



# Optical networks for Research and Education in Brazil

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- **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.**
- **We discuss:**
  - A brief look at RNP
  - Optical Metropolitan Networks
  - Project GIGA: an optical networking testbed
  - Project ION-NE: synergy between testbed and production networking



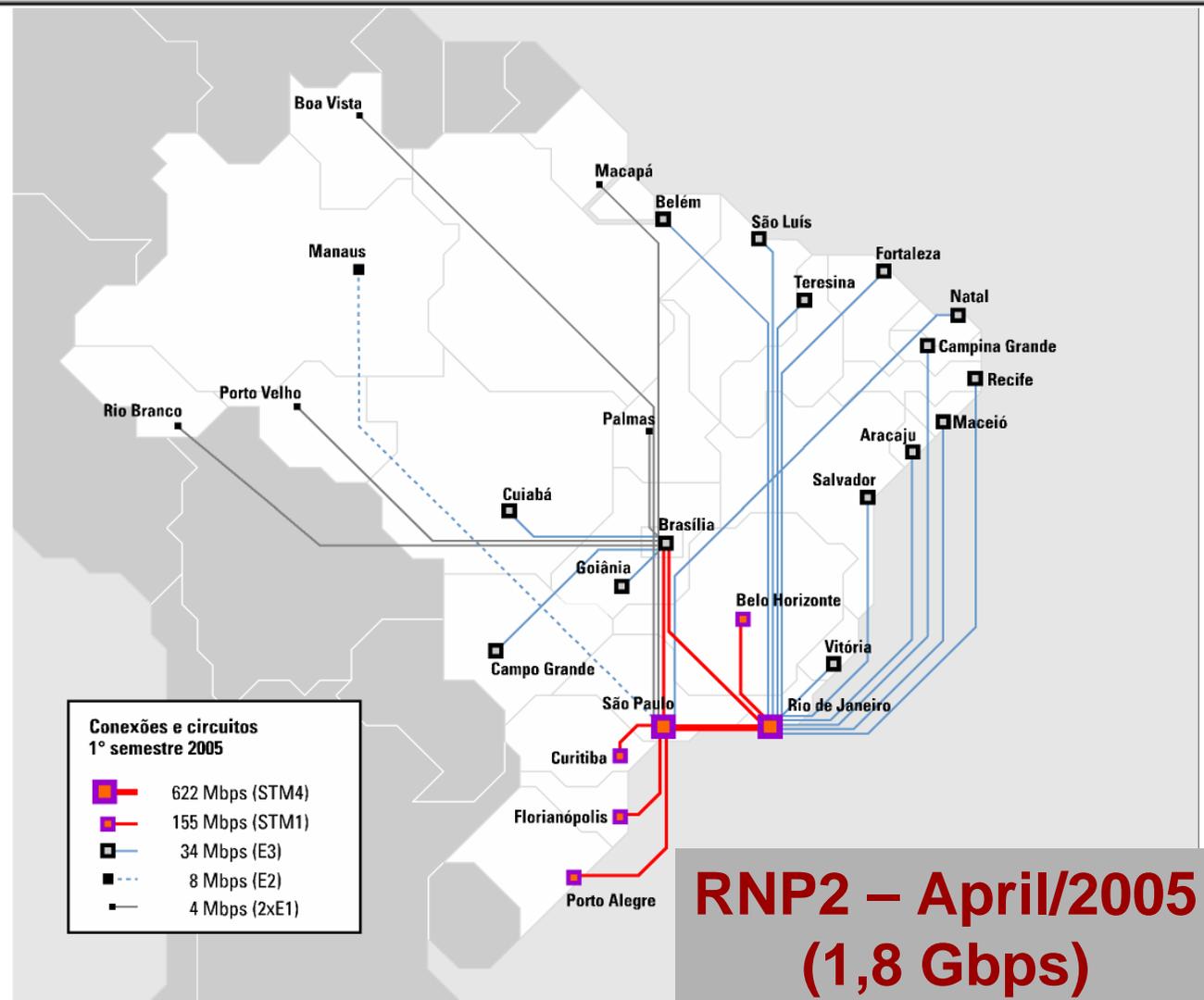
- **Brazilian NREN, created as a project of the federal government in 1989**
- **Now non-profit organization contracted by the federal government (ministries of Education and Science & Technology)**
- **Annual cost to the government about US\$17 M – about 75% in telco contracts**
- **Operates a national backbone network with Points of Presence (PoPs) in 26 states and the federal capital**
- **End users: around 250 universities and research centres, served through a combination of RNP and state networks**
- **Full service: access to global research and education networks (Internet2) and to commodity Internet**
- **Network currently in expansion:**
  - 2003: ATM + FR – 350 Mbps aggregate capacity
  - 2004: some SDH – 1.6 Gbps
  - 2005: some lambda – 27 Gbps

# RNP backbone: current implementation



## Notes:

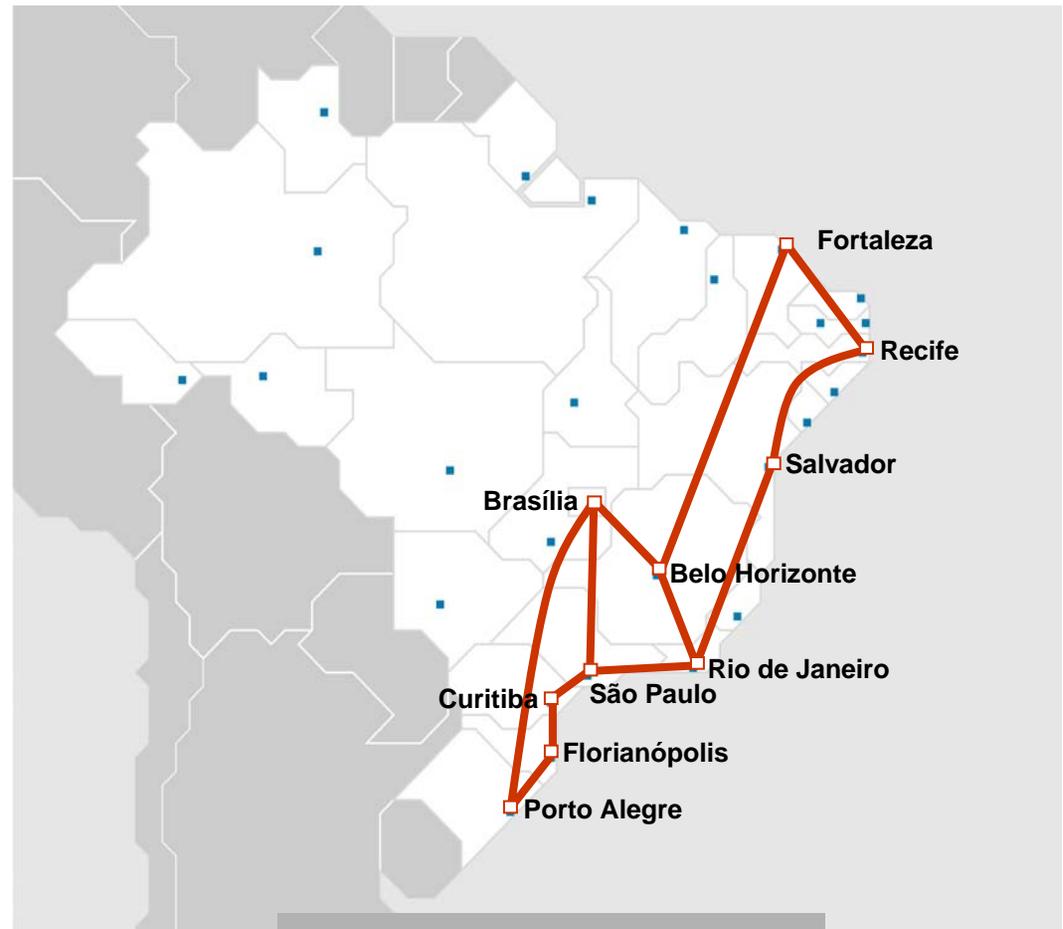
- Brazil is big
- Diameter of about 5,000 km
- Population of 170 millions, unevenly distributed



