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Integrating Latin American and European Research and Education Networks through the ALICE project.

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Abstract

The ALICE (América Latina Interconectada Con Europa) project is being jointly funded by the European Union and the national research and education networks (NRENs) of 18 Latin American countries. It has as an objective the interconnection of the Latin American NRENs by means of a regional backbone network and the establishment of a direct Internet connection between this backbone and the pan-European backbone network, GÉANT. The talk describes the previous experiences of providing international research and education networking connectivity both in Europe and Latin America, and presents key characteristics of the future network and of the CLARA (Cooperación Latino Americana de Redes Avanzadas) organisation, the recently created association of Latin American NRENs.

Keywords: Internet, International connectivity, Latin America, ALICE project, CLARA, DANTE, GÉANT

1 Introduction

Until the middle of the 1980s, because of the relatively high cost of telecommunications services, computer networking carried out by the research and education (R&E) community was usually geographically confined to metropolitan distances, or, at a pinch, within the limits of a single national state. International networking was extremely expensive and thought to be difficult to justify. Then, within the space of a very few years, not only has international networking become extremely common, but it has come to be recognised as an essential part of the infrastructure required to support everyday activities within this community, easily supplanting all competing forms of communication, due to its speed, flexibility and *low* cost.

In this article we shall discuss something of the history of how R&E networking has developed in Latin America from the time of the first connections to e-mail networks, such as UUCP and BITNET, to the present age of the global R&E advanced networking community (Internet2). After discussing the particular state of European networking, we go on to present the ALICE project, currently underway, to provide for the first time new international connectivity within Latin America, and between this region and Europe.

In this article, the countries we are concerned with in Latin America are Argentina (AR), Bolivia (BO), Brazil (BR), Chile (CL), Colombia (CO), Costa Rica CR), Cuba (CU), Ecuador (EC), El Salvador (SV), Guatemala (GT), Honduras (HN), Mexico (MX), Nicaragua (NI), Panama (PA), Paraguay (PY), Peru (PE), Uruguay (UY) and Venezuela (VE).

The structure of this paper is as follows: in section 2 we present a brief history of the evolution of R&E networking in Latin America, and some of the challenges and opportunities currently available. In section 3, the history of pan-European R&E networking and the role of DANTE are described. In section 4, the development of the ALICE project is presented, and in section 5 some conclusions are drawn.

2 A Brief History of Research and Education Networking in Latin America

2.1 The beginning: from BITNET and UUCP to the Internet

Although the first successful long distance network was based on what would become Internet technology, this technology only became widely used after 1985, with the creation of the NSFNET in the USA. The first widely used long-distance networking technologies were BITNET and UUCP, both of which supported low-speed connections up to 9600 bps) and little more than e-mail services. However, as was quickly discovered, the only classes of service not found in these e-mail networks were interactive or real-time applications. For these, Internet technology provided a general solution, usually at a higher cost, because of the requirements of greater bandwidth, or because of the need of specialised routing equipment.

Within Latin America we thus can observe the same general pattern of development of networking services, beginning with e-mail networks, such as BITNET and UUCP, and migrating to IP networking some time afterwards. The only real difference between different countries tends to be when this process starts. In the specific case of the 18 countries in Latin America of interest to us here, the first e-mail networks were installed between 1986 and 1994, being followed by IP networks between 1989 and 1996 (see Table 1).

	MX	CL	BR	NI	UY	PY	VE	AR	CR	CO	EC	PE	BO	CU	PA	GT	SV	HN
email	86	86	88	88	88	89	90	90	90	90	91	91	91	91	92	92	94	
IP	89	92	91	94	94	95	92	93	93	94	92	94	95	96	94	95	96	95

Table 1: Year of introduction of international connectivity for e-mail (BITNET/UUCP) and IP networks

The other characteristic we can observe is that it is extremely uncommon for these R&E networks to develop in isolation, without international connectivity. Typically, the *first* networking connection is usually an international connection to a global network. Only when this connection has been established is there any incentive to link to other, national, partners, and then mainly to share the high costs of international connections. (However, it is known that in the case of Honduras (HN), there was an existing national e-mail network, based on UUCP, which only acquired international connectivity when that country obtained IP connectivity in 1995.)

