Creating advanced Internet services in collaboration with the research community

Michael STANTON†, Iara MACHADO, Daniela F. BRAUNER,
André MARINS, Alex S. MOURA, Leandro N. CIUFFO
Brazilian Research and Education Network – RNP,
Rua Lauro Muller 116/1103, Botafogo, 22290-906Rio de Janeiro, RJ, Brazil
† on secondment from Computing Institute, Universidade Federal Fluminense - UFF
Email:{michael,iara,daniela.brauner,amarins,alex,leandro.ciuffo}@rnp.br

Abstract

We describe the experience of RNP, the Brazilian NREN, in creating advanced Internet services in partnership with the national research community in networks and distributed systems, how this model was later adopted with adaptations by the RedCLARA (Latin American regional network) community, and also some successful results in both of these domains.

The RNP Working Groups programme was launched in 2002 with the objective of developing collaborative projects between RNP and research groups, to demonstrate the feasibility of using new network protocols, services and applications. The development teams are called Working Groups (WGs), formed by a coordinator, who is usually a researcher in a public or private university or research institution, and a team of assistants. RNP staff members follow closely the activities of the WG. The WG concept has been adopted at RNP both for developing new end-user application service, and also for introducing new technologies into core areas such as security services, performance monitoring and dynamic provisioning of virtual circuit services, in order to accompany international trends to add such advanced features to the service offerings of research networks.

The paper also describes related work in theRedCLARA community to coordinate development activities carried out by Latin American NRENs, to establish working groups to study and propose new services for RedCLARA.

Keywords

Collaborative development of network services, NREN services, advanced Internet, Brazil, Latin America.

1. Introduction

We describe the experience of RNP, the Brazilian research and education network, in creating advanced Internet services in partnership with the national research community, how this model was later adopted by the RedCLARA (Latin American regional network) community, and also some successful results in both of these domains.

Nowadays the big challenge to Internet Service Providers (ISPs) is create new services to be competitive at low costs in a very aggressive market. NRENs have to participate in the ISP marketplace and must offer advanced Internet services in order to differentiate themselves from commercial ISPs. How should an NREN deal with this challenge?

The RNP Working Groups programme was launched in 2002 with the objective of developing collaborative projects between RNP and national research groups, which demonstrate the feasibility

of using new network protocols, services and applications. Projects are proposed by national research groups, in response to an open call for proposals published annually by RNP. The groups responsible for the selected proposals are called Working Groups (WG). Each WG designs and develops a pilot service, which is later evaluated and, if approved, will in the end be made available to RNP users. Each Working Group has a coordinator, who is usually a researcher in a public or private university or research institution, aided by a team of assistants. One or more RNP staff members interact closely with the activities of the WG. RNP client institutions also participate in these activities, providing user requirements and feedback to RNP about the service in development.

The WG concept has also been adopted at RNP for introducing new technologies into core areas such as security services, performance monitoring and dynamic provisioning of virtual circuit services, in order to accompany international trends to add such advanced features to the service offerings of research networks. At RNP such developments contribute to the Advanced Internet programme. In these cases, the theme of the working group is decided by RNP. However there are great similarities between these two manifestations of WGs. In both cases, research groups from the academic research community are the engines for the development of technology for RNP.

Since 2005 RedCLARA community created a programme to coordinate activities carried out by Latin America NRENs, to establish working groups to study and propose new services for RedCLARA. A second objective of this programme is to promote similar levels of knowledge and a similar portfolio of services in all NRENs connected to the RedCLARA network.

Some examples of services originated from WGs at RNP include: the Cafe Identity Federation, Fone@RNP (Internet telephony), ICPEdu (a Public Key Infrastructure), Video@RNP (video streaming), MonIPÊ(perfSonar performance measurement) and Cipó (dynamic circuit provisioning), and at RedCLARA: PITVoIP (Internet telephony interchange) and eduroam.

The remainder of this paper is structured as follows. In section 2, we describe the Working Groups Programme for developing new services and products at RNP, in response to open calls for proposals from the research community, and we present the results of this programme over more thn 10 years of operation. In section 3, we present the use of the Working Group concept for developing RNP's Advanced Internet programme. In section 4, we turn attention to similar activities in RedCLARA, which have used the term Working Group in a slightly different sense. The conclusions are presented in section 5.

2. The Working Groups Programme (WG-RNP)

2.1 Objectives and the research and development process

As the Brazilian NREN, RNP is responsible for promoting the development of networks in Brazil, including the development of innovative applications and services, especially for the benefit of its user organisations, comprised almost entirely by research institutes and universities. In the departments of computer science, information technology and telecommunications of many of these user organisations there are research groups in areas related to networks,engineering and distributed systems (middleware).

