

Tendencias en Redes Ópticas

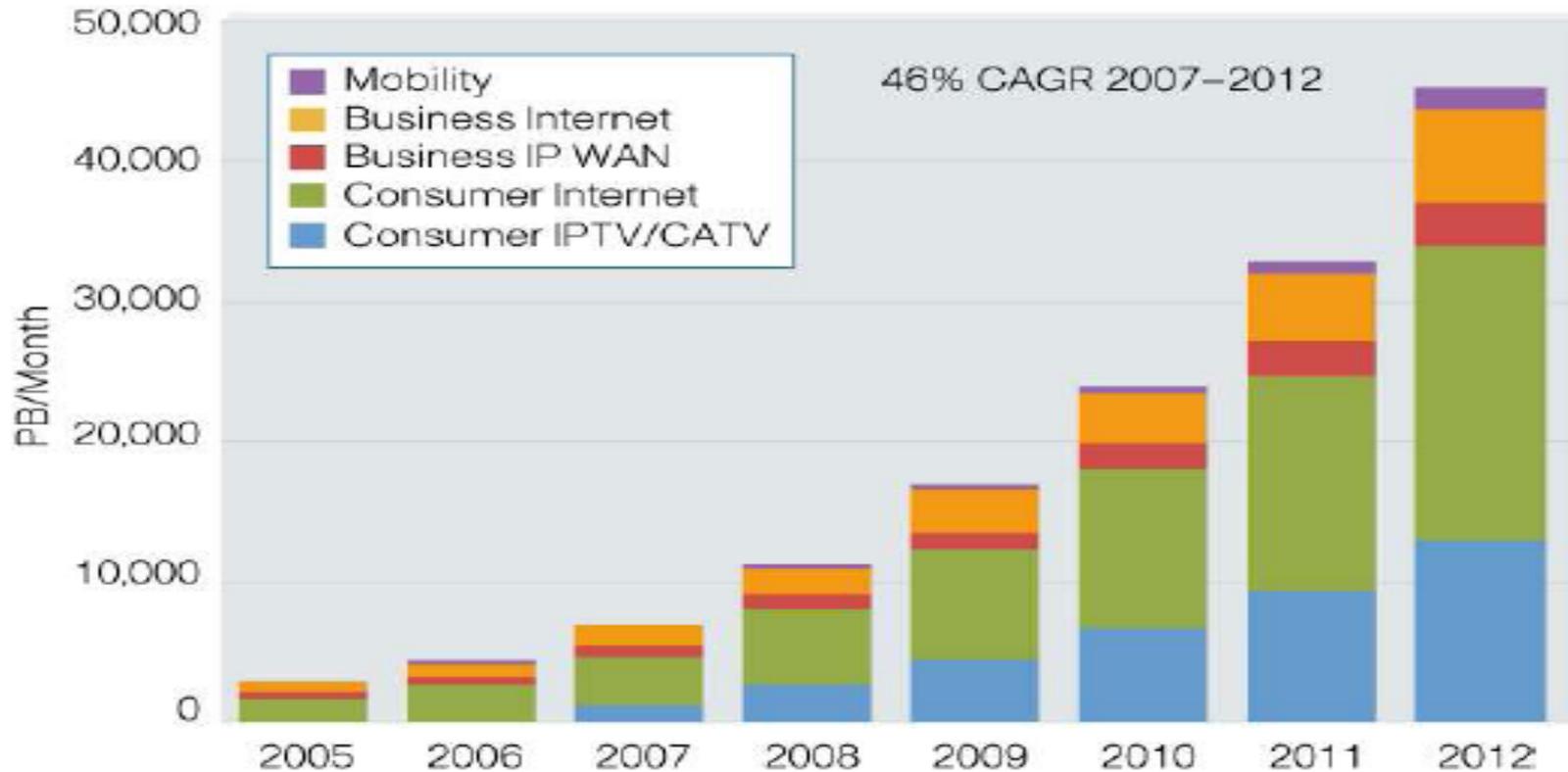


Michael De Leo
CTO LATAM



Networks for the Zettabyte Era

Figure 1. Cisco Forecasts 44 Exabytes per Month of IP Traffic in 2012

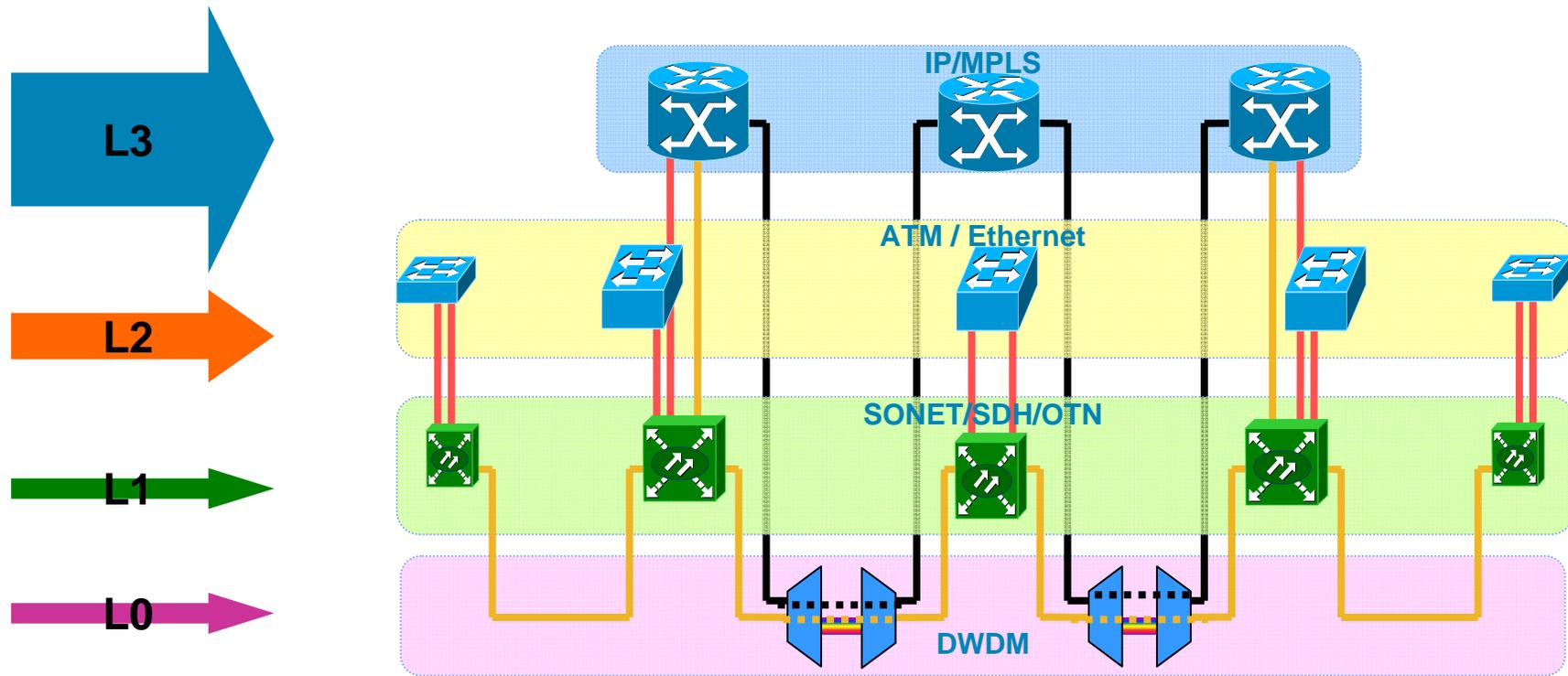


For more details, see the paper entitled "Cisco Visual Networking Index – Forecast and Methodology 2007–2012."

