



Company Overview and Case Studies

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Padtec

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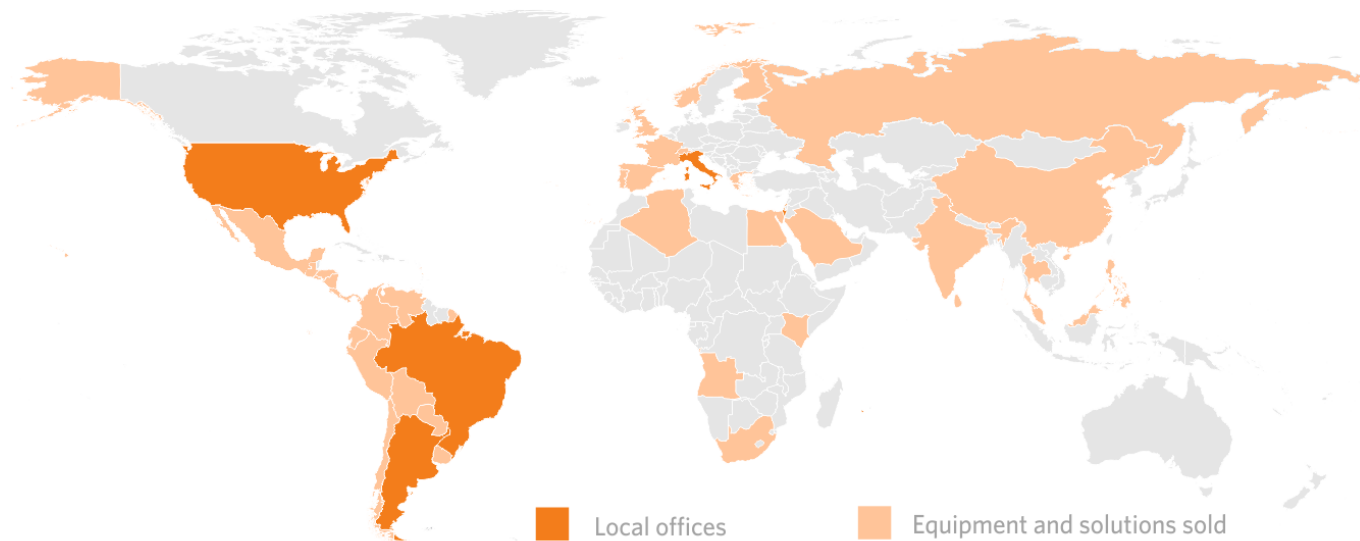
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Contents



THIS PRESENTATION COVERS THE FOLLOWING TOPICS:

1. History and Vision
2. Optical Portfolio Coverage
3. SDN Philosophy
4. Case Studies
 - SDN (SC'14)
 - OpenWave
5. Conclusion



History and Vision

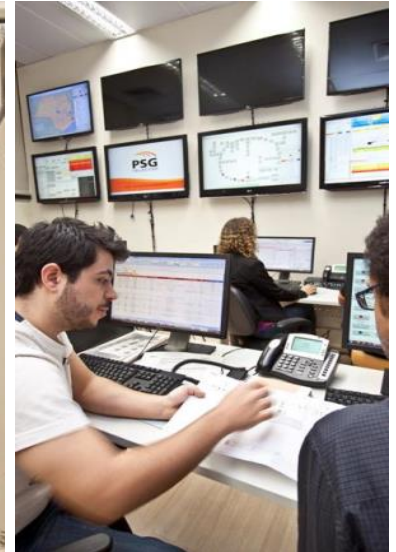
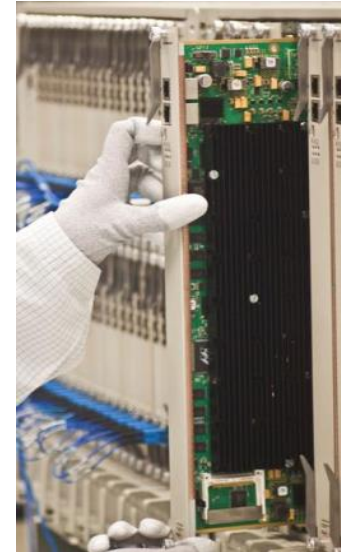
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History

- Operations started in August, 2001.
- Largest Optical Networking Manufacturer in Brazil.
- Global supplier: equipment and solutions sold in 40 countries.
- Productivity: revenue of USD 400 k per employee per year.
- R&D investment: up to 15% of revenue.



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Mission and Vision



Mission

Provide for the global market, with agility and flexibility, devices solutions, equipment and optical communications systems that exploit the potential of optical layer.

Vision

Being the global market leader in providing innovative and high value-added solutions, exploiting the potential of technology and contributing to the progress of telecommunications.



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Customer Profile

Padtec offers solutions to the major organizations in areas as:

- Telcos/Carriers
- *Carriers of carriers*
- Information Technology
- Utilities
- Integrators and Service Providers
- Research and Education
- MSOs/CATV
- ISPs

