Overseas Update
Future Internet Testbeds in Brazil: Activities and Goals

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Topics

- RNP and CPqD organisation
- RNP Infrastructure
- Testbed networks and collaboration
- Future Internet initiatives

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RNP: organisation and functions

- Non-profit private company with a long-term management contract to Brazilian federal government to operate and develop the national R&E network
- Support provided by 4 ministries: Science and Technology, Education, Culture and Health
- Provides collaboration and commodity Internet services through the operation of its national network infrastructure, providing connectivity to over 600 campi of over 400 public and private institutions, including 130 universities.
- Develops advanced Internet services for users
- Provides support for national and international collaborations for specific user communities
- Provides testbed facilities for R&D in networking and distributed applications

Services to academic community

- **CAFe – Federation authentication (shibolett based)**
- **ICPEDU – PKI for education**
- **fone@rnp – VoIP**
- **video@rnp – Video on demand (CDN)**
- **Conferencia Web – webconf (adobe connection)**
- **IDC – Internet data Center**
- **FIX – PTT**
- **Service Desk – user support 1st level**
- **Cipo – Dynamic circuit provisioning**
- **Ipê – IP connection**

CPqD

- **Major telecom R&D center in LATAM with expertise in various areas:**
  - **Optical (WDM, PON), Wireless (WiMax, LTE), IP (IMS/NGN, OpenFlow), OSS/BSS, Digital TV…**
  - **Today with ~1200 highly-skilled employees**
- **Created in 1976 as R&D branch of Telebras - Brazilian telecom monopoly**
- **Private foundation since 1998 after Telebras was privatized**
- **Purpose to foster innovation to help (mainly) Brazilian companies and society**
  - **Focus on technology R&D**
  - **Bridge the gap between universities and the industry**
- **Near highly-ranked universities in Brazil**
  - **History of collaborations**

CPqD – Network division

- **Various product technologies transferred to the Brazilian industry (since privatization)**
- **Most successful spin-offs (and consumers of CPqD technology)**
  - **Tropico: created in 1999 with focus on NGN/IMS; US$ 120M revenue in 2008, with growing presence in South America**
  - **Padtec: created in 2001 with focus on WDM; US$ 150M revenue expected in 2011; WDM market leader in Brazil, with growing presence in South America and Europe**