Source: Cisco, 2008 http://www.cisco.com/en/US/netsol/ns827/networking_solutions_sub_solution.html

Perspective: 10 Exabyte = 50x world print (or 2x words ever spoken)

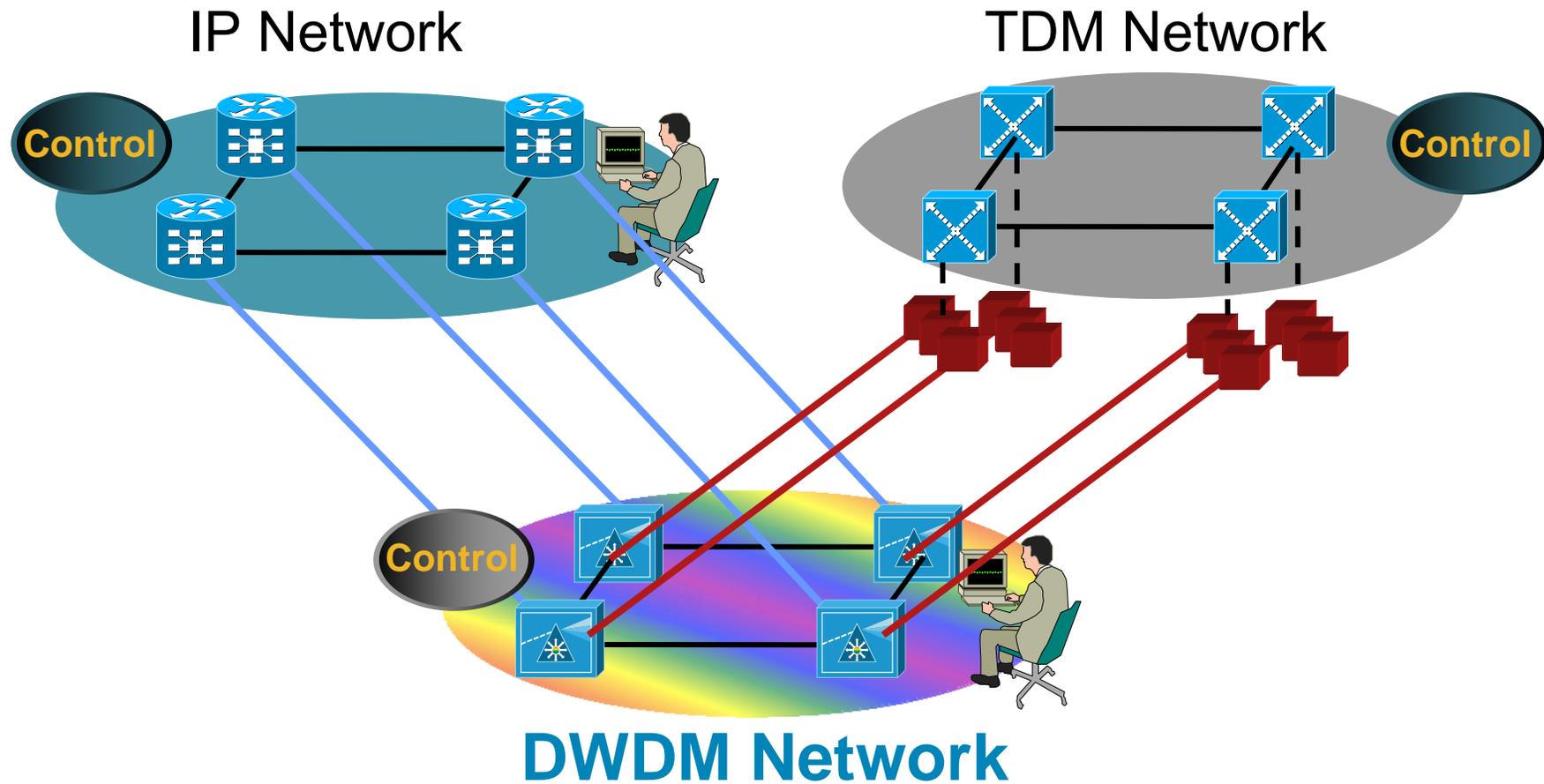
How good Today's Architecture for IP traffic?



- High OPEX unjustified
- CAPEX and power higher – spread over multiple technologies
- Sensitive to accurate forecast per service type

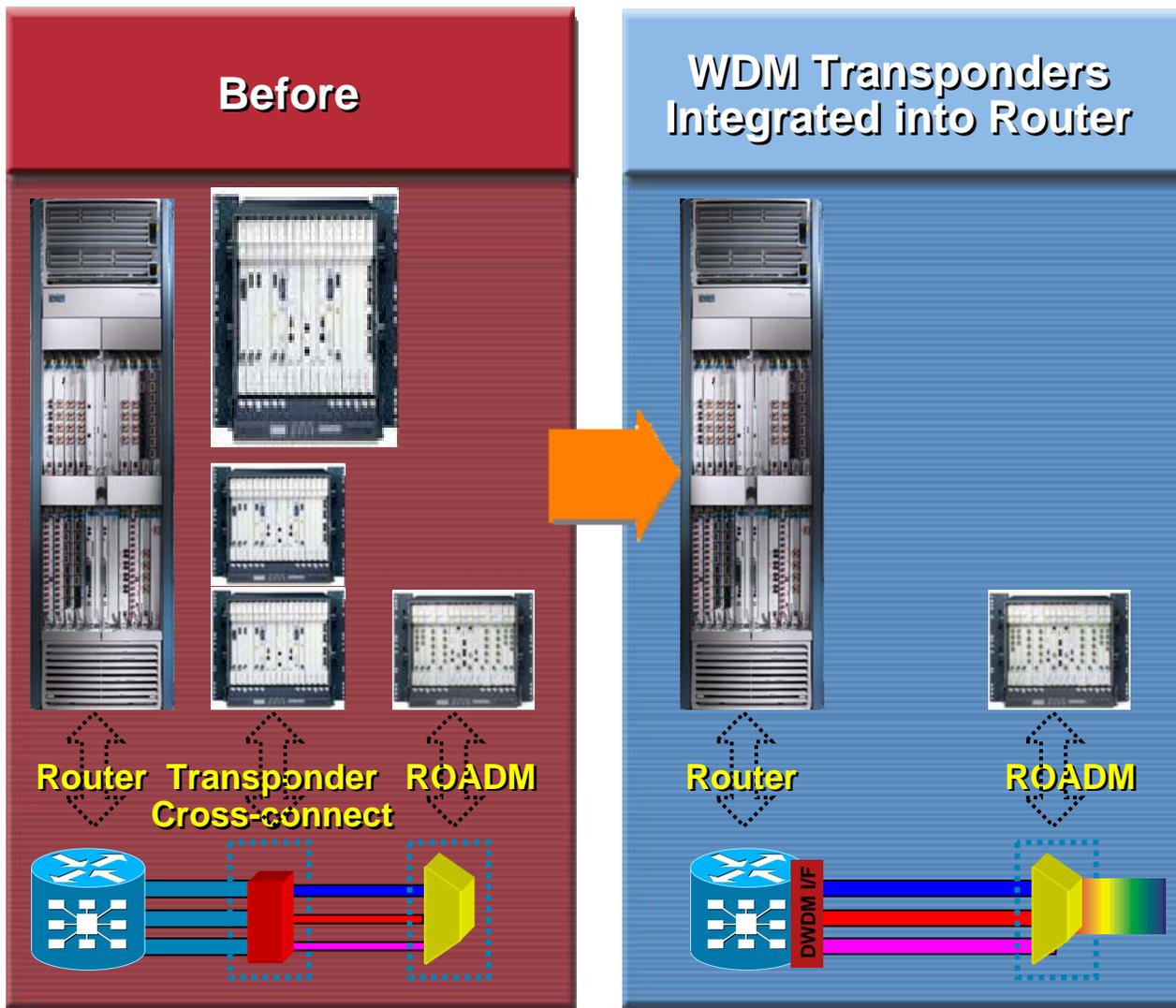
IP over DWDM solution

The converged IP NGN transport



Scalable, flexible and lowest cost per bit to support IP traffic growth.

