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«The European Union is made up of 25 Member States who have decided to gradually link together their know-how, resources and destinies. Together, during a period of enlargement of 50 years, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms. The European Union is committed to sharing its achievements and its values with countries and peoples beyond its borders».

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White Paper

Advanced Networks in Latin America:
Infrastructures for regional development in science, technology and innovation

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This document is a summary of the set of studies conducted during 2009, which present the state of networks in developed countries and Latin America. They cover networking structure, services, funding, the role of scientific policy, legislation, similarities and differences and illustrative projects, among others.

The reference material is available at http://redesalatina.wordpress.com/.

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Executive summary

Advanced networks or National Research and Education Networks, NREN, and their user communities constitute a favourable environment for scientific and technological research and innovation processes. Various technologies and services have been designed and tested over these networks and then widely spread in a permanent and increasing transfer process. The most frequently quoted example is the World Wide Web, but there are other technologies like file transfer, P2P systems (peer-to-peer), the extended use of videoconferences and semantic web research, just to name a few. All of them were pioneering initiatives initially tested or spread over advanced networks which then migrated to the so-called commercial internet.

> Technologies which are subsequently adopted by commercial internet are first tested over advanced networks.

Despite the global phenomenon that the internet represents and the existence of a consolidated industry around it, advanced networks are not in danger of extinction. Quite on the contrary, research and education communities concentrate the most demanding internet users. In order to satisfy their needs it is necessary to have strong infrastructures which are capable of providing and maintaining inside them the space for the development of tests and new technologies; this is a model that ISP –Internet Service Providers- are not interested in following since it requires huge investments with long-term return. They have preferred to focus on a more profitable business: providing services to enterprises and domestic users.

From the point of view of public policy design and funding for enabling infrastructures for science, technology and innovation (STI hereinafter), it is beneficial to support the deployment and strengthening of these advanced networks as well as the increasingly extended use of the internet among the population. These two political objectives have the same importance since they are complementary infrastructures rather than substitutes.

We must not forget a key fact; there are several processes which stress the need for these infrastructures: The successful experience of the Internet, where the academic sector played a crucial role in its onset and then in its transfer into the private sector, demonstrated to a group of scientists and universities, as well as science and technology policymaking bodies, that the virtuous circle of research and subsequent use by the private sector should be repeated. As the greatest technology transfer from laboratories into the civil, governmental and private spheres was implemented thanks to the internet, it was necessary to sustain this effort.

Advanced networks are crucial:

- New services and applications are developed over them, and this makes it possible to sustain the internet's growth and strengthening.

- The wider scientific community requires an infrastructure for collaboration, education and access to equipment that the private sector cannot provide.

- The network itself is a laboratory to test new protocols, improve quality of service and speeds which are not available in commercial internet.

- The infrastructure enables a collaboration environment to address global challenges which require many research groups working together with a huge amount of data.

- The joint negotiation allows for a significant reduction in connection costs for research institutions.

From another point of view, the globalization of Research and Development (R&D) is a tangible fact that can be appreciated through the number of global-scale projects, the opportunities available to maintain the "state of the art" in an area and the need to articulate shared answers to challenges which cover the entire globe, such as climate change or the prevention of natural disasters.

> The advanced network is the infrastructure for scientific collaboration which makes it possible to address global challenges. At the same time, it is the test field for what will become the internet of the future.

Even enterprises participate in this effort. Recently the OECD mentioned the cases of China, India and Brazil as emerging countries in R&D with the following argument: "The high cost and risks of R&D (due to its multidisciplinary nature and increasing complexity) and the global competition in innovation, have led companies to reduce their R&D costs while they speed up the development process. This has led companies to search for external sources of technology and knowledge and to trust more in those sources of innovation. The increase of globalisation in science and technology capacities and the vast number of entities with an appealing grounding in this field have expanded the opportunities to invest on R&D abroad"[1].

> Advanced networks are fundamental for R&D globalisation. Given Latin America's relative position and the reduced amount of critical mass of researchers, the joint actions of these networks are even more necessary, as they are the natural effectiveness mechanism. The region has an infrastructure for this purpose, RedCLARA, which must be preserved.

In order to establish that collaboration, top-level technologies and infrastructures are needed. It is obvious that this is one of the privileged environments, if we regard advanced networks as R&D collaboration networks: "New technological opportunities, especially in information and communication technologies (ICT), are among the key drivers of the internalization process, since they have allowed for new forms of collaboration and have led to a greater specialization of the global

1 OECD (2008) Research and Development: Going Global. Policy Brief. OECD, Paris. At: http://www.oecd.org/dataoecd/30/52/41090260.pdf.

innovation system. ICT Advances have also facilitated the organization of scattered activities in innovation and have enabled R&D outsourcing"[2].

In Latin America we can see the need to create institutional structures which allow countries to integrate with each other in order to be able to compete within the globalised economy. Bilateral free trade agreements and the creation of spaces like Mercosur, NAFTA or the Central American Common Market are examples of the integration needed and to be strengthened.

The Latin American countries that have advanced networks – most of them-, have developed a unification strategy so as to be able to address the identified issues, with critical mass as an enabling condition. They have created the Latin American Cooperation of Advanced Networks, CLARA, an international law non-profit organization that came into legal existence on December 23th, 2004, when it was acknowledged by the legislation of the Oriental Republic of Uruguay.

CLARA is defined as a Latin American collaboration system using advanced telecommunication networks for research, innovation and education. It has 17 member countries (Argentina, Bolivia, Brazil, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela) and only thirteen of them are connected to RedCLARA. The non-connected countries are Bolivia, Paraguay, Cuba and Honduras. The last two countries are regarded as "non-active members", but their full incorporation is expected in the near future.

RedCLARA's backbone is made up of seven main routing nodes, connected in a linear topology (point-to-point). Each main node (IP) represents a PoP (Point of Presence) for RedCLARA. Six of them are located in a Latin American city: Sao Paulo (Brazil), Buenos Aires (Argentina), Lima (Peru), Santiago (Chile), Panama City (Panama) and Tijuana (Mexico). The seventh node is located in Miami (USA), where Central American networks get connected as well.

All the connections between national Latin American networks are carried out through one of these six nodes. RedCLARA is also interconnected to networks in Europe (GÉANT), the Asia-Pacific basin (APAN, TEIN3, AARNET), the USA

2 OECD (2008), óp. cit.

(Internet2), Canada (CAnet4) and the Mediterranean basin (EUMEDCONNECT2), among others.

In rough terms, national advanced networks offer a platform based on the articulation of a high-speed backbone, where it is possible to integrate different resources and services. For example, they can provide dedicated communication channels for individual research projects; favour the creation of suitable environments to introduce new tools for resource administration and testing; put forward dissemination activities among local communities and facilitate dynamics which allow for the networks' physical interconnection and the exchange between people and research groups located in different countries. In other words, they become an essential agent for local transformation in the field of scientific and technological research.

This unique infrastructure for scientific research activities impels Latin American countries to clearly determine the degree of political and financial support they are willing to give to the national entities that manage advanced networks. After five years work and numerous projects executed, that decision is still to be made.

The region faces important challenges across the hemisphere in relation to the sound administration of their ecosystems, some of which are unique in the globe. Desertification and the shrinkage of biological diversity, just to name a few pressing challenges, are not likely to be better addressed through national strategies because the problem's scale is larger.

Together with these challenges, the Latin American researchers' community is faced by other challenges stemming from a deep change of paradigm in the way of making science. This change, called "e-Science", defines a new phenomenon linked to the emergence of ICT and the role of advanced networks.

Today a new opportunity emerges for the modernisation processes of national ICT systems, based on a true fact: Latin America already has an infrastructure of advanced networks interconnected to each other and to major networks in North America, Europe and Asia. What is still necessary is to integrate it with the design of public policies which put it in a visible place within the ICT system and which provide it with financial support and sustainability over time.

> The contribution that can be articulated from a well-supported and well-coordinated advanced network infrastructure can make the difference between being able to address problems efficiently and not having the chance to do so in the right direction by not having a suitable instrument.

As a reference experience, Europe features the most paradigmatic example of the construction and management of an advanced next-generation supra-network (GÉANT), which today is deployed in 33 countries and interconnects 36 national advanced networks (four of them as associates). When looking at them individually, several differences can be appreciated from the point of view of their size, structure, budget, funding mechanisms, staffing, and services provided for their end users. However, they share a common feature: they are well established, they pursue the same objectives and the government plays a predominant role in their funding, combined with shared-funding from users at two levels: regular membership fees (distributed depending on the bandwidth demanded) and special research projects.

Multiple research projects are carried out over advanced European networks. Two are the marks that distinguish most of them: they are network services and application intensive initiatives and they are collaborative, since several local and foreign institutions participate. They are also open to welcome other actors from the productive world such as laboratories, private companies and telecommunication companies.

CLARA's management capacity has already been proved through its encouraging the creation of local networks in at least six countries in the region, through its technical capacity and relation with Europe and the effort done to make advanced networks visible and to favour possibilities of use among scientific communities.

The decentralised administration chosen by CLARA to operate is an alternative which distributes commitments and responsibilities among its members, while promoting a learning capacity in local nodes, which means that the collaboration ethos has been materialized in the agency in charge of the network's technical management and of the dynamisation of the scientific community it caters for.

In Latin America, however, an explicit public policy on advanced networks as a key element for the national innovation system is almost non-existent, except in Brazil, and to lesser extends in Mexico and Colombia; furthermore, they usually are supported only from the financial point of view. Although other networks receive a tepid financial contribution from their governments, the fact is that no regional body shows a firm and long-term line of argument which aims at the integration of their research communities through advanced networks.

> There are distinctive characteristics of the European model which serve as reference for Latin America: the explicit support from public agencies, mixed funding schemes and incorporation into scientific and R&D policies. For In order to move forward towards a greater degree of development, it is crucial for Latin America to have an explicit public policy on advanced networks as a central element of the national innovation system.

Additionally, critical mass is concentrated in one single country, Brazil, with almost 50% of the researchers in the region, followed by Argentina and Mexico. If we add Chile, Colombia and Venezuela, the resulting picture involves more than 80% of the critical mass of natural advanced network users.

The conclusion is obvious at looking at the European experience, where explicit public policies can make a difference in the networks' incremental growth and sustainability.

In Europe advanced networks try to cover all areas of knowledge in showing their usefulness for all research communities. But we cannot forget about the critical mass of researchers that these nations have and the governmental support shown in the field of public policies.

> It must be shown, in a continent with great inequalities, that R&D investment results in solutions which improve the quality of life and strengthen development in a wider sense.
> That possibility exists: There are ongoing initiatives and agreements.

In Latin America, although there is a philosophy based on the offer and which aims to cover all areas of knowledge, the level of critical mass –as indicated above- makes it difficult to attain a significant degree of specialization. Therefore, it is necessary to define priority areas on which to focus the efforts of the local nodes that run the advanced networks, or to wander what these areas are.

The current scientific policy in all Latin American countries aims to maintain a support base in all areas of knowledge, together with certain bets on key sectors in countries possibly having comparative advantages within a globalised environment, or they respond to social needs where there is an articulated consensus, beyond the political alternatives of the specific governments in power.

In a continent with significant inequalities, investment in R&D results in solutions that improve the quality of life and strengthen development in a wider sense. It is fundamental to articulate a regional discourse in those areas which appear as natural candidates to show their impact on the solution of social challenges, and to introduce a framework where all countries can cooperate –given the similar problems and from their various strengths- in a collaborative programme. It is equally fundamental to develop and present a coherent discourse based on reality which facilitates cooperation with developed countries, from a more egalitarian perspective focusing on the needs identified.

The actual people responsible for advanced networks, when asked about the priority areas or the projects these should support in Latin America, reached a consensus: health (telemedicine), education and climate change (and/or natural disasters). These were followed by culture, in a wider sense, and agriculture and/or biotechnology.

This identification of priorities is in line with the priorities identified by the governments across the region (health, education), is linked to perspectives on changing the productive development pattern (natural products aimed to be exported and/or promises of biotechnology, effects of climate change, energy efficiency), and makes sense at involving the role of the Nation State (disasters prevention or mitigation, maintaining identity).

The definition of priority areas is supported by their potentiality to articulate projects where many actors can collaborate from their different specialities and where it is possible to take scalar leaps and not “reinventing the wheel”- which provides an argument for legitimacy in the face of social challenges – and because these areas are embedded in the public policy discourse:

- Global Change: involves projects like climate change modelling, disasters monitoring and prevention (for example deforestation and the El Niño-Southern Oscillation, among others).

- Health-Telemedicine: from advanced systems based on remote operations, R&D hospital networks, regional diseases, to online attention in rural communities. The region’s needs, in this regard, determine the agenda.

- Agriculture (Biotechnology-Genomics): focusing on the national protection of the native or high-impact varieties, such as natural products (and even active principles) aimed to be exported.

- Education: understood as e-Learning in the field of higher education, due to the increasing internationalisation of collaborative platforms and tools, which also cover technical-professional and secondary education.

- Cultural heritage and knowledge: in two dimensions: a) digitalisation of collections and cultural heritage and b) emphasis on the social dimension of knowledge (systems to access national and international information with equitable and modern mechanisms).

A remarkable aspect is that both in developed countries and in Latin America there are specific projects which address these demands and also strong experiences of advanced networks incorporation as part of the basic infrastructures for scientific and technological research.

More projects in these areas will allow universities and governments and, at the same time, the entire population, to see concrete results, although with a long-term view, on the importance of having advanced network infrastructures. They are urgently needed, critical mass is required, they offer long-term solutions and make it possible to get connected to the best international experience and advances.

It is evident that in order to sustain public support it is necessary to have more projects which firmly show the network's social power to solve the region's extended problems and challenges. For most people gigabits mean very little: networks better express themselves when they host projects which promote and consolidate higher education, model climate change, prevent and monitor natural disasters, identify the native species' genome and its applications, expand medicine in all its forms to all the regions in the country, when they make their cultural heritage become part of the world and promote egalitarian access to public and scientific information.

The strongest networks will be those which align their objectives with the country's scientific policy.
The free-flowing dialogue with the people in charge of materializing the Knowledge Society must lead to the stable funding of the advanced networks' operation or infrastructure so that they become the platforms which enable state-of-the-art R&D.

What society demands today from their National Science, Technology and Innovation Systems is enormously more challenging because results and products must pass a new exam: their effective transfer into society under the form of solutions which improve the quality of life of the population that funds those efforts.

The strongest networks will be those which align their objectives with the country's scientific policy. The free-flowing dialogue with the people in charge of materializing the Knowledge Society must lead to the stable funding of the advanced networks' operation or infrastructure so that they become the platforms which enable state-of-the-art R&D.

