RESEARCH AND EDUCATION NETWORKS WITHIN THE CONTEXT OF INNOVATION SYSTEMS: THE CASE OF ULAKNET IN TURKEY

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ABSTRACT

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This thesis will examine national/multi-national/international research and education networks of the some countries in context of innovation systems, and then Turkish case will be discussed. The developed countries are the pioneers of research and education network efforts, developing and undeveloped countries were integrated to the global research networks. Although Turkey has a lot experience in academic networking, its NREN (ULAKNET) should adapt itself to the global trends(i.e. direct fiber access, IP/DWDM networks, very demanding applications like grid), and networking and supercomputing requirements in national innovation policies should be revised accordingly. Turkey can acquire some benefits from the global innovation policies and practices in order to improve its research networking infrastructure.

Keywords: research networking, research and education networks, research network infrastructures in innovation systems

ÖZ

YENİLİK (İNOVASYON) SİSTEMLERİNDE
ARAŞTIRMA VE EĞİTİM AĞLARI:
TÜRKİYE'DE ULAKNET'İN DURUMU

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Bu çalışmada dünyadaki bazı araştırma ve eğitim ağları, yenilik sistemleri kapsamında incelenecek ve sonrasında Türk eğitim ve araştırma ağı hakkında durum saptaması yapılacaktır. Gelişmiş ülkeler eğitim ve araştırma ağları konusunda öncülük yapmakta ve gelişen ülkeleri küresel araştırma ağına dahil etmeye çalışmaktadırlar. Türkiye, ulusal akademik ağı ULAKNET aracılığı ile araştırma ağları konusunda oldukça deneyimli olmasına rağmen, eğitim ve araştırma ağını dünyadaki gelişmelere paralel olarak (direk fiber erişimi, IP/DWDM teknolojileri, grid benzer uygulamalar için yüksek band aralığı gereksinimleri) geliştirmeli, yenilik sistemi politikalarını ağlaşma ve yüksek başarımlı hesaplama gereksinimlerine uygun olarak yenilemelidir. Türkiye küresel yenilik politikalarından ve deneyimlerinden yararlanarak araştırma ağı altyapısını geliştirebilir.

Anahtar Kelimeler: Araştırmada ağlaşma, araştırma ve eğitim ağları, yenilik (inovasyon) sistemlerinde araştırma ağı altyapıları

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CHAPTER 1

INTRODUCTION

National Research and Education Networks (NRENs) are organizations to serve research, learning and communication needs of universities and government R&D institutions. With the wide spreading of Internet usage in early 1990's, they had been used as just a tool to reach the information by their members. After late 1990's, they have begun to be used as more than a communication tool in order to access information. Research, innovation and collaboration on network environment would be their new mandate and NRENs have been optimized to support the specific network needs of special communities where huge amount of data is transferred and processed, and scientific discovery takes place. Because the resources or the services of commercial Internet is not able to provide the required bandwidth, specialized transport protocols and a necessary infrastructure required by these special communities and the researchers whose studies will enable production of new technologies and services, the responsibilities of NRENs became crucial for the achievement of the national innovation goals and they became the platforms for the much of the research and collaborative projects in the developed countries.

This study deals with the matter of research networking in the context of technological innovation systems. The main aim is to determine how Turkish NREN can be restructured to serve in accordance with the necessities of a world-class research and innovation network infrastructure.

In this study, the first point that will be stressed is the relationship between innovation systems and research networks. Then we will answer the questions:

.How is this relation associated by national policies in different countries?

.What are the goals of these policies in global framework?

.Why do developed countries encourage and support the others to provide them connected to global research networks by fighting the digital gap?

After we evaluate the expected impacts of collaborative research through research networks, we will concentrate on the NRENs in different countries in order to compare Turkish NREN with them:

. What are the differences of Turkish NREN with NRENs of different countries from the technological and infrastructural points of view?

. Does Turkish NREN have sufficient capacity and capability to give advanced network services for the requirements of a national innovation system? If not, what are the reasons?

. How should the requirements for research networking be handled in science and technology policy programs, and why those requirements have not been handled by policy makers for years?

. What is the situation in Turkish telecommunication infrastructure and services market after the privatization of Turk Telecom and ongoing liberalization process? What are the opportunities for Turkish NREN in this new period on the way of being high performance research network?

. Is it possible for Turkish NREN to play a strategic role in future expanding plans of European Union in Middle East, Caucasians and Silk regions? If so, what to do about it?

As a summary, our study firstly described the framework in order to make the related concepts –innovation systems, research infrastructures, national research ad education networks- clear. After we examined the international research and education networks, we compared Turkish NREN with the other NRENs and answered the research questions. We believe that Turkish NREN should realize an infrastructure impetus to integrate with the global research networks and provide a world class networking environment for the members of national innovation system. But the policy makers should take into account the requirements of a research infrastructure which will foster the new working and collaboration methods in Turkey and Turkish NREN policy should be revised to enable the collaboration of university-industry-government R&D institutions through networking facilities.

Chapter 2 presents an overview of the innovation systems focusing on the information infrastructures and communication networks. In this chapter after the realization of innovation system concept, we will focus on the importance of networking in innovation systems. Information and communication infrastructures/networks will be discussed further.

Chapter 3 explores the relationship between the research networks and the national innovation systems, offering a series of international comparisons on research and education networks. We will give information about the telecommunication regulations and legislative environments for the development of different research networks on the base of national (USA, Japan), multi-national (EU) and international context.

Chapter 4 focuses in detail the Turkish case (science and technology policies, state development plans, telecommunication infrastructure status, history of Internet and Turkish NREN - ULAKNET) and evaluates the current performance of the ULAKNET.

Chapter 5 analyses the information presented in previous sections in order to answer our research questions. Some action plans will be proposed to support our aim that Turkish NREN has to become an environment to serve networking necessities of a national innovation system.

In the last chapter, it is presented some issues that need to be addressed by future efforts for Turkish research and education network. We also summarize our thesis and present the conclusions of our study at this point.

CHAPTER 2

INNOVATION SYSTEMS AND COMMUNICATION NETWORKS

This chapter presents a description of innovation systems and communication networks in order to obtain a base for the research network concept. We will describe the National Information Infrastructure (NII) concept and construct a logical link between liberalization process in telecommunication market and research network infrastructures. NII policies of EU and USA will be examined in detail to put the case clearly.

2.1. Introduction to Innovation Systems

Innovation concept is a huge discipline of economics, business, technology, social systems and policy making, each containing a vast literature. The term innovation simply refers to both radical and incremental changes to products, processes or services.

From the economic point of view, Schumpeter (quoted passage from Langois) defined the concept of innovation as;

> "The concept," he writes, "covers the following five cases
> 1) The introduction of a new good —that is one with which consumers are not yet familiar—or of a new quality of a good.
> 2) The introduction of a new method of production, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially.
> 3) The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.
> 4) The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.
> 5) The carrying out of the new organization of any industry, like the creation of a monopoly position or the breaking up of a monopoly position" (Langois 2002)

National Innovation System (NIS) is a system that supports the ability/capacity of a country to innovate – especially to adapt and create science and technologies for economic and social use. According to Griffiths (2005) the main objectives of NIS are: (i) Value added in general, especially raw materials, natural products, exports; (ii) Diversify domestic and export economies; (iii) Greater technological sovereignty for agriculture, public health, civil infrastructure (water, communications, construction), SME's and above all; and (iv) Generate economic growth.

In an OECD report (1997), national innovation system was explained as:

> The national innovation systems approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes. For policy-makers, an understanding of the national innovation system can help identify leverage points for enhancing innovative performance and overall competitiveness. It can assist in pinpointing mismatches within the system, both among institutions and in relation to government policies, which can thwart technology development and innovation. Policies which seek to improve networking among the actors and institutions in the system and which aim at enhancing the innovative capacity of firms, particularly their ability to identify and absorb technologies, are most valuable in this context.

The same study of OECD (1997) stresses that the concept of national innovation systems rests on the premise that understanding linkages among actors involved in innovation is the key to improving technology performance, and continues as:

> "Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take the form of joint research, personnel exchanges, cross-patenting, purchase of equipment and a variety of other channels. There is no single accepted definition of a national system of innovation. What is important is the web of interaction or the system, as reflected in the definitions"

Freeman (1987), Lundvall (1982) (first person to use the expression "national innovation system"), Niosi (1993) and Metcalfe (1995) have defined the national innovation systems as;

> "The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1987).
>
> "All parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring" (Lundvall 1992).
>
> "NIS is the interactive system of existing institutions, private and public firms (either large or small), universities and government agencies, aiming at the production of Science and Technology within national borders. Interaction among these units may be technical, commercial, legal, social and financial as much as the goal of the interaction may be development, protection, financing or regulation of new Science and Technology" (Niosi *at al*. 1993).
>
> "That set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and arte facts which define new technologies" (Metcalfe 1995).

Freeman (1991), in his synthesis on innovation, mentioned about the vital importance of external information networks and of collaboration with users during the development of new products and processes (Freeman 1991). Freeman (1991) emphasized the central importance of external collaboration with users and external sources of technical expertise (by referring some empirical studies like the SAPPHO project in 1972), and then classified the network of innovators into 10 categories. One of these 10 categories (or network of innovators) was "computerized data banks and value-added networks for technical and scientific interchange" although Freeman highlighted that there were very limited research about this type of networking because it was the most new type.

From these perspectives and context, although we understand that an innovation system has not a simple structure, we see that there are some clear ingredients or subsystems in the formation of National Innovation Systems. The people, the institutions and the infrastructure are among some of them. Policy environment and political willingness are the others but the important complementary subjects. For our study, the networking (covering all the words like: relationship, linkage, interaction, cooperation, collaboration) between the players of innovation system will be the key word. But we would like to emphasize that there are a vast literature and discussions about different forms of networking in innovation systems. In this study, we will only focus on the research network infrastructures between university-government-industry communities (an innovative Triple Helix model –of Loet Leydesdorff- in the Information and Communication Technologies) rather than to deal with diffusion of knowledge or technology between the networks of firms, business or industry communities.

One important aspect of modern ICTs (Information and Communication Technologies) is that they provide a material basis for research network infrastructures. In another OECD report (1998), it was stated that technological innovations of the 1990s, such as communication satellites, sophisticated antennas, digital subscriber line technologies, fiber optics, and other technologies, connect people and organizations world-wide and made rapid and extensive information exchange possible on a global scale. The report continues as:

> "They act as the technical devise to allow globalization to occur. Spatial and topical expansion of knowledge is countered with enlarged and accelerated mechanisms for its diffusion through modern ICT. Particularly the emergence of the Internet's key infrastructure applications, the WWW and the browser, has greatly expanded the potential of ICT. Through this technology, computers and communication systems are linked with each other in an open network that significantly increases their utility" (OECD 1998).

As we already quoted before in the Freeman study, there were not enough studies and research about contributions of the value-added networks for technical and scientific collaborations and knowledge interchange to the innovation in the early 1990's. The final report of EU Serenate Project summarized the situation in the following years:

> "There is impressive evidence of growing network requirements from all areas of research. These needs will grow dramatically over the next 5-10 years, in all disciplines and in all countries. At the same time as many of the natural sciences are pushing towards a very broadly based deployment of Grid computing, we have been shown compelling examples of how research in the humanities could benefit greatly from advanced networking, while the aspirations of social scientists, ecologists, musicologists and geographers are also very challenging. There is absolutely no 'divide' in the field of user requirements" (EC 2003b)

Both Serenate study of EU and Internet2 project (US research network) defines the research network infrastructures as "national asset for the economic growth". In other words, connectivity, communication and collaboration between the institutional elements or members (education system, research institutions and business R&D firms) of research networks provide the innovation and technology transfer to the national industry. Therefore, we can claim that research network infrastructures constituting the core of research and education networks are the cutting-edge points for National Innovation Systems. But as stated by Carayannis and Patrice (2004), "the significance of a national innovation system to national economic and technological competitiveness depends in part on the degree to which that particular nation is embedded in transnational systems of innovation." Therefore, the scope of innovation systems can be enlarged to the global manner, although Georghiou (1998) argued that 'competitiveness' and 'institutional mismatch' were barriers for the firm-based international collaboration. As it is already specified, we will not deal with national and transnational firm-based networking, but it is worth to note here that like institutional mismatches, national priorities can be mismatch in these types of international collaborations. Thus, national governments should be very careful while defining their international science and technology policies.

2.2. Research Infrastructures

In this section, we will focus on the National Information Infrastructure (NII) and research infrastructures (RI) issues; the forces shaping NII and RI, the services deregulation on telecommunication sectors which is the most important factor for the deployment of NII and RI. Thus, it is important to examine the different stances adopted by different governments. But first of all, we would like to explore the definition of ‘infrastructure’, in order readers to better understand subsequent terms -‘information and communication infrastructure’, ‘research network infrastructure’ and ‘grid infrastructure’- used in our study.

Terminology

In Wikipedia web page, infrastructure defined as “most generally, is a set of interconnected structural elements that provide the framework supporting an entire structure”[i]. While there are different types of infrastructures, Longhorn (2001) pointed that:

> “..virtually all infrastructures created by society have some elements in common. These components include (a) high-level policies that set the overall goals and objectives for creating the infrastructure, (b) implementation technologies, (c) standards to guarantee various levels of interoperability for the components within a single type of infrastructure as well as across related (dependent or superior) infrastructures, (d) rules and regulations and (e) resources to create the infrastructure, then to operate it, maintain it and enhance it over time”

Groot (1997) defined the origins of infrastructure term as:

> “the term ‘infrastructure’ was first used in the middle of the 18th century in relation to railway tracks and rights of way for trains. Its meaning has evolved to include a complex of shared structures and services that support broad social participation and economic activity. In this sense, we all recognize roads, electric power, energy transmission, telephone services and networks, etc, as infrastructure”

Longhorn (2001) highlighted that “Providing or gaining access to products or services is the primary goal for most infrastructure projects”. Thus we can claim that ‘offered service’ is the keyword for any infrastructure type and any service given on any infrastructure can effect and increase the efficiency in any other infrastructure.

According to Talero (1997), an important characteristic of infrastructures is that “they have significant economies of scale and spillover effects on

[i] http://en.wikipedia.org/wiki/Infrastructure

non-users, particularly as enablers of other forms of economic activity", and defined NII as "the telecommunications networks and strategic information systems necessary for sustainable economic development."

2.2.1 National Information Infrastructure (NII)

In official documents presenting the US Government plan for the construction of the National Information Infrastructure (NII term became popular after this US plan for National Information Infrastructures), it was stated that NII was "a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips" (Information Infrastructure Task Force 1993). NII program were representing that, while in the past NII policy had only been implicit and part of other national goals such as national defense policy, as the first time, US government have approached to NII as an explicit policy towards information technology production and use. Actually it should be noted that while information technology production is itself the result of technical innovation, new products or services will facilitate the creation of new knowledge and new ways for the innovation system.

According to Hudson (1997), "if the information is critical to development, then telecommunications, as a means of sharing information, would not simple a connection between people, but a link in the chain of the development process itself". Therefore, we can note two forces of technology shaping the NII as: information and communication, or in terms of technologies; processing and telecommunication technologies respectively. Later in this chapter, we will present how this convergence was used as an infrastructure tool for the improvement of technological and economic performance in USA and EU.

Initially, we would like to stress on a report entitled “Europe and the global information society” (also known as the Bangemann report), endorsed full liberalization of the European telecommunications sector to enable a European 'single market' and advocated a new form of public-private sector partnership.

The Bangemann report (1994), consistent with the NII and GII (Global Information Infrastructure which is an outgrowth of NII perspective on a global scale) initiatives of United States, proposed a list of applications which should be developed for demonstration purposes and to jump-start initial supply and demand. These applications were: “teleworking, distance learning, university and research networks, network for SMEs, road traffic management, air traffic control, health care, electronic tendering, trans-European administration network, and connection of households to multi-media services.”

It is no doubt that such an infrastructure could not have been implemented under the monopoly control of state-owned incumbent operators of European telecommunication markets. The Bangemann report (1994) recommended that “member states of EU should accelerate the ongoing process of liberalization of the telecommunication sector by opening up to competition infrastructures and services still in the monopoly area and by removing non-commercial political burdens and budgetary constraints imposed on telecommunications operators”. The report also specified that “financing of information infrastructure was mainly the responsibility of the private sector”. But it was pointed that,

> “at the Union level, the process may have been required some reorientation of current allocations under such headings as the Fourth Framework Programme for research and development and the Structural Funds. On the other hand, it was emphasized that it was the task of the European Union and its Member States to create a coherent statutory framework to avoid the circulation of information being impeded by different national regulations” (Bangemann Report 1994)

This report can be seen as a European version of US NII program although Schneider (1997) argued that US initiative had highly visionary than EU program, and a social and political vision as a much as an economic perspective. He had criticized the EU initiative as a much more commercial character.

The recommendations on Bangemann report were then elaborated in an action plan by European Commission, "Europe's Way to the Information Society", which serves as a reference framework for the EU's activities on the information society. Action plan was about regulation, networks, services, and social aspects. Related with the 'regulation issue', European Commission (1994), as a reference to the Bangemann report, underlined the importance of infrastructure liberalization in competitive environment:

> "On the regulatory and legal framework issue, Commission decided to seek agreement on the principle of infrastructure liberalization in the telecommunications sector, together with clear dates for its implementation. Full service regulation on telecommunication sector was the primary goal and a second step, Commission would publish a Green Paper on infrastructure immediately. This paper would open to a broad consultation process on the conditions for general liberalization of infrastructure for the provision of public telecom services."

In 1996, the framework was incorporated into a Rolling Action Plan. Probably, one of the most important actions of EC on the way to the Information Society was the liberalization of European's telecommunication sector. Liberalization of Europe's telecommunications market culminated at the beginning of 1998 with the full liberalization of all telecommunications networks and services in almost all EU Member States (Exceptions were Portugal and Greece. Both countries have benefited from derogations until January 1, 2000 and December 31, 2000 respectively). Action plan (EC 2004) emphasized that:

> "The developments in technology, innovation in service offerings, lower prices and improvements in quality brought about by the introduction of competition have provided the basis for Europe's transition to the Information Society. The creation of a dynamic and truly competitive Information Society is vital for Europe's competitiveness."

