Research and Education Networking in Latin America: a Time of Change

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Abstract

- Since 2004, when RedCLARA was deployed as the first Latin American regional network, there have been significant infrastructure developments in some of the national networks, as well as in RedCLARA itself, mostly due to the use of optical transmission systems. This presentation describes some of these developments and the impact they are having on advanced applications and collaboration.

Notes:

- The population of Latin America is around 600M (10% of world), and there are some 750 universities and significant sites relevant for international scientific activities, especially in astrophysics, high-energy physics, climate and environmental studies.
- Distances are very great (region diameter ≈ 10,000 km).
- We use here LA here to mean “Latin America” or “Latin American”

The international networking context

- Around the year 2000, international Research and Education (R&E) networking was beginning to reorganise itself in function of great increases in transmission capacity due to the adoption of optical networking, the so-called “advanced networks”.
- At this time the US networks were still at the centre of worldwide academic networking, especially after the creation of Internet2 (around 1996), and it became desirable for R&E networks to seek to become “advanced” and to link up to similar networks around the world to support advanced collaboration activities.
- There thus grew up a dichotomy in international academic communications between the use of two sets of networks:
  - the **commodity** Internet networks
  - direct **collaboration** between the advanced R&E networks
- Except for México, all of LA used commodity connectivity for all international traffic before 2001.

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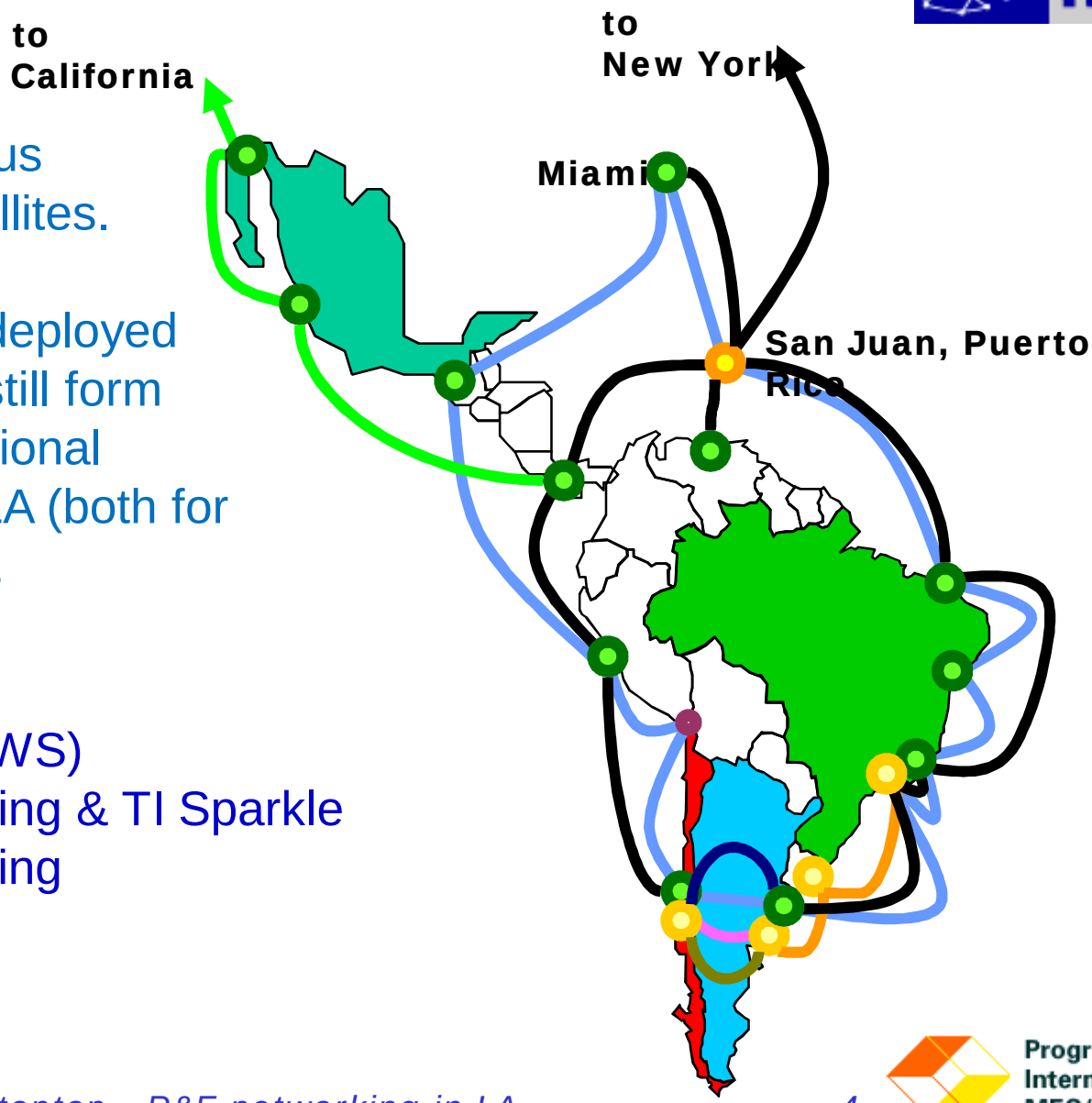
High-capacity Optical Cables in LA

Replaced the previous dependence on satellites.

These cables were deployed around 2000. They still form the basis for international communications in LA (both for commodity and R&E collaboration traffic)



- E-mergia (TIWS)
- Global Crossing & TI Sparkle
- Global Crossing
- ImpSat
- Transandino
- UniSur

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R&E networks in LA in 2004

- Only in Argentina (AR), Brazil, Chile (CL), Costa Rica (CR), Mexico (MX), Uruguay (UY) and Venezuela (VE)
  - Most other LA countries had created academic IP networks between 1992 and 1996, but most of these had disappeared or become commercial networks by then.

- Examples of national backbone networks:
  - Brazil: 14 ATM nodes and 13 Frame Relay nodes (links ≤ 25 Mbps) plus access and metro networks in some states
  - Chile: ATM (10 nodes, links ≤ 60 Mbps)
  - Mexico: Sonet/SDH (20 nodes, links ≤ 155 Mbps)

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Advanced Int'l R&E Connectivity in LA before 2004: US as the hub for LA

AmPath (Florida Int'l U) from 2001

- used Global Crossing
- connections Argentina, Brazil (2), Chile, Venezuela
- 45 Mbps (one size fits all)
- connections are point to point from Miami

Mexico from 1998

- cross-border connections to USA (TX and CA)

Brazil from 2000

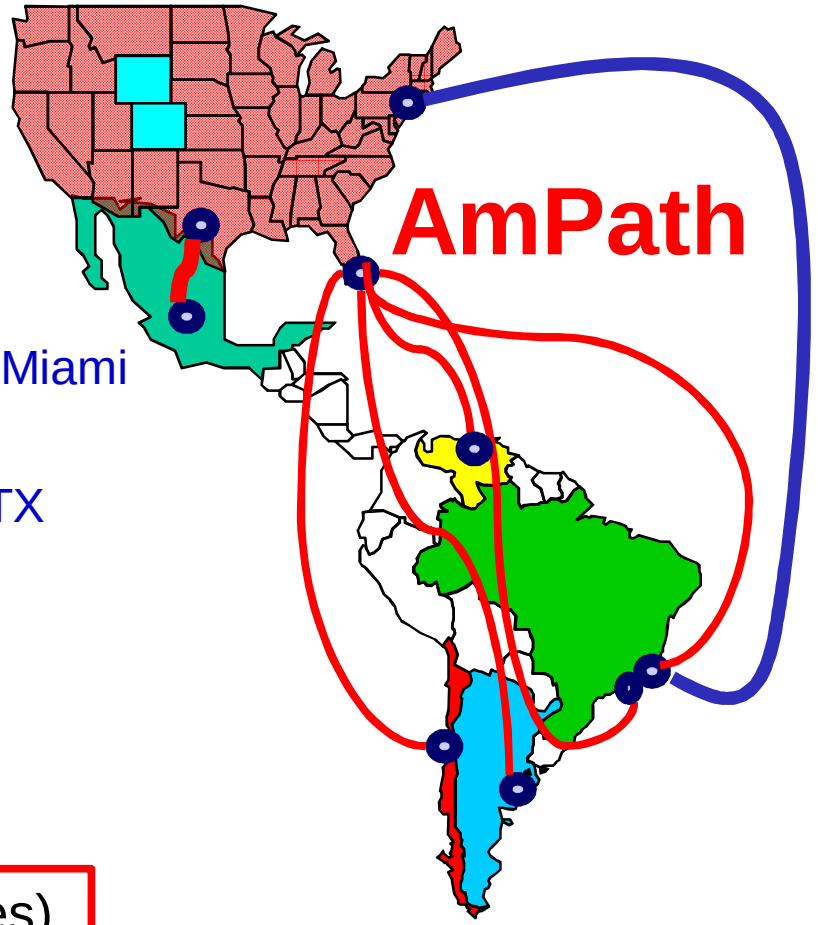
- 155 Mbps link to NYC (commodity)