We live in a region of disparate countries. The institutional heterogeneity under which the CLARA Management works is real, although it is not an insurmountable condition. In fact, CLARA operates within the context of a continent characterized by that heterogeneity, which is reflected on the structure of several regional institutions.

The lack of a specific policy for advanced networks is also the opportunity for regional bodies to adopt a stance about them. In this situation, it becomes necessary to consolidate an advanced networks infrastructure as a heritage and as a regional public asset that must be duly safeguarded by countries through ensuring their use, sustainability and impact on the quality of life improvement for the inhabitants of Latin America.

Today, public policies, in different areas, aim at a mid-term in which to establish an economy with a strong growth component that results in an acceleration of economic growth, environmentally-wise, with significant reduction of the poverty divides and inequalities in terms of income distribution, and with the resulting increase in social cohesion and equity.

It is fundamental to state, at this point, that almost all advanced networks are governed by non-profit institutions, which gives them a high flexibility and dynamism; but if we added a strong national public support in terms of membership and funding, they would become realities very unlikely to be reversed (its continuity and sustainability, as well as the resulting scientific and social benefits, would be structured on strong bases). History shows that nothing can be taken for granted. Every connection must be taken care of and maintained.

I. Advanced networks and the Knowledge Society

National Research and Education Networks (NREN) and their user communities, constitute a favourable scenario for the development of scientific and technological research and of the countries' innovation processes. Various technologies, applications and services have been created or tested at a larger scale over academic networks in the beginning or over these advanced networks, to be then widely spread in a permanent and increasing transfer process. The most commonly quoted example is the World Wide Web itself, but there are other technologies such as electronic mail, file exchange and storage, point-to-point connection systems – P2P (peer-to-peer), the extended use of videoconferences through H.323 protocol, and grids or demonstrative applications in semantic web, to name a few. All these technological tools that are more well-known nowadays were once pioneer initiatives that were tested at a larger scale in the first academic networks and in some advanced networks, and then migrated towards commercial internet.

But the global phenomenon that the internet represents, and the existence of a consolidated industry around it, does not threaten the existence of advanced networks. In fact, the research and education communities concentrate the most demanding internet users, and in order to satisfy their needs it is fundamental to have powerful and strong infrastructures which are capable of serving as platforms for the creation and development of tests and new technologies and applications, ensuring security, quality and capacity for the transfer and storage of amounts of data which are measured in Gigabytes, Terabytes and Petabytes. This is the scope of advanced networks and the explanation why ISP (Internet Service Providers) are not interested in this market, which requires huge investments and only offers long-term returns, which is the exact opposite of providing (commercial internet) services to companies and domestic users.

But there is a mutual dependence situation: advanced networks cannot exist without commercial internet, since this platform offers services which are fundamental for research communities. In turn, commercial internet depends on these advanced networks as its main source of innovation.

Thus, from the point of view of public policy design and the funding for empowering infrastructures for Science, Technology and Innovation (STI), it is beneficial to support the deployment and strengthening of advanced networks, as well as the internet's increasingly massive use among the population; two political objectives of equal importance, as they are complementary infrastructures and not substitutes.

Even if the broadband commercial internet's coverage grew at nearly 100%, research communities would still require the existence of advanced networks, since specific services are deployed only over them and broadband is not limited to ADSL service, but also implies higher speeds in different degrees of magnitude (gigabits), as it happens for researchers who use them as an irreplaceable infrastructure for their projects.

Today, advanced networks are the "laboratories" where to test the actual feasibility of reaching homes with a broadband technology of one giga, which should be the broadband standard within a few years.

In Latin America we can see, with increasing urgency, the need to create institutional structures which enable countries to become integrated in order to compete within the globalised economy. Bilateral free trade agreements and the creation of spaces like Mercosur, NAFTA, or the Common Central American Market, are examples of the integration required and which needs to be strengthened.

According to the OAS, our advanced networks represent "a fundamental instrument to drive countries in the region towards competitive knowledge-based economies (...) by providing access to scientific and technological resources across

> Without well-supported advanced network infrastructures properly disseminated among their users, Latin America will not have the same possibilities of reducing its dependency rate and developing more autonomous development models.

the globe, and strengthening important social and economic activities" (OAS, 2005)[3] . But at the same time they show great limitations and difficulties; the main one, according to the OAS, is the lack of a strategic relation between having these advanced networks as part of the information infrastructures and the design and implementation of policies, as well as the absence of suitable legal frameworks for their creation and maintenance.

In addition, an industrial configuration in the field of telecommunication companies which increases the costs of ICT infrastructures, particularly broadband, and a scarce amount of specialized human resources for their management.

In response to this, the Latin American countries that have advanced networks, i.e. the majority, have put forward a unification strategy in order to be able to address issues with a critical mass that is an enabling condition. But things are still in a consolidation stage, where a small group of countries – Brazil, Mexico, Colombia, Argentina and Chile- have constituted a stronger hub, "not only in terms of the productivity of those networks, but also in terms of ICT use and incorporation into society in general[4].

The CLARA experience is the most important one in this field, since it establishes the advanced regional network, RedCLARA, as a unique infrastructure for development of scientific research activities, and impels countries to take a clear stance in relation to the degree of political and financial support that they are willing to provide to national entities in charge of their management. After five years of work, and several projects executed, the question remains to be answered.

The IBD has defined Latin American advanced networks as regional public assets. They are scarce, but fundamental in their opinion to promote development,

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3 OEA. AG/RES. 2087 (XXXV-O/05). Report from the First Science and Technology Ministers and Senior Authorities Meeting (approved during the Fourth Plenary Session, held on June 7th, 2005).

4 OEA. AG/RES. 2087 (XXXV-O/05), óp. cit.

but their strengthening is based on previous processes like regional integration and cooperation, which contribute not only to economic growth and to poverty reduction, but also to even the dissimilarities between neighbouring countries: "Regional integration is even more important for the most sparsely populated countries, which have to depend more on regional markets rather than on local ones to take advantage of larger economies in terms of industry, public administration and research and development"[5].

Today, Latin America faces significant regional challenges related to the wise administration of their ecosystems, some of which are unique in the globe. Desertification and the shrinkage of biological diversity, to name a couple of pressing challenges, are not likely to be addressed through national strategies because the problem's scale is larger. The contribution that can be articulated from a well supported and well coordinated advanced network infrastructure between countries can make the difference between being able to address problems effectively and not having the opportunity to do so along the right direction due to the lack of a suitable instrument.

But the regional network –if conceived as a "public regional asset"- is also useful in other fields where public intervention cannot be replaced. For example, it could increase educational coverage and efficiency or could help address supra-national problems such as the effects of climate change, while at the same time it could become an element that may help speed up economic integration.

Together with the hemisphere's challenges, the Latin American researchers' community faces other challenges stemming from a deep change of paradigm in the way of making science. This change, identified across the globe as e-Science, defines a new phenomenon linked to the emergence of ICT and the role of advanced networks.

Bill St Arnaud, one of the creators of the Canadian advanced network Canarie, points out that "e-Science's ultimate objective is to allow students and, eventually, the general public, to be not only spectators but also active participants in basic

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5 United Nations, Millenium Project. "Investing on development: a practical plan to achieve the Millennium Development Goals. Part 3. Recommendations for the international community to support processes in each country, chapter 15 "Regional and global assets" pp.266. The chapter can be downloaded from http://www.unmillenniumproject.org/documents/spanish-chapter15-highres.pdf.

research. The e-Science projects will make use of high-speed networks, like the CA*Net4 proposal, wavelength discs and community fibre networks in order to interconnect thousands of computers located in our colleges in Grids so as to carry forward large-scale distributed applications in various fields of basic research"[6].

In early 2000, John Taylor, general director of the UK "Research Council", announced funding for a national e-Science programme. Its definition aims at "large-scale science which will be increasingly carried out through distributed global collaborations facilitated by the internet. In general, one of the features of this collaborative scientific endeavour is that it will require access to very large data collections, large-scale computing resources and high-quality visualisation for each particular scientist"[7].

A few concepts that define the e-Science effort can be taken from these quotes:

- It is a global approximation to the research challenges required by a type of networks which cannot be offered by the commercial sector.

- Scientific activities become virtual. A great deal of the practices known as "experiments" require massive data processing, commonly distributed.

- The ICT social meaning is stressed, understood as a type of network that facilitates the incorporation of the educational sector and whose dream is to materialize a network where fibre reaches everyone without distinctions.

- It is the "large-scale" or also distributed science, where experts are located in different parts of the world and address a common issue, usually in an interdisciplinary way.

We can discuss the existence of e-Science as a concept, or whether at the end of the day it is still the same science and research with new tools which make it more effective. The truth is that the global scale justifies the existence of advanced networks in every continent in order to facilitate the interconnection with their peers across the globe, since the prevailing tendency under the current scientific

6 Arnaud, Bill. "All science will soon be e-Science". En CAnet-3 News. March 24th, 2001.

7 "News from the e-Science Programme". At: http://www.rcuk.ac.uk/escience/news/firstphase.htm.

paradigm is the integration and promotion of world collaboration networks to take advantage of the resources scattered around throughout the globe.

Although until now that kind of science decentralisation has benefited developed countries, which are the ones that decide the topics for research, the availability of empowering infrastructures, like advanced networks, together with advanced human capital's capacities found in Latin America and the social and economic urgencies that can be answered by science, provided there is a suitable balance between incentives and opportunities and a capacity to articulate efforts in macro-projects showing cogent results.

But, what are we faced with?

It is convenient to go back to the basic objective of advanced networks and to go back to the basic concepts of "basic research", "applied research" and "experimental development". Basic research consists in experimental or theoretical work which is mainly carried out in order to obtain new knowledge on the basis of phenomena and observable events without the intention of using this knowledge for any specific application. Applied research is also based on original work carried out in order to gain new knowledge; however, it is aimed at a specific practical objective. Finally, experimental development consists in systematic which that build on existing knowledge obtained through research and/or practical experience, and it is aimed at producing new materials, products or devices, or at implementing new processes, systems and services, or at the substantial improvement of the existing ones[8].

Today, the R&D effort in the "laboratory" practice can contain the three elements and in many areas it usually does it. Actually, in applied research it is sometimes necessary to resort to basic research and the boundaries are not firmly fixed.

The first element to be taken into account, given the fact that we see that advanced networks work almost like transference laboratories, is to take a look at R&D in relation to innovation. To this end, the Frascati Manual states that "the technological innovation activities are the set of scientific, technological, organizational, financial

8 OCDE (2002). Frascati Manual. Practical norms proposal for Experimental Research and Development Surveys, paragraph 64. OCDE, Paris.

and commercial stages, including investments on new knowledge, which lead, or try to lead, to the implementation of new or improved products and processes. R&D is simply one of these activities and can be carried out across different stages of the innovation process by being used not only as the source of creative ideas, but also to solve problems which can arise in any stage until its completion"[9].

A national innovation strategy must regard advanced network infrastructures as connection points between the world of R&D and innovation. Understanding that there is not a linear model gives novel possibilities for networked collaboration.

Thus, in innovation processes, R&D can occur either at the beginning or at the end, or when research questions come up. In other words, it is not a linear process that assumes that there must be basic research first, and then applied research and then experimental development to finally begin innovation activities in the market.

This implies stating that a national innovation strategy must consider the advanced network infrastructures as points of connection within the field of R&D and innovation. Since there is no linearity, the interaction between market demands and the answers on which the research community works can be more free-flowing. Moreover, in many developed countries the natural candidates for interconnection come from R&D laboratories in companies or hospitals which conduct research and their connection demands are based on the importance of working collaboratively.

Science has always been, up to a certain extent, globalised, but advanced networks make this change of paradigm possible and, at the same time, are the infrastructures demanded by the community to participate more actively in this collaborative effort or simply to have access to the advances in more developed countries. This is nothing new within the academic world. What is outstanding is that this process can also be appreciated in the industry.

It is increasingly common that R&D is carried out "abroad" by companies doing the greatest part of the efforts in this area. And the factors are well-known: quality

9 OCDE (2002). Frascati Manual. Óp. cit., paragraph 21 (underlined by the author).

of the R&D staff, access to public and university R&D and quality of infrastructures like advanced networks. An additional element is that European countries and the USA begin to risk R&D investments in developing countries, given the expansion of these markets.

In Latin America, advanced networks are still on the margins of the research-teaching relationship, the techno-cultural incorporation of ICT both internally (university community) and externally (community in general), and in the development of the competitiveness of the countries in the region within the global economy. This early stage opens up a new opportunity for the modernisation processes of national ICT systems, based on a true fact: Latin America already has an infrastructure of advanced networks interconnected to each other and to the main networks in North America, Europe and Asia. What is still pending is to incorporate it into the design of public policies which establish it in a visible place within the ICT system and provide it with financial support and sustainability over time.

II. Advanced networks in Europe

Europe features the most paradigmatic case of the construction and management of a last generation advanced supra-network which today is deployed in 33 countries and coordinates 36 advanced networks.

The operational and management coordination duties fall on DANTE (Delivery of Advanced Network Technology to Europe), an entity which plans, builds and operates the pan-European network GÉANT, which interconnects all the NREN across the region (see Figure 1). DANTE is owned by the European advanced networks and works alongside the European Commission.

In turn, the Trans-European Research and Education Networking Association, TERENA, is in charge of the technical aspects of the network's operation at a continental scale. TERENA is, above all, a collaboration organisation. Its main business is to bring managers, technical specialists and other members of the national advanced networks together with their counterparts in other European countries in order to share knowledge and experiences accumulated by hundreds of professionals in that field, on the understanding that the development and progress of the internet technology, the infrastructure and services, has been a task accomplished by the researchers community from the early days of the networks network. In Europe, the leadership is possible thanks to the collaboration of network engineers, and facilitated by this entity.

The prevailing tendency in the technology of European advanced networks is the use of optical networks (WDM), with backbones that reach from 10 to 40 gigabits, and a significant multiplication is expected for the next two years. Advanced networks persistently aim at increasing their figures or venturing into the ownership of dark fibre so that the upgrading of speed, based on technology advances, depends on the decisions made by the networks themselves.

