Networking for Research and Education in Brazil

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Summary

- New optical transmission and switching technologies allow significant reduction in the costs of setting up and operating research and education networks.
- By means of examples we show how these opportunities are being exploited in Brazil.
- Our agenda:
  - A brief look at RNP
  - Project GIGA – an optical networking testbed
  - IPÊ – the next-generation national network
  - Redecomep – Community-based Optical Metropolitan Networks
  - International connectivity
  - Some special user application areas

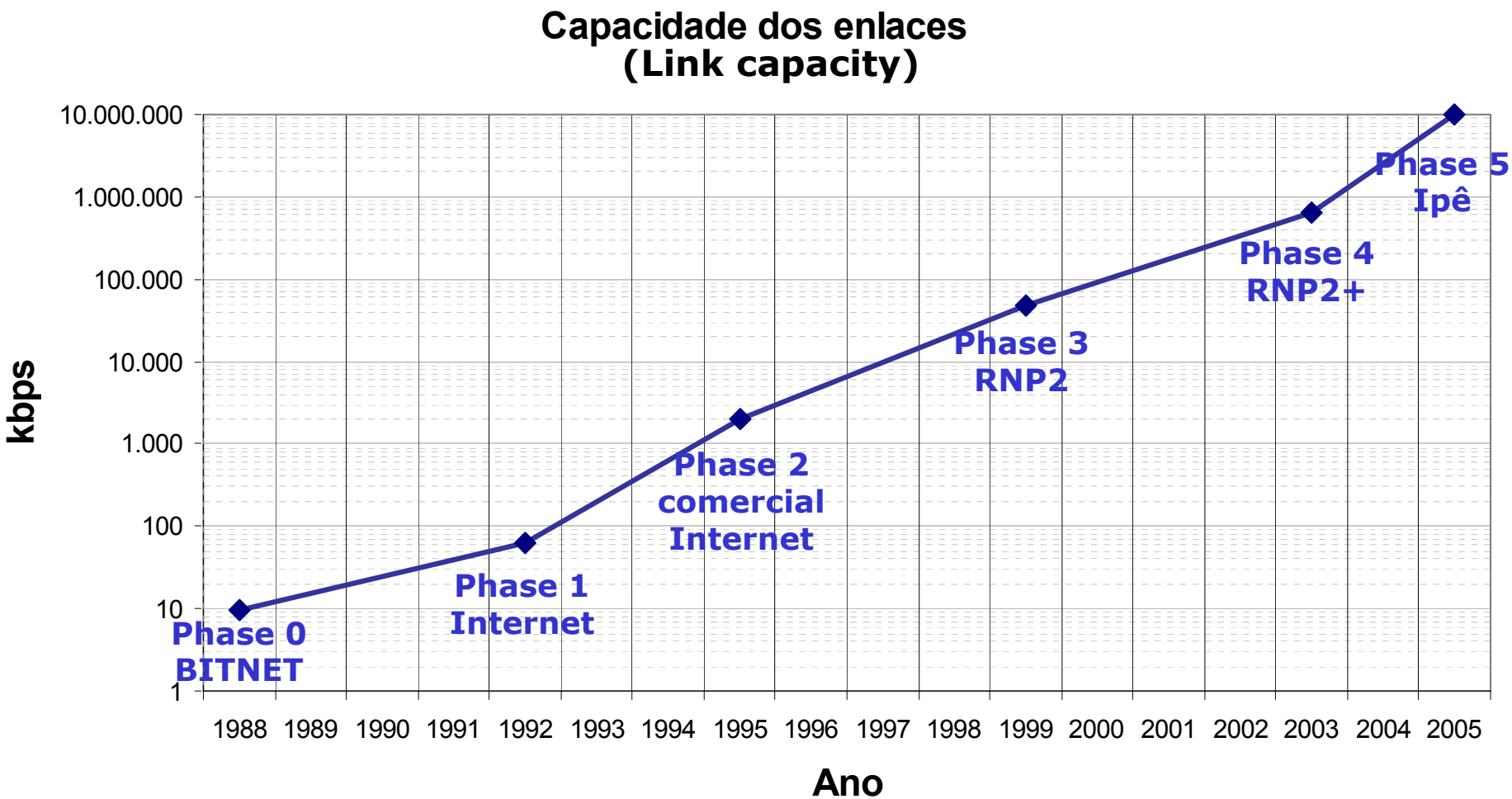
RNP – Rede Nacional de Ensino e Pesquisa

- RNP is the Brazilian national research and education network
  - maintained by the Brazilian government (since 1989)
  - provides national (inter-state) and international connectivity for more than 400 universities and research centers through the provision of advanced networking infrastructure
    - collaboration – links to other similar networks internationally (Internet2, GÉANT, APAN, RedCLARA)
    - commodity – links to the commercial Internet
  - supports the development of advanced networking and applications
- RNP is managed for the federal government by a non-profit private company, RNP-OS

Evolution of academic networks in Brazil

RNP Phase	Year	Technology	Link capacities	Comment
	1988	BITNET	up to 9.6 kbps	first national network
1	1992	Internet	9.6 and 64 kbps	first national IP network (RNP)
2	1995		up to 2 Mbps	*also:* commercial IP deployed
3	1999	IP/ATM, IP/FR	VC up to 45 Mbps, access up to 155 Mbps	RNP2 national backbone; testbed metro networks in 14 cities (using ATM/dark fiber)
4	2003	IP/SDH	34, 155, 622 Mbps	*also:* IP/WDM interstate testbed network (Project GIGA)
5	2005	IP/WDM	2.5 and 10 Gbps	IPÊ national backbone; metro networks in 27 capitals