2.2 Telecommunications infrastructure

Computer networks are naturally based on existing telecommunications infrastructure. The very first connections of the e-mail networks would make use of whatever infrastructure was available for voice networks, either as dialled circuits for UUCP, or dedicated circuits in the case of BITNET and IP. In the 1980s, this meant the use of existing metallic cables, or the then increasingly popular geosynchronous communications satellites, essential for higher bandwidth connections. Geosynchronous satellite communications have certain interesting properties. For instance, point-to-point link costs are independent of geographical distance within the footprint of the satellite's coverage, and, as a consequence, there is no incentive to use short-distance links, if greater functionality can be obtained from longer links. In particular, the most robust topology for an access network is a star centred on the most appropriate connection point. This has naturally led to most Latin American countries acquiring direct satellite links to the USA, rather than to neighbouring countries, as in the RedHUCyT programme supported by the Organisation of American States (OAS), which led many NRENs to connect to the NSFNET at the PanAmSat facility in Florida.

Another characteristic of geosynchronous satellite communication is the long end-to-end round-trip time, as a result of the long propagation delays on the space segment, around 240 ms per satellite hop. In consequence, all interactive applications are affected, and interactive voice communications are badly affected, since the space segment round-trip propagation delay alone exceeds the maximum tolerance recommended by the ITU. This last consequence essentially rules out geosynchronous satellite communication for telephony and videoconferencing applications.

These long-distance voice applications have now been made feasible, mainly due to enormous advances in telecommunications, specifically through the use of optical technologies, such as DWDM, for long-distance terrestrial transmission using fibre optic cables. In such cables the round-trip propagation delays are about 10ms/1000km, or 200ms for halfway round the world, as opposed to the 480 ms for the space segment of geosynchronous satellites. Thus this new medium is much more friendly to interactive voice communication, due to low round-trip delays.

Additionally, the available bandwidth is very great and expansible, as the marginal cost of adding one more *lambda* is much smaller than laying the original cable and setting up the DWDM infrastructure. These optical transmission technologies have revolutionised the provision of long-distance telecommunications services, reducing final costs to a small fraction of prices only a few years ago. Figure 1 shows the evolution in prices of international bandwidth in Europe between 1996 and 2001. Please note that the vertical axis uses a logarithmic scale! The significance of this evolution in prices is two-fold. On the one hand it shows the almost unbelievable drop in prices per Mbps per year, but on the other hand it also shows the widening gap between average offer prices and lowest offer prices. Whereas you can find high-capacity wavelengths all across Western and Central Europe, bandwidth is still being rationed in North Eastern and South Eastern Europe. In relative terms, the digital divide in Europe has broadened since 1996.

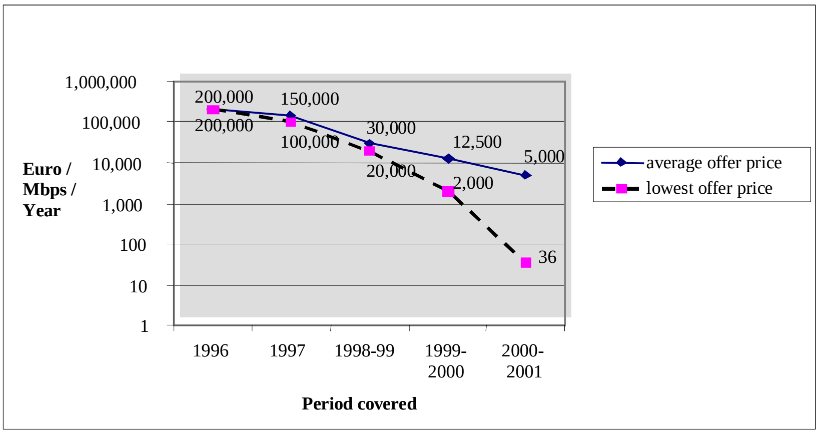

Figure 1: Development of Prices for International Bandwidth in Europe (source: DANTE)

Similar economies of scale also apply to long distance fibre optic communication using submarine cables. This is important for Latin America, as there has been considerable investment in this kind of telecommunications infrastructure since the late 1990s, with several separate cables laid around the South American continent, and along both the Pacific and Atlantic coastlines of Central America and Mexico.