As a way of promoting greater interaction between RNP activities and such research groups, and also continuous innovation of RNP products and services, the RNP Working Groups Programme (WG-RNP)was created in 2002 within the Research and Development directorate (DPD). WG-RNP aims to develop collaborative projects that can demonstrate the feasibility of using new protocols, services and network applications to meet the needs of users from educational and research institutions connected to the RNP network. Since then, this initiative has attracted, through an annual call for

proposals, the interest of research groups from all over Brazil, challenged to build innovative applications and tools. The proposals are examined by a selection committee with external representatives and the development teams for the selected proposals became Working Groups (WGs) at RNP.

The WGs receive funding to carry out their R&D activities, always closely monitored by staff members from DPD. This monitoring has proved to be an excellent way to promote interaction between RNP and the development teams, providing guidance and facilitating the delivery of results.

Each WG is coordinated by a researcher in public or private institution, and his/her team of assistants. RNP may appoint one or more of its staff to participate in WG activities. RNP partner institutions (other universities or companies) may also participate in the activities.

The WG process is organised in three consecutive stages, described as follows.In the first stage, which lasts 12 months, each group develops and demonstrates a working prototype of a new product or service, which is then evaluated for its functionality and performance by a committee including members of the committee responsible for its initial selection as a WG. Most of these WGs are usually approved for progress to the following stage. Here, the WGs refine their prototypes in order to implement a pilot to be tested out on a small group of RNP user organisations. At the end of the second stage the results are again evaluated, and the team may then be funded for a third year, known as the experimental phase. If the end result is a service, and the result of the experimental phase is judged to be satisfactory, the service is deployed in production andbecame part of the RNP service catalogue. If the end result is a product (a software or hardware artifact), it is made available for use by RNP user organisations. Figure 1 shows the WG-RNP development process borrowing the concept of the innovation funnel of Open Innovation, where not all the results are used by RNP and some may exit the funnel to be used for developing new business models.
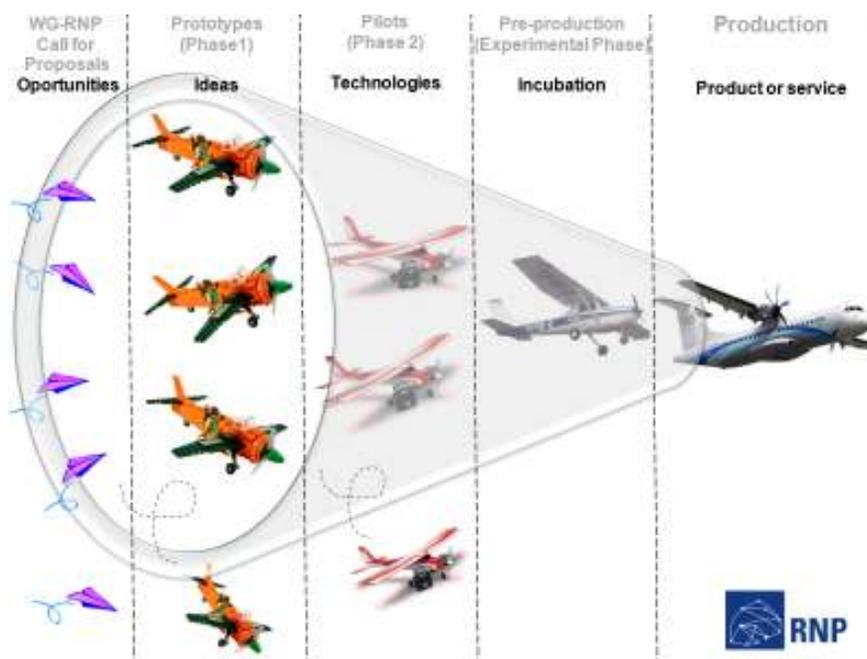

Figure 1 WG-RNP Programme research and developmentprocess.

Each stage of a WG is a 12 month development project, financed by RNP, carried out by a small development team and costing about US$ 85K. If progress towards the prototype after one year is judged promising, renewal for a second year may be conceded, in order to demonstrate the feasibility of a limited product/service (pilot). Starting in 2002, RNP has supported 72 instances of WGs, currently at the rate of 8 per year (see Table 2). The successful demonstration of a pilot by the end of the second year means that the resulting product or service becomes a candidate for an experimental phase the following year, and the final decision to deploy a product or service experimentally will be taken by the board of directors of RNP. Normally a successful experimental phasewill lead to a production product or service. This life cycle is summarised in Table 1. The management of the programme, including the monitoring of the working groups has been carried out by a small but very effective team at RNP.

