Non-Commercial Networking in Brazil

Michael A. Stanton [1]

Abstract

After a short introduction to the country, the article describes the present telecommunciations infrastructure in Brazil, and explains how this was used starting in 1988 to set up a number of different non-commercial networks linking Brazilian organizations and providing them with access to international networking. It then goes on to describe the creation of a "second generation" network based on Internet technology, which began experimental operation in 1991 and which currently provides the principal non-commercial service in the country. The article concludes with a look at other internationally connected network technologies in Brazil, and at the future perspectives for academic and research networking in the short and medium term.

I. Introduction

Brazil is a relatively recent participant in global academic and research networking, as evidenced by her complete omission from John Quarterman's 1990 edition of "The Matrix". In fact, Brazilian researchers have had international network access since September 1988, and there has been steady growth in traffic since this time. The most recent (January 1993) census of Internet hosts places the Brazilian top-level domain (br) as the 30th most populous out of about 60 in the world ranking, with around 2000 registered hosts, and a very high growth rate. This article presents the historical evolution of the Brazilian networking initiative, and describes its current characteristics.

II. The country, the government and research

Brazil is a country of continental dimensions — the fifth largest in the world — with a total area of 8.5 million km2 and a diameter of 5000 km, corresponding approximately to the eastern half of South America. Geographically, Brazil straddles the Equator and the Tropic of Capricorn, extending between latitudes 5 degrees North and 35 degrees South, and longitudes 35 to 75 degrees West. As a consequence, the principal time zone is GMT−3, placing the main populated regions about equidistant timewise from the US and Europe.

The population of about 150 millions is unevenly distributed, being concentrated mainly within 500 km of the South Atlantic seaboard, and very sparse in the huge tropical hinterland. The country possesses about 10 cities with a population in excess of a million, including the two megacities of São Paulo (14 millions) and Rio de Janeiro (9 millions), situated 400 km apart in the densely populated southeast region.

The language of Brazil is Portuguese, as a result of more than 300 years of Portuguese colonization starting after 1500. In fact, the great majority of the world's speakers of Portuguese are Brazilians. There are no other languages spoken in the country of any practical significance, although there are a significant number of indigenous languages used among the small and declining population of "unabsorbed" amerindians, numbered in the thousands, rather than millions.

Brazil declared its independence from Portugal in 1822, and after a period of constitutional monarchy, became a federal republic in 1889. There is a gross constitutional similarity with the US, Brazil currently having 26 states and one Federal District (the capital), each of which possesses its own elected government.

The Brazilian economy is ranked as 11th in the world, and has an annual per capita Gross Domestic Product of around US$ 2000. This wealth is unevenly spread, and the country displays great contrasts between and even within different regions. For instance, since the seventies there has existed a local computer manufacturing industry, and Brazilian organizations, especially in the banking sector, have developed a high degree of automation, in large part based on locally manufactured products.

Research and higher education in Brazil is principally conducted by government, with an extensive system of federal universities (administered by the Ministry of Education), and generally smaller state university systems in most states. There are also a large number of private institutions of higher education, but with one or two notable exceptions, these do not en-

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gage in significant research activities. A number of federal government agencies also support research in a wide range of fields. The principal research agency is the National Council for Scientific and Technological Development (CNPq)c subordinated to the Ministry of Science and Technology. The CNPq provides individual research grants to research workers and students in different institutions, apart from maintaining a number of national research laboratories in different parts of the country.

Some of the individual state governments also provide direct support for research activities, generally through state secretariats for science and technology, or through foundations for the support of research. The most important activity of this kind is performed by the government of the state of São Paulo (SP), which has about 20% of the population and generates 50% of the total wealth. The SP foundation for the support of research (FAPESP) is well endowed and provides extensive support for research activities in that state. It is also worthy of note that the SP state university system is the most developed in the entire country, and includes the leading universities of São Paulo (USP) and Campinas (UNICAMP).

III. Telecommunications Infrastructure

Telecommunications is a state monopoly in Brazil, exercised by companies of the Telebrás group. These include a long distance carrier, Embratel, and (usually) one or more regional operating companies offering local and access services within each state. Until 1989, the provision of data communications services was an explicit monopoly of Embratel and the regional companies offered few value-added services. Since then, they have begun to compete with Embratel in offering data communications services, at least within their own region.

Since 1970, the telecommunications infrastructure has been greatly expanded and modernized, both at the local level and for long-distance traffic. On account of the size of the country, it is instructive to look more closely at the long-distance infrastructure installed by Embratel. The eastern half of the country, which is much more populous, is served by a network of more than 23,000 km of microwave trunks, of which an increasing number are being converted to digital transmission. Most of the remainder of the country, which includes the vast Amazon region, is served by (domestic) satellite communication betwen more than 50 ground stations.

From the point of view of data communications, Embratel offers a number of different services, including leased lines (300 to 9600 bps), PSDN service (X.28 and X.25 access at up to 9600 bps) and VSAT using the domestic satellites. It has also been possible to negotiate special higher speed services in certain circumstances, and these services are shortly to be part of the regular offerings of the company, although there is as yet no general solution to the Last Mile Problem, the usual telecommunications term for the providing the required service as far as the client's premises.