Other R&E networks

- used Int'l commodity providers

All int'l links to US (just like satellites)

No direct links between LA countries



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An alternative paradigm: Pan-European R&E networking

- In Europe, global networking also began with direct BITNET and IP links to the US from separate countries
- Since the early 1990s great efforts were invested in pan-European networking, through the creation of a series of regional backbone networks:
- These networks have been built and managed by DANTE (Delivering Advanced Networking Technology to Europe), with financing by European NRENs and the EU
- Four versions of the pan-European backbone network
  - EuropaNET (1992-1997)
  - TEN-34 (1997-1998)
  - TEN-155 (1998-2001)
  - GÉANT (2002-)

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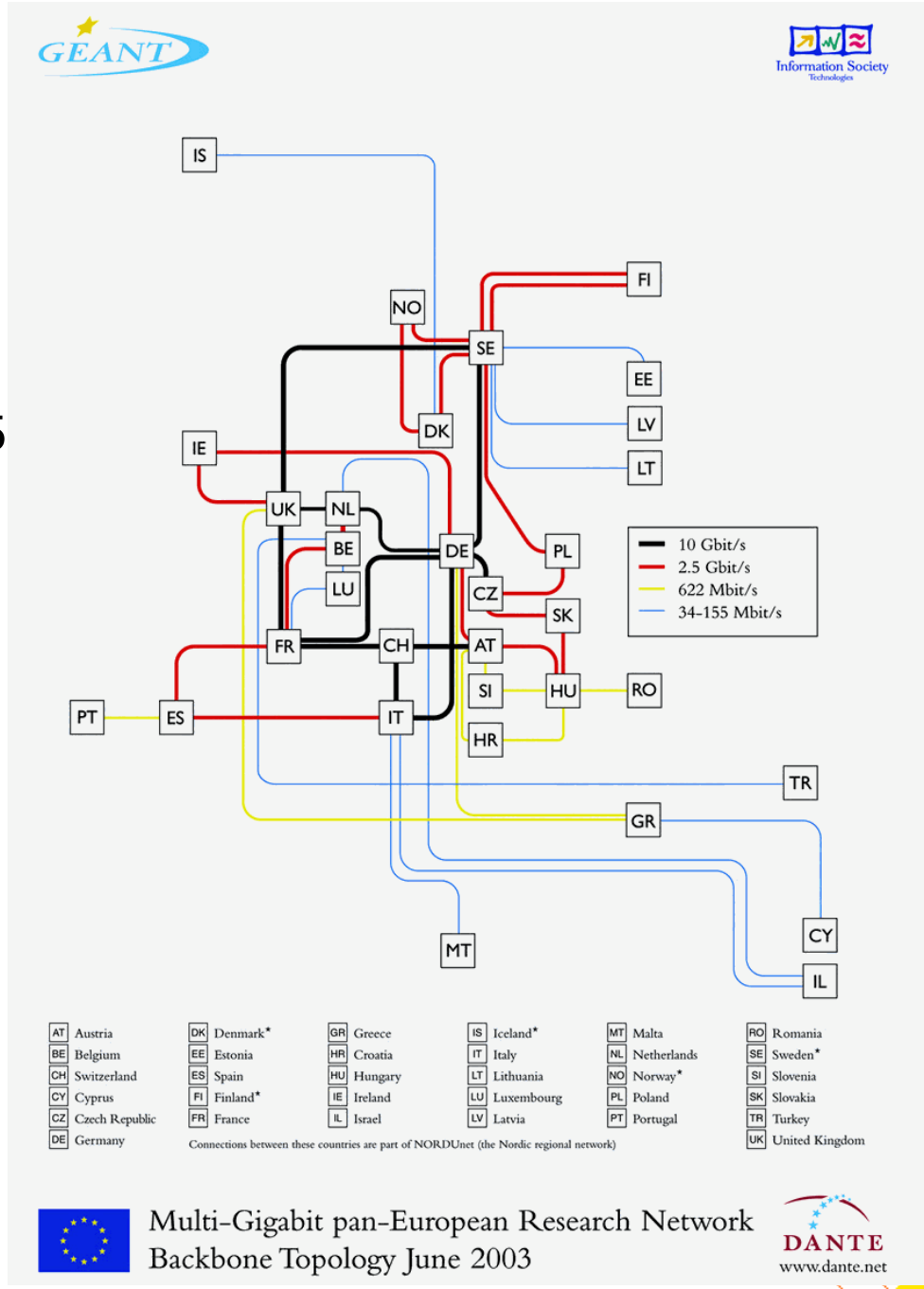
GEANT in 2003

- First network of the “Bandwidth Age”
- 20-fold increase in capacity over TEN-155 for the same cost
- Principal connections were 10 and 2.5 Gbps wavelengths
- When built, it was the largest capacity operational IP network in the world



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The @LIS iniciative (2003)

- Through GEANT, the European R&E community already enjoyed high bandwidth connectivity with N. America
- Initiatives were taken to improve connectivity between Europe and the Asia-Pacific, Mediterranean and Latin American regions, with support from the European Commission :
  - @LIS: Alliance for the Information Society (2003-2005)
    - 62.5 Million Euros for EU-LA on Information Society Issues
    - 10 Million Euros for Interconnecting Europe & Latin American Researchers
- DANTE and the R&E networks from Spain and Portugal organised a workshop in Toledo in 2002, attended by R&E networking leaders from LA, where it was decided:
  1. To create CLARA, a cooperation between different national R&E networking initiatives in LA
  2. Jointly to propose the ALICE1 project to the @LIS programme

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Clara

Cooperação Latino-Americana de Redes Avançadas
Cooperación Latino-Americana de Redes Avanzadas

- Association of NRENs in LA open to all LA Countries
  - constituted in Uruguay (like LACNIC) in 2003
- CLARA not limited to @LIS time scale and restrictions
- Intended to connect LA to Europe and to other regions
- intended to improve connectivity to US by optimising LA participation in AMPATH
- Initial members:
  Argentina, Brazil, Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela
- Expected future members:
  Bolivia, Colombia, Cuba, Dominican Republic and Honduras

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ALICE1 project: building RedCLARA

ALICE1 - América Latina Interconectada Con Europa (2003-2008)

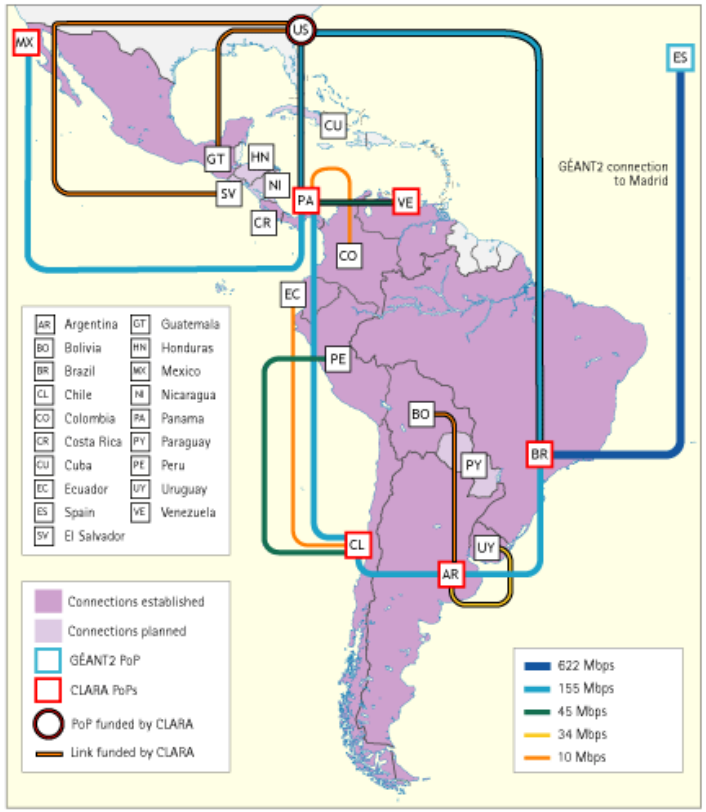
- Coordinated by DANTE, with participation of NRENs from Italy, France, Spain, Portugal and the CLARA countries, and eventually CLARA itself
- Budget: EC 10 M€, CLARA partners 2.5 M€c
- Objective: build a regional R&E network in LA, and link it to GEANT.
- Early achievements:
  - May 2004: RedCLARA network begins deployment, with Network Engineering Group (NEG) at RNP (Brasil) and Network Operations Centre (NOC) at CUDI (Mexico)
  - Nov 2004: first HEP use by Alberto Santoro (UERJ, Brazil) for demo at SC04 (400 Mbps sustained bandwidth) (via Europe)
- Other important results:
  - Deployment of new national R&E networks in 6 countries (Colombia, Ecuador, El Salvador, Guatemala, Panama and Peru)
  - Capacitation of network technical staff at half yearly events
  - Increased LA scientific collaboration both with Europe and US

RedCLARA topologies during ALICE1

2005: Initial backbone ring bandwidth of 155 Mbps (connecting BR-AR-CL-PA-MX)

Initial connection to Europe at 622 Mbps from São Paulo; to US expected via Tijuana.

