Verizon Optical Network Strategic Vision

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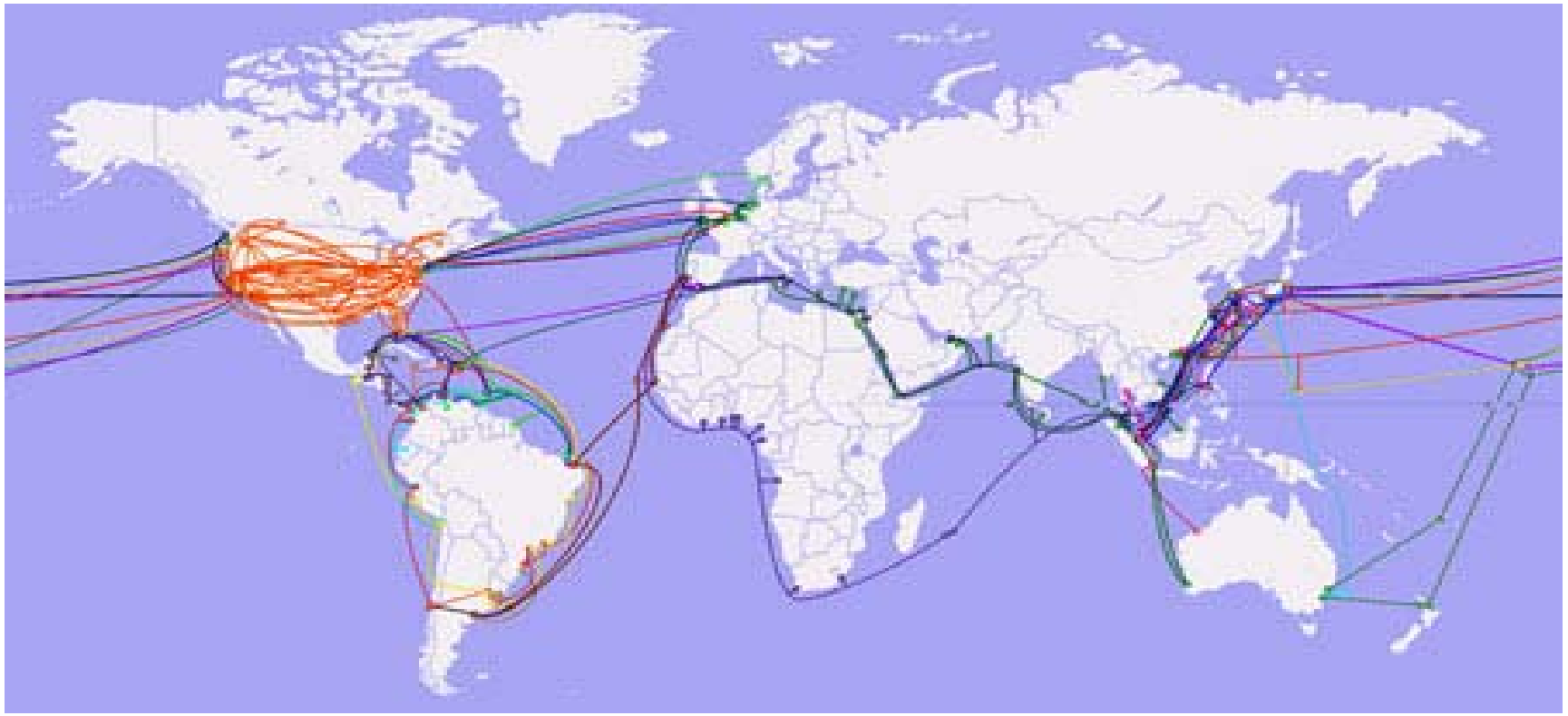
Agenda

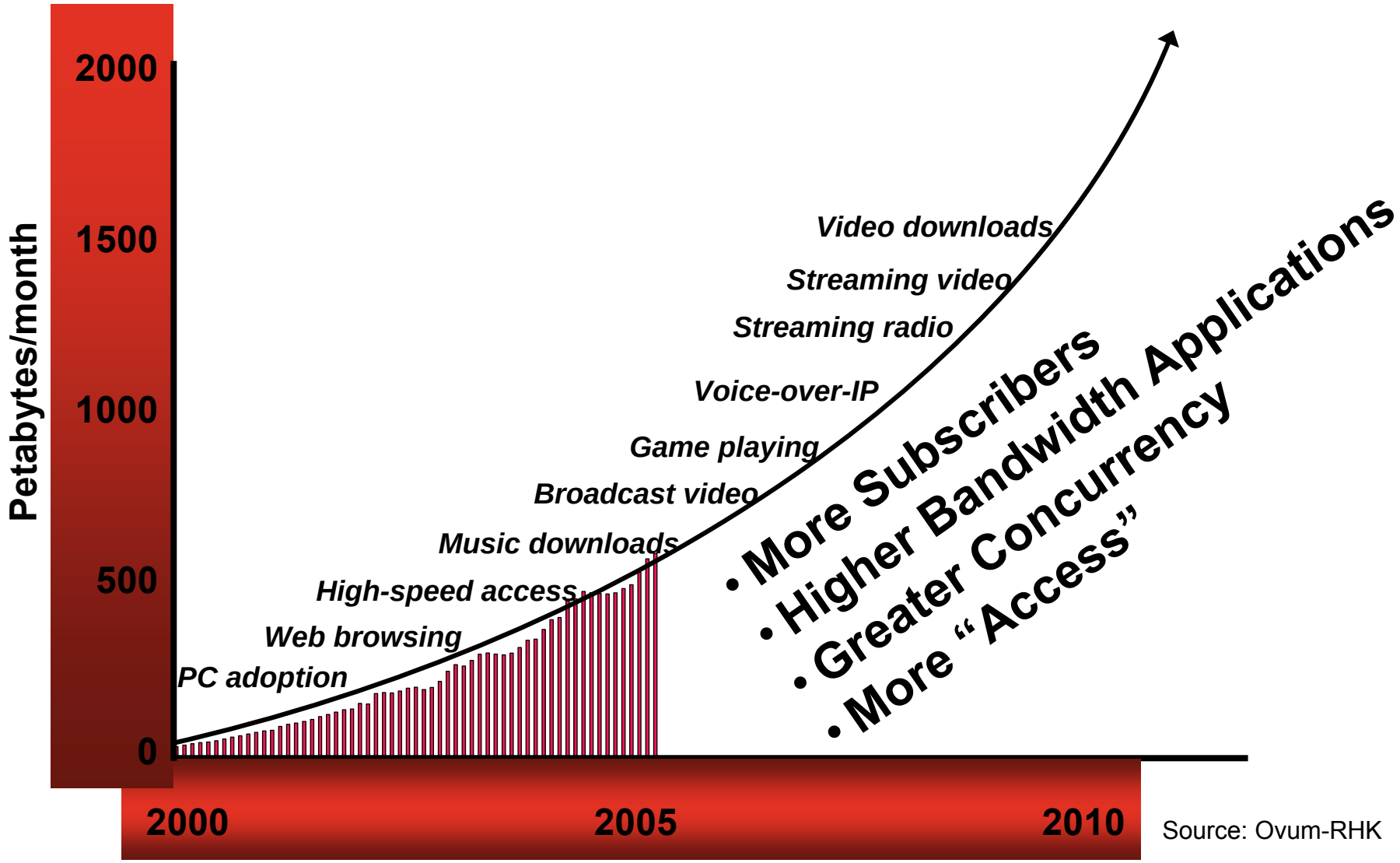
- **Drivers & Strategy**
- **Metro/Core Transport Transformation**
- **Access**
  - Core Extension - *Network for Networks*
  - FTTP
- **Optical Control Plane**