Evolution of academic networks in Brazil



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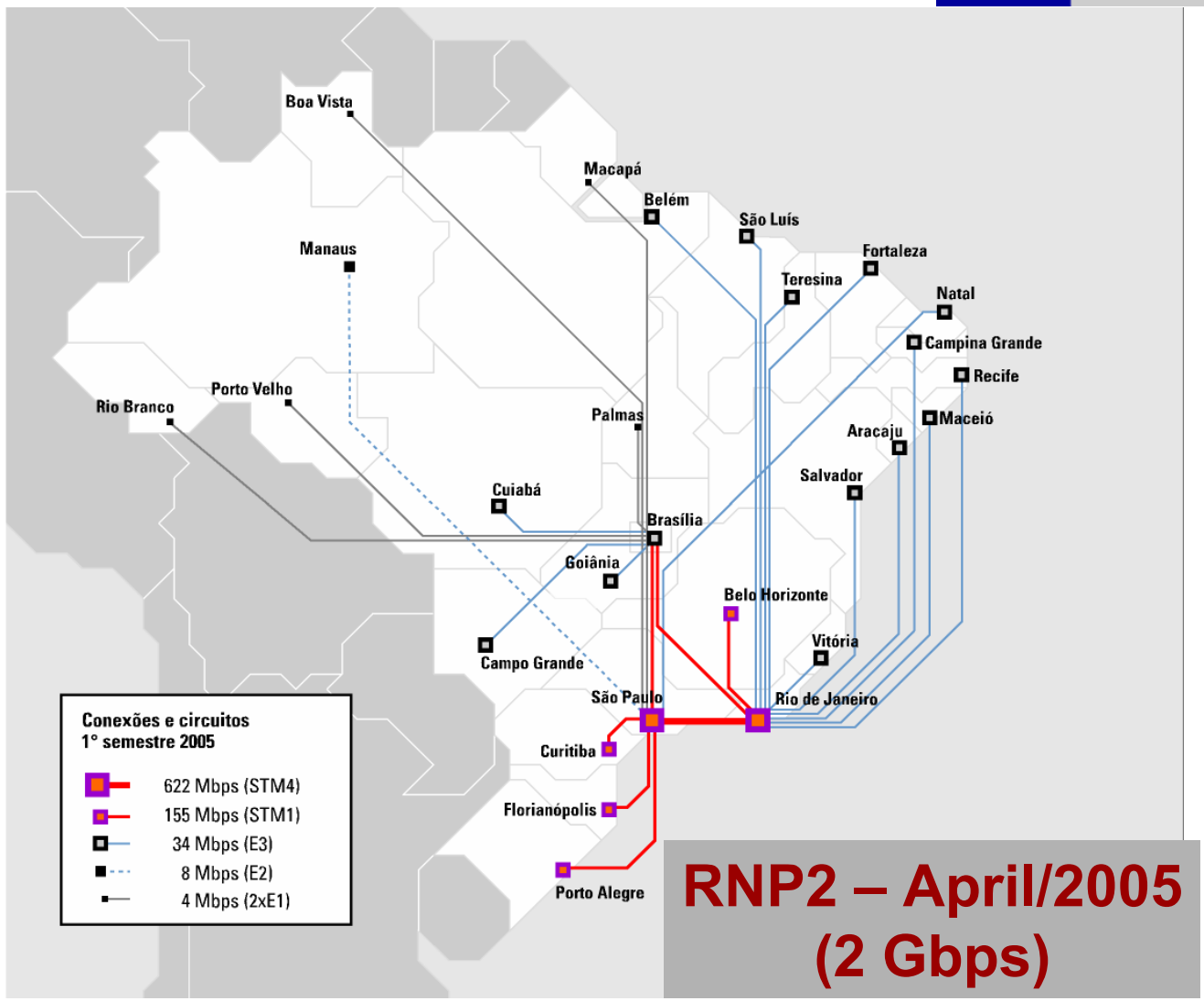
RNP2 backbone network (until Nov 05)

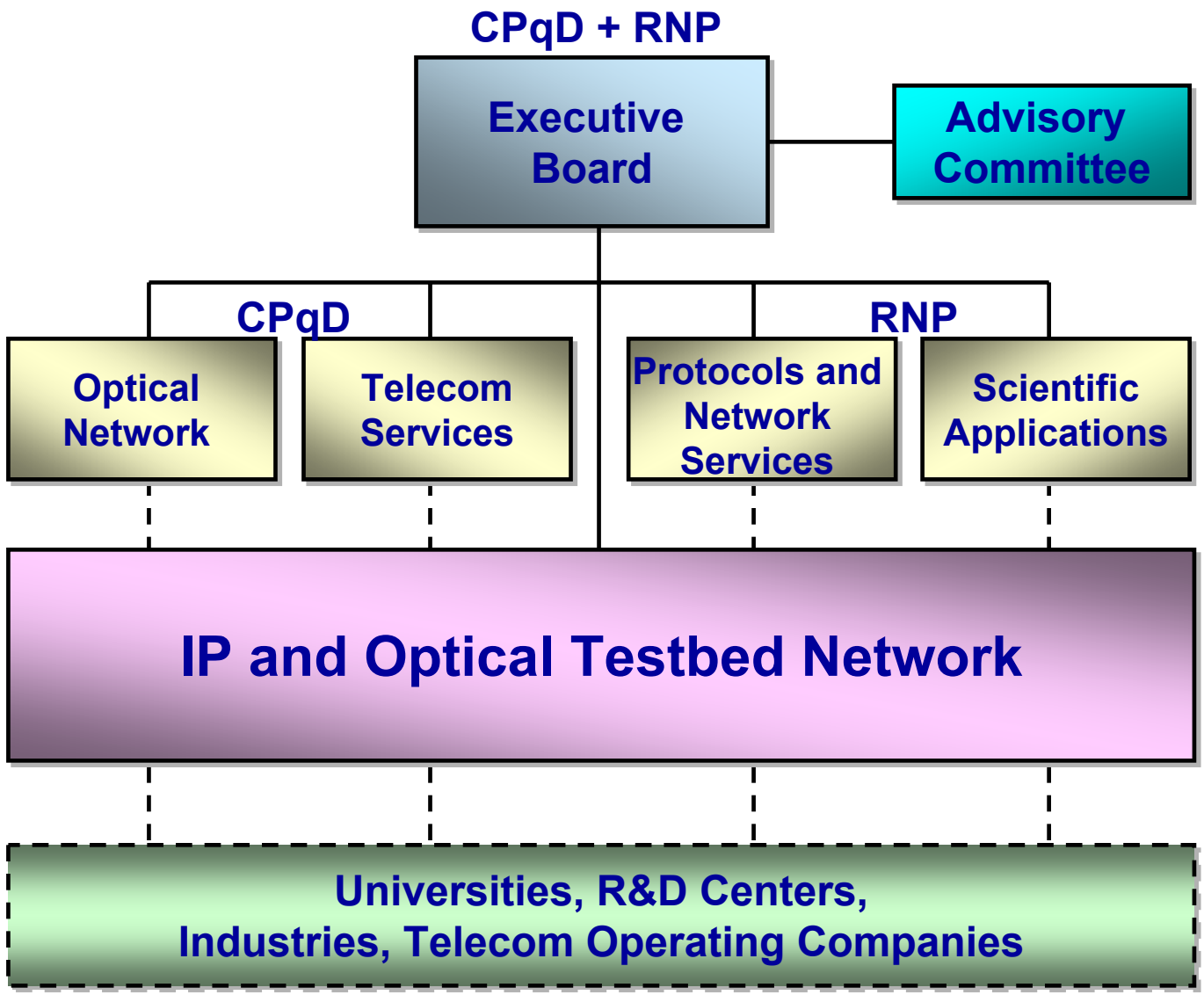
- Introduced in 2004/5
- IP/SDH (replacing IP/ATM)
- first multi-provider network
  - until late 1990s telcos were state monopolies
- 6x the aggregate capacity of the previous (ATM) network at 2/3 cost



Project GIGA – optical networking testbed

- Partnership between
  - RNP
  - CPqD (telco industry R&D centre in Campinas, SP) www.cpqd.com.br
  - R&D community in industry and universities
- 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
- Industry participation
  (telcos provide the fibres; technology transfer of products and services to Brazilian Industries and telcos required)
- Government funding of US$ 20 M (via FUNTTEL/Finep) – project started December 2002

Project Organization



R&D areas

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GIGA testbed network – objectives

- explore user control of optical fibre infrastructure
  - interconnect 20 academic R&D centres in S.E. Brazil
  - use of IP/WDM with Ethernet framing

- provide Networking Research Testbed (NRT) for optical and IP network development
- provide Experimental Infrastructure Network (EIN) for development and demonstration of applications

(NRT and EIN are terms defined by NSF in 2002)