Embratel also provides international telecommunications, through the INTELSAT and INMARSAT systems, through three submarine cables (two to Europe and one to the US), and through terrestrial links to neighbouring countries to the south and southwest. International data communications have traditionally been provided through both leased lines (up to 9600 bps) and through interconnection of the PSDN service.

From the legal point of view, the state monopoly of telecommunications has been interpreted as prohibiting the carrying of third party traffic by Embratel's clients. This naturally restricts the setting up of data communications networks to serve different communities, and has so far only been relaxed in three cases: the SWIFT system for the international financial community, the SITA system for airline reservations, and the academic and research networkc described here. In the former two cases, the international access point was actually installed on Embratel premises. In the latter case, the solution has been technically more conventional. Embratel currently regards the academic and research community network service as a "restricted service", which for the moment limits the nature of the traffic which may be carried.

IV. First steps

By 1987, the importance of computer networking for the academic community had been recognized in several different institutions, and a number of different independent projects were already being prepared to provide partial solutions, especially at LNCC, FAPESP and UFRJ (see below). It was in this context that the first meeting was held in São Paulo in October of that year to discuss the setting up of a national research network, with the sharing of access to international networks. Apart from participants from research institutions and government agencies, Embratel was also represented, and the legal question of third party traffic was brought up, but not resolved. At this meeting, the different actors in future Brazilian networking were brought together for the first time, and the show and tell climate of the meeting was important for helping to avoid the adoption of solutions which would make more difficult the future integration of the different initiatives. As a direct result of this meeting, the seed was sown for what would later develop into a purpose-built national research network. A final consequence was the Brazilian participation in the 6th International Networking Workshop, held the following month at Princeton, where for the first time extensive contacts were made with the international research networking community.

Embratel only decided to permit the carrying of third party traffic by the academic and research community networks in October 1988, one month after the first international network link had already been established, and the plans for others well advanced. The previous restrictions had led to the first projects being devised to work around the legal limitations. Thus the first link established, a 9600 bps BITNET link from the Laboratório Nacional de Computação Científica (LNCC) of the CNPq, in Rio de Janeiro, to the University of Maryland at College Park, was designed to provide widespread access to BITNET by the expedient of permitting dial-up access to LNCC by any member of the national research community, formally to be considered as a researcher of the CNPq. The second international link, initially at 4800 bps and concluded in November of 1988 between FAPESP in São Paulo and the Fermi National Laboratory in Chicago, was planned to serve the university and research system of the state of São Paulo, thus by-passing the legal restrictions on third party traffic. This was a DECnet link, designed to carry HEPNET and BITNET traffic. A third independent BITNET link at 4800 bps was also installed in May 1989 between the federal university of Rio de Janeiro (UFRJ) and the University of California at Los Angeles (UCLA).

Thus, by May 1989, Brazil had three separate islands of BITNET access, two in the city of Rio de Janeiro and one in the state of São Paulo. The removal of the third party traffic restriction now opened the doors to a rationalization of this situation, and to the establishment of a national network which could share access to the international networks. This was done over the next two years, during which time the separate islands were interconnected, and connectivity extended to the principal research centres of the country. This happened by the simultaneous growth of the two islands based on LNCC and FAPESP. Thus, by the end of 1991, the Brazilian national network was topologically a linked double star, and very few states did not possess at least one network node.

Figure 1 illustrates the leased line connections in use at the end of 1991. It should be noted that a number of additional institutions were also linked to this network by PSDN or dial-up (UUCP) access, mainly to the FAPESP node in São Paulo. The great majority of the connections shown are BITNET connections. However a small number of institutions had HEPNET access over DECnet links, and a handful had Internet access over very slow speed links (see next section). It would be accurate to say of this time that the only network service that was nationally available was electronic mail. However this is well known to be an excellent launchpad for more ambitious projects!

V. Experimenting with the Internet

It had been clear from the beginning that electronic mail alone would be insufficient for many researchers, who required interactive access or extensive file transfer facilities. The question of which technology was a vexed one, mainly because of the important role then played by the federal government's Special Informatics Secretariat (SEI), which held widespread powers to determine the computer and communications technology to be used in the mainly government-run academic and research community, as well as being the citadel of the federal government's industrial policy for information technology. SEI was a strong defender of OSI/ISO solutions for computer communications, and it had been made very clear to the academic and research community that only such solutions would be acceptable in a national network. BITNET was initially merely tolerated as a pragmatic and immediately available solution for a restricted service. Internet technology was not considered to be a suitable alternative to OSI, since it was not governed by formally agreed international standards.

Curiously, this position was simultaneously being subverted in the research laboratories sponsored by another agency (CNPq) of the same Ministry of Science and Technology, where there were being installed a growing number of engineering workstations using Ethernet LANs and Internet communications technology. By 1989 it was already apparent that Internet technology was a winner on the international stage, so far as academic and research networks were concerned.