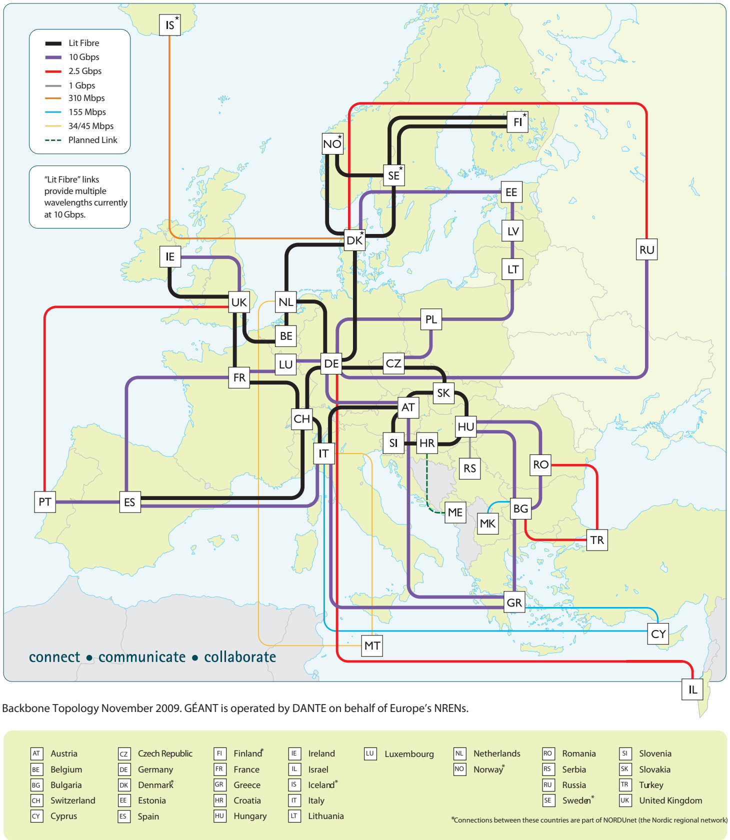

Figure 1: Topology of the GÉANT backbone, November 2009 (see original at: http://www.geant.net/Network/NetworkTopology/pages/home.aspx).

When looking at advanced networks individually several differences can be seen from the point of view of their size, structure, budget, funding mechanisms, work teams and services provided for their end users. However, they share one basic characteristic: they are well established in their corresponding countries and pursue the same objectives.

From the point of view of their institutional structure, in general they are private non-profit entities, something that gives them a certain independence from the governments in power and a greater flexibility in terms of administration (hiring staff, defining services). But they have an indirect relationship with the government, either because government officers or representatives from large state universities and public research centres are part of their Administration Councils and Directing Boards.

In general, European NREN are constituted as private non-profit bodies with strong governmental support and funding, based on specific action and achievement plans, an extensive and inclusive membership.

The natural users of advanced networks are universities and research centres. The strength lies in the greater number of member institutions. This is a cornerstone because insofar as they do not have a strong membership policy their expansion towards other fields can be questioned.

In part, the service coverage for other users responds to the network's internal policies and to mandates from the government itself. For example, the connection of hospitals that conduct research can be a mandate, while the connection of primary or secondary schools in carried out through other networks specifically intended for this purpose.

It is evident that the government plays a predominant role in the funding for the network's basic infrastructure (the core equipment and the backbone's updating and maintenance). To this end, annual plans (two to five years) are made, including performance contracts with service policies, technologies and services to be provided, among other aspects. This structure is combined with co-funding by users in two dimensions: regular membership fees (distributed according to the bandwidth demanded) and special research projects which are made possible with other funds. That is to say, specific application or service projects through grant funds (state-owned, private or from the same institution).

An analysis of the funding models designed by SERENATE[10] indicates that the most appropriate one is the centralized one in three cases:

- When the advanced networks is in an early stage. Centralized funding implies a vertical and quick decision-making, which is useful at this stage of deployment.

- This kind of funding is also suitable for advanced networks located in countries with a lesser degree of relative development or where the funds allocated for research or education have significant opportunity costs to correct imbalances and disparities.

- Finally, centralized funding can also be appropriate to test new technologies and to develop new services which will not imply income returns in the short term for institutions.

Funding formulas where funds are provided by members, modelled depending on the requirements of advanced networks' member institutions, their size or how they use the infrastructure (or a combination of all these criteria) has the advantage of offering strong incentives to keep network services adapted to the users' current needs.

"In practice, there are big differences between countries in the way the research networks' local and international levels are funded. This ranges from a full centrally-provided funding to self-financing (through the institutions connected themselves). The best solution depends on the local circumstances. The great majority of countries have a mixed system, which can work very well if the investments with long-term returns are centrally funded and some of the services whose costs can be directly related to the institutions involved are funded by themselves"[11].

This mixed funding model can also be applied in GÉANT, the pan-European supra-network, which is partially funded by contributions from the European Commission,

10 SERENATE was a project started in May 2002 and completed in December 2003, whose objective was to conduct strategic studies which aimed at providing the European Commission with elements for initiatives to keep European advanced networks on the frontier of world developments. See http://www.serenate.org/.

11 Summary Report on the SERENATE Studies. D21, "Networks for Knowledge and Innovation", pp. 12 y 13.

although the greatest part of the costs is funded through local contributions, based on an algorithm agreed by the participating advanced networks and which can be updated whenever necessary.

One of the effects of the algorithm chosen has been the leveling of the big differences in the cost of internet services in different countries. In spite of all this, this cost-distribution model may not be strong enough to cover the expenses related to new applications, which generate a great deal of traffic between a few places, and it can be seen that it is necessary to think of other financial alternatives to cover those ways of making use of the network, which in the end are the ones that aim at the ultimate objective: to stretch the frontier of what is possible.

The technological convergence also results in a more homogeneous service offer. Although each advanced network has its particularities, there are some common patterns.

The network's monitoring function is permanent, even though it is carried out, in some cases, through outsourcing. The local equipment are or make up the incident response infrastructure which collaboratively identifies from network failures to malicious attacks.

Where services are diversified is in the area of Quality of Service (QoS) policies aimed at specific projects which recommend it.

A greater diversity can also be found in the provision of identification and authentication services for certain applications. This responds to the fact that authentication is not an internationally standardised service. After all, their implementation will depend on the service structure offered by the network and its mandates.

This is why it is possible to state that what is becoming the standard is the provision of two services:

- Videoconference: there is no network that does not offer this, either because they have the equipment in their venues or because they have signed agreements for shared use with other entities. In general, services range from high quality H.323 to platforms for simultaneous communication of users from their PC.

- Support to computing grids: as in the previous case, either because it facilitates the use of the grids needed by these networks or because in their structure they include services for the different grids in the form of middleware.

Applications like this one, plus the tendency to offer remote access to high-cost services and academic information repositories, will promote a homogenisation of authentication, even if this may take some time. What appears to be more uncertain is the permanence of a mirroring or hosting policy. When connectivity throughout the country and internationally begins to increase, distributed access tends to become more well-established.

Finally, advanced networks play a fundamental role in areas where they produce synergies. Most of them carry out at least one annual tendency meeting on high-speed networks, new technologies and services, as well as opportunities to articulate what the research world demands from the networks.

2.1 THE STRENGTHS OF THE EUROPEAN MODEL

In Europe, political support and public funding have been crucial, since it can be seen that the development of advanced networks is a matter of governmental intervention.

It is evident that the advanced networks' service provision is not a matter to be left entirely in the hands of the market. To do so implies accepting there will be a slower and more difficult development in them. "The development and deployment of networked research services have been faster and more successful in those countries where national authorities have become aware of their responsibility at an early stage. Those countries whose governments also able to appreciated the economic potential of research networks have been even more successful, since they were able to combine education and research policies with the industrial policy"[12].

12 Summary Report on the SERENATE Studies. D21, "Networks for Knowledge and Innovation", pp. 15 (translation by the consultants).

The services of an advanced network

There is a set of services which are becoming the standard in an advanced network:

Networks:

- WDM technology in their backbones which enable high speeds
- Virtual circuits for research projects
- Joint procurement or consultancy on links according to the community's requirement
- Traditional IP (IPv4) and IPv6
- Multicast network
- Permanent monitoring of the network's condition
- Upgrade planning

Services:

- Incident response
- Videoconference services
- Certification: secure communication channels in internet servers (web and others), which offers the possibility of using certificates automatically recognised by customers (browsers, mail readers, etc.).
- Authentication: public key infrastructure
- Authorisation: Similar to Shibboleth. It makes it possible to Access federated resources.
- Mobility: network access for mobile users (in Europe).
- Telephony over IP (in some countries).

Collaboration:

- Grid service on the network or facilities for this potential to be materialised through the optical network.
- Cooperation with researchers to determine the technical feasibility of their projects.
- Fundraising through grant funds for projects that make use of the network.
- International connectivity.

There are distinctive features in the European model which serve as reference for Latin America: the explicit support from public agencies, mixed funding schemes and incorporation into scientific and R&D policies.

There are distinctive features in the European model which serve as reference for Latin America: the explicit support from public agencies, mixed funding schemes and incorporation into scientific and R&D policies.

In spite of all this, the organisation that run the advanced networks and their users' communities need to keep decision-makers informed regularly and sufficiently about the goals reached by advanced networks and the requirements and opportunities stemming from their activities.

That is to say, to take care of their own visibility on the political agenda is one of the survival musts of advanced networks, together with strengthening their identity as institutions with an irreplaceable level of experience and specificity in their management.

As recalled by John Dyer when analysing the pan-European network: "The NREN is almost always a non-profit organisation, where part of the staff are members or very close to the research and education community. Many teams within the NREN are proud to be part of the community they work for and are highly motivated by the positive way on which their work contributes benefits that support academic advances. There is a sense of belonging in the NREN which is one of the main driving forces of their success. It is very unlikely that this feeling could exist if the NREN development were left in the hands of commercially driven organisations".[13]

2.2 THE CONTRIBUTION OF ADVANCED NETWORKS

Numerous research projects are deployed over European advanced networks. Two are the marks that distinguish most networks: they are network services and

13 Dyer, John (2009). "The case for National Research and Education Networks", TERENA. The document can be downloaded at: http://www.terena.org/publications/files/20090127-case-for-nrens.pdf.

application intensive initiatives and they are collaborative, since several local and foreign institutions participate in them.

The EGEE project (Enabling Grids for E-sciencE) is paradigmatic in that sense. It is an initiative funded by the European Union's 7th R&D Framework Programme, where over 120 centres located in 52 countries in Europe and Asia Pacific participate, coordinated by the European Organisation for Nuclear Research (CERN), and which has succeeded in establishing the largest distributed computing infrastructure (grid), operating 24 hours a day, seven days a week[14].

This computer network, with more than 70,000 processors and around 20 petabytes (20 million gigabits) of available storage capacity, is a support infrastructure for research in fields as diverse as high energy physics, life science, finance, geophysics and multimedia contents. One of its objectives is to make it possible to use distributed resources in a collaborative and coordinated way for the shared execution of applications between the different academic and research organisations.

EGEE is now in its third stage (EGEE III), following the infrastructure deployment of the previous two stages. Today the aim is to expand it and optimise it, as well as migrating from a user-community based model towards a model consisting in a federation of national grid infrastructures.

The more than 7,500 users send to it around 150,000 papers a day, on areas like archaeology, astrophysics, fluid dynamics, high energy physics, fusion, life science or material science. Furthermore, there are several requests from entrepreneurial sectors that are carried out over the EGEE grid as applications from geophysics and the plastic industry.

The GridGuide website, belonging to GridTalk, shows the human side of the computer network and encourages visitors to explore an interactive world map when visiting a sample of the thousands of scientific institutes that participate in projects by the computer network.

The countries that have advanced networks can also use dark fibre. That is to say, they can use those unused optical fibre channels, due to the fact that networks are

14 EGEE-III. See: http://www.rediris.es/proyectos/egee-iii/.

planned by overdoing their capacity so that it is not necessary to make subsequent costly investments to increase bandwidth. An example of the use of dark fibre is the JANET-Aurora project, executed in the UK since 2006. Its dark fibre works as a support for optical networks research, and interconnects the dedicated groups belonging to the Universities of Cambridge, Essex and University College London. Thanks to the connection, it is possible that research is conducted without the limitations of a network still in production.

JANET provides access to intermediate locations along the fibre's path, which makes it possible to test cutting-edge equipment and infrastructure under real operational conditions. It also offers the JANET Lightpath service, which makes it possible to transfer in real time large volumes of files, and offers remote control and visualisation. The service is used by astronomical and computer centres. In the case of astronomy, the service has been used in the e-VLBI project, which enables telescopes located in different parts of the globe to observe the same region in the sky: the data are then correlated and aligned thanks to a central data processor. For example, e-VLBI managed to perform data transfer and correlation in real time between China, Australia and Europe.

The physicists working on the Large Hadron Collider (LHC) are also users of JANET-Aurora. They experiment with the transport of large amounts of data as part of the "service problems" that put the LCG's (LHC Computing Grid) data processing infrastructure to the test. These tests try to prove that the LCG will be capable of dealing with the large amount of experimental data that will be produced when the Large Collider resumes operations in the near future.

In order to take advantage of wireless technologies, TERENA has executed since 2003 the EDUROAM project, currently operating. It consists in a secure network access service for mobile users and which covers a wide group of educational and research networks. Based on a policy of use and a series of technological and functional requirements, EDUROAM allows its users to move between the networks, while having access to the network at all times. In other words, they have permanent wireless connectivity and a virtual work environment with connection to the internet, access to services and resources from their parent organisations, as well as access to services and resources of the organisation hosting them in that moment. Outside the European shared mobility space, there is a similar initiative in Asia Pacific deployed over the advanced network APAN.

At an end user scale, having one single authentication mechanisms implies significant savings in time when accessing the resources of their institution, regardless of the place where the person is.

Other initiatives have a nation-wide space for deployment, as in the case of the "Television on the Internet, IPTV" project, executed over the advanced network JANET and funded by the Higher Education Funding Council for England (HEFCE), through the Joint Information Systems Committee (JISC). The project hosts technologies that enable university campuses to use, through an IP network, high definition television services. The members in the campus can watch TV through their personal computer without the need to be connected. The IP network replaces traditional television.

The usage flexibility of an IP network to deliver television services implies that users benefit from a greater interactivity and the possibility of having a sort of "menu" when choosing a TV programme.

The television channel's contents –with copyrights duly respected- is broadcasted by JANET, which has a fibre capacity that reaches 40 Gbps, using multicast, which is why hardware is not necessary to receive television signals (that is to say, without aerials, receivers or servers). Students who wish to watch the programmes simply need to download customer software to their PC. This configuration has several technical and practical advantages compared to a local server-based solution.

In general, the use of data networks to provide services like IPTV and voice is increasingly common, which eliminates the need to separate telephony and television networks. In the case of this project, JANET has experienced a significant increase in the number of sites connected (university campuses) that make use of IPTV technologies. Many of them already deliver IPTV services for students' halls of residence and campuses, which involves a more flexible medium in comparison to the one offered by television's traditional use. It has also been used for students from the field of communications to show their projects to the community through this network.

This progress has led the BBC itself to explore multicast technologies: sending a signal towards distributed points in the network, where many of them are connected, instead of emitting numerous signals from one single source.