Verizon's Global Network



One of the Largest Wholly Owned Facilities-Based Networks in the World

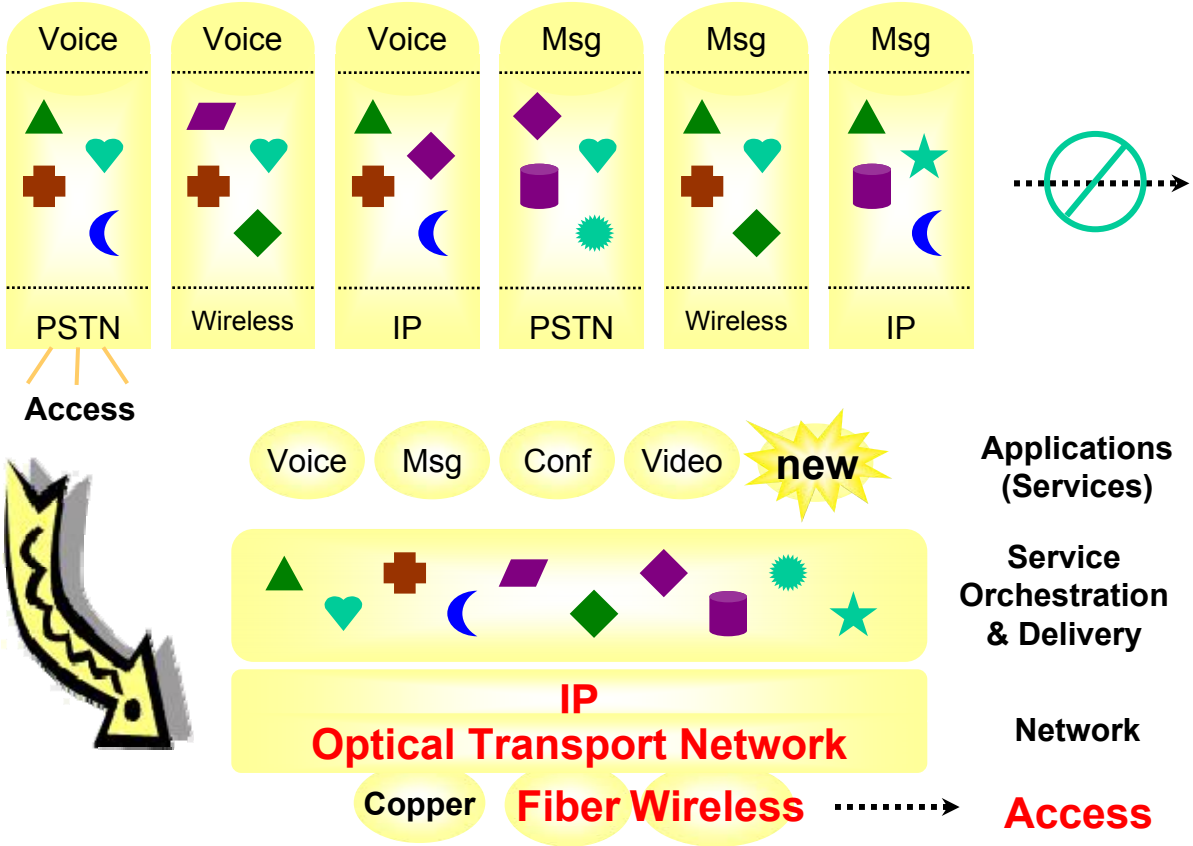
Traffic Growth



Source: Ovum-RHK

Service Trends

- **New Services**
  - **Innovation does not require network expertise**



Network Architecture Optical Strategy

- **Maintain high resiliency, low latency, and guaranteed service rates**
  - Residential, Enterprise, Gov't, Wholesale, and Vz Internal needs
- **Reduce O-E-O points**
- **Wavelength (λ) Centric (Photonic) Network**
  - From SONET and DWDM using point-to-point and small rings
  - To ROADM mesh topologies – 4 and 8 Degree λ Switching
  - Platform Evolution and Convergence
- **Control Plane Enabled Dynamic Network**
  - Scalable service rates for TDM, SAN, and IP services
  - Automated provisioning and dynamic bandwidth allocations
  - STS-1 granularity for 50Mb to 1Gb/s and beyond

End-to-End All Optical Network

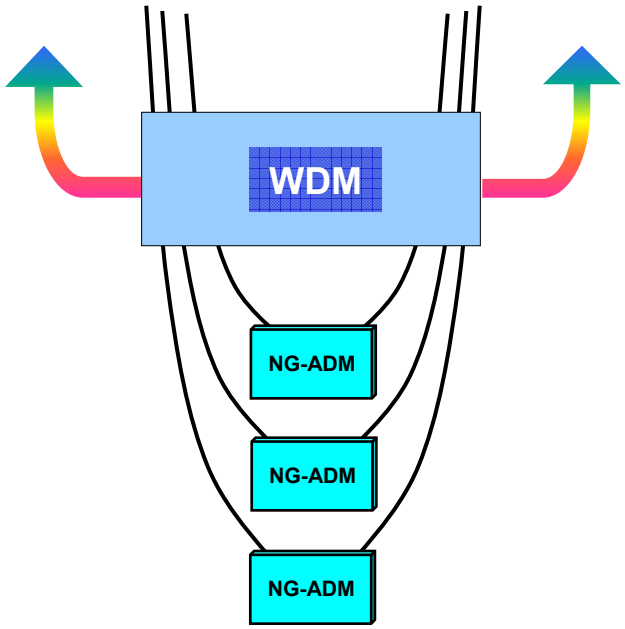
- **Metro/Core Transport Transformation**
  - Platform Evolution w/ROADMs
    - Reconfigurable Optical Add/Drop Multiplexers (ROADM)
    - DWDM, SONET, Ethernet, and Packet
      - Low Latency, High “QoS”, Efficient Processing, Common Platform
  - Wavelength Centric (Photonic) Network
    - Wavelength Switching & Optical Broadcast
    - 10G & 40G λ support, Tunable Optics, Rate Adaptive Clients,
  - Control Plane Enabled
    - Dynamic BBoD Services (50Mb/s to 1 Gb/s and beyond)
- **Access**
  - Core Extension – Network *“for”* Network Connections
  - FTTP