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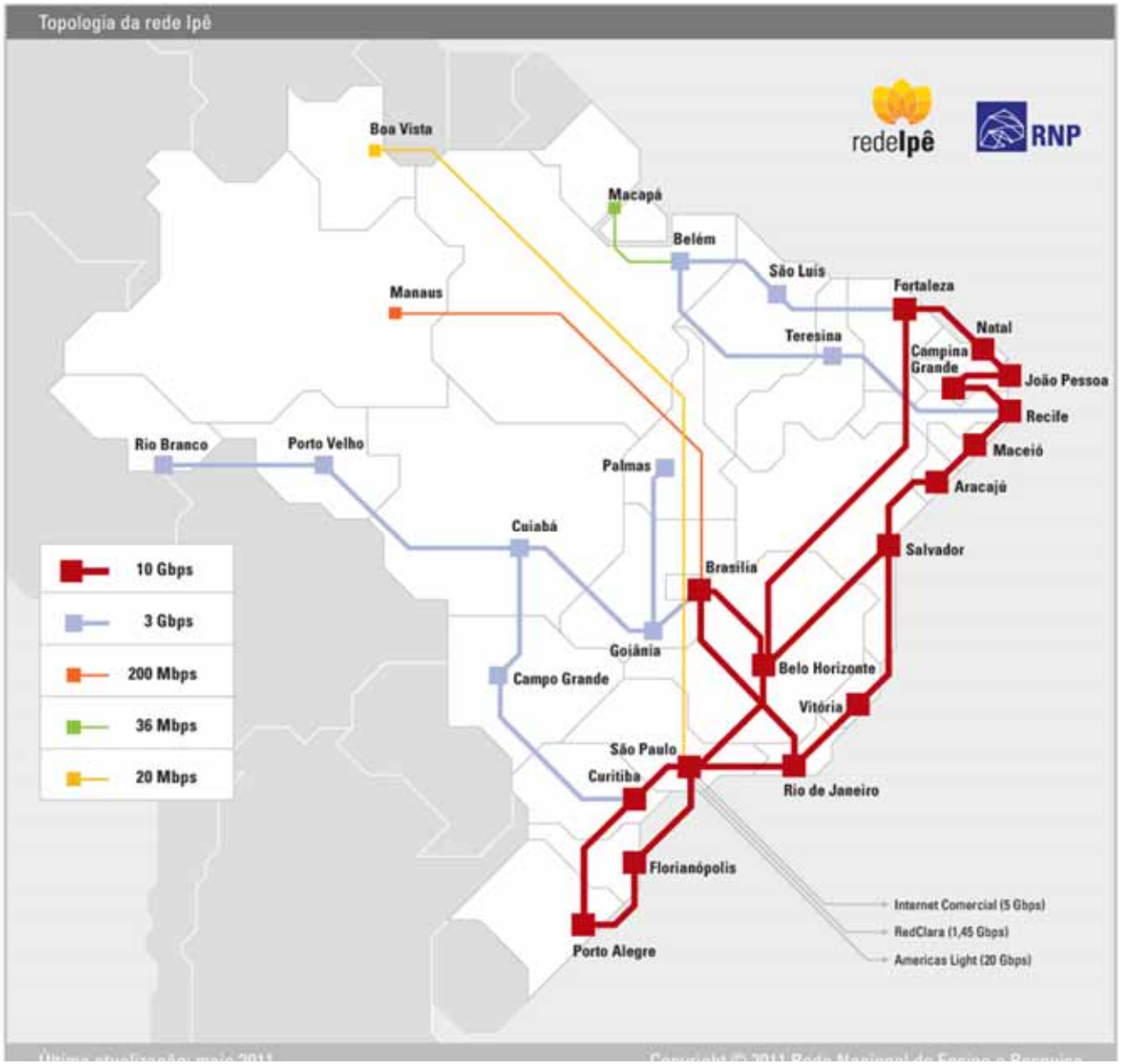
RNP infrastructure:
Phase 6 national backbone in 2011



- Agreement with local telco Oi, brokered by regulatory agency
- 16 states - 10 Gbps
- 9 states - 3 Gbps
- No terrestrial fibre to other 3 states
  - Above Amazon river
  - 200Mbps to 20 Mbps
- Hybrid architecture, supporting routed IP and e2e circuit traffic

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RNP infrastructure:
optical metropolitan networks

- Since 2004, RNP programme of metropolitan networks, to provide adequate access to the multigigabit backbone

- Networks are based on overprovisioned dark fiber networks, shared between the R&E institutions served
  - Usually built and owned by RNP
  - Use 1 or 10 GE transport and permit:
    - interconnection of the campi of the participating institutions
    - access to RNP´s IPÊ network PoP