On the other side of the Atlantic, there are several experiences that validate the usefulness and impact of advanced networks on R&D. As an example, the music programmes broadcasted through interactive videoconferences via Internet2, the US advanced network. The initiative, which began in 1998, consists in the transmission of distance musical education lessons and programmes, broadcasted through interactive videoconferences, held from one of the most important music conservatories in the USA, the Manhattan School of Music, which was the first institution to experiment in 1996 with distance musical education through videoconference.

This innovative musical education programme based on an interactive teaching methodology is the first of its kind. With videoconferences (H.320 via ISDN or H.323 via IP) it is possible to connect students, educators and renowned artists distributed across the globe, and achieve significant learning exchanges. Year after year, more than 1,700 students from Albuquerque to New Zealand participate.

The different presentations are adapted to the schools' needs, depending on the age of students, their learning needs or specific requirements for musical performance.

Finally, there is a possibility for exchange between partnered pairs of higher education institutions worldwide for the organisation of master classes on musical instruments and auditions, among others.

In the area of remote operation of sophisticated equipment, we can highlight the "Robot Da Vinci" project, initiated in 1999 by the Center for Surgical Innovation (CSI) in the University of Cincinnati, in the USA.

Da Vinci is a surgical system of robotic interventions designed to perform minimally invasive surgeries. The robot was created by the CSI, leader in surgical robots. Its name is homage to the artist Leonardo Da Vinci, who built the first robot more than 500 years ago.

It consists of two modules, the arm and the control console. The robotic arm makes it possible to operate a patient by means of laparoscopy while the control console allows the surgeon to make the operation.

Thanks to a built-in computer system in that console, the surgeon can operate in very small areas of the body, make accurate incision and avoid possible involuntary movements. Two of the four robotic arms have high resolution cameras that are introduced in orifices just millimetres small, which gives the surgeon 3D vision of the zone to be operated. The other two arms make it possible to manipulate the environment by means of a series of different scalpels, similar to the ones used in traditional laparoscopy.

The advanced network's importance in this technological advance would consist in the development of remote tele-surgery; that is to say, it would make it possible for a surgeon to get connected and operate a patient located thousands of kilometres away. There have been some experiments along these lines, like the one performed in April 2005, during the American Telemedicine Association Meeting: a nefrectomy performed on a pig located in Sunnyvale, California, from the Denver Conventions Center, 900 miles apart. The results of that intervention and other research always led to the impossibility of reducing the time passed between the action performed on the remotely located patient and the return of the image to the corresponding robotic console where the surgeon was located. Only through advanced networks it was feasible to attain the response time and image quality that are necessary for this challenge.

Although the network's strength continues to be a major concern for the future clinic use of this tele-surgery system, Internet2 may provide capacity –from the point of view of image fidelity, latency reduction and loss of packages- for clinical use, but this is still being discussed.

Due to the usefulness expected in the near future, research on remote tele-surgery has been promoted and sponsored by the NASA and by the US Department of Defense. These two bodies appreciate great advantages in its use. For example, to help astronauts in emergency situations during space missions, considering the cost of evacuating the crew to the Earth. Another area of use is the battlefield: the great majority of wounded soldiers die due to secondary haemorrhages. To be able to remotely stop these haemorrhages with the Da Vinci robot would be very helpful.

From the microscopy of the human body to the macroscopy of natural phenomena, advanced networks have a role to play in one of the most pressing problems of our times: climate change. The Florida International University, FIU, in the USA, together with the Universidad Federal Fluminense and The Catholic University in Santos, both located in Brazil, participate in the International Hurricane Research Center, which started out in 1997 and is still operating. This is a multidisciplinary centre aimed at mitigating the damages produced by hurricanes on people, their possessions, on buildings and on natural environments.

According to the Center, the economic losses after a hurricane are high: 40 percent of small and medium sized companies can close down within 36 months if they are forced to suspend their operations for a few days after a big hurricane.

The center has four research laboratories, Laboratory for Coastal Research, which assesses the vulnerability of coastal areas, especially in regards to beach erosion and storm surges by utilizing airborne laser technology and computer animation. Some of its research, for example, is on tidal modeling, elevation of the sea level and coastal erosion maps.

In order to carry out its research projects, the Center uses a computer grid modeling software to predict the weather: the Weather Research and Forescasting (WRF). It is computer intensive and needs interdisciplinary knowledge. The forecast model for hurricanes is also a multiplatform distributed application, which speeds up results. The important thing is that the decision to use computer grids for modeling purposes was adopted due to the need to achieve response times which are suitable for the phenomenon being studied.

The Center has obtained funding for three years (2006-2009) to conduct further research on grid modelling, but especially to sustain a cyber infrastructure based on advanced networks which is transparent for end users, since the research conducted is a global cooperative effort.

2.3 THE GLOBAL ORIENTATION

In Europe, DANTE not only deals with the management of the European network, but also has expanded its scope towards other geographical regions through the interconnection of its advanced network, GÉANT, to other infrastructures.

In Latin America, the ALICE project, funded by the funds from the 6th Framework Programme, made it possible to interconnect in 2004 the local advanced networks to their European peers.

At the same time, DANTE has executed similar problems with other regions like the Mediterranean (EUMEDCONNECT), and with Asia Pacific through TEIN2 (Trans-Euraisa Information Network), the first large scale network which connects ten countries in the region and provides direct connectivity to the European network GEANT.

Today, TEIN3 is already operating, after receiving MM 12 million from the European Union and significant contributions from Asian counterparts. This network, which operates at 2,5 Gbps, responds to an inclusive policy, as countries like Japan and Korea have stronger infrastructures than Vietnam or Thailand, for example. However, it promotes international and regional cooperation through egalitarian access to advanced resources.

Technological disparities between countries may not be an obstacle, but an enticement, as shown by the “Internet Education and Research Laboratory (intERlab) project, executed by the Pierre and Marie Curie University in France and counterparts in Japan and Cambodia. This project supports an e-learning system in two modalities, “virtual learning classroom” and “on-demand virtual lessons”, for medical students.

The network configuration used by the project features a real technical challence, since it is a combination of a high-speed network (Renater-GÉANT2) which connects France to Japan through the use of advanced technologies (IPv6, multimedia and mobile or wireless internet) with a satellite connection of relatively low speed between Japan and Cambodia, thanks to the participation of the Asian Internet Interconnection network, AI3 (www.ai3.net).

This configuration is used to simultaneously deliver enhanced multimedia contents from the Pierre and Marie Curie University by means of DVTS (Digital Video Transport System) in uncompressed VDO format to sites with Gigabit links, while the compression for lower speeds is carried out in real time to be sent to the Health Sciences University in Cambodia. In that location, in the “virtual classroom”, students and teachers take part in live conversations through audio-video, while they work with synchronic collaboration applications to chat, or make use of the VoIP technology.

The “on-demand virtual lesson” modality allows students to work through their computers with distance learning resources without the need to be connected at the same time as their teachers.

In Japan, the Asian Institute of Technology (AIT) is in charge of the operational, network supervision and performance measurement procedures. It also coordinates the e-learning platform.

Another similar project, this time over the advanced network TEIN2, is “remote surgical education in Asia Pacific over advanced networks: distance medical training and education”, started in 2003 and still operating. It features the participation of major institutions like the University of Kyushu Hospital (Japan) and the Seoul National University Bundang Hospital (Korea) and has associated institutions in Asia (China, Vietnam, Thailand, Pakistan and India), Europe (Spain, Italy, Norway, Greece and Germany), America (USA, Canada and Brazil), Africa (Egypt and South Africa) and is supported by the European Institute for Tele-Surgical Training. In total, there are 94 participating institutions.

Based on telemedicine, the initiative allows experimented surgeons to teach medical minimally invasive surgery techniques to medical students located in different parts of Asia Pacific and Europe. By making use of ICT, the professionals share their knowledge through videoconference. Thus, multidisciplinary medical teams which make up virtual communities participate, in real time, in a surgery. For example, if an intervention is performed in a hospital in Naples, professionals located in Barcelona, Malaga and Japan can witness it. To do so, it is necessary to have an internet connection, a computer connected to surgery equipment and the great bandwidth of advanced networks. In this case, TEIN2 connected to the pan-

European network GÉANT makes it possible that the surgeries, performed in real time, are transmitted to remote locations. Thanks to the DVTS technology (Digital Video Transport System) it is possible to see and maintain images in high definition. This new technology leaves behind conventional telemedicine, which worked with a low bandwidth that limited the quality of images.

Slowly, but persistently, this teaching methodology for the exchange of medical points of view has expanded to countries like Vietnam, Indonesia and Malaysia.

The connection with GÉANT has enabled the interaction between teams in Asia Pacific and European professionals, and has also led to an extension of the surgical tele-training through the creation of an international virtual community. This way, technological standards in medical are improved, and patients are provided with a better attention.

In the area of initiatives for interconnection to other networks, in 2009 DANTE added two more projects: to connect GÉANT to countries in Central Asia – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, through the CAREN initiative. This will begin operations in early 2010 and will consist of an overland network that will replace the current satellite links. This network is jointly funded by the European Union and an initial MM 5 euro contribution until 2011.

Another cross-regional project is a feasibility study, conducted by KTH, Royal Institute of Technology in Sweden, to connect Sub-Sahara African countries to the European network. The first stage of this initiative, which is also supported by the European Union, is called FEAST (Feasibility Study for African – European Research and Education Network Interconnection) and is a roadmap on the best scenarios to deploy a sustainable backbone based on overland connections instead of satellite ones.

The emphasis is on regional integration and the economic development potential. Furthermore, the project is very clear about another objective: “African people can benefit from the knowledge and experience, in a wide range of areas, from the research conducted worldwide on matters of particular relevance for Africa, such as malaria and other diseases, or the effects of climate change”[15].

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15 Supporting the connection of African research and education to the global Internet via GÉANT (2009). FEAST Project. See at: http://www.feast-project.org/documents/20090423-feast-brochure.pdf.

This last initiative, in turn, synergically interacts with the UbuntuNet Alliance project. This project aims to take advantage from the recent availability of optical fibre to build an advanced network backbone in the region. Its founding members are Kenya, Mozambique, Rwanda and South Africa, followed by Sudan, Tanzania, Uganda and Zambia.

Although the network has not been deployed yet, it represents an important effort to connect a continent that has remained outside advanced networks. On the other hand, these countries are very aware of the fact that together they can negotiate more favourable connectivity conditions between national advanced networks, and later on with the international ones. In fact, for the 2009-2010 period a substantial increase in submarine cable connections towards developed countries is expected.

The African case represents a particular state of advanced networks, as in order to have connectivity between nations, they seek for access to fibre at a marginal cost or as a spinoff from an ongoing deployment project. "During the design stage, cable operators will offer UbuntuNet the alternative, at marginal costs, of buying long-term rights of use for two or more fibres"[16].

Thus, once more, the idea is coherent with the global trend of having a sustainable infrastructure in terms of rights of use and straightforwardness to perform upgrades on the end points, depending on technology advances. From another point of view, all statistics show that under the current circumstances, connectivity costs in Africa are much higher than in developed countries, which limits its potential for economic development.

16 What is UbuntuNet? (2008). See: http://www.ubuntunet.net/sites/ubuntunet.net/files/What%20is%20UbuntuNet%20v9%20-d3%20printed%20on%20081108%20web.pdf.

III. Advanced networks in Latin America

Today Latin America has an advanced networks' infrastructure, unthought-of only ten years ago. Over that period, CLARA, the Latin American Cooperation of Advanced Networks, was created as an international right non profit organisation, which came into legal existence on December 23rd, 2004, when it was recognised by the legislation of the Oriental Republic of Uruguay.

CLARA is defined as Latin American system for collaboration through advanced telecommunication networks for research, innovation and education. It has 17 members (Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Chile, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela). Currently, only thirteen countries are connected to RedCLARA. The non-connected countries are Bolivia, Paraguay, Cuba and Honduras. The last two are regarded as "non-active members", but their full incorporation is expected to take place in the near future.

CLARA's institutional government bodies are the Directing Board (highest organism constituted by the President. Vice-President, Secretary, Treasurer and one Director), an Audit Commission (made up of three members of the Assembly who are not part of the Board) and a Technical Commission (with seven members, engineers from the networks connected to RedCLARA), which watches over the network's development, technical implementations and security.

The CLARA Assembly holds meetings every six months to define action points and policies to be implemented. In the Assembly each country has one representative.

3.1 REDCLARA, AN OPPORTUNITY TO STRENGTHEN DEVELOPMENT

CLARA develops and operates RedCLARA, an advanced network established in Latin America for region interconnection. As of September 1st, 2004, RedCLARA began to provide direct connectivity at 155 Mbps by linking the advanced networks in Argentina, Brazil, Chile, Panama and Mexico, and connect them to the European network GÉANT at 622 Mbps through the connection between Sao Paulo (Brazil) and Madrid (Spain). This infrastructure was officially launched on November 17th, 2004, at the Ministerial Forum on the Information Society, held in Rio de Janeiro.

During 2005, the advanced networks in Uruguay, Peru, Costa Rica, Panama, Guatemala, El Salvador and Ecuador got connected to RedCLARA, which increased the number of connected networks to twelve. In 2006, connections to RedCLARA continued with Colombia, Venezuela and Nicaragua. However, that same year Costa Rica decided to pull out due to economic reasons, a fact that was reverted in 2009. In 2007, conversations for Bolivia's connection began, but Nicaragua decided to put an end to its connection to RedCLARA and its participation in CLARA because of economic reasons[17].

RedCLARA is based on telecommunication capacities hired from various operators, over which a high-quality IP network is deployed, both in IPv4 (version 4 of the Internet Protocol) and in IPv6 (version 6 of the Internet Protocol). Thus, RedCLARA becomes a last generation technological platform on advanced networks which enables connectivity with bandwidths and speeds unavailable in commercial networks, which provides Latin American scientists, academics and researchers with an infrastructure that enables them to effectively collaborate with the global scientific community.

According to data taken from CLARA's website, it is estimated that considering only the countries currently connected to RedCLARA, its participants include 729

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17 López, María José. eLAC2007 Work Group Document, January 2008. Goal 10 eLAC2007: RedCLARA and National Research and Education Networks. See at http://www.cepal.org/SocInfo.