EU Commission has given a high importance to the communication sector. In the document; “Electronic Communication: The Road to the Knowledge Economy”, the importance of communications sector was expressed as:

> “…lies in its impact on all other sectors of the economy. It offers the potential for organizations to make best use of their investment in information technology and to realize productivity gains, improvements in quality and opportunities for greater social inclusion. The sector is therefore of fundamental importance to the full development of the knowledge-based economy. Higher productivity leading to higher growth with more and better jobs and greater social cohesion is one of the objectives of the Lisbon strategy designed to transform the economic, social and environmental performance of the European Union by the end of the decade” (EC 2003a).

The Lisbon Strategy, also known as the Lisbon Agenda or Lisbon Process, was an action and development plan for the European Union. It was set out by the European Council in Lisbon on March 2000. It was adopted for a ten-year period in 2000 by the European Council. It broadly aims at making "the EU the world's most dynamic and competitive economy" by the 2010 deadline and main issues taken into account was to strengthen the EU's research capacity, to promote entrepreneurship and to facilitate take-up of information society technologies[i].

Information and Communications Technologies are playing a vital role in the world economy. Advancing in ICTs helps to underpin innovation in all other sectors of the economy. The importance of Information and Communication Technologies (ICTs) were also vital in reaching Europe’s Lisbon Goals. As an example, around %20 of FP7 budget will be used for ICT based technologies[ii].

As we already mentioned, EU has placed economic growth and employment at the heart of its policy. The latest EU25 data show that although ICT represents only 5% of the GDP, it drives 25% of overall growth and 40% of labor productivity growth. Although this data is not so bad, EU believe that they could do better, because US productivity growth was 60% derived

[i] http://www.euractiv.com/en/agenda2004/lisbon-agenda/article-117510 [Nov 1, 2006]
[ii] For FP7 budget: http://cordis.europa.eu/fp7/budget.htm [Nov 15, 2006]

from ICT (EC 2006a). Also, Viviane Reding (2005), Commissioner for Information Society and Media expressed that "All sectors of Europe's economy depend on ICTs. We must continue to invest heavily in research and in bringing innovations to market". Therefore, EC (2005a) renewed the Lisbon strategy at the mid-point of the progress in 2005 to close the growth gap with North America and Asia:

> "Europe's performance has diverged from that of our competitors in other parts of the world. Their productivity has grown faster and they have invested more in research and development. We have yet to put in place the structures needed to anticipate and manage better the changes in our economy and society."

Under renewed Lisbon strategy, the first initiative to be implemented is i2010 initiative. According to the outlined priorities in i2010 initiative (EC 2005b), it will focus on the most promising sector –Information and Communication Technologies- of the EU economy. Investment in networks and knowledge, investment and innovation in research are the key functions of i2010 initiative. Hence, it is obvious that EU will continue to fund the development of research infrastructures in order to increase the European research capacity.

2.2.2 Research Network and Grid infrastructures

As we already highlighted, collaboration is one of the significant activities in innovative-based research. In this section, we will focus on why and how EU policies support collaborative projects on digital research infrastructures (e-Infrastructure). The key components of e-infrastructures are high speed network infrastructures and huge amount of computational resources like supercomputing and grid facilities.

Terminology

It can be a bit confusing to understand the differences between 'Internet', 'information infrastructure' and 'research network infrastructure'. Simply we can say that information infrastructure covers the definitions of both

Internet and research network infrastructure. In other words, any computer, resource, institution, firm or researcher can be a component of a national/global information infrastructure, but it may not be possible to reason that it is also a component of research network. Research network infrastructures are the platforms where the research is performed in a network environment, and where the research is performed for networking. Most of the services and products developed in research networks can later find their ways in Internet for commercial use. Hence, we can claim that internet has a commercial character while research network infrastructures are test-beds environments for new services and products to be later used in Internet.

Like in US NII/GII initiatives, the eEurope 2002 Action Plan of EU (EC 2000), aiming to ensure the objectives targeted by Lisbon Agenda, emphasized "faster internet for researchers and students" as one of its priority activities. In this action plan (EC 2000) it was stated that the importance of creating "a very high-speed trans-European network for electronic scientific communications linking research institutions and universities, as well as scientific libraries, scientific centers and, progressively, schools", and grid infrastructures for scientific work and collaboration in all areas.

In Wikipedia pages, 'Grid Computing'[i] is defined as "an emerging computing model that provides the ability to perform higher throughput computing by taking advantage of many networked computers to model a virtual computer architecture that is able to distribute process execution across a parallel infrastructure". The idea behind the grid infrastructure is that, in the future, the global network of computers will become a whole computational resource that anyone may access on demand whenever they needed and don't aware where that computational resource is located. Foster (2001) defined that the Grid concept as:

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[i] http://en.wikipedia.org/wiki/Grid_Computing

> “the real and specific problem that underlies the Grid concept is coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations. The sharing that we are concerned with is not primarily file exchange but rather direct access to computers, software, data, and other resources, as is required by a range of collaborative problem-solving and resource-brokering strategies emerging in industry, science, and engineering.”

The significant differences of Grid with other Internet technologies is that, as Foster (2001) stated, Internet addresses the communication and information exchange among computers but Grids coordinates the use of resources at multiple sites for computation. Baxevanidis (2002) enumerated the applications within research and education where most Grid work has been performed to date as: “desktop access to remote simulation capabilities (e.g., science portals), distributed collaborative work (e.g.,teleimmersion), large-scale distributed computation(e.g., meta computing), computer enhanced instrumentation and large-scale distributed data analysis.” It is obvious that these new innovative applications running on grid infrastructures will share high volumes of data and computing resources and need a huge demand for bandwidth. Thus, those countries that do not have the requisite infrastructure will have to make large investments for transmission, switching and routing equipment (high technology products that can only be imported by companies of developed countries like; Alcatel, Cisco, Juniper etc.) and computation resources (if you have not local industry producing them, you should purchase from abroad) as well as the regular costs of communication links.

Research Infrastructures in FP6 and FP7

FP6 was a financial instrument to help make European Research Area –ERA- (Lisbon result for the creation of an internal market for S&T) a reality. One of four thematic activity areas of FP6 was structuring the ERA, and this activity had 5 schemes:

> 1. Transnational access to major research infrastructures for research teams and individual researchers,
> 2. Integrating activities combining cooperation networks with transnational access and research projects, integrating activities including networking activities only,

3. Communication network development in conjunction with thematic priority 2 (Information Society Technologies) to establish a high-capacity and high-speed communications network for all researchers in Europe (GEANT) and specific high performance Grids and test-beds (GRIDs).
4. Design studies: feasibility studies and technical preparatory work for new infrastructures with European dimension
5. Development of new infrastructures: optimizing of European infrastructures by providing limited support in duly justified cases, alongside with other funding agencies (EC 2002)

If we combine the above plans related with ERA and Figure 1 showing the role of research networks in EU, we can claim that research networks will be used to create knowledge, innovation, technological convergence, collaboration and cohesion not only within EU but also with other countries having willingness to integrate with European research infrastructure. The situation is not different in US policies as we later examine.

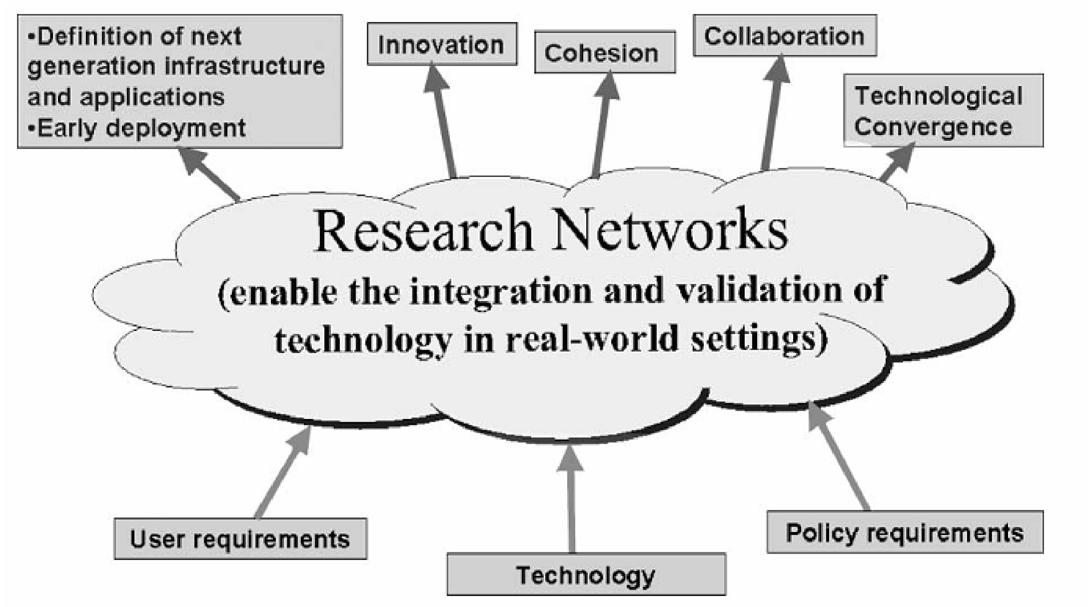

Figure 1: The role of research networks in EU research programmes, quoted from Baxevanidis *at al*. (2002).

Figure 2 represents that GEANT, as an underlying research network infrastructure, provides high speed communication network and advanced services to the European National Research and Education Networks (NREN) and Grids, as a user of GEANT but also a service provider for users, satisfies the requirements of very demanding user in terms of storage and computing power.

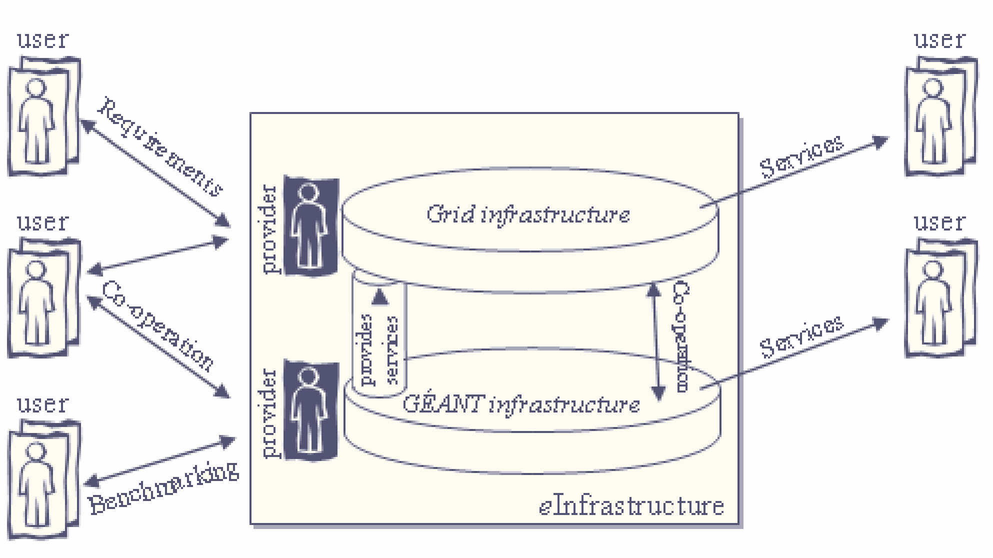

Figure 2: Simplified view on EU e-Infrastructure[i] (GEANT and grid enpowerred infrastructure)

In FP7 for the period 2007-2013, there are 4 categories each has a specific program to promote and encourage the creation of European scientific excellence; Cooperation, Ideas, People and Capacities:

> "Under the 'Capacities' specific program, which will focus on improving research capacities throughout the Europe, one of the main actions is to support to research infrastructures. According to the approved European Commission's Amended Proposal for FP7, EUR 2008 million will be invested to the Research Infrastructures during 2007-2013" (EC 2006b) (Total amount of money to be spent will be EUR 50521 million for FP7 specific programs)[ii]

The research infrastructure theme under "Structuring the ERA" scheme of FP6 is transferred to "capacities" specific program in FP7. In capacities program (EC 2006c) GEANT network is expressed as 'Internet of future' which will reinforce Europe's position 'as a hub for global research

[i] FP6 IST web page: <http://cordis.europa.eu/ist/rn/ri-cnd/e-infrastructures.htm> [Oct 15, 2006]

[ii] The budget of research infrastructure were then reduced to EUR 1850 million in July and to EUR 1715 million in October. For FP7 budget: http://cordis.europa.eu/fp7/budget.htm [Nov 15, 2006]

networking' and it is stated that GEANT "will provide a pan-European e-Infrastructure bridging the digital divide and enabling all scientists in Europe to participate in collaborative work on equal terms independent of their location."

2.3. Evaluation

In this chapter, after we defined the conceptual framework of innovation systems and focused on the relation between innovation systems and research networks, we examined research network and grid infrastructures with particular reference to developments in Europe.

The convergence of processing and communication technologies, after 1990's, enabled global centralization of data processing through high-performance computers linked to computing sites around the world by high speed communications. Liberalization of state-owned telecommunication operators and competition in telecommunication services has lowered connection costs in domestic and international market. Therefore, cost effective dark fiber acquisition solved the limitations of communication networks using expensive bandwidth-based costs. Accessing data repositories and computing resources from anywhere without regarding with underlying high speed and cost effective infrastructure has opened a new way of network-based collaborative innovation. Differently from the National Information Infrastructures which serving business, government, education and household users, research infrastructures particularly serves to the members of knowledge triangle; education, research and innovation. Research network and grid empowered computing infrastructures have enabled not only the collaboration of researchers and scientists in networking environment but also the provision of new advanced services for the global/national information infrastructure.
But in transnational scope, we would like to emphasize that third countries may have in a dilemma about connecting to global research networks in

which the policy and user requirements are defined and technology is pushed by the countries forcing the globalizm in research. In most of policy documents of EU, you can find "digital divide" or "digital gap" expression which is defined in Wikipedia pages[i] as "the gap between those with regular, effective access to digital technologies and those without. In other words, those who are able to use technology to their own benefit and those who are not." The dilemma is that whether third (undeveloped or developing) countries, even they have access to digital technologies, will be able to use technology to their own benefit or mostly for the benefits of developed countries.

It is obvious that new innovative applications running on grid infrastructures will share high volumes of data and computing resources, and will need a huge demand for bandwidth in research networks in addition to initial investments for the networking equipment. Thus, very big investments are prerequisite to integrate (or in other words to close the digital divide) with global research networks by those countries that do not have the requisite infrastructure. Actually, integrating to global research networks can be thought as sharing the costs of the research done internationally particularly on big sciences (particle physics, nuclear research, space research etc.) which may not be a national priority for most of the countries. On the other hand, we can claim that while EU is expanding its research infrastructure to other regions of the world (like Africa, South America, Middle Asia, Caucasians, Asia-Pacific) to close the digital divide, also aims to constitute a collaborative environment for the production of new knowledge and innovation, and to sustain its economic growth with contributions of scientists from all over the world. Anyone can think that this collaboration environment is a new form of brain drain.

[i] http://en.wikipedia.org/wiki/Digital_divide

CHAPTER 3

RESEARCH AND EDUCATION NETWORKS IN INNOVATION SYSTEMS

This chapter initially presents the history of National Research and Education Networks (NREN) as well as the history of computer networks and Internet. A series of different national and international research and education networks (USA, EU, Japan, Brazil and Poland) will be examined in order to make determinations for global trends of NRENs.

3.1. National Research and Education Networks (NRENs)

The term National Research and Education Network - (NREN) refers an interconnected (historically kilobit, megabit, gigabit, terabit) computer network devoted to national research infrastructure and high performance computing, and simply referred to as an information superhighway.

> During last decade, data networks (computer networks, communication or digital networks) have become increasingly important as information vehicles in the context of scientific and industrial research. They have grown all around Europe at the national (or regional level) to provide dedicated facilities to researchers and higher education communities. These facilities, as well as the entities operating them are commonly called by the same generic appellation of National Research and Education Networks (Bisquin and Liikanen 2000).

The origin of computer networking can be traced back to 1968, when the first packet-switching network was implemented at the National Physical Laboratories in England. Next year, ARPANET was developed by the Department of Defense of USA. Quickly following them, MERIT (the Michigan statewide higher education network), BITNET (Because It's Time NETwork), NSFNET (National Science Foundation NETwork), and the structure of Internet were built.

Although Internet started its life as a network of interconnected computers at universities and research establishments, from the mid-1990s commercial interests and usage have dominated Internet service provision. After the commercialization, and then the commoditization of Internet, the position of research networking has dramatically changed and firstly USA and European countries have begun to separate their commodity Internet and research traffics. Today, a worldwide system of networks for research and education exists besides the commodity Internet. Therefore the network traffic within research and education network consists of traffic; research traffic with other research and education networks in the world and commodity traffic with the global commodity Internet. The research traffic has to allow development and piloting of new applications before they can be introduced into the commodity Internet, so has a need to a higher service quality and high speed. In this new point of view, as Serenate Project (EC 2003b) reported, “research networks are the extraordinary sources of technical innovation”. As in the case of World Wide Web, technologies and applications find their way from research networks to the commodity Internet. Research networks are important drivers for the innovation and collaboration between scientists and they are indispensable parts of national innovation systems. Existence of thousands of online researchers that are seen to be the innovator of the Internet, help the pushing available technology to always its limits.

Duncan (2002) focused on global research networking and defined grid computing as the ultimate evolutionary target of distributed computing:

> “….information technology has radically impacted the methods and tools of research. In many areas, including particle physics, remote sensing of earth resources, oceanography and astronomy, expensive measuring tools routinely produce massive amounts of digital data, within which scientific illumination hopefully awaits the analyst. This has led to a dichotomy between “primary” and “secondary” research. In primary research, well-funded teams build great instruments, performs experiments and capture oceans of data. Secondary research is the extraction of patterns, insights, lessons, conjectures and other intellectual harvests from the data ocean. Any researcher anywhere can do this, provided that he or she has adequate access to the data ocean and to adequate computing resources.”

It is also crucial to emphasize that the progress and the evolution of research and education networking can not be uniform in all countries. Popov (2003) explained the importance of government support to NRENs as:

> "It is clear that in some form or another, directly and indirectly, the government plays and should play a vital role in the development an institution/organization responsible for the internal and external connectivity of the national research and education institutions. This is also consistent with the argument that both science and education have a crucial place in creating economic growth, foster national and international understanding and cooperation, and thus create the right climate for political and social stability that improve the well-being and the life of every citizen"

Governmental policies, economic development level, telecommunication infrastructures and regulations, innovative capacities and on the whole, the priorities can vary among different countries. Now, we firstly will provide a series of international comparisons on NRENs with their international collaborations, connectivity to global research network, telecommunication infrastructures and legislative environments.