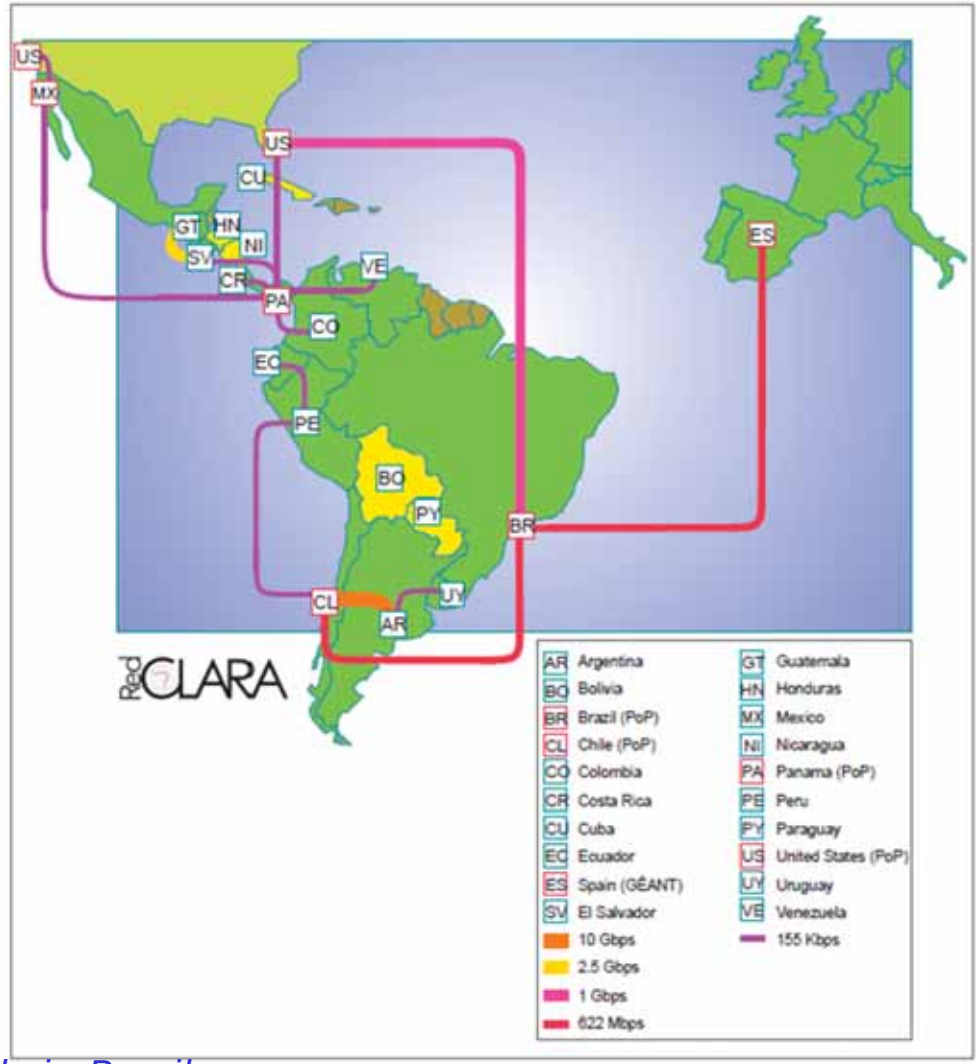
- 21 networks already operating
  - All 27 capital city metro networks by end 2011

- Extension underway to 14 non-capital cities – first networks to be concluded in 2011

RNP infrastructure:
international connectivity

- RedCLARA: regional R&E network in Latin America
  - Created 2004 with partial funding by EU (ALICE and ALICE2 projects)
    - Currently links 13 countries in region
    - 622 Mbps Brazil-GEANT
    - Connections to US networks
- AmLight (US IRNC2 project) – RNP, FAPESP & NSF funds
  - Provides 3 links to LA networks
    - 2 cross-border dark fibre links between US and Mexico
    - 20 Gbps between US and Brazil (São Paulo)
      - Currently includes 8 Gbps commodity traffic and 1 Gbps RedCLARA
      - Also used for GLIF link to Brazil networks

RNP infrastructure:
AmLight and RedCLARA – 2011
(courtesy Julio Ibarra and María José López, respectively)



Testbed networks and collaboration

- Two large-scale testbed structures have been established in Brazil in recent years for support of networking and distributed applications:
  - Project GIGA testbed network
  - Project KyaTera

- These testbeds are linked nationally and internationally through
  - RNP network in Brazil
  - GLIF international collaboration in circuit services

- RNP backbone will offer circuit services to its connectors in 2011, which will permit extending testbed networks to 24 states in Brazil

Project GIGA

- First R&D project in South America with emphasis on large-scale network experimentation
- Main objectives:
  - Development of advanced skills and scientific knowledge by participants
  - Develop Brazilian industry/service companies
- R&D focus on:
  - Optical networking
  - Current Internet services and applications
  - Future Internet architecture (from 2009)
- Funded by Funttel under Finep management
  - Phase I (2003-2007):
    - Included R&D and installation of network testbed
  - Phase II (2009 – 2012):
    - Includes R&D and some minor upgrade of the network testbed
- Collaboration between CPqD and RNP