Metro/Core Transport Transformation

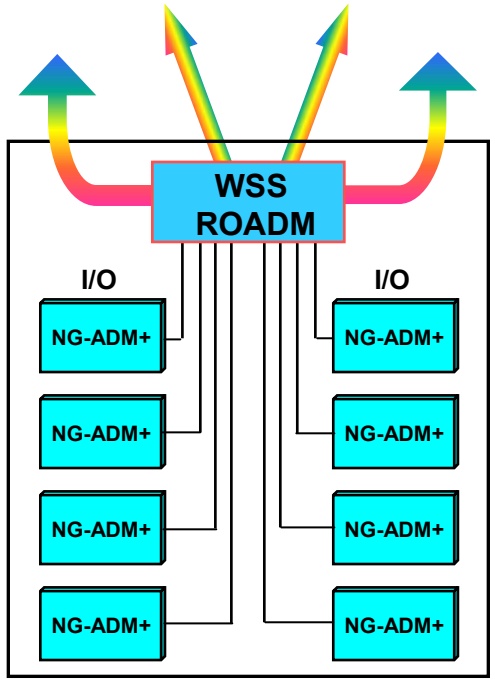
Transport Evolution – ROADM Node

Packet – Optical Transport Platform

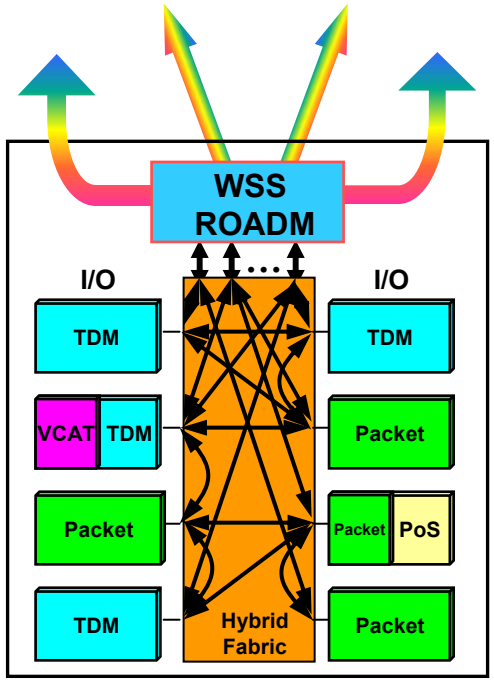
NG-ADM & DWDM Pre-2007 Builds



OTP

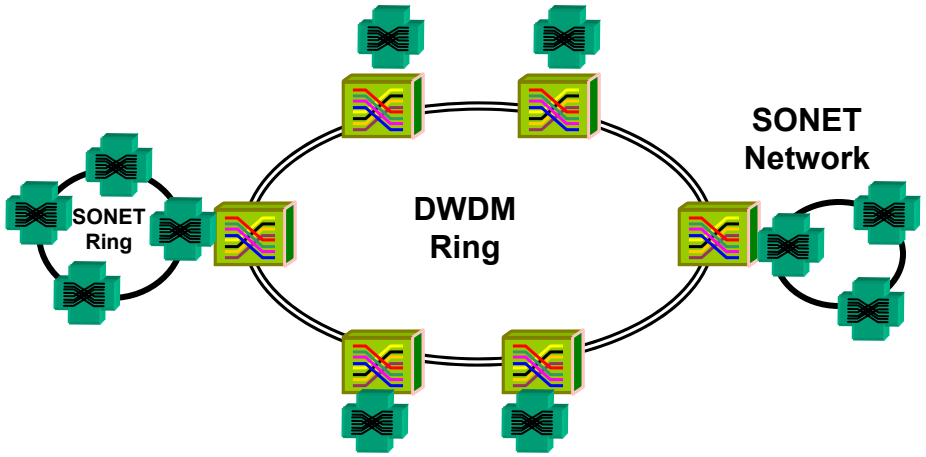


P-OTP

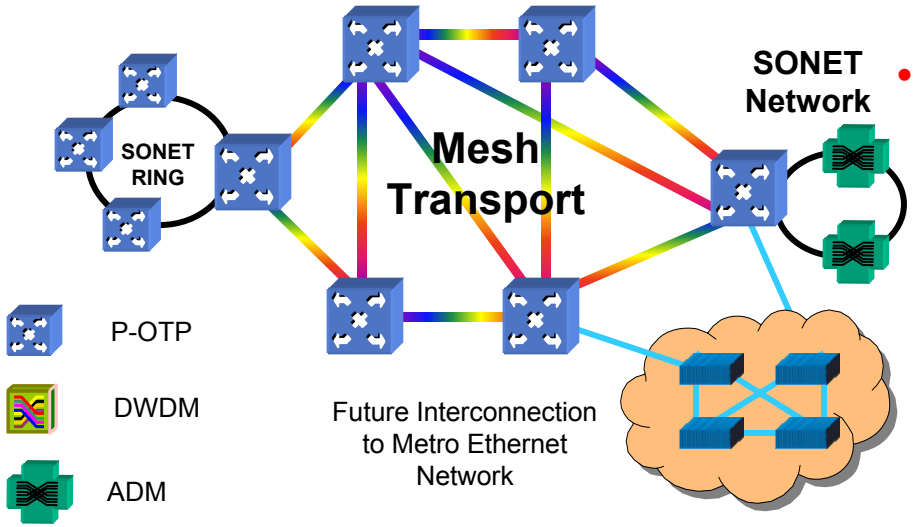


- Integrated Platform – WSS, Fabric, Client Interfaces
- Wavelength Selectable Switch (WSS) Provides Multi-Degree Optical Switching
- TDM and Packet Aggregation via Hybrid Electrical Switch Fabric
- Tunable Optics and Rate Adaptive Client Ports