# RNPng: next generation core network (2005)



- Use of at least 2.5 Gbps for interstate links
- Lambda (if possible) or SDH
- Currently under tender



**RNPng – 3Q2005  
(25 Gbps)**

- 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
  
- We consider the city of Belém, capital of state of Pará (eastern Amazonia) – population of over 1 million



## 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 networking



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

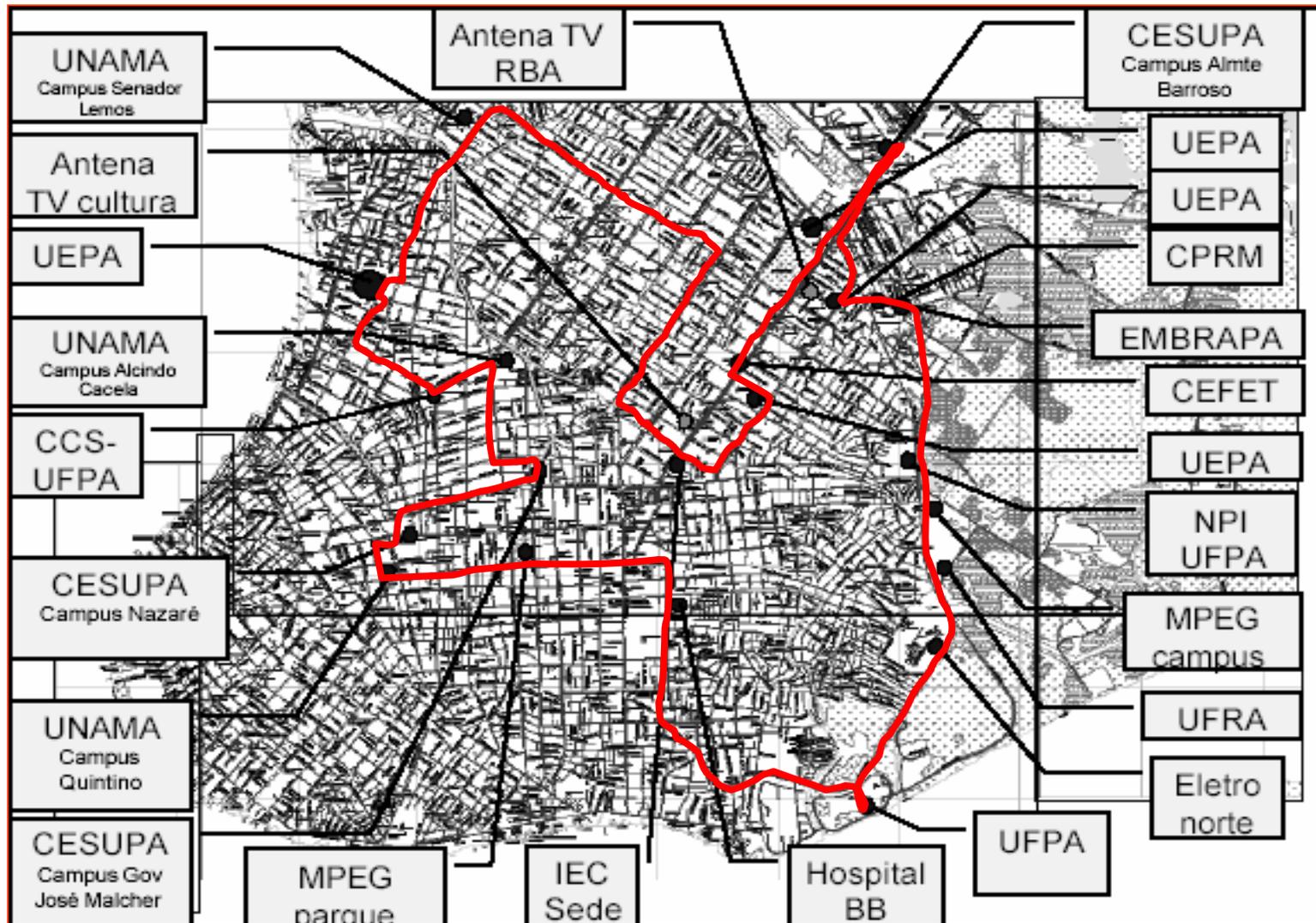
## ■ Costs involved:

- Building out the fibre: using utility poles of electric company
  - US\$ 7,000 per km
  - Monthly rental of US\$1 (about 25 poles per km)
- Equipment costs: mostly use cheap 2 port GbE switches
- Operation and maintenance

## ■ In Belém for 11 institutions using all GbE connections:

- Capital costs around US\$500,000
- Running costs around US\$40,000 p.a.
- Compare with current US\$240,000 p.a. for traditional telco solution

# Belém: a possible topologia (30 km ring)



## RNP activities in metro networks 2005/6



- In December 2004, RNP signed contracts with Finep (agency of the ministry of Science and Technology) to build optical metro networks in all 27 capital cities in Brazil
- Total value of more than US\$15 millions
- Most of this money will be spent in 2005
- Tender for cabling Belém to be published in May