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Project GIGA Testbed

- First large-scale experimental network in South America (2004)
- "Pre-deployment" large-scale lab for experimenting ideas of interest to telecom operators, service providers and RNP
- External connectivity via RNP PoPs in Rio de Janeiro and São Paulo
- 800km total fiber span over 7 cities in 2 states (SP, RJ)
- 66 labs from 26 institutions connected (fiber to the lab) at 1 and 10 Gbps
- e2e dynamic (VLAN) multidomain protected circuits for L2 and above on demand experiments

KyaTera research network in SP state

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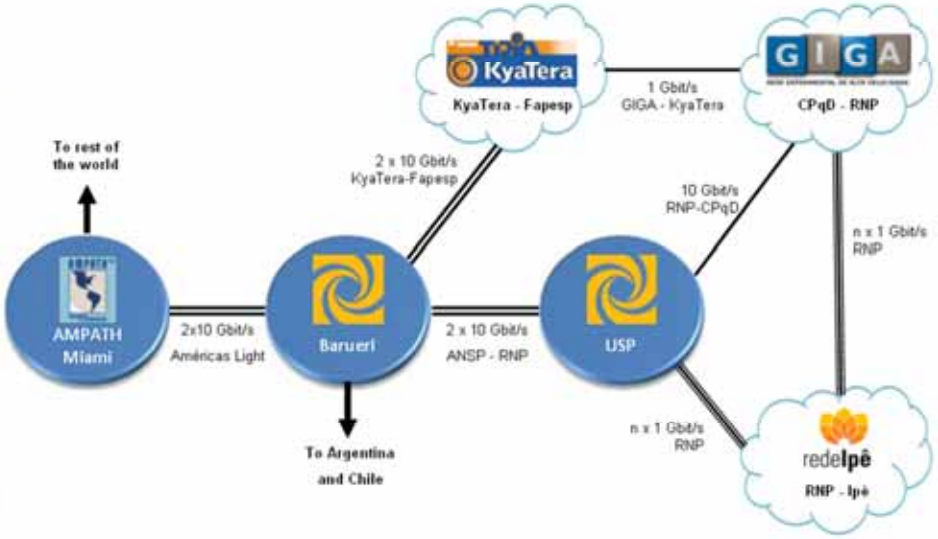
KyaTera: details

- Dark fibre network from carrier (Telefonica)
  - 1000km total fiber span over 9 cities in SP state
  - 90 labs from 26 institutions connected (fiber to the lab) at 1 and 10 Gbps
- Layer 1 equipment (ROADM) from Padtec (Brazil)
- Layer 2 equipment (Ethernet) from Datacom (Brazil)
  - 10G channels between São Paulo, Campinas and São Carlos
  - 1G on other links
- External connections nationally (via RNP networks) and internationally via AmLight and GLIF
- Research program includes network development

Interconnections of Experimental Networks in Brazil



Future Internet Testbeds in Brazil

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Summary of Networks supporting Experimentations in Brazil

	GIGA	Kyatera	RNP-Testbed
Connectivity	• Fiber to the Lab • 1 / 10Gbps over fiber	• Fiber to the Lab • 1 / 10Gbps over fiber	• Fiber to the campus • 10Gbps over fiber
Offer to experimentation	• e2e dynamic (VLAN) multidomain restoration-capable circuits for on demand experiments at network or application level • Manual provision of wavelength for L1 experimentation	• Manually provisioned (VLANs) circuits for experiments at network or application level • Manual provision of fiber/Wavelength for L1 experimentation	• Stable IP-routed network for experiments at application level • e2e dynamic (VLAN) multidomain circuits for on demand experiments at network or application level
Main goal	• Technology R&D	• Scientific research	• Support academic research
Coverage	• 66 labs • 7 cities in the states of SP and RJ • 800km total span	• 90 labs • 9 cities in the state of SP • 1000km total span	• 24 of all 27 capitals of Brazil • 600 campi • 30000km total span

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Future Internet activities and plans

- Brazilians have been tracking FI initiatives in other countries since 2007, and wider discussion and activities began in 2009, with:
  - Nick McKeown's keynote address on the Clean Slate Program to INFOCOM in Rio de Janeiro
  - the reactivation of the GIGA project, and the funding of other FI projects
  - the understanding reached by the Brazilian government and the European Commission on joint funding of ICT projects
- The annual Brazilian Symposium on Computer Networking has also debated this topic since 2009, and has included the Workshop on Experimental Research in FI since 2010.
- The growing awareness in the networking community that to participate in FI R&D is of strategic importance to the country still needs to translated into more widely available funding.