2.3 The commercial Internet and its consequences for R&E networking

The Internet is such a good thing, that it has to be for everyone. At different stages during the 1990s the public, commercial or commodity Internet reached all countries in Latin America, with the exception of Cuba. In several countries of the region, such as Panama (PANNET), Peru (RCP) and Brazil (RNP), the existing NREN opened its doors to public use. (In the case of the RNP, this was the result of deliberate government policy, in order to encourage the diversification of the ISP marketplace, and lasted until 1998, when network returned to its original role as a pure NREN.

In yet other countries, the appearance of independent Internet Service Providers (ISPs) provided attractive and competitive rates for Internet connectivity, and the young NRENs in these countries lost their client institutions to this competition, and disappeared for the moment. By the end of the 1990s only a few structured NRENs continued to function in Latin America, namely those in Argentina (RETINA), Brazil (RNP), Chile (REUNA), Costa Rica (CRnet), Cuba (RedUniv), Mexico (CUDI), Uruguay (RAU) and Venezuela (REACCIUN). These have survived, either through the financial support of government, or by building a sustainable membership organisation to maintain the networking infrastructure and its operations.

2.4 Internet2 and the AMPATH project

In the USA, the development of the commodity Internet in the early 1990s led directly to the termination in 1995 of the government-funded NSFNET, the USA's NREN, leaving client R&E institutions to seek arrangements with commodity Internet providers. This situation caused some considerable discomfort to the R&E community in the USA, and as a direct result the Internet2 project was born in 1996, run by UCAID, a consortium of R&E institutions, with the significant participation of industrial partners. Internet2 was a project for a *advanced network*, based on IP technology, and connected to the global Internet. However, this advanced network was designed from the start to support applications which could not be used on the commodity Internet for its insufficiency of capacity or performance. In the USA, the Internet2 community built its own advanced network, known as Abilene.

The Internet2 example of building advanced networks has since been followed in several other parts of the world, notably in Canada, in several individual European countries and their interconnecting networks (see section 3, below), and even in Latin America, where a number of Internet2-inspired networks have been built. Of course, the state of the art is anything but static, and although all of these networks began in the mid 1990s with link speeds of at least 155 Mbps, the leading networks now use 10 Gbps links. These advanced networks are usually linked to one another at similar speeds, to form the global R&E advanced networking community infrastructure.

The AMPATH project has been developed since 1999 by the Florida International University (FIU) in collaboration with several private sector industrial partners. Its purpose is to interconnect the R&E networks in Latin America and the Caribbean to the Abilene network, and thus to the global R&E advanced networking community infrastructure in Miami. Connections are made using Global Crossing’s undersea optical-fibre network. Global Crossing has donated to AMPATH the use of ten DS3 (45 Mbps) circuits, and these are being provided, at no cost, to R&E networks in the region for three years in order to connect to Abilene. While the DS3s are cost-free, the participating R&E networks contribute financially to AMPATH to share the other associated costs.

The Global Crossing South-American fibre ring was only activated in 2001, and the donated AMPATH bandwidth only became available in July of that year. By 2003, Latin American networks served by the AMPATH project include REUNA (Chile), RNP and ANSP (Brazil), RETINA (Argentina) and REACCIUN (Venezuela).

3 A Brief History of Research and Education Networking in Europe

3.1 EuropaNET and TEN-34 (1992-1998)

The last two decades have witnessed an increasing demand for on-line communication between members of the research and education communities in Europe and globally. In most European countries National Research and Education Networks (NRENs) were set up in the 80s to satisfy the demand for rapid data exchange nationally. Just as today in Latin America, however, high-bandwidth connectivity across the whole of Europe was missing for a long time.