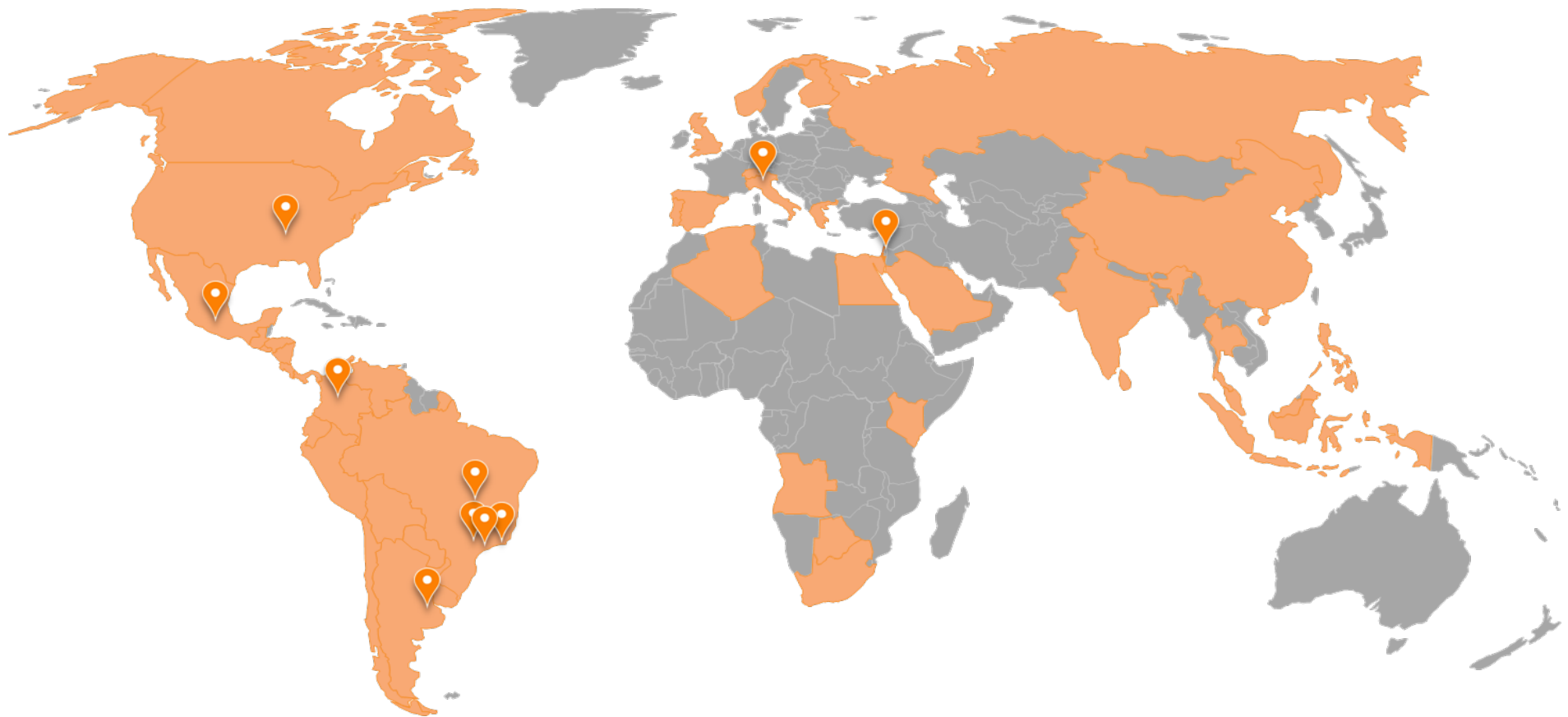


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Global Presence



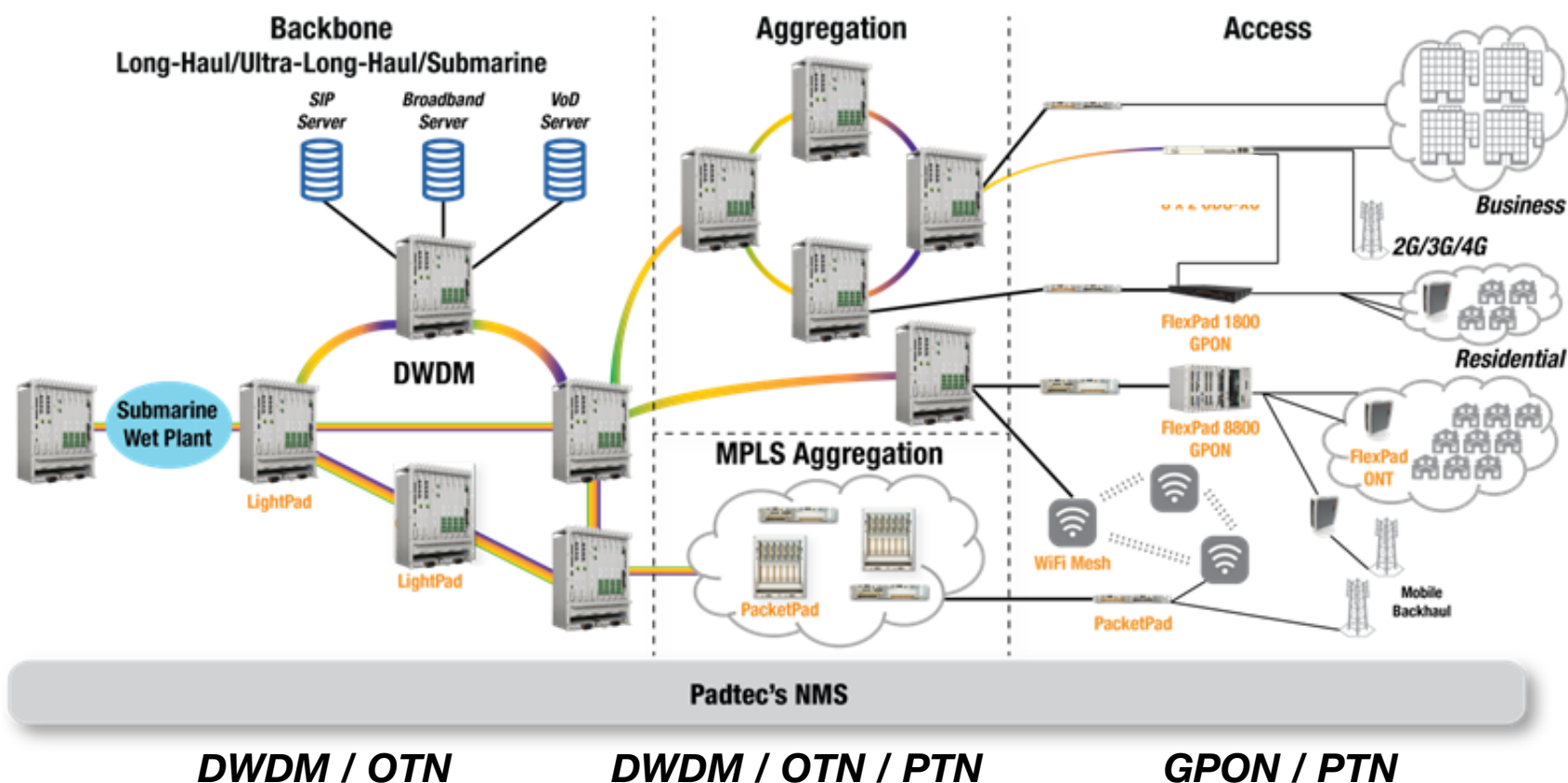
 Equipment Deployed

HQ: Campinas, SP – Brasil
Regional offices: São Paulo, Rio de Janeiro and Brasília
Abroad offices: Argentina, USA, Mexico, Colombia, Italy and Israel
Equipment and solutions in more than 42 countries.

Optical Portfolio Coverage

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Integrated Solutions in Optical Communications



DWDM: Dense Wavelength Division Multiplexing (LightPad Platform)

OTN: Optical Transport Network (LightPad OTS Platform)

PTN: Packet Transport Network (PacketPad Platform)

GPON: Gigabit Capable Passive Optical Network (FlexPad Platform)

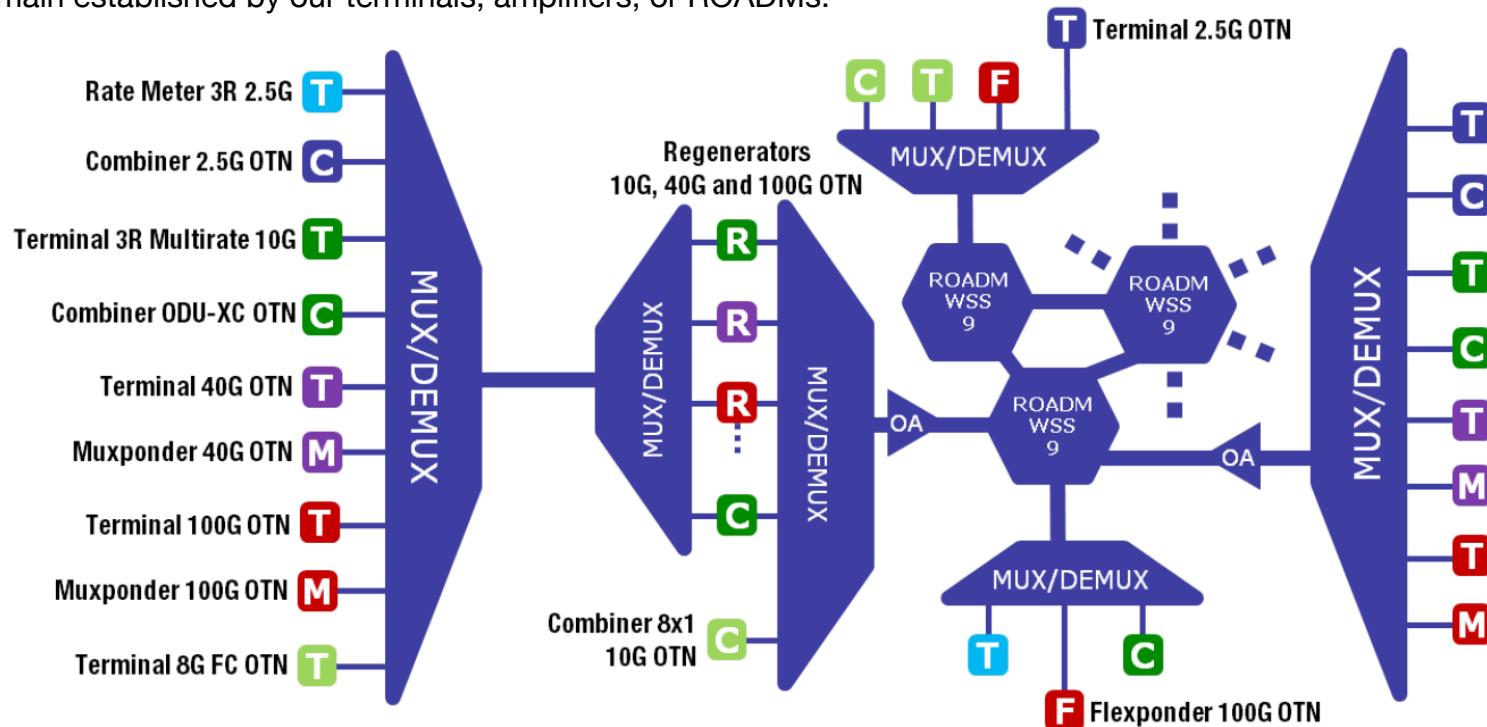
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Protocol Support and Alien Waves

Padtec's LightPad Platforms are, by design, built upon an open optical architecture allowing third party waves to flow along the spectrum allotted for in the network design.

Although we are convinced Padtec's transponders will yield the best performance, flexibility, and price points **we do not impose additional licenses, fees, or royalties for alien wavelength transport** over the optical domain established by our terminals, amplifiers, or ROADMs.



