of a political initiative to change the telecommunications regulation and policies. As a consequence, unless the situation changes dramatically, prices of connectivity to these countries can be expected to remain excessively high. For the research and education community in the region this means that the very best to be achieved in the next years will be a very limited connection to other world regions with very low capacity.

[23] see http://www.dante.net/eumedconnect/

6. Conclusions

The purpose of this report is to analyse the development of the transport infrastructure for European research and education networks within a five-year perspective. This evolution depends on a wide range of organisational, regulatory, technical and economic parameters. The regulation defines, for example, the rules related to various options for ownership and specifies possible special obligations. The organisation or structure of infrastructure providers sets the framework for how their networks are managed and affects the overall design. The technology adopted by providers defines the technical options and specifies characteristics, availability and prices of equipment. Together these factors determine the underlying costs for the operator. Finally, the market conditions in the connectivity market shape the availability of and the prices asked for various types of connections.

The European research networks are currently organised in a system of three levels (or four, if the intercontinental level is included):

- the pan-European level
- the national level
- the local level.

This hierarchy reflects the underlying organisational structure where each research institution operates its own internal network, which is connected to other research institutions via the national research network operated by the respective national research and education networking organisation. (In some cases there is an intermediate level of regional or metropolitan networks, which usually are not under the control of the national research and education networking organisation.) The national networks are interconnected via the pan-European GÉANT network, which is managed by DANTE.

A partial alternative to the current organisation could, for example, be the establishment of regional networks that cover a number of countries, like is the case with NORDUnet for the Nordic countries, or to replace the pan-European network by bilateral connections between bordering countries. The latter option could in theory reduce costs as international connectivity could be established by self-owned connections between neighbouring nodes close to the border (border hopping). However, this model would cause considerable problems in relation to organisation and management. In addition, the real savings might be small as fibre links between capitals are often cheaper than the much shorter links connecting smaller cities on each side of the border. The border hopping option will therefore only provide a feasible alternative in special cases.

There are two reasons why regulation is important to research and education networking organisations:

1. Regulation is shaping the market for telecommunications services and thereby the conditions under which the research and education networks lease lines, dark fibres etc.

2. Regulation affects the conditions for construction and operation of research and education networks.

The new European Union framework for telecommunications regulation aims to create a competitive market for telecommunications services and it was foreseen to be implemented by mid 2003. However, the implementation is delayed in some countries and inadequate procedures for licensing and interconnection will thus continue to hamper the development of real competition in the least developed telecommunications markets. In this respect there is no sharp border between the EU member states and the accession countries; rather there is a sliding scale basically following the ranking from low-income to high-income countries.

The European countries are categorised in four groups of markets:

- Liberal markets with transparent pricing: Belgium, France, Germany, Italy, the Netherlands, Switzerland, the United Kingdom and the Nordic region

- Liberal markets with less transparent pricing structure: Austria, the Czech Republic, Hungary, Ireland, Luxembourg, Slovakia and Spain

- Emerging markets without transparent pricing: Croatia, Poland and Slovenia

- Traditional monopolist markets: Bulgaria, Cyprus, Estonia, Greece, Latvia, Lithuania, Malta, Portugal and Romania.

Today there are huge differences between the four groups of countries in the price for high-capacity international connectivity. Setting the minimum price to 1, the prices vary from 1-1.4 in transparent liberal markets, 1.8-3.3 in less transparent liberal markets, 7.5-7.8 in emerging markets, and 18-39 in de-facto monopolistic markets.

Three scenarios have been constructed to show how the markets in the four groups could develop:

1) An optimistic scenario with annual price reductions of 10% on the liberal markets and convergence to the same level in the other groups of countries, resulting in a uniform market price

2) A neutral scenario with annual price reductions of 10% within each group of countries

3) A pessimistic scenario with slight increases in prices on liberal markets, while emerging and de-facto monopolistic markets remain stable.

The first scenario is considered unlikely without significant new policy initiatives. The probability of the two other scenarios depends among others on how the demand will develop. Up to now the telecommunications markets have seen dramatic decreases in prices for high-capacity lines, and on some routes the prices are now lower than the underlying costs, in particular for long distances. It is therefore possible that certain markets will see prices increase. On the other hand, technological developments and increasing demand will lead to cost reductions in the long term.

The new EU framework allows in principle research and education networking organisations to establish their own networks, but in reality there may still be problems related to getting a license and obtaining rights of way. Although these issues may complicate the construction of a national research and education network's own network facilities in some countries, the Do It Yourself approach will become a viable option also in the current de-facto monopolistic markets.

In markets where dark fibres and wavelength connections are either very expensive or not available, the research and education networks should consider acquiring own fibres – in particular if construction costs can be reduced through co-operation with other users or infrastructure providers.

Looking at the three scenarios for market development, a form of ownership of telecommunications facilities will in general not be viable in the first scenario, where prices in all parts of Europe will converge towards cost-based prices. This is because of the substantial economies of scale that can be exploited only by network carriers with high volumes of traffic. But even in this scenario the Do It Yourself option can be considered on a few shorter routes, where demand from others than the research and education networks is limited. A Gigabit Ethernet NIL connection provided on a dark fibre is the most attractive solution on routes where it is technically possible to implement.

In scenario 2), where the markets remain largely as they are today, ownership options should be considered for countries with de-facto monopolistic markets, and as far as national connectivity is concerned also in countries with emerging markets for routes outside the major cities. The same conclusion is valid for scenario 3). It should be noted however that even with a slight price increase prices in liberal markets will still be on a level that is too low to consider laying one's own fibre, thereby making the most far-reaching ownership option – laying fibres and lighting them all on one's own – not viable.

Finally, this also implies that the four groups of countries are likely to change, both in scenario 1) and in scenarios 2) and 3). Scenario 1) implies that there will be one competitive market in Europe. In scenarios 2) and 3) the use or just the potential use of the Do It Yourself model might push some countries into a more liberal environment. Which of the countries this will affect, will depend on demand and on network strategies adopted by the research and education networking organisations.

In any case, knowledge of the Do It Yourself model and of the possibility to implement it is useful in negotiations and important for future market shaping.