In 1990, the newly elected government of Brazil severely curtailed the powers of SEI, transforming its rump into the Informatics Policyg Department of the Ministry of Science and Technology, a change which heralded the end in 1992 of the independent industrial policy for computer manufacture in the country. One immediate consequence was an abandonment of open opposition to the academic use of Internet technology, although the preferred technology for government use continued to be OSI, a position confirmed in 1992 with the publication of the first version of a Brazilian GOSIP.

Meanwhile, the national networking project, whose seed had been planted in 1987, had had its growth strongly stunted by the requirement of OSI technology, and by July 1990 proposed little more than a OSI-compliant electronic mail network. The OSI mould was first broken in Rio de Janeiro in September of that year, when, for the first time, an Internet technology project received official support, given in this case by FAPERJ, the Rio de Janeiro (RJ) state foundation for the support of research. The project was for a regional network for the state of RJ, to be linked to the Internet.

Although this project took almost two years to reach fruition, it served as a model for a number of similar projects in other states, and also for the reformulation of the national network, which occurred shortly afterwards. The details of these projects are discussed in the next section. It also provoked for the first time discussion of Brazil at the CCIRN/IEPG level, due to the prospect of multiple Internet connectivity between Brazil and the US, and a subsequent visit by a CCIRN member to Brazil in November 1990, to discuss the situation with networking specialists from Rio de Janeiro and São Paulo.

Internet access from Brazil became possible in February 1991, when FAPESP, who had already upgraded the speed of their link to Fermilab to 9600 bps, installed TGV's Multinet software and began transporting IP traffic, in addition to DECnet and BITNET. IP connectivity was soon extended to a small number of institutions in the states of SP, RJ, Rio Grande do Sul and Minas Gerais by slow speed (i.e. 2400 to 9600 bps) leased lines or over PSDN connections, and provided a learning environment for networking support personnel, as well as an operational e-mail service for a number of previously unconnected sites. It also provided a great incentive for the establishment of campus networks integrating previously isolated LANs, especially those linking the growing number of engineering workstations which were being delivered to research workers through grants made by the CNPq.

VI. A second generation network

The networking situation in Brazil at the end of 1991 was eminently cooperative in nature, with each connected institution paying its own telecommunications costs to link either to Rio de Janeiro or to São Paulo. (Interestingly, the direct link between Rio and São Paulo was paid for by the federal government, in the interests of national harmony.) A definitive solution to the problem of designing a national network should probably prefer a mesh topology, which would provide greater robustness and might even reduce telecommunications costs by the greater use of shorter links.

To organize such a topology requires some administrative structure, as it is no longer a straightforward matter to allocate costs. A strategy would have to be adopted whereby government funding would be sought at least for the initial provision of networking infrastructure. This strategy was designed and executed by the team working under the auspices of the CNPq and coordinated by Tadao Takahashi, and was based on a network architecture which reflected the administrative organization of the country. This architecture is similar to that used by the NSF in the US, with a three tier structure of national backbone, regional networks and campus networks. In the Brazilian case, the national backbone network would be a project of the CNPq, financed by the federal government, whereas the regional networks would be the responsibility of the state governments, either singly or collectively. Functionally, the regional network would link together the campus networks in a particular region, and the national backbone would just provide interconnection services between regionals. In principle, international connections would be made to the national backbone network.

The network technology of choice would be TCP/IP, but, in order to accommodate current minority interests and possible future OSI requirements, the national backbone and regional networks should use multiprotocol routers. Lastly, the line speeds to be used in these networks should be the highest available, subject to financial limitations. At the time that this architecture was being designed, there was no generally available service at higher data rates than 9600 bps (except for the extremely expensive 2 Mbps). However it was expected that a 64 Kbps service would soon become available, especially on urban and international links. Therefore it was urged that these be utilized as soon as feasible.

VII. The implementation of the new network

The first three components of the second generation network were put in place in 1992. These were the national backbone network of the CNPq's National Research Network (RNP), and the state networks of Rio de Janeiro and São Paulo, financed respectively by FAPERJ and FAPESP. The latter two networks were installed together on the eve of the June 1992 United Nations Conference on the Environment and Development (UNCED-92), held in Rio de Janeiro, as both involved new international 64 Kbps links which were to be used initially in support of the Global Forum, a meeting on Non-Governmental Organizations (NGOs) held in parallel with UNCED-92.

The Rio de Janeiro project, also known as the RedeRio, broke new ground in employing 64 Kbps circuits within the city of Rio de Janeiro, where most of its constituent institutions are located. This technique uses a single digital voice channel in the extensive Pulse Code Modulated (PCM) network which connects local telephone exchanges within the city. The Last Mile Problem is solved by the use of baseband digital modems over the local loop. After the use of 64 Kbps circuits was pioneered in the academic networkc TELERJ has added it to its repertoire of regular commercial services. The same technique is also used to carry the international 64 Kbps circuit from the Embratel point of presence to the federal university (UFRJ), where it terminates. This circuit now links the RJ state network to the NSFnet backbone at the San Diego Supercomputer Center. Multiprotocol routers supplied by Cisco are used in all nodes.