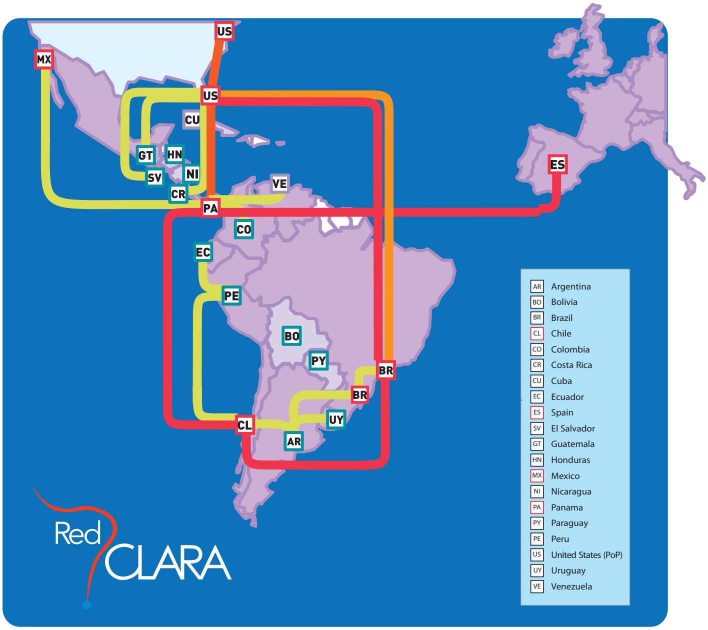

Figure 2: Topology of the RedCLARA backbone, projection for March 2010 (see original at: http://alice2.redclara.net/images/ALICE2/brochure/ALICE2_brochure_02_2009_tiro.pdf).

universities, with a total of 671,000 academics, 104,607 researchers and 3,763,142 students.

The RedCLARA backbone is made up of seven main routing nodes, connected in a linear topology (point-to-point). Every main node (IP) represents a PoP (Point of Presence) for RedCLARA. Six of them are located in a Latin American city: Sao Paulo (Brazil), Buenos Aires (Argentina), Lima (Peru), Santiago (Chile), Panama City (Panama) and Tijuana (Mexico). The seventh node is located in Miami (USA) and this is where Central American networks get connected (shortly they will be connected to the Panama node).

All the connections of Latin American national networks to RedCLARA are carried out through of one these seven nodes. The connection with the USA is carried out by means of the links from the Tijuana node (Mexico) to San Diego (US Pacific Coast) and from the Sao Paulo (Brazil) node to Miami.

RedCLARA is also connected to networks in Europe (GÉANT), Asia and Pacific (APAN, TEIN2), Canada (CAnet4), the Mediterranean Basin (EUMEDCONNECT), among others. In Figure 2, the RedCLARA topology is illustrated.

CLARA's Network Engineering Group (NEG) is in charge of the advanced network's engineering and architecture, the types of links and the procedures for traffic exchange. The Network Operations Centre (NOC) is responsible for the administration, control, monitoring and everyday operation of all the backbone's physical and logical infrastructures.

3.2 SERVICES

In general terms, national networks offer a services platform based on the articulation of a high-speed backbone, where it is possible to integrate different resources and services. For example, they can provide dedicated communication channels for individual research projects, promote the creation of suitable environments for the introduction and testing of new resource administration tools; to encourage dissemination activities among the local communities and facilitate a structure that enables the networks' physical interconnection and the exchange between people and research groups located in different countries. In other words, it can become a distinctive local transformation agent in the field of scientific and technological research.

To date, RedCLARA offers IPv4, Multicast, IPv6, IPv6 Multicast, and On-demand Bandwidth (QoS) services, as well as specialised services for projects like computer grids and videoconferencing, which is the application most intensively used by researchers.

> The region has services which can be similar to those in developed countries, but with an unequal deployment in terms of coverage, figures and scope of projects.

The value chain of CLARA services implies working for partners who, at the same time, are collaborators and providers of some services (through outsourcing) and act as intermediaries before "end customers", constituted by researchers, teaching staff, academics, students and all individuals and public and private institutions, either local or international, related to scientific and technological research on education and health.

Nowadays, advanced networks in Latin America show an unequal development. There are countries where they are part of regular infrastructures for research on science and technology, which does not mean that they are given a homogeneous use or that they have the same visibility, weight and priority on the public agenda (Brazil, Mexico, Colombia and Venezuela).

A second group is constituted by the countries where advanced networks are seen as an available enabling infrastructure, without them being integrated into a larger strategy or science and technology public policy: Chile, Argentina and Ecuador.

The third group is constituted by those countries are in the process of consolidation from the technical and institutional feasibility and financial points of view: Costa Rica, El Salvador, Guatemala, Panama, Peru and Uruguay.

Finally, the fourth group includes the countries where advanced networks are a promise to be fulfilled, specially its longed-for connection to RedCLARA: Bolivia, Cuba, Honduras[18] and Paraguay.

3.3 IN PURSUIT OF SUSTAINABLE FUNDING

Despite the economic crisis in the last 15 years, over this period Latin America has managed to become a region connected internally and to its peers in Europe, the USA and Asia.

The creation of CLARA, in 2004, has promoted the creation of local networks in at least six countries in the region, which is an unequivocal signal of the increasing

18 For this country, the advanced network's specific objectives are: research, communication with other universities, technological updates areas and virtual libraries, to allow technological and knowledge transfer.

importance acquired by these infrastructures for the development of scientific and technological research, education and innovation.

CLARA's role, beyond its technical management and counterpart relation with Europe, has also served to make advanced networks visible and to explore possibilities for use among scientific communities. At the same time, the decentralised administration chosen by CLARA[19] to operate in an alternative that distributes commitments and responsibilities among its members, as well as strengthening the learning capacity in local nodes, which means that the collaboration philosophy has imbued the agency in charge of the network's technical management and the dynamisation of the scientific community it caters for.

It is true that CLARA's governing mechanisms and funding schemes need to be strengthened. The presence of public agencies in the local networks' administration bodies and their commitment in areas of management, funding and the design of policies and programmes which integrate these infrastructures into longer range objectives, should ensure that these objectives are attained.

An immediate challenge for the entire ICT system is to increase the GDP percentage destined to R&D in Latin American countries. On average, this reaches 0,65% while developed countries invest between 2 and 3% of their GDP on R&D.

This meagre investment has a direct impact on the funding structure of the platforms to support ICT activities, like advanced networks. The lack of resources and their alternative uses in the face of important social problems makes it difficult to justify in the short term the funding for international links (more costly than in developed countries) and the necessary expansion of the network towards the whole national territory.

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19 CLARA's Network Operations Centre (NOC) is based in REUNA (Chilean advanced network). It administrates, controls, monitors and operates all the physical and logical infrastructures that make up RedCLARA's backbone, and aims to ensure high levels of performance and operation for the network and its connections. CLARA's NEG (Network Engineering Group) depends on CLARA's Technical Committee (CLARA TEC). The objective of the latter is to keep CLARA on the frontier of IP network advanced services and must do so through the coordination of the NOC and NEG. In turn, the CLARA Projects Management is based in Mexico; the Administration and Finance Management in based in Montevideo, Uruguay, and the Executive Management is based in Santiago de Chile.

Once again, relatively stable elements of funding which are supported by public discourse have made it possible to sustain a growth and service level for the entire community. This can be seen in Colombia, Brazil and Mexico.

Funding restrictions mean high costs or the impossibility to run a central cluster of services which are stable over time. The consequences are evident:

- Problems to renew the network's infrastructure.
- Lack of stable service levels for partners.
- Possible increase of membership fees.
- Problems to negotiate in the mid-term with providers, and therefore visualize the "purchase" of fibre for the network.
- Limited territorial extension.
- Staff turnover
- Participation in projects where a significant part must be destined to operational costs instead of the incremental costs of the activity.

In developed countries private enterprises carry out an important part of R&D or they are technology producers and operators. Furthermore, the same public policy states that these networks must favour the innovation that, by default, takes place in the market where technology users and producers interact.

> Clear and stable public funding has resulted in growth for some countries. This is a key issue, since Latin America features little private investment on R&D and little participation in these networks

Because of this, advanced networks welcome the participation of private laboratories, which is the standard in Europe, or the participation of private companies (patronage). This is the case of Internet2, in the USA, or of some developed countries where telecommunications (fibre owners and operators) and equipment (usually routers or high-performance equipment) companies are active members who support these initiatives.

The above is also consistent with another promise of advanced networks: its capacity to serves as testing sites for new services and applications which are transferred to the private sector.

In Latin America there is still a long way to go. There is no private support which is consistent over time, given the research structure (highly focused on the traditional academic sector) and –with outstanding exceptions- international R&D companies do not undertake these activities in the continent. In fact, in 2007 funding from enterprises for R&D at a regional level, and seen optimistically, reached 37%[20]. When seen as executors, this figure goes down to approximately 28% in the same year.

In turn, international equipment branches have seen support for advanced networks as specific actions which favour the creation of a steady market or a certain level of human capital for new technologies.

The relationship with telecommunications operators has been less productive, with a few exceptions in Mexico. Either there have been national monopolies which see advanced networks as a threat for their "business", or deregulated markets which see them as another market they can "capture". In this regard, it is necessary to point out that the majority of advanced networks have not been proactive in opening up to the active participation of private actors.

Here there may be an opportunity, since an important part of public policies in the region are aimed at innovation. In that case, a set of advanced networks which are more open to the entrepreneurial world can play an important role as an element that justifies public support.

From another angle, a regional articulation with major companies could bring benefits, although it has not been an easy task.

What is even more crucial, the history of disagreement with telecommunication companies shows that the alternative of consolidating a network with ownership of dark fibre makes sense as a differentiating element. It increases the capacity for

20 This figure represents the average for Latin America. Source: RICYT. S&T expenditure by area of funding. At: http://www.ricyt.org/indicadores/comparativos/09.xls.

negotiation and through the connection of central capitals it alleviates, in part, the work of advanced networks, which can focus on national expansion.

Advanced networks in the region need to be legitimated before the public world. Developed countries have been much more active in incorporating museums, libraries, schools and hospitals into the high-speed network. There are cases which confirm the exception, like Brazil and Colombia, but this is still not a generalized situation in Latin America.

However, networks are not only a matter of figures. The regional vocation is a key aspect of networks, although it represents a part of the global R&D production and cooperation within the region is not as crucial as that of developed countries.

The European case is paradigmatic. Advanced networks in most countries are explicitly part of the scientific policy strategy expressed in public documents. It is remarkable, in that sense, how little the same advanced networks have changed over the last twenty years in terms of the functions they perform, despite the changes in governments.

This in fact reflects a long-term vision which features the consolidation of the need of an advanced network for scientific policy. In parallel to this, or more precisely, coherently and in synergy with the above, the same structures in the European Union and in the General Research Directorates have been crucial to take this need to a more visible position.

It is not a coincidence that TERENA, DANTE and hallmark projects receive regular funding. They are infrastructures for a research community which maintains the competitiveness and leadership of a community vision. Likewise, they are seen as key elements to facilitate researchers' mobility, avoid the "brain drain" and allow remote access to resources and experiences where national frontiers must be "transparent" in this shared construction.

> The region requires an explicit public policy on advanced networks, which covers the integration of research communities and promotes development and innovation through the incorporation of financial support.

Other developed countries do not have this strong community sense, but their public policy vision is sustained and consequent. It is not in vain that Canada has been one of the most outstanding nations in telecommunications innovation. The cultural reasons are simple: it always saw networks as the motorways to connect a large nation. The USA, with a similar frontier philosophy, has, in turn, the particularity of being the nation where the internet was born within the academic world, which is related to a historical persistence about enabling infrastructures (electricity, roads, and watering systems).

The Asian case can also be explained by considering that for 30 years nations like Japan, India, Korea and Singapore have "industrial" policies where information technology as an economic development driver has been a strong component. Phrases like "intelligent city", "R&D services export platform" and "gigabits country" are already part of the discourse of nations that are certain about the need to get connected and compete in the world with better resources.

Finally, Australia and New Zaeland have been countries where telecommunications deregulation was originated and where the physical distance is also seen as a challenge to be overcome through national and international connectivity.

Where does Latin America stand?

Explicit public policy on advanced networks is practically non-existent. And when they are mentioned, it is not common that this results in support from the financial point of view. No regional body shows a consistent and long-terms discourse which aims at the integration of its research communities through advanced networks.

On top of this, critical mass is concentrated in one single country, Brazil, which brings together almost 50% of researchers in the region. It is followed by Argentina and Mexico. If we add Chile to the list, which stands out because of its productivity, and Colombia and Venezuela, the resulting picture involves more than 80% of the critical mass of natural users of advanced networks in Latin America.

As it often happens, there are some nuances. There are realities which are difficult to be modified in the short term; but in the globalisation era there is always a public action margin that can "speed up" or "slow down" developments.

Public policy does make a difference. Brazil, Mexico and Colombia maintain or improve their relative position.
The lack of sustained support in Chile and Argentina has resulted in a challenge for managers in those countries.
Brazil has strongly incorporated the advanced networks discourse and the integration of its research communities into the developed world.
Colombia, despite political conflicts, national policies to support infrastructure and advanced networks have been consolidated, with a significant permanence over time.

Nuances also respond to historical traditions. Clearly, Brazil is the exception in the region. Its ICT public policy has been explicit and consistent over the last 30 years and has firmly incorporated the discourse on advanced networks and the integration of their research communities into the advanced world. Likewise, it has the regional vocation to collaborate with the effective participation of the rest of the continent.

In the second place we find Mexico, which also shows background records of the development of stable Science and Technology infrastructures and policies. The difference is that the strong regional vocation that it had in relation to Central America twenty years ago has lost part of its strength because of its links with the US through NAFTA.

A meritorious case is that of Colombia, where despite political conflicts, national policies to support infrastructure and advanced networks have been consolidated, with a significant permanence over time. Colombia points at a road it is possible, with explicit governmental support, to move forward more quickly and, maybe, surpass other countries. In part, Venezuela has also followed that road and this has enabled it to maintain its relative position.

If we take a closer look, it is not a coincidence that two out of the three examples above represent the first countries to consolidate an internet connection (Brazil and Mexico with infrastructures similar to the current ones, the role of supporting Science and Technology bodies, critical mass).

There is another side of the coin. Chile, who was the pioneer in the region, has not achieved an explicit political support for its advanced network which brings together the entire academic community. The strong competition within its university system and the lack of policies have threatened the growth speed experimented twenty years ago. In fact, the articulation of the system with a long-term vision is a recent task which began with the creation of the National Innovation Council for Competitiveness, not more than two years ago.

Another case that features possible delays is Argentina. Its initial thrust, two decades ago, has also suffered the effects of the government changes and is likely that the new Ministry of Science, Technology and Productive Innovation consolidates a long-term plan.

The conclusion is obvious. Explicit public policies can really make a difference in incremental growth.

3.4 ONGOING PROJECTS

The scientific communities in Latin America, as in Europe, the USA and Asia, have become involved in projects that demand the use of advanced networks. There are examples across all areas and many initiatives have now become permanent services. Below some of these are presented as an example:

Large Scale Experimento n the Biosphere-Atmosphere in the Amazon (LBA Project)

The Project started in 1996 and in 2008 completed its first stage, and has been institutionalised as a Brazilian state project. Today it is in its second stage, led by the National Amazon Research Institute, INPA, and the Ministry of Science and Technology, in Brazil.