Network was inaugurated in May 2004

GIGA testbed network – localization

- dark fiber-based 700-km inter-city backbone in states of São Paulo and Rio de Janeiro
- Initially 20 universities and R&D centers in 7 cities
- 2.5G DWDM in the inter-city backbone
- 2.5G CWDM used in the metropolitan area

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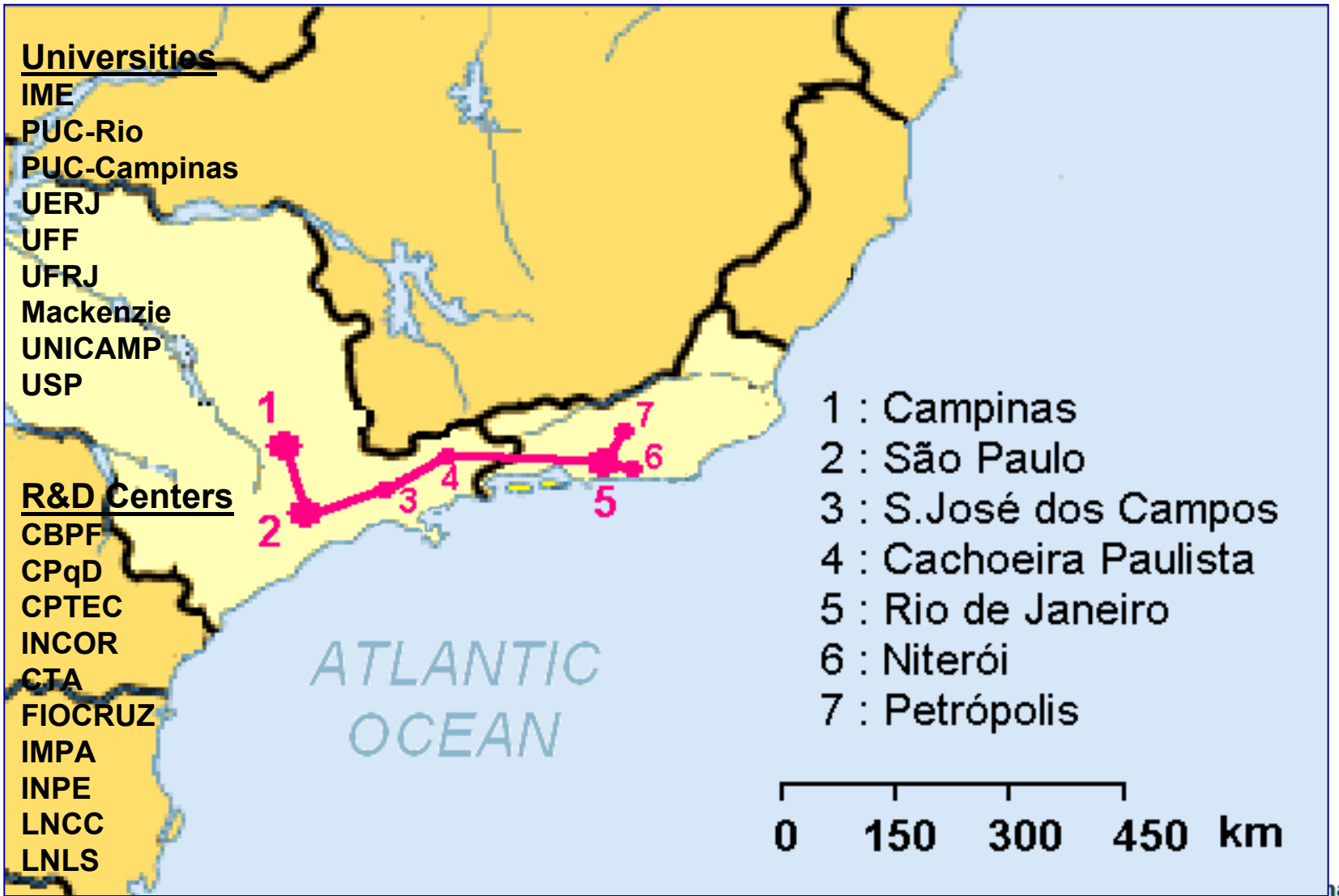
GIGA testbed network – localization



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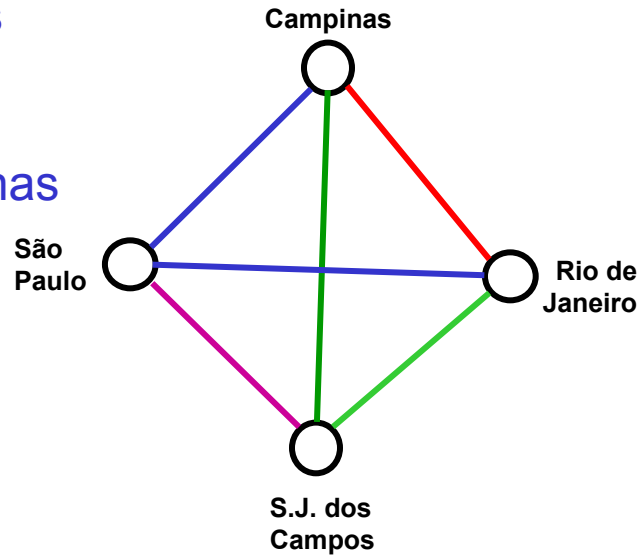
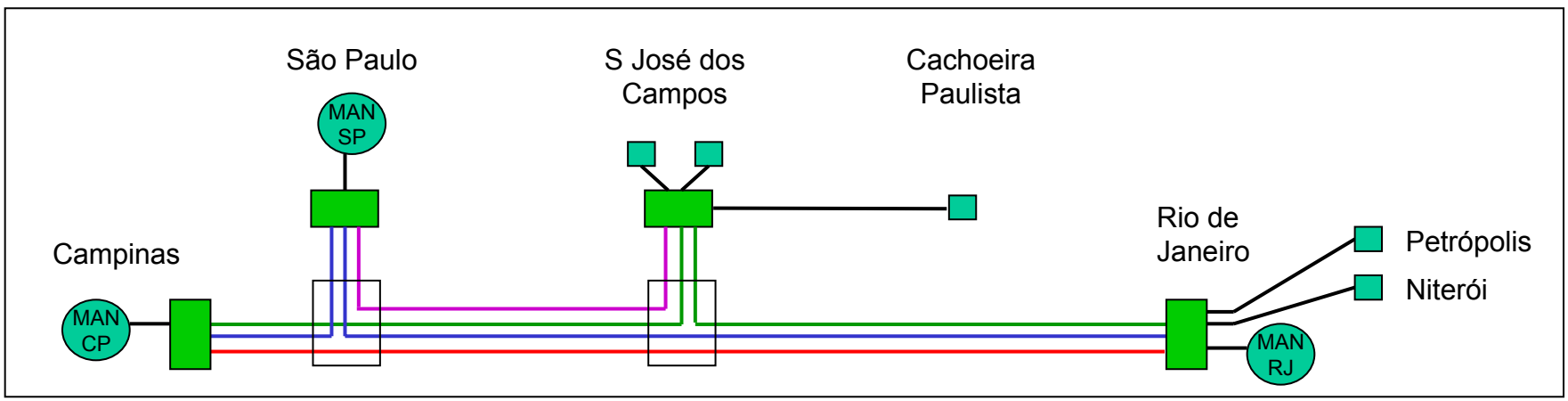
Initial network design

- 2.5G DWDM inter-city network between Campinas and Rio de Janeiro
  - up to 4 waves per link (can use 8)
- 2.5G CWDM metro networks in São Paulo, Campinas and Rio de Janeiro
- all links currently 1 Gigabit Ethernet
  - optical equipment from Padtec (www.padtec.com.br)
  - IP equipment from Extreme Networks





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R&D activities

- 2/3 of the GIGA project budget is for R&D activities in the following areas:
  - Optical networking (CPqD)
  - Network protocols and services (RNP)
  - Experimental telecommunications services (CPqD)
  - Scientific Services and Applications (RNP)
- Most of the R&D activities are contracted out to research groups in the university community (at more than 50 different institutions throughout Brazil)
  - Incentives for technology transfer to industry
  - The network may also be used for the development and/or demonstration of high capacity networking applications by scientific researchers in various areas (HEP, computational biology, earth sciences, environmental sciences, etc), often using grid computing.