Transport Evolution – ROADM Network

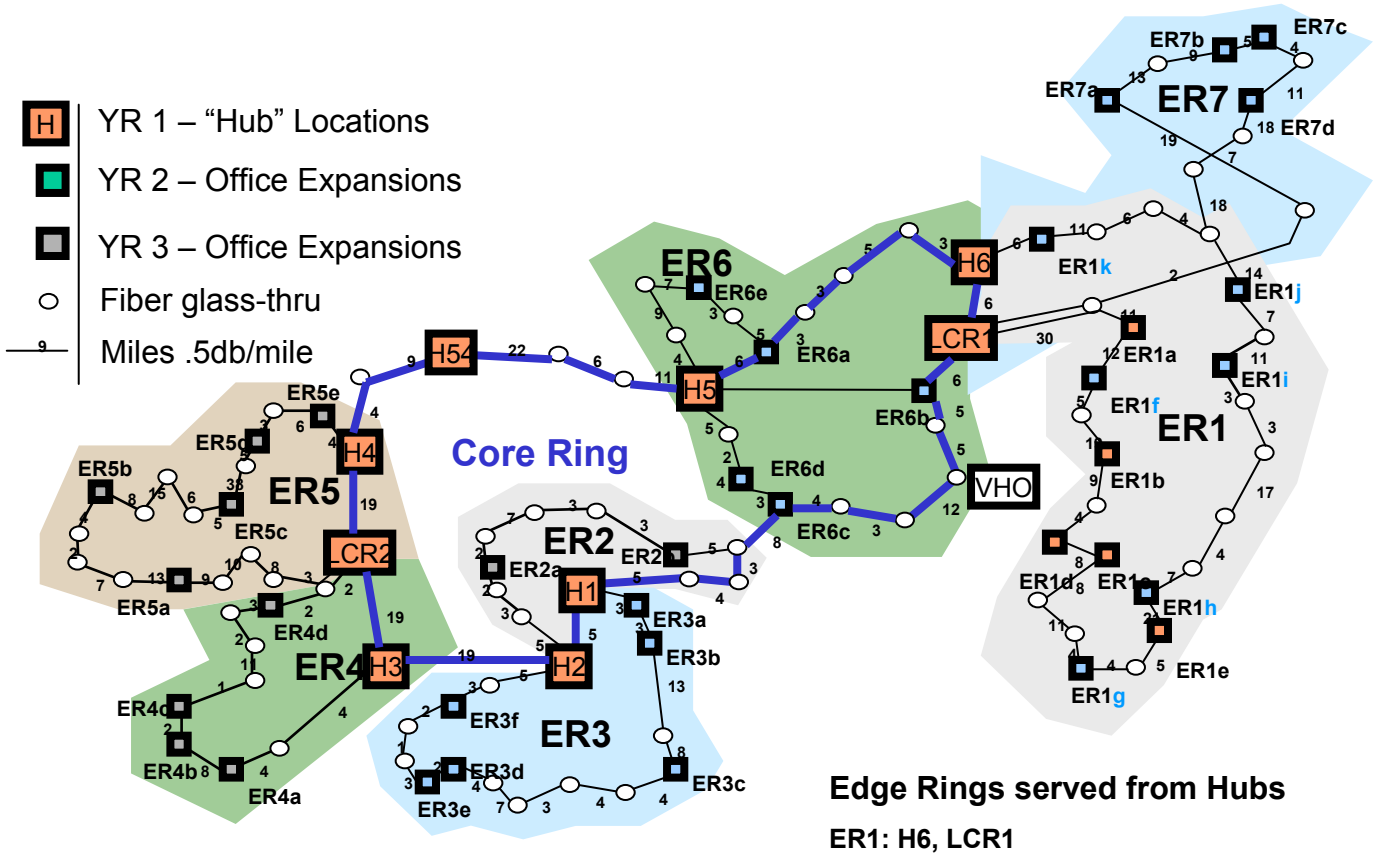


- **Previous Mode of Operation**
  - Separate DWDM and SONET NEs – Stacked "Networks"
  - DWDM supports ring and linear configurations
  - Support for 16-32 λs @ 2.5G
  - Small Rings 4-5 Nodes
  - Fixed optics



- **ROADM Mode of Operation**
  - Wavelength Centric Mesh
  - λ Switching - 4 & 8 Degree
  - ADM-on-λ
  - Native & Switched Ethernet Capability
  - Support 44 & 88 λs @ 10G / 40G
  - λ Performance 1000+ Km