WG year 1 (Prototype)	WG year 2 (Pilot)	Experimental Phase	Production
• selection through annual Call For Proposals involving research community • 4 projects selected from 21 proposals received in 2012 • WG develops and demonstrates a prototype	• selected through evaluation at end of year 1 • 4 projects from 2012 selected for 2013 • WG develops and demonstrates a pilot	• selected through evaluation of impact, relevance and financial disponibility at end of year 2 • 2 experimental services/profducts in 2012 • deployment normally carried out by RNP staff	• Service/product generally available

Table 1: Life cycle of development and deployment of new services.

The partial results of the WGs are presented to the network research community during the RNP Workshop (WRNP), held in conjunction with the Brazilian Symposium on Computer Networks and Distributed Systems (SBRC) [SBRC, 2012] promoted by the Brazilian Computer Society (SBC) [SBC, 2012]. In 2013, the 14th edition of WRNP will be held in Brasilia, –the national capital, on May 06 and 07. WRNP has been held annually since 1999 and is an opportunity where network experts, researchers and users are invited to discuss innovations in Brazilian and worldwide academic networks.

Since 2002, several themes have been pursued in the WG-RNP, including: Internet telephony, wireless networks,network performance, identity management, collaborative systems, distance learningand others. The table in Table 2 shows the projects that have participated in this programme.

On September 27th, 2012, the WG-RNP selection committee, formed by representatives from RNP, the Brazilian Computing Society (SBC) and the National Laboratory for Computer Networks (LARC) [LARC 2012], selected four new proposals from the 21 received. The list of the selected WGs for the 2012-2013 cycle of the WG-RNP is available (only in Portuguese) in the RNP website [RNP WG Programme, 2012].

Table 2 Historical view of the topics studied in 10 years of the WG-RNP Programme.

2002-3	2003-4	2004-5	2005-6	2006-7	2007-8	2008-9	2009-10	2010-11	2011-12	2012-13
VoIP	Advanced VoIP	Advanced VoIP	Network storage	Virtual Community Grid (VCG)	VCG	Virtual Worlds	Torrent Universe Monitoring (Unit)	UniT	Accessibility as a Service (AAAS)	AAAS
Digital Video (VD)	VD-II	Reliable Multicast	Digital TV	Digital TV	Virtual museums (MV)	MV	Mixed Reality (RM)	Multi-Web conference (MConf)	MConf	Interactive Video on Demand
Videoconf. in education	Configuration	Pervasive grids	Wireless Mesh network (ReMesh)	ReMesh	High-speed transport (Travel)	Travel	Federated Authentication Credentials Transposition (STCFed)	STCFed	My Scientific Cloud (mc²)	mc²
Diretories in Higher Education.	Diretories and Applications	Middleware	Remote Visualization	Distance Learning Infrastructure (IEAD)	IEAD	Federation of repositories of Learning Objects (FEB)	FEB	Wifi AP Controller (SciFi)	SciFi	High-speed transport in dynamic circuits
Quality of Service (QoS)	QoS-II	Measurements (MED)	MED	MED	Distance Learning (EDAD)	EDAD	802.11s mesh with high scalability	Linked Open Data	Cloud for Science (CNC)	CNC
	Public Key Infrastructure for Education (ICP-Edu)	ICP-Edu	ICP-Edu	Automatic Recovery Network Fault (ADReF)	ADReF	Flow-based Monitoring (BackstreamDB)	BackstreamDB	Video collaboration in Health (AVCS)	AVCS	Information-centric networks
	Peer to Peer (P2P)	P2P	Management of Video (GV)	GV	Overlay Service Network (Overlay)	Overlay	Software components for Social Interaction & Collective Intell.	Digital Preservation (DP)	DP	Internet of Things ecosystem
						Digital Media and the Arts (MDA)	MDA	University Bus Network	Monitoring Video Applications (IMAV)	IMAV

Production Service

Experimental Phase

Candidate for future service/product

2.2 Some results of the WG-RNP programme

Services at RNP are usually deployed and managed by the Solutions and Services directorate (DSS), and over the years an increasing number of production services have been generated as a result of the WG-RNP programme, as already indicated in Table 2. In this section, a number of these services are briefly described.

2.2.1 Fone@RNP (Internet telephony)

One of the first services to be deployed as a result of the programme was Fone@RNP, which offers Internet telephony to RNP users, routing phone calls between users by means of the *Ipê* network. This service not only supports voice communication using a VoIP enabled phone (hardware or software) via the Internet, but also integrates telephone switchboards at client institution, making possible VoIP calls from regular POTS terminals. For client institutions, this means potential savings in long-distance calls. Theservice can also support dial-out to the (usually local) public telephone network, when the destination institution completesVoIP calls and is prepared to absorb the calling fees involved. Fone@RNP uses the SIP protocol for call signalling and can also support H.323. Currently, the service connects about one hundred and twenty (120) institutions.