Optical networks for the R&E community

- Based on practical experience with the testbed network of Project GIGA, RNP began to deploy in 2005 a multi-Gbps network for the national R&E community

- This has two main components:

  - IPÊ multi-Gbps backbone network
    - ipê: (a word in Tupi pronounced “ee-pay”) is Brazil’s national flower (Tabebuia chrysotricha)
    - i-pê: IP (Internet Protocol) in Portuguese
    - IPE: Inovação, Pesquisa, Educação (Innovation, Research, Education)
    - (Aranguaney is the name of the same tree, which is also the national tree of Venezuela!)

  - Redecomep: community-based optical metropolitan networks
    - for shared local Gbps access to IPÊ PoPs

yellow ipê in blossom

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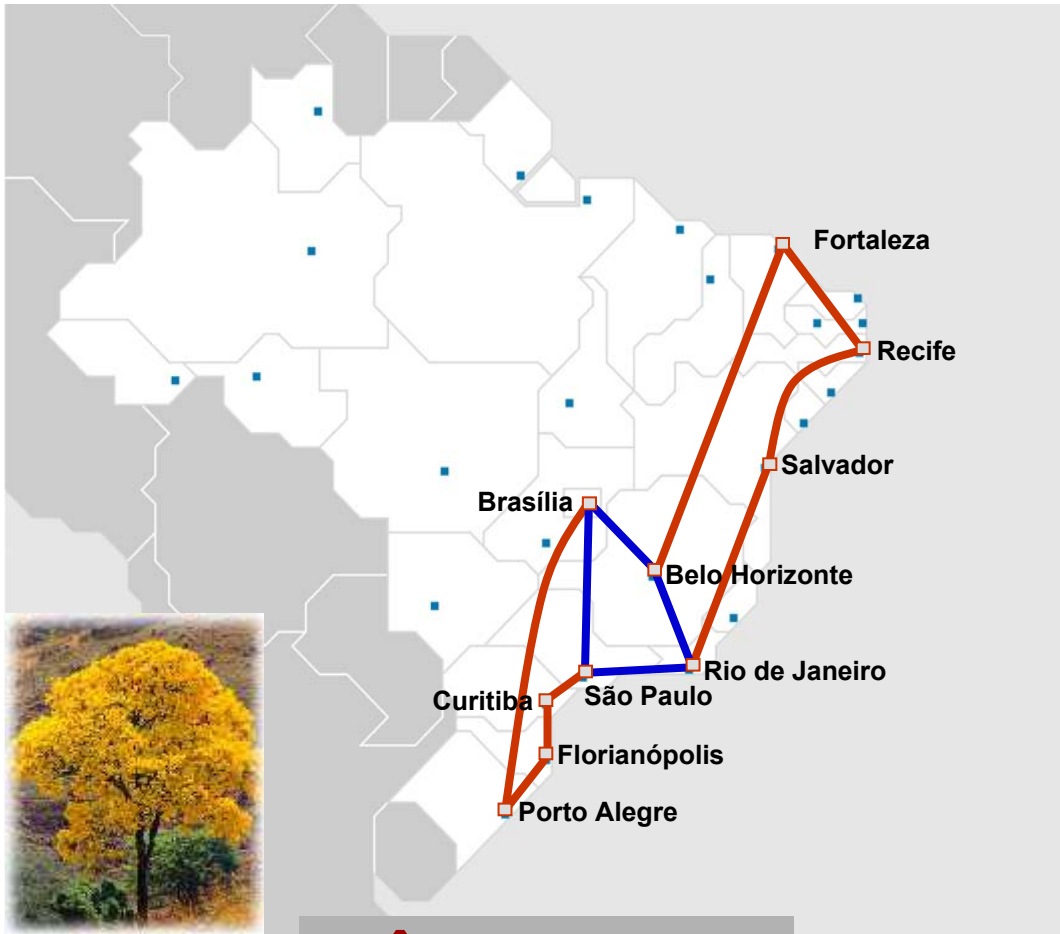
IPÊ: next generation network (2005)

- use of multiple Gbps for interstate links initially between 10 cities
- unprotected 2.5 and 10G waves from two telcos
- only 3x cost of the previous SDH network for around 40x the aggregate capacity
- routers from Juniper Networks (M320, M40)
- commissioned in November 2005



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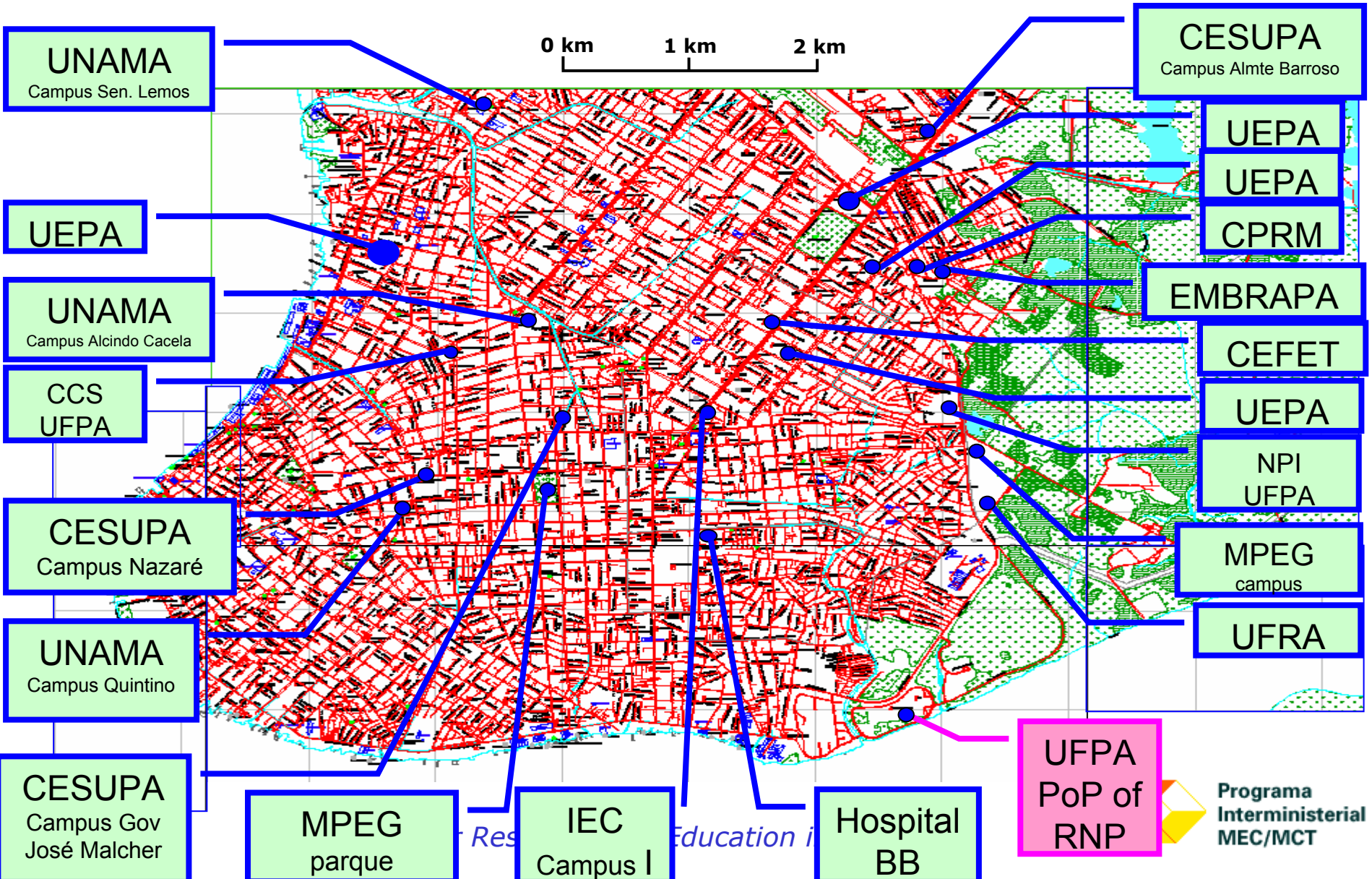
Redecomep – Optical Metropolitan Networks for the R&E community