3.2. US Research Network (INTERNET2 – Abilene Network)

Internet2 is a non-profit organization who led by more than 220 U.S. universities, working with industry and government, develops and deploys advanced network applications and technologies for research and higher education, accelerating the creation of tomorrow's Internet. Internet2 recreates the partnerships among academia, industry, and government that helped foster today's Internet in its infancy[i]. Actually, Internet2 is the name of the consortium not a name of a computer network. Although it is used as a logical name for the next generation Internet backbone, in fact, Internet2 network (or consortium) is referring the network backbone known as Abilene Network.

[i] INTERNET2 web page, http://www.internet2.edu, [July 8, 2006]

The Abilene Network supports the development of applications such as virtual laboratories, digital libraries, distance education and tele-immersion, as well as the advanced networking capabilities that are the focus of Internet2. Abilene complements and peers with other high-performance research networks in the United States and internationally[i]. Abilene Network (its name came from the Abilene railhead in Abilene, Kansas, which in the 1860s represented the frontier of the United States in the context of the nation's railroad infrastructure) backbone of the US had a capacity of 2.5 Gbps when it had established in 1999. In 2003 backbone capacity were upgraded to 10 Gbps and the goal of the project is to offer 100 Gbps connectivity between every node by the end of 2006.

In 1998, Vice President Al Gore announced the Abilene network during a ceremony at the White House. But the announcement of new national advanced network backbone was the last step for fruit of much study which had been pursued by for a decade. Here we try to explore the footsteps of this long process by focusing on a review of various initiatives that have been proposed and implemented by USA government and non-governmental organizations.

In 1987, the Federal government issued a report calling for a new program to create an advanced national research network by the year 2000. In report, It was recommended that

> "U.S. government, industry, and universities should coordinate research and development for a research network to provide a distributed computing capability that links the government, industry, and higher education communities. It was reported that a strong program of research and development was needed to advance the technology of computer networking in order to achieve data communication and switching capabilities to support transmission of three billion bits per second (3 Gbps) with deployment within fifteen years." (Executive Office 1987)

In this report (Executive Office 1987), the emphasized headings other than networking were "high performance computing industry, software

[i] ABILENE web page, http://abilene.internet2.edu,[July 8,2006]

technology for the computing technology and microelectronics, and the requirement of basic research to become major sources of innovation in the development and use of computing technology”

In 1988, Albert Gore, then Senator, sponsored the Supercomputer Network Study Act to explore the potential of high capacity fiber optic networks to link supercomputers in the nation. In his introduction of the Act, Gore projected:

> “a national computer network linking academic researchers and industry, clustering research centers and businesses around network interchanges, and using the nation’s vast data banks as the raw material for increasing industrial productivity and creating new products...to create an information inter-state highway for the 1990’s, to transport information, rather than goods, at nearly the speed of light”(U.S. Congress 1988)

In 1993, US Congress has indicated, the plan of the High Performance Computing included the creation of the NREN and the development of the National Information Infrastructure (NII). The NREN would be a telecommunications infrastructure which would expand and upgrade the existing interconnected array of research and information networks. It would be:

> “a universal communications network connected to national and international networks [that] enables electronic communication among scholars anywhere in the world, as well as access to worldwide information sources, special experimental instruments, and computer resources” (U.S. Congress 1989)

It is here important to note that National Research and Education Network, NREN was a part of the larger High Performance Computing and communications (HPCC) program and that the HPCC program played a central part in the Clinton Administration's vision to enhance the National Information Infrastructure (NII). Here, we will focus on the relationships between the NREN, HPCC and the NII in USA information system.

In 1990, National High Performance Computer Technology Act (HPCT) was introduced to the Senate and accepted by the Senate. An identical bill was also introduced to the House of Representatives. The Act was passed by both houses of Congress in November and signed as public law in December, 1991. As a part of this Act, NREN were referred to as the "Gore bill" because its chief sponsor was then Senator Al Gore. The education, research, and library communities strongly supported the establishment of the NREN. Instead of a centralized, physical communications network it was more accurate to view the NREN as a program to support improvements and enhancements to the existing Internet. NSFNET, the main Internet "backbone" network funded by the National Science Foundation (NSF), has been designated as the "Interim NREN". In "The National Research and Education Network: A Report to Congress" (Executive Office 1992), it was emphasized that NREN had the following goals:

> - establishing a gigabit network for the research and education community and fostering its use;
> - developing advanced networking technologies and accelerating their deployment;
> - stimulating the availability, at a reasonable cost, of the required services from the private sector; and
> - catalyzing the rapid deployment of a high speed general purpose digital communications infrastructure for the nation.

NREN's initially intended to serve just to research and academic communities. But, then, communications industries, information service vendors, and end-users would have been expected to share funding responsibilities with the Federal government to establish, maintain, and develop NREN. The report (U.S. Executive Office 1992) continued as:

> "The Federal government would allocate funds for the operations of the Federal agencies' networks that make up the backbone of the NREN, and for users who serve the missions of the Federal government. Communications industries would provide funds to invest in manufactory plants, develop communications transport services, support technological development, and invest in the initial deployment of the network. Information service vendors would contribute funds to develop information service and pay fees for connectivity and transport of information. And end-users would pay fees for network subscription, connectivity charge, and information service".

According to PCAST (President's Council of Advisors on Science and Technology) panel report in 1992, "NREN was not intended to grow into a commercial network, nor was NREN designed to serve as an all-inclusive educational network. The “network” was stated as functional, not physical. And the optical-fiber physical medium for transmission and broadband switches would be implemented by purchasing services from common carriers and other commercial vendors of communication services” (U.S. Congress 1992). The similar approach was reported to the congress by Office of Science and Technology Policy:

> “The National Research and Education Network (NREN) Program is a multi-agency activity that will provide for the evolution from the current federally funded research and education (R&E) networks, to a gigabit network system that allows for both the interconnectivity and interoperability of federally funded R&E networks with each other and with private sector networks by the mid-1990~s to support the increasing demands in R&E. As its name indicates, the NREN activity is primarily for research and education, not general purpose communication. Nonetheless, the NREN Program incorporates vital connections to industrial and governmental sectors and develops general testbeds for new communications technologies.”(Executive Office 1992)

As it is mentioned before, the NREN was one part of the larger federal program known as the High Performance Computing and Communications (HPCC) program. The HPCC program was outlined in "Grand Challenges 1993: High Performance Computing and Communications" and five specific components of the HPCC program were; “High Performance Computing Systems (HPCS), Advanced Software Technology and Algorithms (ASTA), National Research and Education Network (NREN), Basic Research and Human Resources (BRHR), Information Infrastructure Technology and Applications (IITA)” (Grand Challenges 1993).

In relation to the NREN, the Grand Challenges report (1993) noted that "The NREN was both a goal of the HPCC program and a key enabling technology for success in the other components.”

During the next four years the Administration spent over $5 billion on the HPCC program. Two objectives of the HPCC program were "to implement by 1995 a tera-ops (10-12 operations per second) computer and a skeletal gigabit National Research and Education Network" (U.S. Congress 1992).

The HPCC program was a critical part of the Administration's effort to enhance the National Information Infrastructure (NII).

In early 1993, President Clinton formed the Information Infrastructure Task Force (IITF) to articulate and implement the Administrative vision for the National Information Infrastructure (NII). The White House circulated "The National Information Infrastructure: Agenda for Action", describing the vision, definition, actions, benefits and applications, and so forth (Information Infrastructure Task Force 1993), and began to actively promote the NII activities. Agenda for Action presented in the White House in 1993 was the first comprehensive statement of the Administration's visions and goals for the U.S. National Information Infrastructure. The purpose of the plan was to promote the use of networking and computing technologies to give Americans unprecedented access to information and communication services. Since then, the Clinton Administration has made the creation and development of a NII a top priority. While the Internet is a forerunner of the NII and evolving to be a major part of it, the NII was conceived to be much broader then Internet.

The IITF was organized into three committees: the Telecommunications Policy Committee, which formulates Administration positions on key telecommunications issues; the Committee on Applications and Technology, which coordinates Administration efforts to develop, demonstrate and promote applications of information technologies in key areas; and the Information Policy Committee, which addresses critical information policy issues that must be dealt with if the NII is to be fully deployed and utilized. In addition, a Security Issues Forum assesses the security needs and concerns of users, service providers, information providers, State governments and others.

> "Later in July, 1993, the House of Representatives passed the National Information Infrastructure Act (NII) of 1993. As an extended vision of the NREN, the NII will be a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at

users' fingertips. It will create "virtual communities," in which people located anywhere on the planet can share common interests or information. It is expected that the development of the NII can accelerate an information revolution that will change the way people live, work, and interact each other. The White House has pledged that by the year 2000, all of the classrooms, libraries, hospitals and clinics in the USA will be connected to the NII" (White House 1994)

Popov (2003) emphasizes that the importance of private initiative for the research and education communities in USA as:

> "In USA the academic communities have always in mind the market and the forces of the private initiative. Consequently, they often use the highly competitive environment to achieve acceptable prices and quality levels, as well as to induce some kind of equity. It is a common knowledge that many research and education networks, and in fact the Internet have been developed through federally funded research projects."

A major issue for developing the National Information Infrastructure in US is "how government should work with the private sector to ensure that all Americans benefit from the communication revolution" (Gore 1994). In this point, it should be pointed that the legislation of NII had to be supported by acts regulating the related environment. The new regulatory framework should keep pace with the rapid technological and market changes that pervade the telecommunications and information industries. Thus, in this period, a number of acts were legislated by the US government. One of them was the National Competitiveness Act authorizing advanced computing and networking technology applications in education at all levels, digital libraries, manufacturing, government information, energy, and health care. The acts were designed to facilitate the development of NII by removing restrictions of private companies.

In 1996, the US President signed the law of Telecommunications Act (U.S. Congress 1996) which was the first comprehensive telecommunications legislation since 1934. The aim was "to promote competition and reduce regulation in order to secure lower prices and higher quality services for American telecommunications consumers and encourage the rapid deployment of new telecommunications technologies" (U.S. Congress 1996). By removing barriers in front of different companies from different sectors, it was being also tried to provide a competitive environment for the NREN program and NII as we early mentioned above. However the needs of the research and education community had gone beyond the functionality of the Internet as defined in the mid 90's.

> "In September 1996, Internet2 concept was firstly announced by over 100 universities to undertake a collaborative effort to develop advanced Internet technologies and applications to support research and education missions. This group of universities contended that increasing traffic on the Internet, combined with their expanded needs to conduct high performance computing research, made an upgrade of the Internet imperative. In addition, the promise of future technologies and applications, such as real time computing for medical diagnostics or sending multimedia over high-speed and high-capacity broadband networks, made it likely that current technologies would not be able to support future applications" (NCSE 2000).

Almost simultaneously, the Clinton administration announced the Next Generation Internet (NGI) Initiative. The goals of NGI were:

> 1-Promote experimentation with the next generation of network technologies.
> a) The networks developed under the NGI Initiative will connect at least 100 NGI sites-universities, federal research institutions, and other research partners-at speeds 100 times faster than today's Internet.
> b) The NGI networks will connect on the order of ten NGI sites at speeds 1,000 times faster than the current Internet.
> 2-Develop a next generation network testbed to connect universities and federal research institutions at rates that are sufficient to demonstrate new technologies and support future research.
> 3-Demonstrate new applications that meet important national goals and Missions (NGI 1997)

These two projects were closely intertwined because the Internet2 Project had responsibility for Goal 1(a) of the NGI Initiative; additionally, the Internet2 members were the key participants in achieving the other NGI goals. The third NGI goal had an aim to produce new applications on areas health, education, scientific research, environment, emergency cases, design and production. These applications would be developed in next generation network. Here it is obvious what advanced research networks should have the real goals.

> Initially, while both Internet2 and the NII were similar in goals and objectives, the Internet2 was driven by university research needs while the NII has been national in scope and focused on concerns coming from both the private and public sectors. As the NII policy was supported by federal programs, the early Internet2 effort by the universities tended to focus on attaining a common consensus. By

> 1997, however, a consortium was formed by the universities to provide a single platform for attaining Internet2 goals and objectives (NCSE 2000)

Although several research universities had already signed on as members of Internet2, after Clinton's announcement of NGI, 100-university proposal (Goal 1.a of NGI) sounded to observers a lot like then ongoing private Internet2 project. We will try to clarify this situation to prohibit any misunderstanding. NGI was a federally funded research and development effort to advance state of the art data communication, which is incorporating connections with Internet2 as a way to create the experimental network called by Clinton. But Internet2 was a private-university consortium to build a new high-speed Internet service for university research and connecting US supercomputing centers, which would use the vBNS (which was a federally funded very high-speed data communications backbone service supported by NSF as a communications research facility) as a core backbone for its system.

> The key distinction between the NGI initiative and Internet2, however, was that NGI was led by and focuses on the needs of the federal mission agencies, such as DoD (Department of Defense), DoE (Department of Energy), NASA, NIH (National institutes of Health) and others. However, because of the great deal in overlap between universities and those federal agencies in terms of network infrastructure, needed applications and the researchers working often in both communities there was a great deal of synergy between NGI and Internet2[i].

As we stated early, Internet2 have used leased telecommunication lines like other networks. The cross-country backbone is 10 gigabits per second, with the goal of offering 100 megabits per second of connectivity between every Abilene connected desktop. Internet2 efforts have included both network research and research in other domains that require or benefit from access to high-performance networking. Each organization has an advisory council comprising representative network researchers and a council designed to represent scientific research in general and other academic disciplines. The Internet2 provides a large-scale deployment of tools for one-to-one, one-to-group, and group-to-group collaborations

[i] NGI web page, http://government.internet2.edu/ngi.html, [Aug 1, 2006]

enabling the Internet2 research and education community to hold distributed working groups, classes, meetings, and events. One can easily expect that these working groups on different subjects will provide collaborative environment for the innovative based purposes. On the other hand, on May 2003, National LambdaRail, Inc. (NLR) was announced:

> NLR Inc, was a consortium of several major U.S. research universities and organizations, regional and national advanced networking organizations, and Cisco Systems to deploy a new national optical networking infrastructure to foster the advancement of next-generation, network-based applications in science, engineering, and medicine, and to reenergize innovative research and development into next-generation network technologies, protocols, services, and applications. It was officially formed as a new not-for-profit organization to carry out this initiative (NLR announcement 2003).

The defining characteristic of the NLR infrastructure was its ability to support many distinct networks for the US research community using the same core framework and would provide enabling a new network infrastructure for new methods for research in science, engineering, health care and education. This new infrastructure would be owned by consortium and not to be leased from telecommunication companies.

> "The difference between NLR and Internet2 was that they were both nationally recognized consortiums that seek to advance research through high-performance production networking and experimental networking. Within this broad goal, NLR tended to focus on network research (including technology, protocols, services, and management). Alternatively, Internet2 efforts have included both network research and research in other domains that require or benefit from access to high-performance networking. Each organization had an advisory council comprising representative network researchers and a council designed to represent scientific research in general and other academic disciplines."[i]

NLR was, for the first time in USA, providing the research community with direct control over a nationwide fiber optical infrastructure and its users are independent of carrier service constraints and requirements. By using DWDM technology (Dense Wavelength Division Multiplexing) which was capable of transmitting 40 simultaneous wavelengths (each wavelength gives 10 Gigabit per second) the enormous richness and flexibility would be provided with robust technical support services and this infrastructure

[i] National Lambda Rail web page, http://www.nlr.net, [Aug 1, 2006]

would allow multiple concurrent large-scale experiments to be accomplished.

Nowadays, there is another project to merge Internet2 and National LambdaRail initiatives somewhere in the 2006-2009 timeline. At the end of this project, NLR will dead, Internet2 will be shut down and a new research network “NewNet” will be built on the basis of these two infrastructures. In NewNet, Internet2 consortium will not own the fiber optic links, but will contract with telecommunication companies to get the right of operational control over the network. The mundane works such as repairing the broken cables will be under the responsibilities of the telecommunication companies. Each institution connected to the new infrastructure will have access two wavelengths; one for commodity Internet and the other for research use.

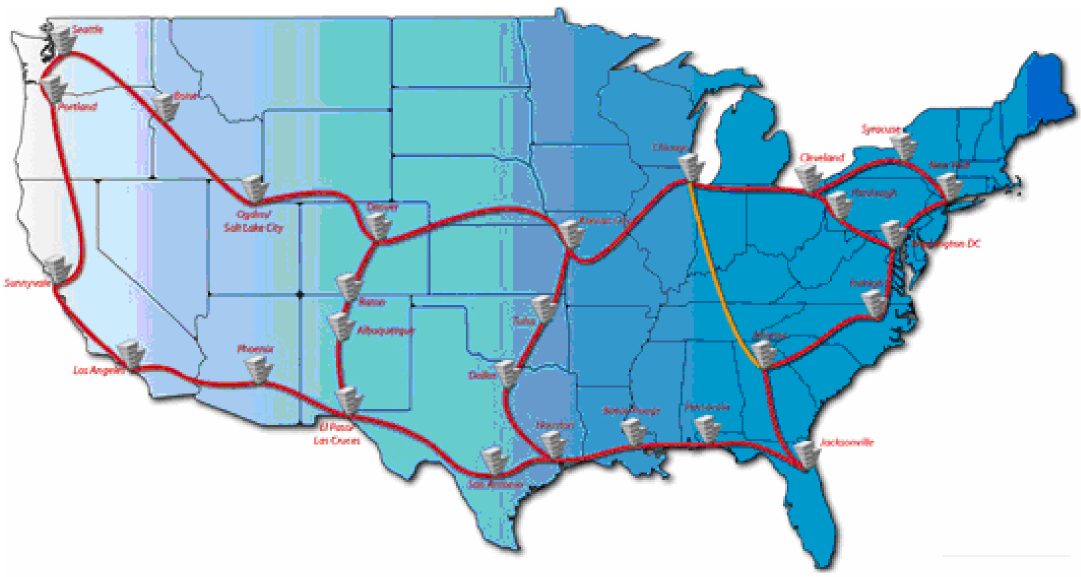

Figure 3: NLR backbone (http://www.nlr.net, accessed Aug, 2006)

In figure 3, current NLR current backbone is seen. Bold links are DWDM connections over fiber optic cables. All the other sites that are not seen on figure are connected to the edge points according to their service requirements.