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FI: GIGA Phase 2 - FI testbed

- The original project (RNP & CPqD) was funded until 2007
- In 2009, CPqD was once more funded by Funttel, and RNP via Ministry of S&T
- In this phase focus on **Future Internet** experimentation, with active search for international partners:
  - CleanSlate Program de Stanford U (OpenFlow):
    - OpenFlow implemented on Brazilian switch (CPqD)

GIGA Testbed : OpenFlow data plane

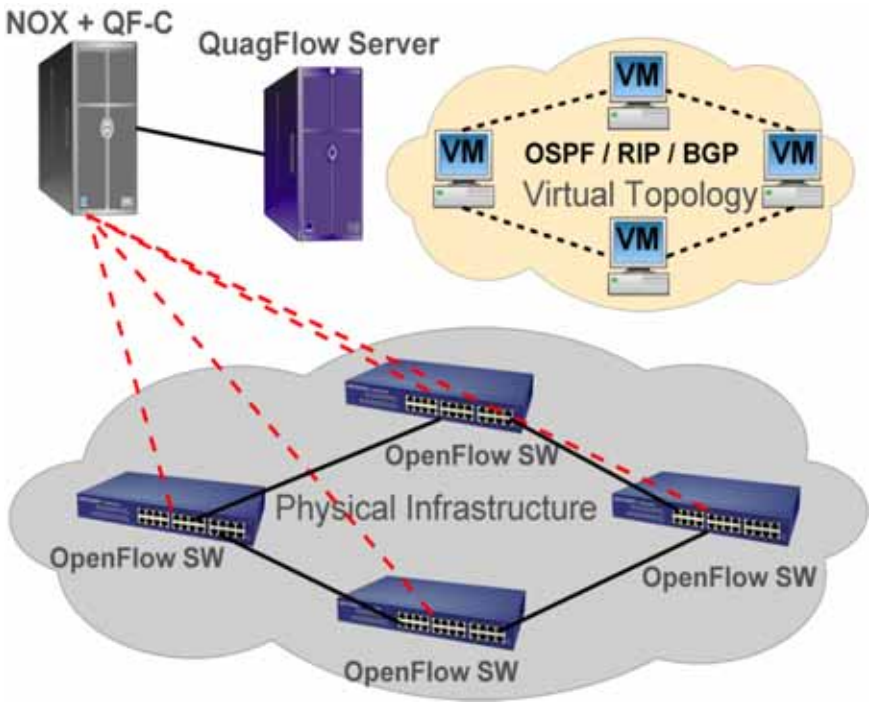
OpenFlow Switch

- **24 x 10/100/1000**
- **2 x 10Gb**
- **L2/L3**
- **~2000 flow entries**
- **No protocol stack**

OpenFlow ROADM

- **WSS for mesh networks**
- **3 / 5 degree**
- **Directioned / Coloured**
- **Virtualization-capable**
- **Multicast-capable**

GIGA Testbed : Separated control plane over OpenFlow data plane



RouteFlow:

- IP Routing stack on top of OpenFlow Controller
  - Currently Quagga on top of NOX, but should work with other stacks and controllers
- Routing instances run as virtual entities in standard PC server(s)
  - Currently each instance is a virtual machine, but investigating other virtualization schemes
- Routing virtual entities interconnected to mimic the physical topology
- Source code available upon demand
- Approach to be taken to support GMPLS over NOX to control OF switches and ROADMs