- Long distance networks arrive in a particular point of each city served – Point of Presence (PoP)
- To serve a set of clients in the same city, necessary to provide individual access to the PoP – problem of the Last Mile
- A similar problem arises when we wish to provide connectivity between branches of a single organisation in the same city

- Traditional telco solution to the "problem of the Last Mile":
  - Rent telco point to point data services to get to PoP
  - Recurrent cost a function of bandwidth
  - Often results in "under-provisioning" due to high cost

- Case study in 2004: Belém, capital of state of Pará (eastern Amazonia) – metropolitan area population of almost 2 millions

Belém:
12 universities and research centers



Situation of local access in Belém in 2004

Institution	Summary of local network connections	Annual cost (US$)
CEFET	Access to provider at 512 kbps	22,200
CESUPA (4 campi)	Internal + access to provider at 6 Mbps	57,800
IEC/MS (2 campi)	Internal at 512 kbps + access to provider at 512 kbps	13,300
MPEG (2 campi)	Internal at 256 kbps; Access to provider at 34 Mbps (radio link)	7,600
UEPA (5 campi)	Internal at 128 kbps; access to provider at 512 kbps	18,500
UFPA (4 campi)	Internal at 128 kbps; Provider PoP	16,700
UFRA	Access to provider at 1 Mbps	16,000
UNAMA (4 campi)	Internal wireless links, access to provider at 6 Mbps	88,900

Total telco charges for POOR local access = US$ 241,000 p.a.

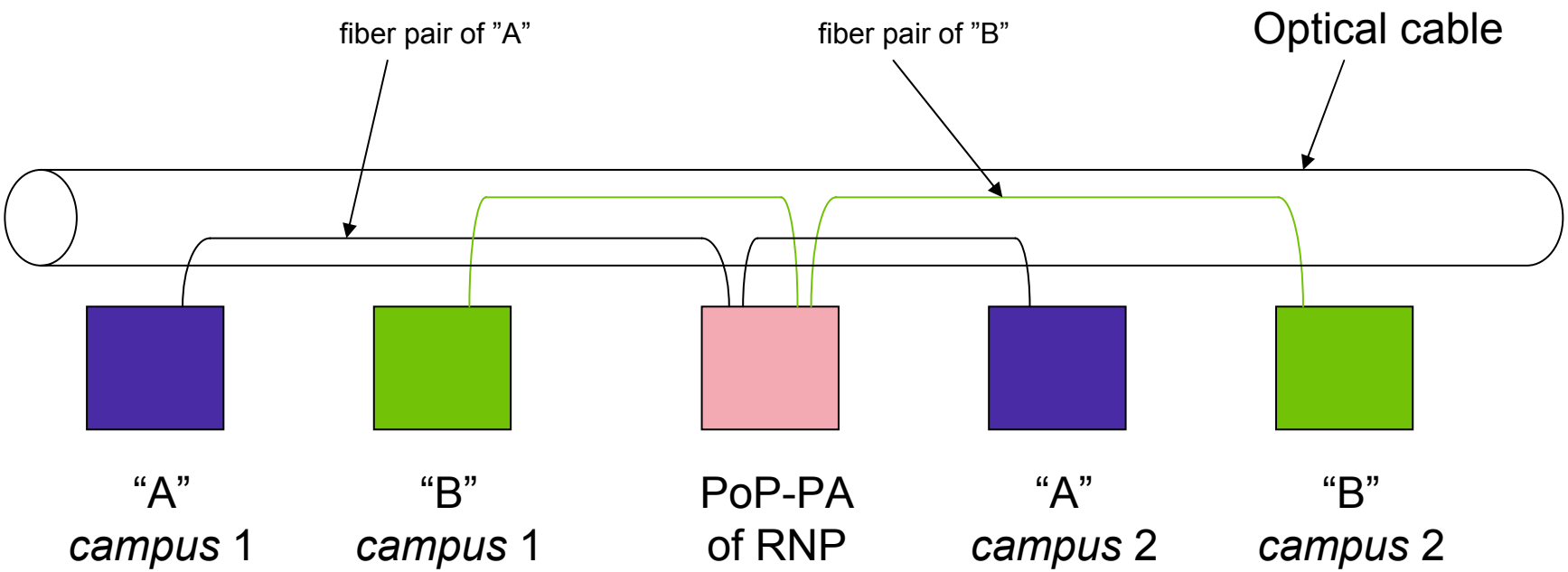
An alternative approach – DIY (do-it-yourself) community networking

1. Form a consortium for joint network provision
2. Build your own optical fiber network to reach ALL the campi of ALL consortium members
3. Light it up and go!