The SP state network, also known as ANSP, initially only employed 9600 bps circuits, but the use of higher speed circuits is slowly growing. In this case, the international link continues to be between FAPESP and Fermilab, where it connects to the ESnet backbone. As in RJ, the choice of routers was Cisco.

The third of the new network components, the national RNP backbone came gradually on-stream during the second half of 1992. Initially the backbone connects points of presence located in the federal capital Brasília and in ten different state capitals (see Figure 2). The backbone is multiply connected, and initially is implemented with 9600 bps circuits. These will be replaced by 64 Kbps circuits on the major links, as soon as these become available. In May 1993, the first long-distance 64 Kbps circuit was installed, linking São Paulo and Porto Alegre, in the southern state of Rio Grande do Sul. It is expected that the triangle Brasília-Rio de Janeiro-São Paulo will migrate to 64 Kbps in the first half of 1993, and that a further 64 Kbps link from São Paulo to Recife will be installed before the end of 1993. As soon as 64 Kbps is available between RJ and SP, it will be feasible to perform automatic backup routing between the two international links, which cannot be done presently. Another highly desirable improvement will be the adoption of dedicated multiprotocol routers on the backbone. As a temporary measure, routing on the backbone is being done by workstations from Sun and DEC.

A number of other regional networks are gradually being developed and are being linked to the national backbone. Amongst these are networks in the states of Espirito Santo, Minas Gerais, Pernambuco and Rio Grande do Sul, as well as in the federal capital. The Appendix to this article includes a list of the second level domain names which correspond to IP networks.

VIII. Complementary actions of the RNP project

The RNP project includes a number of additional initiatives to support the operation and utilization of the new networks. First among these is the indispensable establishment of network operations and information centres (NOCs and NICs). Two NOCs, one primary and one backup, will be based on the present facilities located at FAPESP (São Paulo) and LNCC (Rio de Janeiro). A national NIC will also be established in Rio de Janeiro, and it is intended that further regional centres be established in Brasília, Recife and Belém.

As networking is relatively new to Brazil, and as comparatively little literature is available in Portuguese, a major activity of the RNP project has been and continues to be the preparation of suitable manuals and educational materials. Most of these will probably be based on translating the best of recently published material from abroad.

Another important initiative related to the Portuguese language is the widespread provision of electronic mail facilities able fully to express correctly the use of accented letters in texts. The recent appearance of MIME (RFC 1341) with support for the ISO 8859-1 (Latin-1) character set goes a long way to providing an internationally acceptable way of solving this very general problem for languages other than English. Consequently, the main problem is seen as how to spread as widely as possible the use of MIMEcompliant mailers amongst users of the network.

IX. Other non-commercial networks in Brazil

For completeness, it is opportune to mention some of the other non-commercial networks being used in the wider Brazilian society, which also offer international connectivity.

The Association for Progressive Communication (APC), an international organization of NGOs, includes the node Alternex/IBASE, which is located in Rio de Janeiro and which was established with the support of the UNDP in 1989. Alternex offers newsgroup and electronic mail services to individuals and non- profit organizations. Until 1992, Alternex/IBASE performed their international communication with IGC (APC's Internet gateway in California) using UUCP. In that year, Alternex/IBASE was assigned the responsibility of providing computer communications support for the Global Forum held in June, and the resulting project, organized in close collaboration with the RNP and RJ state network projects, resulted in providing Alternex/IBASE with permanent Internet access through the RJ state network.

An extensive network of BBSs has been set up in Brazil, and is connected to the international FidoNet through a gateway in Recife. Preliminary contact has been made between the FidoNet national coordinator and the RNP project, but so far no discussions about interoperation have yet taken place.

The amateur packet-radio community is well represented in Brazil, and the network is connected internationally. Because of licensing restrictions, it is not intended to interoperate between this network and the academic and research networks. However, it should be recorded that at least one experiment is underway in the southern state of Rio Grande do Sul where a number of public schools use amateur packet radio for intercommunication, and for communication with the wider (amateur packet radio) world. In this case, each school has a responsible person who has taken out an amateur radio licence. It is also worth pointing out that the low orbit satellite communication is also used by the Brazilian amateur packet radio community (there is even a microsatellite in operation which belongs to a Brazilian amateur radio enthusiast!), and that this technology may well be an inexpensive form of communicating with the more remote parts of the country lacking in infrastructure.

X. Future developments

A number of directions can be glimpsed for extending the scope of networking beyond its current limitations. Currently the network supported by the RNP project is mostly dedicated to use by the academic and research community. In line with tendencies in other countries, it is conceivable that it will tend to serve a wider community than this, and already tentative steps are being taken to seek ways of involving the wider education (K-12) community and interacting with the government and business communities. For the moment, these experiments are mostly limited to the use of electronic mail.