2.2.2 CAFe (Identity Federation)

In 2002, RNP established a WG on directories, in order to evaluate how this technology could be used in the context of academic networks. From this initial study another WG evaluated the challenge of organising academic information in one harmonised and integrated directory, in order to support digital identity, and developed a set of tools to enable an institution to build a trusted Identity Provider. In 2007, work began on deploying anidentity federation for R&E institutions in Brazil. Through this federation, a user keeps all identity information at the home institution and can access services offered by other institutions participating in the federation. Thus was born the service called CAFe – Federated Academic Community. Since the service was launched in 2011, it now includes thirty-four (34) Identity Providers and four (4) Service Providers, including the Periodicals Portal administered by the CAPES education agency, which provides access to an extensive digital library of scientific periodicals and databases for postgraduate and research users [CAPES 2012].

2.2.3 Video@RNP (CDN)

Another successful example of building a platform for community education and research in the through WG-RNP was the project WG-Digital Video. Beginning in 2002 from the need to build a low-cost Content Delivery Network platform, this WG developed a system to distributed content using a set of distributed servers as an overlay network, routing the content from the source to the destination using application layermulticast. Associated with this system another WG developed a digital video portal that allows storage and retrieval of content. This platform is also used to perform live video transmission as well as the exchange of digital content between university TV stations. Video@RNP service is available to all users of RNP [Video@RNP 2012].

Since 2010 RNP has launched three different production services as results of previous R&D cycles as working groups. The following three subsections highlight three services with different periods of maturation: with durations of six years, three years and one year, respectively.

2.2.4 ICPEdu (PKI for Education)

ICPEdu (Public Key Infrastructure for Education and Research) is a production infrastructure that enables a trust chain of security for Brazilian R&E institutions. Being part of ICPEdu enables an institution to issue its own digital certificates and security keys,used as identity credentials or for issuing electronic signatures.

A remarkable milestone of the ICPEdu initiative was the adoption of its Hardware Security Module (HSM)for use as the official HSM in the Brazilian government's own PKI (ICPBrasil).Today the HSM developed by RNP has been certified internationally. The two PKIs, ICPEdu and ICPBrasil, complement each other:ICPEdu has been developed by RNP with the collaboration of R&D institutions, and ICPBrasil is used by organisations that require legal compliance and validity of their digital certificates.

The current ICPEdu production service is a consequence of thecombination of several R&D results generated during a exceptionally long development cycle conducted by RNP with the collaboration of researchers from UFSC, Unicamp, UFMG, UFF and LNCC. The mainstream R&D was funded between 2003 and 2009,after which RNP provided training and guidance on ICPEdu adoption to more than 25 different R&E institutions from all over the country.

Governance of the service is provided through a Steering Committee, that deals with policy and clientrequirements,and a Technical Committee, that coordinates long-term technology prospection and the Identity and Access Management (IAM) scientific community. Both committees are maintained by RNP and include staff from both the service and R&D sectors of RNP.

2.2.5 Videoaula@RNP

Videoaula@RNP provides an infrastructure to store and distribute interactive audio and video content in the format of a video class using storage and communications infrastructure provided by RNP in partnership with some PoPs (Points of Presence) distributed across the national backbone network.

A video classuses a container and aggregator format, based on Flash technology, originally created as a prototype of the earlier EDAD (Distance Education) working group in 2007. Its main component is video, synchronized together with slides and some other components, that may offer asynchronous interactions between professor and student during the course of a video class. The EDAD project also developed a publishing tool that allows content providers to upload their video classes to the service by putting together the different components from which it is formed.

During its WG phase, EDAD evolved as a pilot project involving some RNP partners (UFRJ, CEDERJ and UFJF) in 2009. Later, in 2010, EDAD had its was deployed as an experimental service with the collaboration of a larger number of RNP clients (IFES, UTFPR, UFPR, UFVJM, UFJF, UFAM, MAST, among others).

Finally, in July 2011 EDAD was transitioned to a production RNP service, renamed as Videoaula@RNP.

2.2.6 eduroam

The main goal of eduroam (Education Roaming) is to support a secure authentication service for providing transparent and easy wireless access for academic users from any of the participating institutions, even when they are visiting other collaborating institutions.

Between June 2011 and June 2012 RNP funded and managed a pilot project to setup eduroam infrastructure, governance and an experimental service in Brazil. Several Brazilian institutions (UFF, UFRJ, UFMS, UNICAMP, UFES, UFMG, UFRGS, UFPA, among others) collaborated with RedCLARA-connected institutions from Peru, Chile, Costa Rica e Venezuela and with RNP to define, setup, deliver and test eduroam security wireless technology.

The results of this R&D project were transferred to RNP's portfolio and were launched as a production service in August 2012.

