Lambda-Based Testbed Architecture Enabling Advanced Experimental Research

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Agenda

- KyaTera Overview
- Kyatera Goals and Its Conceptual Structure
- Motivation and Objectives
- Architecture
- Real, Emulated and Simulated Networks
- Final Considerations

What is the KyaTera Project?

- A testbed for research of the Internet, a distributed lab facility to test ideas in
  - Transmission and Networking technologies
  - Advanced Internet applications

- Consists of multiple networks interconnecting laboratories (FTTLab):
  - Optical cables with multiple fibers (single mode)
  - Fibers with multiple wavelengths (WDM)
  - Flexible testbed: any technology, topology, application
  - Stable network – 1 Gb/s end-to-end
  - Stable and experimental networks coexisting
  - No (tangible) bandwidth limit, high quality, secure, trustworthy, robust, ubiquitous,…

- Funded by FAPESP through its TIDIA Program
  - FAPESP: The State of São Paulo Research Foundation
  - TIDIA: Information Technologies in the Development of Advanced Internet


FAPESP
TIDIA
Tecnologia da Informação no Desenvolvimento da Internet Avançada
FAPESP
TIDIA
KyaTera
São José do Rio Preto
unesp
Ribeirão Preto
USP
São Carlos
USP
ufscar
Bauru
unesp
unesp
Rio Claro
PUC
CAMPINAS
Campinas
CenPRA
Centro de Pesquisas Renato Archer
UNICAMP
São José dos Campos
USP
São Paulo
PUCSP
ipen
Mackenzie
Santos
UNISANTOS
Fases de Implantação
1ª Fase -
2ª Fase -
3ª Fase -

KyaTera Goals

- To do research in Internet enabling technologies
  - Communications (optical in first year)
  - Networking
  - Remote control of lab instruments
- To implement a fiber optic network interconnecting laboratories
  (FTTLAb: Fiber-To-The-Lab)
  - Dark fibers; cables with multiple fibers and multiple lambdas.
- To develop advanced applications and special uses of the INTERNET
  - WebLabs – WebBee; Remote Medicine Equipment Tuning
  - Multimedia applications – HDTV; High-Energy Physics; Astronomy.

- **Generate HUMAN RESOURCES in quantity and quality**
- **Generate KNOWLEDGE, IDEAS**
- **Promote Academy – Industry COLLABORATIONS**

WebBee – Information network about biodiversity among Brazilian native bees

- Species database:
- **images** and text

KyaTera Goals

- **Creation of an environment that enable collaborative research, project development, publication and knowledge dissemination.**
  - ➔ **Fulfil the need of different research groups:**