Metro Network Build Example



Edge Rings served from Hubs

ER1: H6, LCR1

ER2: H1,H2

ER3: H1,H2

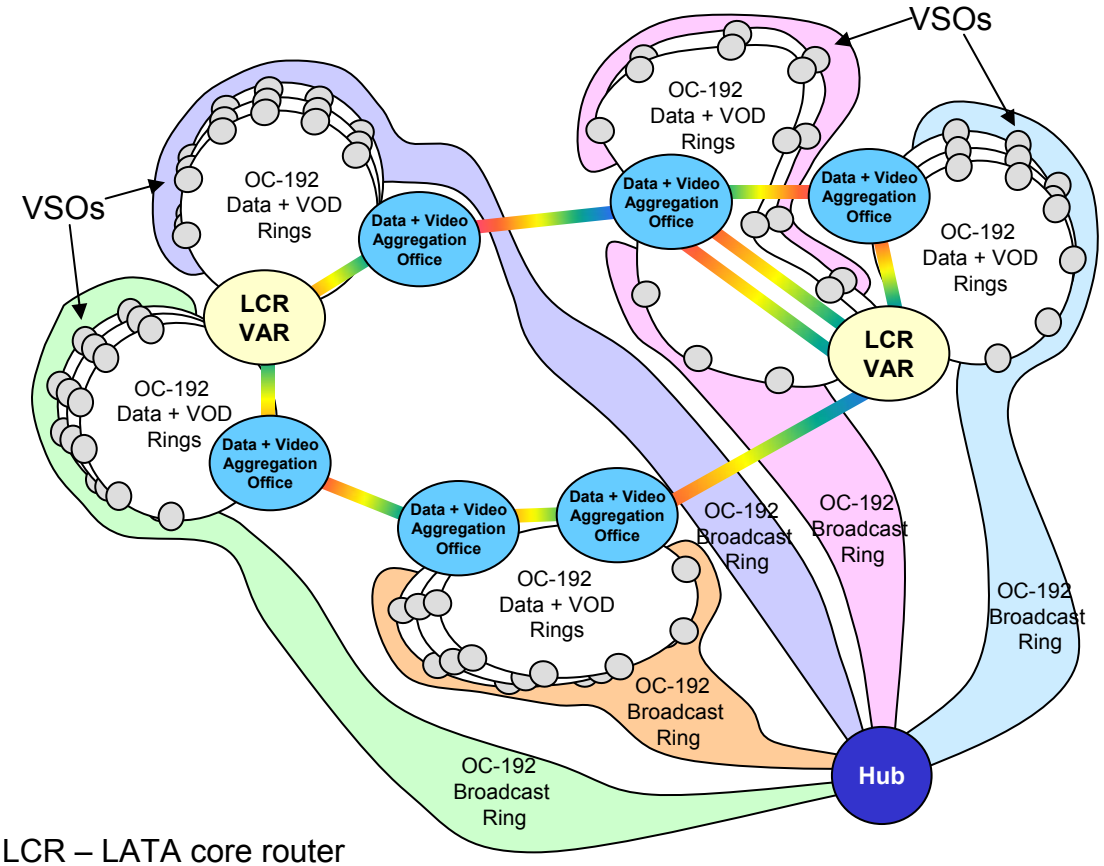
ER4, LCR2, H3

ER5: H4, LCR2

ER6: H5, H6

ER7: H6, LCR1

“Pre-ROADM” Mode of Operation

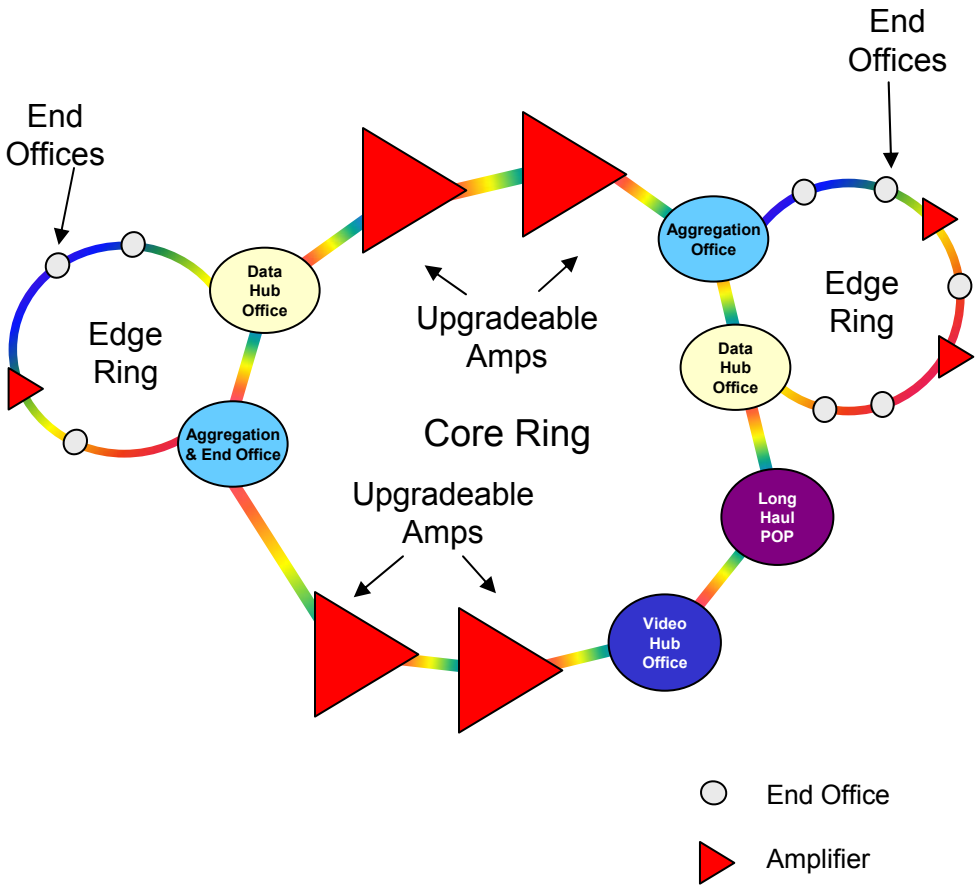


LCR – LATA core router

VAR – Video aggregation router

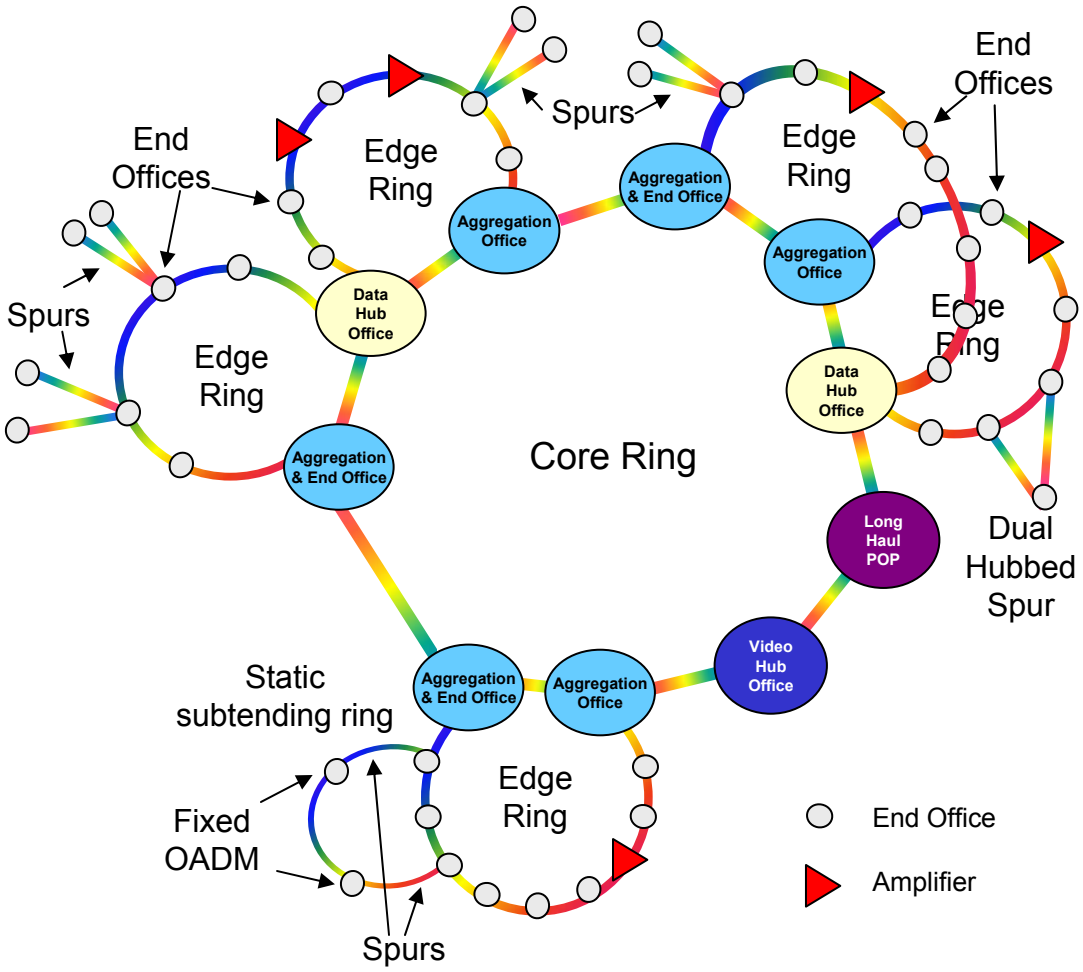
- **Core DWDM ring**
- **Separate networks to transport broadcast video and IP data/video-on-demand**
- **Multiple SONET Rings for VOD and Data to each VSO**
- **Multiple SONET Rings for broadcast video - VHO to VSOs**
- **Large number of network elements including layered SONET Rings**

ROADM Infrastructure (1)