It is an international scientific collaboration project, one of the largest in the world, which aimed to explain how changes in the Amazon soil use affected regional and global climate and how global climate variations influence the forest's biological, chemical and physical functioning and its sustainability.

It featured the participation of 281 national and foreign institutions, and the collaboration of 15 countries. More than 1,500 scientists, almost 500 students and 156 research projects, of which 100 have already been completed. LBA has also played an important role in the training of human resources.

The LBA proposal is to promote a multidisciplinary and interdisciplinary study which is capable of integrating physics, chemistry and biology into an analysis of the various ecosystems in the forest and, thus, understand the possible environmental consequences that the planet risks due to man's action on the environment.

The project intends, by the end of the process, to influence environmental policies and leave in the region at least one hundred teachers and doctors specialised on biosphere-atmosphere interaction. The field work is carried out in an area of approximately 7 million square kilometres, which covers the entire Amazon basin and one part up to Brasilia.

The great amount of data generated after the project consumed a great deal of bandwidth, which called for a suitable computational infrastructure. Thanks to the RNP network, member of RedCLARA, the great volumes of information could be distributed among partners located in Brazil, and send them to Latin America, North America and Europe.

The information obtained was processed in the different project's offices and travelled along the RNP network up to the LBA-DIS (Data Information System), located at the Centre for Weather Forecasting and Climate Studies (CPTEC), in Sao Paulo. The material that arrived at the Centre was consolidated, organised and sent to associates. Participants, from their corresponding countries, were able to assess the information and collaboratively discuss ideas and hypotheses.

The results obtained by the different teams of scientists have made it possible to understand some of the mechanisms that rule the interactions of forests with the atmosphere, both under natural conditions (untouched forests) and when subject to intervention.

The LBA has contributed to the improvement of the models to forecast the weather and the level of carbon emissions from hydropower plants in the Amazon and the potential use of methane to generate electricity in additional plants. It also came to important conclusions on the real density of wood in the southern Amazon.

In September 2007 LBA was included as a governmental programme and a second stage was initiated with the aim of expand understanding on the functioning of the region's ecosystems and integrate social and economic dimensions.

South American-European Network for Climate Change Evaluation and Impact Studies (CLARIS)

An initiative similar to the one presented above, funded by the European Union, was carried out between 2004 and 2007 in the Rio de la Plata basin. The "South American-European Network for Climate Change Evaluation and Impact Studies (CLARIS)" project was coordinated by two French institutions: the National Centre for Scientific Research (CNRS) and the Dynamic Oceanography and Climatology Laboratory (LODYC). On the Latin American side, the participants were The Brazilian National Space Research Institute, from the University of Sao Paulo, the Federal University of Santa Catarina, the Federal University of Parana, the Argentinean National Scientific and Technical Research Council, the University of Buenos Aires and from Uruguay the National Agricultural Technology, the National Water Institute and the University of La Republica.

The aim of the project was to build an integrated Euro-south-American network promoting the creation of common strategies for climate research to observe and predict climate changes and their socio-economic impact, bearing in mind South America's climate and social characteristics.

Its contribution would make it possible to design adaptation strategies for agriculture, medical healthcare, hydroelectric energy production, fluvial transport, hydric resources and ecological systems in wetlands in a region highly dependent on climate variability, based on a set of regional hydro-climatic scenarios and their uncertainties. It would also be possible to plan possible scenarios in the evolution of soil use for the 2010-2014 period and rural development's adaptation strategies for the most vulnerable areas.

During its execution, the project favoured the transfer and adaptation of the knowledge and experience on Terrestrial Systems Models and their different components and combined procedures, which enabled the European and South American teams involved in the regional climate modelling to compare and exchange methodologies.

It also established a high-quality daily climate data base (temperature and rainfall), which is regarded as very important to validate and assess the future capacities of the Climate Assessment European Plan, through the simulation of climatic tendencies and frequency changes of external phenomena.

The communication achieved and the exchange of research results have been useful for the progress and identification of promising research strategies. Likewise, it strengthened the link between public and private organisations in topical areas which require recommendations on climate variability to design or adapt management and investment strategies in vulnerable regions.

In the Southern Cone's western side there is another climate modelling project which aims to understand how the El Niño-Southern Oscillation affects climate variability in the coasts of Peru and Chile, and thus be able to identify a set of patterns. The initiative has lots of positive externalities from the social and economic point of view, since climate simulation and weather forecasting are some of the most costly computing scientific activities.

With the use of computing grids resources were shared in parallel and applications, data and infrastructure were exchanged between participating institutions, which were geographically distributed. This way, it became possible to access a shared and distributed computing and storage capacity, and a greater generation of simulations and modelling were achieved, compared to what could be available locally.

The initiative, which is part of the EELA project (E-Infrastructure shared between Europe and Latin America, 2006-2007, Europe-Latin America, funded by the 6th

Framework Programme) featured the participation of the University of Cantabria in Spain, the National Meteorology and Hydrology Service in Peru and the University of Concepción, Chile.

Telemedicine University Network (RUTE)

Health is one of the priority areas in the execution of various projects over the last years in Latin America. One outstanding example is the Medicine University Network (RUTE) which started in 2006 in Brazil with funding from the Ministry of Science and Technology, through the Studies and Projects Funder (FINEP), and is coordinated by the professionals in the advanced network RNP, and supported by the Brazilian Association of University Hospitals (ABRAHUE).

RUTE is a support initiative to improve infrastructure for telemedicine in university hospitals. Thanks to this initiative, it is possible to exchange information between participants, make questions through videoconference, diagnose and transfer medical images to locations where the necessary hospital infrastructure is not available.

It also aims to promote the incorporation of projects between participating institutions, within and outside Brazil, thus expanding multi-focus research and telemedicine experiments in high-speed networks. After all, its ultimate objective is to increase the quality and accuracy of healthcare for the entire population.

One of the economic objectives is to reduce the future cost of communication networks development within and between participants, as well as the amount of journeys for patients. Another essential objective is the early detection of infectious outbreaks.

The infrastructure provided by RNP enables the interconnection and medical collaboration with different university hospitals in Brazil. Through RedCLARA, RNP can also collaborate with institutions abroad and access European and North American connections.

During the first RUTE stage, 19 hospital units from 14 Brazilian regions were connected. Today, it includes 60 university medical institutions located in the country's 27 regions. These institutions interact with each other and also with other associated institutions in Brazil and abroad.

T@lemed

A similar telemedicine project was started in 2004 by the German Fraunhofer Society and involves Colombia and Brazil. It is funded by the European Commission and aims to bring basic medical services available in large hospitals to geographically isolated places.

By having T@lemed, a doctor located in a distant area can electronically transfer images and data about his/her patient to a hospital centre. In that centre, the image can be seen immediately and, if necessary, specialists set up a videoconference in real time with the patient.

The objective of these clinical applications, in the case of Brazil and Colombia, are the region's typical infectious diseases, malaria and tuberculosis, while ultrasound applications, in general, are used for pregnancy control, urology and cardiovascular diagnosis.

It is also intended to generate a medical data base based on the evidence and develop and promote the "e-health" community as a discussion forum where to exchange experiences on telemedicine systems and services, and obtain and give advice on related aspects.

The infrastructure provided by RedCLARA and GÉANT enables the almost instantaneous transmission of high-resolution images and of large files from and to separated geographical points (within the same country or Europe). It also makes it possible to immediately deliver diagnosis and to request additional information.

Caracas Clinical University Hospital

In the area of tele-surgery, and thanks to the capacities of the Venezuelan advanced network, REACCIUN, member of RedCLARA, the Caracas Clinical

University Hospital has a virtual space for their students and traumatologysts to simulate operations, as part of their training, with virtual patients.

The objective is to reduce expenses and the time length of interventions and offer patients greater security, since with this system it is possible to measure mistakes or good decisions made by doctors.

It also enables doctors and students at the School of Engineering to visualise the strength of prosthesis materials, and thus improve their construction.

Although the Surgical Simulation Systems, SSS, have been a huge step forward within the development and practice of surgical processes, the tool has not been able yet to overcome, until now, the human body's physical conditions barriers. To structurally simulate the muscular or bone mass of a patient in order to determine the degree of pressure, the form and precise movement that must be applied to the scalpel in contact with the organ, is still an obstacle that these tools must overcome.

EELA WISDOM

Another project where REACCIUN is involved is EELA WISDOM (Wide In Silico Docking of Malaria), initiated in 2006 by the Computing Platform for Life Sciences in France and supported in Venezuela by the National Centre for Scientific Computing in the University of Los Andes.

In the initiative computer grid technology is used to analyses thousands of data which make it possible to understand the interaction of different drugs with the parasite responsible for malaria, a disease that affects more than one million people in Latin America.

In the case of Venezuela, computing studies are carried out with the Plasmodium vivax, the most dangerous species in Latin America, responsible for causing malaria in approximately 80,000 people a year. This virtual laboratory could facilitate the next experimental studies to create medical products against malaria and reduce risks.

The analysis of WISDOM results, conducted at the Fraunhofer Institute for Algorithms and Scientific Computing (SCAI), in Germany, has brought together the project's participants and have made it possible that one thousand of the most promising compounds, among one million candidates, are selected by means of a scale of relative classification between the different ligands. The initiative identified two known candidates and two new ones, which shows the approach's validity[21].

Pierre Auger Observatory

A natural area for advanced networks is the massive data transfer. In that sense, astronomical centres are one its main clients and promoters. In Latin America, since 2004, the Pierre Auger Observatory, located in Malargüe, Argentina, collaborates with 77 institutions in 19 countries, to which it transmits huge volumes of information. It is a basic science experiment and in 2007 it was one the ten most relevant scientific activities worldwide.

The Observatory is aimed at detecting ultra-high energy cosmic rays. To do so, it implemented a hybrid detector made up of 1,600 tanks which cover a surface of three thousand square kilometres and six fluorescence detectors in the borders. Thanks to the Argentinean advanced network, Innova|Red, data were transmitted to repositories in the USA and France.

Electronic culture

It is not possible to participate in the world without being able to build an identity day after day. This identity is not a fixed state over time which was lost in some stage of development. It is a process of confrontation and self-knowledge through being exposed to the others, where the permanent articulation of history provides new clues about the process of memory and makes it possible to see under a different light.

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21 Source: http://cordis.europa.eu/wire/index.cfm?fuseaction=article.Detail&rcn=5344 [last visit: 06/07/2009].

Hence –in a globalised world- identity is understood as a construction; it is a reflexive and self-knowledge process. Because of this, as a constant issue, this desire for identity is materialised in recovery and digitalisation projects for museums, libraries, and archives, among others, projects which are then made available for many sectors.

The above is also linked to access to information and knowledge. Efforts in Brazil, Argentina, Chile, Colombia, Ecuador, Uruguay and Peru have enabled, over the last five years, cooperative access to entire text collections of mainstream journals. To participate in the access to relevant information from geographical distance is a matter of high consensus and impact. And not only abroad: experiences in Latin America like the electronic library SciELO, started out in Brazil by Bireme (OPS), have created and promoted knowledge at a scale that is replicated with the creation of other open-access local archives.

In the area of cultural projects currently carried out over advanced networks in Latin America, there are two outstanding initiatives: information services based on the Colombian cultural heritage over RENATA: Museum of Gold Case, and the creation of the Colombian Digital Library.

The first features the participation of the University of the Andes, the Bank of the Republic, the National University of Colombia (Manizales branch), the University of Alberta (Canada) and the Republic's Museum of Gold.

This last museum has a historical collection of incalculable economic value. There are few researchers who have access to pieces for study; visits are limited and carried out under supervision in order to ensure conservation, as the current interest exceeds the Museum's attention capacities. This limiting factor became an opportunity to show virtually the collections in detail, making use of the RENATA advanced network and the new technologies for information retrieval, interaction and visualization.

To visualise and interact with three-dimensional reproduction of pieces selected from the Museum's collection implies the possession of a haptic system, which makes it possible to "touch" the digitalised pieces, while the personal 3D system makes it possible to see them more realistically. To do this with the actual pieces is practically impossible, given the access restrictions that the Museum must enforce.

The current mechanisms of 3D information retrieval work relatively well under controlled conditions and for a certain type of materials, in general opaque and smooth ones. The Museum's gold ware pieces are a problem to be solved.

The long-tem objective is that information can be accessed from international high-speed networks and, temporarily, from a spot located in the Museum's Interactive Room. When a system 's customer logs in and requests services, the server analyses the user's permissions, as well as the visualisation and interaction capacities of the workstation where he/she is located, and sends the corresponding information.

The advanced network RENATA is fundamental to facilitate the interaction with pieces. The high-quality representation of an object can demand a significant volume of information in the server (gigabits) and its distribution requires having an acceptable and reliable bandwidth to ensure a smooth and continuous interaction.

In the second project, the creation of the "Colombian Digital Library", there are 14 participating universities since 2007. The aim is to incorporate digital repositories or libraries to provide access and visibility to the contents from the national academic and scientific production.

Today there is a large number of scattered digital documents on the internet, without a suitable classification, unavailable for the external community and without relevance for education and research communities. This is why it is important to have a suitable organisation and structure of digitalised information which enables users to quickly and directly access the information they want.

The existence of digital libraries in not something new, but the Colombian initiative's contribution is the creation of a cooperation community or network, which until now did not exist in Colombia. That network must develop the basic platforms and infrastructures for repositories, internally and externally, in order to share contents scattered across the network, as well as promoting basic and advanced research on digital libraries in the country.

Although the RENATA network's infrastructure helps interconnect higher education institutions and research centres, there are no efficient mechanisms to create regional, national and international communities. This is why the project's interoperability is fundamental to communicate, share and exchange digital objects, metadata, services, security and knowledge in a fast, effective and consistent way, under the open access modality.

International Potato Centre

One area where the use of advanced networks has become compulsory is genomics, since the initiatives that aim to protect the phylogenetic heritage of countries are increasingly more relevant for its future sustainability and demand a huge computing capacity.

In Latin America, the Potato International Center, CIP, in Peru, implemented a High-performance computing (HPC) systems network dedicated to advances in molecular biology and biotechnology upon the basis of germplasm crops and information and bioinformatics systems.

The data are available for scientists and partners who collaborated in the Global Generation Challenge Programme (PCG) for them to contribute from different centres and locations.

The objective is to use phytogenetic diversity, advanced genomic science and compared biology to design and test tools and technologies which help produce better varieties of crops to be used by low income farmers. This represents a contribution to the emergence of new crops and to bridging the underdevelopment gap.

CIP has its head office in Lima, from where it can manage, thanks to its connectivity to the Peruvian advanced network RAAP, a RedCLARA member, an HPC system which enables collaboration between different researchers and partners in the Generation Challenge Programme by the Consultancy Group for International Agricultural Research (CGIAR).