Bleeding-edge Technologies & Functionalities

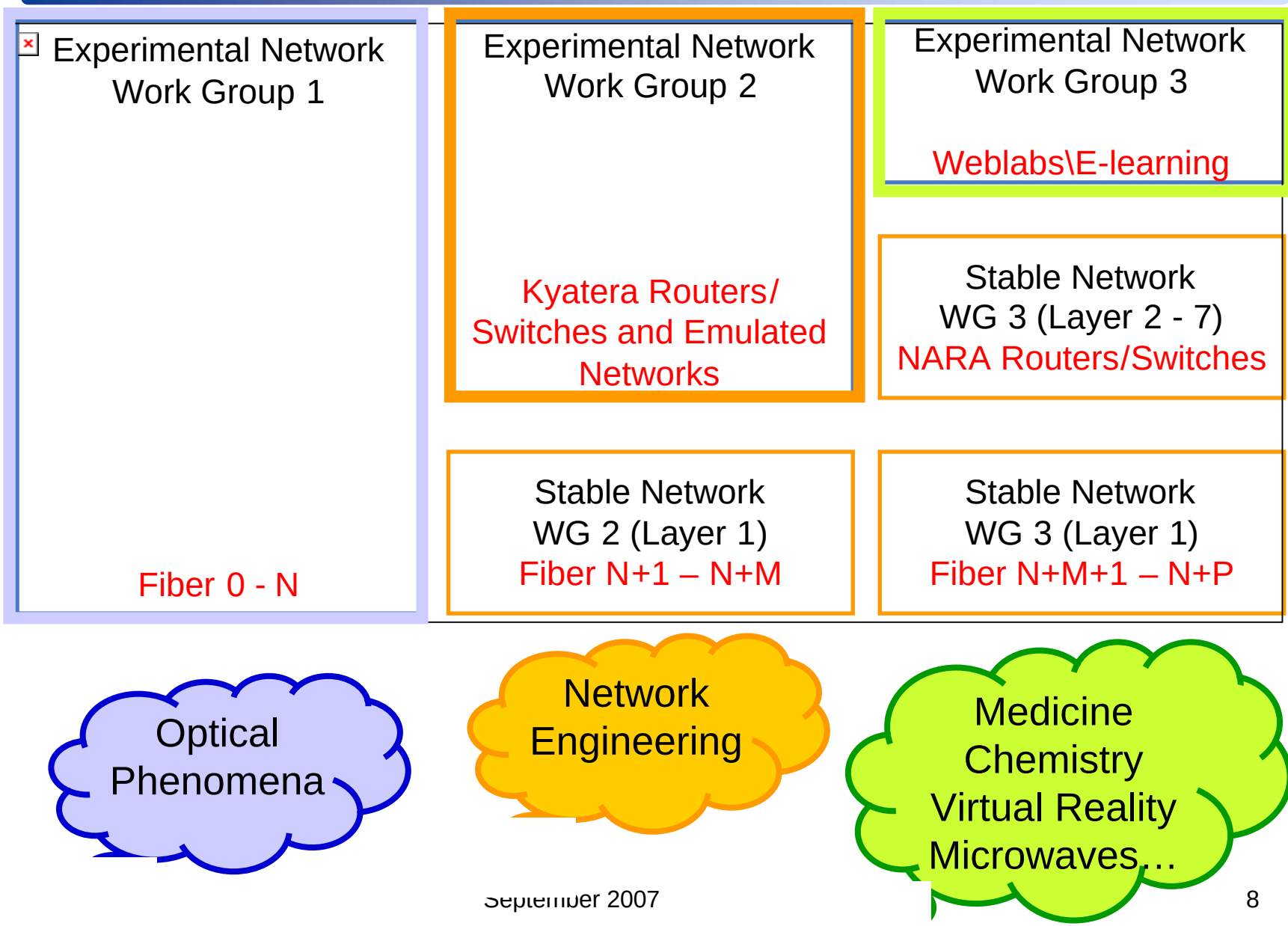
High Throughput High Reliability

Network Engineering

Optical Phenomena

Medicine
Chemistry
Virtual Reality
Microwaves…

Architecture – Kyatera Organization



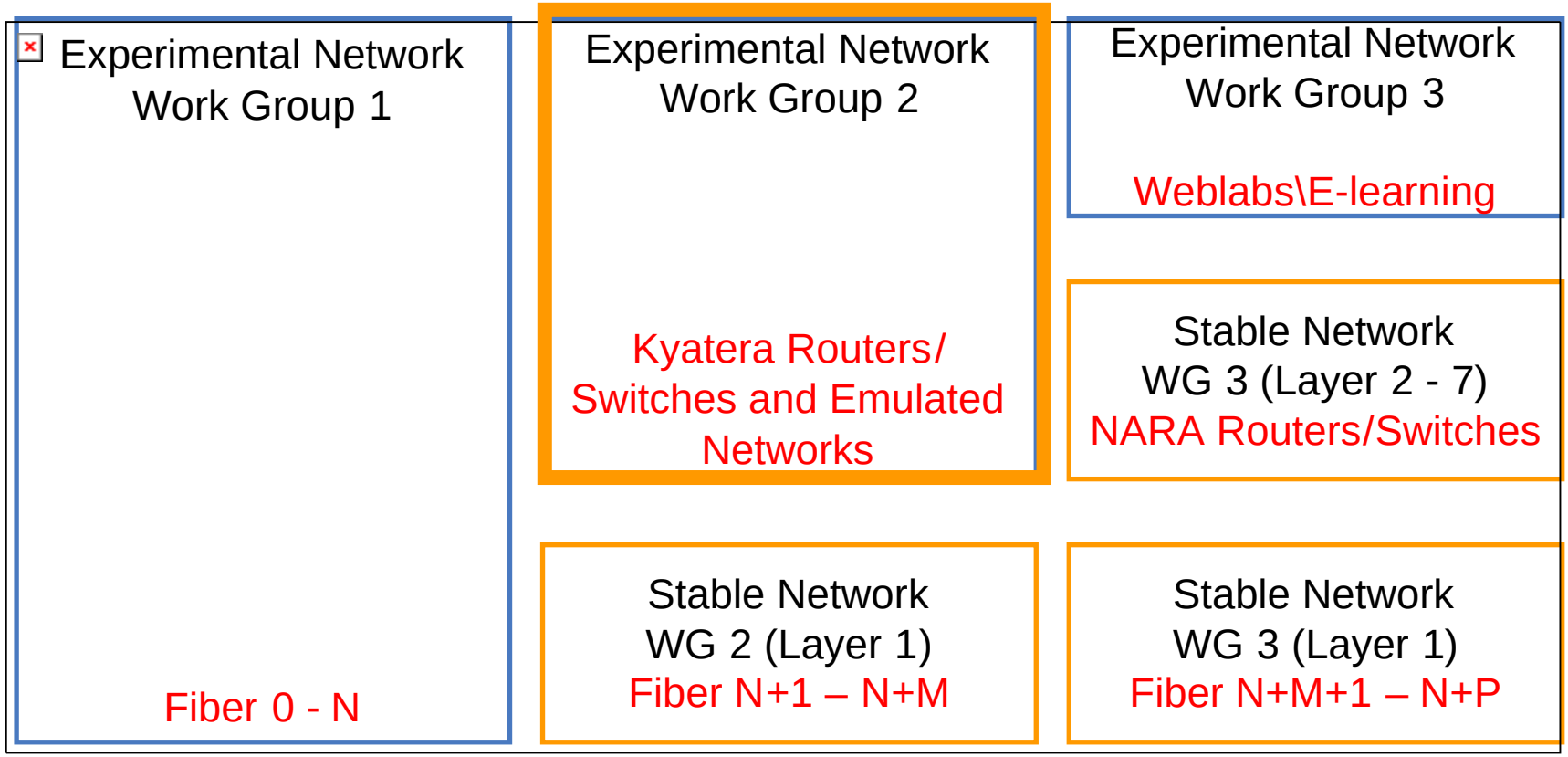
Three KyaTera Layers

- **Applications Layer**
  - Web enabled Laboratories (WebLabs)
    - ➔ Control and automation, robotics, GPIB, USB, LAN