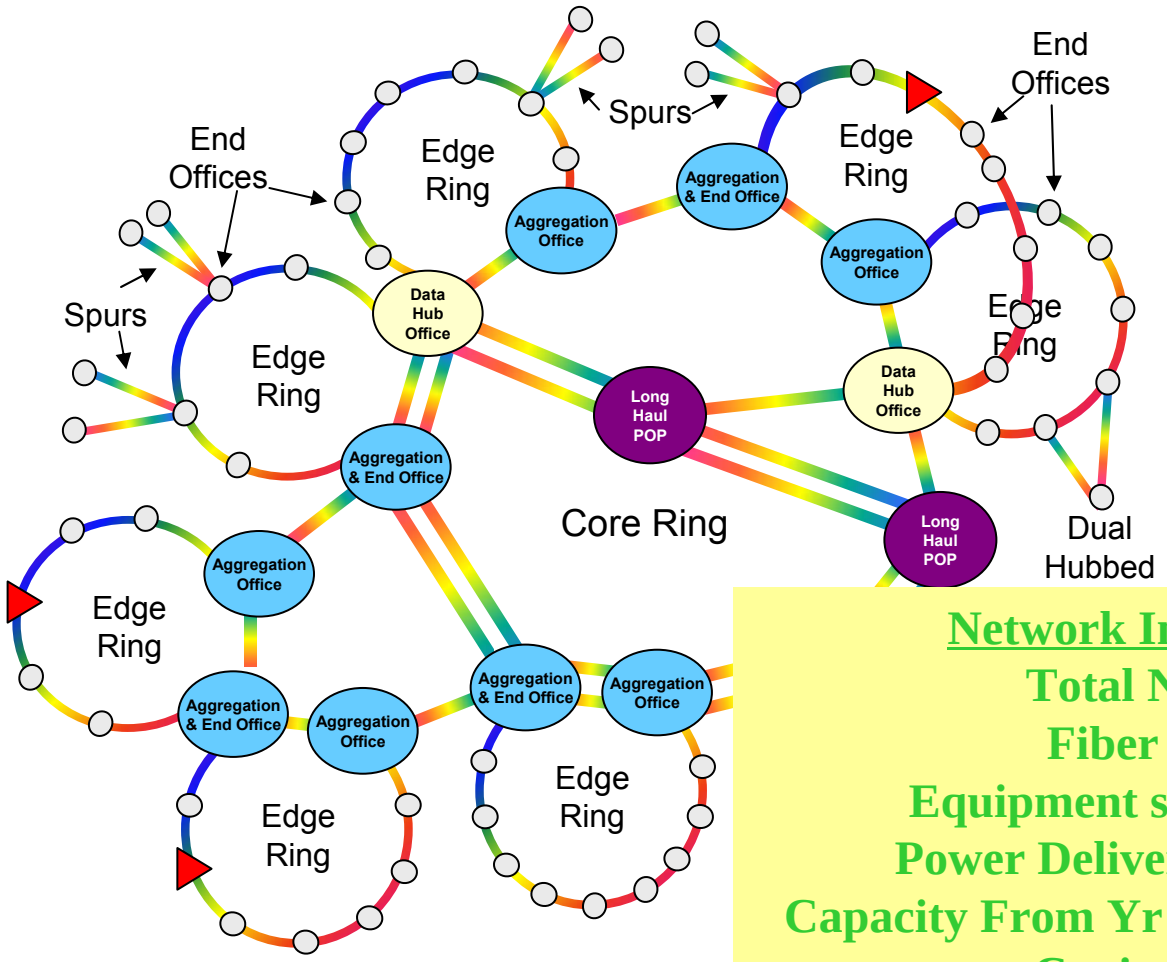
- **Core Ring Connects**
  - Long-Haul POPs
  - VHO
  - LCR
  - Aggregation Offices
- **Edge Rings Serves**
  - VSOs
  - Broadcast Video λ
  - VOD and Data
  - Future VSOs passed w/ upgradeable Amplifiers
- **Creates Wavelength Centric Mesh Network**

ROADM Infrastructure (2)



- **Degrees & Spurs Added**
  - Cost effective
  - No additional switching components
  - Single and Dual hubbed
  - All λs Extended
- **Supports λ Services**

ROADM Infrastructure (3)



- **Sub-Divide the Core**
  - 2nd fiber path added to increase capacity
  - Interconnect of data hubs doubles the capacity between the data hubs and end offices
- **Core Extended with Aggregation Offices**
  - Redundant LH POPs

Network Impact vs. Pre-ROADM

Total NEs from 160+ to 32

Fiber Pairs from 20 to 6

Equipment space from 108 to 32 bays

Power Delivery from 80 KW to 30 KW

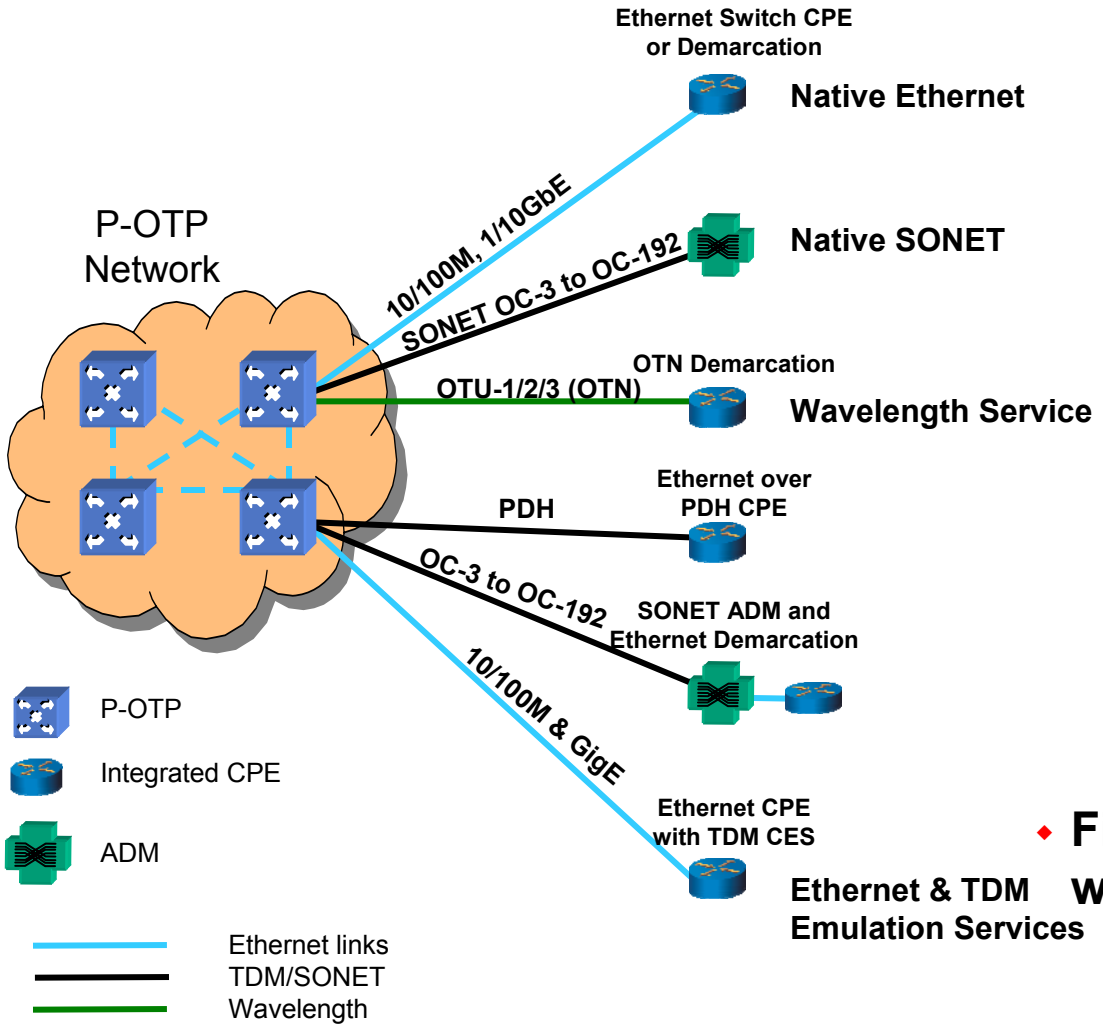
Capacity From Yr 1 Exhaust to Multi-Yr Growth