2.2.7 MonIPÊ – perfSONAR multidomain end-to-end performance measurement

The MonIPÊ Service is the infrastructure for multidomain end-to-end monitoring deployed in RNP's*Ipê*backbone network, based on the perfSONAR ("**Perf**ormance focused **S**ervice **O**riented **N**etwork monitoring **AR**chitecture") framework [perfSONAR 2012]. The MonIPÊ service offers to RNP users a monitoring environment of network performance metrics that are collected, processed and offered for user consumption by way of web-based tools that present performance statistics and reports on demand. Any qualified user organization connected to any of the PoPs or metropolitan networks can become a user of the service. The multidomain nature of the service also allows use by end users from other NRENs, to request network performance information for traffic that terminates in or passes through the RNP domain.

In the past many tools have been created to perform measurements in IP networks, but these have usually focused on certain metrics. perfSONAR aims to bring together information in order to provide a complete picture of a network.

The variability of network monitoring is an issue particularly in multi-domain environments. For example, in the collaboration of research backbone networks, perfSONAR targets to hide the differences among the domains to provide an end-to-end view (or at least an edge-to-edge view). For instance, a researcher connected to a local area network (LAN) on a campus would like to transfer data to another researcher connected to a LAN in another country. The connection between these two usually makes use of both LANs, perhaps regional networks, national research backbone networks, and international research networks, so that a lot of administratively independent domains are involved. In case of a performance problem (e.g. low throughput on the connection) it is difficult for the researchers to determine precisely where the problem may be located in the network (assuming that it is not an application issue). perfSONAR aims to collect information from the domainsinvolved.

MonIPÊ aims to support the following user groups:

- Network end users
- Participants in such international projects as the Large Hadron Collider (LHC), Enabling Grids for E-sciencE (EGEE), or Distributed European Infrastructure for Supercomputing Applications (DEISA)
- Members of Network Operation Centres (NOCs) and Performance Enhancement and Response Teams (PERTs)

- Administrative network staff

The MonIPÊ service infrastructure was deployed across all RNP backbone PoPs starting in 2008, when the project distributed a hardware set containing a GPS synchronization hardware kit and two servers for active measurements and data collection.

MonIPÊ is capable of offering a large set of monitoring data, including:

- one way and round-trip latency, jitter and packet loss (using the OWAMP, ping and powstream tools)
- end-to-end achievable bandwidth for TCP and UDP
- end-to-end Monitoring Measurement Point and Measurement Archive (E2EMon MP and MA). These services collect data for multi-domain circuits which are composed out of segments. For the segment an abstract status with the values up and down is determined from hardware vendor-specific information. The status data are composed to derive end-to-end status data.

3. RNP Advanced Internet Programme

This programme was established in 2008, firstly to carry out prospection, together with RNP's more demanding users,of new services, especially those to be used in their international collaborations, and also track the evolution of the service offerings of international academic networks, to ensure that the RNP services offer similar degrees of innovation to those offered in other countries. The results of this programme serve as a basis for the planning of the next generations of the RNP network.

This programme takes a different approach to WG-RNP, and consists of collaboration projects with research groups in specific themes selected by RNP, as a result of the prospection activities.Initially the programme was named "Future RNP",however, in 2011, it was renamed "Advanced Internet".

The scope of the Advanced Internet Programme in 2012 includes four areas: user communities and their application demands; network architecture and technologies; user applications support (Middleware); and advanced applications. This separation reflects the relationship between the results generated by projects each theme, of which there were several in 2011, from which we can highlight:

- Advanced Applications for Remote Visualisation
- Dynamic Circuit Provisioning
- Monitoring Technical Committee (CT-Mon)
- Education Roaming (eduroambr)
- Identity Management Technical Committee (CT-GId)

3.1 Advanced Applications for Remote Visualisation

In July 2009 RNP provided network support for a unprecedented demonstration at the FILE (Electronic Language International Festival) event, where a 4K feature film was simultaneously streamed from Brazil to the US and Japan [FILE 2009]. This was also accompanied by an HD video-teleconference (VTC) between the three sites. This was the first time a feature length 4K

film was streamed across three continents and the first uncompressed HD VTC between the northern and southern hemispheres.

Since then RNP has continued to participate in and promote demonstrations related to streaming very-high-definition content over networks. However, working with such a high-resolution media requires the usage of specialized equipment, which, until recently, were not available for the consumer market. Even today, only a few companies are able to manufacture 4K projectors and players. Usually such equipment is very expensive and unavailable in developing markets like Brazil.