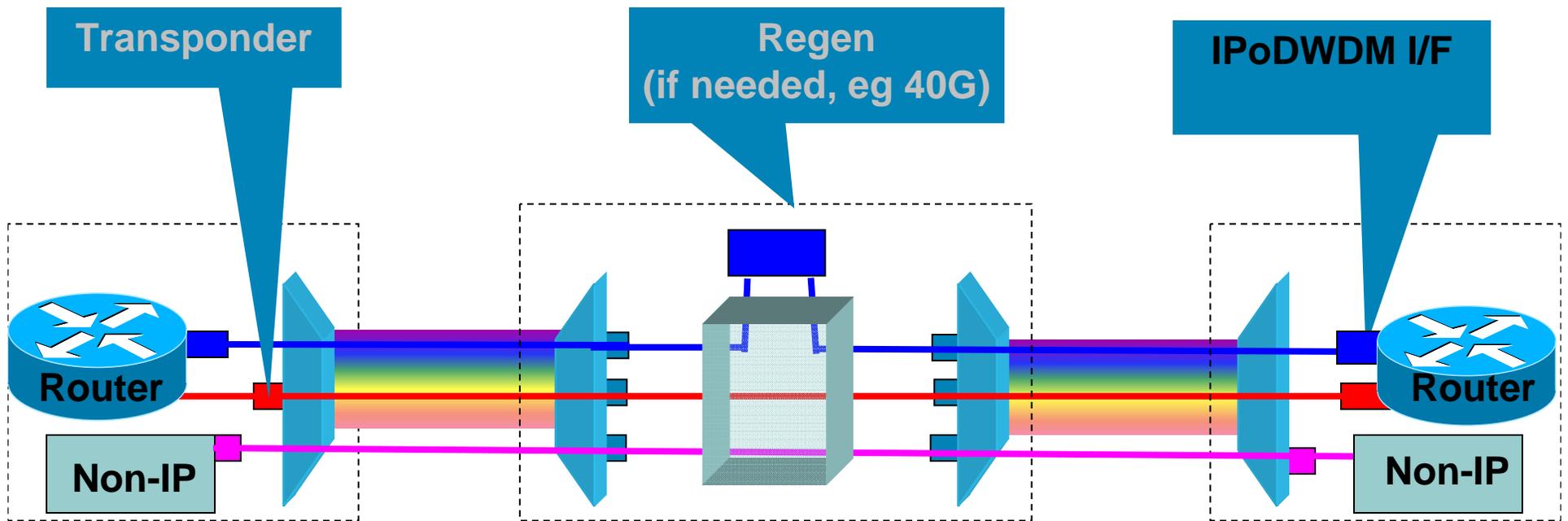
Benefits of IPoDWDM solution



- Lower CapEx
- Elimination of OEOs
- Lower OpEx
- Space, power, management
- Enhanced resiliency
- Fewer active components
- Investment protection
- 40G and beyond, interoperability over existing 10G systems

IPoDWDM Scalable Deployment

One Channel at a Time



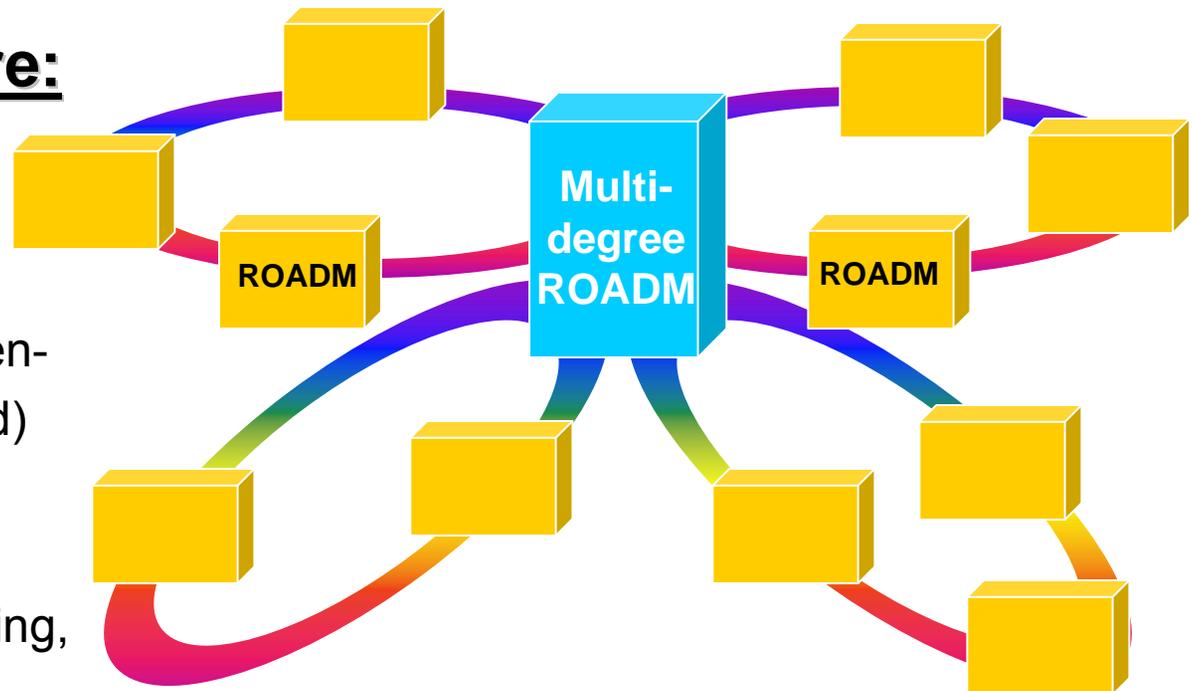
IPoWDM can be deployed one channel at a time,
leveraging Open WDM layer, with proven interop over existing (NELAS)
infrastructure as “alien-wavelength”...

Containing cost (OpEx) for the high growth IP traffic...