Capital Savings 50-60+ %

(Common and Incremental)

Access

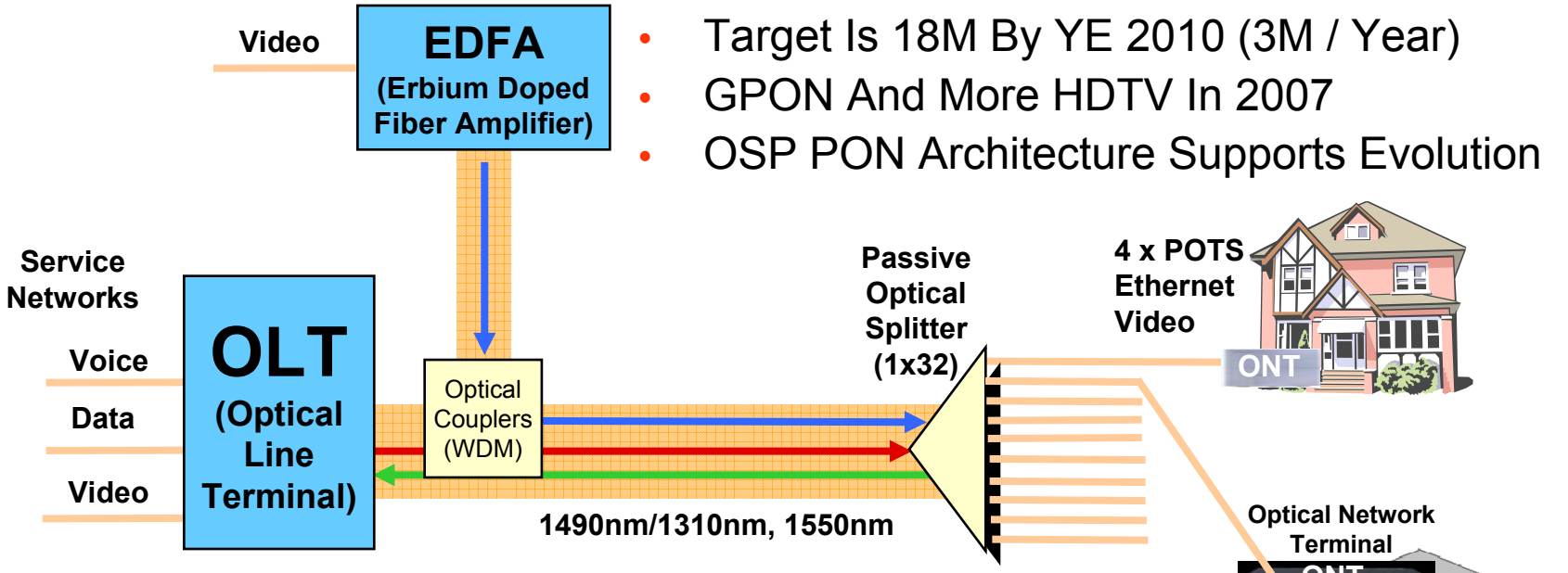
Access "Core Extension"

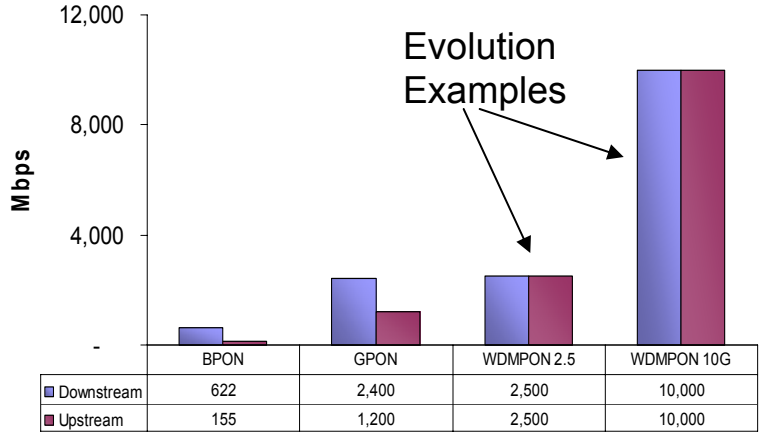


- **Integrated/Optimized CPE**
  - SONET, TDM, OTN
  - GigE Switch with uplinks 10/100Mb & GigE
  - 10GbE Switch with uplinks 10GbE or OTN
  - GigE Switch with Circuit Emulation Service (CES) for DS1 or DS3
  - Ethernet over PDH (nxDS1 or nxDS3)
  - 1GbE/10GbE/10G OTN Demarcation
- **Fiber Penetration Synergies w/FTTP Build**

Access FTTP Architecture

- Over 9M Homes Passed, YE 2007
- Target Is 18M By YE 2010 (3M / Year)
- GPON And More HDTV In 2007
- OSP PON Architecture Supports Evolution





Optical Control Plane

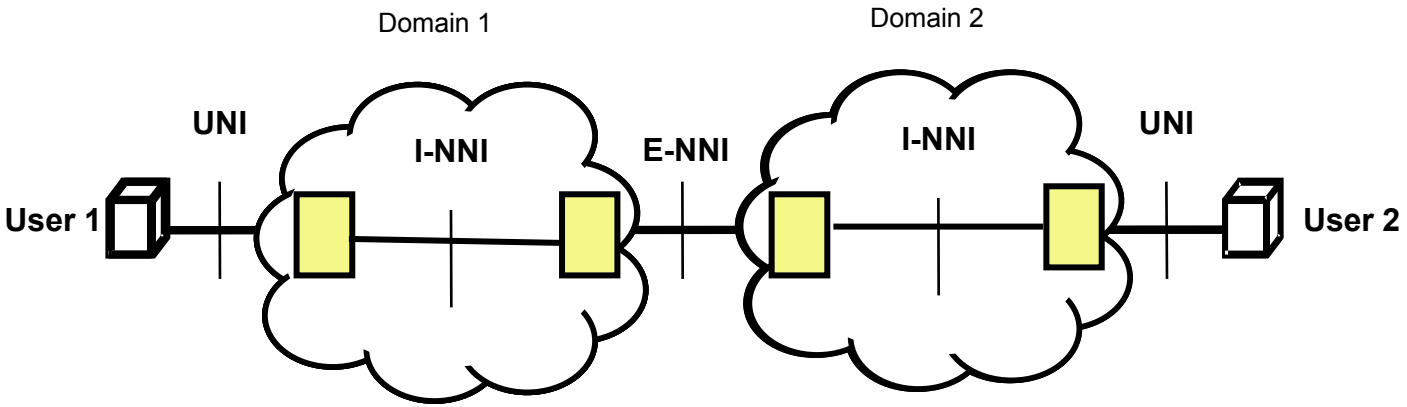
Optical Control Plane

- **Goal: Evolve the static SONET/SDH and DWDM layers, of today, to a dynamic optical transport network**
- **Network "aware" elements**
  - Auto-discovery for inventory
  - Awareness of neighboring NEs, connection type and topology
- **Dynamic provisioning and service activation**
  - Automate the end-to-end circuit routing/provisioning process
- **Create new services and revenue streams**
  - Dynamic Broadband Bandwidth on Demand (BBoD)
  - Optical VPN Capabilities
- **Self-healing**
  - Auto protection and restoration