In addition to high prices of equipment, shipping costs and import taxes in Brazil add to the costs, doubling the price. This has led RNP to foster the development of a national technology for 4K equipment. To do so, a new programme called "Advanced Applications for Remote Visualization" was created in 2011 [VRAA 2012]. Three Working Groups were funded to develop three complementary parts of a 4K-chain: WG1 (player and streamer), WG2 (exhibition and collaboration) and WG3-(content production).

The WG1 was in charge of developing a low-cost 4K player and streamer, using consumer-based equipments available in the market. WG2 had the mission to figure out other ways of displaying 4K content other then using projectors. This WG based their solution on tiled display walls controlled by the SAGE middleware [SAGE 2012]. WG3 provided the last piece of the chain: a very-high-resolution content to be streamed and displayed.

As a CineGrid member [CineGrid 2012], RNP could have borrowed some 4K content from the CineGrid media repository in order to perform tests with our new 4K playerprototype. However, it was decided to create our own content by producing and shooting a short 4K-3D movie. Named "StereoEssays: Five or six stereoscopic essays in search of a narrative" [StereoEssays 2011], this 15-minutes movie was the first of its genre in Brazil. It was shot in Rio de Janeiro using the latest RED Epic camera, rented from a company in Los Angeles. In addition to its use to test the 4K player prototyped by WG1, the StereoEssays movie was invited to participate in several exhibitions and film festivals worldwide.

In 2012 and 2013 the Remote Visualization working groups will continue to work on enhancing the prototypes created in 2011. In particular, for what concerns WP1, the "low-cost" 4K player, known as "Fogo", is being prepared to go into production by equipping a dozen movie theatres maintained by universities. Several experiments still need to be carried out, but we are confident that this technology has the potential to be used in other world regions.

3.2 Network Architecture and Technology

In 2011 the deployment began of an experimental service for Dynamic Circuit Provisioning.This activity would culminate in the launch of the Cipó Experimental Service (SE-Cipó) over the RNP backbone, reaching 15 user institutions – including Points of Presence, metropolitan networks, regional and campus networks. Five R&D groups from universities and research centres participated in this project, in addition to the participating PoPs, which provided collaboration support.

During the GLIF workshop held in Rio de Janeiro in September 2011, the SE-Cipó team carried out a demonstration of dynamic circuit configuration between universities in Brazil and in the

United States. A number of management, provisioning and monitoring tools, some of them already available and some developed by the project team, were used in this demonstration.

Most of the planned results have so far been successfully achieved. A number of issues in the documentation and the refinement of the software systems as well as with the operational procedureswere identified and fixed. SE-Cipó has been deployed in five PoPs (Pará,Santa Catarina, Rio Grande do Sul, São Paulo and Rio de Janeiro) and also in the metropolitan network of Florianópolis, SC. Besides that, the service interoperated with the corresponding ION service of Internet2 network in the US, and two of their user organizations participated in the demonstrations. In 2012, SE-Cipó was extended to include three more PoPs (Espírito Santo, Bahia and Ceará), four universities (UFPA, UFSC, UFRGS and USP) and also the MetroBel metropolitan network at Belém, PA. Other activities to be developed will be the planning for the production service model of operation and the handover to the internal areas of RNP that will be responsible for the deployment and operation of the production service, as well as the marketing and dissemination for end users.

In October 2012, SE-Cipó was also used in another international demonstration during the GENI Engineering Conference (GEC15), connecting Emulab sites at the Universities of São Paulo and of Utah, in Salt Lake City.

3.3 Support of User Applications

The main areas of interest are Identity Management and Monitoring. The first is due to RNP'sinvolvement in the development of trust federations and digital certification, and the latter due to involvement in the development and use of the perfSONAR framework.

Two Technical Committees were created, respectively,for Network Monitoring (CT-Mon) and Identity Management (CT-GId), to follow further advances in the development of these middlewares, and to ensure that RNP will be tracking developing standards being adopted by other NRENs,guaranteeing that the services will interoperate at a global level.

CT-Mon has the objective of following and collaborating with the evolution of the perfSONAR platform, to support RNP in the technological evolution of the Interdomain Monitoring Service MonIPÊ deployed in the backbone.In addition, CT-Mon collaborates with the international effort to standardise and develop this environment, through the prospection of networks monitoring technologies and the alignment of Brazilian efforts with other international actors.

4. RedCLARA Working Groups Programme

In 2005, the RedCLARA technical community created a Working Groups (WGs) programme, aimed at the exchange of knowledge between the participating networks, encouraging collaborative R&D within the community and thecoordination and/or integration of ongoing activities. Several challenges were encountered in building this collaboration, due toseveral differences between the different national networks in the RedCLARA community, such as their size and national penetration, number of institutions served, legislation (for instance, concerning VoIP), culture, and network management development. Despite these difficulties, the result of this work has been very positive.