3.3. European Union Research Network (GEANT2)

The European networks for research and education have been working together since 1993 (although since the mid-1980's there were research networks dedicated organizations like EBONE, EARN/BITNET, we will not deal with these networks which were fundamentally away from the research issues) to have in place a shared infrastructure to interconnect them with broadband capacities. The previous successive networks, which were deployed in the past, were named as EuropaNET, TEN-34 and TEN-155.

As we already mentioned, Bangemann report (1994) recommended to establish a network for universities and research centers to help networking of Europe's brain power. Research and Education Networking application of the report targeted the thirty percent of European universities and research centers linked through advanced communications networks by 1997 and pointed out the requirement for;

> 1.The development of a trans-European advanced network (high bandwidth, high definition, carrying interactive multimedia services) linking universities and research centres across Europe, with open access to their libraries.
> 2.The productivity of research programmes through broader team creation leading to synergies between institutions. Society in general through more efficient diffusion of research findings and knowledge (Bangemann Report 1994)

The first initiative EuropaNET, which was active from 1993 to 1997, connected 18 countries at speeds of 2Mbps and used classical IP technology. Commercialization of Internet and the initiatives in USA like Internet2 and NGI, obliged the Europeans to build a high performance European network for research and education to create an European research space and to increase knowledge exchange and co-operation in higher education and training of European researchers. TEN-34 and TEN-155 networks were deployed during FP4 and FP5 respectively. TEN-34, which was active only from 1997 to 1998, was again connecting 18 countries, but at speeds of 34Mbps and used both IP and ATM technology.

TEN-155, using again both IP and ATM technology, connected 19 countries at speeds of between 155 and 622 Mbps.

The current version of the pan-European backbone is named GEANT. This network was the main outcome of a EC funded FP5 project (GN1), carried by the consortium of more than 34 NRENs. The coordination of the consortium (and of the GN1 project as well) have been made by DANTE (Delivery of Advanced Networks to Europe, http://www.dante.org.uk), a not-for-profit company, based in Cambridge - UK, which have been owned by the European NRENs. GEANT has already connections to the other NRENs in the world (like North America, Asia-Pacific, Latin America, Mediterranean Basin and Middle East, South East Europe, etc)

GEANT can be seen as a fundamental to the advance of the EU's European Research Area (ERA) aims. According to Robertson (2003), Public Relations Manager of DANTE which is responsible for coordinating the project, "the advantage of GEANT is its cohesiveness, in that it links the various European national research networks together. As research is becoming more collaborative and international in scope, GÉANT provides significant help to researchers in linking to their colleagues in other countries."

GEANT model is a 3-tier federal architecture, partially subsidized National and EU Research and education funds: At the lowest tier, there are campus and metropolitan area networks (LAN/MAN) which are national education and research centers and connected to each other in second tier. At the 3rd tier, we see the Pan-European Network interconnecting those NRENs at high-performance and high-capacity (TEN-34, TEN-155, GEANT –GN1 in FP5-, GEANT2 in FP6 and in the future GEANT3 in FP7)

The main idea behind the next generation networks of IST and structuring the ERA programs are to make research networking. Research Networking in these programs has a dual objective; networks for research and research on networking. While deploying a pan-European advanced information network for the use of researchers in all disciplines and fostering intercontinental connections is an important goal, promote research on advanced information network technologies by setting-up test-beds, which serve as a focal point for integration and validation of all aspects of these technologies in the context of advanced user driven applications. There is a close interrelation and mutual benefit to be derived from these two objectives that:

- Scientists need the most advanced communication technology to carry on successfully their work and to be competitive in their respective areas of innovative research. They are also critical users and early adapters of innovative technologies, very well placed to play their part in the cycles of research development deployment.
- The advanced network features of the European research infrastructure are used as testbeds to experiment, validate and demonstrate new technologies and services on a large scale and in real-world settings. In addition, testbeds promote international cooperation and foster partnership between academia and industry. In this way Europe is able to contribute significantly to the development of standards and play a leading role in defining the next generation networking and application technologies that go beyond the current state-of-the-art (EC 2002)

Beginning with Lisbon Strategy, EU began to give importance to research networking on high-capacity fiber optic links. After the liberalization of most of the European telecommunication markets (after 1998-2000), the costs of fiber optic links began to drop substantially (Although there are still quite differences between the costs of the non-liberalized east and liberalized west markets of Europe) By providing gigabit-speed (up to Nx10Gbps) connectivity between NRENs, GEANT backbone has created an huge increase in the capacity to European researchers compared to former networks, like TEN-155. Liberalization has, in some locations, allowed direct access to physical connections, typically fiber optic cables. This has enabled also some NRENs to implement their own local transmission infrastructure rather than being dependent services provided by telecommunications operators. Decreasing costs and a variety of available technical options for constructing research networks laid the groundwork for the national and pan-European grid infrastructures. Large amount of data can only be transferred by high speed networks. Hence, we can strictly determine that data intensive computing and research networking can come together with high capacity networks. As we have mentioned in previous chapter, ‘grid technology’ also demands high capacity networks which can only be provided by dark fiber acquisition. e-IRG report (2005) stated that:

> “Longer term strategic issues not directly dependent on current practices and cutting edge technologies must drive e-Infrastructure planning, including research & education networking. The emerging business model should resolve fundamental questions like ownership of infrastructures, sharing policies, foresight of capital investment, consequences of technology driven choices etc.”

Differently from the traditional IP (Internet Protocol) based networks, grid infrastructures requires end-to-end dedicated connections with high bandwidth capacity needs.

> “The deployment of hybrid optical networks, as enablers to high - end users in the e-Science world creates a paradigm shift. The traditional IP-centric approach, based on hierarchical networking (Campus - NREN - GEANT) and peering for global connectivity is being replaced by a combination of IP routed services and switched end-to-end Gigabit light-paths. The former provides ubiquitous, high quality IP service to millions of European researchers and students, while the latter aims at providing configurable links and "private" networks at gigabit speeds to demanding scientific virtual communities. This capability emerged thanks to the dark fibre availability, both within and across national territories, and to advances of switching technologies for optical networks.” (Magliris 2005)

In figure 4, current GEANT2 network map is shown. Black links between DE, NL, BE, UK, IE, CH, FR, IT, AT, SK, CZ, HU, HR, SI and DK (Point of Presence for Scandinavian research networks) shows the dark fiber links which provides multiple wavelengths at 10 Gbps. This infrastructure is used for different innovative purposes. For example, 11 Supercomputing centers in countries having dark fiber links are interconnected to each other with FP6 DEISA project (Distributed European Infrastructure for Supercomputing Applications) to integrate the national supercomputing facilities of those countries.

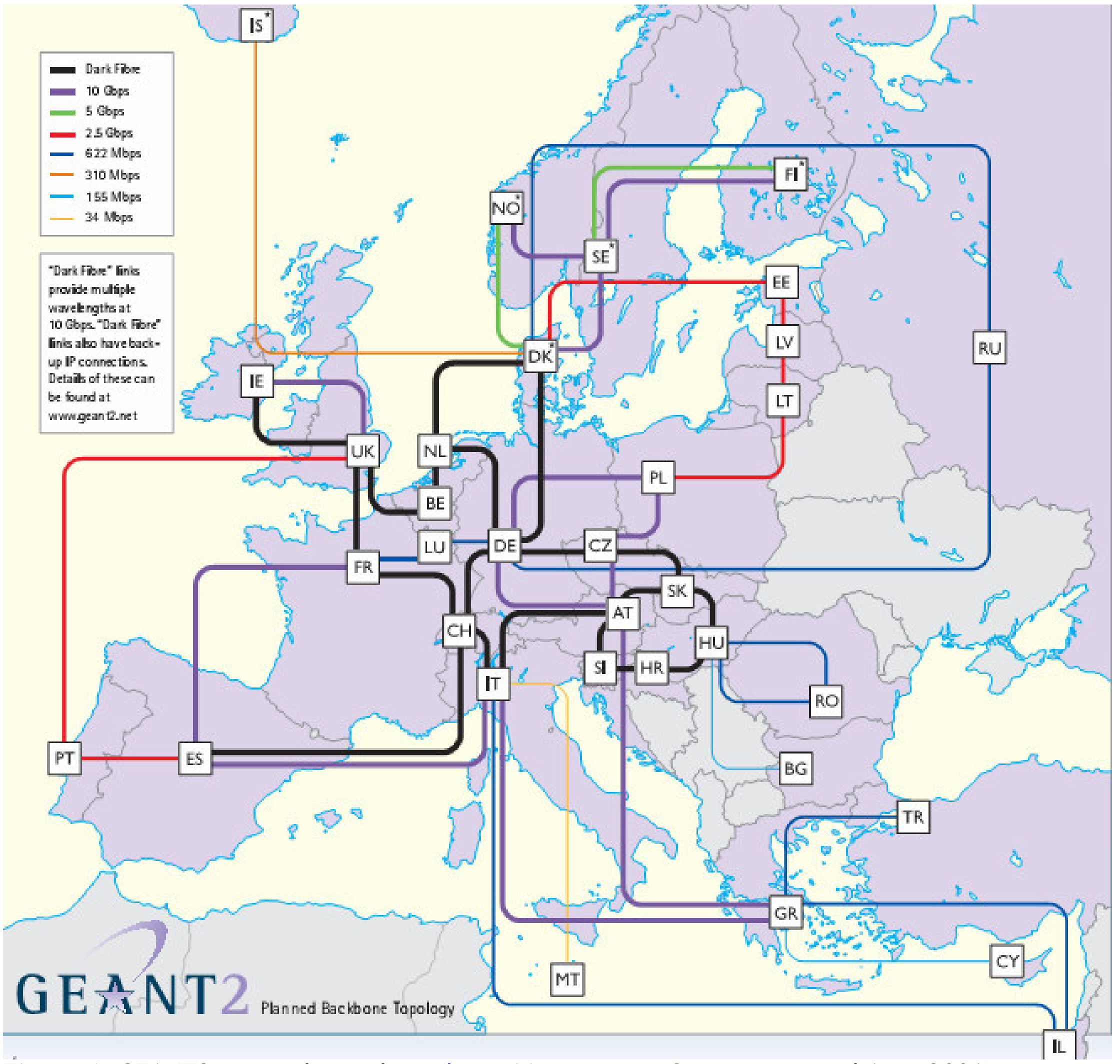

Figure 4: GEANT2 network topology (http://www.geant2.net, accessed Aug, 2006)

3.4. Japan Research Network (SINET)

The other NREN we would like to examine is the JAPAN NREN, SINET. We will present history of S&T policies and NII in Japan, the technology used in current SINET and international projects connecting Japan and Asia Pacific region, respectively.

In late 1970s the Japanese Ministry of Education, Science, Sports and Culture (MONBUSHO) firstly began to investigate a computerized system for the whole academic information circulation, and the Science Council to the Minister produced a recommendation, "Formation of the Science

Information System for the Future" in 1980. This became the basic document to lead the subsequent entire developments in academic information picture of the country. The recommendation included the following items, early realization of which was highly expected:

> 1) Databases of scientific information, mainly abstracting and indexing ones from overseas, should be more introduced and utilized in universities.
> 2) Construction of original databases should be promoted.
> 3) An automated cataloging system to cover all university libraries should be constructed.
> 4) A center should be established to develop the necessary systems and to coordinate the above activities at universities (Negishi 2002)

In 1987, an academic research network, named the Science Information Network (SINET), was started to give service to the main universities and libraries. This network was a traditional packet switching network as its contemporaries. The aim was to give an access to national computer resources like databases and cataloging system which were recommended earlier by MONBUSHO as stated above. SINET packet switched network had been able to live until 2002 and have emerged with Super SINET network which was an important part of e-Japan Priority Policy Program.

> “E-Japan Priority Policy Program was a policy package to materialize e-Japan strategy (started by Advanced Information and Telecommunications Society Promotion Headquarters of Cabinet in January of 2001 to make Japan ‘World’s most advanced IT nation within 5 years’) and detailed Japan government actions that should be implemented expeditiously and intensively”(2nd Japan Science and Technology Basic Law 2001).

Promotion of education and learning as well as to develop human resources and digitization of administration and application of information and telecommunications technology in the public sector were vital issues.

According to the program, one of the policy areas was to formation of the worlds most advanced information and telecommunications networks (assuring security and reliability). Government would not only play direct roles in public areas, such as e-government, dissolution of digital divide and R&D, but also establish an environment where private sector could exert its full potential through deregulations[i].

Also, another Cabinet Office -Council for Science and Technology Policy which has authority to lead science policy headed by the prime minister, has been preparing the Science and Technology basic plans for Japan. After the first and second basic plans (for the periods 1996-2000, and 2001-2005 respectively), this year, third basic plan was taken into affect for the 2006-2010 period. The first plan had given a responsibility to government to develop networks among R & D institutes. The government would:

- Promote the development of inter-institutional networks that connect computers and LAN to each R&D institution.
- connect national research institutes into key networks with a national scale, as soon as possible, and upgrade the data transmitting speed of backbone lines to that in the United States (150 Mbps level, for the present time being) and extend efforts to increase the speed to the gigabit level where necessary.
- Upgrade the data transmitting speed of the Science Information Network (SINET) that connecting universities to the level of which in the United States (150 Mbps level, for the present time being) and extend efforts to increase the speed up to the gigabit level (1st Japan Science and Technology Basic Plan 1996).

In the second basic plan, under the subject of "Maintenance of research-informational infrastructure", it was pointed that:

> Succeeding this improvement of research-informational infrastructure applying IT innovations, the government should elevate and qualify R&D in Japan through collection and dissemination of research information using the infrastructure. Specifically, following world trends and introducing new technology, the government should arrange intensely research computer network and LAN in laboratories for further speed and intelligence. And the government should promote continuously to digitalize research results, research information like resources, magazines of academic societies, library's functions (2nd Japan Science and Technology Basic Plan 2001).

In the third basic plan; as well as going ahead on advanced information and telecommunication technology and global trends to particularly improve host computers and high-speed networks, Council will also aim to reinforce

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[i] Kantei web page, http://www.kantei.go.jp/foreign/it/network/priority/index.html [July 10, 2006]

international cooperation. In this plan, by emphasizing the international competitiveness as an important aspect, industry-academia-government collaboration will be promoted by the Council (3rd Japan Science and Technology Basic Plan 2006).

> "Super SINET was an ultrahigh speed network based on 10 Gbps optical communication technology to promote Japanese academic researches by strengthening collaboration among leading research institutes. In the first stage, the network was used as a basis for studies in the five fields of high energy and nuclear fusion; space and astronomical science; genome information analysis (bio-informatics); supercomputer-interlocking distributed computing (Grid); and nanotechnology. The Internet backbone connects research institutes at 10 Gbps. The IT-Based Laboratory (ITBL) Project also were using Super SINET as its base. Its costs were fully covered by the government, and no charges were imposed to users" (Negishi 2002).

The National Institute of Informatics (NII) belonging to the Ministry of Education, Culture, Sports, Science and Technology has been operating Super SINET infrastructure as an NREN operator. Below you see the current map and international connections of SINET network:

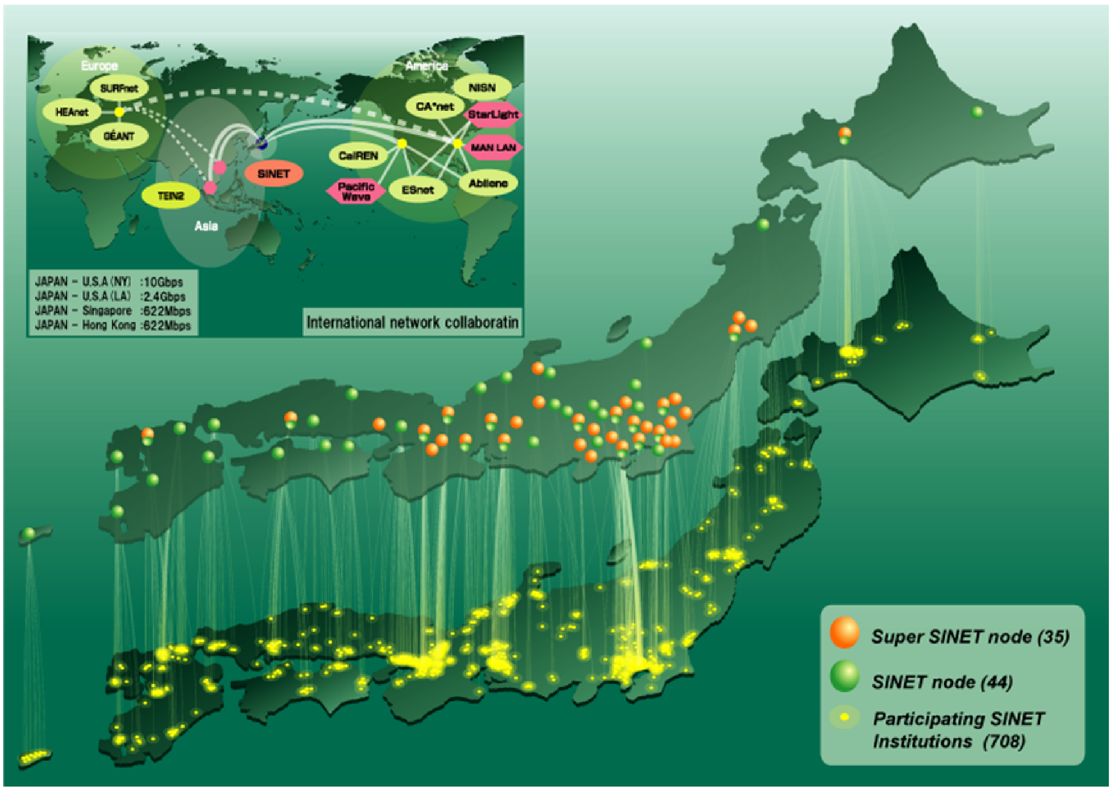

Figure 5: JAPAN Super SINET infrastructure (http://www.sinet.ad.jp/sinet/sinet_kaisen_chizu_1.htm, accessed Nov, 2006)

SINET has been connecting to the world-wide research networks since 1989. The first connection was established with old NSFNet of USA in 1989. SINET and/or Super SINET has connections to GEANT2 of Europe through TEIN2 project and Internet2 of USA through Transpac2 projects.