SDN Philosophy

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Management Strategy

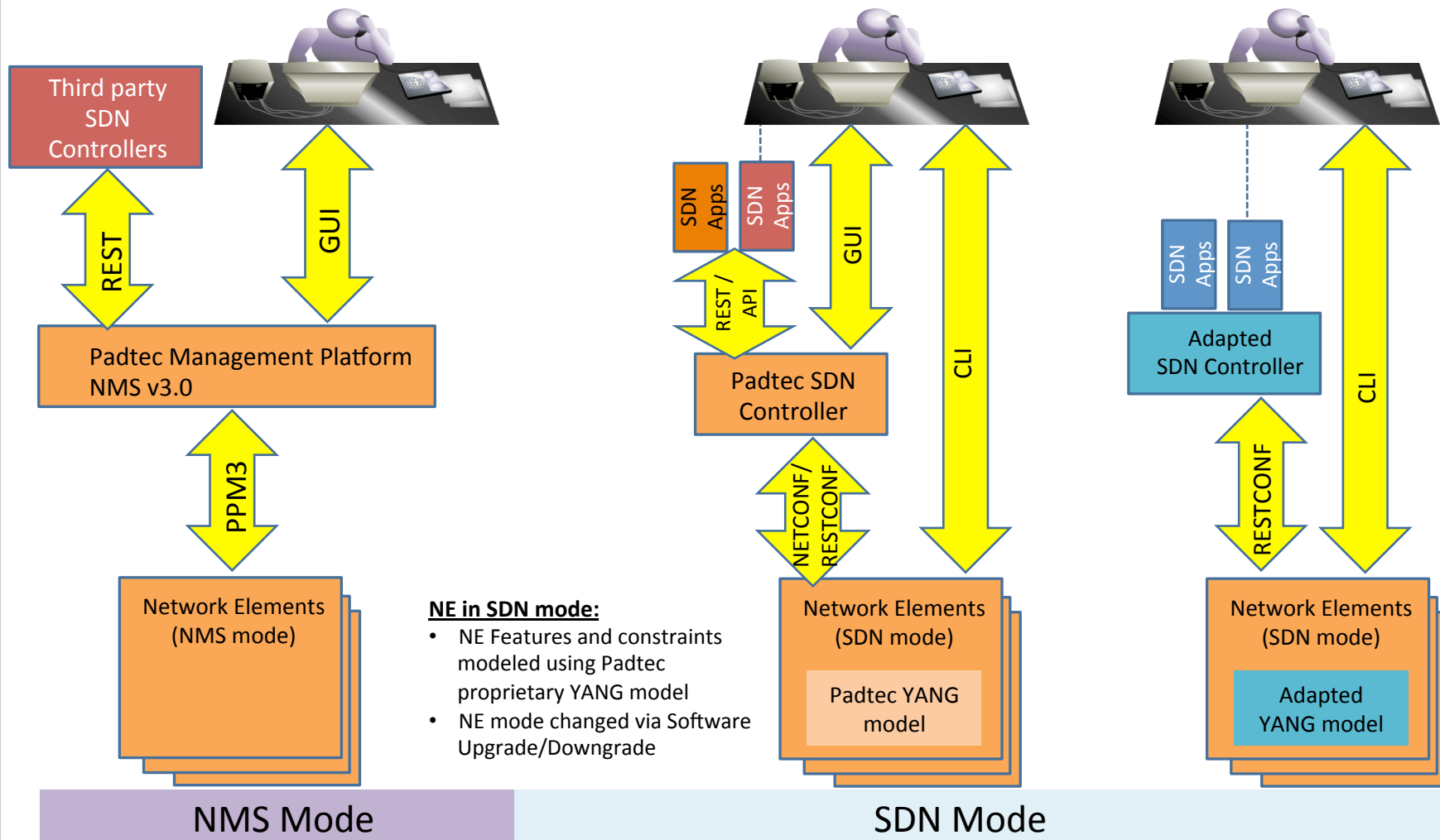


Our solution can support standard TMN model as well as Transport SDN control:

- Network Element working in NMS mode (i.e. controlled by LightPad Management v3.0)
- Network Element fully supporting RESTCONF
- Network Element working in SDN mode, (i.e. managed through Padtec SDN Controller or third party controllers via RESTCONF interface or CLI).

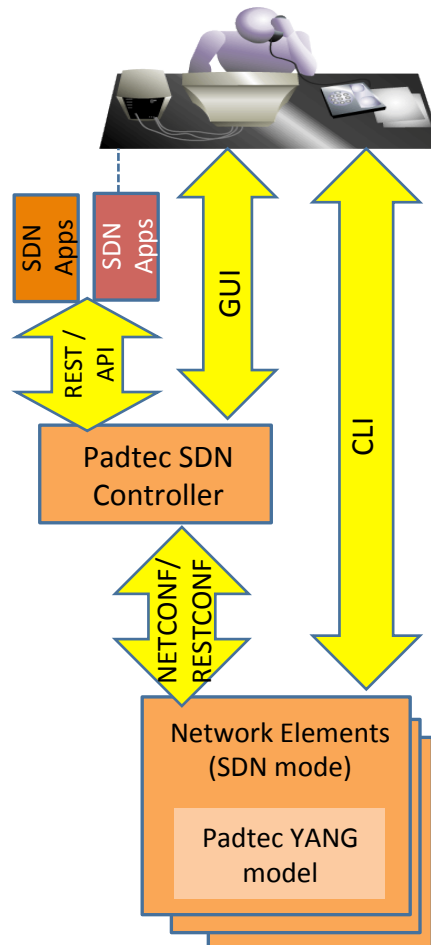
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Management Modes of Operation



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SDN Mode Overview



NE in SDN mode:

- NE Features and constraints modeled using a Padtec proprietary YANG model
- NE mode changed via Software Upgrade/Downgrade

SDN GUI provides:

- Network topology
- Network virtualization
- Basic Network inventory
- Network application management

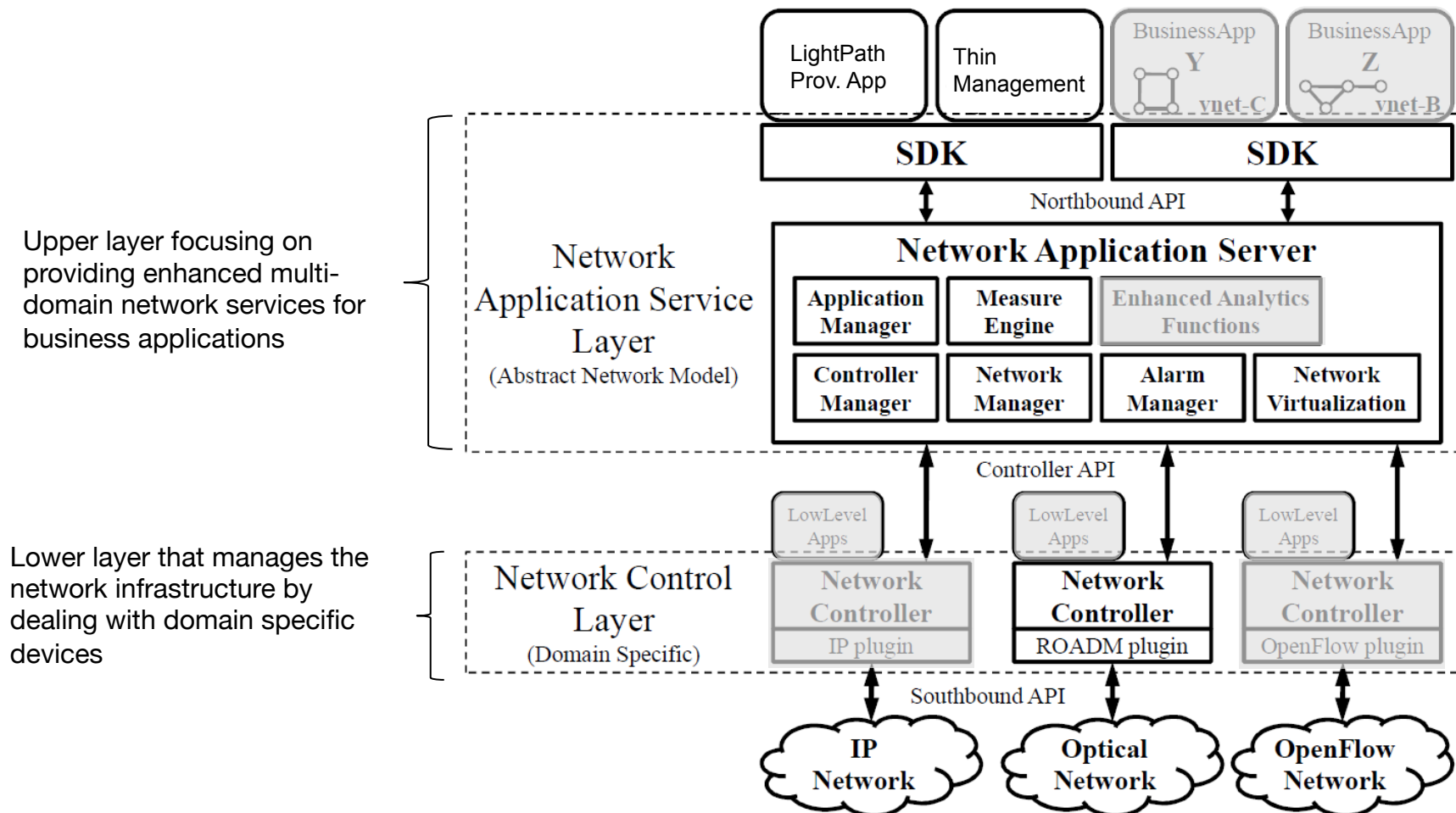
SDN applications can manage, via C++ API or REST:

- Network alarms
- Network state
- Advanced Network inventory
- Lightpath provisioning
- Performance metrics
- Network device configuration

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SDN Controller Architecture



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SDN Mode – Controller Main Features

Network Application Server

- End-to-end *Lightpath* provisioning with flex-grid support
- Consolidation of topology information received from the Optical domain controllers
- Network resources slicing (for network virtualization)
- Path computation library