The goal of these groups in the early years was limited to coordinating the discussion of important issues in building academic networks in each country, where the more experienced

networks assisted those with less experience in the creationof their services. Groups were created on the following topics:Measurements, Routing, Security, IPv6, Multicast, VoIP and Videoconferencing.

It is important to observe that all this work was done collaboratively, without any funding,except for travel assistance from the ALICE and ALICE2 projectsto enable the participation of the WG coordinators at twice yearly RedCLARA technical meetings. All collaborative work is carried out through electronic mailing lists, wikis and Webconference.

In 2009, RedCLARA published a call for proposals, inviting researchers to collaborate with this programme. The idea was to advance by introducing new services for the RedCLARA NRENs. The groups established are listed in Table 3.

Table 3: RedCLARA working groups 2009-2011

Working Group	Coordinator
WG IPTV	RENATA (Colombia)
WG Videoconference	RAAP (Peru)
WG eduroam	RAAP (Peru)
WG Security	RNP (Brazil)
WG Measurements	RNP (Brazil)
WG IPv6 services	CUDI (Mexico)
WG Hybrid Networks	CUDI (Mexico)
WG VoIP	RNP (Brazil)
WG Training	RedCLARA

Table 4: New RedCLARA working groups selected in 2011

WG name	Objective	Coordinator
WG-SCIFI - Intelligent control system wireless networks	To develop an open platform for centralized control of access points.	RNP/UFF (Brazil)
GT- PIT VOIP | Internet Exchange Point Voice over IP	Modeling and implementing a traffic exchange point of VoIP in RedCLARA through the interconnection of the telephone networks of the NRENs.	RNP (Brazil)
GT-MOF | Mobility with OpenFlow	To promote research and development of a solution capable of providing mobility to Wi-Fi network users using technologies such as Wireless OpenFlow and IPv6	RNP/UFRGS (Brazil)
GT - Measurements	Development of a monitoring infrastructure based on perfSONAR	RNP/UFPE (Brazil)
GT - MCONF| Multiconference system for the interoperable access to Web and mobile devices	To provide a web conferencing system easy to use, that integrates with mobile devices through the creation of an application for Android and the development of an integrated management system on the web.	RNP/UFRGS (Brazil)
GT-IPTV	Implement and produce in the NRENs an IPTV transmission platform that allows IPTV to provide a multichannel IP-TV through RedCLARA with multicast and IPv6 support.	RENATA/Unicauca (Colombia)
GT-DEIM-IPV6	and implementation of activities - projects that enable the design, planning and finally the establishment and implementation of IPv6 in the network segments that are referred to RedCLARA	CUDI/UNAM (Mexico)

	services and applications, and also of the member NRENs.	
GT-CSIRT | Computer Security Incident Response Team	To implement a monitoring infrastructure for RedCLARA with sensors to obtain data about malicious activity and with this information generate notifications of security incidents. Promote agile and coordinated security incident response. Create and disseminate security best practices, focused on academic environments.	RNP (Brazil)
GT-Movilidad | Mobility	Apply middleware and mobile networks technologies and to provide roaming services in RedCLARA secure architectures.	RAAP/ INICTEL-UNI (Peru)

As positive results of this cycle we can mention:

1. the creation of the service SIVIC Multiconference, the first service implemented by RedCLARA in collaboration with Latin American NRENs, which provides a system to organise multipoint videoconferences in different countries, allowing all participants to book their own videoconference rooms in the region;
2. the WG Measurement created a pilot measurement network using perfSONAR among some Latin American NRENs and GEANT;
3. RedCLARA now belongs to the eduroam community based on the work of the WG Eduroam/Mobility;
4. the pilot service PIT-VOIP provides peering between VoIP networks;
5. the expansion of IPv6 services in Latin American academic networks was accomplished through the dissemination carried out by WG IPv6.

In 2011 another call for proposals was published, and new groups were selected (see Table 4),even though some of the new groups are continuing the development of work begun in the previous one.

These choice of these new working groups has demonstrated the maturity of the community in the search for new services and advanced applications to offer their users through this collaboration.We are closing a cycle of reviews in November, 2012, during the next semiannual meeting of RedCLARA in Cuenca, Ecuador.

5. Conclusions

The motivation for the work described here has always been to improve the service offerings provided by RNP, by capitalising on the capacity of the national network and distributed systems research community to develop innovative solutions. Many of these have been motivated by the desire to interoperate with new services and models continually introduced in leading R&E networks throughout the world, and it is a tribute to our development teams that such interoperation has greatly increased in recent years.

The situation is somewhat different within the RedCLARA community, as most of the participating NRENs have neither the scale nor the human resources of their Brazilian counterpart. This situation may explain the extensive involvement of RNP and its associated researchers from academia in RedCLARA's technical development.