In 1993, a number of European NRENs established DANTE – Delivery of Advanced Network Technology to Europe. DANTE was founded to manage and build pan-European networking services on behalf of the European NRENs. The first step in this process was the creation of EuropaNET (1992-1997) which connected 18 European NRENs and also offered direct connectivity to the US and Japan. EuropaNET, like its successor networks since, was co-funded by the European Commission under the European Community’s Research and Development Framework Programme.

In the first half of 1997, the European NRENs started migrating to TEN-34, the Trans-European Network at 34 Mbps. By the end of 1997, TEN-34 connected the NRENs of 20 European countries and offered direct connectivity to the US. DANTE managed the TEN-34 network and was Co-ordinating Partner in the TEN-34 Consortium.

In 1997, the TEN-34 network meant that, for the first time, European researchers had access to an international data communications infrastructure to support their work and research collaborations. For the first time, European researchers were able to make large file transfers during the working hours, without packet loss or delay: It could be said that effective communication was achieved.

However, there remained a significant bandwidth gap between what was available nationally to institutions connected to the NREN, typically at 155 Mbps (1997) and the maximum access speed to TEN-34 of 45 Mbps. Thus, TEN-34 was undersized for a true pan-European network and not able to support, for example, multimedia applications. TEN-34 was also an extremely expensive network. The monopolistic character of the European telecommunications landscape in 1997 included commercial and regulatory roadblocks which prevented customers, such as the European NRENs, from obtaining higher bandwidth.

3.2 TEN-155 (1998-2001)

In January 1998, the European telecommunications market was liberalised and harmonised. Liberalisation led to an immediate improvement in the commercial position as prices for international European connectivity dropped in most European countries. Harmonisation paved the way for telecommunications providers to operate across national boundaries, which had formerly compartmentalised the industry, leading to an increase in the availability of cross-border infrastructure.

At the end of 1998, the TEN-155 network became operational. TEN-155 operated with access speeds up to 622 Mbps and connected 20 NRENs and one regional network.

Thanks to the liberalisation of the telecommunications market, and the significant drop in prices for international bandwidth across Europe caused by harmonisation, TEN-155 was able to close the gap between the bandwidth available nationally and internationally. However, in practice the process of liberalisation in Europe was gradual and patchy in terms of geographic coverage. A significant increase of connectivity from TEN-34 to TEN-155 (from 22 Mbps to 155Mbps and later 622Mbps) was achieved for the interconnections among the NRENs in most Western European countries. This increase in bandwidth was, however, much less significant in countries where liberalisation was delayed, such as, for example, Portugal.

3.3 GÉANT – The present pan-European network (2001-2004)

The current pan-European research network GÉANT can be considered a real break-through for European research connectivity. For the first time, the European research community has access to a backbone built during the “Age of Bandwidth” which occurred in Europe in 1999. Operational since November 2001, the GÉANT backbone now interconnects more than 3500 research and education institutions in more than 30 European countries. GĖANT is based on a shared core network of eleven 10 Gbps wavelengths, complemented by another twelve 2.5 Gbps wavelengths and additional SDH connectivity to those locations within Europe where wavelengths are still not cost-effectively available. Today, the total network capacity of over 140 Gbps represents a twenty-fold increase over the predecessor network, TEN-155.

3.4 What has this to do with Latin America?

One of the primary objectives of GĖANT is to facilitate global research co-operation by encouraging connectivity between researchers in Europe and those in other world regions. Between GĖANT and the North American research networks (Abilene, CA*net4 and ESnet) this objective has already been achieved, and significant progress has also been made in relation to the research networks in the Asian Pacific region. Building on this positive experience, the European research community, supported by the European Commission, now wishes to connect to other world regions, in particular Latin America and the Mediterranean. Due to its experience in European research networking, DANTE has been asked by the European Commission to project manage the connectivity projects in the Mediterranean and in Latin America.

4 From CAESAR to ALICE via @LIS

The ALICE (*América Latina InterConectada con Europa*) project will develop an IP research network infrastructure within the Latin American region and towards Europe. To make ALICE a success, the National Research and Education Networks (NRENs) of 18 Latin American and four European countries, joined by DANTE and CLARA (*Cooperación Latino Americana de Redes Avanzadas*), have come together to form a consortium for the lifetime of the ALICE project.