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GIGA Testbed : 100Gb (coherent) DP-QPSK

v1 (incomplete) prototype – Sept 2010

First trial (Campinas → São Paulo Campinas=300km) scheduled by end of 2011

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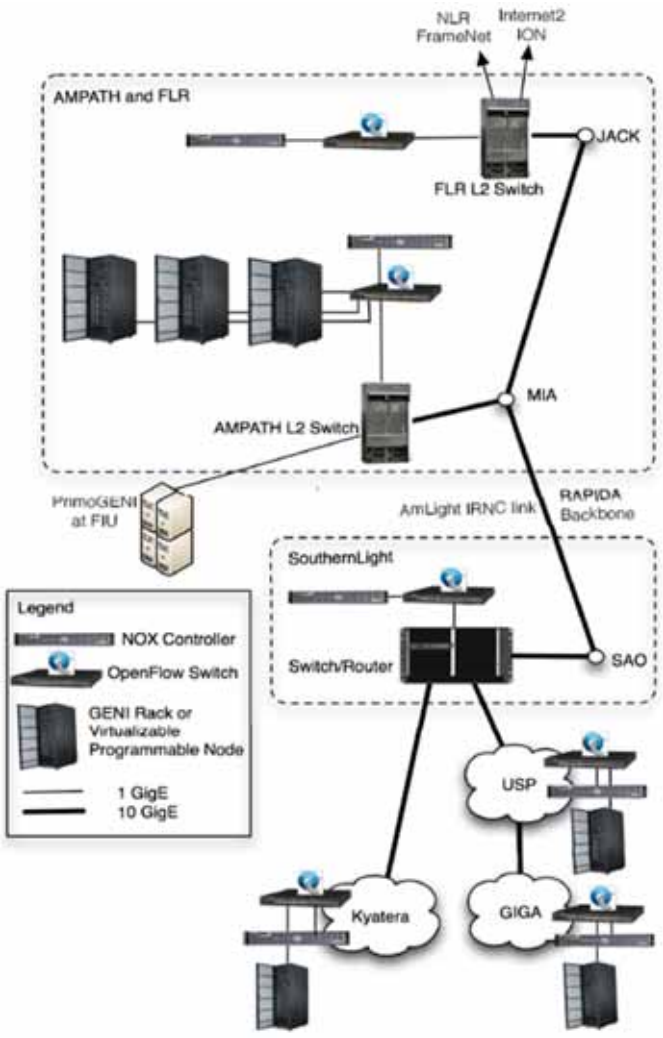
GENI



- **CPqD, RNP and BBN signed a MoU to share resources for FI experimental research**

- **CPqD and RNP have contributed with connectivity and servers to iGENI**

- **Brazilian institutions are participating in two proposals submitted to GENI solicitation 3**
  - **RAPIDA: CPqD, RNP, USP, GIGA, Kyatera, Ipê**
  - **InstaGENI: CPqD, RNP, GIGA, Ipê**

  ... Either should result in GENI racks being deployed in Brazil

RAPIDA

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FI: INCT/WebScience

- Consortium led by Catholic U (PUC) of Rio de Janeiro – more than 110 researchers from around 10 universities
  - Funding provided by CNPq (Agency of Ministry of S&T)
  - in 2008, group of 8 researchers (from RNP, UFF, UFPA, UNIFACS, USP) proposed the research area “Future Internet Architectures”
  - main emphasis on experimental research, based initially on PlanetLab / VINI environment, with extensions for wireless access networks
    - Later evolution to adoption of OpenFlow for software defined networks
  - use of RNP networks for long-distance integration
  - financial support available in 2011