Leveraging the Intelligent WDM layer

Open WDM Architecture:

- ✓ **Transparent Transmission**
high-performance (EFEC, adv. mod.), Bit-rate Independent, 'Alien-Wavelength' (emerging standard)
- ✓ **Operationally Friendly**
G.709 OAMP, tunability, monitoring, GMPLS
- ✓ **Network planning flexibility**
ROADM, Planning tools



✓ IPoDWDM interoperability:

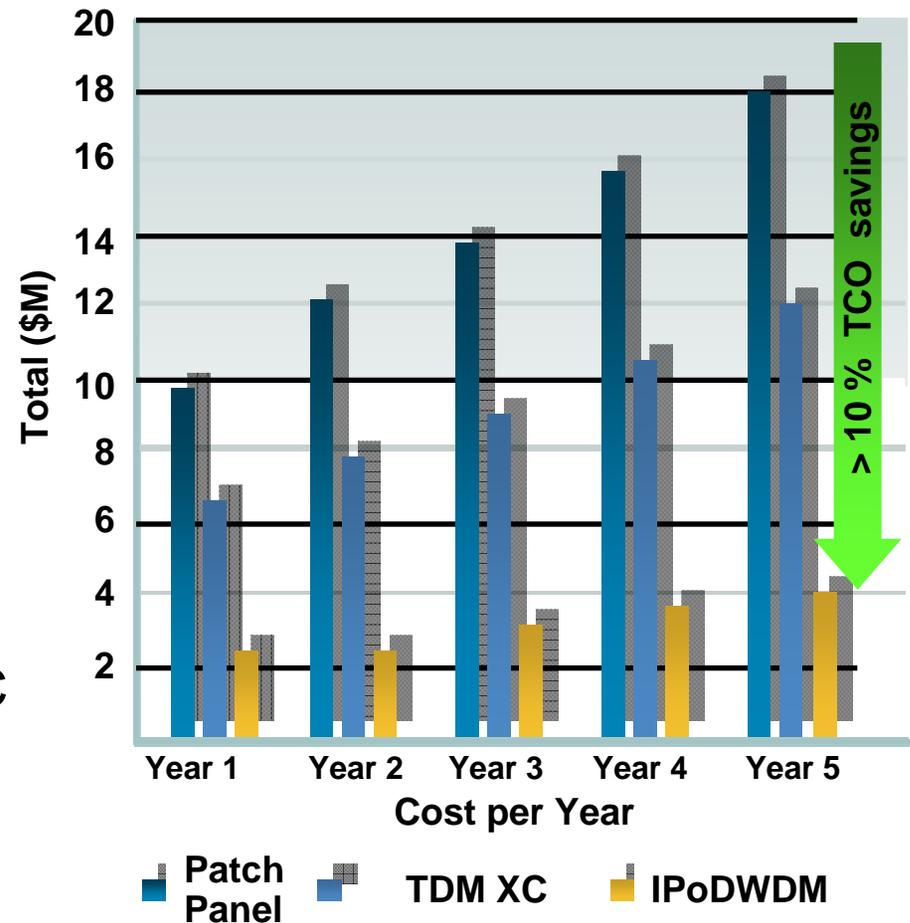
- State-of-the-art performance over MSTP
- Field tested 'Alien-Wavelength' over existing (3rd party) WDM Systems

IPoDWDM: Network Savings

IPoDWDM often > 10% TCO savings due to:

- CapEx Savings: OEO elimination
- OpEx Savings: power, space, maintenance
- OpEx Savings: WDM ROADM provisioned, S-GMPLS (no truck roll nor manual patching of λ)
- Advanced Protection (FRR, per-FEC visibility)

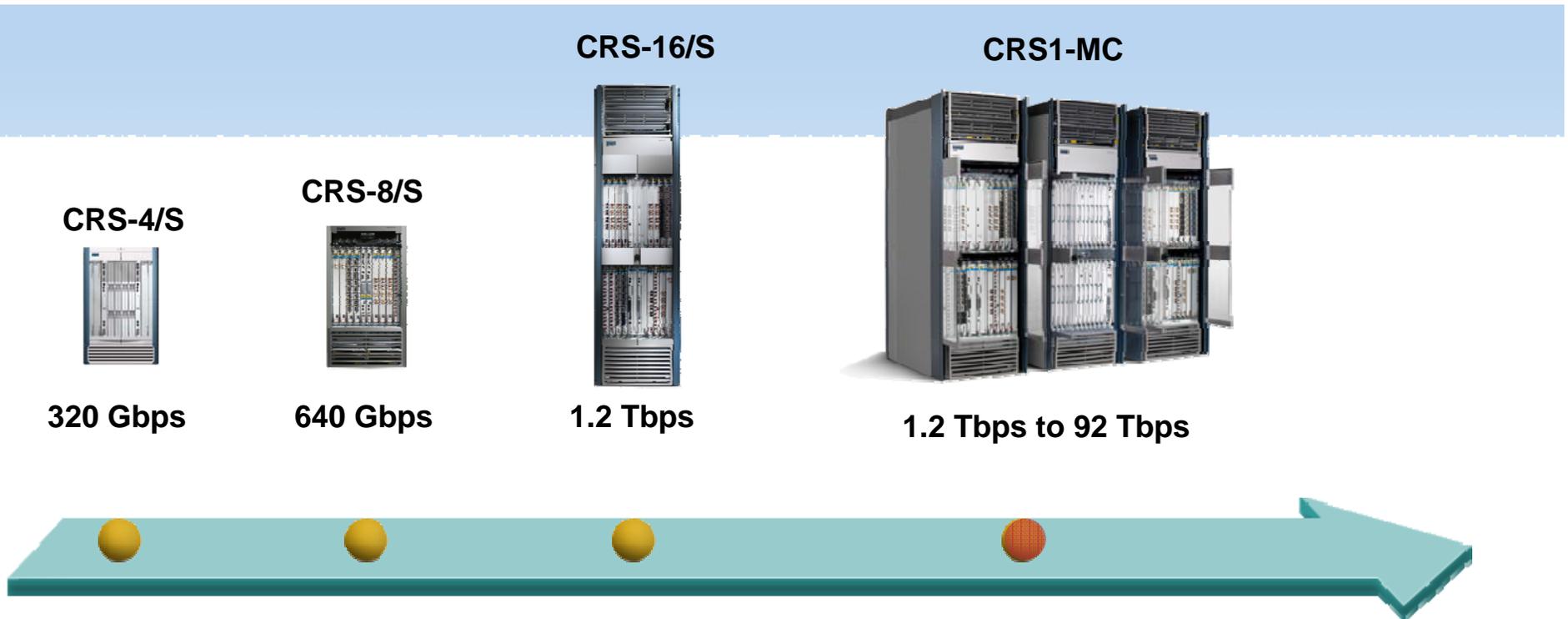
based on detailed analysis of multiple customer networks.