4.1 The @LIS Programme

ALICE addresses the infrastructure objectives of the @LIS programme. @LIS, Alliance for the Information Society, is an EU-funded cooperation programme with Latin America aiming to promote the Information Society and fight the digital divide throughout Latin America. Adopted in 2001, the @LIS programme has a budget of € 77.5 million of which € 63.5 million will be financed by the European Commission. @LIS covers a wide spectrum of objectives aiming at creating a long-term partnership between the two regions in the field of the Information Society. It focuses on the following activities: a dialogue on policy and regulatory aspects, the development of standards, the implementation of demonstration projects of benefit to the civil society, a network of regulators and the interconnection of research centers.

As its principal infrastructure project, @LIS will support the ALICE project and thus the creation of a Latin American research network infrastructure and its link to the pan-European research network, GĖANT.

4.2 How it all started – CAESAR

In order to prepare for the @LIS programme, DANTE, together with FCCN and RedIRIS, the NRENs of Portugal and Spain, worked on the CAESAR project between March and October 2002. CAESAR (Connecting All European and South American Researchers) was a feasibility study, funded 100% by the European Commission (DG Infso).

CAESAR's objective was to analyse the situation of the Latin American NRENs and their demand for interconnectivity and to conduct a market study to IDENTIFY potential connectivity providers and their prices for bandwidth within Latin America and between Latin America and Europe. CAESAR also organised a workshop, which brought together the representatives of 12 Latin American and 3 European NRENs, the European Commission and DANTE. This workshop took place in Toledo, Spain, in June 2002 and represented the start of a fruitful relation between the NRENs of Latin America and Europe and DANTE.

It became clear in Toledo that there was great interest in Latin America to interconnect the NRENs in the region and also to connect directly to GÉANT. Only a month after the workshop in Toledo, 14 Latin American NRENs signed the "Declaration of Toledo" and committed to the creation of CLARA, Latin American Cooperation for Advanced Networking.

In October 2002, the CAESAR project published the final report concluding that there was a real demand for intra-regional Latin American connectivity and a direct interconnection between Latin America and Europe. CAESAR also stated that such an interconnection was technically and financially feasible. Based on these findings, preparations for the ALICE project got underway.

4.3 About ALICE

ALICE (América Latina InterConectada con Europa) is the natural successor of CAESAR. The ALICE project started on 3 June 2003 and will last for 36 months, i.e. until the end of May 2006. DANTE is the Co-ordinating Partner of ALICE and is supported by 22 NRENs, from both Europe and Latin America, and also CLARA.

The European partners in ALICE are GARR, FCCN, RENATER and RedIRIS, the NRENs of Italy, Portugal, France and Spain, respectively.

In Latin America, ALICE is partnered by the NRENs of 18 Latin American countries, namely, RETINA (Argentina), BolNet/ADSIB (Bolivia), RNP (Brazil), REUNA (Chile), Universidad de Cauca (Colombia), CRnet (Costa Rica), RedUniv (Cuba), REICyT (Ecuador), RAICES (El Salvador), RAGIE (Guatemala), UNITEC (Honduras), CUDI (Mexico), UNA (Nicaragua), RedCyT (Panama), ARANDU (Paraguay), RAP (Peru), RAU (Uruguay) and REACCIUN (Venezuela).

CLARA (Cooperación Latino Americana de Redes Avanzadas) is a not-for-profit international organisation registered in Uruguay. The objective of CLARA is to promote co-operation among the Latin American NRENs to foster scientific and technological development. It is expected that CLARA will develop into DANTE's counterpart in Latin America and will take responsibility for the future of Latin American research networking activities.

It should be noted here that the CAESAR/ALICE initiative has been instrumental in reversing the tendency, noted in section 2.3, for a decline in the number of NRENs in Latin America. The prospect of acquiring dedicated international access to the global R&E advanced networking community has acted as a spur in many countries in the region to revive or re-establish formerly active NRENs, or to create new NRENs. These have come together in CLARA to create their own association.