TEIN2 aims to increase direct connectivity for research and education networks between Europe and Asia as well as intra-regional connectivity between Asian partners of ASEM –Asia Europe Meeting countries (Asian partners are: Brunei, China, Indonesia, Japan, Korea, Malaysia, Phillipines, Singapore, Thailand, and Vietnam. European partners are Holland, England and France) TEIN2 connectivity project will act as a catalyst for the development of national research networking in the developing countries in the Asia-Pacific region (TEIN2 is the second phase of TEIN project comprising the feasibility study and finished in 2004) The project combines the expertise and experience of its European and Asian partners in building and managing state-of-the-art research networks. As of January 2006, TEIN2 project had totally 4x622 Mbps connections to GEANT2 (one of them through South Korea and others from Singapore)[i]

Transpac2 project has a goal to increase research and educational collaboration between the US and APAN (Asian Pacific Advanced Network). To increase R&D collaboration, TransPAC2 aims to deploy a secure, production-quality high-performance network infrastructure between Asia and the US and to assist the Asian partners in the deployment of high-performance infrastructure within Asia. Transpac2 is also next phase of Transpac project which had been active between 1997 and 2005 (In this period the bandwidth between Asia and the US increased to 15Gbps in 2005 from 35Mbps in 1997)[ii]. TransPAC2 is part of the NSF's International Research Network Connections (IRNC) program and funded by NSF.

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[i] TEIN2 web page: http://www.tein2.net/ [Aug 13, 2006]
[ii] TRANSPAC2 web page: http://www.transpac.org/ [Aug 13, 2006]

> TransPAC provided scientists worldwide with high performance access to data and computing resources located in Asia. In addition, TransPAC provided scientists with remote access to exceptional, world-class instruments such as electron microscopes, telescope arrays and satellite based imaging devices. TransPAC has laid the foundation for linking powerful Asian resources and economies into the rapidly developing cyber-infrastructure. Scientists and network engineers communicate daily regarding both operational concerns and future plans. These plans include linking the next phase of Asian networking to both the US and Europe, completing a true global network for support of global science. (Transpac 2005)

When Transpac2 began to operate (as of April 2005), initial network topology has consisted of a 10Gbps link between APAN node in Tokyo (SINET) and Los Angeles. In October 2005 network was extended to Hong Kong to provide access for traffic from China (2.5 Gbps) and in January 2006 to Singapore with 622 Mbps which has already a connection to GEANT2 through TEIN2 (can be thought as a backup of European connection of Japan SINET) The costs of these connections funded by Japan governmental institutes like NICT (National Institute of Information and Communications Technology) and NII (National Institutes of Informatics) respectively as an expected result of Japan National Science and Technology Basic plans which were mentioned above.

3.5. Some other NREN examples from the world

Today, many countries have established dedicated, high-performance national research and education networks (NRENs) in order to support the needs of research, teaching, networking and learning. These typically national-scale networks interconnect universities and national research centers providing un-congested, high speed and advanced communication capabilities, separately from the commercial Internet. We have chosen 2 different NRENs to examine: Pionier of Poland, RNP2 of Brazil. Poland is most similar country to Turkey in terms of population (38 million), university distribution (80 universities, 2 million students) and large geographical area in Europe. The monopoly position of Poland incumbent operator shows commonalities with Turk Telekom. On the other hand, RNP2 is an NREN using the model of US Internet2 and construction of RNP2 backbone gives us a good example of collaboration between infrastructure operators, domestic equipment providers and NREN.

Poland (POL 34/622 - PIONIER)

Poznan Supercomputing and Networking Center (PSNC) is the national and education network operator of the Poland. In 1997, POL 34/622 network was built as a first national broadband network using the IP over ATM technology in Poland. It connected 21 academic metropolitan area networks and had got links with the main telecommunication operators[i]. POL 34/622 then connected the Polish research and education community to the pan-European research network TEN-155.

The de-regulation and de-monopolization of telecommunication market eventuated in January 2001. Since that time the research networking in Poland constantly challenges the commercial providers, introducing innovative technologies and networking concepts, thus triggering the Internet development in the whole country. The State Committee for Scientific Research with the cooperation of leading universities and research centers, in 1999, as a response to the 5th Framework Program of EU, formulated the program of development of information infrastructure for academic society – PIONIER "Polish Optical Internet – Advanced Applications, Services and Technologies for the Information Society" (Binczewski *at al.* 2003). Here, it is worth noting that although POL 34 network was launched at the same year with ULAKNET in 1997, and PIONIER was formulated at the same year with TUENA (Turkish National Information Infrastructure Report), ULAKNET is still using the same IP over ATM technology in the core backbone and TUENA could never been implemented in Turkey.

[i] PSNC web page, http://www.man.poznan.pl/about_us/index.html [Aug 14, 2006]

The PIONIER program were outlining the research, developments and deployments areas for research IT infrastructure in Poland for 2001-2005. The program concept envisaged realization of three basic objectives (KBN 2000):

1. Develop information sciences infrastructure in Poland up to the level, which facilitates conducting research in the area of challenges of contemporary science, technology, services and applications.
2. Produce and test pilot services and applications for information society, which form the basis for implementations in sciences, education, administration and economy.
3. Let Poland compete in the area of software development for new applications.

Main project paradigms of the PIONIER were (Binczewski *at al.* 2003);

-to provide advanced networking infrastructure (namely optical, terabit scalable fiber networks connecting all education and research centers in Poland, thus providing a platform for advanced applications and research infrastructures;
-to build advanced research infrastructures such as specialized networks, High Performance Computer centers, data storage centers, distance learning facilities;
-to enable advanced services and application including digital libraries, computations, geographic information systems, environmental resource management, telemedicine, distance learning and others;
-and to improve the international research collaboration by the means of ensuring access to latest technology developments in IT area.

PSNC has started the PIONIER in 2001, selected DWDM technology for its fiber optic infrastructure to be used by Polish academic community. But because no dark fiber were available or offered from telecom operators, PSNC built his own fiber optic infrastructure by sharing costs with independent investors and telecom operators. In Figure 6, you see current PIONEER fiber optic infrastructure. Each backbone node is connected by optic links to at least to two other nodes to provide always-on operation in case of outage of one optical fiber connection.

Figure 6: PIONEER fiber optic infrastructure
(http://www.pionier.gov.pl/network/index.htm, accessed Dec, 2006)

As of 2006, PSNC has more than 6000 km fiber, and according to TERENA compendium, PSNC aims to own 100 percent fiber optic infrastructure in 2008 (TERENA 2006) and its advanced network resources will able to satisfy their requirements until 2010 at least (Binczewski *at al.* 2003). The same study claimed that new advanced applications would create new trends, fashions and demands, driving the IT market, but the effect of synergy between networking, services and tools (i.e. grids), and content was the key factor.

The PIONIER Network has optical cross-border links to research and education networks such neighboring countries as Germany, Czech Republic, Slovakia, Ukraine, Byelorussia, Lithuania and Russia, and connected to the GEANT2 network with 10Gbps link. The one of the important projects driving by the PSNC is the EU funded Porta-Optica project which aims to connect Poland eastern neighbors; Ukraine, Byelorussia, Lithuania and Russia to the GEANT2 network.

Brazil (RNP2 - IPE)

Another national research and education network we would like to examine is the Brazilian NREN, RNP, because of the similarities with the Internet2 of US. Brazil is a country of continental dimensions -the fifth largest in the world- with an area of 8.5 million km2 with nearly 200 millions population.

The principal research agency is the National Council for Scientific and Technological Development (CNPq) subordinated to the Ministry of Science and Technology. The CNPq provides individual research grants to research workers and students in different institutions apart from maintaining a number of national research laboratories in different parts of the country (Stanton 1993).

> "RNP project were started by CNPq in 1989, and is serving to 329 national education and research institutions, and around 800,000 users. The RNP Association (AsRNP) were a non-profit civil society of private right and public interest whose mission is to promote the innovative use of advanced networks in Brazil, founded in 1999 and being qualified as a Social Organization in 2002 by federal government, became Social Organization National Education and Research Network (RNP/OS) in 2002. According to signed contract with the Ministry of Science and Technology (MCT), RNP/OS were aimed at fostering the activities of technological research in development networks and the operation of advanced network means and services that benefit national education and research"[i].

As a global trend in the world, first IP national backbone was launched in 1992 in Brazil, although there were low speed BITNET connections since 1988. By the promotion of Internet in Brazil (as a response to Internet2 initiative in USA) and in the world, RNP were assigned as an organization leading the diffusion of Internet in country. According to Prochnik and Une (2003), from 1995 to 1999, with the opening of the commercial Internet;

[i] RNP web page, http://www.rnp.br [Aug 12, 2006]

> “the RNP was no longer an exclusively academic backbone and started providing a service to the whole of Brazilian society. The RNP acted as a guide to non-academic Brazilian society at this time, by providing an information centre sharing information on network operations and supporting not only the network’s commercial development but also the emergence of private information and service providers.”

After the 3 years of success history in the kick-off of the launching commercial Internet, in 1999, RNP has returned back to its primary duty to providing support only for research and education networking.

Stanton *at al* (2005), in their papers for IEEE 2005 international conference, focused on the developments in research and education infrastructure after 1999:

> “It was during this period of the late 1990s that a strategic plan was adopted by RNP to pursue the separate development of the networking infrastructure for the research and education community, which would follow the Internet2 road of providing support for those advanced applications that could not be used on the existing commodity IP networks due to lack of capacity or poor performance. This led to two important initiatives: the introduction of the RNP2 national network in 1999, and the creation of 14 metropolitan area testbed networks between 1998 and 2000.”(Stanton *at al*. 2005)

We see that the separation of commercial Internet and research network were later than the Turkey case. But, there were some important factors creating the differences between these two countries on the next years, and these factors brought Brazilian research network to front of ULAKNET technologically. Thee telecommunication liberalization in Brazil was a turning point for the RNP. Telecommunication sector had been a state-monopoly until 1997-1998 in Brazil. But the Brazilian Telecommunications Law of 1997, changed the role of the State from telecommunications service provider to sector regulator and policy maker was the main legal instrument through which Brazil’s telecommunication sector was privatized and opened to competition (ITU 2003). But it is important to highlight that until 2002, there were still a monopoly of private companies (who purchased the old privatized incumbent operator; one of them were national, the other 3 of them were regional) in fixed-lines. In 2002, National Telecommunication Agency (ANATEL) subsequently authorized local telephony operators to provide new telecommunications services other than those indicated in their concession contracts. These additional services include international and domestic long distance, data transmission and local telephony service throughout the country, and wireless telephone services (ITU 2003). This new licensing regime has brought new opportunities for the RNP. After December 2002, it was started two projects namely, GIGA and TIDIA:

> "Funded by the Ministry of Communications (MC) and the Ministry of Science and Technology (MCT) of Brazil through the Telecommunications Special Fund (FUNTTEL) and the Financing Agency for Studies and Projects (FINEP), Project GIGA is the first Brazilian project to exploit the potential of large-scale networking testbeds. With a total budget of approximately US$ 18 million over three years (2003-2005), Project GIGA aims both to create critical mass and to boost the ability of Brazilian individuals and companies to play a role in the converged telecom sector. It achieves this by promoting collaborative research, development and experimentation (R&D&E) of applications, services, protocols, equipment and technology at all layers" (Scarabucci and Stanton 2005)

> "TIDIA Program (Information Technology in the Development of the Advanced Internet), supported by the state agency, FAPESP, in Sao Paulo, which has similar objectives to Project GIGA, including the building of an extensive intercity IP over optical network for R&D use, and the financial support of R&D activities in networking and distance learning, and of activities related to technology transfer" (Stanton *at al.* 2005)

With the contribution of these initiatives it is so obvious that Brazilian research community will have next generation network services to end-users through a facilities-based infrastructure, such as dark fiber or WDM technology, rather than one based on leasing services from the telecommunication operator as in the our case in Turkey, like ATM, frame-relay, xDSL or SDH. As shown the latest infrastructure of RNP2 in Figure 7, RNP infrastructure uses same technologies (SDH, ATM/FR) like ULAKNET (which we will later discuss) in its backbone except DWDM technology which provides high bandwidth but requires direct fiber access. But, as another important factor distinguishing RNP from ULAKNET, we would like to emphasize the collaboration between RNP and national R&D companies. For example, although IP network equipment used in the backbone of RNP2 is mostly supplied by the international network companies like Juniper Networks Co., Extreme Networks Co., Scarabucci (2005) states that

> "the optical WDM technology is being development by national CPqD Telecom company (R&D department of former state telecommunication operator) and optical equipments developed by CPqD is being supplied by PAdtec which is another national equipment company. The list of these equipment includes transponders, optical add/drop multiplexers, multiplexers and demultiplexers, and erbium-doped fibre amplifiers"

It is no doubt that, this collaboration helps the testing of national telecommunication products in GIGA test-experimental network before the products to be exported to international markets besides not to import these products from international companies.

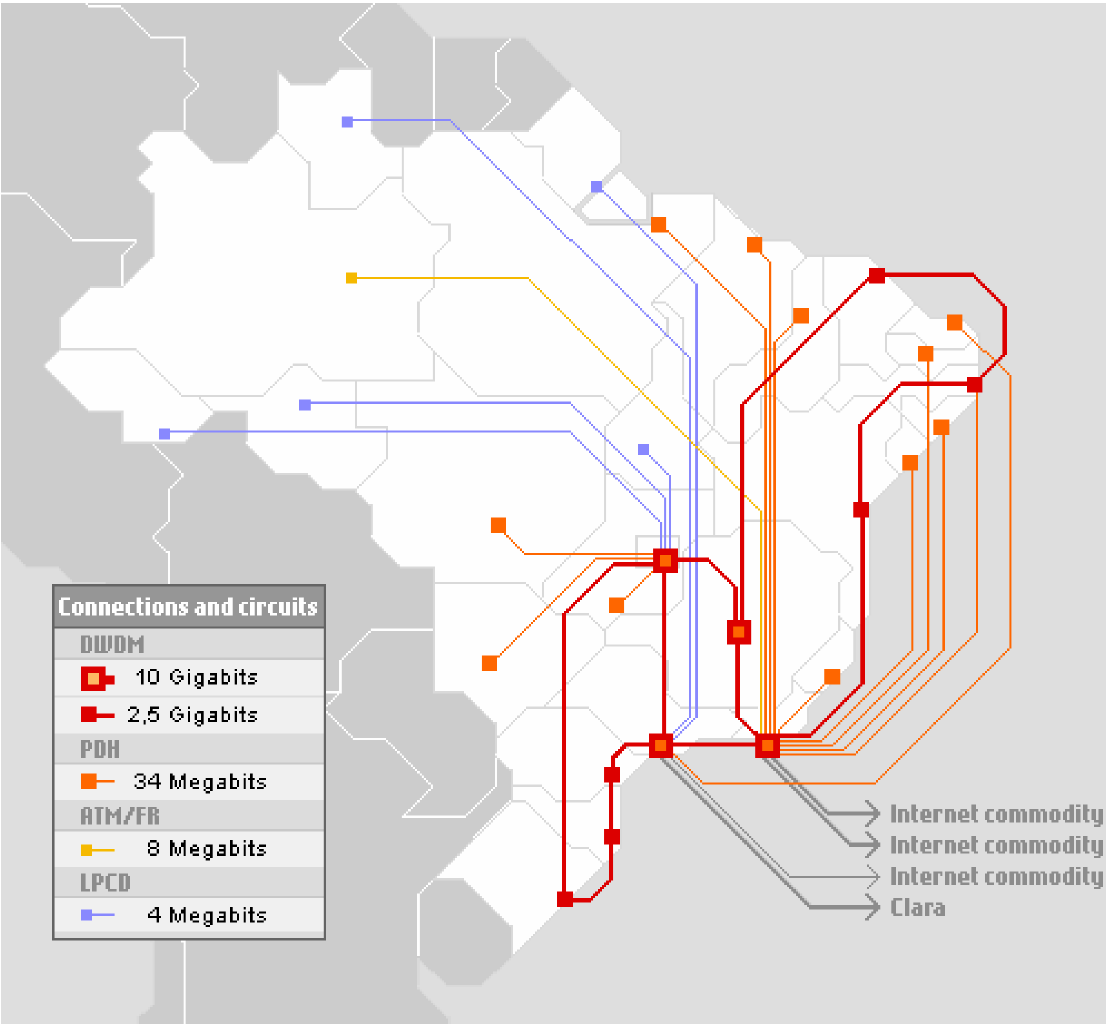

Figure 7: RNP2 infrastructure (2005), http://www.rnp.br, accessed Aug 12, 2006.

The next phase of research networking in Brazil will be IPE network (first letters of Innovation, Research and Education in Portuguese) because GIGA network is only restricted to be used for experimental purposes. By December 2006, it is planned to connect more than 200 institutions with a 1 Gbps connection to the new IPE network and the in the backbone, 10 PoP points will be connected to each other via at least 2.5 Gbps in IP over DWDM technology. Such a network undoubtedly will provide extreme environment for the applications require massive transfer of data from remote sensors, parallel computing using grid technology, remote visualization and high definition of video-image transfer transmission.

On the other hand, RNP as a partner of RedCLARA (Cooperation of Latin America Research Networks) has two international connections to the Internet2 (155 Mbps) and GEANT2 networks (622 Mbps connection which is 80 percent funded by EU via ALICE project[i]) as well as the connections to the other South American research networks.

3.6. Evaluation

New links between NRENs and regional and international research and education networks have created a global web of connectivity among research and education institutions. This infrastructure provides dedicated, high-performance network capabilities not only within a country, but between research and educational institutions located in different parts of the world. A typical NREN today needs to connect into only one or two other NRENs, or directly connected to the hub points in Europe or in USA to reach the entire global set of research networks.

According to the most recent e-IRG (e-Infrastructure Reflection Group, coordinating on a high European level the introduction of an infrastructure for e-Science) white paper (2006), it was pointed that:

> "Research Networking policy should be based on the postulate that the Network is a dominant major element of the e-Infrastructure. No remote accessibility of

[i] http://alice.dante.net [Sep 25, 2006]

distributed resources (computing, storage, data, equipment, and other resources) is possible without an appropriate network infrastructure."