Perhaps the major message here is that RNP's initiative of promoting local development of Internet services has value, not only for Brazil, but also for R&E networks in other countries, both in providing an example of what can be achieved, but also cooperating with such networks in Latin America to contribute to their development.

This article has attempted to describe the results of close collaboration between the the Brazilian NREN, RNP, and the network and distributed systems research community in Brazil, in the joint development of advanced Internet services. This collaboration has a long history – several of the community members involved in the recent development activities described here were already actively involved in the deployment of the first academic networks in Brazil between 1988 and 1992. However, it must also be recognised that new generations of computer science researchers continue to be drawn to the challenges of computer networking and its applications, and that is also the case in Brazil, where most of the proposals received by RNP for new services now come from younger generation scientists. This is indeed a good reason to be optimistic about the future.

References

CAPES(2012) CAPES Periodicals Portal. http://www.periodicos.capes.gov.br/ [accessed 3 November 2012]

CineGrid (2012) CineGrid. www.cinegrid.org [accessed 4 November 2012]

Margolis, T., et al.(2009)"Tri-continental premiere of 4K feature movie via network streaming at FILE 2009". Future Generation Computer Systems, v. 27, p. 924-934, 2011.

LARC(2012) 'National Laboratory of Computer Networks' - LARC.http://www.larc.org.br[accessed 31October 2012].

perfSONAR (2012) perfSONAR. http://www.perfsonar.net/[accessed 3 November 2012].

RNP WG Programme(2012) RNP Working Groups Programme.http://www.rnp.br/pd/gt.html[accessed 31October 2012].

SAGE (2012)Scalable Adaptive Graphics Environment, University of Illinois at Chicago. http://www.evl.uic.edu/core.php?mod=4&type=1&indi=281)[accessed 4 November 2012]

SBC (2012)Brazilian Computer Society –SBC. http://www.sbc.org.br/en/[accessed 31October 2012].

SBRC (2012)Brazilian Symposium on Computer Networks and Distributed Systems-SBRC.http://sbrc2013.unb.br/?lang=en[accessed 31October 2012].

StereoEssays (2011)"StereoEssays: Five or six stereoscopic essays in search of a narrative". http://www.estereoensaios.com.br/ [accessed 4 November 2012]

Videoaula@RNP (2012)http://edad.rnp.br/[accessed 30 October 2012].

VRAA(2012) Advanced Applications for Remote Visualization.http://wiki.rnp.br/display/vraa[accessed 4 November 2012]

Biographies

Michael Stanton is Director of Research and Development at RNP. After a PhD in mathematics at Cambridge University in 1971, he has taught at several universities in Brazil, since 1994 as professor of computer networking at the Universidade Federal Fluminense (UFF) in Niterói, Rio de Janeiro state. Between 1986 and 1993, he helped to kick-start research and education networking in Brazil, including the setting-up and running of both a regional network in Rio de Janeiro state (Rede-Rio) and RNP. He returned to RNP in 2001, with responsibility for R&D and RNP involvement in new networking and large-scale collaboration projects.

Iara Machado is Associate Director of Advanced Internet at RNP. This involves designing RNP's future offering of its network services. Before this she coordinated working groups related to Advanced Application projects. Iara has also worked for more than 19 years at the former state-owned long-distance telecommunications company as a Management System Architect acting in the specification, development, acquisition and implantation telecommunications network area. Iara Machado graduated in Physics from the UFRJ - University Federal of Rio de Janeiro and has a Master's Degree in Computer Science from UFF - University Federal Fluminense. She also has a MBA from UFRJ.

Daniela F. Brauner received her DSc in Computer Science from the Catholic University of Rio de Janeiro (PUC-Rio) in 2008 and now she is working at RNP managing the RNP Working Groups Programme on the coordination of R&D projects in topics concerning network technologies and applications.

André Marins received his MSc in Computer Science from the Catholic University of Rio de Janeiro (PUC-Rio) in 2008 and he now works at RNP coordinating R&D projects in topics concerning network technologies and applications.

Alex S. Moura has been manager for testbed networks at RNP since 2011, where he is involved in network projects in the Advanced Internet Programme and Future Internet research. He first joined RNP in 1995 as a systems administrator. In 2002, after two years working in large scale datacentres, he returned as senior network engineer to RNP and RedCLARA. He received an MSc in Information Systems from Universidade Federal do Estado do Rio de Janeiro (UNIRIO) in 2009., and has been teaching and lecturing since 2004 as professor of Computer Networking at local Universities in Rio de Janeiro.

Leandro N. Ciuffo is manager for scientific communities and advanced applications at RNP. Since 2006 he has also been working in several international projects related to e-science, with responsibilities for dissemination and user support. Leandro holds a MSc in Computing from the Universidade Federal Fluminense (UFF).