The ALICE project receives € 10 Million co-funding through the @LIS programme of the European Commission which represents 80% of the total funding of the project. The Latin American partners in ALICE have expressed their willingness to contribute the remaining 20% of the funding, pending the results of the planning and procurement Phase of ALICE.

4.4 ALICE – why Phases A and B?

The ALICE project is divided into two distinct phases. Phase A – Planning and Procurement - started on 3 June 2003 and is expected to last until February 2004. Phase B will be the Implementation and Operation phase and is expected to last from February 2004 to the end of May 2006.

The European Commission is co-funding 80% of the project with an expected commitment by the Latin American partners of the remaining 20%. However, it became clear very quickly that the Latin American partners could not commit to the remaining 20% until after the results of the procurement were known: CAESAR had indicated that a regional Latin American network and an interconnection to GÉANT were financially feasible, but only an official tender would show what the market was really going to offer and at what price. To avoid having to “buy a pig in a poke”, ALICE was divided into two phases.

At this point in time, all partners in ALICE have committed to Phase A of the project and Latin America contributes 20% of the costs of this Planning and Procurement phase. Once the results of the tender are known, DANTE will ask the partners to commit to Phase B and ALICE will proceed.

ALICE is divided into 10 work packages dealing with management tasks, such as project management and promotion, commercial tasks, such as procurement and contracts, and technical tasks, such as the development and design of the network topology, the planning of operations and in-life operations, as well as training.

For Phase A of the project, DANTE has taken responsibility for most of the work packages, while closely co-operating with all partners. It is important to understand that the role of DANTE and the European NRENs involved in ALICE is to help the Latin American NRENs get the first Latin American regional network up and running. It is anticipated that many tasks that are today managed by DANTE will during the lifetime of ALICE pass to DANTE’s Latin American counterpart, the newly created CLARA. These tasks will certainly include promotion and project dissemination in Latin America, to ensure the long-term sustainability of the Latin American research network and its interconnection to Europe. Obviously, the Latin American network will also have to be operated from Latin America, not from Europe.

4.5 Where are we Today?

Thanks to an extensive preparation period, ALICE was able to hit the ground running when the contract was signed between DANTE and the European Commission in June 2003. Only 5 days after the signature of the contract, the European Official Journal published the contract notice for the ALICE connectivity tender. Connectivity providers across Latin America and Europe where notified and asked to express their interest to participate in the connectivity tender following European rules for public tenders.

The results of the tender, i.e. the offers received, are to be evaluated by a team of experts from Latin America and Europe in August 2003. All going well, the core elements of the network should be up and running by the end of 2003 or early 2004.

5 Conclusion

The resulting impact of greatly improved national and international connectivity for the worldwide R&E community can hardly be exaggerated. Computer mediated communication has made it possible the nearly instantaneous availability of newly published discoveries and inventions throughout the world, access to digital libraries, rapid and cheap personal communication between scholars, as well as remote participation in scientific events through such means as videoconferencing. For developing countries, such as those in Latin America, this has facilitated participation in world class research, in step with activities in the developed world. Another benefit has been much greater access to remote experimental and observational facilities, such as astronomical, astrophysics and geophysics observatories, particle accelerators and high performance processing resources. In several cases, important observational facilities are actually to be found in South America, such as is the case for some of the principal astronomical and astrophysics observatories covering the skies in the Southern Hemisphere.

Fortunately, these benefits have come to be recognised by governments and international organisations, and considerable support has been given to the continuous improvement of computer networking infrastructure to meet the growing needs of the R&E community. This has taken the form of support at a national level for improving and enhancing the telecommunications infrastructure, which also brings other, economic, advantages, and also for improving the preparedness of the R&E institutions to make good use of the opportunities provided by high quality international connectivity, through the provision and improvement both of internal computer networks within these institutions, and of the access networks needed to interconnect them and to make it possible to make adequate use of the newly available international communications.

References and Acknowledgements

Due to lack of space, a fuller version of this paper, with a complete list of references and network maps, will be made available on the ALICE project website at http://www.dante.net/alice.

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