2007: Incorporates all access links to CLARA partners, as well as WHREN-LILA (NSF IRNC) links to US in Miami (now a RedCLARA node) and San Diego (see later)



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IRNC1 (2004) – US involved globally

- In 2004 NSF launched the International Research Network Connections programme (IRNC), partially to fund connectivity to between the US and other world regions.
- 5 projects were funded including one involving LA, called “Western Hemisphere R&E Network: Links Involving LA” (WHREN-LILA), coordinated by FIU and CENIC, and involving CLARA, national networks from Brazil, Chile and Mexico. and ANSP, the state network from São Paulo (Brazil).
- The principal object was to exploit synergy with the RedCLARA network, providing connections from the US to its points of presence in Brazil and Mexico.
  - Miami-São Paulo: link maintained in collaboration with FAPESP (S. Paulo state agency), initially 1.2 G, later 2.5G.
    (used by ANSP, RNP and RedCLARA)
  - San Diego-Tijuana: cross-border dark fibre (WDM-ready).
    (used by CUDI and RedCLARA)

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Links Interconnecting Latin America (LILA) Year 1

- Increases Miami - Sao Paulo link from 622Mbps to 1.2Gbps
  - Q2 2005
  - Evolving to 2.5Gbps
- Establishes a dark fiber segment between San Diego and Tijuana for a 1Gbps link
  - May 2005
- Enables interregional peerings through east and west coasts

(courtesy Julio Ibarra, FIU)

Network development in Brazil after 2004

- Networks in Brazil have developed significantly since 2004, both in capacity and coverage, with the adoption of optical technologies.
- These are increasingly used in both long-distance and access networks, mainly by RNP, but also in some of the state networks.
- Also great increases in international connectivity, and greater involvement in international collaborations based on networking.

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Project GIGA – optical networking testbed

- Partnership between RNP and CPqD (telco industry R&D center in Campinas, SP: www.cpqd.com.br)
- Original objectives:
  - build an advanced networking testbed for development and demonstration purposes
  - support R&D subprojects in optical and IP networking technology and advanced applications and services
- External participation
  - carriers provide the fibers without cost (technology transfer of products and services to business sector required)
  - R&D community in industry and universities
- Government funding for equipment and R&D activities
  - Phase 1: 2003-2008;
  - Phase 2: 2009- : emphasis on Future Internet (a la GENI, FIRE, etc)

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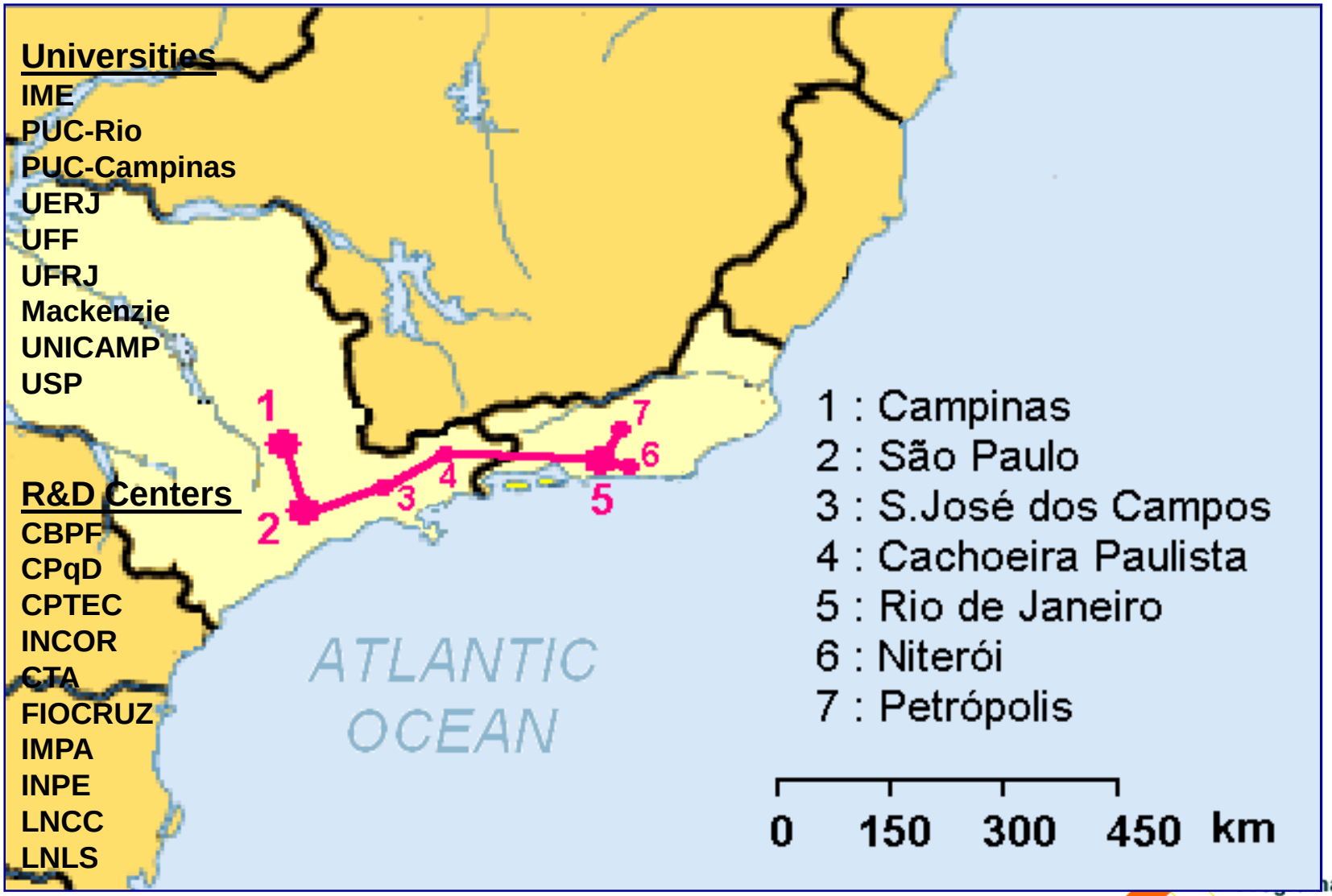
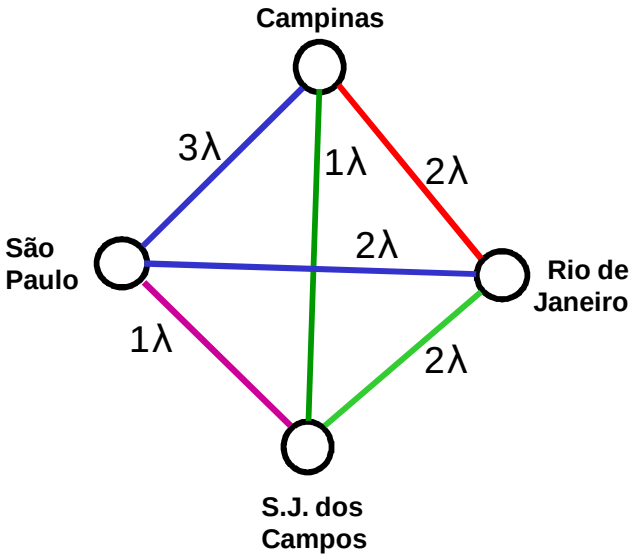
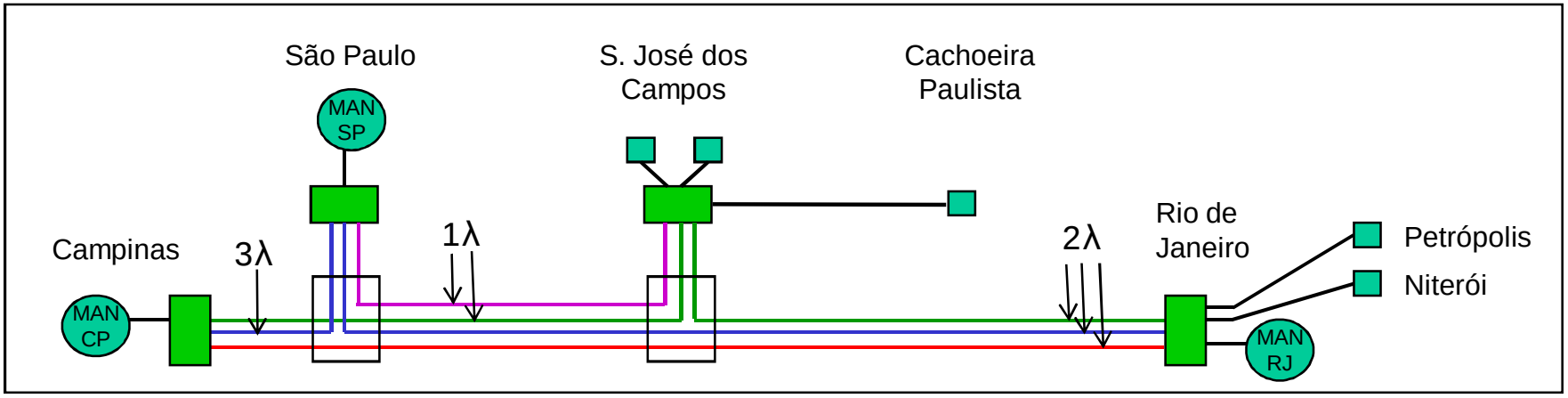
GIGA testbed network (2004-)