Although every country is aware that research and education networking is very important, it should not be forgotten that it is not only for research and education. As we already quoted from the Serenate Study (EC 2003b) and Internet2 project reports, "research and education networks are the national assets and connectivity between the national research institutes fuels innovation and technology transfer to both society and industry"

The important factors affecting the performance of NRENs are liberalization degree of telecommunication sector, and political and stable financial support of the national government. NRENs should not be confused with commercial Internet service providers although most of them had a mission in early 1990's to spread the usage of Internet. After the widespread usage and commercialization of Internet, NRENs became an integrated communication environment for the specific needs of academic and research community. After 2000's, parallel with the liberalization of telecommunication markets as a global trend, the convergence of information and communication technologies has created a new environment for innovation and new knowledge creation through NRENs.

CHAPTER 4

RESEARCH AND EDUCATION NETWORK IN TURKEY

This chapter initially presents an overview of the Science and Technology policies of Turkey in order to obtain a comparison with the other countries examined in previous chapters. Turkish telecommunication sector status is detailed from liberalization point of view. It then focuses the history and current performance of research and education networks in Turkey. At the end, we evaluate our findings in order to solve our research questions in the next chapter.

4.1. Milestones for Science and Technology Policies

Before the establishment of Turkish Republic in 1923, The Ottoman Empire had missed the evolutionary process towards an industrial society during the industrial revolution in 18th and 19th centuries. Young Turkish Republic, in the period from 1923 to 1960, had tried to close her industrialization gap with the developed countries with the support of government. While the industrialized countries were evolving into a new era called as Information Society, catching up the Information Age become another inevitable urgency beside the Turkey's historical industrialization gap.

After 1960, National science and technology policy studies started with the planned economy period in Turkey. As the result of the first Five-Year Development Plan (1961-1966), as one of the first steps, TUBITAK (Scientific and Technical Research Council of Turkey) was founded to coordinate and promote researching in basic and applied sciences.

The first report for the Turkish Science and Technology Policy was prepared as the result of Pilot Teams' Project on Science and Economic Development under the auspices of OECD Scientific Research Committee in 1967. In the final report (OECD 1966), science policy strategies for economic development and social wealth of Turkey were suggested.

Until the liberalization of Turkish economy in 1980, any systematic approach could not have been implemented in practice although Second (1968-72) and Third (1973-77) Five-year Development Plans had mentioned about technological development and technology transfer, and in Fourth Five-year development plan (1979-83), as the first time, importance of an "technology policy" had been taken into consideration(TUBITAK 1996a).

The establishment of Supreme Council of Science and Technology

The second Science and Technology policy document was prepared in 1983 with the contribution of over 300 experts from different disciplines under the coordination of Ministry of State. "Turkish Science Policy: 1983-2003" report, explicitly recognized the role of technology for development, and suggested priority areas of technology for the Turkey. Although these technology areas were broadly defined, this document could be regarded as the first attempt towards defining "critical technologies" in Turkey. This document led to the creation of a new institution in 1983, the Supreme Council for Science and Technology (SCST), as the highest S&T policymaking body managed by the Prime Minister. The Supreme Council enabled designing S&T policies with the participation of representatives of both governmental and non governmental organizations who take part in the management of economic and social life. But the SCST could not have been held until 1989 and the policy report could not have been implemented. After 4 years from the first meeting, in the second meeting of SCST, new document entitled "Turkish Science and Technology Policy: 1993-2003" was approved by the council.

> “In the mid-1990s, the SCST started to play an active role in formulating the national S&T policy as the central component of the National Innovation System, reacting swiftly to worldwide developments. This document paved the way for new policy initiatives, such as R&D support programs, in the 1990s. This was a turning point in the S&T policy era in Turkey, as there was a paradigm shift from "building a modern R&D infrastructure" to "innovation oriented" national policies. The policy formulated in this document was further elaborated in 1995 with "The Project for Impetus in Science and Technology", which formed the S&T chapter of the Seventh Five Year Economic Development Plan (1996-2000)”(TUBITAK 2004a)

In the report of “The Project for Impetus in Science and Technology”, it has been proposed seven specific fields of investment in order to create a concrete base for enhancing the S&T capability of Turkey. These specific fields converging the priority areas suggested by the “Turkish Science and Technology Policy: 1993- 2003” are:

- Construction of the National Information Infrastructure needed for the 21st Century and the Telematic Services Network;
- Process R&D, especially in Flexible Manufacturing and Flexible Automation Technologies, for innovation in the Turkish Manufacturing Industry;
- Upgrading the Existing Railway System on the base of High-Speed Train Technologies;
- Aviation Industry, and R&D on the base of selected aviation products;
- R&D in Gene Engineering and Biotechnology, and project based applications;
- R&D in Environmentally Sound Technologies, and in Effective Use of Energy and Environment Friendly - Renewable Energy Technologies, and nation-wide applications;
- R&D in Advanced Materials; and related industries(TUBITAK 1996b)

In the August 1997, the Supreme Council for S&T has approved “The Agenda in S&T for the years 1996-1998” that can be defined as an emergency action plan by taking into consideration the suggestions in “The Project for Impetus in S&T” report of TUBITAK. And in the next meeting, in June of 1998, it was made some additions and arrangements to the Agenda. According to the Agenda, The Turkish National Innovation System would be established according to the main goals of the National Science and Technology Policy. Here, we will only deal with two subjects of the Agenda. One of them was the devising a Master Plan establishing the National Information Infrastructure, and the other one was the establishment of a National Academic Network and the Information Center.

In 1996, the Turkish Academic Network and Information Center (ULAKBIM) was established and began to build a nation-wide research and education network (ULAKNET). In the next parts of this study, we will intensively examine the history, the current performance and the future of ULAKNET.

Turkish National Information Infrastructure (TUENA) Master Plan on the Dusty Shelf

At the end of 1998, the master plan report for the construction of National Information Infrastructure (TUENA) had been completed by TUBITAK. In master plan, TUBITAK acted as a secretariat body and the coordination duty was of the Ministry of Transportation which was responsible ministry for all infrastructural issues.

> A TUENA Coordination Office was set up within TUBITAK meanwhile the Transportation Ministry established an executive group with the participation of one representative from the Chief of Staff, General Secretariat of the National Security Council, State Planning Organization, TUBITAK, TESID (Turkish Electronic Industrialists Association), Turkish Software Industrialists Association, TTGV (Turkish Technology Development Association) and Turkish Telecom. The executive group controlled the work of the TUENA Office and approved the completed work packages. TUENA comprised of four work packages in concert with a long-term strategic planning approach. Those packages were: Monitoring Environment (Turkey and the world), Infrastructure Planning, National Value-added Instruments, Institutional Restructuring. In the course of the master plan exercise, a total of 52 documents totally more than 3390 pages were produced. Two two-day workshops with the participation of a total 182 experts and actors were held. More than 200 institutions' views were incorporated into the Masterplan through interviews. Fourteen working groups were set up for various purposes (TUBITAK 1999)

The TUENA Masterplan initiative concluded a number of proposals for reorganization and/or for setting up new bodies and for improving principles:

- Information infrastructure/knowledge society bodies: New body as Council of Knowledge Society.
- Telecommunications regulatory bodies: New principles, reorganization, setting up a regulatory body
- Government informatisation and public services: New, Knowledge Society Agency, new principles, and reorganization
- Sectoral ICT industry policy bodies: New principles, new instruments and reorganization (TUBITAK 1999)

Although TUENA master plan have not been put into force by Ministry of Transportation and Prime-Ministry (the coordination duty had been given to Ministry of Transportation by Prime-Ministry), some of the proposals have been implemented in the length of time because of the requirements of ICT sector and under the stress of the global circumstances. For example, the establishment of Telecommunication Authority in 2001 was one of the important developments and after the amendment made on the Law No. 406 with the Law No. 4673 of Turkish Grand National Assembly (12.05.2001) the authorization function in Turkish telecommunication sector was transferred to Telecommunications Authority.

Visio 2023 foresight study: Still waits for the implementation

As we already stated in previous S&T policy experiences of Turkey, TUBITAK had several times prepared long-term S&T strategy documents since its establishment. These were of very limited use and had not been implemented. Hence, TUBITAK decided to prepare a new strategy document based on technology foresight by emphasizing the reasons behind the failures of old studies.

> Visio 2023 foresight study (2023 will be 100th anniversary of the establishment of the Turkish Republic) would involve the first-ever Turkish national Foresight exercise, together with three more sub-projects that aim at collecting and evaluating data on the current science, technology and innovation capacity of the country. Because the implementation of S&T policies had always been a problem in Turkey, TUBITAK underlined the key issues behind the problems on implementing the old studies. The reasons were:
> 1. The lack of ownership, society involvement, political support and dissemination
> 2. Isolated S&T policies
> 3. Fragmentation of researchers and resources (Visio 2023)

TUBITAK's plan was approved, in December 2000, by the Supreme Council of Science and Technology (SCST), and after one year preparation period, SCST approved the Foresight program in December, 2001. The project was initially planned for a 2-year period, and its implementation started in January 2002.

SCST stated the aim of the program as "to implement a long term technological Foresight program for establishing a strategy, considering scientific, technological, socio-economic and political trends in Europe and in the world and taking into account similar exercises previously conducted as well as using input from other modules of the Strategy Document". The important decision taken indicated that the major aim was to support central decision making in the government and as well as in TUBITAK. Visio 2023 was started in order to:

1. Build a science and technology vision for Turkey
2. Determine strategic technologies and priority areas of R&D
3. Formulate Turkey's science and technology policies for the next 20-year period
4. Get a wide spectrum of stakeholders involved in the process, thus gaining their support
5. Create public awareness of the importance of S&T for socio-economic development (Visio 2023)

Visio 2023 Science and Technology Strategy document were used as a base on next SCST meetings. In the 11th meeting of SCST on March, 2005, both Visio 2023 strategy and the National Science and Technology Policy for 2005-2010 application plans were approved by the Council. But on both studies, there was no explicit statement or strategy dedicated to the development of the National Research and Education Network (ULAKNET) with parallel to developments on world-wide research and education networks (i.e. national research fiber optic infrastructure) although implicitly Turkish Research Area (TARAL) program executed by TUBITAK overlaps with issues (like increasing the research capacity of the Turkey) in the European Union’s Research Area program (ERA).

9Th Development Plan

Recently, 9th Development Plan for the years 2007-2013 of State Planning Organization was approved by Turkish Grand National Assembly, on June, 2006. This plan, differently from the old five-year plans, is planned for seven years to be compatible with EU 7th Framework Program for 2007, and it is in accordance with the Visio 2023 Strategy of TUBITAK especially in the technology priorities area. In the plan, main socio-economic development areas are stated as; increasing competitiveness, job creation, increasing the quality and efficiency in public services (including e-government applications), providing regional developments, improving human resources and powering social solidarity. Under the “improving in R&D and innovation” goal of the increasing competitiveness subject, after fixing the imbalance between the contribution rate to the 6^{th} FP and return rate of the projects of Turkey, it was determined that the insufficient national R&D infrastructure and number of researchers, and the lack of interconnection with EU research infrastructure caused this imbalance. In 9^{th} Development Plan, it was planned to increase research capacity of Turkey by improving the collaboration between universities and private sector, and international collaboration with the developed countries on knowledge and technology transfer will be supported.

Knowledge Society Strategy Plan 2006-2010:

Additionally, more recently, State Planning Organization have prepared a Knowledge Society Strategy 2006-2010, and it was published in Official Gazette, at the end of July 2006. Strategy document (DPT 2006) also includes totally 111 different actions for seven strategic priorities on the way of knowledge society for Turkey to meet with EU Lisbon strategy. Firstly we would like to emphasize that there is no specific action for the future of national research and education network although there are action plans on the relevant areas:

i) Research collaboration between government-university-industry (under the strategic priority for the improvement of R&D and innovation)
ii) Incentives and regulations for the next generation telecommunication infrastructures, and implementation of competition on both telecommunication services and infrastructures (under the strategic priority about the competitive, wide-spread and cheaper telecommunication infrastructure and services) (DPT 2006)

It is obvious that “research collaboration between government-university-industry” can not be provided strictly without an advanced network infrastructure.

4.2. Turkish Academic Network (ULAKNET)

Turkish Academic Network and the Information Center (ULAKBIM) has been founded as a R&D facilities unit of the Scientific and Technological Research Council of Turkey (TUBITAK) in 1996. Foundation of ULAKBIM was one of the important results of the “The Project for Impetus in S&T” report which were published in 1995 by TUBITAK.

ULAKBIM aims at providing technological facilities such as computer networks, grid infrastructure support, information technology support, and information and document delivery services, to meet the information requirements of universities and research institutions, and to increase the efficiency and productivity of their end users.

The Turkish NREN (ULAKNET), which undertakes the task of formation of research and education network infrastructure, gives full networking services to their institutions. ULAKNET not only interconnects institutions for research and education to each other but also connects the institutions to the commodity Internet, such that an institution gets all its networking needs satisfied by ULAKBIM. This is similar in the Europe, but different in the USA because of difference in regulations. In this section, we present the history and current performance of academic networks in Turkey. Then, ULAKNET will be analyzed in terms of technological and infrastructural efficiency.

4.2.1. Brief History of Academic Networks and Internet in Turkey

The first initiative in Turkey for a national academic network was TUVAKA (Turkish Universities and Research Institutions Network) which began in

1986. Although TUVAKA was an initiative under the auspices of Higher Education Council (YOK), because of lack of professional staff and budgetary restrictions it could not have been able to provide any services in terms of researching in network, but it only provided low capacity BITNET connection through EARN. (We already mentioned that EARN/BITNET networks were fundamentally away from the research issues in previous sections)

In 1993, TUBITAK and METU (Middle East Technical University) had started a new project named TR-Net to connect the all Turkish citizens (including universities) to global Internet (First Internet connection was to NSF, USA, April 12, 1993) and to each other with TCP/IP protocol. Users and institutions were connected to the TR-Net backbone through leased lines, X25 network and dial-up connections. With the dissemination of World Wide Web service, in parallel with global developments, TR-Net normally had not been able to continue by connecting both private and academic users to the same backbone (Here we should highlight that TR-Net backbone had consisted a 64 Kbps leased line between 2 Points of Presences -TUBITAK and METU, and an NSF Internet connection). Old TUVAKA sites could not adapt their technologies to the TCP/IP environment requiring substantial amount of financial resources. TR-Net actually had been providing Internet connections to all its users and it were absolutely impossible to talk about research networking in Turkey. TR-Net had not a well established structure in administrative and legal points of view. And also according to her foundation law, TUBITAK should not continue to give a public service for all citizens. Hence, it was inevitable to parse the traffics of academic and private users as in the cases of USA and Europe.

At the beginning of 1996, TUBITAK had declared that she would start a new network project (ULAKNET) to separate academic users and researchers from the TR-Net infrastructure. At the same time, Turk Telekom A,S. had begun to build a new infrastructure for the general Internet usage (TUR-NET). Then, in 1998, Turk Telekom A.S has built current national Internet backbone named as TT-Net.

In the Foundation Proposal of ULAKNET, on February of 1996, it was stated that it had a must to build national research and education network to make ready the Turkish academic environment for 2000's. The basic requirements for a new network infrastructure fixed as; insufficient human resource in education (need for distant education), poor quality in research and education (in addition, unable to reach all national academic content), insufficient computer resources (impossibilities building a supercomputer in each university and institution). The main goals of ULAKNET proposal (TUBITAK 1996c) were the followings:

> -ULAKNET would provide a transparent network environment for the universities, public and private R&D institutions, and the institutions making policy for the science and technology. This network infrastructure and its content would actually be a distributed and dynamic national asset.
> -ULAKNET would had a key part for the improvement of higher education and research products to a high quality by disseminating knowledge society issue and socio-economic opportunities nation-wide to lay a concrete groundwork for overall transformation. Improving in human quality would provide competitiveness and sustainable development for Turkey.
> -ULAKNET would start an education, research and communication infrastructure organization to implement remote education in the length of time. This was a must for the young Turkish academicians spreading in a large geography.

In the Proposal, there were some suggestions for the Turkish education system. It was stated that National research and education system, which has a role in the dissemination, assimilation and production of the generic technologies which are the results of science and technology revolution, should be thought as a part of a broader national innovation system so that Turkish academic network have been accepted as a concrete ground for the production of new advanced services and new products in the information technologies area. But this proposal, as we later examine in detail, would have been never implemented by the policy makers.

4.2.2. The present performance of ULAKNET

After the foundation of ULAKBIM, it has been begun to build a nation-wide network for the universities and research institutions. At the beginning, ULAKNET were misunderstood as an Internet service provider for universities by most of the circles, and governmental research institutions were being tried to be separated from the ULAKNET. But one of its important missions was to establish and operate a computer network enabling interaction within the institutional elements of national innovation system, and to provide information technologies support for information production. Maintaining the network at high speed and high performance, opening to new technologies, producing new network services for the national information system, ULAKNET would/should provide an interactive environment for the elements of national innovation system to transform this information into the national economic benefit.

In 1997, Turk Telekom A.S were only giving leased line and X25 data services although it had bought newly ATM and Frame-Relay access devices, and international connection costs were very high because of its monopoly position. Lease line options were very limited because the TDM (Time Division Multiplexing) infrastructure had not been installed widespread domestically. According to the protocol signed between TUBITAK and Turk Telekom, ULAKNET would use ATM technology in backbone (initial backbone capacity was 34 Mbps between 3 Points of Presences in Ankara, Izmir and Istanbul) and Frame-Relay technology on access side, ULAKNET would donate its TDM access devices to the Turk Telekom after their installation on the ULAKNET sites. This test bed environment was the first attempt between Turk Telekom and any other organization in Turkey. After the ULAKNET had begun to operate and give network services on this infrastructure, Turk Telekom set its tariffs and began to give ATM and Frame-Relay services over expanded TDM network to its private and public users. Even this example helps to show the importance of research and education networking in Turkey.

Initial investment and monthly costs of all connections (including 512 Kbps Internet connection to USA) were funded by government resources. In the 4rd meeting of SCST (Supreme Council of Science and Technology) in July, 1998, it was decided to increase the ULAKBIM budget for the next years, and the Ministry of Finance and State Planning Organization were assigned to evaluate the financial needs of ULAKBIM. At the end of the 1999, the number of institution connected to the ULAKNET were increased to 114 (including all 80 universities), total capacity on access side to 75 Mbps and total Internet connection capacity to more than 40 Mbps. This picture shows that, on those dates, ULAKNET was not so behind of the similar networks in Europe and USA from the technical and technological points of view. But actually, 1996-1998 period was a turning point for the world-wide research networking.