- Costs involved:
  - Building out the fiber: using utility poles of electric company
    - US$ 8,000 per km
    - Monthly rental of US$1 (about 40 poles per km)
  - Equipment costs: mostly use cheap 2 port GigE switches
  - Operation and maintenance
- In Belém for 12 institutions using all GigE connections:
  - Capital costs around US$500,000
  - Running costs around US$80,000 p.a.
  - Compare with current US$240,000 p.a. for traditional telco solution

Some architectural details

- Use dedicated fiber pair for each separate institution to permit:
  - Building an internal corporate network
  - Providing access to the PoP
- A physical ring topology is desirable to provide protection through redundancy



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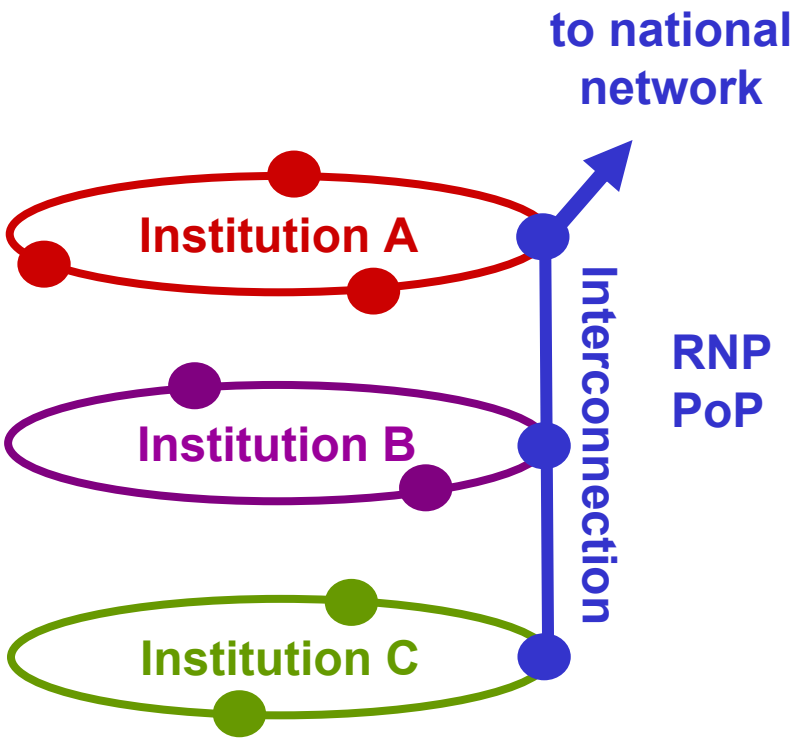
Architecture 1: star of rings



- uses a dedicated fiber pair for each client institution for corporate network
- all fibers meet at the RNP PoP – interconnection point
- needs a large routing switch at PoP
- other switches are simpler, with two optical ports

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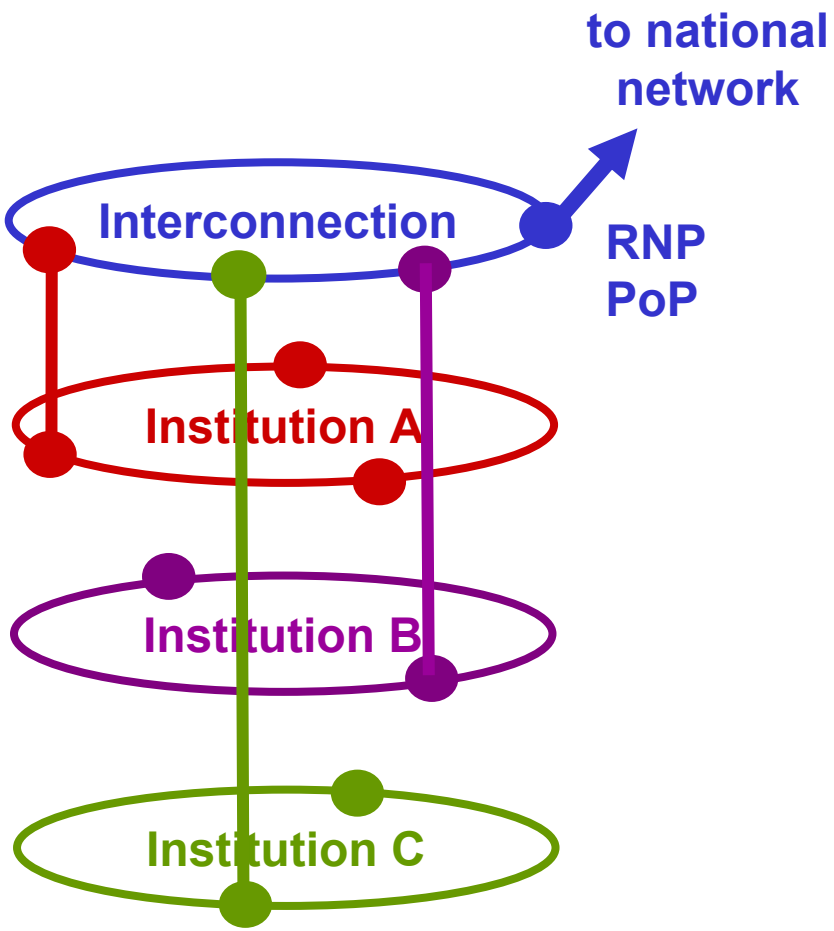
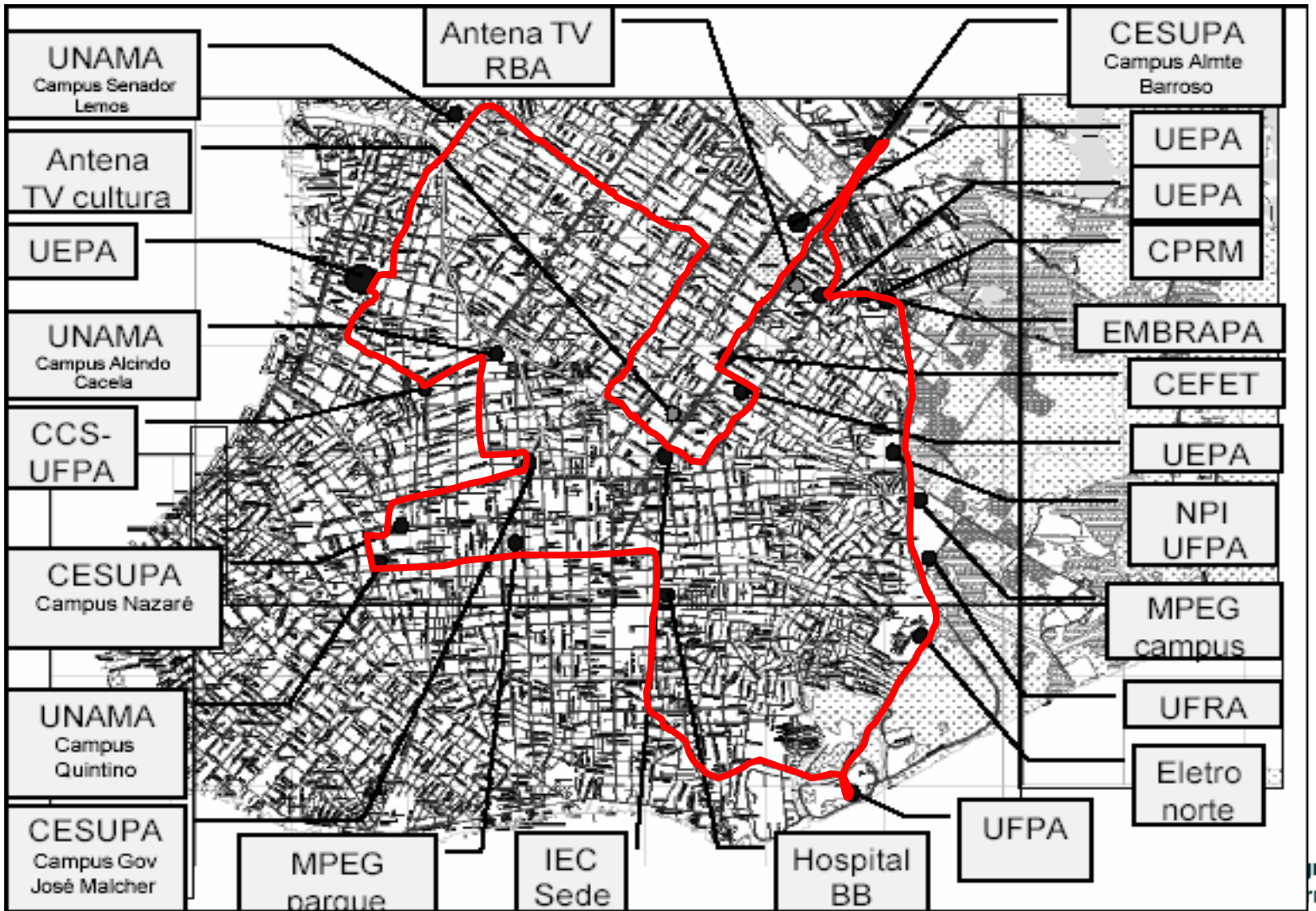
Architecture 2: ring of rings