Optical Domain Controller

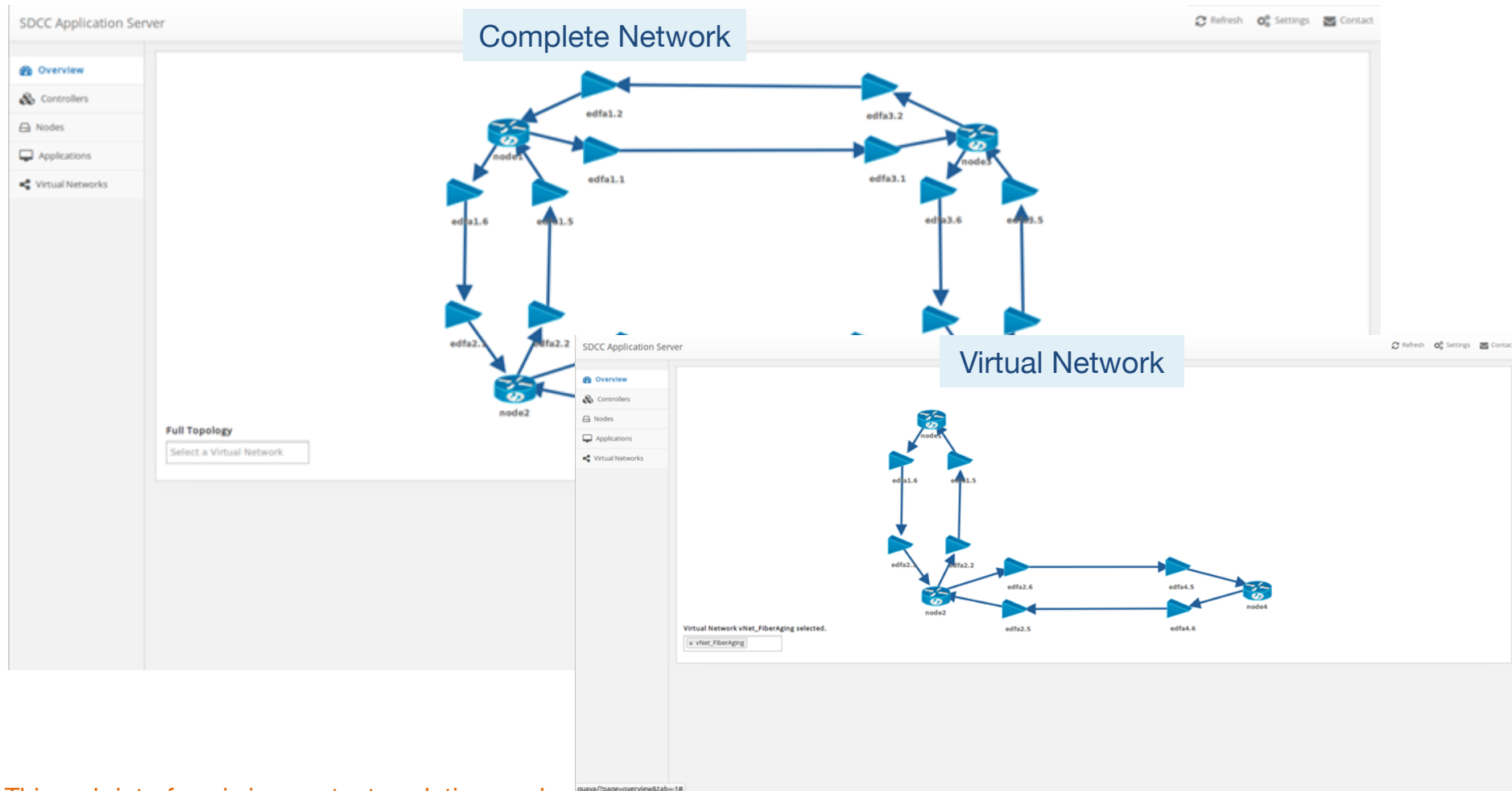
- Topology discovery
- Performance monitoring
- Alarms
- Configuration of ROADMs, Optical Amplifiers and OCM, including flex-grid cross-connections
- NETCONF/RESTCONF southbound

SDN Application APIs

- REST/C++ interface
- Data caching
- Callbacks register and control
- Application runtime loading

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SDN Mode - GUI (Web): Overview



* This web interface is in constant evolution, and may contain some changes in near future

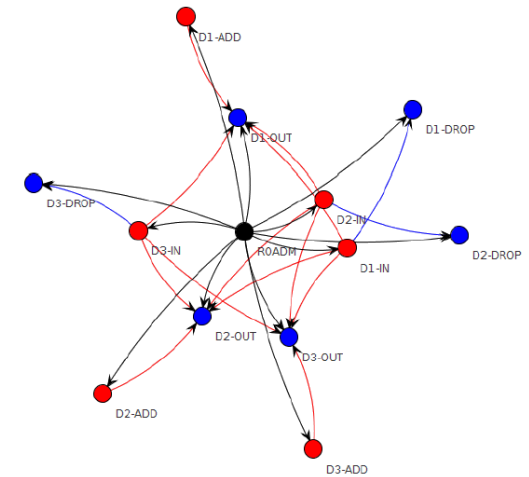
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API Development – YANG Model

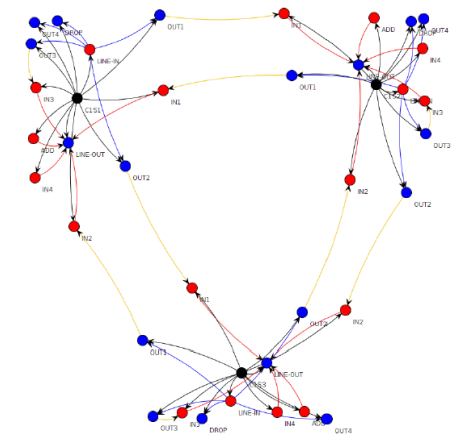


- Extends IETF NETMOD WG base models
- Models the ROADM building blocks, its interconnections, and properties
- Simplifies creating ROADM abstractions and connectivity matrix through model transformation to a graph
- SDN Controller can consolidate ROADM graphs in a network-wide view. Therefore, the network can be managed as a single ROADM
 - Global network view with information about internal node constraints and utilization, allow implementing RWA algorithms with contention minimization, even when using “non-contentionless” ROADMs

ROADM graph



Network graph





SDN Case Study: *OpenDaylight (ODL) Plug-in for Padtec ROADMs (SC'14)*

*Contributing parties from Unicamp:
Alaelson Jatobá, Darli Mello, Christian Esteve
Rothenberg, & Dalton S. Arantes*