In terms of communications technology, a second wave of modernization is currently altering the infrastructure of the telecommunications providers. The main thrust is naturally through the use of broadband services over optical fibre. The regional telephone companies have been installing optical fibre for telephone trunks for a number of years, and are now seeking to offer new broadband services, such as MANs, which can exploit profitably the installed capacity. The Rio de Janeiro regional company, TELERJ, is currently engaged in testing alternative MAN products, with the active participation of the research community. Digital radio links are providing 2 Mbps access to the MAN.

Additionally, Embratel is currently laying down optical fibre on its principal interstate trunk routes, and intends to complete these by 1996, by which year two submarine international optical fibre cables are also to be inaugurated, one north to the US, and the other south to Argentina and Uruguay. Embratel is also seeking to provide optical fibre access direct to end customers, in order to resolve the Last Mile Problem with its own resources. It is not yet clear what networking technology will be made available in this case.

It is clear that these developments will have profound consequences on the way in which networking will be done in the future, and it will an interesting exercise to plan the way in which the academic community can best use the services to be offered.

XI. Lessons from Experience

If there are any special lessons to be drawn from the Brazilian networking experience, these must surely relate to the great inertial resistance to change present in the society, in the government and in the academic community. Although the first halting steps were taken in 1987, it has taken until 1993 to have the benefits of non-commercial computer networking sufficiently widely recognized to be able to enlist the active or passive support of community and political leaders in many parts of the country. That it has been possible to have come so far is a tribute to the efforts of the team from the CNPq, which assumed the leadership of the political process of seeking broadly based sustenance for networking efforts, based on a mixture of state and federal government participation, with the addition starting in late 1992 of international funding from the United Nations Development Program.

Among the more obvious manifestations of inertial resistance must be included the long lead times required for the installation of telecommunications circuits, and for the import of vital communications equipment, such as routers. These more than anything else have led to a reluctance to alter the configuration of installed and operational circuits. It should be noted that in 1993 the Brazilian network still maintains essentially the same three international links to the US which were installed in 1988 and 1989, even if two of these have been significantly upgraded in capacity during this time. On the other hand, it can be noted with satisfaction that the introduction of limited competition in the provision of data communications services has been generally beneficial for the improvement of network connections.

It should also be emphasised that the movement towards peer networking, such as is used in TCP/IP, is closely coupled to the abandoning of the classical model of providing access to computing through a centralized mainframe service. Very many of the academic institutions in Brazil operate such a service as their principal, if not only, form of computing access. It is frequently quite difficult to bring the users of such institutions into the world of modern networking due to the perceptions of the role of computing and networking held by management and technical personnel in such centres. Fortunately, distributed computing is very subversive of such positions, and great advances can be made if user groups can be persuaded of the immediate utility of setting up LANs of workstations or personal computers, in order to share printers or file servers. In a second phase, such networks can be linked together to form a local internet, and, preferably, linked into the Internet. This path has been repeatedly followed in Brazil, and received great encouragement from the wholesale provision by the CNPq of small sets of networked Unix workstations to research groups in institutions scattered around the country. Nowadays, the same effect could probably be obtained with high performance personal computers on a LAN. The widespread availability of good quality low-cost or public domain software greatly eases the job of the large scale integrator.

XII. Conclusion

We have attempted to describe in this article the history of the development of networking capabilities in the academic and research community in Brazil. Networking is already having a profound benefits for this community, reducing the distances between indivuals in this spread-out country, and also bringing them much closer to the mainstream of the international research community than was formerly the case. Fortunately, these benefits have been recognized in a timely manner in Brazil, and there has been widespread support for the considerable financial investments required in a time of great austerity.

Acknowledgements

In a learning experience such as the creation of a large-scale networking infrastructure and culture, important contributions are made very many individuals, and the author would like to acknowledge all the assistance he has received from co-workers and students, both in Brazil and outside, in his efforts to understand and disseminate the science and engineering of networking. Particular thanks are due to Alexandre Grojsgold, Demi Getschko, Paulo Aguiar and Tadao Takahashi, without whose active participation little of what is described here would have happened.