- uses a dedicated fiber pair for each client institution for corporate network
- an additional fiber pair provides interconnection between one (or more) points of each corporate network
  - simpler switch suffices at RNP PoP
  - interconnection points require at least 4 optical interfaces

Belém:
a possible topology (30 km ring)



RNP activities in metro networks 2005/6

- In December 2004, RNP obtained financing from Finep (agency of the ministry of Science and Technology) to build optical metro networks in all 27 capital cities in Brazil (projects MetroBel and Redecomep)
- Total value of more than US$15 millions to be spent by December, 2006
- Tender for cabling Belém published in August 2005
- Joint equipment tender published in September 2005
- Belém cabling begun in March 2006 (to be ready by June)
- Currently plans are under way for installing metro networks in the following cities:
  Manaus, Belém, Fortaleza, Natal, Recife, Salvador, Vitória, Brasília, Curitiba, Florianópolis, Porto Alegre, …

International connectivity

Two kinds of traffic: “commodity” (Internet1) and “cooperation” (Internet2, or Research and Education)

Except for RedCLARA, all current connections are to the USA:

RNP has access to:

- 2 * 155 (Rio) + 45 Mbps (SP) *commodity* to Miami (expected to be upgraded in 2006)
- 155 Mbps *cooperation* via RedCLARA (SP) to LA & Europe
- 1.2 Gbps *cooperation* via WHREN/LILA (SP) to Miami (shared with São Paulo state network)

Building RedCLARA: the ALICE project

ALICE - América Latina Interconectada Con Europa

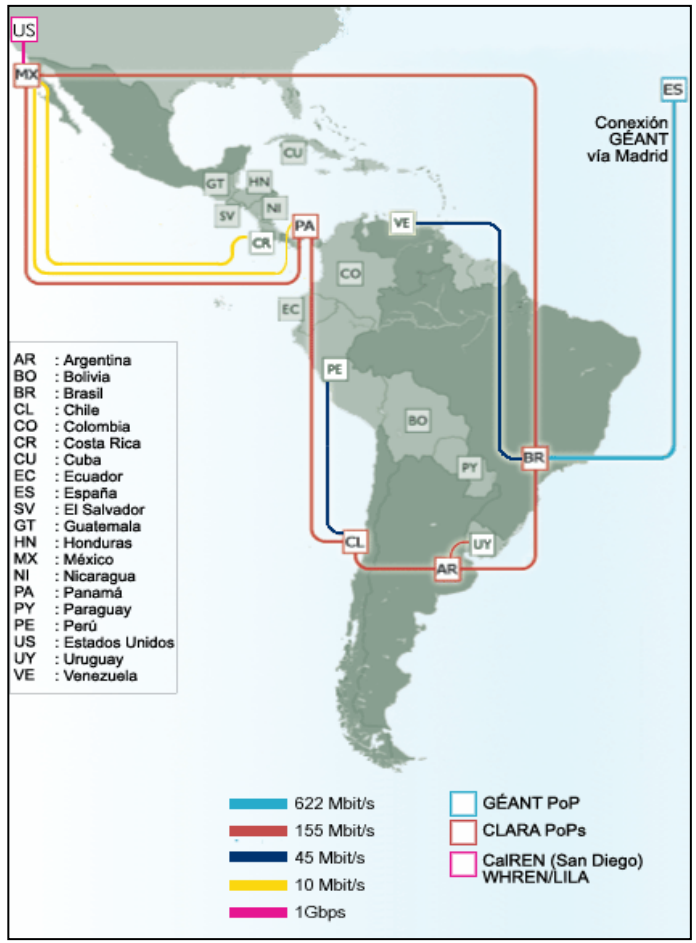
- Coordinated by DANTE, with participation of NRENs from Italy, France, Spain, Portugal and the CLARA countries, and later CLARA itself
- May 2003: ALICE Project approved by European Commission with EUR 10 millions (80%) financing (remainder from LA users)
- June 2003: Open tender for provisioning of links
- June 2004: Link contracts assigned
- Aug 2004: Network operational
- Mar 2006: Connects 14 (of possible 18) CLARA countries

Notes:

- DANTE (manager of the pan-European network, GÉANT) is the project coordinator and will sign contracts with users and providers
- CLARA now represents the interests of LA users

RedCLARA topology

- Initial capacity of the backbone ring: 155 Mbps (Global Crossing + Cisco)
- Access links of 10 to 45 Mbps
- Initial connection to Europe (GÉANT) at 622 Mbps from Brazil (Sep 2004)
- Connection in 2005 to the US via IRNC – International Research Networks Connection



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RedCLARA and WHREN/LILA (IRNC) (4Q2005)

- The main interest of CLARA in this program is to provide good quality connectivity between the US and countries served by RedCLARA, by way of new connections from the US to backbone nodes of RedCLARA, specifically:
  - Cross-border dark fiber from Tijuana, Mexico to the US (shared with CUDI)
    - initial capacity 2x 1 Gbps (Sep 05)
  - Direct access to Southern Cone countries via São Paulo (shared with ANSP)
    - initial capacity 1,2 Gbps (Jan 06)

Some special user application areas

- High-Energy Physics
- Astrophysics

RNP interactions with High-Energy Physics

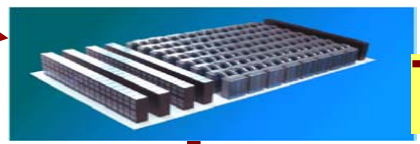
- The Brazilian HEP community participates in international collaborations associated with large accelerators, such as those at Fermilab and CERN
- A prominent example is the CMS project for the future Large Hadron Collider (LHC) at CERN, expected to come online in 2007

HEPGRID (CMS) in Brazil

HEPGRID-CMS/BRAZIL is a project to build a Grid that
- **At Regional Level will include CBPF,UFRJ,UFRGS,UFBA, UERJ & UNESP**
- **At International Level will be integrated with CMS Grids; Focal points include Grid3/OSG and bilateral projects with Caltech Group**