Central America: Opportunity for la Education

In countries like Guatemala, El Salvador, Honduras and Nicaragua, the development of Science and Technology is lesser due to their reduced critical mass of researchers. In spite of this, in Guatemala a project has been started together with the Maracaibo Scientific Modelling Centre, Venezuela, in order to model the behaviour of forest fires according to weather conditions. The country is also cooperating in a European Union project to detect malaria in foetuses.

As indicated by the researcher Luis Furlán, one of the responsible for the Guatemalan network RAGIE: “Within our region I have always thought that the network’s main use will be in the field of education”. This leads to the organisation of distance courses by foreign or local professors at both undergraduate and postgraduate level, thesis defense and use of videoconference, which encourage cross-cultural communication between schools.

It is clear that education is an area where a great opportunity is available. As stated by Furlán: “Another potential use that we find very attractive is the development of postgraduate programmes by establishing alliances between multiple universities across the region”.

This vision is also reinforced from El Salvador by Rafael Ibarra, Director of RAICES, the country’s National Research and Education Network. He highlights the role played by these tools to coordinate joint projects, facilitate thesis work and distance lessons, where they can take advantage of the participation of foreign academics.

3.5 KEY AREAS

In the European case, advanced networks try to cover all areas of knowledge by showing their usefulness for all research communities. But we cannot forget the critical mass of researchers that these nations have and the governmental support provided in the field of public policy.

In Latin America, there is a discourse based on the offer and which aims to cover all areas of knowledge. However, its level of critical mass –with the exception of a few countries- makes it difficult to achieve a very high level of specialisation.

Therefore, it is necessary to define priority areas on which to focus the efforts by the local nodes, or wonder what these areas are, since the list of interests detected does not make it possible to articulate one single priority which brings together part of the joint work and determines a visible impact at a social scale and in decision makers. In fact, the answers are not simple for various reasons.

The region, as indicated above, has not made any explicit declarations supporting advanced networks as public policy instruments in ICT, as opposed to developed nations. It has not defined priorities for these networks, either.

However, the current scientific policy in all Latin American countries aims to maintain a support base in all areas of knowledge, alongside bets on key sectors where countries have possible comparative advantages in a globalised environment, or they respond to social needs where there is an articulated consensus, beyond the political alternatives of the specific governments in power.

Another great opportunity is the emphasis given to innovation in Latin America and the Caribbean. The challenge indicates that innovation takes place in the market, while the S&T structure in the region is not strong in the field of entrepreneurial innovation. This is another motivation to revaluate networks' membership to achieve a closer relation with innovative companies.

It is possible, from another angle, to conclude that all applications are "applicable" in the continent. The key issue is the need for priorities which can be identified from specific angles:

- To show, in a continent with great inequalities, that investments on R&D lead to solutions that improve the quality of life and strengthen development in a wider sense.

- To articulate a common discourse in those areas which appear as natural candidates to show their impact on the solution of social challenges.

- To introduce a common framework where all countries can cooperate, given the similar problems and various strengths, within a collaborative scheme.

- To support decision-makers in universities and governments to sustain hallmark projects which offer an applicable and supportable alternative to face social demands.

- To present and articulate a coherent discourse based on reality, which facilitates cooperation with developed countries in a more egalitarian relation and focusing on the needs detected.

> The analysis of documents, the need for social answers, and the interviews conducted show that there are some areas that can focus on common initiatives in the region in order to actively collaborate with international peers.

In turn, the people responsible for advanced networks have mentioned the importance of videoconferences as an intensely used tool which shows the network's potential. From the technical viewpoint, they mentioned grid or IPv6 projects; and when asked about the priority areas or the projects they should undertake they reached a consensus: health (telemedicine), education and climate change (and/or natural disasters), followed by culture, in a wide sense, agriculture and/or biotechnology.

This identification of priorities is consistent with the priorities defined by the governments in the region (health and education); it is also linked to outlooks on changing the productive development pattern (natural projects aimed to be exported and/or promises of biotechnology, effects of climate change, energy efficiency), and makes sense at involving the role of the Nation State (disasters prevention or mitigation, maintaining identity).

Because of this, the comparative benefits are included within a more reduced list which is still wide but proposes some emphases to concentrate articulation efforts:

- Global Change: involves projects like climate change modelling, disasters monitoring and prevention (for example, deforestation and the El Niño-Southern Oscillation phenomenon, among others).

- Health-Telemedicine: from advanced systems based on remote operations, R&D hospital networks, regional diseases, to online attention in rural communities. The region's needs, in this regard, determine the agenda.

- Agriculture (Biotechnology-Genomics): focusing on the national protection of the native or high-impact varieties, such as natural products (and even active principles) aimed to be exported.

- Education: understood as e-Learning in the field of higher education, due to the increasing internationalisation of collaborative platforms and tools, which also cover technical-professional and secondary education.

- Cultural heritage and knowledge: in two dimensions: a) digitalisation of collections and cultural heritage and b) emphasis on the social dimension of knowledge (systems to access national and international information with equitable and modern mechanisms).

Furthermore, the selection of five key areas is based on the following analysis:

1. ICT can be a separate sector or represent technologies cutting cross all sectors of economic activity. Except in some cases, in Latin America ICT still have not become drivers of economic activities. A regional hardware or software industry that can compete at a global scale with emerging nations in Asia (which represent a comparable parameter) has not been consolidated yet.

2. In the field of advanced networks, rather than a priority area, ICT are enabling technologies as a concept (bases for e-Science) or a set of services that facilitate research and collaboration challenges to solve demands or participate within the global environment of scientific cooperation[22].

22 In this document, advanced networks' technical details have not been discussed in detail in favour of

3. From the analysis made about developed countries, it appears that priority applications cover all areas of knowledge. There is also a vision to "show" their impact on social challenges to justify the high investments.

4. This offers an extensive range of areas, but, how is this supported in the region? The majority of national scientific policy documents do not assign a role to advanced networks as articulators of the R&D priorities defined. In fact, it is difficult to find a regional common denominator regarding priorities by area. The agenda, if there is one, is so wide that it does not achieve a sense of purpose. For example, there are historically strong articulations in biotechnology between Argentina and Brazil; manufacture or ICT in some countries in the Southern Cone, agriculture in Central America, and astronomy in Chile, given the proximity to observatories. But again, is it possible to speak about common priority areas from Mexico to Patagonia?

5. Despite all this, there are some basic agreements articulated over the last decade, which make it possible to take a turn in the context of CLARA and Latin American advanced networks in order to set emphases. These are:

a) The region is still a commodities exporter. Under the current model, its challenge is to add value to its exports in order to compete within a global market. Beyond all appreciations, the predominant model is aimed at the incorporation of economies into globalisation. This is why the exports that are given priority are, in general terms, agricultural, PECUARIOS and forestry products or raw materials. There are certainly some exceptions, such as manufactures in Mexico and Brazil, efforts in Chile in the area of global services; instrumentation in medium-sized countries; policies aimed, in some countries, at a greater alimentary self-sufficiency or greater productive complexity given the huge local market (Brazil, Mexico or Argentina). However, within the regional picture there is no single actor that is an "Asian tiger" in high technology, the new India or the Latin Silicon Valley in software exports.

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articulating more strategic agendas.

b) There is consensus in viewing education as the road towards greater development and as a mandate that stems from the social inequalities present in Latin America. It is not only necessary to strengthen excellence universities which can compete on an equal basis within the world of scientific production, but also to increase the coverage and quality of primary, secondary and technical education. In relation to the above, a basic social welfare grid requires a coverage and quality of health that must range from basic healthcare services and models to excellence in technology to offer equality and state-of-the-art opportunities.

c) A model based on natural resources depends on the visible challenge of climate change. It consists not only in addressing historic natural disasters like earthquakes, floods, hurricanes and society's poor responses. Climate change imposes research on the causes and their consequences, intervention models, forecasting, a more efficient use of natural resources and the search for new energy sources. Understanding how climate is modified and the consequences has an impact on the life conditions of millions of people.

Each country may have national priorities (for example mining and aquaculture in Chile, oil in Venezuela, bio-fuels and nanotechnologies in Brazil); but these big areas can represent the minimum common denominator from where to bring countries together.

Projects in these areas will enable universities, governments and the entire population to see concrete results, even if under a long-term vision, regarding the position and importance of having these infrastructures. They are pressing needs which require critical mass, offer long-term solutions and make it possible to get connected to the best international experience and advances.

The good news is that there are hallmark networking projects in the region which are aimed exactly along these lines, and which have been included in this document as illustrative cases which shed light on the diversity of outlooks to address a challenge.

3.6 FACTORS TO BE STRENGTHENED

Finally, there is a set of factors which must be strengthened so that advanced networks are consolidated as a research environment and are involved in long-term collaborative projects, with a social and regional impact.

3.6.1. The technological factor

It is imperative for the region to have the negotiation power achieved through fibre ownership. The TASK of networks (capitalised) is to connect the capital cities in Brazil, Argentina, Chile, Peru and ideally Colombia and Venezuela. Thus, national networks can focus on territorial expansion and the national and international articulation of their communities.

It is fundamental to find Mexico's connection alternative, which is articulated with Central America (Regional Backbone). Its culture has historically shown a great level of collaboration in the field of higher education and could be one of the discourse strands.

Finally, if the national advanced network wants to become a useful tool, it is necessary to review the local connection's state of the art, and to carry out bandwidth extensions which fit in with the projected needs.

Fibre ownership, finally, is not only a matter of negotiation. It is a technological validity requirement, since it is possible to experiment with new technologies which are used in this network's ends, to thus become a "test field" for new services which could not be deployed by the private enterprise.

3.6.2 The articulator and political role

The region would benefit from the active collaboration with Brazil, which is a driving force at a regional level. Its leadership in research cannot be questioned and its role in supporting the other countries is well established.

It is necessary to move forward from the current rhetorical support to the formulation of public policies and the allocation of financial resources which are sustained over time. This legitimacy makes it possible to better undertake large-scale projects under the certainty provided by the long-term vision. We cannot expect a regional body to assume this task in the short term; the States are summoned to play this role.

Advanced networks in the region must soon open up to the private R&D world and to bodies like hospitals and research centres, as well as to productive collaboration with the school world and culture. This is their political legitimacy within a region where public resources are limited and innovation's participation in science and technology activities is promoted.

It is clear that in order to sustain public support it is necessary to have more projects which firmly show the network's social power to solve the region's extended problems and challenges. For most people, gigabits mean very little. Networks speak more eloquently when they host projects which promote and consolidate higher education, model climate change, prevent and monitor natural disasters, identify native species' genomes and their applications, expand medicine in all its forms to all the country's regions, make their cultural heritage become part of the world and promote egalitarian access to public and scientific information.

This does not mean that research on computer science as such must be left aside. The idea is to aim at the essential: clear and hallmark projects which show the dynamic role of networks and international collaboration in addressing issues related to competitiveness, the quality of life and future of the population in countries still experiencing acute social inequalities.

IV. Conclusions

What society demands today from its National Science, Technology and Innovation Systems is enormously more challenging because the results and products must pass a new exam: its transference into society as solutions which improve the quality of life of the population that funds these efforts.

What are the future tendencies of advanced networks?

Due to economic and technical reasons, advanced networks will be the first promoters or "industry" to decide to "own" dark fibre and illuminate it with the equipment which represents the state of the art. They will become a laboratory more powerful than the future distributed telecommunications system. A telecommunications system where the owners are not traditional operators, but advanced networks, and where users will define their "last mile" and the services they want.

How can it be measured? How can it reach remote places combining fibre and wireless technologies? Which on-demand bandwidth mechanisms will be appropriate? The answers will come from those same communities.

The strongest networks will be those which align their objectives with the country's scientific policy. The free-flowing dialogue with the people in charge of materializing the Knowledge Society must lead to the stable funding of the advanced networks' operation or infrastructure so that they become the platforms which enable state-of-the-art R&D.

Here discourse is not only about "demand". Governments and scientific policy can find in CLARA and ally and an articulator which promotes projects at a regional scale with lessons for the whole continent. Actual practice shows successful models and mechanisms for scientific collaboration to show development ways and illustrate policies to be reinforced between countries.

We live in a world of data and this scenario will grow vertiginously with sensors in all areas. Each sensor is a piece of data and all of them must be managed, retrieved and visualised. It is more than feasible that a global effort with hundreds of researchers will move from a basic research to key problems of the future which have public policy implications. And these are: global change modelling, genomics, health disasters prevention and mitigation, educational and cultural heritage and energy.

Each one of these areas will have related challenges, but out of the endless number of priorities, social pressures will come from very precise nodes. They are global challenges with local particularities. And here advanced networks must be conceptualised as “cross-cutting platforms”. Their future incorporation is seen in a faster internet, which is more collaborative for its actors. But at some point, from another perspective, they will be transparent. Public motorways required for R&D to simply provide the answer to concrete problems.

And in this point new lessons and challenges can be appreciated:

- The mere call for proposals or grant funds without a vision and collaboration requirements which produce synergies does not lead to efforts sustained over time, with the desired impacts or to national infrastructures.

- A network that does not produce network externalities; that is to say, a network that does not have full membership of its whole community, has legitimacy problems to access national funding.

- From the university sector the pressure comes from the most active users who require these facilities. Although it is part of universities’ priorities, it is probable that their promoters are the institutions devoted to research. In turn, the simple fact of a globalised education puts them in a scenario of massive use of videoconferences and collaborative systems for education.

- The private sector is a driver for R&D in developed countries. This is why networks have made their use policies more flexible in order to incorporate other actors.

- With the help of their governments, public hospitals will increasingly be key actors, given the needs for telemedicine in all its various manifestations in all countries.

- Finally, in education the tendency foreseen would indicate that this network's models and lessons are transferred into that sector. The connectivity level and degree of collaboration with advanced networks will strongly depend on the educational policies of each government or State.

What is the conclusion?

A sort of new telecommunications operator, with an identity driven towards its customers, which tests what will be an internet for wider sectors of the population within five or ten years. That is its historical mission: to indicate and open up new roads for technologies that will be subsequently transferred to the commercial sector.

In Latin America, CLARA represents the articulation of local advanced networks to favour theirs creation as a regional environment for collaboration. Its management capacity has already been proved in its promoting the creation of local networks in at least six countries in the region, its technical capacity and counterpart relation with Europe, and its effort to make advanced networks visible and explore possibilities for use between scientific communities.

The task is not free from challenges: CLARA must combine technical expertise to keep the network on the technological frontier with a convening capacity to build and maintain an increasingly extended user community. These are two different skills which require local counterparts aligned with this twofold objective and with implementation capacities in these two areas.