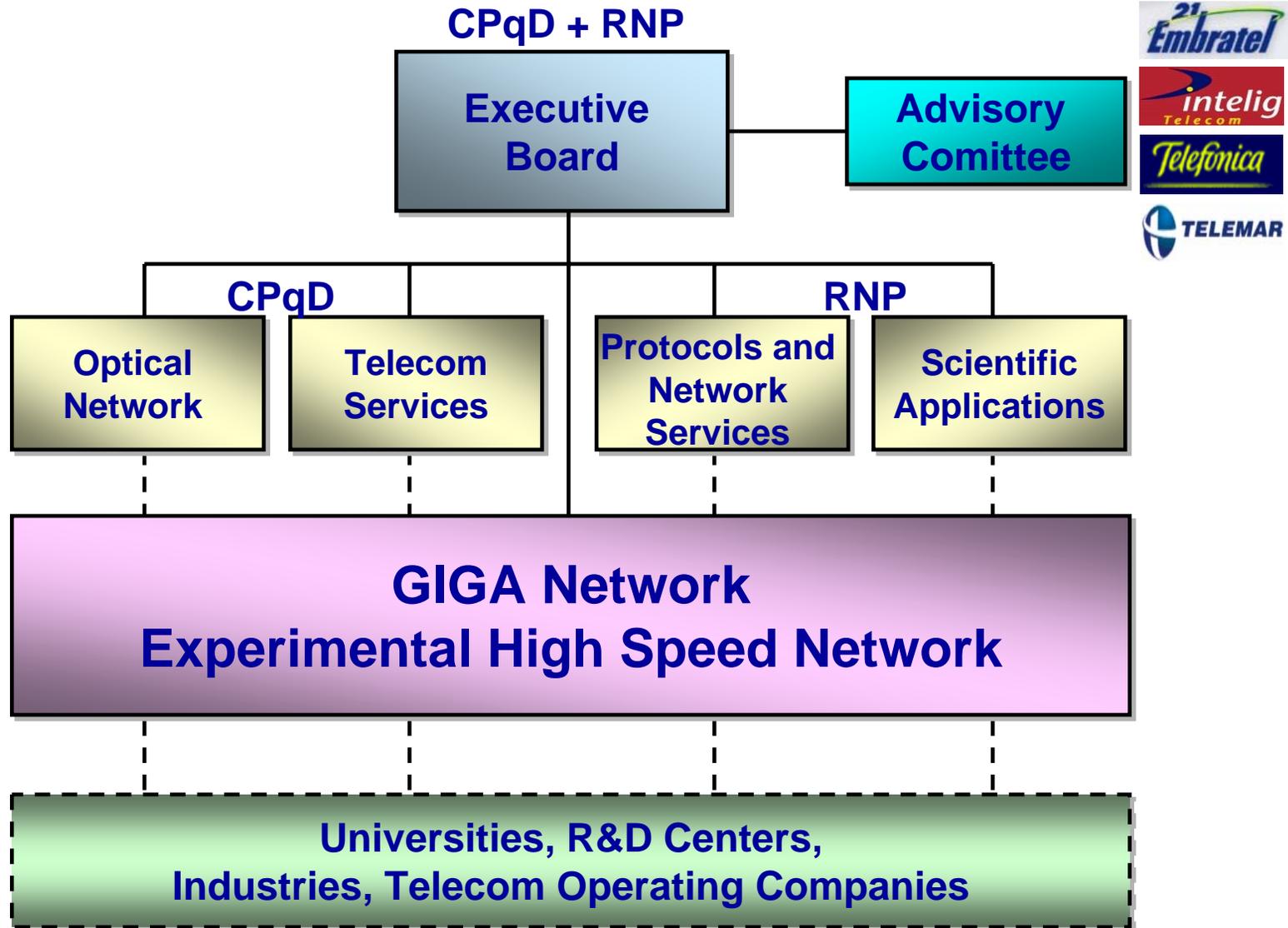
# Project GIGA – optical networking testbed



- Partnership between
  - **RNP (Brazilian national research and education network)**  
[www.rnp.br](http://www.rnp.br)
  - **CPqD (telco industry R&D centre in Campinas, SP)**  
[www.cpqd.com.br](http://www.cpqd.com.br)
  - **R&D community in industry and universities**
- 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 for 3 years (via FUNTTEL/Finep) - started December 2002