    - ➔ Multimedia communications

- **Transport Layer**
  - Telecom Networks
  - Computer Networks
    - ➔ IP, MPLS/GMPLS, Protocols, QoS, Network Security and Management.

- **Physical Layer**
  - Fiber-Optic Transmission Systems
  - All-Optical Networks
    - ➔ DWDM, CWDM, photonic devices

Architecture – Kyatera Organization



Motivation and Objectives

Motivation and Objectives

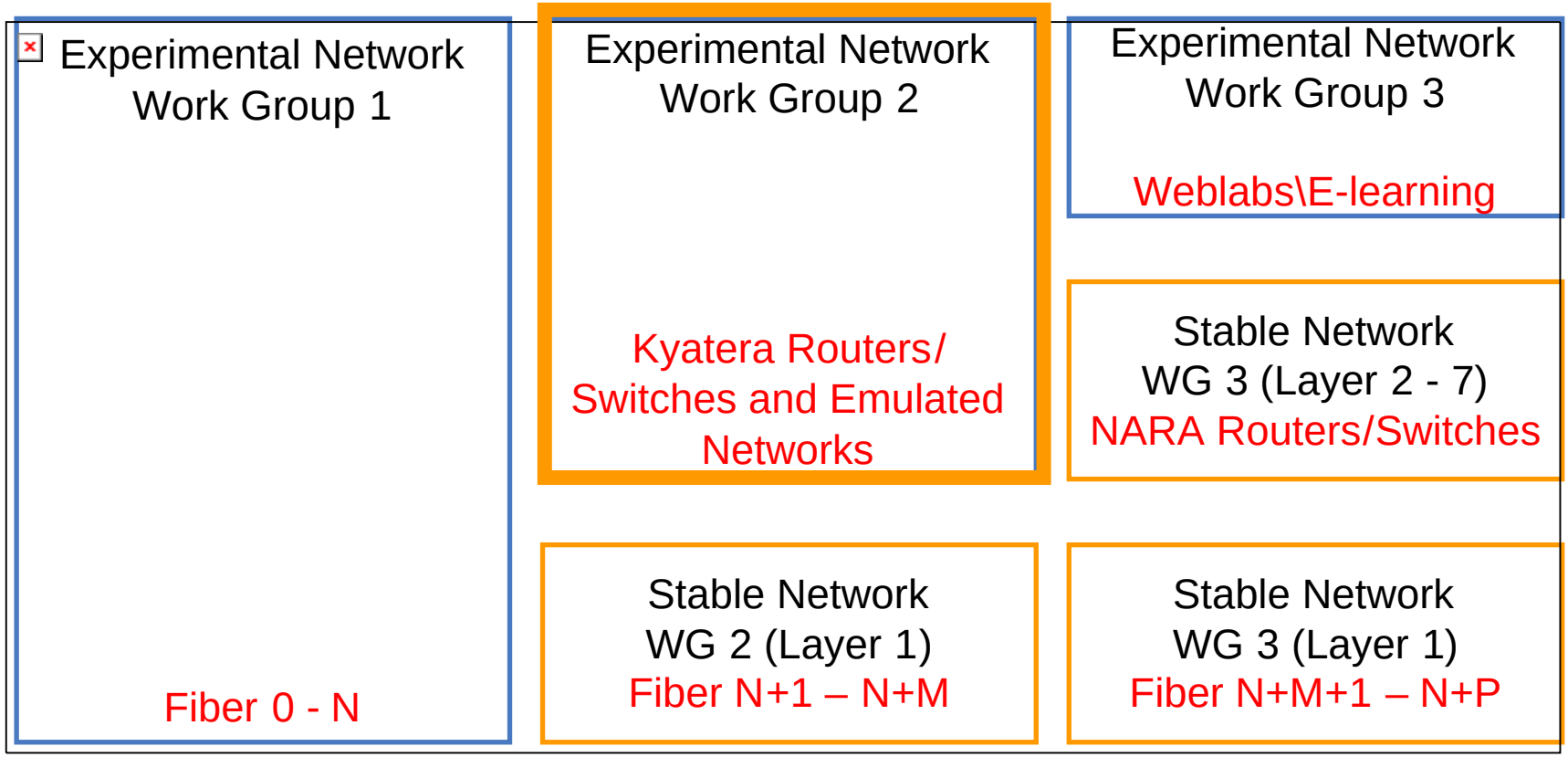
- **Create an experimental network for advanced research on IP networks (Layer 3) and on optical networks (layers 1 and ½).**
  - **Alignment with the most advanced worldwide testbeds such as JGN-II/Japan, Geant2/EC, LamdaRail/US, Canarie/Canada and Surfnet/Holland.**
  - **Creation of an environment that enable collaborative research, project development, publication and knowledge dissemination.**