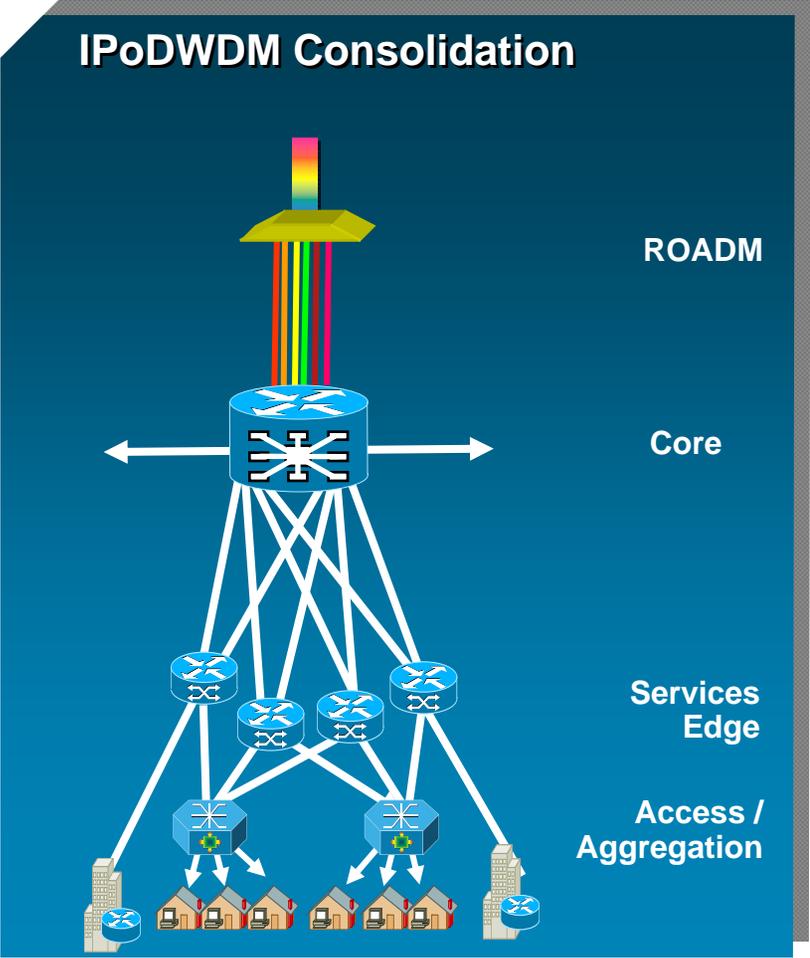
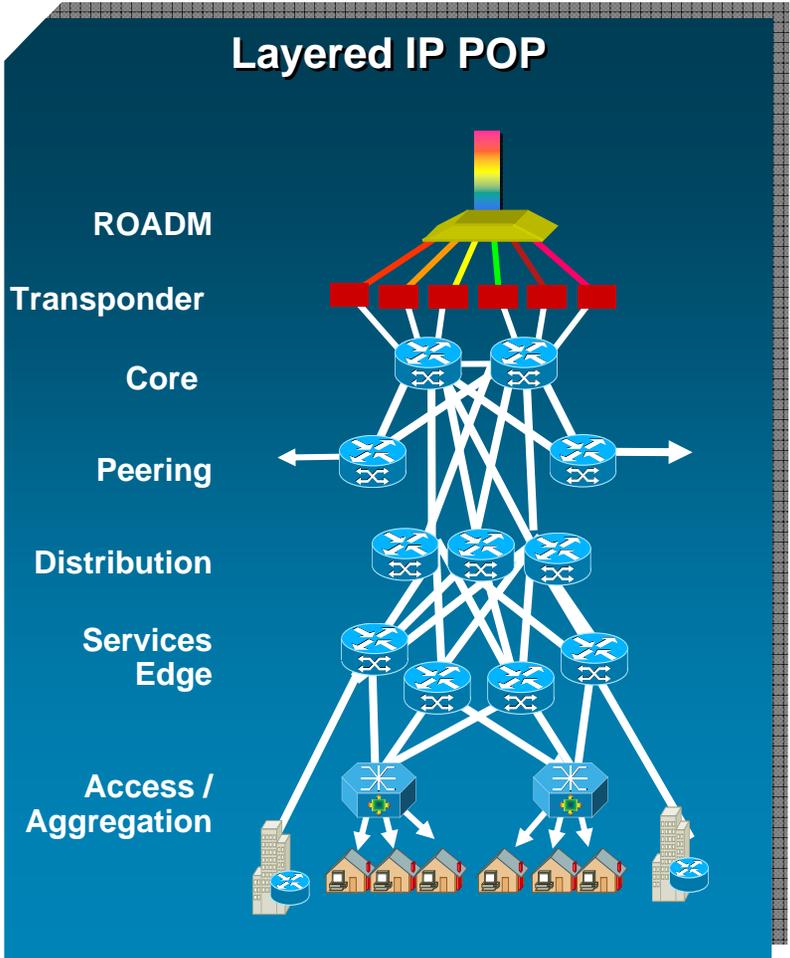
Carrier Routing System-1 Product Family

Single Chassis to Multi-Chassis

- Single architecture from 320 Gbps to 92 Tbps
- Investment protection—common forwarding engines and I/O modules
- Flexible/programmable control and data plane to meet evolving service requirements
- Intelligent multicast support with fabric based multicast
- IOS-XR Fully modular OS w/ In-Service Software Upgrades