# Project Organization



## 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

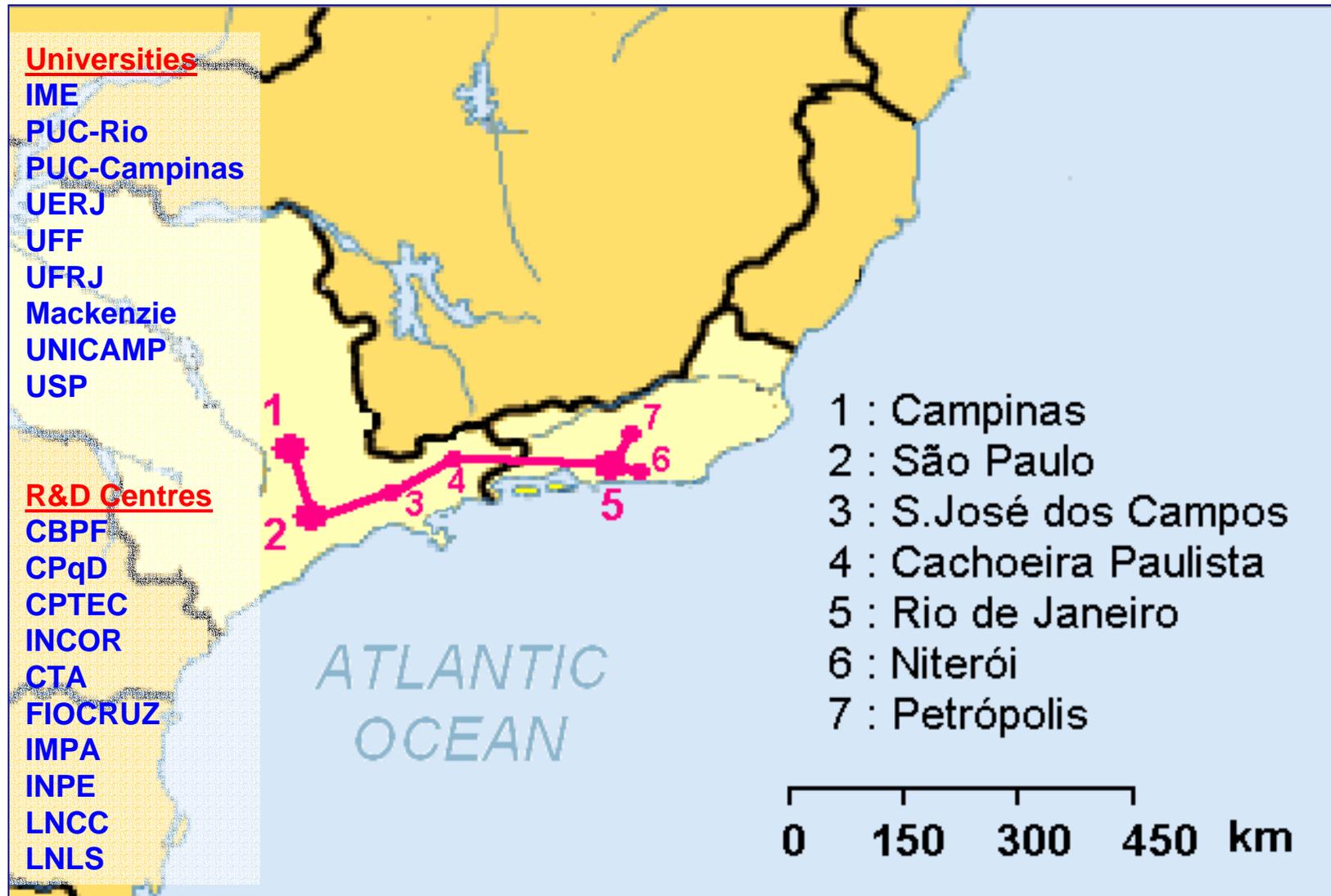
# GIGA testbed network - localisation

## Two kinds of applications:

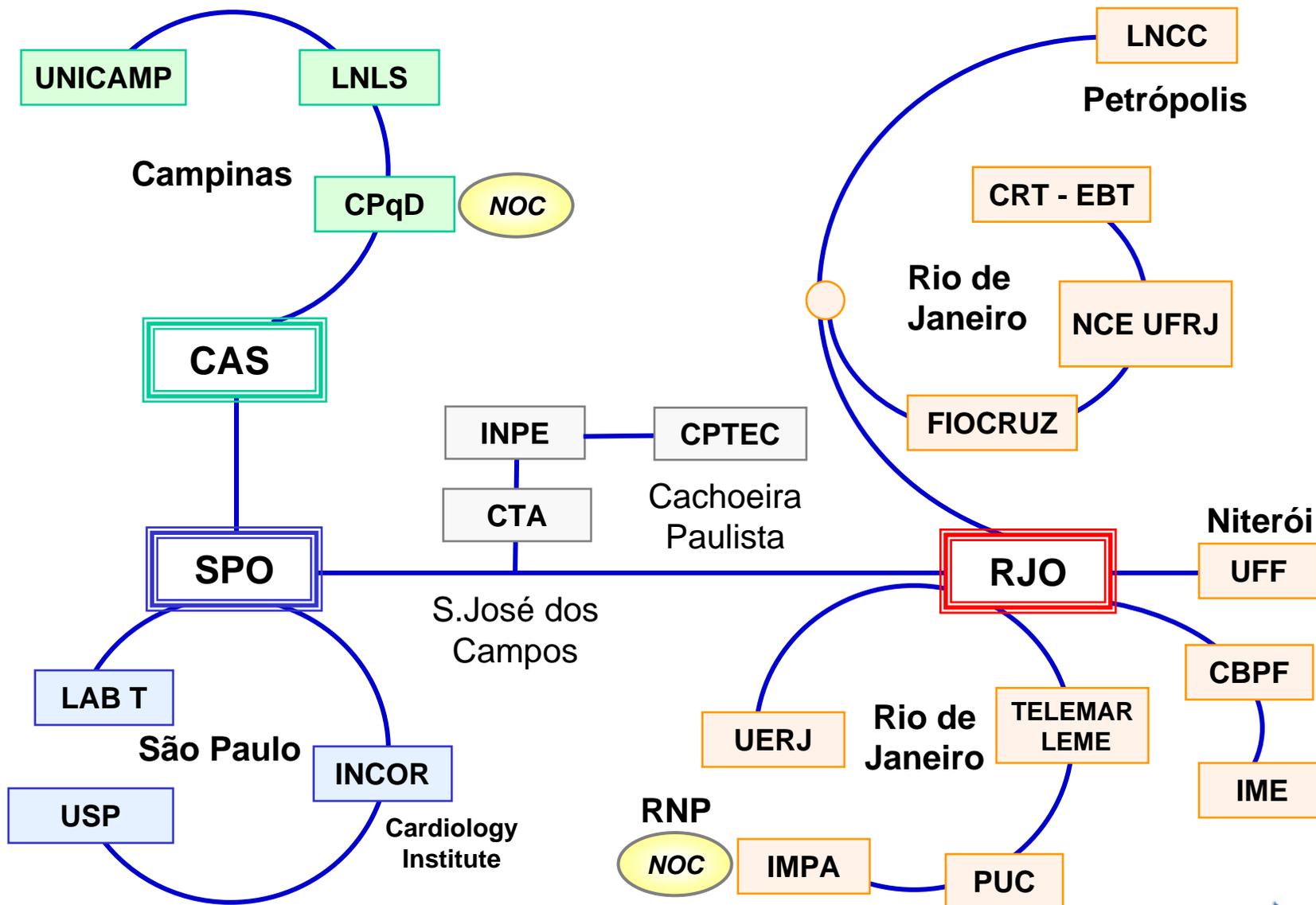
- R&D on optical network and protocols
- R&D on Internet services and applications
- dark fiber-based 700-km backbone
- Initially 20 universities and R&D centers in 7 cities
- GIGA Network will be extended to other regions of Brazil
- Technology: IP/GbE/WDM network
- 8 x 2.5 Gb/s DWDM channels in the backbone
- 3 x 2.5 CWDM channels in the metropolitan area



# GIGA testbed network - localisation



# Network – physical topology

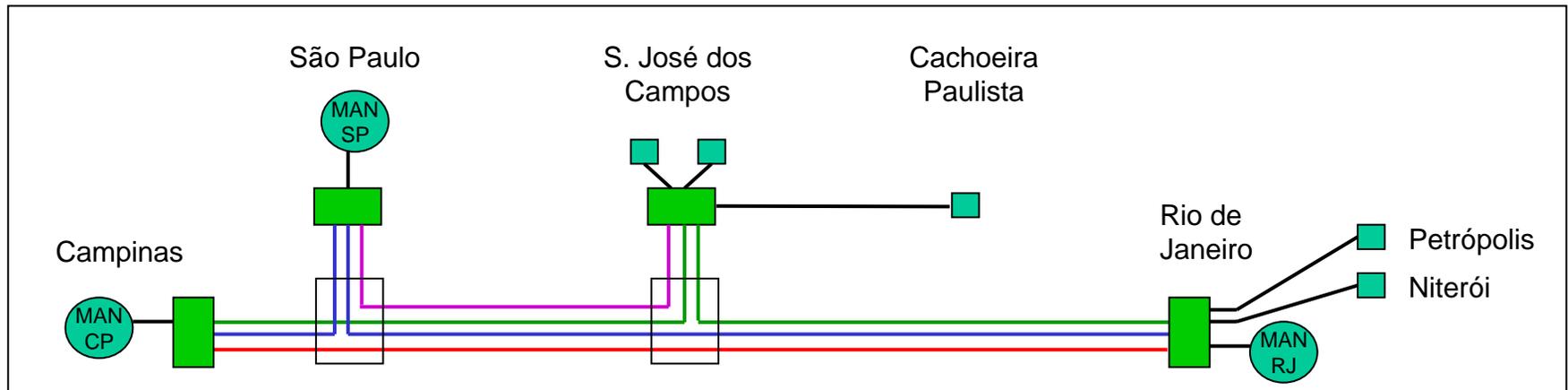
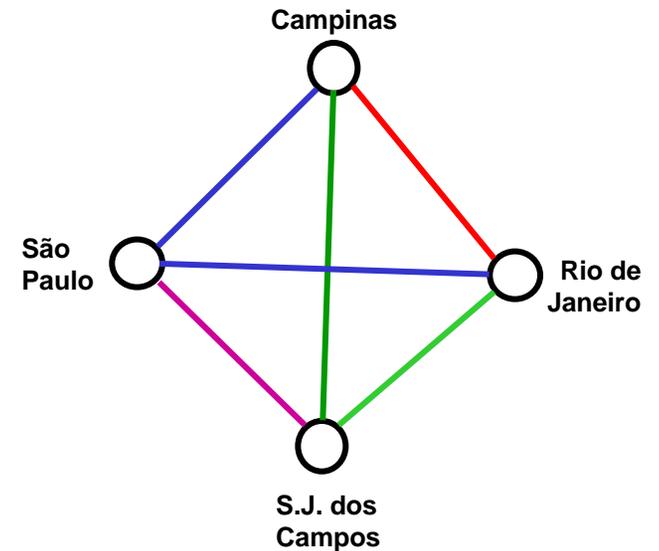