Testbed network design

- Initially 2.5G DWDM inter-city network between Campinas and Rio de Janeiro (some 10G waves, 100G in test)
  - up to 6 waves per link (can use 8 or more)
- 2.5/10G WDM metro networks in São Paulo, Campinas and Rio de Janeiro
- all Layer 2 links currently 1/10 Gigabit Ethernet
  - layer 1 equipment from Padtec (Brazil) (www.padtec.com.br)
  - layer 2/3 equipment from Extreme Networks





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KyaTera network (S. Paulo state) 2007 -

- Similar network to GIGA
  - Dark fibre network from carrier (Telefonica)
  - Layer 1 equipment (ROADM) from Padtec
  - Layer 2 equipment (Ethernet) from Datacom
    - 10G channels between São Paulo, Campinas and São Carlos
    - 1G on other links
- External connections to US (WHREN/LILA) and nationally (via RNP networks)
- Research program includes network development

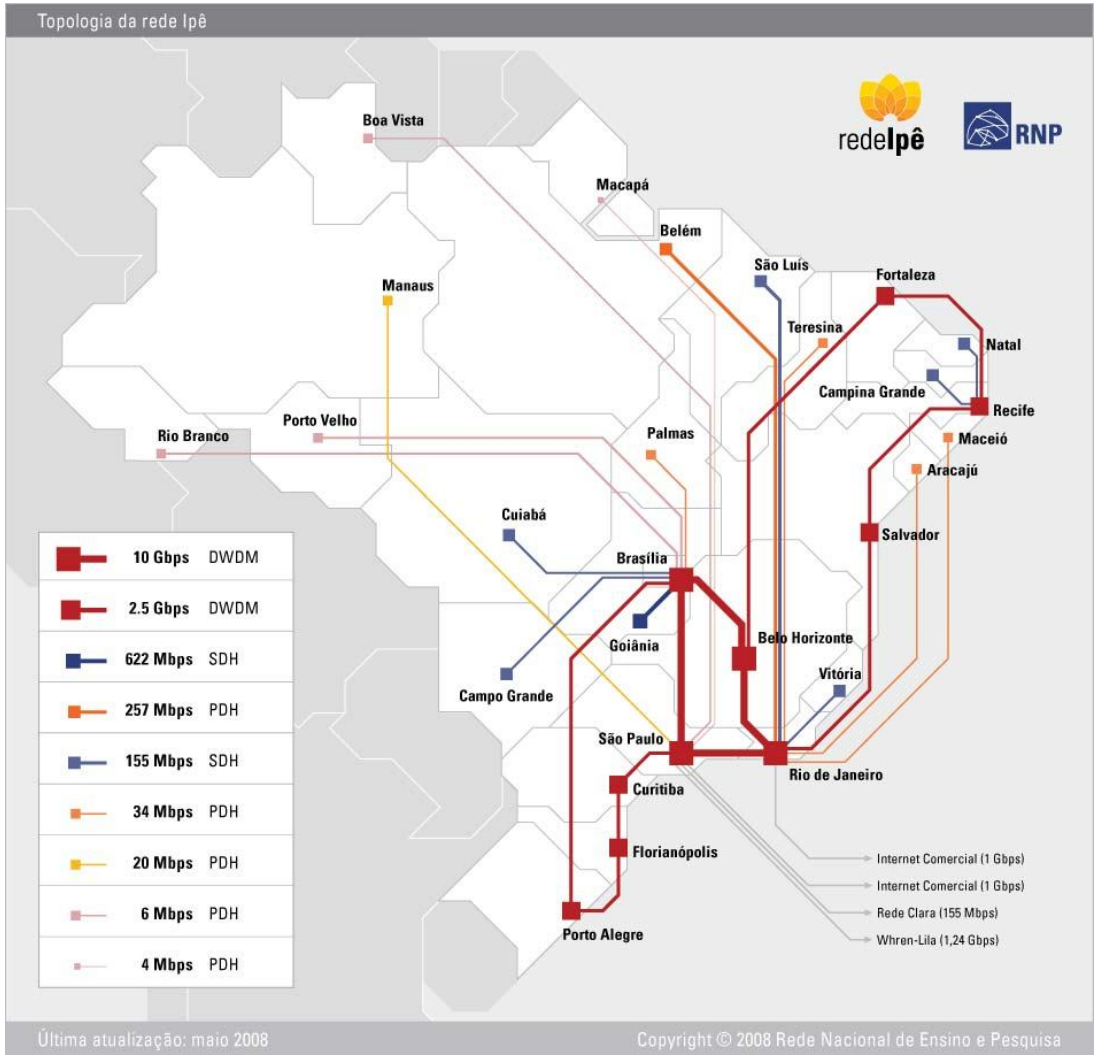
KyaTera research network in 2010

IPÊ –
RNP's national R&E backbone network

Major upgrade in 2005
- Next one in 2011 (next slide)

Capacity reflects available and affordable carrier infrastructure

Composed of:
- Multigigabit core network
  - 4 PoPs at 10 Gbps, and 6 PoPs at 2.5 Gbps
  - IP over lambdas (12.000 km)
- Terrestrial SDH connections to 15 PoPs
  - Most links are 34 Mbps
  - Manaus at 20 Mbps
  - Some upgrades to 155, 257 and 622 Mbps
- 2 PoPs connected by satellite at 4 and 6 Mbps