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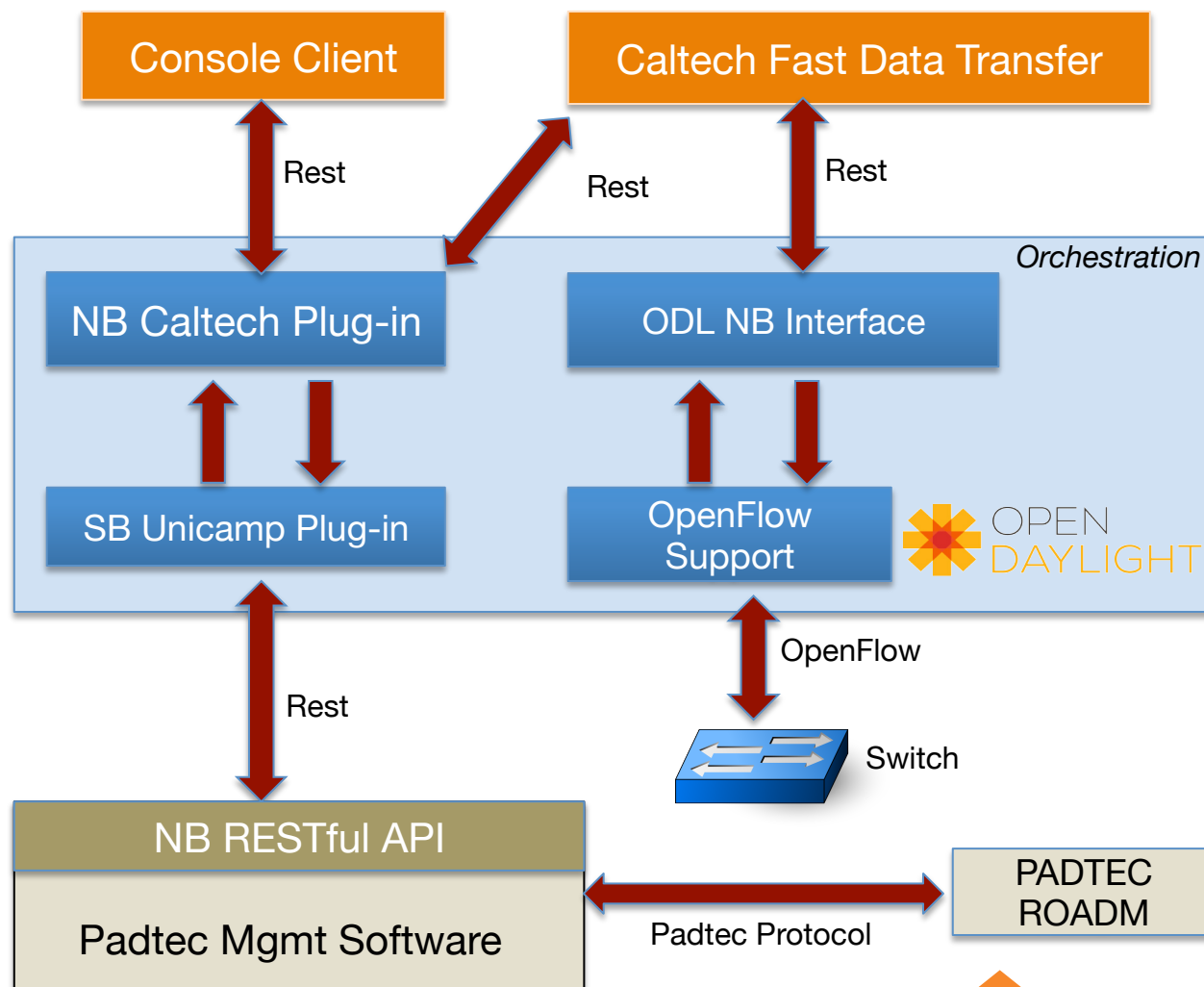
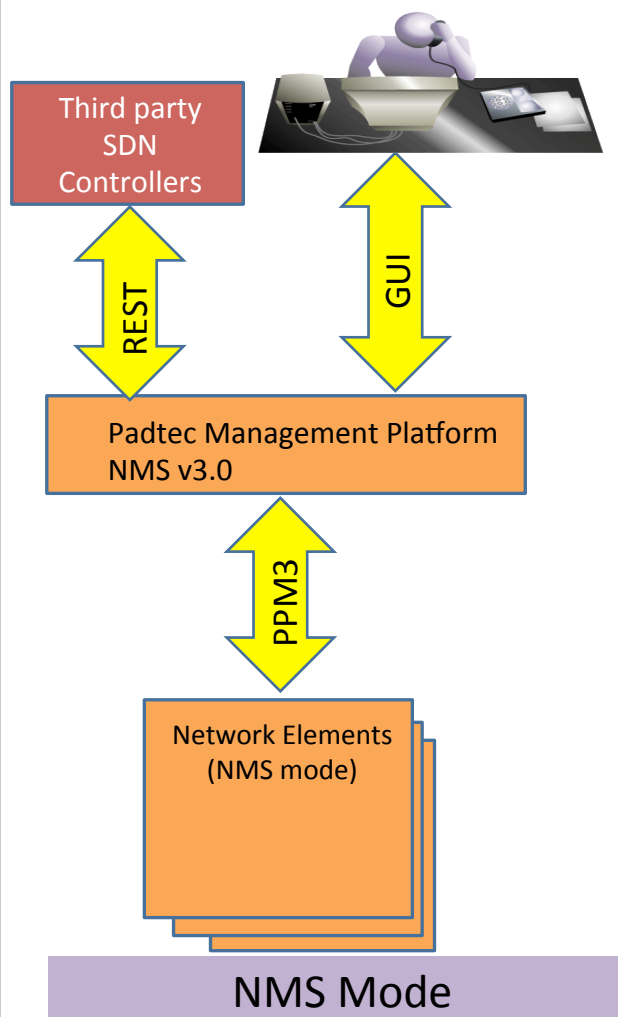


SDN Case Study: Overview

- Software developed by Padtec and Unicamp for demonstration at Super Computing 2014 (SC14).
- Plug-in controlling Padtec's Reconfigurable Optical Add/Drop Multiplexers (ROADMs), providing support to software defined networking (SDN) using the OpenDayLight (ODL) controller.
 - Maximize the wavelength utilization;
 - Reduces the blocking probability;
 - Assign appropriate routes and wavelengths over the lightpaths to maximize throughput;
 - Manage lightpath establishment in real-time;
 - Provisioning resources on demand (Manage connection request).
- The main achievement was a peak rate of 1.55 Tbps provisioned using a third-part client application that sends commands to the ODL controller, increasing and decreasing the bandwidth as needed.

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SDN Case Study: Architecture



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SDN Case Study: ODL Plug-in Implementation & Features

Implementation:

- Implemented by the Unicamp team based on Padtec NMS RESTFul APIs, abstracting the hardware complexity features of the ROADM device;
- Offers to the user two simple methods (increaseBandwidth and decreaseBandwidth). Channel selection and other messages of Padtec's management software are not exposed to the user;
- Works as an OpenDayLight plug-in providing SDN programmability and orchestration to Padtec's devices.

Features:

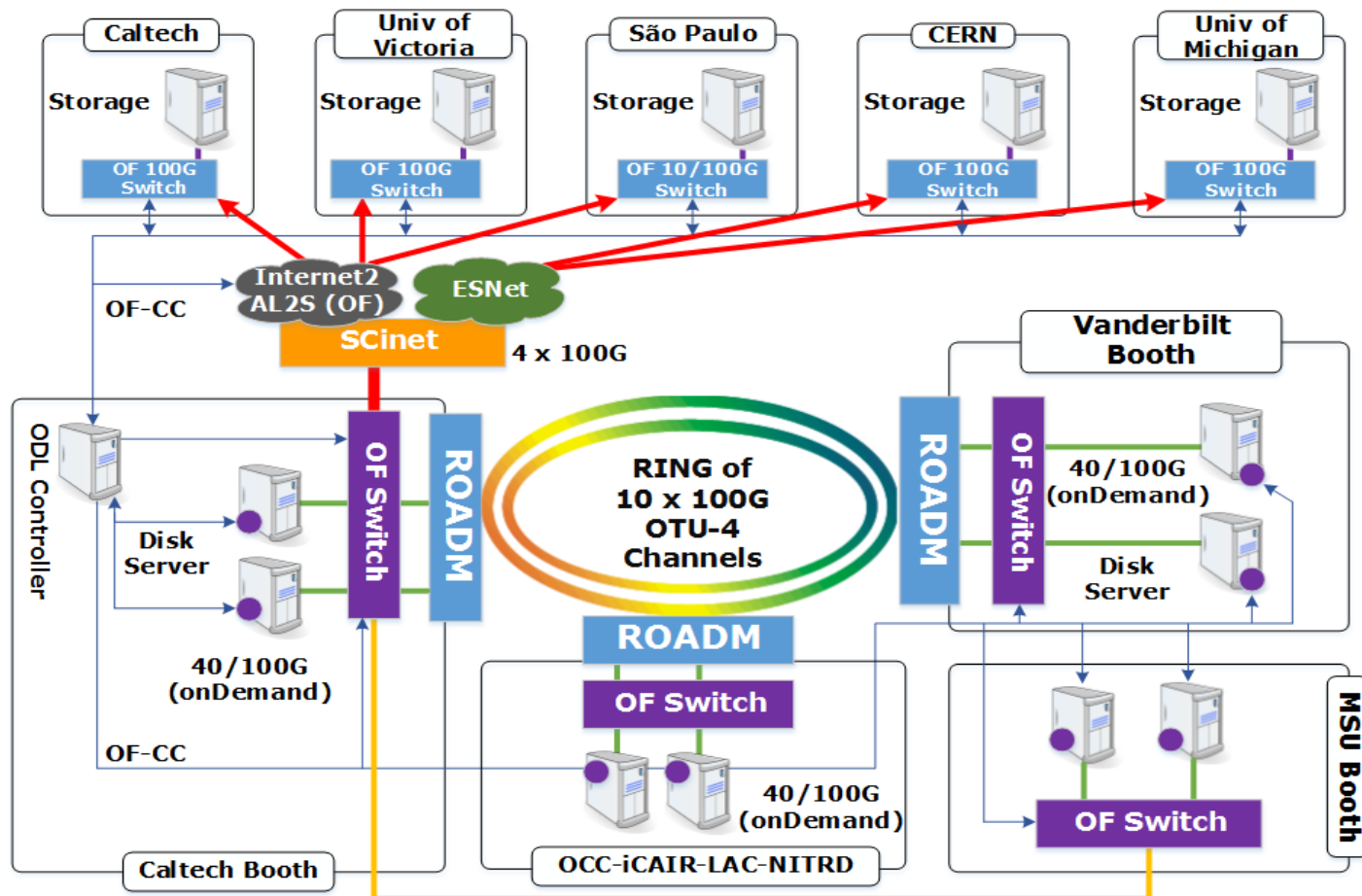
- Acts as a South Bound interface in the OpenDayLight;
- Implements the RESTFul API to control the Padtec ROADMs;
- Keeps a memory of the connection states;
- Keeps a route table;
- Implements the first-fit algorithm in order to choose the lambda to provision and remove channels;

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SDN Case Study: SC'14 Floor Layout

Global Software-Defined Dynamic Circuits for Data Intensive Science
(PhEDEx – ANSE – PANDA – OpenDayLight)