NOC – Network Operation Center

# Initial network design



- intercity 2.5G DWDM network between Campinas and Rio de Janeiro
  - **up to 4 lambdas (wavelengths) per link**
- metro 2.5G CWDM networks (MANs) in Rio, S. Paulo and Campinas
- all links currently 1 Gigabit Ethernet
- optical equipment from Padtec (Brazil)
- IP equipment from Extreme Networks



# GIGA PoP at CPqD



**CPqD DWDM and CWDM Equipment    Extreme Networks L2/L3 Switches**

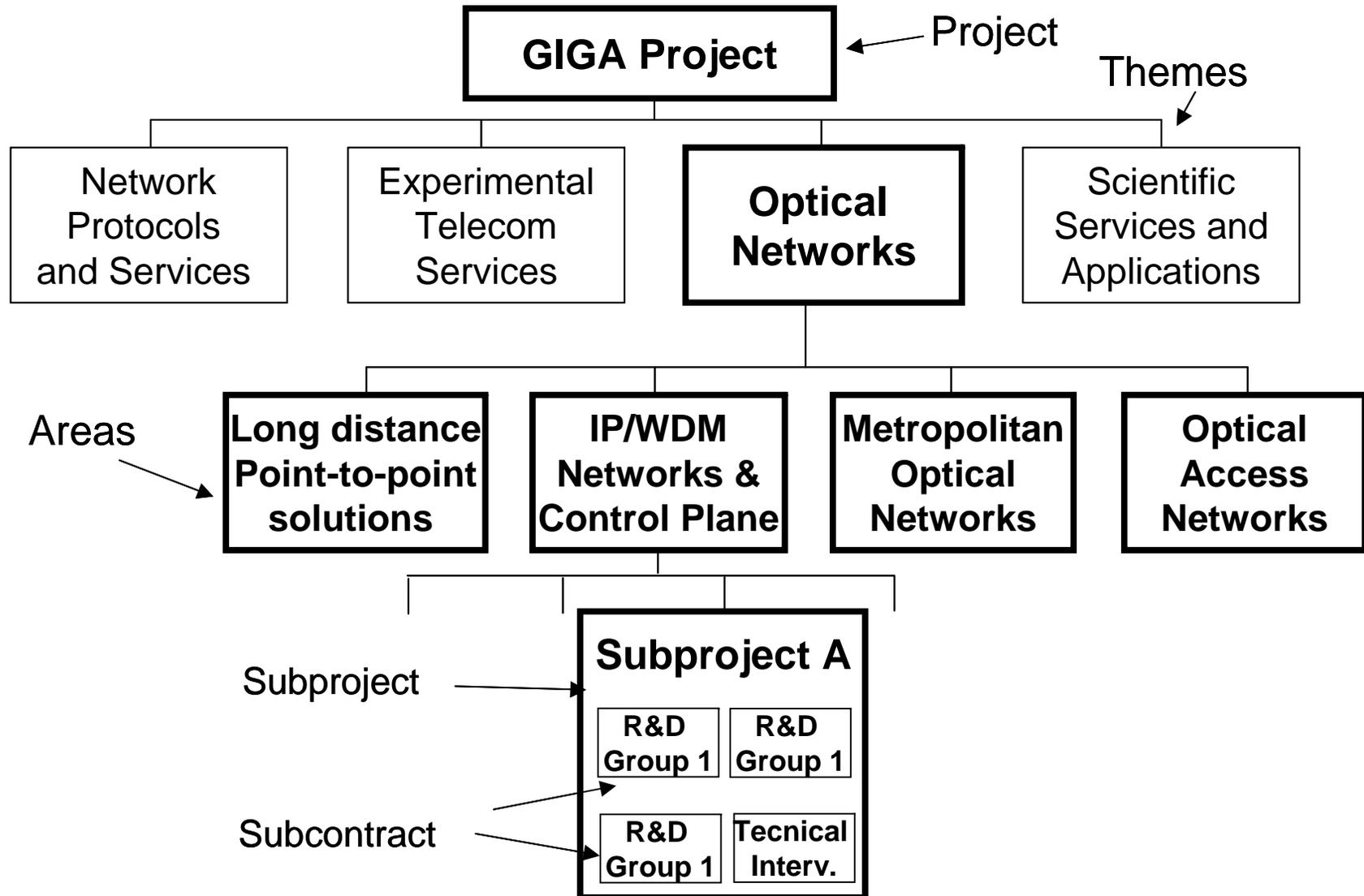


- 2/3 of the GIGA project budget is for R&D activities in the following areas:
  - **Optical networking (CPqD)**
  - **Network protocols and services (RNP)**
  - **Experimental telecommunications services (CPqD)**
  - **Scientific Services and Applications (RNP)**
- Most of the R&D activities are contracted 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.**