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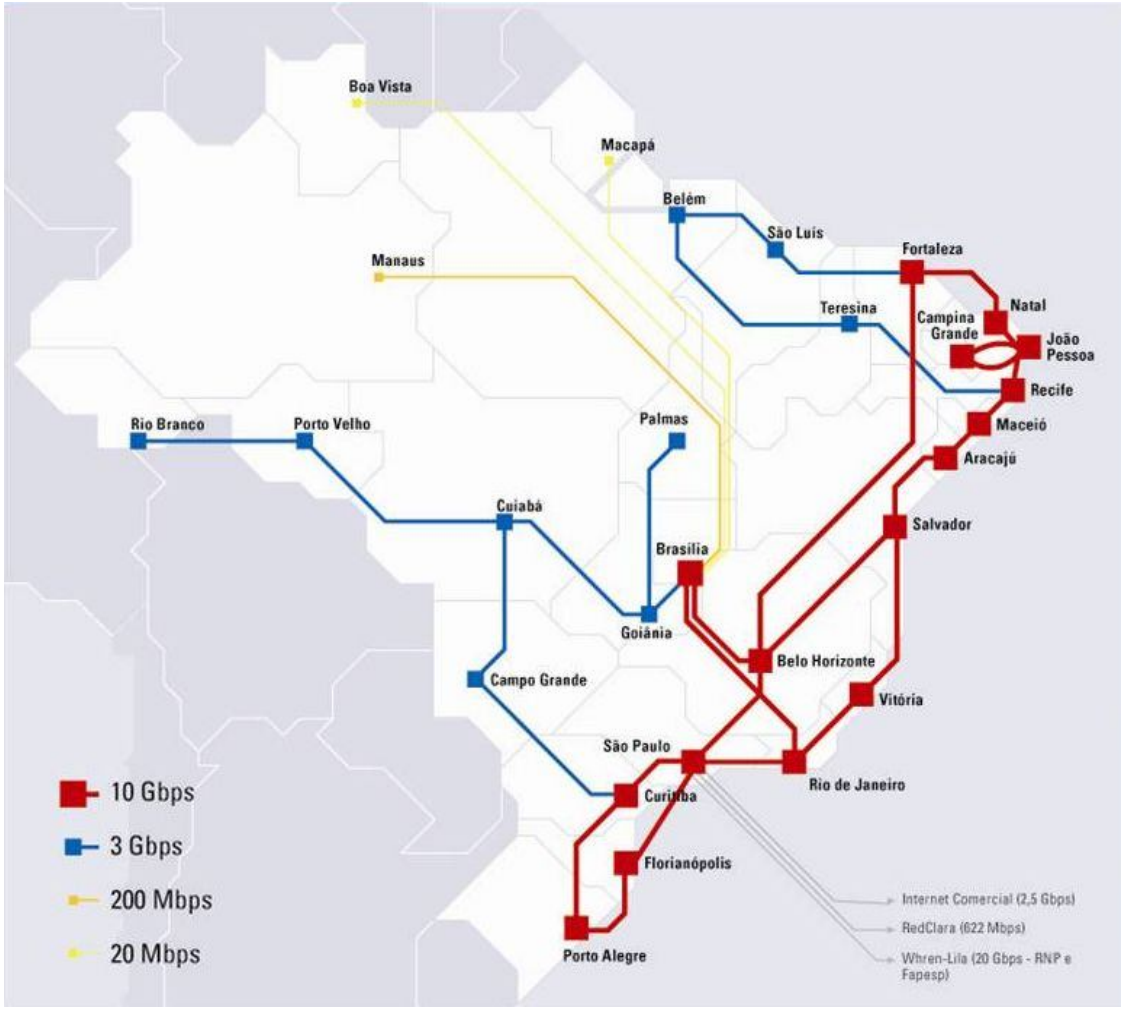
National backbone 2Q2011



- Agreement with local telco Oi, brokered by regulatory agency
- 3 and 10 Gbps to reach 24 of 27 capitals
- Currently no fibre to last 3 capitals (2013?)
  - 2 terrestrial links
  - 1 satellte link
- Hybrid architecture, supporting routed IP and e2e circuit traffic

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2009 US-Brazil link upgrade to 20Gbps

- Since 2004-5 RNP and ANSP used international connectivity:
  - RedCLARA: general collaboration traffic (155M)
  - WHREN-LILA: includes RedCLARA link + separate high-volume collaboration traffic (HEP, etc) (on request)
  - Several Gbps of commodity transit in Brazil via int'l ISP
- In 2009, RNP and ANSP adopted new model for link to US
  - Carry commodity and R&E traffic on same link
  - Buy commodity transit in US (much cheaper)
  - With savings invest in larger pipe to US
- Result: upgrade to 20 Gbps of S. Paulo-Miami link
    - 10 Gbps (FAPESP + IRNC1+2) a.k.a. ANSP link - (1+0) protection
    - 10 Gbps (RNP) - unprotected
    - thus: 5 G protected and 15 G unprotected (to be upgraded in 2011)
  - 2 links jointly managed by RNP and ANSP

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Last mile access: optical metropolitan networks

- Since 2004, RNP program of metropolitan networks, to provide adequate access to the multigigabit IPÊ network
  - Model influenced by Canarie and Surfnet experiences
  - Funding provided by S&T ministry, plus from state and city governments and private R&E participants
- Networks are based on overprovisioned dark fiber networks, shared between the R&E institutions served
  - Usually built and owned by RNP (fibre leased in 2 cities)
  - Use 1 or 10 GE transport and permit:
    - interconnection of the campi of the participating institutions
    - access to RNP´s IPÊ network PoP
- 1st network operational in 2Q2007
  - 21 networks already operational
  - all 27 capital city metro networks by end 2011
  - programme being extended to other cities

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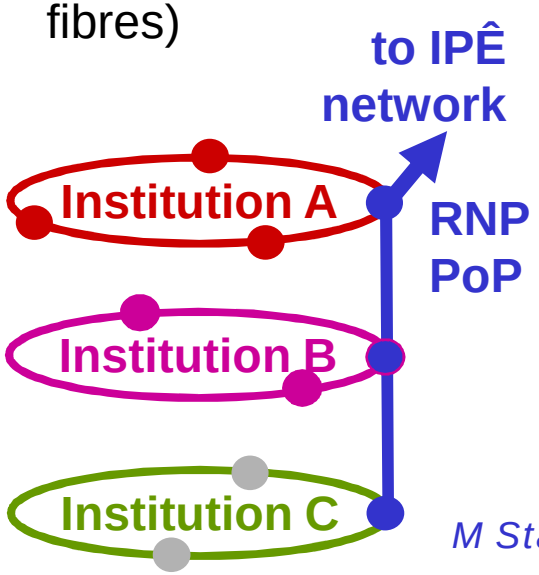
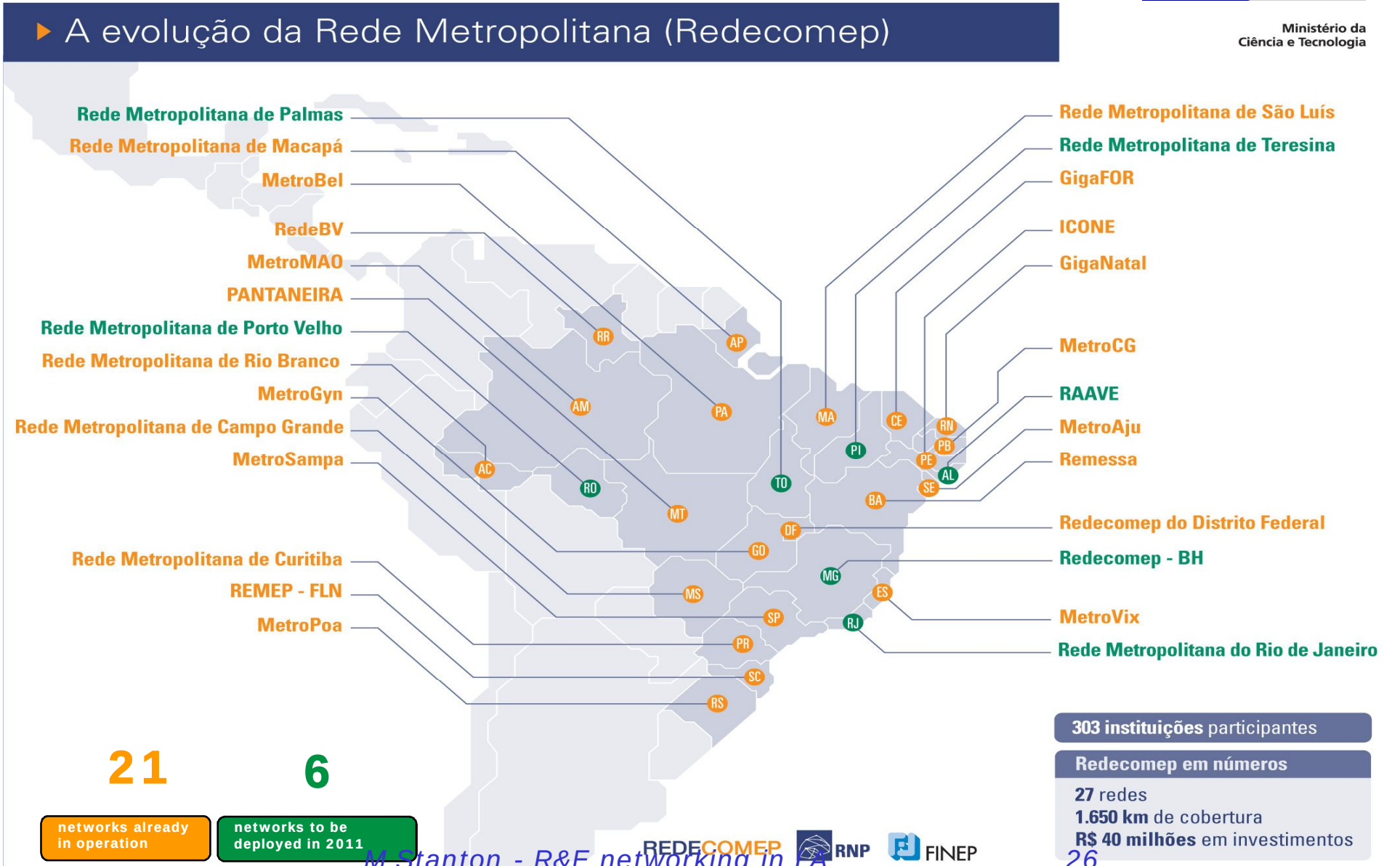
Pilot (2007): Belém, Pará