Motivation and Objectives

- **Enable research on:**
  - **Optical Networking**
    - ➔ **Lightpath" Switching, λ Switching, λ Blocking, Optical channel protection, Grooming.**
  - **IPv4, IPv6**
    - ➔ **Multicast, QoS, Addressing, Grid**
    - ➔ **Video/Audio, VOIP**
    - ➔ **HDTV, DV**
  - **Mobility**
  - **MPLS and GMPLS**
  - **Security and Management**
    - ➔ **Granular Traffic Management, Security Mechanisms for High-Speed Networks, Security Services, Image and video protection, Quantum Cryptography.**

Architecture

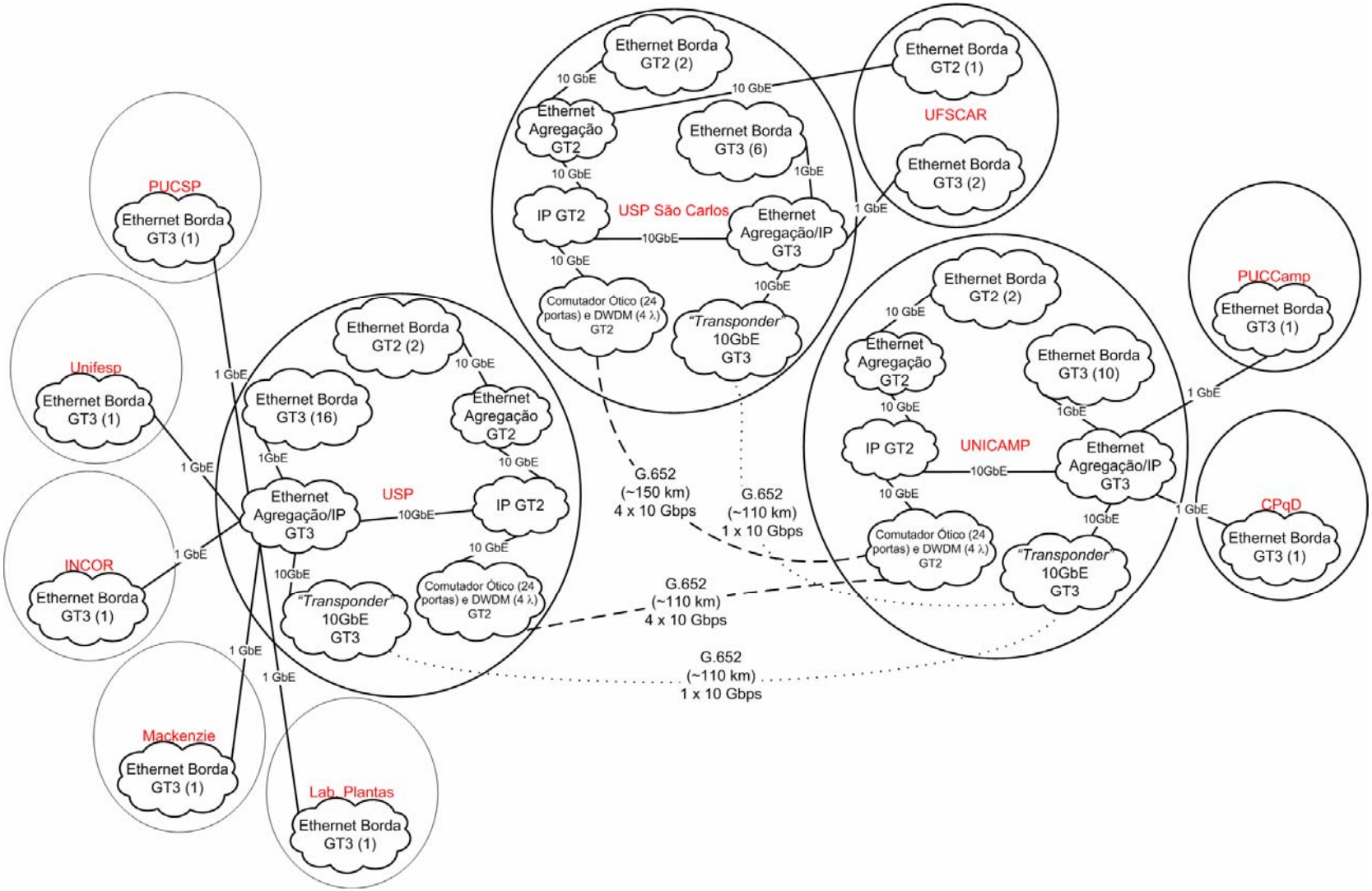
Architecture – Kyatera Organization



Architecture Requirements

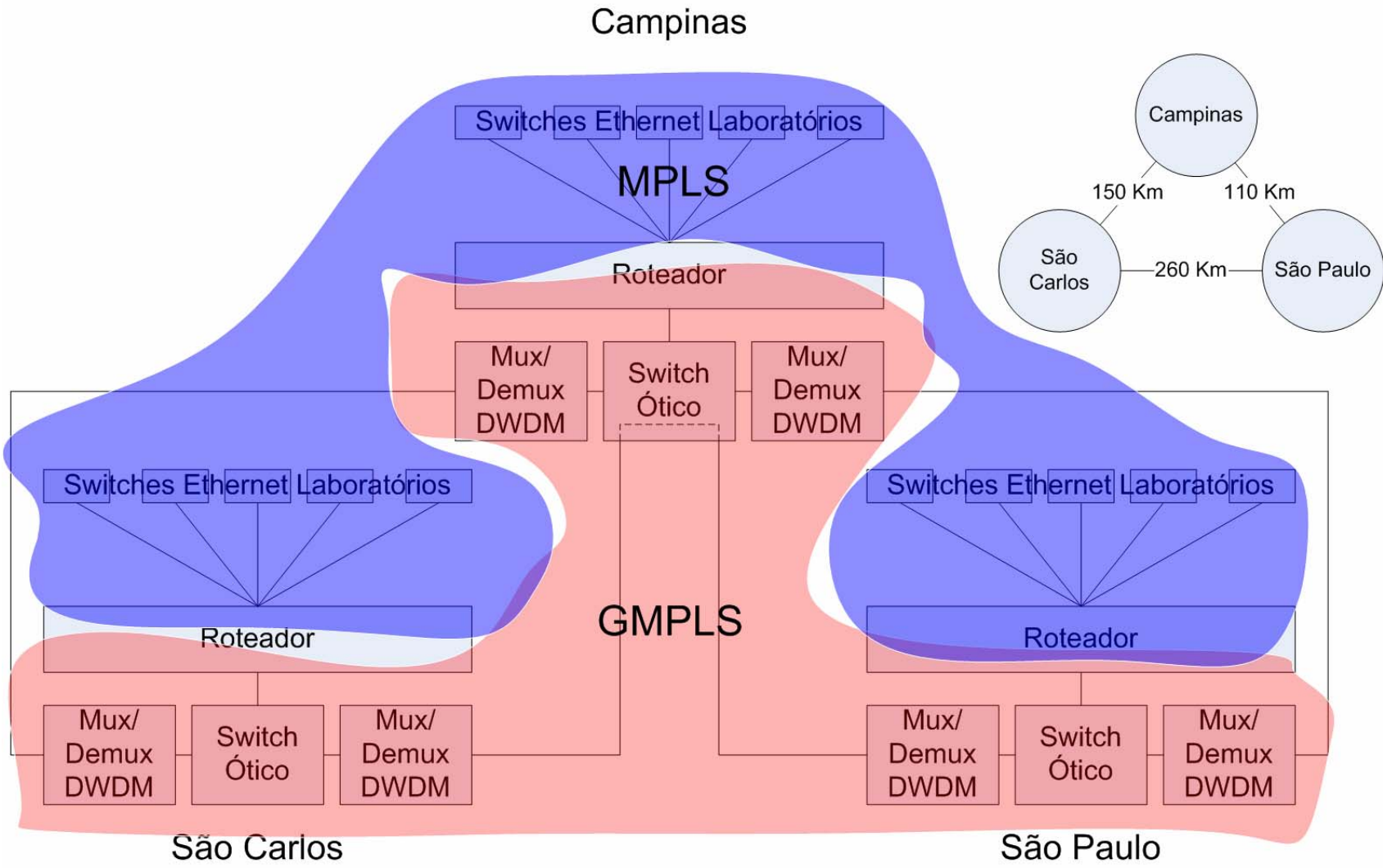
- Multiple topologies (i.e. point to point, ring and mesh).
- Equipment distributed among locations (sites), offering all functionalities required by the research enabling technologies.
- Traffic exchange among all sites through routing/switching on network, link and physical layer of the OSI stack (e.g. VPNs, VLANs e lightpaths).
- "State-of-the-art" optical or electronic networking equipment in flexible configurations.
- Possibility of expansion of the number of communication circuits (e.g. number of "lambdas").
- Possibility of expansion of the capacity of communication circuits.
- Planned geographical expansion of the network (phases 2, 3 e beyond).
- Tight integration between the physical (real) and emulated networks.