ULAKNET was designed fully dependent on Turk Telekom’s infrastructure and some value-added services different from the TR-Net and TUVAKA networks which only leased the lines from the national incumbent operator. It was obvious that ULAKNET’s design had some advantageous on issues like initial investment costs, reliability, redundancy, scalability and maintenance. But as a disadvantage, future of research networking would directly dependent on investment decisions of Turk Telekom. Because regulatory context were not suitable and capital investment costs were very high, there were no choice other than using the Turk Telekom’s infrastructure and services.

The capacity of ULAKNET was increased slightly until mid 2002. Actually a project called as “ULAKNET Capacity Upgrade Project” had already started in 2000 but because due to the budgetary restrictions (for both initial investment and monthly costs) ULAKBIM had to wait until 2002 for the upgrade. In 6th SCST meeting, in December 2000, it was approved to upgrade capacity of ULAKNET, and in 7th meeting of SCST, in December 2001, it was decided Ministry of Finance to assign 18 million USD budget annually for the capacity upgrade project of ULAKNET which was seen as one of the important parts to reach eTurkiye goals with parallel to eEurope+ goals of European Union (BTYK 2001).

"UlakNet Capacity Upgrade Project" started by mid 2002 after the procurement of financial resources by the Ministry of Finance. 3 Gigabit routers and 3 pairs of STM-16 SDH equipment were installed for three Points of Presence (PoP) located in Ankara, Istanbul and Izmir and ATM backbone with capacity of 155Mbps was set up between these PoPs. After this procedure all universities, research and development institutions, some governmental organizations, and military and police academies were connected to this backbone with access speeds range from 2 Mbps to 155 Mbps. The bandwidth of UlakNet to the global Internet connectivity was increased to 465 Mbps. After all improvements, connection to other National and Research Networks in the world became inevitable. Such connection was very important for stimulation the integration of the Turkish academic community into the international projects. As a result in December 2002, a 34 Mbps link to European Research and Education Network-GEANT has been established via satellite and this link was increased to 155 Mbps in January 2003. Table 1 shows the evolution of academic networks in Turkey.

TABLE 1: Evolution of Academic Networks in Turkey.

Name	Period	Technology	Explanation
TUVAKA	1986-1995	BITNET	Up to 9.6 Kbps First academic network
TR-NET	1993-1996	Internet (X25, leased lines, dial-up)	9.6-64Kbps.First IP network (including commercial users)
ULAKNET	1996-2002	IP/ATM,IP/FR	Access up to 8 Mbps, Backbone 34 Mbps
ULAKNET (after upgrade)	2002-	IP/ATM,IP/FR, IP/ADSL, IP/POS, IP/SDH	Access up to 155 Mbps Backbone 622 Mbps

Currently, in November 2006, ULAKNET has more than 2 million users and more than 80.000 researchers connected to the network. Commodity Internet connection is about 2Gbps through TT-Net and global research networks connection is 622Mbps through GEANT2 project (Figure 7 shows the current map of ULAKNET backbone). There are more than 600 governmental R&D institutions and university nodes connected to the 3 PoPs which are connected to each other with 310-622 Mbps speeds. Some advanced services that are available on similar research networks like QoS (quality of service), Multicast, VoIP (Voice over IP), IPv6 and CSIRT (Computer security incident response team) services are offered by ULAKNET infrastructure.

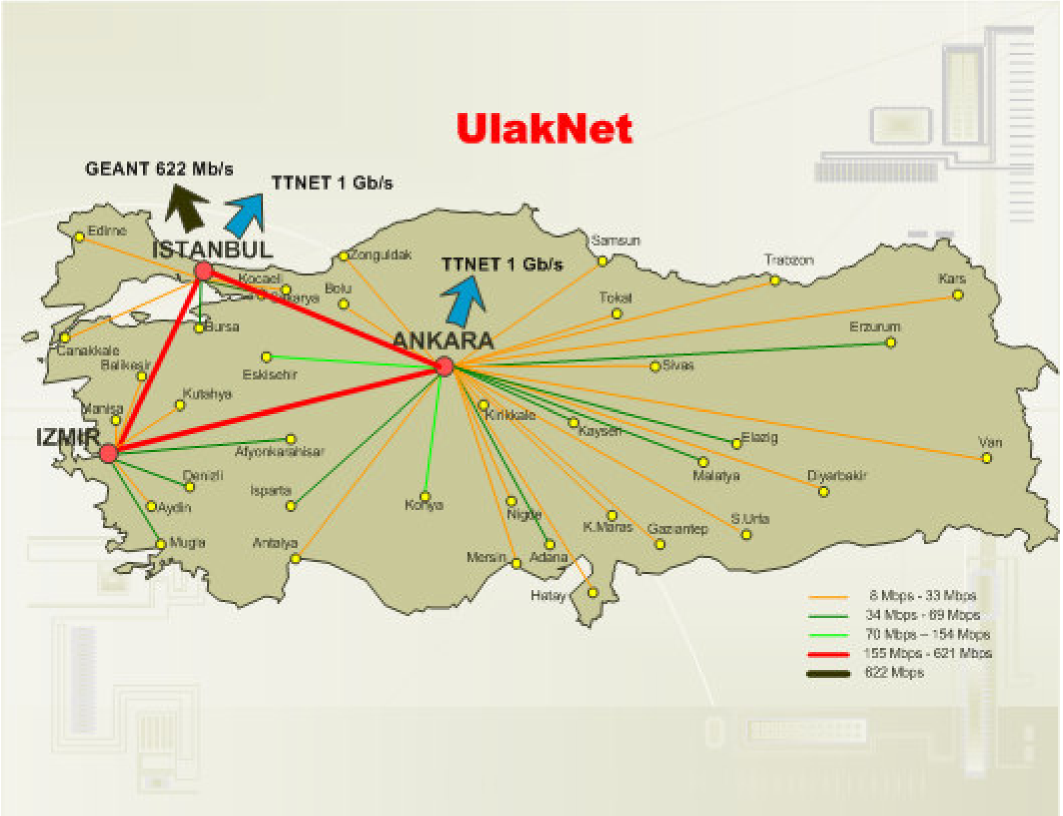

Figure 7: ULAKNET November 2006
http://www.ulakbim.gov.tr/hakkimizda/tarihce/ulaknet/dunbugun.uhtml, accessed Nov 15, 2006.

In addition, in Turkey, there have not been any national centers for High Performance Computing available to the whole research community till 2003. Each university or research institute did provide computing power for its own users. The use of supercomputers in all institutes was limited or even non-existing. ULAKBIM started National Grid Initiative (TR-Grid) in Turkey in 2004. As an NGO (National Grid Organization) of Turkey, ULAKBIM’s major project is to form a Turk National Grid e-Infrastructure which will become operational at the end of 2006. The objectives of the project are to build an e-Infrastructure that is distributed among universities which will provide computational resources to researchers, to make this huge computing power a part of International Grid projects and to extend this infrastructure nationwide. When infrastructure become operational, more than 600 CPU’s and more than 50 Tbyte storage capacity will be available for Turkish researchers. Participant universities in TR-Grid initiative added and in future will add their own equipment to the general shared e-Infrastructure. This project will provide an operational e-Infrastructure distributed over 7 nodes or virtual laboratories connected to ULAKNET early by 2007.

4.2.3. Analysis of ULAKNET: Problems

Today, research and education networks are essential tools for much of the ongoing research and collaborative projects. No scientific community can progress and improve its knowledge without exchanging information with similar communities throughout the domestic and international connections. Commodity Internet will not be able to provide a necessary infrastructure and advanced services for the researchers whose studies will enable production of new technologies and services for their nation's to reach a sustainable development progress.

In Turkey, research and education networks (currently ULAKNET) were not built as a demand of internal dynamics (universities, R&D institutions) but as a result of global tendencies. Turkey is not among the countries who fully established their national innovation system and used their national information system to produce information technologies. It is obvious that research networks are tools to create national competitiveness and provide economic growth rather than being only a purpose to connect their users to Internet or to the global information data houses. Hence, although different Science and Technology policies have been tried to implement for 40 years, none of them has proposed a true "research networking" environment or infrastructure for the collaboration and communication of the elements of national innovation system. We can distinguish the TUENA Report (National Information Infrastructure Masterplan-1999) of TUBITAK from the others. But besides TUENA report has not been supported by government policies, it has not been improved in 2000s according to the developments in global telecommunication markets.

In the design and first deployment phase of ULAKNET infrastructure, in 1996-1998, liberalization of telecommunication markets has not started in most of countries, although Final Act of Uruguay Round (General Agreement on Tariffs in Services) were accepted, and Turk Telekom was one of the important incumbent operators of the world in terms of total capacity and service diversity. Thus as we mentioned before, ULAKNET began to provide technologically an enhanced service for its users at the beginning. But this full dependency to Turk Telekom services would have created a bottleneck for the ULAKNET. Because Turk Telekom have not been able to keep up with the global trends in telecommunication sector, or in other words, Turkish governments have been late about regulations on sector and restricted the investments of Turk Telekom due to political and economic reasons, ULAKNET have fallen technologically behind of the similar NRENs in the world although annual payments for the leased connections to Turk Telekom were very high when compared with those NRENs (more than 20 million $ annually)

The liberalization of European markets (starting with 1998), produced positive results: as an example, the total cost of maintaining TEN-155 in 1999 has not been superior to that of TEN-34 in 1997. Similarly in the year 2000 it was possible to remove the last bottlenecks by upgrading to four times the capacity at the same costs. (Busquin and Liikanen 2000)

As we noted above, 1996-1998 period was a turning point for the world-wide research networking. It is obvious that the overall state of the national market for telecommunications and network infrastructure is a barrier for the development of NRENs. If there is a lack of investment in telecommunications infrastructure in a country like Turkey, because of an insufficient de facto liberalization of the market or because of general economic circumstances or because of the political reasons, then it is difficult for that NREN to deploy its new and advanced services to its research community. Conversely, for the countries where large investments have been made in the telecommunications infrastructure, there may be a wide choice of options for those NRENs.

The pressures to change in the telecommunication industry began in the mid 1980s when the state monopoly on the telecommunication services was privatized in US, UK and Japan. By the late 1990s, with the agreement to fully liberalize its telecom market of the European Union and the similar agreement of the World Trade Organization (WTO), the essentiality of liberalization of the telecom industry became a consensus (Fransman 2002). At the beginning of 2002, more than half the countries in the world had fully or partly privatized their incumbent telecom operator. Countries with a privately-owned incumbent operator account for 85% of the world market by revenue (ITU 2002). Here, we do not want to make determinations about the benefits or disadvantages of liberalization of national telecommunication markets or the privatization of national incumbent operators. We only would like to point out the very demanding applications and services of NRENs require high speed transmission capabilities and high performance infrastructures. Research networks, for 10 years, have been running to end-to-end switching environment from the packet switched networks. International collaboration between the research communities everyday requires more and more bandwidth for huge amount of data transfers (data grids) to be used in real time processing, for sharing of computation resources irrespective of location (computational grids) and for high quality video demanding services. Actually telecommunication equipment suppliers are making innovations for these demanding applications. For example, in 2000 it was announced that Lucent Technologies' Bell Labs had pushed 1.6 trillion bits, or terabits, of information through a single optical fiber by using the dense wavelength division multiplexing technique (DWDM).

DWDM technology and fiber optic infrastructures offer enormous opportunities for research and education networks in the world, regarding cost and management and in relation to the network capacities and services that can be provided.

In addition, fiber optic infrastructure becomes an asset of crucial importance, not only for research and education, but also for the economy and society in general. A competitive market for fiber infrastructure were being promoted and provided by the liberalized markets. Accessing to fiber optic infrastructure by DWM technologies at reasonable prices have changed the vision of NRENs, and low costs of cross-border and oversea fibers not only have increased the research collaboration between neighboring countries but also provided a high speed environment for end-to-end applications.

> "The liberalization of the telecommunications markets in Europe has had a major impact on the environment in which National Research and Education Network organizations (NRENs) operate. In many parts of Europe, the prices to be paid for the components of networks have been reduced enormously. Europe is now a world leader in several aspects of research networking. However, progress has not been uniform."[i]

According to TERENA Compendium (TERENA 2006), the data from the member countries shows that:

> "with the leading of EU NRENs, NRENs are switching over to (dark) fiber as the technology of the future. Compendium shows that in 2008, almost half of the EU-25/EFTA countries will have fiber access with proportion at least two-thirds of their core backbones. The same study states that as well as providing NRENs with the ability to better control, manage and exploit their network infrastructures, dark fiber provides new opportunities to enable users to define their own dedicated end-to-end links across the network, and to do so within fixed NREN budgets."

Below in the Table 2, you see the near future plans of some NRENs connected to GEANT2 (TERENA 2006):

[i] DANTE web page: http://www.dante.net [June 1,2006]

TABLE 2: TERENA (2006) research for dark fiber access in European NRENs (existing in 2005 and expected for 2008)

	NREN	2005		2006		2008 (expected)	
		% own	% IRU+ leased	% own	% IRU+ leased	% own	% IRU+ leased
Czech Rep	CESNET	-	-	0	100	0	100
Germany	DFN	0	0	0	90	0	90
Greece	GRNET	0	0	0	100	0	100
France	RENATER	0	5	0	25	0	25
Hungary	HUNGARNET	0	1	1	10	1	50
Ireland	HEANET	0	10	0	18	0	58
Netherlands	SURFNET	0	100	0	100	0	100
Poland	PIONIER	73	0	77	11	100	0
Portugal	FCCN	-	-	25	1	50	10
Sweden	SUNET	0	5	0	100	0	100
Switzerland	SWITCH	2	85	5	95	5	95
Switzerland	SWITCH	0	2	0	50	0	60

The important point to be underlined here is that, networks traffics of NRENs were averagely doubling each year (TERENA, 2006). If an NREN continue to lease bandwidth from the incumbent telecommunication operator, as in the case of ULAKNET, this will increase the costs of links substantially. As we try to explore the cases of different countries above; technological improvements in transmission area, liberalization of telecommunication markets, falling prices as a result of competition in telecommunication infrastructure services continue in parallel and this new trends provide different opportunities for high capacity requirements of research networking world.

In Turkey, telecommunication infrastructure had only been owned by Turk Telekom excluding some cases (including security reasons) in which the owner can not sell its infrastructure to third parties for financial purposes (General Directorate of Highways, State Railways, Petroleum Pipeline Corporation, Electricity Transmission Companies, Military and Police Networks, and Municipalities are the examples). After the establishment of Telecommunication Authority, as per the Law No. 4502 in 27 January 2000, Turkey's telecommunication sector was transformed into a new structure. Regulating the sector was left to the Telecommunication Authority. With this law, monopoly period of Turk Telecom were defined (as of 1.1.2004 voice monopoly of Turk Telekom were ended) and a full competition and a transparent licensing policy were established. Until the privatization of Turk Telekom in 2005, we can say that Telecommunication Authority have not effectively fulfilled its functions expected by private firms because of the political reasons and ongoing privatization process, especially on those areas under the monopoly power of Turk Telekom.

The ULAKNET network infrastructure is still obtained by leasing bandwidth from the Turk Telekom for both domestic and international lines. The main issue for ULAKBIM and TUBITAK for the future is to decide whether such infrastructure would be better owned (or leasing with long-term contracts) by the research community. There are many issues related to this, in terms of capital investment and regulatory context as well, which need to be considered.

Recent ULAKNET capacity upgrades will be insufficient for participating in international projects, for collaborating and competing with international partners, for producing advanced networking services requiring high-speed backbone capacity. This hinders research and academic activity; make our researchers difficult to compete with the researchers in other parts of the world, thus, it become inevitable to make a substantial improvement in overall capacity and core structure of ULAKNET. But if your infrastructure is insufficient for the studies requiring high speed and performance, then integration, collaboration and so the competition will be difficult for Turkish researchers with international colleagues. Hawkins (1996) pointed out this issue from the technical design point of view and expressed that technical upgrades in a national network had to be consistent with the arrangements by which that network was connected to other networks.

4.3. Evaluation

In 2006, the situation is now different then 1996 from the technological, the research networking requirements and the telecommunication market points of view. In 1996, the requirements for the establishment of ULAKNET could have been provided by Turk Telekom, and we already stated there were no other choices for TUBITAK and ULAKBIM. But in 2006, new innovation strategies, technological improvements in telecommunication sector shows that ULAKNET must be re-designed in terms of both infrastructure and usage policies to create synergy between the elements of national innovation system in consistency with the Government Development Plans. Such an integrated approach will favor the deployment of the research experimentation environments necessary for the coherent integration of policies, strategies, legal issues, technological trends and researching needs.

Actually one of the important developments for the future of ULAKNET has recently materialized. Telecommunication Authority began to give licenses concerning “Infrastructure Operation” to the national and international private telecommunication infrastructure provider firms. This operation was the result of “Amendment of Regulation concerning the Authorization within the scope of Telecommunication Services and Infrastructure” which was published in the Official Gazette in September 7, 2005. In March of 2006 licensing process were started and as a complementary act, in May of 2006, “The Rights-of-Way Regulation Act” were passed by

Telecommunication Authority. ULAKNET can utilize from this new situation by making IRU (Indefeasible Right to Use) contracts with licensed operators to get dark-fiber access. It is here important to point that, after the amendment made on the Law No. 278 with the Law No. 5344 in 4 May 2005, the establishment act of TUBITAK were changed by Turkish Grand National Assembly as giving right to TUBITAK (and ULAKBIM) to built and operate network infrastructures giving electronic communication services for the research and education purposes among the research and education institutions. We can translate this adjustment as TUBITAK-ULAKBIM has now a right to own fiber optic cables for her research network.

On the other hand, research and education network issue have not been thought as a part of a broader national policy since the approval of “the Agenda in S&T for the years 1996-1998” by SCST. For example, recent 9th Development Plan while determining the importance of collaboration both in national and international area, we do not see any research networking plan for the implementation of this idea unlike with the other countries we already examined in detail. Additionally, it is obvious that networking become one of the most effective ways of closing the digital divide -in the plan, digital divide problem were not mentioned anywhere- between developed and developing countries as well as between different regions of countries. Turkey has a large geography and every year new universities are being founded by the government. Thus, we believe that it is not possible to provide equal opportunity in education system and to increase the quality of researchers without utilizing the advanced services (like video conferencing, remote education, information access, very demanding grid applications etc.) of network environment.