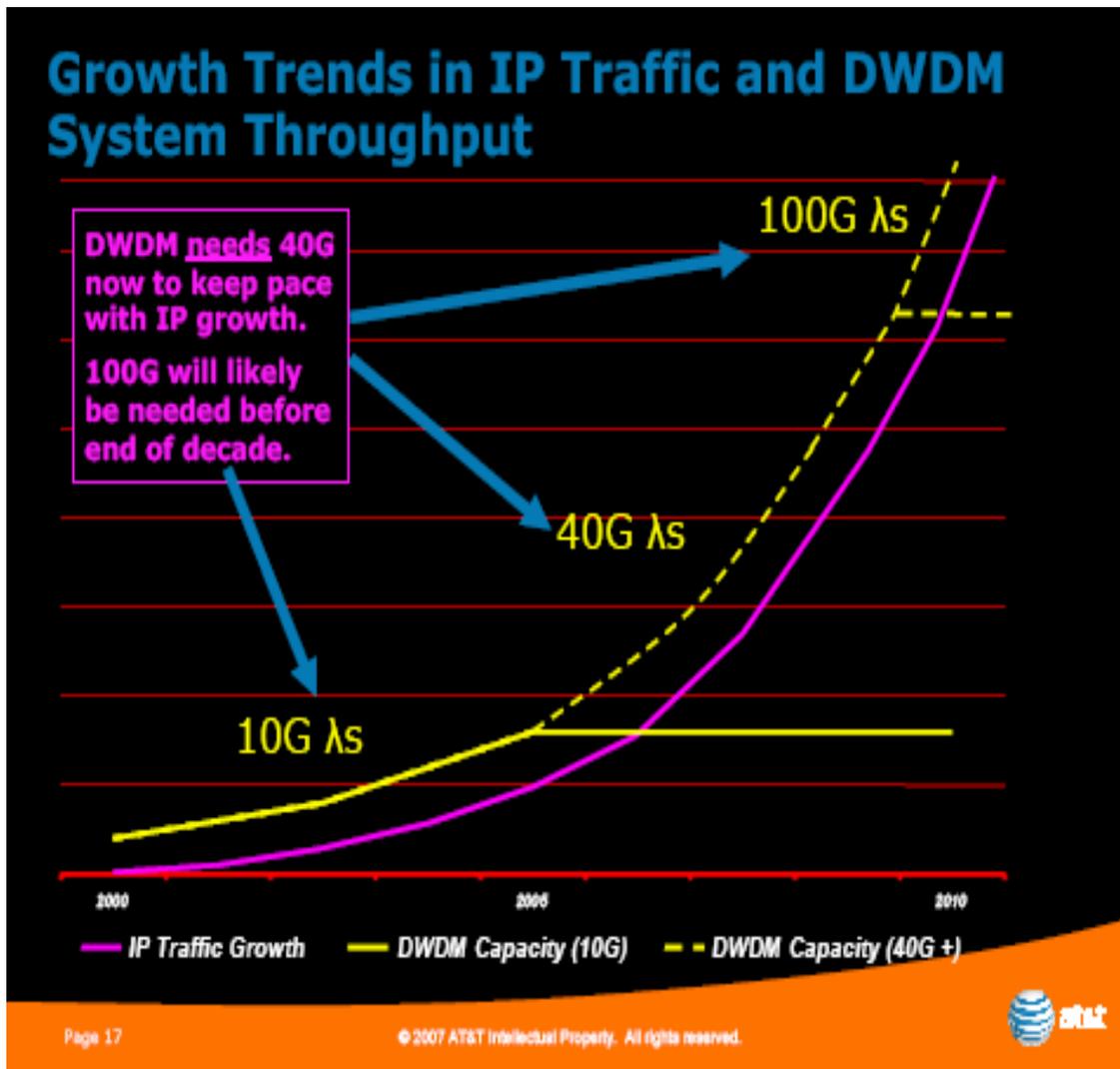


IP NGN POP Consolidation



Capex/Opex reduction, Increased Service Flexibility →

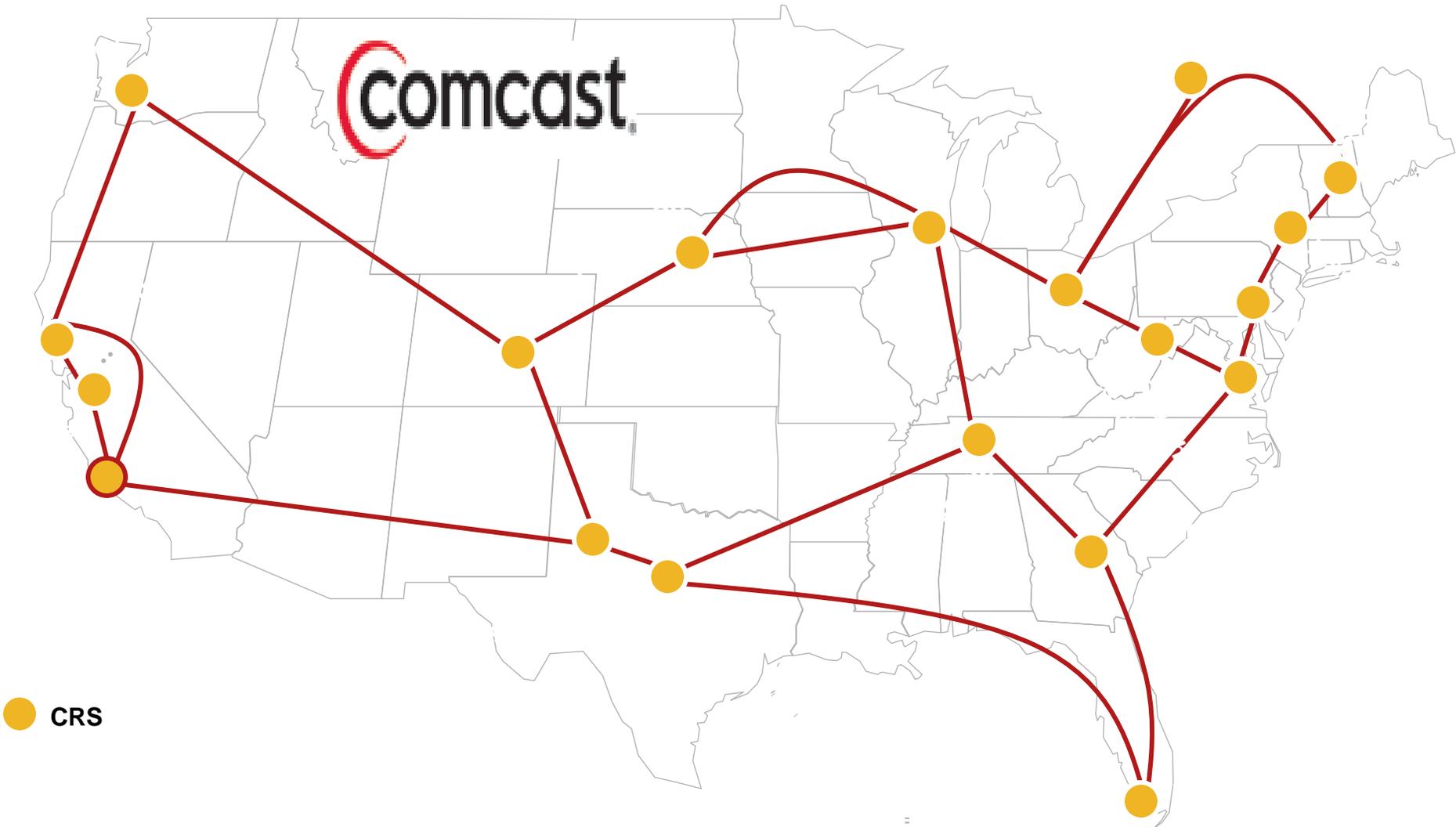
WDM Transport Evolution to 40 and 100 G



- Higher rate initially deployed in highly congested links
lower TCO vs higher \$/bit/s/km/channel
- Higher rate channels (= less wavelengths) preferred (less HW & managements)
- **Higher rate preferable over IP link bundling**
- Mainstream deployments require operational parity (OSNR, PMD), TCO advantage

Comcast Innovation

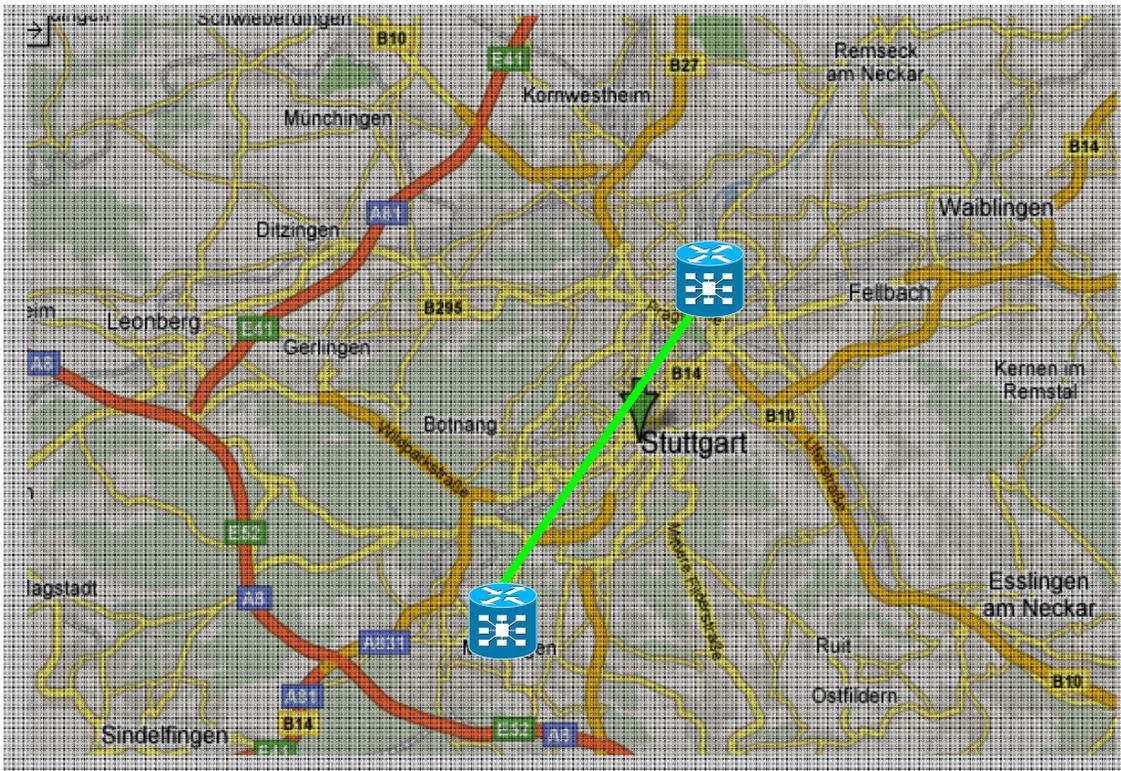
Nationwide 40G IPoWDM Production Network