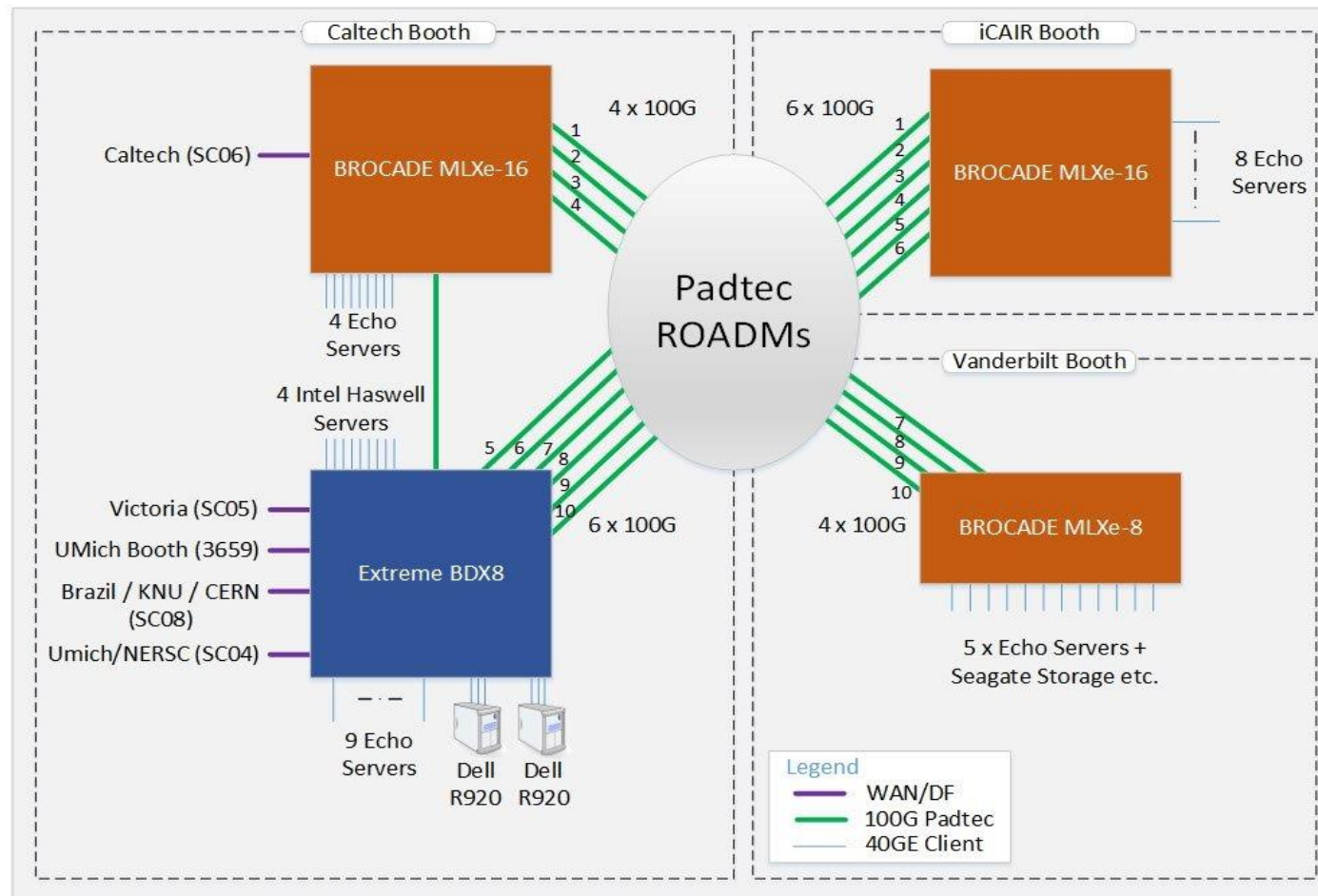


Three Booths:

- Caltech: 10 x 100 Gbps
- iCAIR: 6 x 100 Gbps
- Vanderbilt: 4 x 100 Gbps

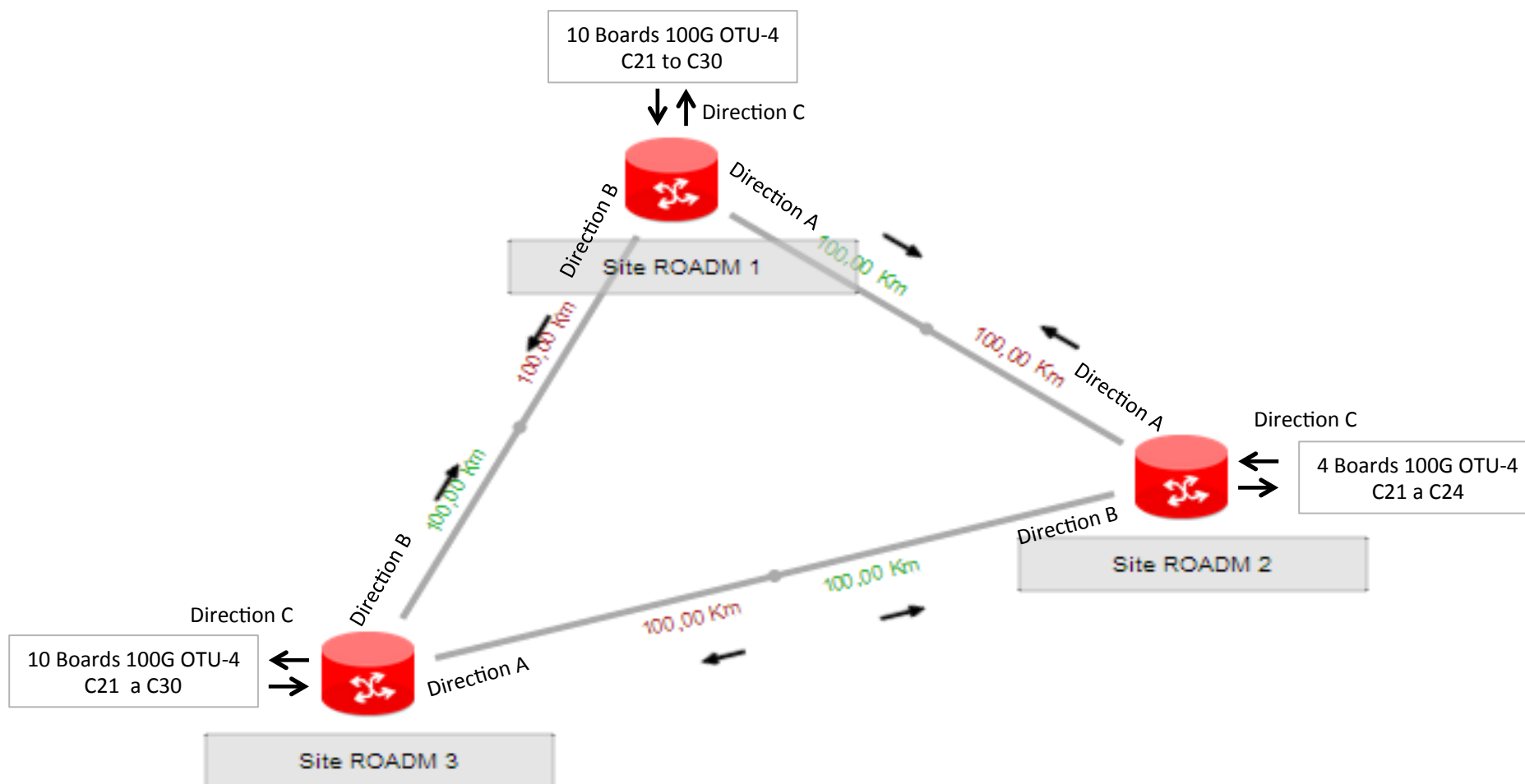
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SDN Case Study: SC'14 Demo Topology