- 12 institutions with 32 campi
- each institution has its own pair of fibers (for internal connectivity)

- 30 km ring (48 fibres)
- 10 km extension to Ananindeua (36 fibres)
- 12 km access links (6 fibres)



Status of Metro networks (1Q2011)



Brazil in 2011

- The Brazilian R&E networks provide access to over 300 institutions, including 130 universities and 30 public and private research centres. As many of these have multiple campi in different cities, the total number of connected sites is more than 600.
- By end 2011, RNP will provide 1Gbps campus connections to more than 200 R&E sites located in 27 capital cities.
- "Interiorisation" of broadband access is going ahead, together with the federal government's plan to provide broadband backhaul to thousands of cities throughout the country, using its own long-distance infrastructure (based on state-owned energy utility companies)
- RNP is a partner to this process, and expects to be able to reach most of its clients with 1 Gbps access within 5 years.

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National Broadband Plan – 2014

(based mainly on use of state-owned utility fibres)

The ALICE2 Project (2008-2012)

- € 18 M budget over 4 years (12/2008 thru 8/2012)
  - 2/3 to be provided by the EC, through EuropeAid
  - 1/3 by LA National R&E Networks (NRENs)
- Emphasis on creating an upgraded, long-lasting, financially sustainable infrastructure – RedCLARA2
  - Preference for facilities-based infrastructure (use of long-term IRUs) over leased circuits
- Tendency to build a primarily terrestrial infrastructure
  - Permits sharing of infra with national network partners
  - Exploit synergy with other network projects

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ALICE2 Partners

Argentina
Bolivia
Brazil
Chile
Colombia
Costa Rica
Ecuador
El Salvador
Guatemala
México
Panamá
Perú
Uruguay
Venezuela

Cuba
Honduras
Nicaragua
Paraguay

Spain
France
Italy
Portugal
DANTE (UK)

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The vision: RedCLARA2.0

a terrestrial ring in South America with a spur to Mexico and US
Submarine cables for redundancy and intercontinental links

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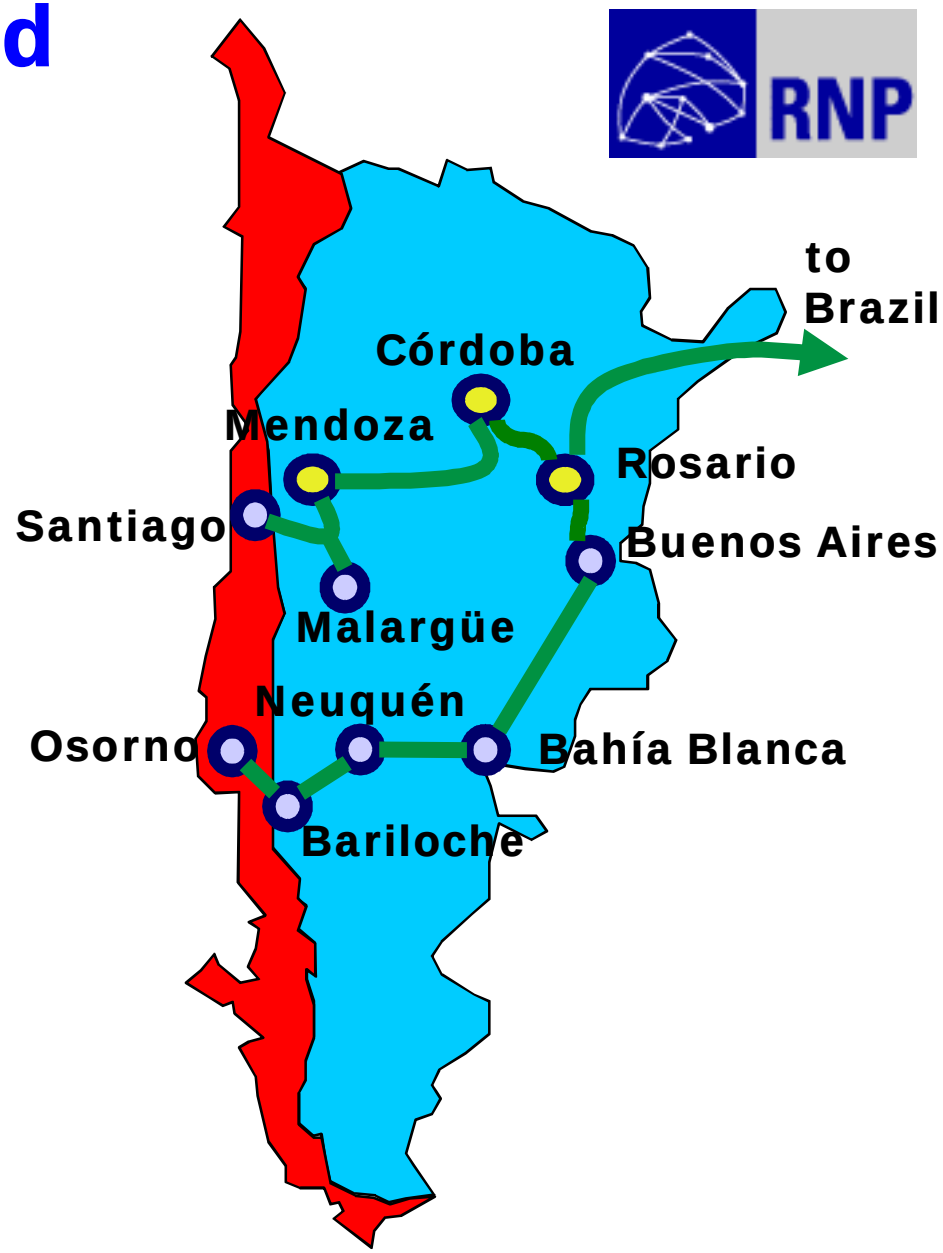
Synergies with other projects

- Argentina
  - Build-out of new national optical network
  - Access to Pierre Auger Southern Cosmic Ray Observatory
- Chile
  - Access to Optical and Radio Astronomy sites near to La Serena (AURA, CTIO) and Antofagasta (ESO, ALMA)
- Brazil
  - IOLACT project to link RNP to R&E networks in neighbouring MercoSul countries (Argentina, Paraguay and Uruguay)

Argentina: Innova|Red + Auger

- Innova|Red, the principal R&E network in Argentina, is building a brand-new national network
- Facilities based: cooperation agreement with a local telco with two fibre routes from Buenos Aires to Chile
  - 10G Northern route: BsAs to Santiago (with CLARA, RNP, Auger)
    - spur to Auger observatory in Malargüe
  - 10G Southern route: Bs As to Osorno
  - operational in 2011



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Chile: REUNA and the EVALSO Project

- Paranal Observatory (ESO) is located 130 Km South of Antofagasta in Chile
- To install Optical Fibre from Cerro Paranal to Antofagasta and connect there with REUNA and RedCLARA
- Purpose, to develop new modes of observation

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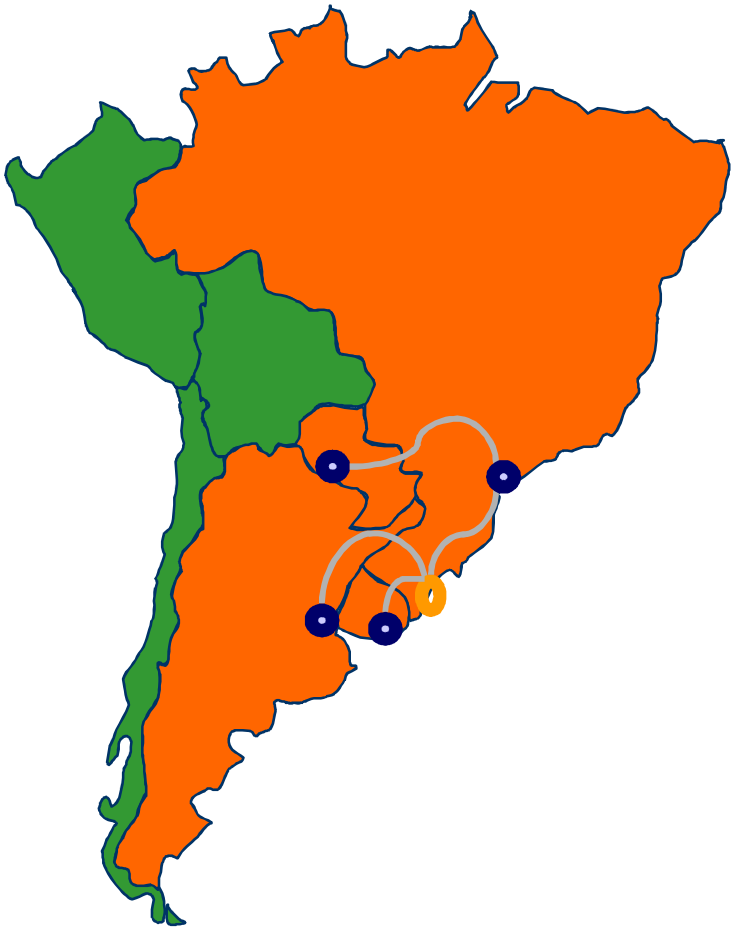
Brazil: links to Mercosur neighbours