CRS 40G-WDM DT Deployment (Early Adopter)

Initially single-channel

http://newsroom.cisco.com/dlls/2006/prod_120406d.html



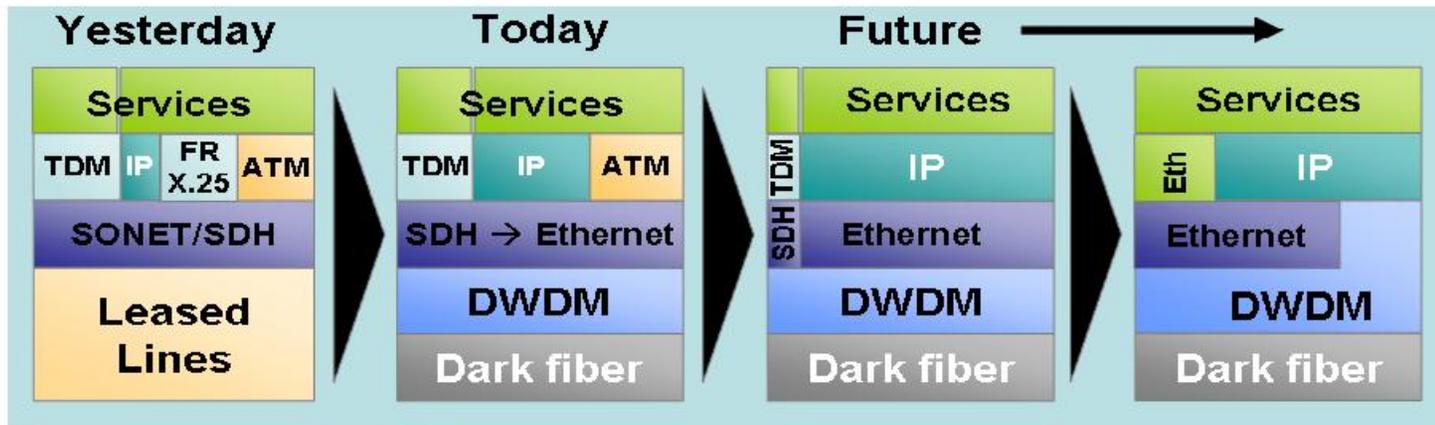
Cisco Carrier Routing System Selected by T-Com to Power Growth of IPTV Services

Monday December 4, 1:30 pm ET

"The Cisco CRS-1 system is configured with a 40 gigabit-per-second (Gbps) IP over Dense Wavelength Division Multiplexing (IPoDWDM) interface, an industry-leading solution that seamlessly integrates element, control and management between the IP layer and the optical DWDM layer, helping T-Com to cost-efficiently increase throughput of its existing fiber infrastructures to manage traffic growth from video and IPTV services."

Other Vendors also Believe now in this Future...

Ethernet (IP) Over Optics (WDM) Technology Enables Cost-Efficient Terabit Connection



- Optical transport (and access) will jointly evolve with class of e2e services
- Carrier Ethernet transport will over time substitute Sonet/SDH-based TDM services with improved service features & significant opex savings
- Cross-layer optimization will continue to improve overall cost efficiencies
- IP-over-WDM technologies, along with packetized optical networks, will serve the new Internet connectivity infrastructure for both fixed & mobile communities





CESNET Introduction

- The CESNET (Czech Educational and Scientific Network) association was formed by the Czech universities (27) and Czech Academy of Sciences in 1996
- Non-profit organization, funded by Ministry of Education, Youth and Sports of the Czech Republic, association members and external sources (EU)
- 7-year research plan “Optical High Speed National Research Network and Its New Applications” (2004-2010)

CESNET Introduction

Research activities

CESNET2 NREN development

Optical networks

Programmable hardware

Network and traffic monitoring

AAI and mobility

METACentre (Distributed computing, GRIDs)

Multimedia and collaborative environment

Application support (High energy physics, medical image transfer and storage, etc.)

For more details see www.cesnet.cz

CESNET Introduction

Participation in a number of international projects and research activities:

GÉANT2 (Pan-European backbone research network),

<http://www.geant2.net>

EGEE II. (Enabling Grids for E-science)

<http://egee.cesnet.cz>

VINI (Virtual Network Infrastructure)

<http://www.vini-veritas.net>

GLIF (Global Lambda Integrated Facility)

<http://www.glif.is>

Optical fibers

- **Customer Empowered Fiber (CEF) concept**

- Utilization of dark fibers by own transmission technology

- The first lines lighted in 2000 (2.5 Gbps PoS and 1 GE lines)

- SMF (Standard Mode Fiber) G.652 and NZDSF (Non-zero Dispersion Shifted Fiber) G.655 fiber types

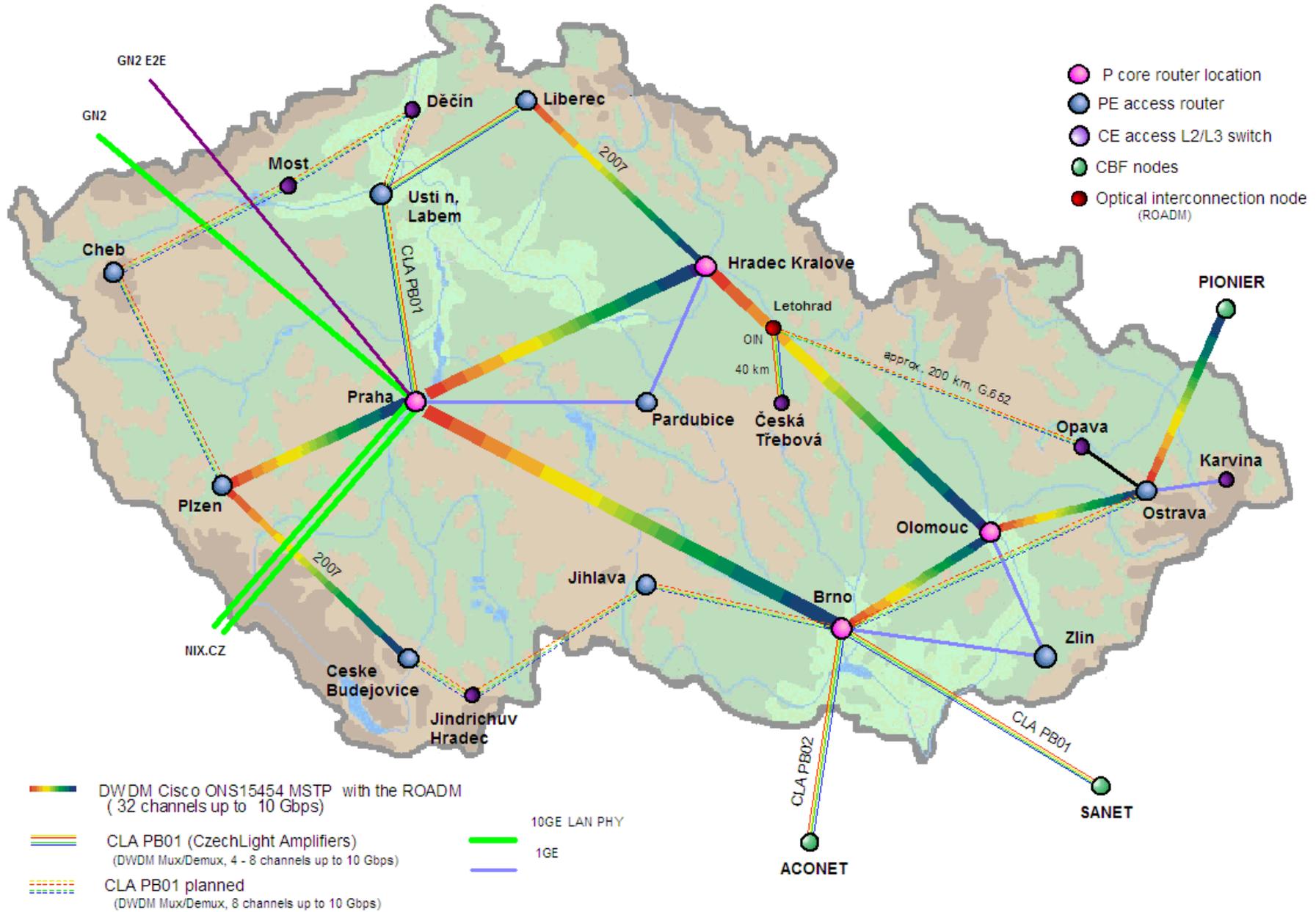
- We have 4951 km of leased dark fibers now