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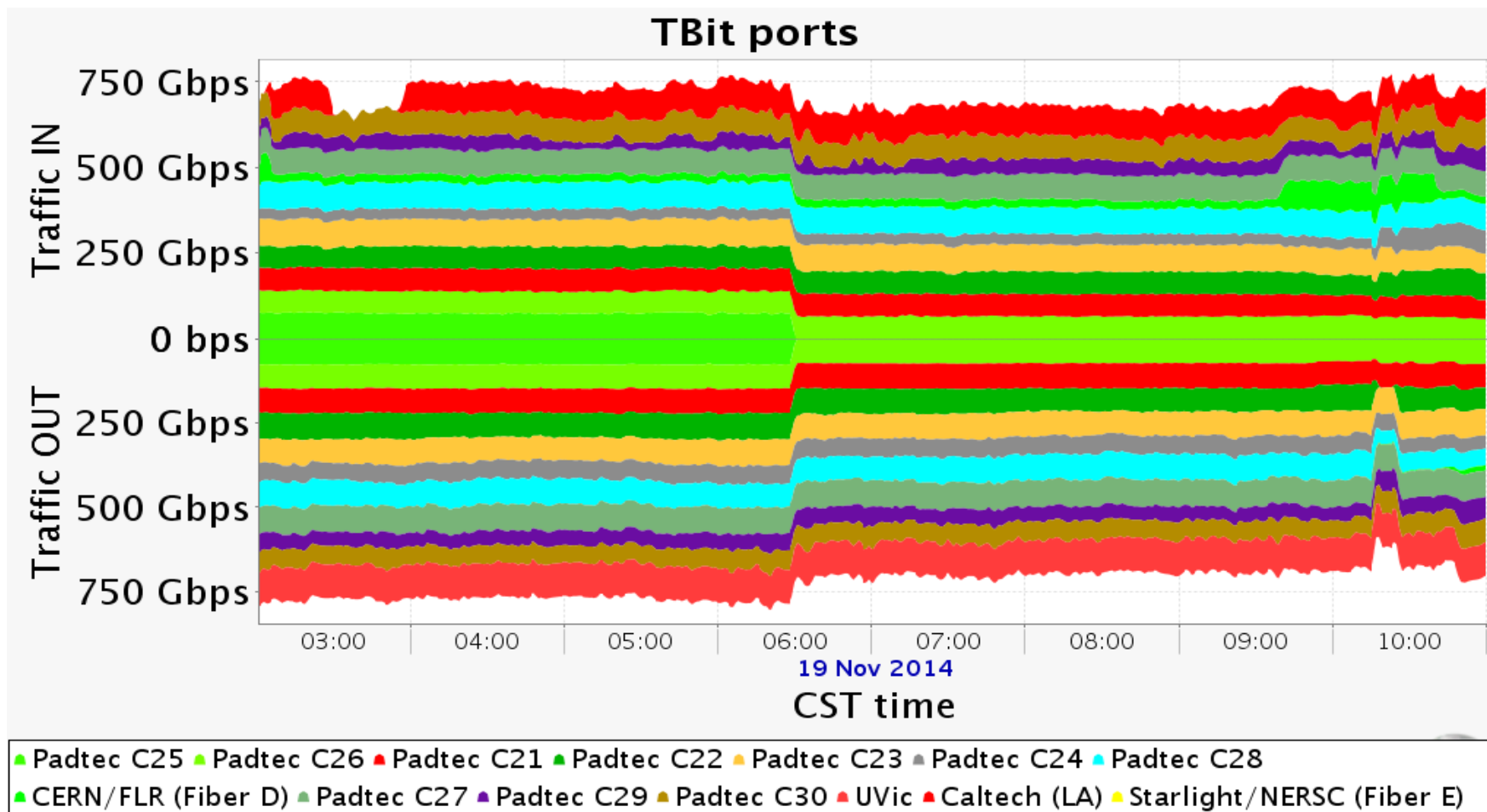
SDN Case Study: SC'14 Padtec Directionless ROADM



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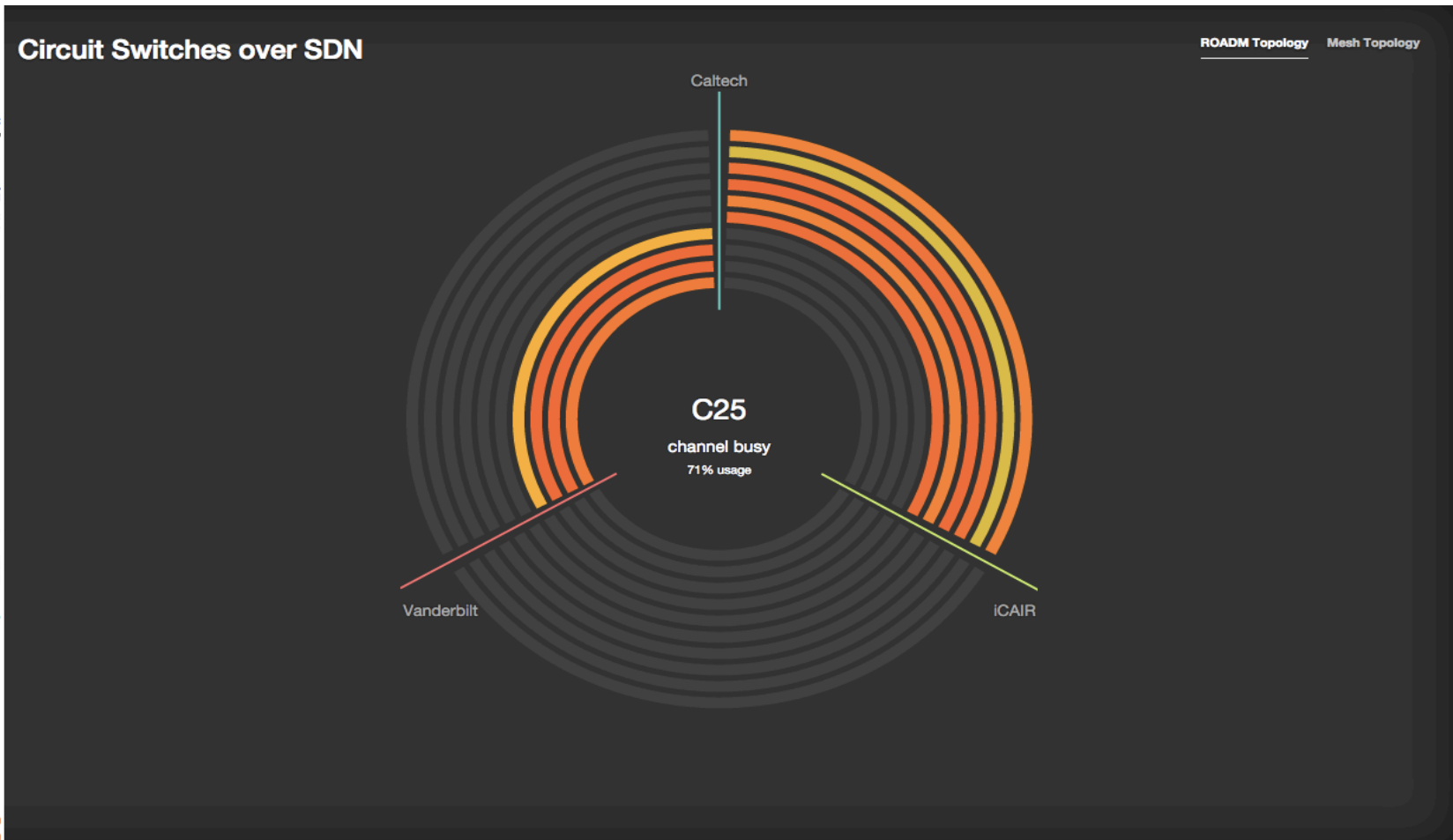


SDN Case Study: 1.55 Tbps peak rate - Memory to Memory transfer



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SDN Case Study: Channel Load



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Center for Internet Augmented
Research & Assessment



FLORIDA INTERNATIONAL UNIVERSITY
Division of Information Technology



OpenWave Case Study: *Submarine Alien Wave Miami to Sao Paulo*

*Contributing parties from CIARA:
Julio Ibarra, Jeronimo Bezerra*

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OpenWave Case Study: Overview

- OpenWave is a project under NSF IRNC ProNet AmLight award for U.S.-Latin America connectivity
- OpenWave will deploy an experimental 100G alien wave between the U.S. and Brazil
 - Deployed using Padtec's transponders within a live hybrid submarine network
 - Coherent Differential Quadrature Phase Shift Keying (DQPSK)
- Impacts:
 - Facilitating academic access to submarine spectrum
 - Brings a new resource to science and education, preparing for future science demands, such as the Large Synoptic Survey Telescope (LSST), which is expected to push to the limits of 100Gb/s network connections, bridging the southern and northern hemispheres.
- Brings together the efforts of:
 - Florida International University via the AmLight Project
 - Brazil via the ANSP and RNP
 - Latin American Nautilus, submarine cable system operator
 - Florida LambdaRail (FLR)
 - Internet2
 - Padtec