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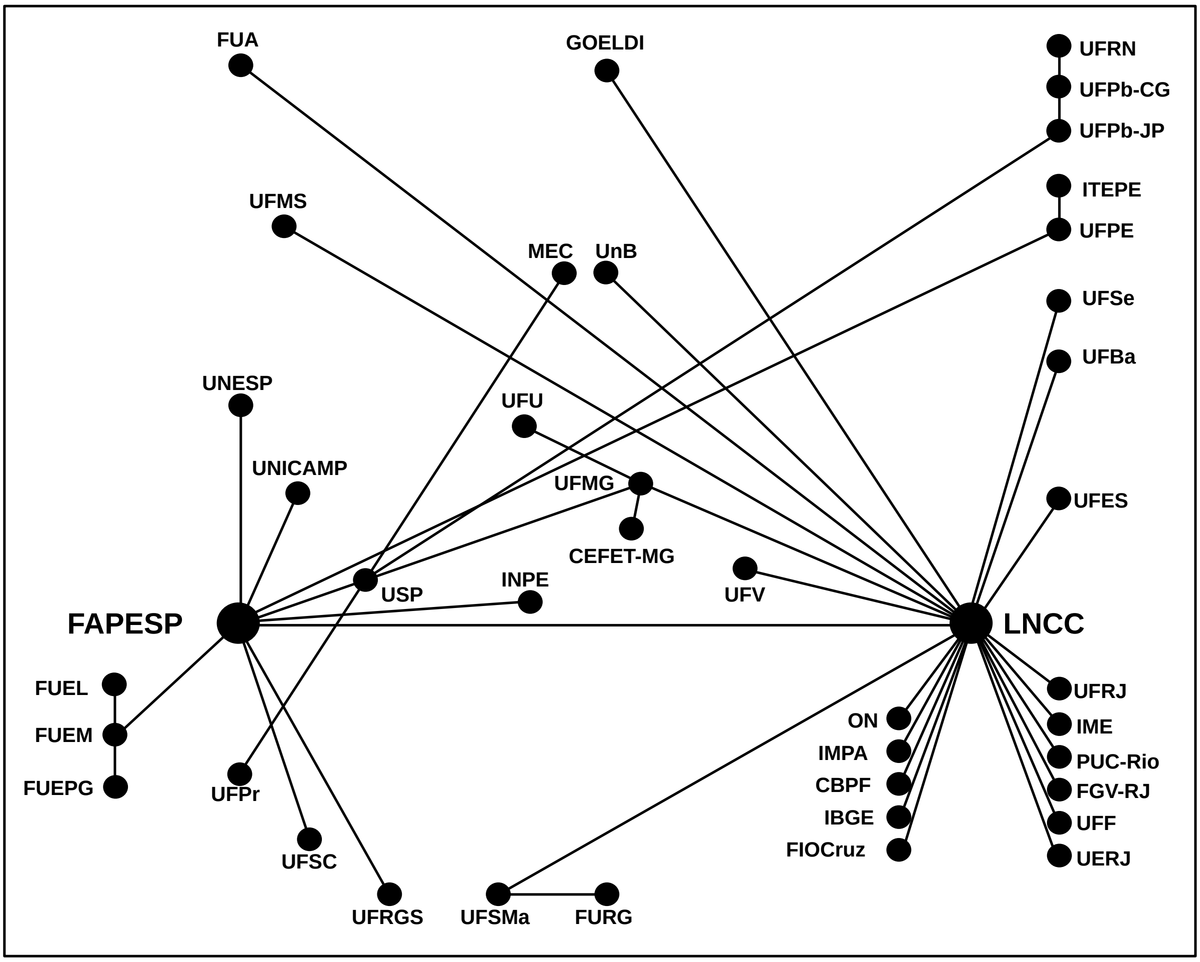

Figure 1: Leased line connections in the Brazilian network in December 1991.

Appendix: Maps and Tables

Maps and networking information have been collected together here for convenience.

Key to Figure 1: Institutions on the network in 1991

Name	Institution	City, State
CBPF	Centro Brasileiro de Pesquisas Físicas	Rio de Janeiro, RJ
CEFET-MG	Centro Federal de Ensino Técnico	Belo Horizonte, MG
FAPESP	Fundação de Amparo a Pesquisa do Estado de SP	São Paulo, SP
FGV-RJ	Fundação Getúlio Vargas	Rio de Janeiro, RJ
FIOCRUZ	Fundação Instituto Oswaldo Cruz	Rio de Janeiro, RJ
FUA	Fundação Universidade de Amazonas	Manaus, AM
FUEL	Fundação Universidade Estadual de Londrina	Londrina, PR
FUEM	Fundação Universidade Estadual de Maringá	Maringá, PR
FUEPG	Fundação Universidade Estadual de Ponta Grossa	Ponta Grossa, PR
FURG	Fundação Universidade de Rio Grande	Rio Grande, RS
GOELDI	Museu Paraense Emílio Goeldi	Belém, PA
IBGE	Fundação Instituto Brasileiro de Geografia e Estatística	Rio de Janeiro, RJ
IME	Instituto Militar de Engenharia	Rio de Janeiro, RJ
IMPA	Instituto de Matemática Pura e Aplicada	Rio de Janeiro, RJ
INPE	Instituto de Pesquisas Espaciais	São José dos Campos, SP
ITEPE	Fundação Instituto de tecnologia do Estado de PE	Recife, PE
LNCC	Laboratório Nacional de Computação Científica	Rio de Janeiro, RJ
MEC	Ministério de Educação	Brasília, DF
ON	Observatório Nacional	Rio de Janeiro, RJ
PUC-Rio	Pontifícia Universidade Católica do Rio de Janeiro	Rio de Janeiro, RJ