As we already emphasized in previous sections, recent Knowledge Society Strategy Plan 2006-2010 of State Planning Organization is far away from solving the networking requirements of the research and education environment. In the strategy, there should be action plans giving the

ULAKNET high priority to build an advanced infrastructure in order to meet the expectations of innovative elements.

It is also very interesting not to find any implementation plan for the grid infrastructures in both 9th Development Plan and Knowledge Society Strategy Plan while both EU and USA (and the other countries) were giving (and will continue to support in the future) a very high importance to the grid technologies and infrastructures for the very demanding applications. Easy access to every type of data/information, collaborative tools like grids and video conferences are what the researchers need. So these types of services should be the part of delivery mechanism and national policies.

Visio 2023 Study have foresighted the requirement for the efficiency in some information and communication technologies (broadband, wireless, optics etc.) Although Visio 2023 strategy have not been implemented, we would like to note that even in the Visio 2023 report there was no explicit expression for the usage or the requirement of a high-speed and advanced research network infrastructure so that it can be used to test new hardware, operating system upgrades, vendor inter-operability and other new features in a testbed environment.

Again in both Visio 2023 strategy and the National Science and Technology Policy for 2005-2010 application plans approved by the Supreme Council of Science and Technology in 2005, there was no strategy dedicated to the development/improvement of the National Research and Education Network (ULAKNET) with parallel to developments on world-wide research and education networks (i.e. national research fiber optic infrastructure) although implicitly Turkish Research Area (TARAL) program executed by TUBITAK overlaps with issues (like increasing the research capacity of the Turkey) in the European Union’s Research Area program (ERA).

In ULAKNET, the campus side is the weakest link in the network chain. But even after the establishment of competition in fiber optic infrastructure operation, there will still be a lack of competition in this side (because Turkish universities are distributed in a large geography) and the services provided by Turk Telekom will inevitably be the only alternative for the universities in rural area. Efficiency in broadband and wireless access technologies is one of the opportunities of Turkish ICT sector. Research networks have been used as the test-bed environments for the national information and communication technologies sector in the world. ULAKNET should become an appropriate experimental infrastructure for the national industry in the priority areas.

In Table 3 and Table 4, we compared the countries we have examined in previous sections. The turning points of global research networking were chosen as the emergence of WWW, the liberalization of telecommunications markets and the Grid technology. It can easily seen that ULAKNET, when compared with similar networks world-wide, although its high link costs, is behind approximately 7-9 years technologically. Turkish telecommunication sector is restructuring after the privatization of Turk Telecom and after new enacted licences especially in infrastructure operation area. On the other hand, research capacity of Turkey were being tried to be expanded by the programs like Turkish Research Area (TARAL). By means of these programs and EU funded projects, we will see that there is an increase in the number of collaborative projects among university-government-industry. It is so obvious that most of these projects can require high processing power and high speed communication environment. Thus, there is a sine qua non condition for Turkish research area to have an advanced high speed and high performance research network e-infrastructure to communicate, collaborate and cooperate with both in domestic and international area. If we cannot provide such a competitive environment for our scientists and researchers, as we highlighted in 2nd

chapter, they will undoubtedly be the servants in innovation systems of the developed countries.

The significance of Grid technology and services is increasing everyday as a fundamental element for the development of national and international research and collaboration between researchers in the world. ULAKBIM as a coordinator of TR-Grid initiative has been carrying on 3 EU funded Grid projects (EGEE -Enabling Grids for E-sciencE, SEE-GRID - South Eastern European GRid-enabled e-Infrastructure Development, EUMEDGRID - Empowering eScience Across the Mediterranean) with its partners from different universities under TR-Grid initiative. Turkish National Grid e-Infrastructure will be constructed by ULAKBIM at the beginning of 2007. However, even after the construction of e-infrastructure and integration with the European grid e-infrastructures, the lack of collaboration of universities and government R&D institutions with industry will cause to the research studies remain as new academic knowledge, and can not be converted into new technological products or services contributing to the national economic prosperity.

TABLE 3: Summary of the findings (1968-1995)

Year		**USA**	**EU**	**Japan**	**Brazil**	**Poland**	**Turkey**
1968			First packet network in UK				
1969		ARPANET,BITNET					
1986		NSFNet	EBONE, EARN/BITNET	Privatization of NTT			TUVAKA (86-95)
1988		Supercomputing network study		SINET	BITNET (88-92)		
1989				**WWW and HTTP**			
1990	Internet				RNP project		
1992					Internet		
1993		HPCC+NII					Internet + TR-NET
1994			Bangemann Report				
1995		Privatization of NSFNet		Liberalization of telco services			Impetus Project in S&T

TABLE 4: Summary of the findings (1996-2010)

Year		USA	EU	Japan	Brazil	Poland	Turkey
1996-1999	**Telecommunication Act of US + Full liberalization of services in EU**						
1996		NGI+Internet2 initiatives	Rolling Action Plan + TEN34	1st Basic Plan (1996-2001)			**ULAKNET-34**
1997					Telecommunications Law	POL-34	
1998		Abilene Network	TEN155			POL-155/622	TUENA Master Plan
1999			GEANT1		RNP2	PIONIER	
1997-1999	**GRID technology**						
2000	**Research Infrastructures**		Lisbon strategy				
2001				2nd Basic Plan (2001-2005), E-Japan Priority Policy Program		Liberalization of telecommunication market	
2002		National Lambda Rail	eEurope Action Plan, GEANT2 (10 Gpbs backbone)	SUPER SINET (10 Gbps backbone)	GIGA and TIDIA projects (fiber optic backbone), IPE network	Fiber optic research backbone, IP/DWDM, 10 Gbps	**ULAKNET-155/622 upgrade**
2003		Nx10 Gbps backbone					Vision 2023
2005			i2010 initiative				Privatization of TT
2006				3rd Basic Plan			Liberalization on Infrastructure Operating, Knowledge Society Action Plan (2006-2010)
2010		NEWNET	FP7 GEANT3				

CHAPTER 5

RECOMMENDED ACTIONS FOR THE IMPROVEMENT OF RESEARCH INFRASTRUCTURE IN TURKEY

Before the 1990's, the networks were mainly built on mission-oriented aims. Then in early 1990's, we saw that most of the private networks (especially in USA) were integrated according to the rules of economies of scale. Internet was the key factor. But it was later seen that commodity Internet served a very large number of users with relatively small capacity requirements and transactions, and research and education environment needed different requirements for their small number of large capacity users. Late 1990's and 2000's were again the years of mission-oriented (experimental-based) research networks with each connected to the other networks through high capacity exchange points as well as having secure connections to the commodity Internet. It is obvious that experimental-based research networks are the resources of innovation for the countries on areas differing from scientific to social (like; high energy, astronomy, biomedicine, geophysics, earth sciences, computational chemistry). The goals of research networks are not only to provide a high-speed infrastructure and access to the commodity Internet, but also to promote new advanced services like middleware services for access to the computational and data resources as well as the classical and premium Internet protocol services (like Voice over IP, Video on Demand, Quality of Service, IPTV, dynamic bandwidth allocation for end-to-end applications). It's not so much worth just getting hardware connectivity to the researcher's desktop, but increasingly delivering a set of services needed by researchers (and other users).

The collaboration of different institutions such as governments, universities, firms, and non-governmental organisations become increasingly essential for the research networks. But ULAKNET is still a network for only the universities and governmental R&D institutions. The name of ULAKNET refers the “national academic network” in Turkish language although Foundation Proposal of ULAKBIM (1996) implied that “ULAKNET would provide a transparent network environment for the universities, public and private R&D institutions, and the institutions making policy for the science and technology”. Thus, we believe that ULAKNET policy should be revised accordingly to change its vision from being “an academic network” to being “a research and education network”. Now, non-government R&D institutions can not be connected to ULAKNET because: i) natural members of the network do not want to share the government funded resources ii) these institutions do not want to pay money separately for both Internet and research networks because of high setup and leasing costs of Turk Telecom iii) There is no need for a collaboration with the members of academic network iv) Private sector has a little awareness about the advantages of having connectivity to the research network. Private R&D should show an interest to contribute to the research network, and it can only be achieved by increasing the awareness of the private sector as well as giving incentives like decreasing their connection costs. We can consider that research infrastructureis a complementary tool in the innovation process, that is, other conditions must exist for the maximum developmental benefits from the research network infrastructures to be succeeded. In Turkey, may be one of the crucial issues is the lack of awareness of a need for an R&D network infrastructure. Typical problem in less-advanced countries is low level of funding to these networks. But it is known that ULAKNET is getting sufficient funds for its current budget from Ministry of Finance. But because the need for an advanced research network infrastructure is not supported or related with broader policies (like eTurkiye, Knowledge Society Strategy, Development Plans), it is not easy to obtain large amount of investment funds from the State Planning Organization. In near future, we hope that this investment problem will be able to be solved by the funds of Turkish Research Area (TARAL) which is under the control of TUBITAK (The Scientific and Technological Research Council of Turkey, which is mother organization of ULAKBIM). As a reflection of combination of newer technologies and the introduction of competition in the telecommunications marketplace, ULAKNET will not only reduce its annual link costs, but also own and provide a next generation research environment for Turkish research community. Moreover, in the proposal document of ULAKNET (TUBITAK,1996c), it was stated that a new academic network infrastructure would require a huge amount of investment and bulk purchasing on both of core and end-site equipments, and this would cause a new market for the national IT equipment producers as in the case of Turkish telecommunication market in 1980s. New embodied R&D projects of universities and industry on hardware production and software development would make contribution to the GNP and job creation. This vision should be realised in near future.

Additionally, in the Information and Communication Strategies document of Visio 2023 study (TUBITAK 2004b), some IT areas (production and design production of integrated circuits, broadband technologies, production of display sensors) were suggested as a priority areas for ICT sector. As the universities (as the natural members of national innovation system) become willingness to work in collaboration with the both national industry and international partners in the design and production of new products, the importance of networking for research will become more vital issue for collaborative design and modelling studies.

ULAKNET can also acquire benefits from the practices of different countries which have already liberalized telecommunication market. The restructuring telecommunication market of Turkey will give different service and infrastructure opportunities at competitive prices other than the only ones of old monopoly Turk Telekom. When we look at the world as a whole, some research and education networks lease circuits or obtain wavelength services at competitive or monopoly prices. They have either no alternative (like the old case in Turkey) or they may not feel much pressure to establish their own infrastructures (this will be a case for Turkey, if ULAKNET will not be renewed). If ULAKNET will be decided to have a new an advanced infrastructure, then there will be two alternatives other than If Turk Telekom will not give dark fiber access any more: One of them will be the option of establishing its own infrastructure by the negotiations with telecommunications operators in order to receive lower price offers, and the other one will be able to provide state-of-art services by deploying its own infrastructure by using its acted right last year when if it confront with unacceptable high price offers. On the other hand, Internet service providers (ISPs) telecommunication infrastructure operators should not see ULAKNET as a rivalry, because the users of research networks are neither the potential buyers of operators, nor the research networks wait for a commercial benefits from their users. National research and education networks have simple goals; networking for research and research for networking.

ULAKBIM should play an active role in the deployment of research activities in national Grid e-Infrastructure especially in the areas like climate estimate, earth sciences, biotechnology and emergency management which have a great socio-economic return for the Turkey. The impact from the use of the grid by public administration agencies will be directly interpreted to better quality of life for Turkish citizens. Recent studies showed that how international collaboration and grid technology can be transformed into a socio-economic benefit.

> "The EU funded "Enabling Grids for E-sciencE" (EGEE) and the "E-Infrastructure shared between Europe and Latin America" (EELA) projects have been already investigating volcano sonification at Mount Etna, Sicily, extended this study to include Ecuador's Tungurahua volcano. The research project digitally collected the geophysical information on seismic movements before using data sonification to transform them into audible sound waves, which could be scored as melodies.

> The resulting music is then analysed for patterns of behaviour and used to identify similarities in eruption dynamics and so predict future activities of the volcano."[i]

For the interconnection, a transatlantic 622Mbps link of ALICE project (80 percent co-funded by EU) is being used to transfer data across GÉANT2 to the RedCLARA (South American Research and education Network) networks. The other study was on "Avian Flu virus" with the collaboration of Asian and European laboratories, and they have analysed:

> "300,000 possible drug components against the avian flu virus H5N1 using the EGEE Grid infrastructure. The goal was to find potential compounds that can inhibit the activities of an enzyme on the surface of the influenza virus"[ii]

As we already mentioned, Grid issue did not take place in the current Turkish governmental policy documents. But according to the Delphi results of Visio 2023 study, we see that Turkish experts thought that "Combinatorial sciences"[iii],[iv] could contribute national added value[v].

NRENs have emerged in many countries in the face of high demand for the commodity Internet to meet the requirements of universities and national research institutes. But multi-national (GEANT2, Internet2, APAN, RedCLARA etc.) networks were shifted the paradigm from national to global. ULAKNET has already been connecting to the global research networks through GEANT network since 2002. The objective of GEANT2 network is to develop a top-class European infrastructure interconnecting national research and education networks and meeting to requirements of users from the research and education sphere. Main ideas of the project are very high quality connection support for the end users and supporting grid activities. EU, by means of GEANT project, is not only connecting the

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[i] EGEE project Web page. http://www.eu-egee.org [Aug 13, 2006]
[ii] EGEE project Web page. http://www.eu-egee.org [Aug 13, 2006]
[iii] Combinatorial science provides high-quality results on all aspects of computer-assisted methods and combinatorial techniques, as well as their applications in organic and inorganic chemistry, medicinal chemistry, biochemistry, drug design, and materials science.
[iv] Accessing to a grid infrastructure directly benefits the automation of the calculation workflows.
[v] For Visio 2023 Delphi Results: http://vizyon2023.tubitak.gov.tr/yayinlar/delfi [Aug 15, 2006]

NRENS of EU members to each other and global research network but also trying to expand its research network infrastructure to the other regions of the world. EU funded projects like EUMEDCONNECT (for the Mediterranean region), SEEREN (for the Balkans), ALICE (South America), TEIN2 (Asia-Pacific) projects are the results of this goal. In the future, new initiatives for the Caucasians, Silk Road and Middle-East will most probably be started (Caucasians and Silk Road region has already a NATO funded but a low speed satellite connection through Turkish satellite operator TURKSAT to the GEANT) by the EU. ULAKNET has an opportunity to become regional Point of Presence for the countries in these regions through terrestrial connections, and such integration between these countries can increase the collaboration and knowledge transfer between Turkish scientists and especially those scientists originally from the old Soviet Union. This vision will enable Turkey to play the role of a central node for the entire area of the Eastern Mediterranean, Middle-East and Caucasians (as in case of EU funded Porta-Optica Project for eastern neighbors of Poland).

Also, in GEANT project, the partners have been driving activities to create and to deploy on next generation advanced services. Besides thinking GEANT project as only an infrastructure to connect researchers to global research networks, ULAKBIM should involve in these joint research activities to transfer and to implement these new services to Turkish information system.

CHAPTER 6

FINAL WORDS

This chapter presents the issues that need to be addressed by future efforts for the Turkish research and education network. We will also summarize our thesis and present the conclusions of our study.

6.1. Conclusion

In this study we have described our vision of the Turkish National Research and Education Network Infrastructure serving the networking necessities of Turkish innovation system. To summarize the major findings of interest from this descriptive study:

- The Policy makers of Turkish science and technology policies and national innovation strategies should take into account the necessity of research infrastructures for Turkish scientists and researchers. An e-infrastructure policy group, consisting members from bureaucracy, academy and industry, should be founded as a coordinator and advisory body to make policies about research infrastructures and to ensure the efficient use of national resources by all institutions of national innovation system.

- An International S&T and innovation policy strategy should be adopted, and national research priorities should be defined for international collaboration areas.

- Turkish NREN should be restructured as a true and world-class research network infrastructure enabling the collaboration of university-industry-government R&D institutions through networking facilities. Such a network infrastructure should provide experimental test-bed environment for domestic industry and a mission-oriented environment for scientific communities allowing end-to-end dynamic bandwidth allocation.

- Such a network infrastructure providing very large network capacities and advanced services to users with their high-level requirements can only be established cost effectively by owning or obtaining long-term access to fiber optic infrastructure.

- Direct access to dark fiber (either by owning or obtaining via long-term agreements) will be possible in 3 ways: a) via new infrastructure operators licensed after de-regulation process in 2006 b) via Turk Telekom c) By means of the amendment made on the establishment act of TUBITAK approved by Turkish Grand National Assembly as giving right to TUBITAK to built and operate network infrastructures giving electronic communication services for the research and education purposes in 2005.

- The funding of new research infrastructure may be supplied from the State Planning Organization. But because "Knowledge Society Action Plan" of State Planning Organization did not take into consideration the requirements of innovation-based networking, it will be better to fund the project from the Turkish Research Area (TARAL) which is under the control of TUBITAK.

- The future of Turkish NREN should not be based on the "infrastructure fetishism". Turkey has to transform research networking facilities to produce acquisition for the economic benefits, innovation ability and national interests.

- The geopolitical position of Turkey may make it possible to play a strategic role during the integration of eastern countries (Eastern Mediterranean, Middle-East, Caucasians, Silk Region and India) to the European research network. Turkey can become a regional Point of Presence for GEANT connections of these countries to the Europe. But the success will be highly dependent on the cooperation between The Ministry of Foreign Affairs, Turk Telekom and TUBITAK. If this vision is implemented, the collaboration and knowledge transfer can be provided between Turkish scientists and especially those originally from the old Soviet Union.

6.2. Future Research

In this study, we described the conceptual framework about research networking on national innovation systems, and discussed the current and potential problems of Turkish NREN after compared it with other NRENs in the world. We presented concrete solutions which have to be implemented in near future in order Turkish NREN to fulfill the requirements of a high performance research network infrastructure. The underlying network infrastructure is a dominant factor for upper layer e-infrastructure applications and services like digital repositories, access and security control, roaming, virtual laboratories and organizations, digital libraries, middleware resource sharing software, high performance computing centers, grids, sensor networks, national scientific databases, remote education etc. Therefore, Turkish NREN should be organized as service integrator (rather than being a classic Internet service provider) according to developing demands from the different innovative communities, and for each new service, further study will be required to examine the case in terms of the national priorities, global trends, expected socio-economic returns, infrastructural requirements and cost efficiency.

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