- RNP using funding from FINEP (Brazil) will provide US$ 10,000,000 to support acquisition of dark fiber and optical equipment for Mercosur Countries (Brazil, Argentina, Paraguay, Uruguay)
- Additional funding is expected from Argentina and Uruguay for this project.

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RedCLARA advances to 2011

- Backbone upgraded to ≥ 622 Mbps
  - S.Paulo, Santiago, Panama City, Miami
- Almost all other links to 155 Mbps
  - Colombia and Venezuela to 1 Gbps in 2011
- External links:
  - Europe (GEANT): 622 Mbps
  - US (East): via Atlantic Wave
  - US (West): via Pacific Wave

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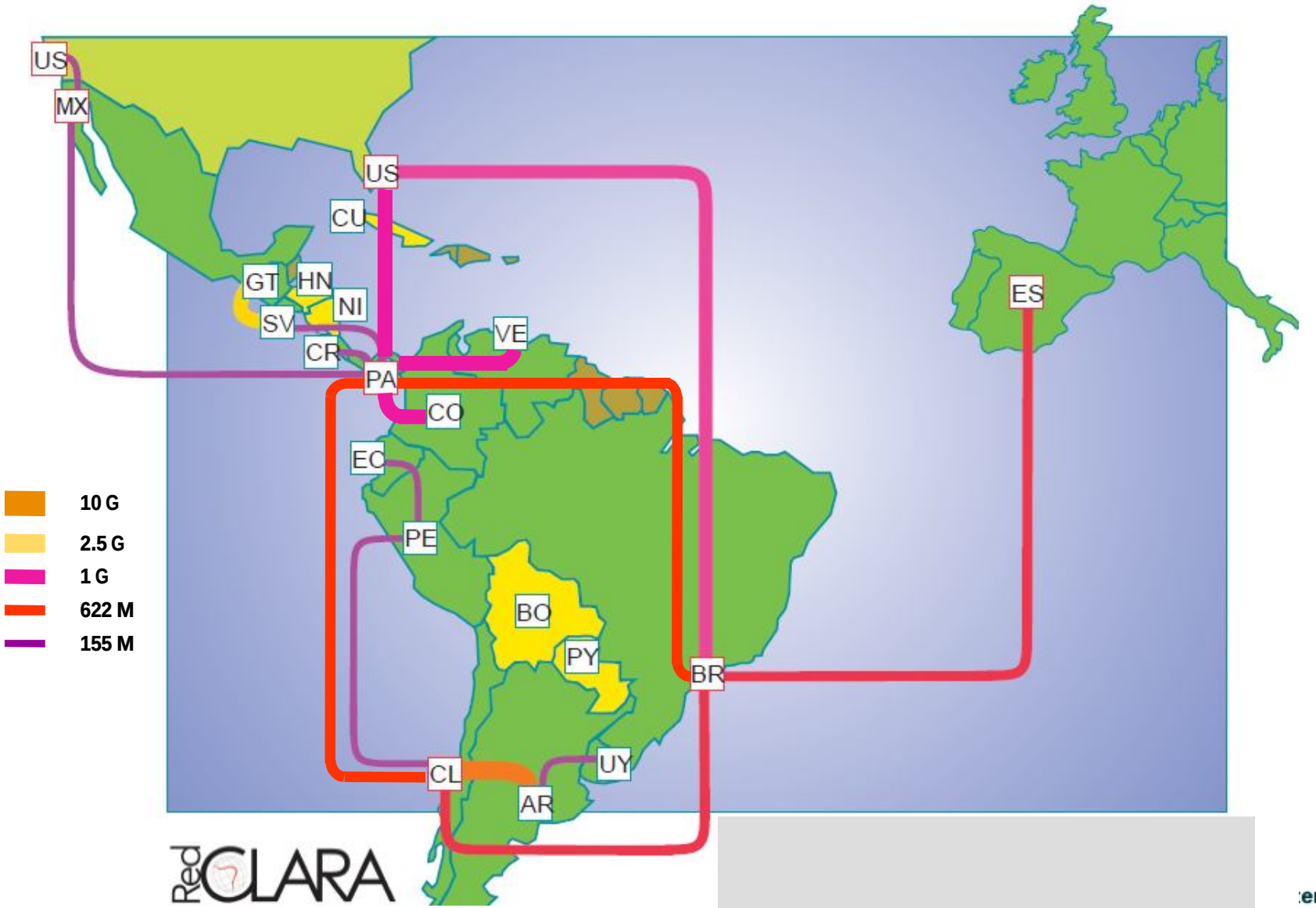
RedCLARA2 in 3Q2011



LA on the 2011 GLIF map

Brazil has been on the GLIF map since 2008.

The new map to be released in 2011 clearly shows the large increase in reachable cities in Brazil, and also in Argentina and Chile.

The GLIF2011 workshop will be held in Rio de Janeiro on Sept 13-14.

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Conclusion

- Application of (especially) optical network technologies is permitting a huge upgrade in network capacity for R&E
- In its turn, this allows significant and meaningful collaboration in new application areas, such as high-performance e-science and high-definition video transmission, both at national and international levels
- These opportunities are already available , or will be available not later than 2011, in the capital, and sometimes the interior cities, of na increasing number of LA countries.

Yellow ipê in blossom
(Brazil's national flower)

Thank you!

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Additional slides

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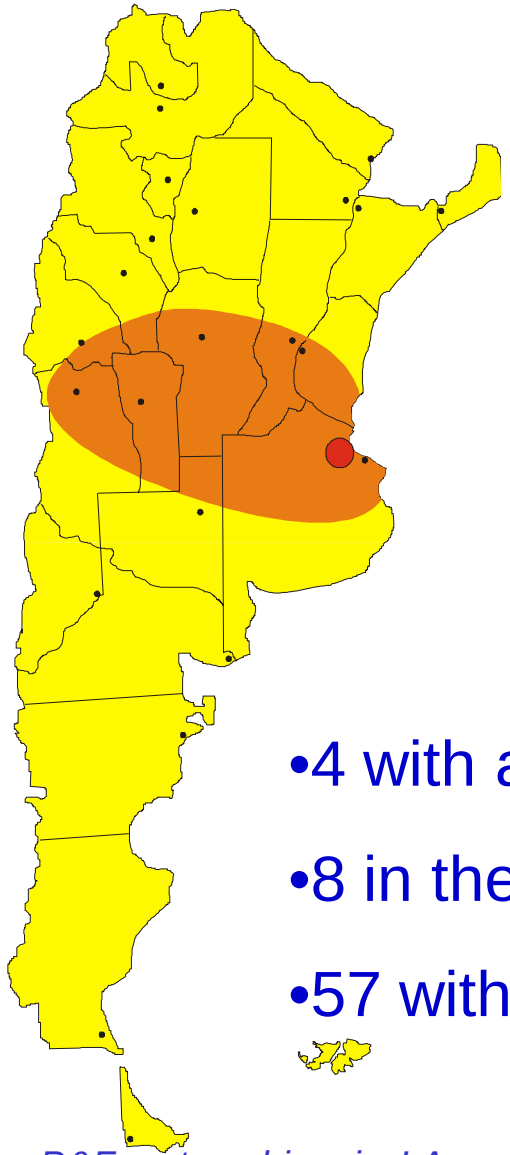
Argentina: the RETINA network in 2004