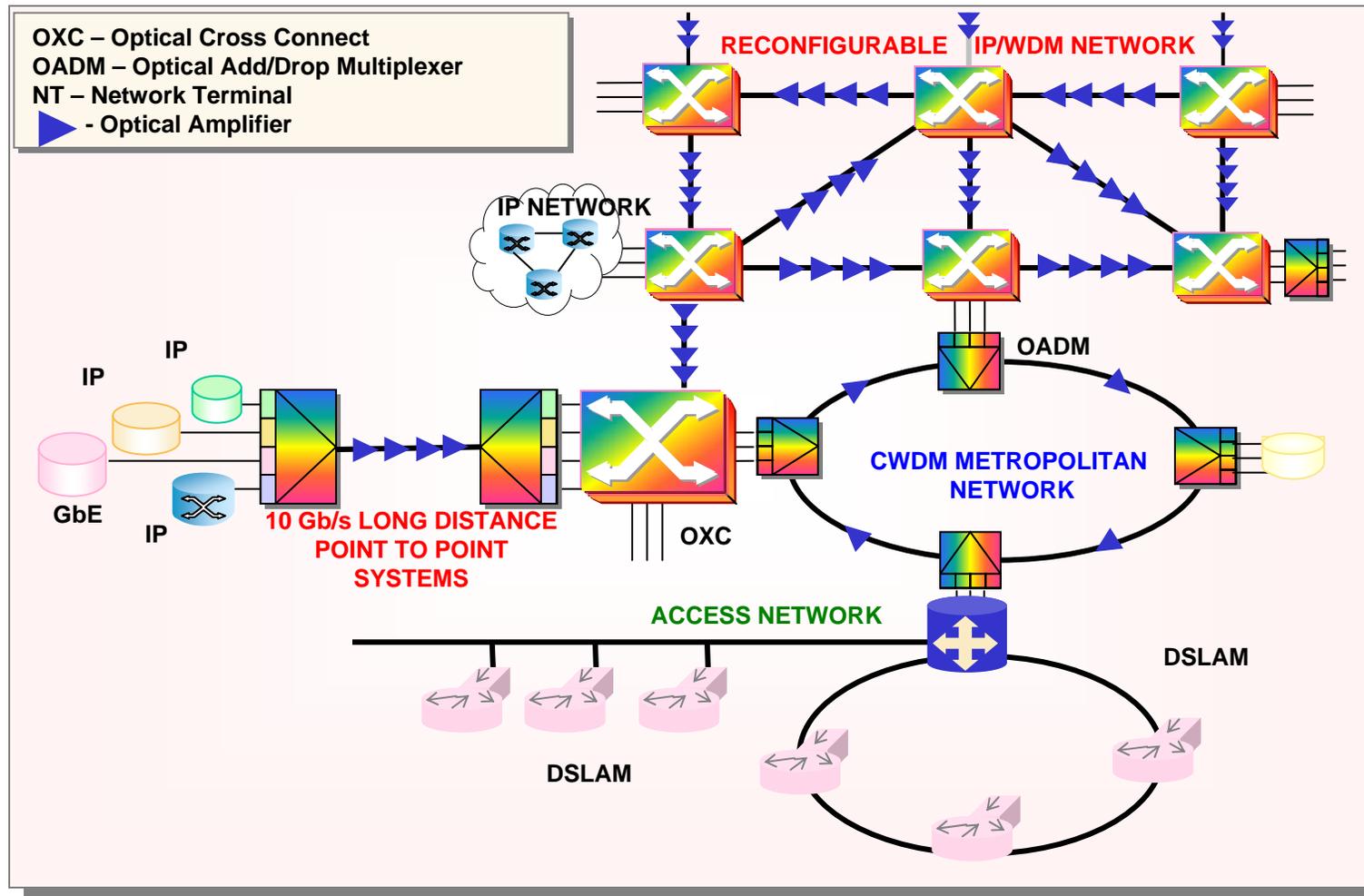


- 20 contracts signed with universities
- In course at CPqD : 4 large projects for development of optical equipment, and 1 for telecommunications services
- Brazilian companies selected to accompany and participate in the Project

# CPqD: R&D in optical networks



- Goal: Develop solutions for the optical layer of an IP/WDM network in collaboration with universities and R&D centers aiming technology transfer to Brazilian industries



- 10 Gb/s Long Distance Point to Point System: **Develop innovative technologies for a point-to-point long distance WDM system operating at 10 Gb/s aiming to improve capacity and span scalability**
- IP/WDM Network with Control Plane: **Develop optical networking technologies for dynamic provisioning, reconfiguration, and restoration of light paths integrated with IP and management layers**
- Metropolitan Optical Network: **Develop low cost technologies for metropolitan optical networks with flexible interfaces regarding services and protocols**
- Optical Access Network: **Develop low cost technologies for access networks**

- Goal: **Develop experimental telecom services for people and organizations in areas of education, culture and health**  
Subprojects
- **SDMD Digital Media Distribution System**
- **This service allows the *Distributors* to publish their media so that the *Exhibitors* can use them, in real time or download**
  - Some possible utilization scenarios:
    - **Communication:** creation of groups to communicate through video conferencing
    - **Tele education:** interconnection of classrooms where teachers can communicate and exhibit didactic material from libraries located in other schools and organizations
    - **Tele Medicine:** video conferencing among health professionals with access to exams, check ups and patient visits
    - **Culture:** creation of a new scenario for Cinema, the **Digital Cinema**, avoiding the costs associated to copies and distribution of films.



- 4 thematic areas contemplated:
  - **Network and transport protocols in advanced networks**
  - **Management of advanced networks**
  - **Real-time multimedia applications in advanced networks**
  - **Large scale distributed applications (includes GRID computing and also “non-telecom” applications)**
  
- Open call for subproject proposals
  - **39 proposals received from consortia of two or more institutions**
  - **33 proposals approved involving research teams from 45 institutions in 15 (of 27) states**

- Network and transport protocols (2)
- Management of advanced networks (5)
  - **IP/WDM (2), PBNM, automatic configuration, measurements**
- Real-time multimedia (9)
  - **Cooperative TV, virtual environments (4), QoS in multimedia, applications (3)**
- Large-scale distributed systems (17)
  - **13 in grid computing**
    - 4 “generic”
    - 4 biology (incl. genome, bioinformatics, etc)
    - 2 physics
    - 3 other applications

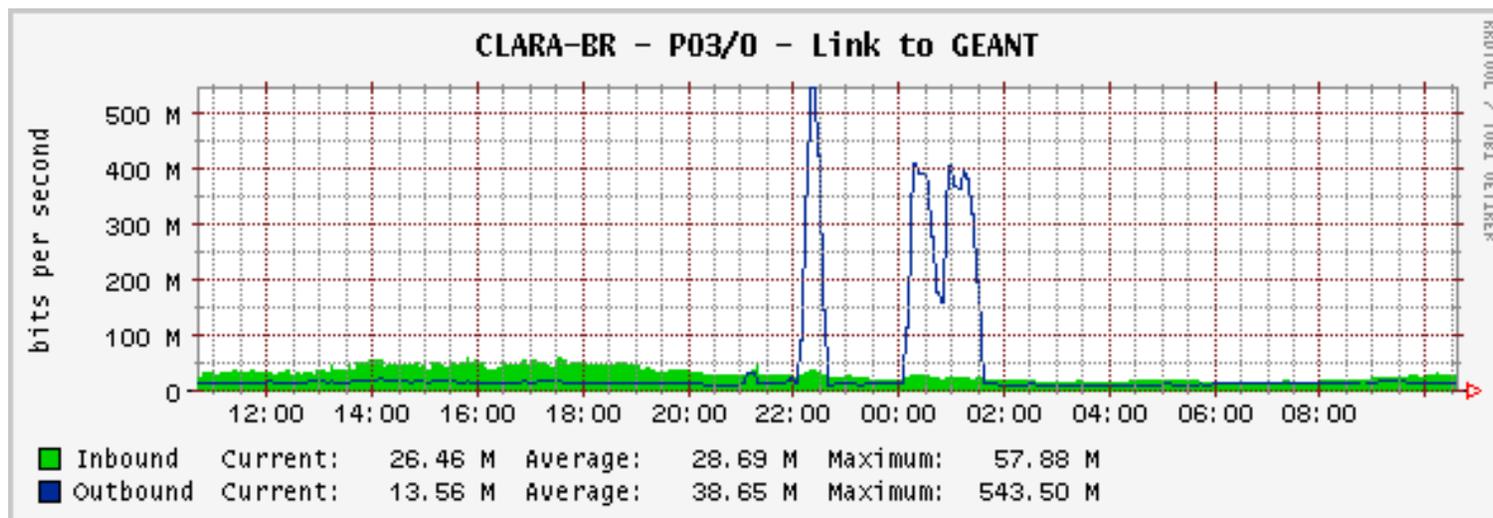


- Testbed Network
  - Design and installation
  - In operation since May 2004
  
- 10 Gb/s Demonstration
  - 300 km distance without electronic regeneration
  - First step to upgrade the WDM channels to 10 GbE
  
- Intercontinental HEP GRID Experiments
  - Demonstration at SC2004 (Brazil, USA and Europe)