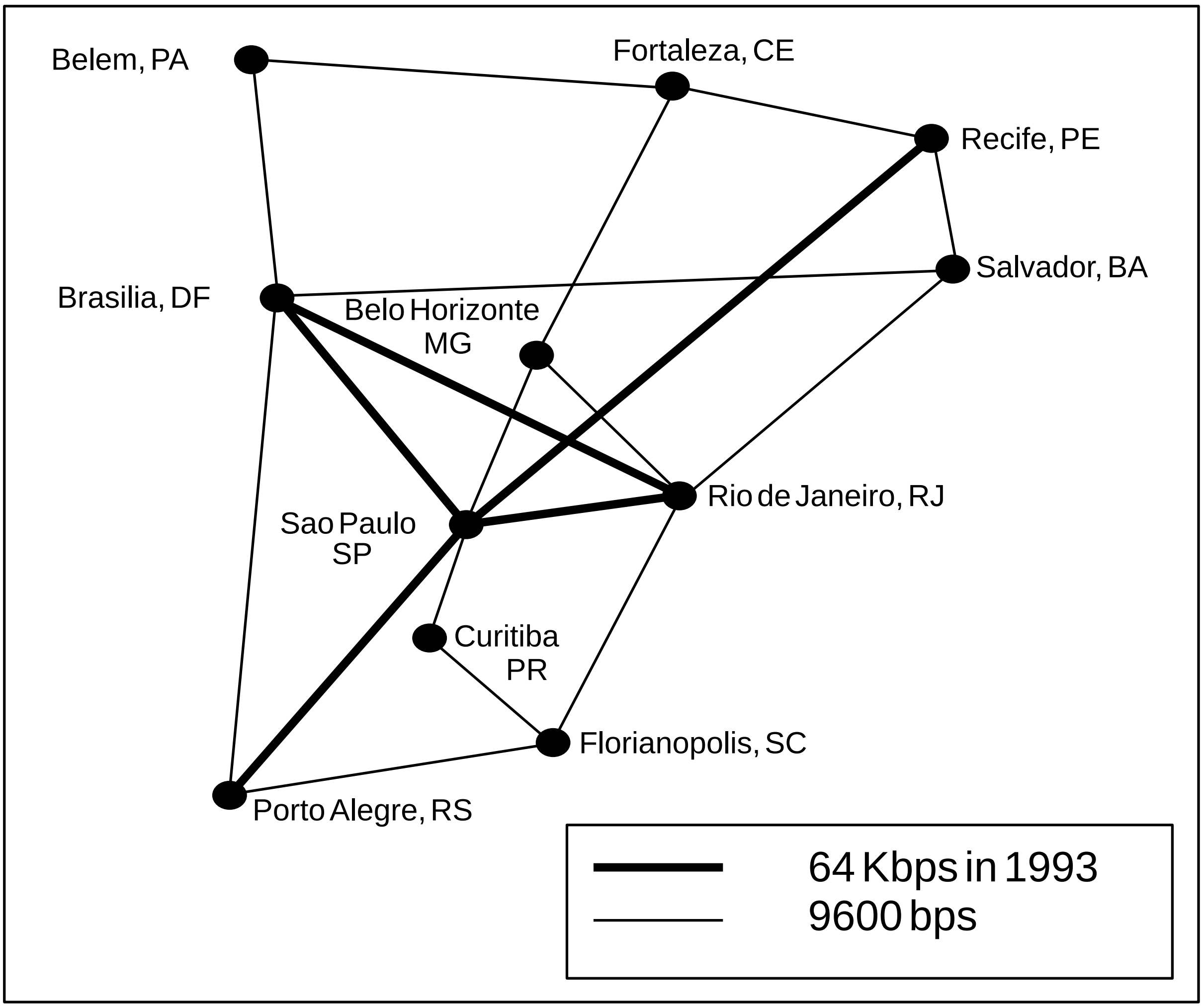

Figure 2: National IP backbone in 1993

UERJ	Universidade do Estado do Rio de Janeiro	Rio de Janeiro, RJ
UFBa	Universidade Federal da Bahia	Salvador, BA
UFES	Universidade Federal do Espírito Santo	Vitória, ES
UFF	Universidade Federal Fluminense	Niterói, RJ
UFMG	Universidade Federal de Minas Gerais	Belo Horizonte, MG
UFMS	Universidade Federal do Mato Grosso do Sul	Campo Grande, MS
UFPb-CG	Universidade Federal da Paraíba	Campina Grande, PB
UFPB-JP	Universidade Federal da Paraíba	João Pessoa, PB
UFPE	Universidade Federal de Pernambuco	Recife, PE
UFPR	Universidade Federal do Paraná	Curitiba, PR
UFRGS	Universidade Federal do Rio Grande do Sul	Porto Alegre, RS
UFRJ	Universidade Federal do Rio de Janeiro	Rio de Janeiro, RJ
UFRN	Universidade Federal do Rio Grande do Norte	Natal, RN
UFSC	Universidade Federal de Santa Catarina	Florianópolis, SC
UFSe	Universidade Federal de Sergipe	Aracaju, SE
UFSMa	Universidade Federal de Santa Maria	Santa Maria, RS
UFU	Universidade Federal de Uberlândia	Uberlândia, MG
UFV	Universidade Federal de Viçosa	Viçosa, MG
UnB	Universidade de Brasília	Brasília, DF
UNESP	Universidade Estadual de São Paulo	Bauru, SP
UNICAMP	Universidade Estadual de Campinas	Campinas, SP
USP	Universidade de São Paulo	São Paulo, SP