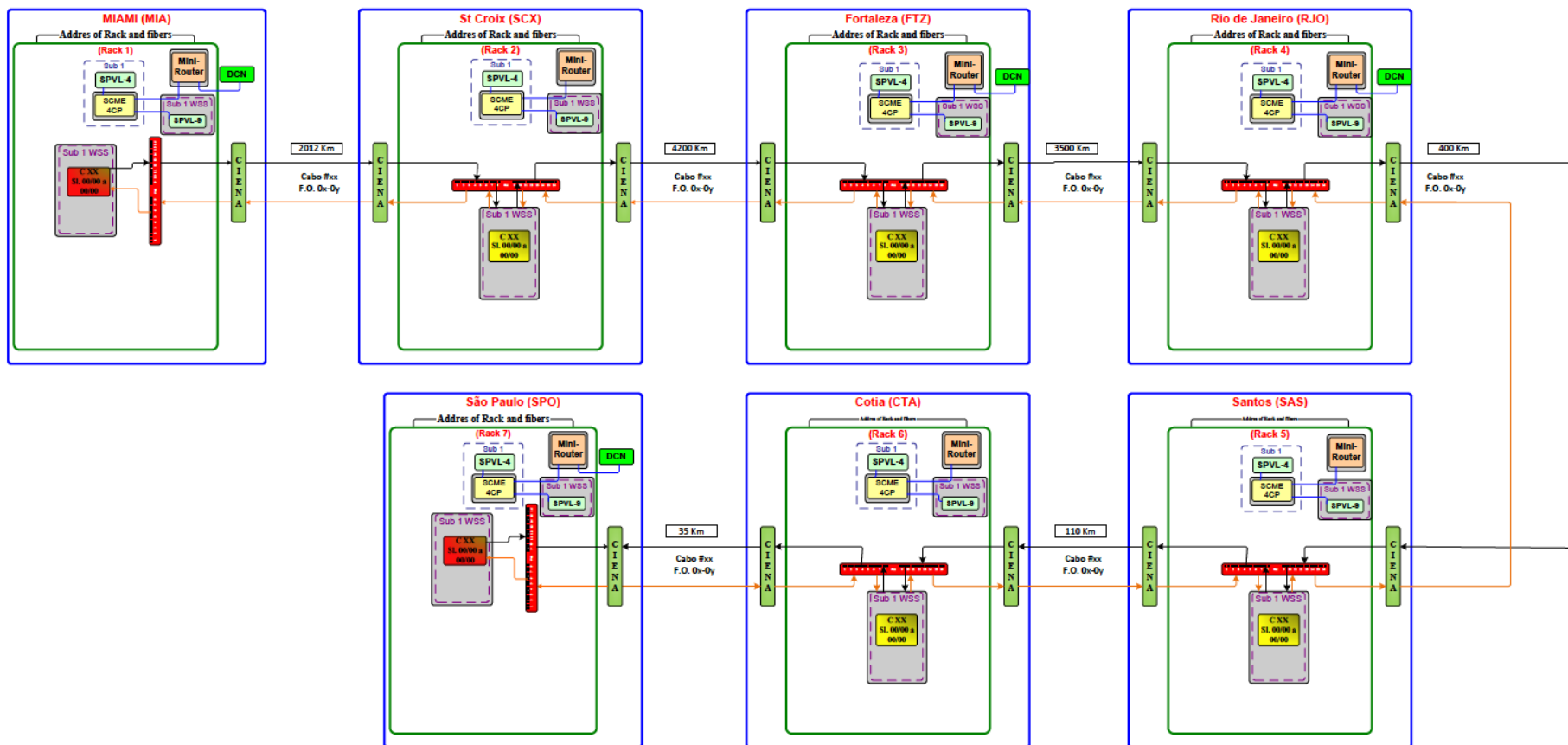
OpenWave Case Study: Overall Network Topology

- Four (4) 100G segments:
 - Miami-St. Croix (STX): 2,400km
 - St. Croix (STX)-Fortaleza: 4,200km
 - Fortaleza-Rio: 3,500km
 - Rio-Santos: 400km
- ANSP: 2x 10G links
S Paulo – Miami
 - (W) via Santiago (LAN)
 - (E) direct (Telefonica)
- RNP: 2x 10G links
S Paulo – Miami
 - (W) direct (Telefonica)
 - (E) via Rio de Janeiro & Fortaleza (LAN)
(+ redundant terrestrial links)



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OpenWave Case Study: LightPad i6400G Deployment



CXX TR100GC94-DRS-DRS-CA - Transp. Regen. 100 Gb/s G.709 Bidirec. DP-QPSK OTU4 Detecção Coerente

CXX TT100GC93-DRS-CSA-CA - Transp. Term. 100 Gb/s G.709 Bidirec. DP-QPSK OTU4 Detecção Coerente

VOAB-2A16AA - Equalizador de Potência 2U c/ 16 VOA's (Canais Equalizados) e Atenuação de 0 a 15 dB config. remoto

SPVL-4 SPVL-4 - Supervisor Pai de Transponders 4U

SPVL-4SM SPVL-4SM - Supervisor Filho de Transponder 4U

SPVL-9 SPVL-9 - Supervisor de WSS Pai (Linux) 9U

SCME-4CP SCME-4CP - Canal de Supervisão Fast Ethernet s/ ALS

Mini-Router mRC05G-D01A - Mini Router Card 05 Portas Ethernet (1U)

DCN DCN - Conexão com Rede DCN

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OpenWave Case Study: LightPad i6400G Highlights

- DWDM transmission
 - Up to 20 Tbps per fiber pair
 - Up to 59 dB of single fiber span
 - Alien wavelength friendly
- ROADM capabilities
 - Up to 9 degree nodes
 - Advanced Colorless, Directionless and Contentionless add/drop features
 - End to End provisioning through ASON/GMPLS, NMS or SDN interfaces
- OTN features
 - ODU Cross-connect
 - Multi-service transport
 - Carrier class OAM
- Datacenter support
 - 1 Tbps in 1 RU transport solution



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OpenWave Case Study: LightPad i6400G 100G Coherent Transponders



- Four 100G products
 - 10x 10G Muxponder
 - 1x 100G Terminal transponder
 - 2x 40G + 2x 10G Flexponder
 - OTU4 Regenerator
- Hard and Soft FEC with flexible overhead rate
- Flexible modulation formats
 - DP-QPSK and DP-DQPSK
 - DP-16QAM
- Minimal channel spacing of 37.5 GHz in DP-(D)QPSK
- Four dispersion compensating ranges: +/-2, +/- 55, +/- 125 and +/- 250 ns/nm
- DGD tolerance of 100 ps
- OSNR Tolerance of 11.5 dB with 2 ns/nm (0.5 dB of penalty in 250 ns/nm)

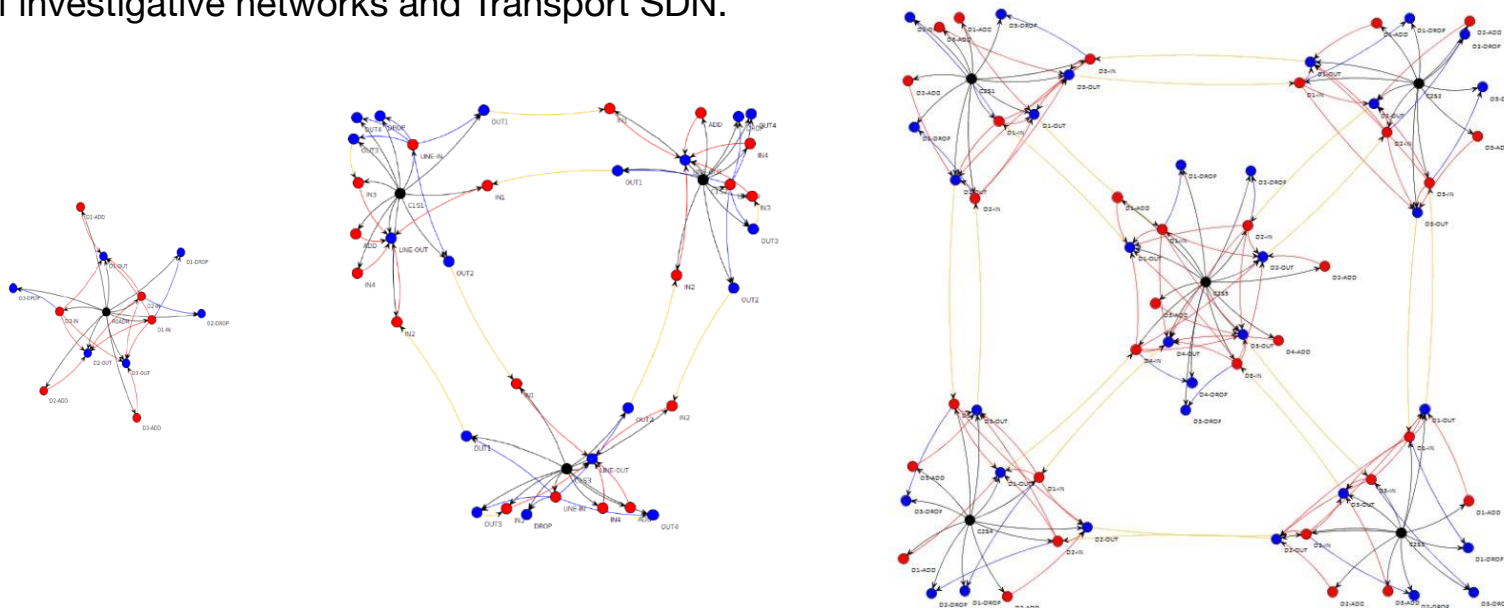
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Conclusion

Our holistic approach includes:

- State of the art hardware and cutting edge SDN developments
- Sharing our experience in these developments
- Agility and flexibility in creating and customizing customer driven solutions
- Working hand in hand with research institutions and carriers in further advancing the state of investigative networks and Transport SDN.



By putting forth our advances in technology, experience, and resources we are confident that Padtec provides the most flexible solution that not only meets and exceeds our customers expressed needs but also enables them to move into a leadership position in the Transport SDN arena.

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Thank you!

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