We live in a region of disparate countries. The institutional heterogeneity under which the CLARA Management works is a reflection of the above, but it is not an insurmountable condition. In fact, CLARA operates within the context of a continent characterized by that heterogeneity, which is reflected on the structure of several regional institutions. As opposed to developed nations, there is no explicit support policy for advanced networks as enabling R&D infrastructures in public documents in this area. It is true that there are exceptions, but these are a minority.

No regional body has adopted a long-term outlook aiming at its communities' integration through advanced networks, as a consistent discourse validated by financial support. This is better appreciated in IBD and OAS R&D projects, but not in the strategies of other bodies or more political forums.

This lack is also the opportunity for regional bodies to adopt a stance about them. In this situation, it becomes necessary to consolidate an infrastructure of advanced networks interconnected to each other and to the world's major advanced networks as a heritage and as a regional public asset that must be duly safeguarded by countries trough ensuring their use, sustainability and impact on the quality of life improvement for the inhabitants of Latin America.

The interests of science and the potential for international collaboration cover all areas, but the incorporation of advanced networks in the region must take place within a specific context in order to ensure its relevance and feasibility as an enabling infrastructure.

Today, public policies, in different areas, aim at a mid-term in which to establish an economy with a strong growth component that results in an acceleration of economic growth, environmentally-wise, with significant reduction of the poverty gaps and inequalities in terms of income distribution, and with the resulting increase in social cohesion and equity.

There are four elements to be taken into account. First, the emphasis on innovation policies in the region. The challenge lies in the fact that innovation takes place in the market while science and technology structure in the region is not strong in the field of entrepreneurial innovation.

In the second place, there still inequalities and social demands which expect from national investments –and research itself- visible solutions on the application of knowledge.

Thirdly, the region has adopted a model where its strategy aims at adding value to its exports based on knowledge in order to improve its relative position within globalisation's phenomena.

Finally, there are inequalities regarding the critical mass of researchers, the size of their markets and ICT institutional structure.

All of the above leads to move discourse towards the field where scientific and technological research capacities, social needs and the challenges stemming from the movement towards the so-called Knowledge Society come together.

Therefore, the strategy aims at defining some priority areas which engage advanced networks' collaboration and visibility from various areas. This is supported by these areas' potential to articulate projects where many actors can collaborate from their individual specializations, and where it is possible to take big leaps which provide a legitimacy argument in the face of social challenges included in the public policy discourse.

These priority areas, discussed in detail in section 3.5 of this document, are:

- Agriculture (Biotechnology-Genomics).
- Health-Telemedicine
- Education (e-Learning).
- Global Change.
- Cultural heritage and knowledge.

This is where ICT appear as cross-cutting technologies present across all sectors of economic activities and which facilitate research and collaboration challenges to solve demands or to participate within the global environment of scientific cooperation. More specifically, grids, semantic web, optical networks, data mining, network security, modelling, high-performance computing, virtual reality, are beginning to offer a concrete discourse on the needs and as tools for applied research.

A remarkable aspect is that both in developed countries and in the region there are specific projects which already address these demands and also strong experiences in the incorporation of advanced networks as part of basic infrastructures for scientific and technological research (mainly Brazil, Mexico and Colombia). The first two countries stand out because of their size and historical tradition and, in the case of Brazil, an explicit political articulation which offers coverage for projects at a national scale. Colombia stands out because of the sustained progress from the point of view of an institutional structure and the articulation with its user communities.

In these cases, the local node is not only seen as a technical agent, but also as an entity capable of articulating and organise intentions, which has dialogue and lobbying capacities with decision makers in the political sphere and has managed to use the network for the execution of projects which are not only paradigmatic because of their technical deployment, but also because they are inclusive, participative and with applicable results and products.

This is relevant since a significant part of the projects that today make use of grid infrastructures, for example, have been proposed by European counterparts, but their results are applicable at a local scale. That kind of efforts cannot continue to be the capital of local institutions and a national framework where to include them is required. Otherwise, they run the risk of not transcending or not achieving the desired impact.

The persistent message in this analysis is that incremental leaps are not easy to achieve. But public policy does play a role in slowing down or speeding up certain developments. In the same way we have seen key advances in Colombia, it is reasonable to think that Chile and Argentina may have improved their relative position from 20 years ago if they would have received a more consistent institutional support.

This heterogeneity leads to think in a differentiated incorporation strategy in decision-making bodies and stakeholders in each local node. The appropriate characterisation of each country's situation should serve as an element to outline relevant strategies to strengthen local clusters, empower their managing staff and achieve public visibility (which implies bridging the abyss between political rhetoric and public management practice).

In the public policy's priority agenda of some countries with severe deficiencies there are issues which need to be so urgently solved that, in this point, it is necessary to review the advanced network's perspective. Once again, the differentiated incorporation strategy continues to be valid insofar as the advanced network must be established as a valuable resource for the political authority's agenda priorities, rather than a restricted space for elite scientists.

This reinforces the definitions of wide priorities which make sense to for the political authorities as a national answer and the possibility to take incremental leaps offered by collaboration.

It is fundamental to bear in mind, as explained above, that almost all advanced networks are governed by non profit institutions, which gives them a flexibility and dynamism which, if combined with a strong national public support in terms of membership and funding, would turn them into even more powerful instruments for their nations' development.

As a conclusion, there is a set of specific actions to be undertaken in order to consolidate this infrastructure:

To include in each country's ICT agenda the role of advanced networks as basic infrastructures

This implies ensuring funding which, even if lesser, is consistent over time. This is a political fact that provides legitimacy and, in the end, can be more relevant a support, because of a declaration by political authorities at an international meeting. The latter is important and favours the former, but local validation through a budget line allows for a wider horizon which goes beyond the current government in power.

Define priorities for each advanced network

A national infrastructure which articulates technology, projects, training, deployment, e-Science promotion, or a small cluster with high quality of services, specialised in one focus: top-level national and international connectivity. In this case, the dynamic use must be produced by other actors (universities, enterprises, regions, government).

A more inclusive public discourse

A not less important issue is the relevance of the research making use of advanced networks and their characterisation, since it is clear that the scientific discourse is not good for disseminating results under the political logics. A dissemination effort is pending when there is such small public presence of the work done by advanced networks.

This implies developing a “public discourse” which is more closely related to the social needs that the advanced network could satisfy, and leave aside the technical “jargon” which eventually isolates the local node’s efforts, or restricts them to the understanding of an “elite” audience.

Populate the advanced network with validated and hallmark R&D projects

This requires actions on national grants that fund research projects in science and technology. All Latin American countries have these grants as tools for allocating resources through competitions. An affirmative discrimination policy which favours the use of advanced networks in research projects could be the alternative. In the second place, specific funding for projects which make use of advanced networks with specific characteristics: priority areas, international collaboration, impact measurement, brief evaluations and implementation timescales. The experiences of Colombia and Ecuador support this alternative.

Extend membership

The local entities which run the national networks must restudy their membership and service policies in order to develop national infrastructures of advanced networks services, with minimal incorporation restrictions, reduced operation costs and services designed to satisfy the specific requirements of end users. This aggressive membership extension policy requires not only covering the entire university sector, but also opening up advanced networks to government agencies and independent research centres, productive collaboration with the school and cultural worlds and innovative companies. The region demands in its policies a greater effort from the private R&D sector, which requires a real opening towards that sector. Taking a scalar rather than an incremental leap implies rethinking networks as national infrastructures for science and technology and not as an exclusive resource of university and institutions that are currently members. This is their political legitimacy in a region where public resources are limited and innovation's participation in science and technology activities is encouraged.

Revaluate the relationship with telecommunications providers

Except in some cases, it has not been a fruitful relationship and usually advanced networks have been seen almost competitors. This entails the survival mandate of having dark fibre as a strategic asset and cooperating on a more egalitarian relationship.

The above requires directing their high-speed technology advances towards outlooks aiming to take real bandwidth solutions to wide sectors. This is the area where technology becomes visible, offers ways and examples, and provides political legitimacy. Advanced networks, through their fibre's empowerment, can be hallmark cases to show governments feasible alternatives of making their bandwidth dreams come true.

Santiago de Chile, November 2009.

Appendix: Brief status of the networks connected to RedCLARA

Country: Argentina
Network's name: Innova|Red
Website: www.innova-red.net

Description: Innova|Red is the Argentinean national network that replaced RETINA (Academic Tele-Informatics Network), which operated from 1990 to 2006 and was administrated by the Ciencia Hoy (Science Today) civil association. In March 2001 it ran the RETINA2 project for access to Internet2 and advanced academic networks and promoted the development of these networks in Argentina.

In December 2006, an agreement was signed between the Nation's Communications Secretariat (SECOM), the Science, Technology and Productive Innovation Secretariat (SECYT) and the National Council for Scientific and Technical Research (CONICET). This agreement aimed to get the INNOVA-Tec Foundation (Non-governmental organisation created in 1993 by CONICET within the context of the Law n. 23.877) to manage the international connection with the advanced networks system and to take over the national operation of this connection as part of the project called Innova|Red.

To date, 42 universities and higher education institutions, eight national research laboratories and five governmental agencies are part of Innova|Red.

Country: Brazil
Network's name: National Research and Education Network / RNP
Website: www.rnp.br

Description: The National Research and Education Network (Rede Nacional de Ensino e Pesquisa, RNP) is the Brazilian advanced network infrastructure for collaboration and communication in education and research.

It is administrated by the RNP Association, a private non-profit organisation created in 1999 upon completion of the RNP project, created in 1989 by the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq). In 2002, the RNP Association was qualified by the federal government as a social organisation.

Today the network connects nearly 600 institutions, including practically all research units and higher education public institutions in Brazil, as well as other public and private education and research organisations like universities, technical schools from the Ministry of Education, hospitals and institutions which promote research.

Country: Chile
Network's name: National University Network / REUNA
Website: www.reuna.cl

Description: The National University Network, REUNA, is administrated by a private law non-profit corporation. It was created in 1992, following the existence of the first university network connected to internet since 1986. In 1998 it became REUNA2, the first high-speed network in Latin America. In August 2000, advanced academic networks were incorporated through the connection to Internet2.

REUNA's mission is articulated in a twofold purpose; to develop, operate and administrate the national advanced network and design, promote and support R&D project management. To date, REUNA has obtained funding for more than 30 national and international collaborative projects and the elaboration and implementation of projects using the advanced network is one of the services that the Corporation delivers to its members.

Country: Colombia
Network's name: National Academic Network for Adavced Technology / RENATA
Website: www.renata.edu.co

Description: In Colombia, the advanced network is administrated by the National Academic Network for Advanced Technology Corporation, RENATA, a non-profit entity, with legal personality and mixed participation, whose objective is to promote the development of the high-speed network's infrastructure and services, its use and incorporation, as well as articulating and facilitating actions to carry out education, innovation and science and technology projects.

Furthermore, RENATA promotes the development of new projects which make an extensive use of the advanced network, such as the Digital Library project, and the organisation of training activities for human resources, development of local and international seminars, courses or events on issues related to advanced networks and their incorporation.

There are three government agencies involved in RENATA: the Ministry of Communications, the Ministry of Education and the Science, Technology and Innovation Administrative Department, COLCIENCIAS. Although RENATA is a non-profit entity, it receives governmental funding and operates in COLCIENCIAS facilities.

Country: Ecuador
Network's name: Ecuadorean Consortium for Advanced Internet Development / CEDIA
Website: www.cedia.org.ec

Description: The Ecuadorean Consortium for Advanced Internet Development Foundation, CEDIA, was born in September 2002 with the creation of the consortium at the Governmental Palace in Quito. In its creation initially seven higher education institutions participated, as well as two public entities, and two scientific research and development institutions. In January 2003, the Ministry of Education and Culture approved its statues.

The network's first version began to operate in January 2005, based on a backbone which covered six provinces in Ecuador.

Country: El Salvador
Network's name: Salvadorean Research, Science and Education Advanced Network / RAICES
Website: www.raices.org.sv

Description: RAICES is a non-profit private organization created in 2004, which brings together seven Salvadorian higher education institutions.

Its objectives include to promote and coordinate the development of telecommunications and computing networks, aimed at scientific, educational and research development in El Salvador, and to promote the development of new applications which are useful for the academic community and the country, and which make use of advanced networks technology.

Country: Guatemala
Network's name: Guatemalan Advanced Network for Research and Education / RAGIE
Website: www.ragie.org.gt

Description: The Guatemalan Advanced Network for Research and Education is a non-profit civil association constituted by universities, research institutions and other institutions devoted to research and education, which develops projects for the achievement of its purposes through networks and telecommunications exploitation.

Its current members include seven universities and one telecommunications company.

Country: México
Network's name: University Corporation for Internet Development / CUDI
Website: www.cudi.edu.mx

Description: The University Corporation for Internet Development (CUDI) is a non-profit private association founded in April 1999 and constituted by Mexican universities.

Its mission is to promote and coordinate the development of a telecommunications network of the most advanced technology and wide capacity, focusing on scientific and educational development in Mexico.

CUDI is the entity that manages the advanced network project in Mexico and aims to encourage the development of applications which make use of this network by promoting collaboration in research and education projects between its 222 member institutions, which include universities, institutions, research centres and international bodies.

Country: Panama
Network's name: Scientific and Technological Network / RedCyT
Website: Does not have an active website.

Description: REDCYT (Scientific and Technological Network) is a non-profit foundation with academic bases, created in September 2002, whose purpose is to promote the development of the country's s scientific and technological interest. REDCYT also represents the physical network that will join research and higher education institutions and provide them with access to information and new applications.

Country: Peru
Network's name: Peruvian Academic Network / RAAP
Website: http://www.raap.org.pe/

The Peruvian Academic Network (RAAP) was created in April 2003. It is a non-profit civil association sponsored by the National Science and Technology Council, CONCYTEC, and the participation of different public and private institutions.

Its mission is to promote scientific and technological research, relations between researchers and research centres and the exchange of knowledge in these areas, through the intensive use of information and communication technologies, and the use of new internet technologies.

Country: Uruguay
Network's name: Uruguayan Academic Network/ RAU
Website: www.rau.edu.uy/redavanzada

Description: The Uruguayan Academic Network (RAU) is an initiative by the University of the Republic, administrated by the University's Central Informatics Service (SeCIU), which operates since 1988. It brings together the faculties, schools and services of the University, as well as other higher education and research entities in the country.

RAU aims to become an integration, communication and discussion environment at the service of the objectives of education, research and society's transformations.

Country: Venezuela
Network's name: Academic Network of National Research Centres and Universities / REACCIUN
Website: www.cenit.gob.ve

The National Technological Innovation Centre (CENIT) is a foundation belonging to the Ministry of Popular Power for Science and Technology (MPPCT), created through a presidential bill on April 17th, 2006. Its objective is research, development and innovation in the area of communication and information technologies, depending on the needs of the country's socio-productive model. Since 2007 this entity administrates REACCIUN, Academic Network of National Research Centres and Universities.

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