- 45 Mbps to AmPath



Abundant

Medium

Narrow

- 4 with advanced connectivity
- 8 in the near future
- 57 with low connectivity

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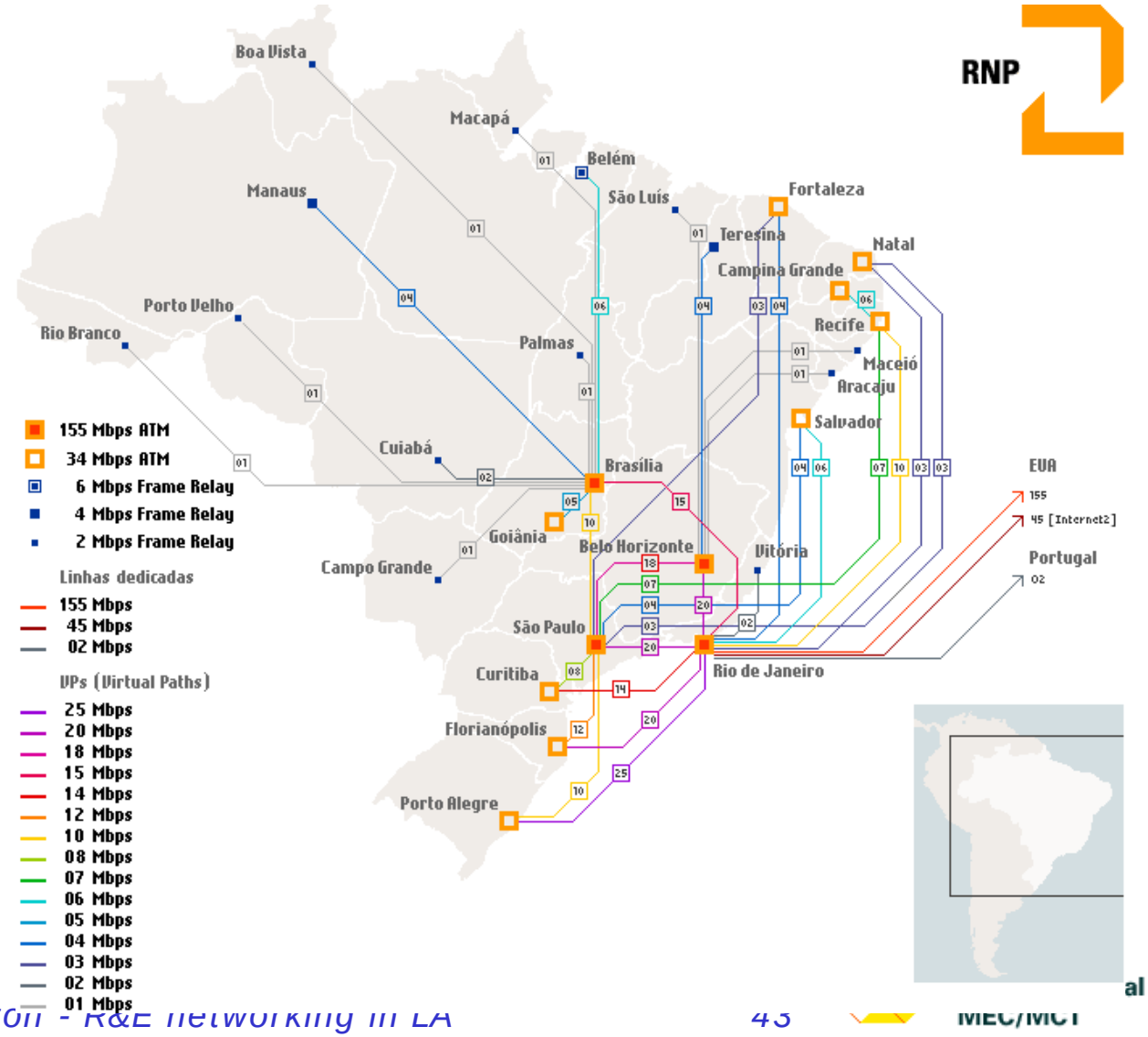
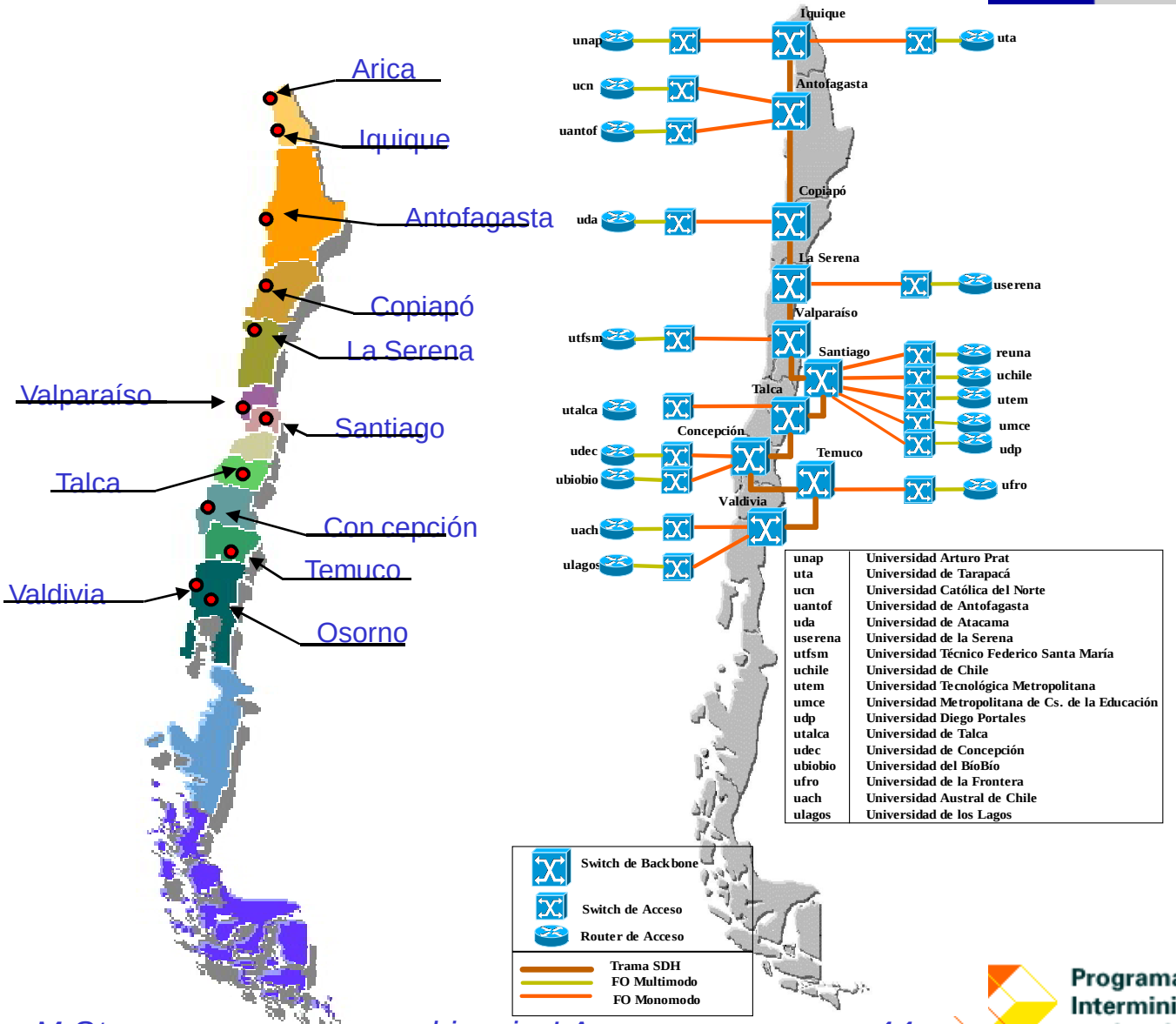
Brazil : RNP in 2004

- ATM backbone
  - 14 nodes
  - 300 Mbps total b/w
- FR to other PoPs
- 15 state networks
- Aggregate int'l b/w over 500 Mbps (incl. 90 Mbps to AmPath)



Chile - REUNA in 2004

- ATM backbone
  - 10 nodes
  - 10/60 Mbps
- 45 Mbps to AmPath



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Mexico: the CUDI network in 2004

- Internal links at 155 Mbps
- 400 Mbps of int'l connectivity

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The Digital Divide in LA: cost of access circuits to RedCLARA

- The proposed costs of access connections from NRENs to the CLARA backbone were initially extremely high in the case of Central America and Colombia
- This has required that these countries' NRENs negotiate better pricing with their national provider

	Annual cost for access circuits from CLARA backbone to country point of entry	Internal country costs for access circuits
2 Mbps	€ 347.780	€ 1.051.077
10 Mbps	€ 982.033	€ 5.061.526
34 Mbps	€ 3.310.757	€ 9.932.272