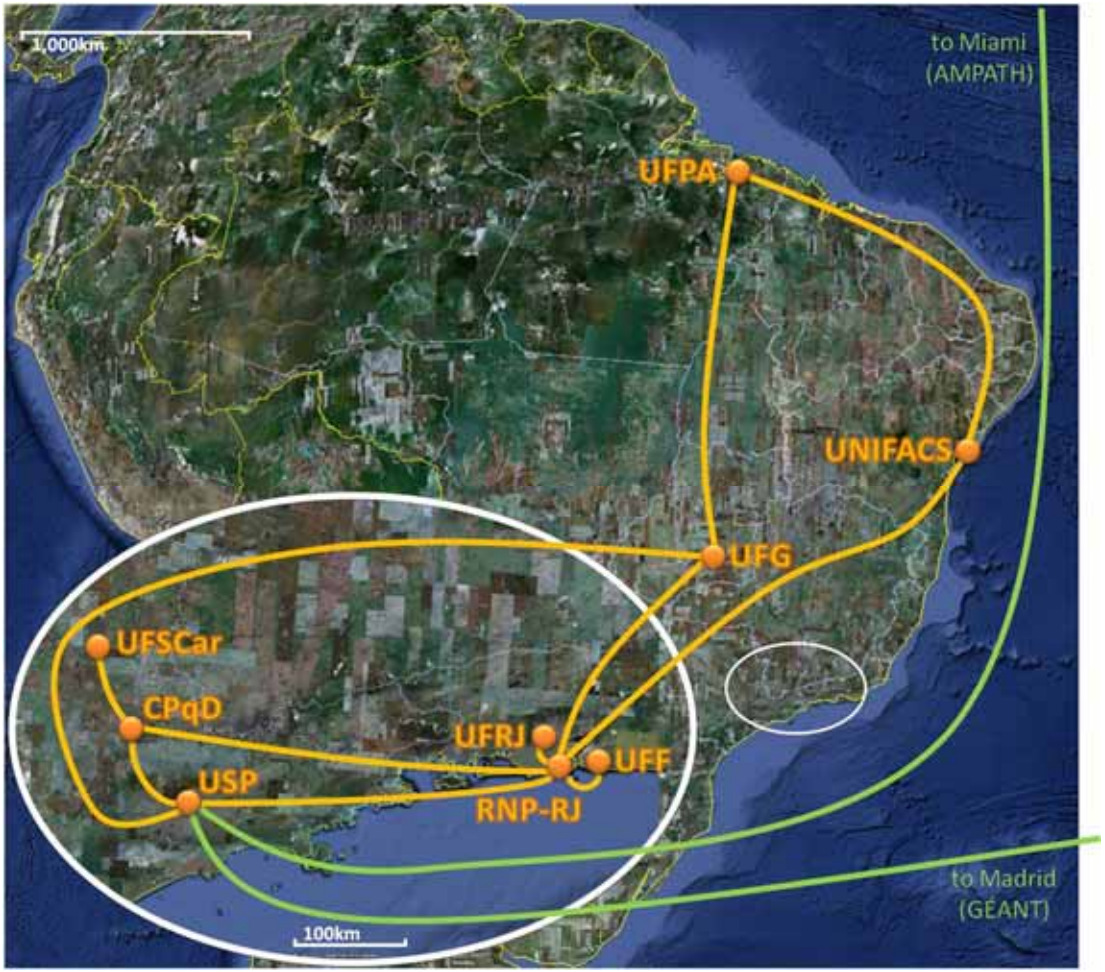
Funding for collaboration with EU partners

- Wide-ranging discussions between the Brazilian government and the European Commission led to bilateral funding of projects in ICT:
  - **Coordinated calls Brazil-EU in ICT (Sept 2010)**
  - The 5 call topics included:
    - Future Internet - Experimental facilities
    - Future Internet – Security
  - Project approved :
    - FIBRE – Future Internet Experimetal facility

FIBRE:
FI testbeds between BRazil and Europe

- Proposed collaboration between 9 partners from Brazil (6 from GIGA and INCT projects), 5 from Europe (4 from Ofelia and OneLab) and 1 from Australia (from OneLab), with a proposal for the design, implementation and validation of a shared Future Internet research facility, supporting the joint experimentation of European and Brazilian researchers.
- The objectives include:
  - the development and operation of a new experimental facility in Brazil
  - the development and operation of a FI facility in Europe based on enhancements and the federation of the existing OFELIA and OneLab infrastructures
  - The federation of the Brazilian and European experimental facilities, to support the provisioning of slices using resources from both testbeds.

The FIBRE consortium in Brazil



- The map shows the 9 participating Brazilian sites (islands) and the expected topology of their interconnecting private L2 network
- Possible international links are also shown.