Architecture – General View I



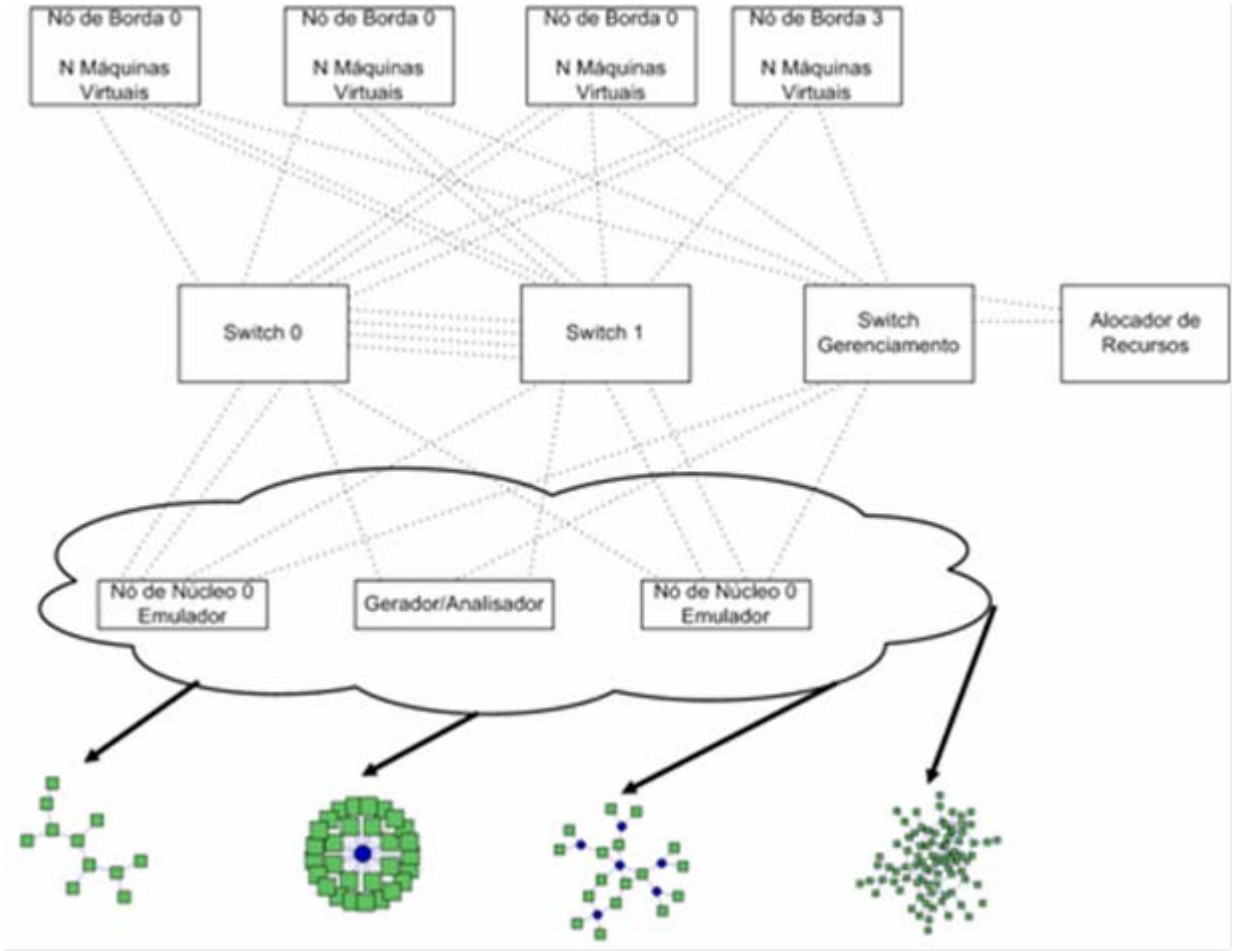
Kyatera Network – General View

Architecture – General View II



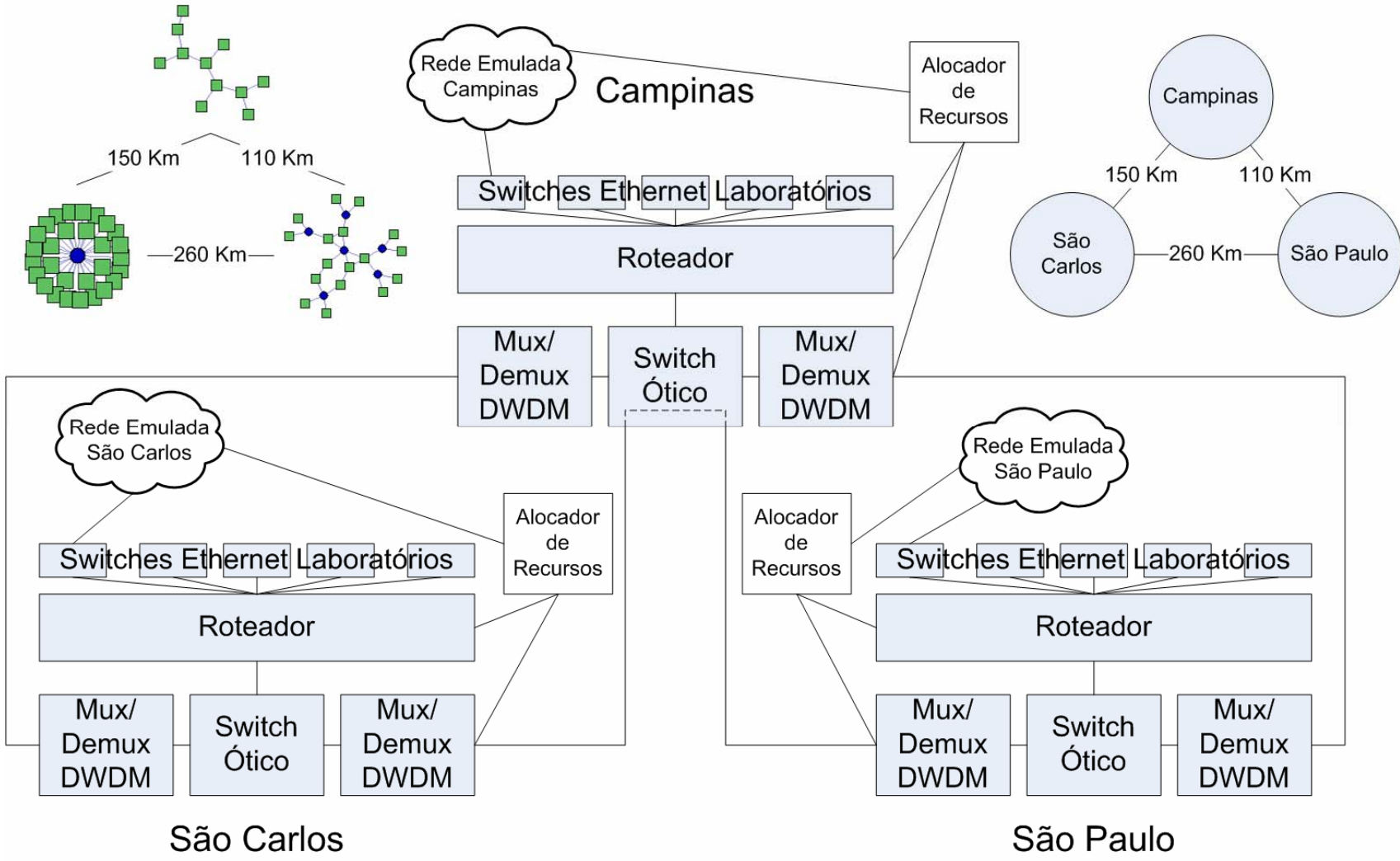
Kyatera Network– Physical Network WG2 (Not Emulated)