# Demonstration of international collaboration



- The RedCLARA network (built and maintained through the EuropeAid-financed ALICE project) facilitates international communication with other advanced networks
- Evidence of this was given during the Bandwidth Challenge (BWC) during SC2004 in November 2004 in Pittsburgh, USA.
  - participation by HEPGrid group from UERJ (Rio de Janeiro)
  - used GIGA testbed + RedCLARA + GÉANT + Abilene
  - peak traffic 500 Mbps, sustained traffic 400 Mbps (Nov 10-11)

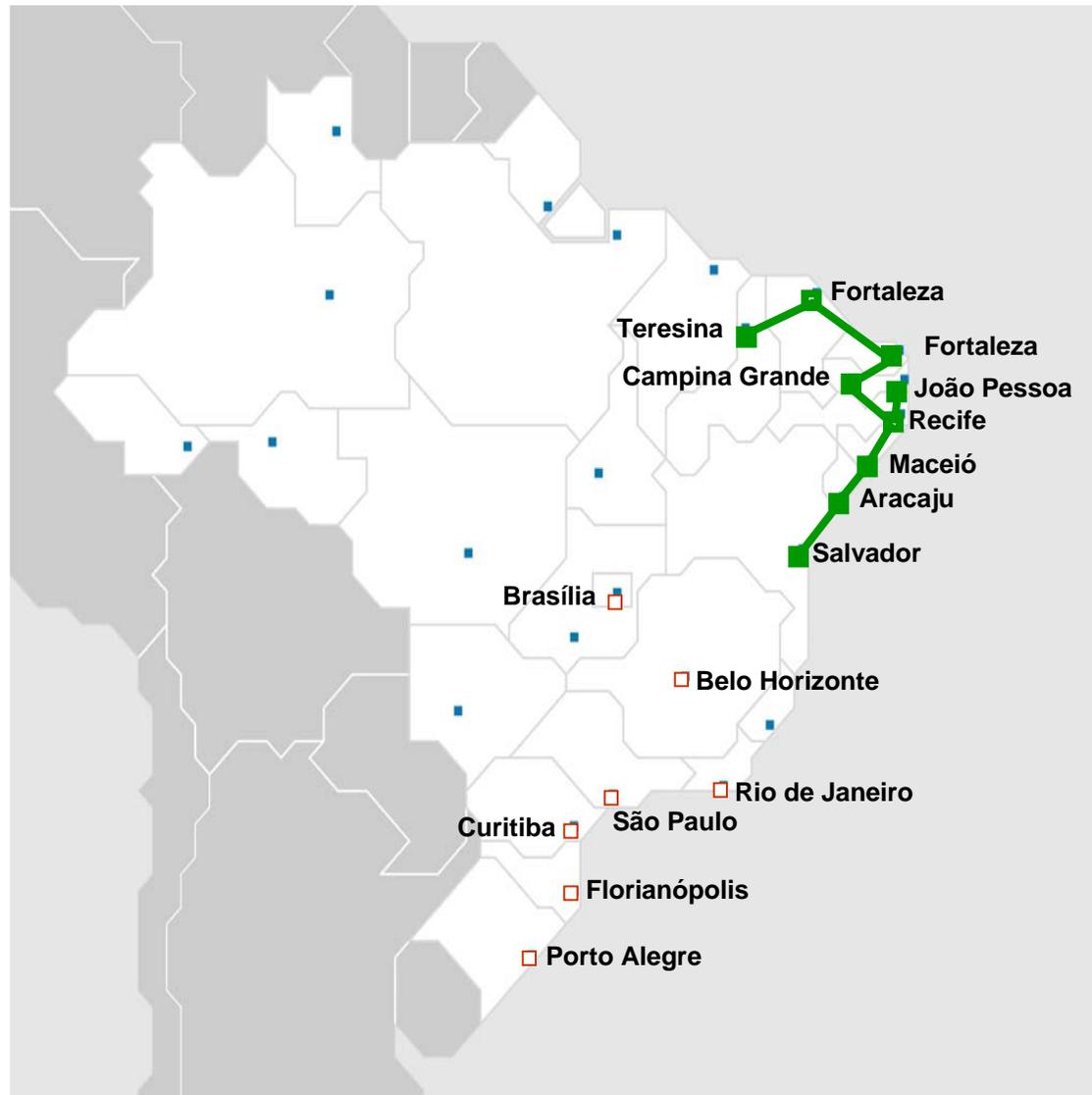


## Future plans for networking testbed



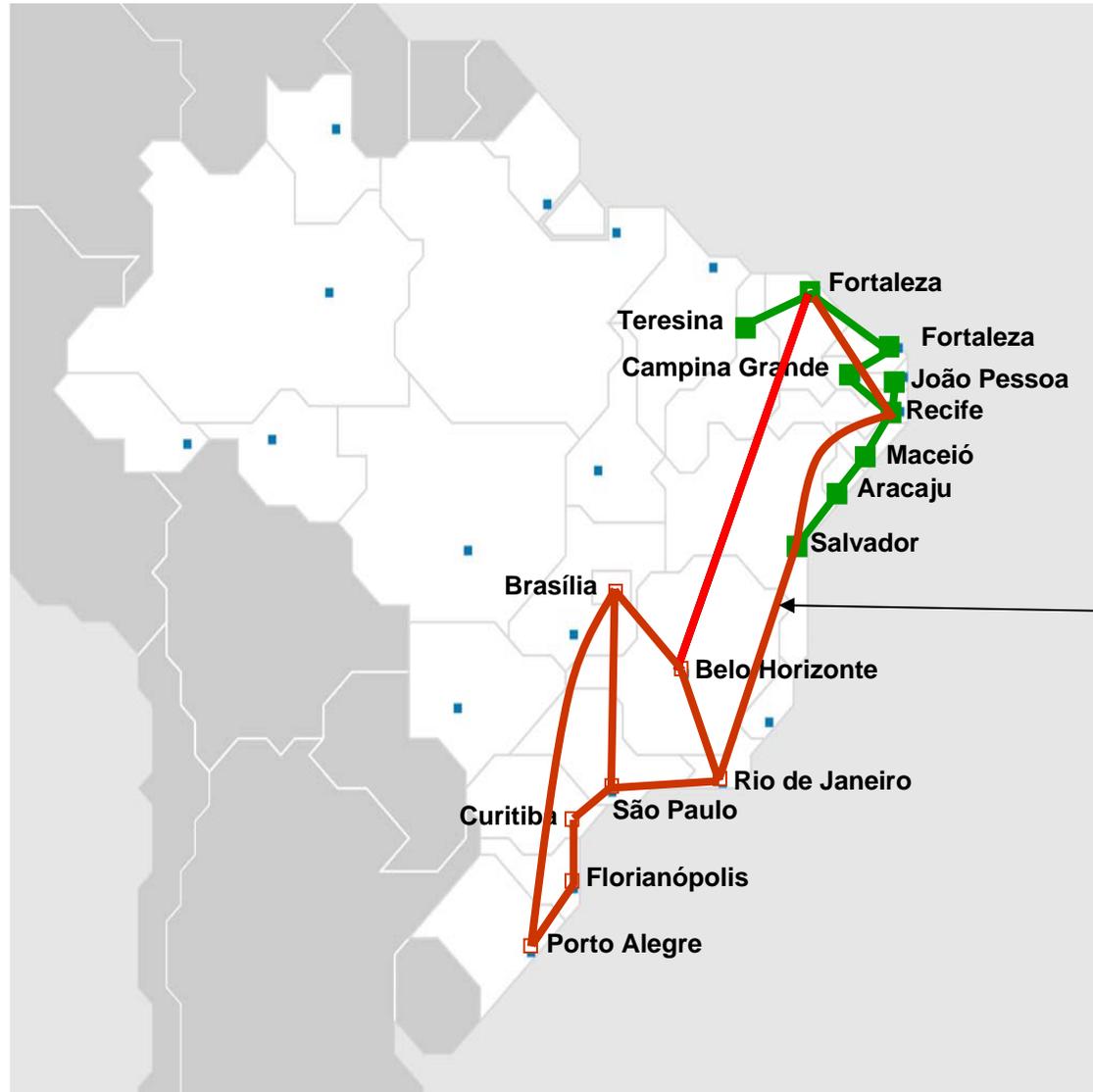
- Fibre lent to Project GIGA is for 5 years and these contracts are renewable.
  - Both the Brazilian government and the R&D community wish to extend the research testbed to other parts of Brazil.
  - An opportunity is being pursued in NE Brazil, to install there an extension of the testbed network, using fibre of the state-owned electrical company, CHESF.
  - This is being combined with the RNPng initiative – the next phase of development of RNP's national network to support Research and Education (R&E) => **Synergy!!**
- Project ION-NE: WDM transport network in NE Brazil to provide
- **Production IP service for R&E institutions**
  - **Extension of the testbed network to R&D institutions**