Table of subdomains of the top-level domain 'br'

Name	Institution	City, State
cbpf.br	Centro Brasileiro de Pesquisas Físicas	Rio de Janeiro, RJ
celepar.br	Companhia de Processamento de Dados do Estado do PR	Curitiba, PR
cnpq.br	Conselho Nacional de Desenvolvimento Científico e Tecnológico	Brasília, DF
cta.br	Centro Técnico Aeroespacial	São José dos Campos, SP
embrapa.br	Empresa Brasileira de Pesquisa Agropecuária	Brasília, DF
emparn.br	Empresa de Pesquisa Agropecuária do Rio Grande do Norte	Natal, RN
emprel.br	Empresa Municipal de Informática	Recife, PE
fapeal.br	Fundação de Amparo a Pesquisa do Estado de AL	Maceió, AL
faperj.br	Fundação de Amparo a Pesquisa do Estado do RJ	Rio de Janeiro, RJ
fapesp.br	Fundação de Amparo a Pesquisa do Estado de SP	São Paulo, SP
fgvsp.br	Fundação Getúlio Vargas	São Paulo, SP
finep.br	Finaciadora de Estudos e Projetos	Rio de Janeiro, RJ
fiocruz.br	Fundação Instituto Oswaldo Cruz	Rio de Janeiro, RJ
ftpt.br	Fundação Tropical de Pesquisa e Tecnologia André Tosello	Campinas, SP
funceme.br	Fundação Cearense de Meteorologia e Recursos Hídricos	Fortaleza, CE
ibase.br	Instituto Brasileiro de Análises Sociais e Econômicas	Rio de Janeiro, RJ
impa.br	Instituto de Matemática Pura e Aplicada	Rio de Janeiro, RJ
inpe.br	Instituto de Pesquisas Espaciais	São José dos Campos, SP
ipa.br	Empresa Pernambucana de Pesquisa Agropecuária	Recife, PE
ipen.br	Instituto de Pesquisa de Energia	São Paulo, SP
iprj.br	Instituto Politécnico do Rio de Janeiro	Nova Friburgo, RJ
itep.br	Fundação Instituto de Tecnologia do Estado de PE	Recife, PE
lmrs.br	Laboratorio Associado de Sensoriamento Remoto	Campina Grande, PB
lncc.br	Laboratório Nacional de Computação Científica	Rio de Janeiro, RJ
on.br	Observatório Nacional	Rio de Janeiro, RJ
puc-rio.br	Pontifícia Universidade Católica do Rio de Janeiro	Rio de Janeiro, RJ
rederio.br	RedeRio (Rio de Janeiro state network)	Rio de Janeiro, RJ
rnp.br	Rede Nacional de Pesquisa	Campinas, SP
softex.br	Softex 2000	Campinas, SP
uerj.br	Universidade do Estado do Rio de Janeiro	Rio de Janeiro, RJ
ufba.br	Universidade Federal da Bahia	Salvador, BA
ufc.br	Universidade Federal do Ceará	Fortaleza, CE
ufes.br	Universidade Federal do Espírito Santo	Vitória, ES
uff.br	Universidade Federal Fluminense	Niterói, RJ
ufg.br	Universidade Federal de Goiás	Goiânia, GO
ufmg.br	Universidade Federal de Minas Gerais	Belo Horizonte, MG
ufpa.br	Universidade Federal do Pará	Belém, PA
ufpe.br	Universidade Federal de Pernambuco	Recife, PE
ufpr.br	Universidade Federal do Paraná	Curitiba, PR
ufrgs.br	Universidade Federal do Rio Grande do Sul	Porto Alegre, RS
ufrj.br	Universidade Federal do Rio de Janeiro	Rio de Janeiro, RJ
ufsc.br	Universidade Federal de Santa Catarina	Florianópolis, SC
ufsm.br	Universidade Federal de Santa Maria	Santa Maria, RS
unb.br	Universidade de Brasília	Brasília, DF
unesp.br	Universidade Estadual de São Paulo	Bauru, SP
unicamp.br	Universidade Estadual de Campinas	Campinas, SP
usp.br	Universidade de São Paulo	São Paulo, SP

Key to names of Brazilian states

AA	Amapá	MA	Maranhão	RJ	Rio de Janeiro
AC	Acre	MG	Minas Gerais	RN	Rio Grande do Norte
AL	Alagoas	MS	Mato Grosso do Sul	RO	Rondônia
AM	Amazonas	MT	Mato Grosso	RR	Roraima
BA	Bahia	PA	Pará	RS	Rio Grande do Sul
CE	Ceará	PB	Paraíba	SC	Santa Catarina
DF	Distrito Federal	PE	Pernambuco	SE	Sergipe
ES	Espírito Santo	PI	Piauí	SP	São Paulo
GO	Goiás	PR	Paraná	TO	Tocantins