On line sys ``tems

Brazilian HEPGRID



T0 +T1

T2 Inauguration + GIGA/RNP Agreement December 2004

CERN

1 - 2.5Gbps … 10 Gbps

T1

France **Germany** **Italy** **BRAZIL** **622 Mbps** **USA**

T3 ➔T2

UNESP/USP SPRACE Working

UERJ HEPGrid T2 Working

T2 ➔T1

UFRGS

Gigabit

UERJ

CBPF

UFBA **UFRJ**

UERJ: T2➔T1, 100➔500 Nodes; Plus T2s to 100 Nodes

T4 Individual Machines

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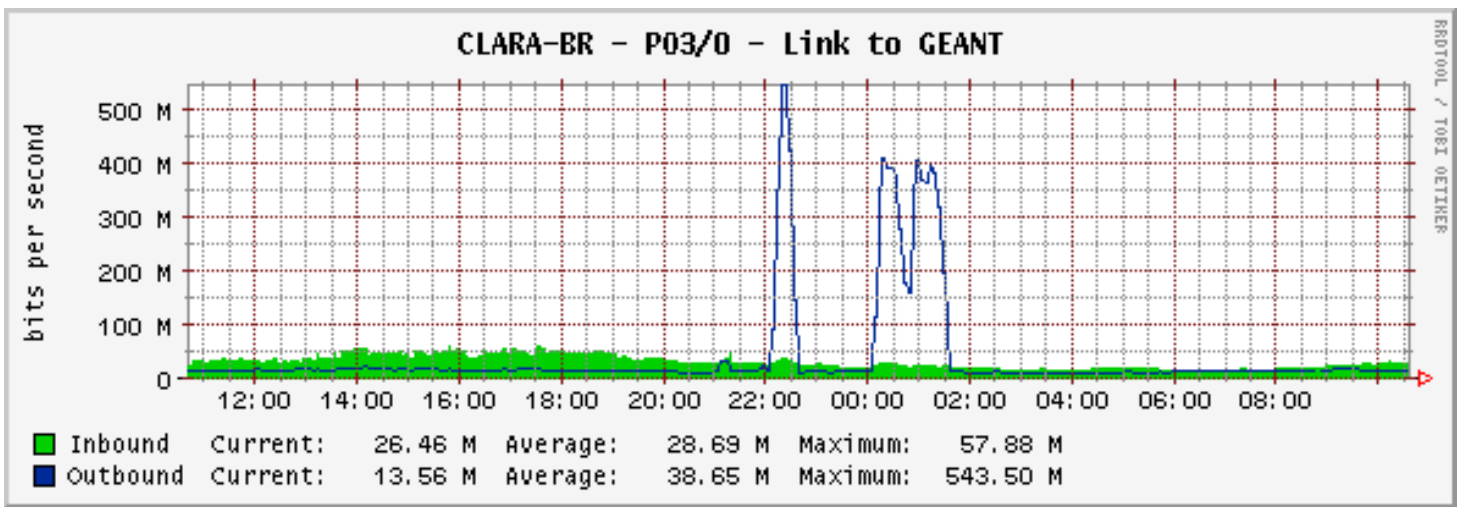
RNP support for participation in SC2004

- The RedCLARA network facilitates international communication with other advanced networks
- Evidence of this was given during the recent Bandwidth Challenge (BWC) during SC2004 in the US
  - participation by HEPGrid group from UERJ (Rio)
  - used GIGA testbed + Red CLARA + GÉANT + Abilene
    (Rio to S. Paulo) (to Madrid) (to New York) (to Pittsburgh)
  - peak traffic 500 Mbps, sustained traffic 400 Mbps (Nov 10-11, 2004)



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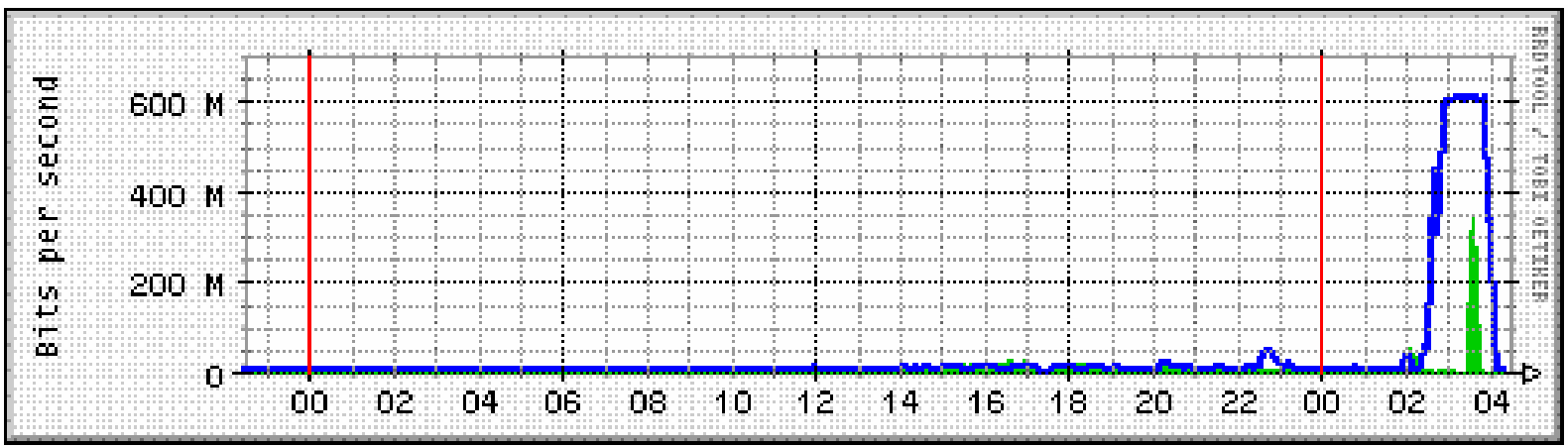
RNP support for participation in SC2005

- With the inauguration of the IPÊ network and the WHREN/LILA connection between S. Paulo and Miami, connectivity to the US has greatly improved.
- The new route from Rio to the US used
  - IPÊ network + WREN/LILA + Abilene
    (Rio to S. Paulo) (to Miami) (to Seattle)
  - 2.5 Gbps was provisioned between S. Paulo and Miami to accommodate 2 HEP flows of 1 Gbps.
  - bandwidth effectively used was around 1 Gbps
    - Group from Rio transmitted around 600 Mbps (see below)



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RNP interactions with Astrophysics (new projects)

- SOAR (Southern Observatory for Astrophysical Research), Cerro Pachón, Chile
  - 30% viewing time is for Brazilian scientists
  - demand for “assisted remote observation”

- Brazilian Virtual Observatory
  - provide access to remote databases of astrophysical images for data mining
  - will be integrated into IVOA (International Virtual Observatory Alliance)

- e-VLBI using ROEN (Radio-Observatório Espacial do Nordeste) in Eusébio, near Fortaleza
  - expected to transmit initially 100 Mbps to MIT starting 4Q2006, when GIGAFor metro network to be deployed
  - Bandwidth needs should double in 2007

Conclusion

- RNP is engaged in extending
  - the quality and capacity of its networking infrastructure,
  - the range of the services offered, and
  - its participation in multidisciplinary collaboration projects

Thank you!

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