# Project ION-NE: WDM transmission network



**Chesf**

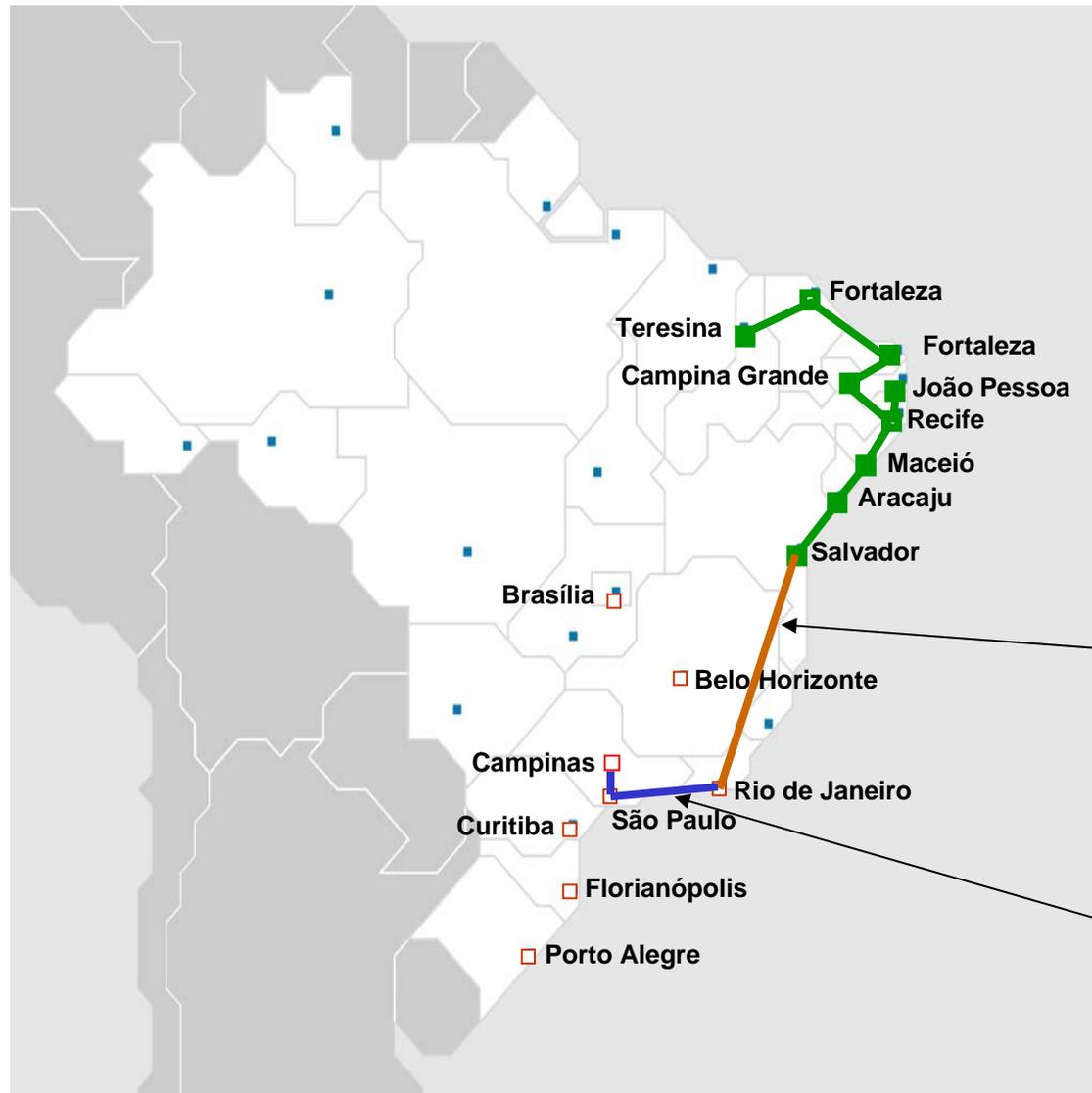
# Project ION-NE: integration with RNPng



RNPng b'bone  
(2.5 Gbps)  
in 2005

**Chesf**

# Project ION-NE: extension of GIGA testbed



Interconnect to present testbed

Project GIGA testbed

**Chesf**

## Project ION-NE: future of Project GIGA



Project GIGA lasts for 3 years, until the end of 2005.

We have as a product a large laboratory for R&D in telecommunications and advanced networking – the testbed

Project Rede Nordeste should extend this testbed from 700 to 4.000 km, connecting R&D institutions in cities in NE Brazil.

It is expected that Project Rede Nordeste also includes support, from 2006, for:

- maintenance and operation of the extended testbed network
- new R&D activities in telecom and advanced networking using the extended testbed



- **The model of working in partnership with the state-owned electrical companies has several advantages:**
  - The 4 major companies have national coverage with (mainly) OPGW cabling
  - The model being used is a partnership, sharing the same fibre and WDM transmission system with the electrical company
    - The company has a serious interest in maintaining and operating the transmission system
  - Optical transmission equipment costs:
    - Installing 2,5 Gbps DWDM on CHESF fibres costs around US\$2,000 per km (lots of OADMs to handle CHESF capillarity)
    - Costs can be as low as US\$1,100 per km for long runs without branching

# The cost of a national WDM network



- Consider the present Eletronet footprint (based on federal electrical companies' transmission lines)
- 16,000 km extension – touches 18 of Brazil's 27 states
- Using CHESF costs, we have CapEx not more than US\$ 32 M
  - Compare with RNP's current telco costs of US\$13 M p.a.
- Note that the optical metro networks currently under construction will provide local access in the cities reached





***Thank you!***

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[www.rnp.br](http://www.rnp.br)

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