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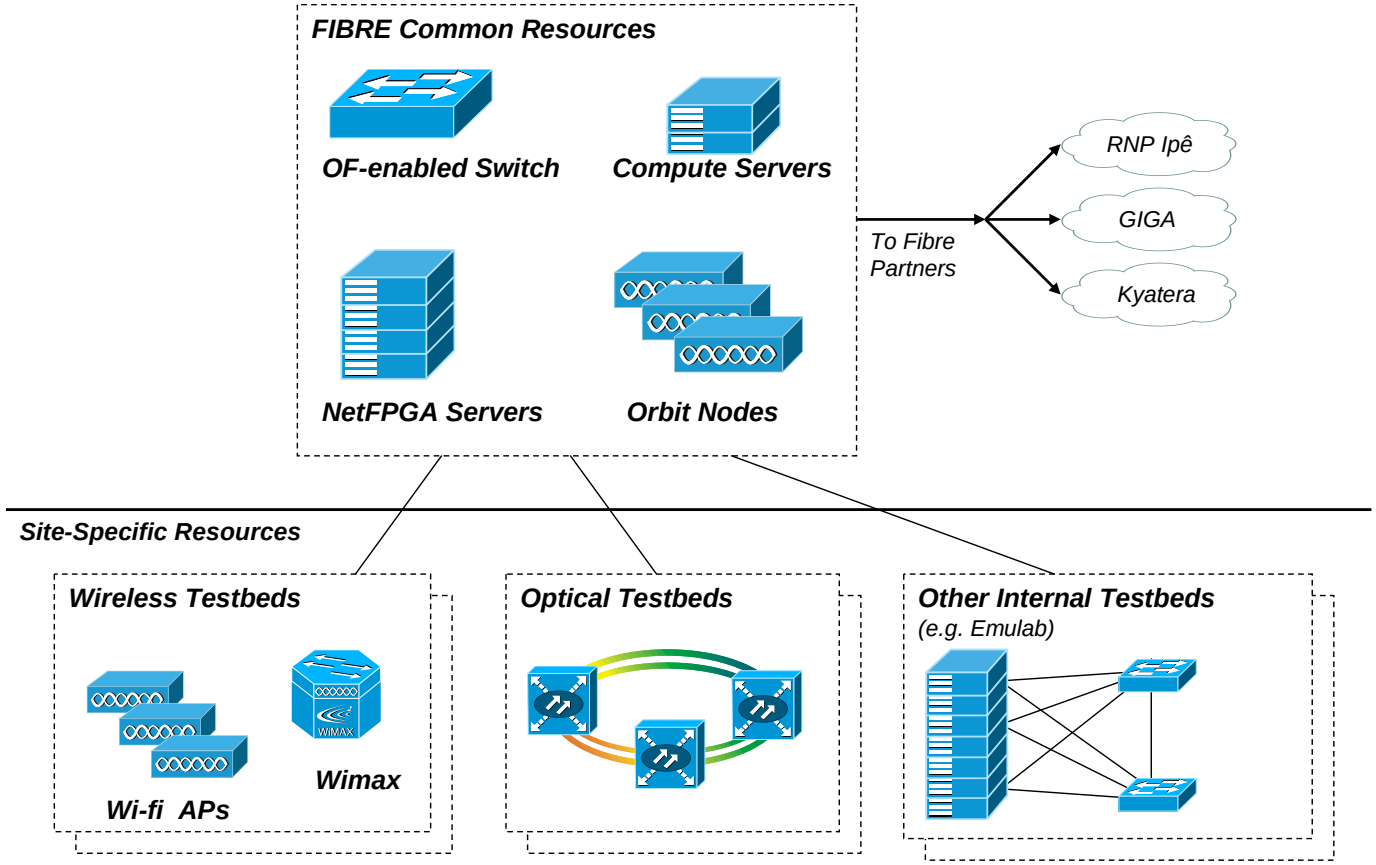
FIBRE site in Brazil



- The figure shows site-specific resources and external connectivity

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Perspectives

- Funding has already assured by RNP and CPqD to launch a large-scale, OpenFlow-based testbed this year involving most of the Brazilian partners of the FIBRE consortium
- A slice-based FI testbed facility will be made available for the use of the Brazilian R&D community, and federation with similar initiatives in other countries will be welcomed.

Yellow ipê in blossom

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