Architecture – General View III



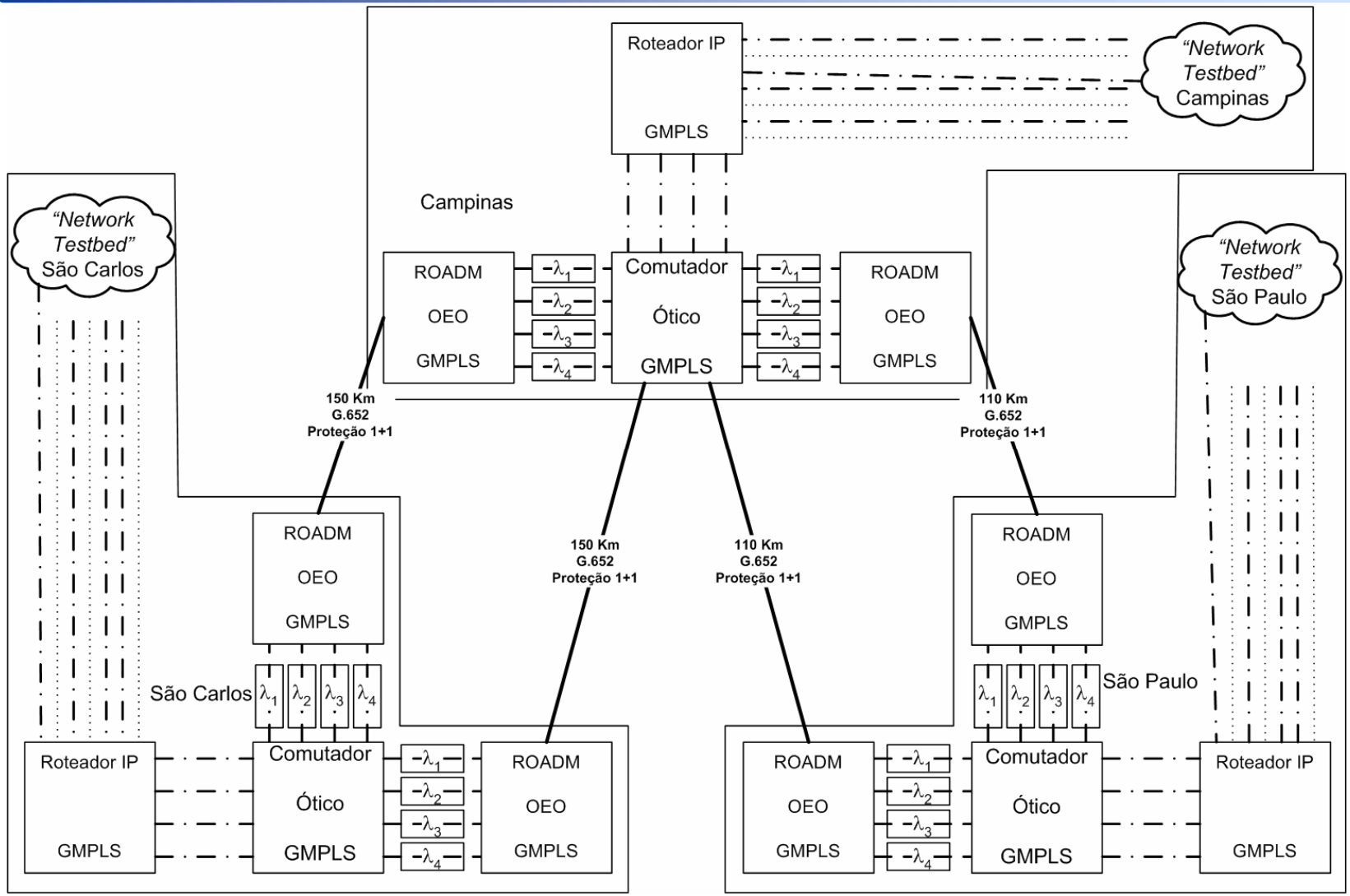
Kyatera Network – WG2 Emulated Network

Architecture – General View III



Kyatera Network – WG2 Integrated Network

Architecture – Diagram



Kyatera Network – WG 2 Network/Data Plan

Real, Emulated and Simulated Networks

Outside Plant Status – November 2006

KyaTera Proprietary
Optical Fiber Plant
Deployment

City MAN	Campus LAN	Labs in campus	Cable (m)	Fiber (m)	Fusion splices	PC / APC connectors	Splicing boxes
São Paulo							
	USP-SP	19	11,586	282,2136	694	502 / 192	2+4
São Carlos							
	USP Scar	9	2,769	42,992	168	144 / 0	1
	UFSCar	4	763	5,724	42	42 / 0	0
	USP-UF Link		6,110	14,664	72	24 / 24	1
Campinas							
	Unicamp	16	7,211	169,418	592	424 / 144	2+2
	PUC-Camp	1	4,502	108,048	48	24 / 24	0
	CPqD	1	5,203	124,872	96	24 / 24	3
	TOTALS	**54**	**38,144**	**747,854**	**1,712**	**1184 / 408**	**15**

Eng. Marco Aurélio Fortes 26-Oct-05

Network Emulation

- **A compromise solution in a attempt to preserve the best characteristics of simulation and real-world experiments.**

- **Characteristics such as:**
  - **Possibility of creation of large experiments with complex topologies**
  - **Low cost.**
  - **High degree of repeatability.**
  - **Performance fidelity**
  - **Application transparency**

Emulated Network Infrastructure - Features

- Allows simulation, emulation and real-world experiments.
- Defined links in the experiment's topology can be mapped in physical WAN links or emulated in traffic-shaping nodes.
- Applications are executed without modifications in the virtual nodes (FreeBSD Jail).
- Automatic experiments configuration and provisioning.
- Experiments are created by means of GUI interface or ns script and submitted in a Web Interface.

Final Considerations

Final Considerations

- For supporting Research projects on Networking, it requires to be a "very innovative" network testbed.
- Integration between the real and emulated network allows the execution of large scale experiments (100´s- 1000´s nodes) geographically dispersed with an arbitrarily complex topology.
- Scalable, multiuser and reconfigurable *testbed* permanently available for advanced research.
- Possibilities of research in a collaborative environment.
- Possibilities for partnership with research centers, universities, telecommunication operators, ISP and industry worldwide.

Final Considerations

Project Status

- All campuses have been connected internally via a new and separated fiber optics infrastructure.
- The connections among the campuses have been negotiated with Telefonica (Telecommunication Operator) .

- **Networking:**
  - ➔ Layer 1, 2 & 3 Stable Network – Equipment Acquisition Phase (1G and 10G links).
  - ➔ Layer 1 Experimental Network – ready (Agreement with local industry).
  - ➔ Layer 2& 3 Experimental Network (10 G links) – Under discussion with FAPESP.

- **Emulation & Simulation:**
  - ➔ We are creating a new instance of Emulab network, initially with 17 nodes.
  - ➔ We are working also with PlanetLab + VINI.

Final Considerations

- **More detailed information about Brazilian Networks…**
  - **CEF Networks Workshop (September 19th)**
    - ➔ **Optical Networking in Brazil**

      R&D&I and Deployment

      Michael Stanton - RNP

www.kyatera.fapesp.br