- **DWDM deployment in CESNET2**

- Commercially available equipment and solutions

- Cisco ONS 15454 MSTP

- Static DWDM based on own CzechLight project amplifiers (CL), optical kit based on commercially available optical elements (repeaterless NIL/Nothing-In-Line approach)



CESNET2 DWDM Deployment

- **CESNET expectations**

 - IP/MPLS network capacity upgrades (10 Gbps and more)

 - Migration from single-channel “gray” solution to many independent optical transmission channels (lambdas)

 - Flexible provisioning E2E optical services at L1 and Ethernet services at L2 to meet the research activities requirements

- **DWDM network provides services namely for**

 - IP/MPLS network layer at 10 Gbps (Cisco OSR 7609 routers)

 - E2E services (low latency, guaranteed capacity) for research projects and activities

CESNET2 DWDM Description

Core CESNET DWDM network based on Cisco ONS 15454 MSTP and 2-way ROADM technology

32 channels with the 100 GHz spacing according to ITU-T G.649.1 in C-band

The whole network is calculated not to exceed $BER \leq 10^{-15}$

Chromatic dispersion compensation adjusted to deal with the mixture of different fiber types

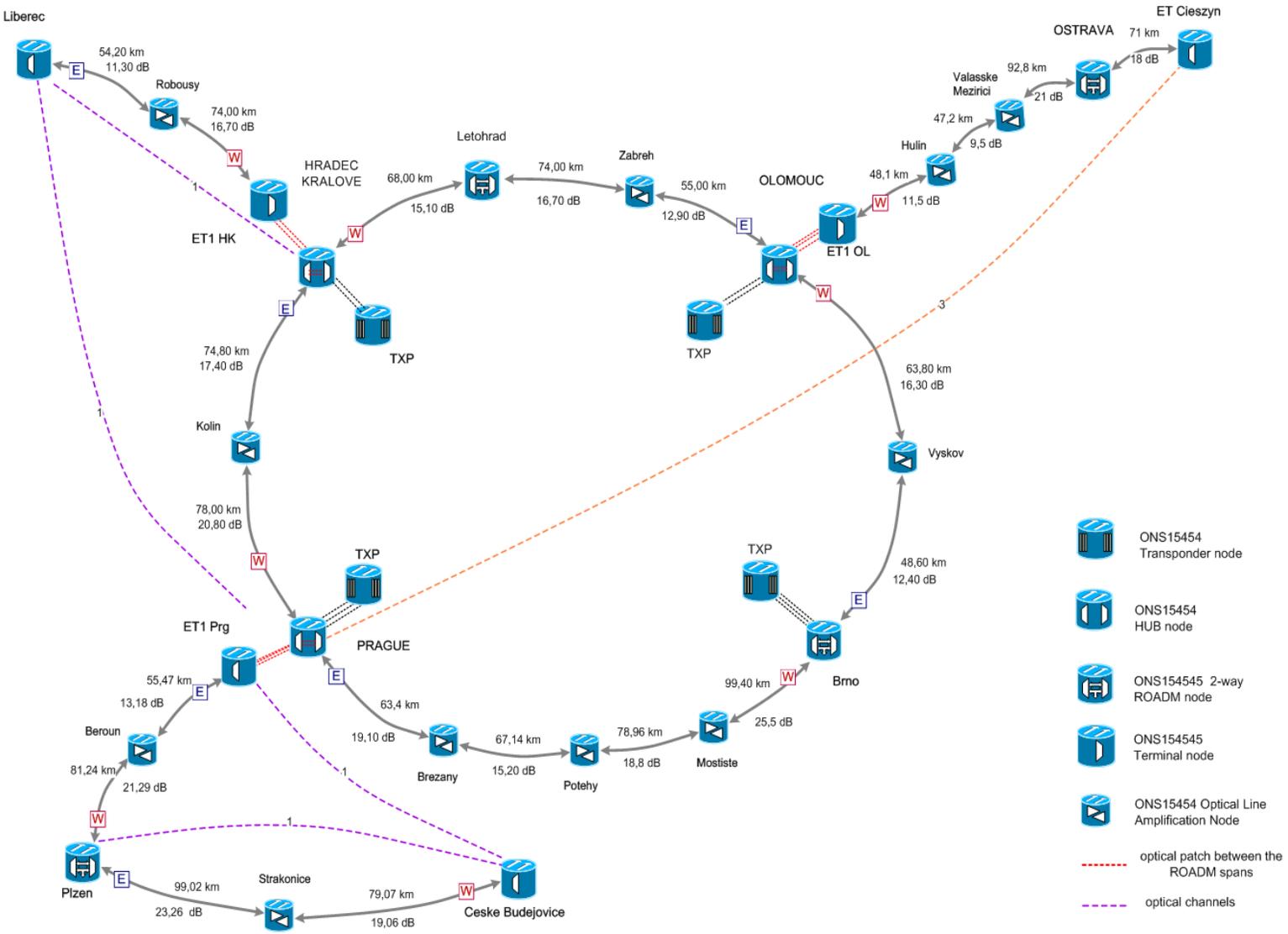
Alien wavelength transport (Alien wavelength and client connection by pluggable optics)

Full-tunable Enhanced 10GE (E-FEC) and multirate 2.5 Gbps transponders (1GE and OC-48 pluggable optics)

At least 2 dBm power margin per span

Current SW version 8.0, planned upgrade to 8.5x

CESNET2 DWDM Topology



Conclusion

CESNET2 DWDM network is flexible and stable

No services affected problems, no errors on optical channels

No services affected SW upgrades experienced

Flexible optical channels configuration between any ROADMs nodes “on demand” remotely (Multi-Degree ROADM)

Effective network and wavelength routing planning (CTP)

Integrated Layer2 functionality

Conclusion

CESNET2 DWDM network future plans

40 Gbps transport

Integration with the IP network layer (IPoDWDM, GMPLS)

Optical protection (alien wavelengths included)

More optical channels (50 GHz spacing, L-band extension)

100 Gbps transport

Colorless ROADM idea and IP/DWDM integration looks O.K.