Examples of Control Plane

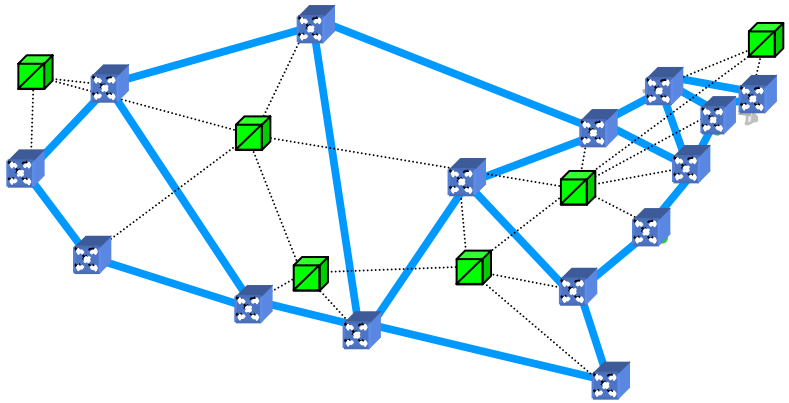
PSTN -- SS7
IP -- Datagram (TCP/IP), MPLS
ATM -- UNI, B-ICI, PNNI

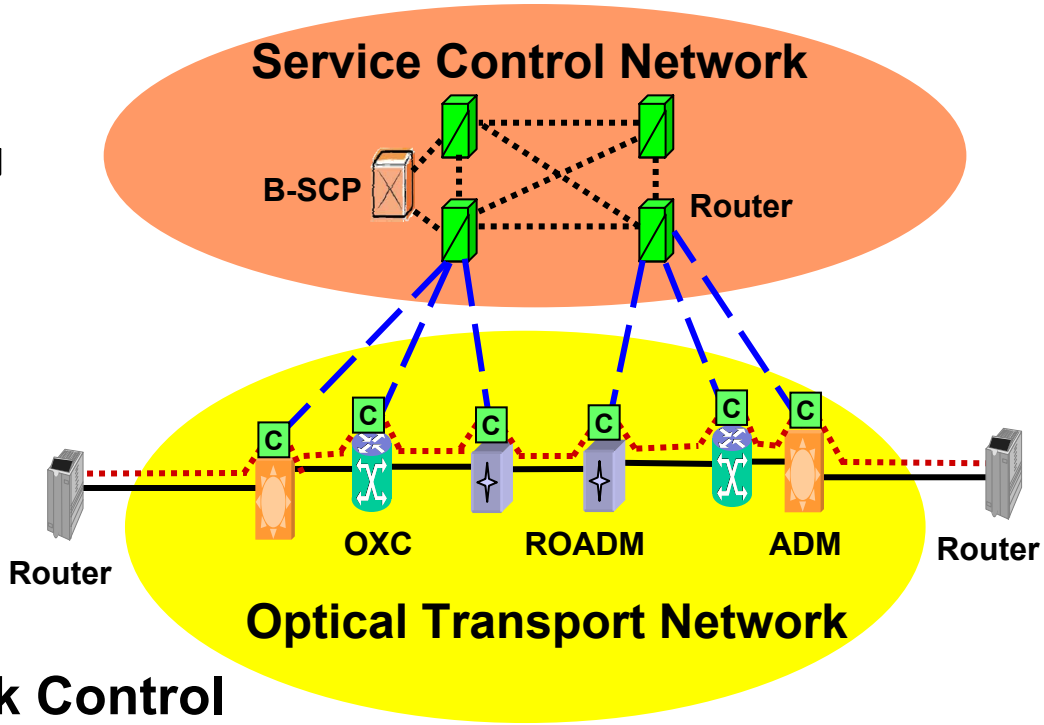
Control Plane Architecture Framework



- **UNI – Demarcation between user and service provider**
  - Un-trusted interface
  - Signaling only
- **E-NNI – Demarcation supporting cross-domain connection**
  - Intra-carrier/Inter-domain (Trusted) or Inter-carrier (Un-trusted)
  - Signaling with limited routing info exchanges
- **I-NNI – Intra-domain node-to-node interface to support control plane functions**
  - Fully trusted
  - Signaling
  - Routing

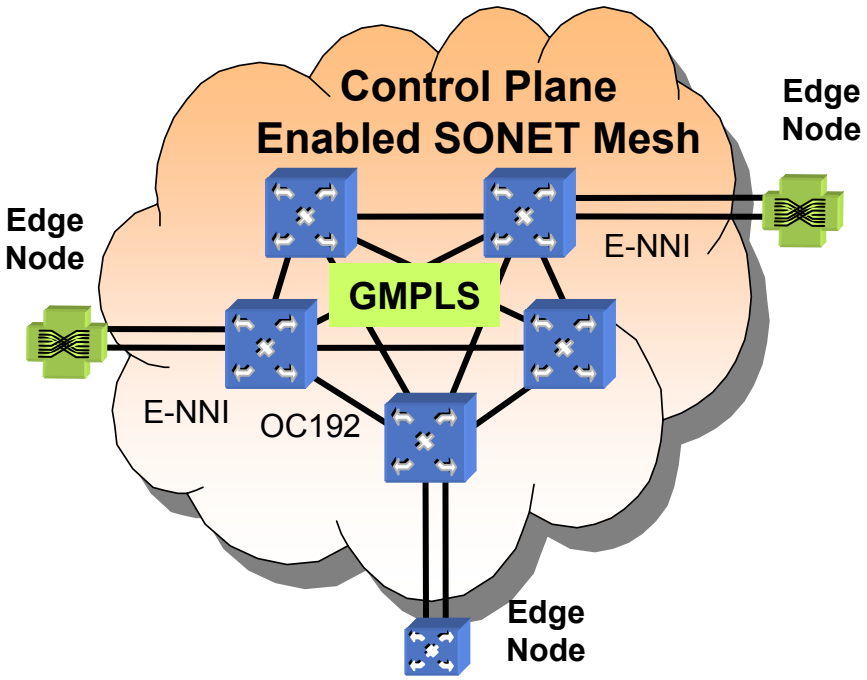
Control Plane Enabled SONET Mesh





- **Real Time Dynamic Network Control**
  - Auto-Discovery & Self-Inventory
  - Dynamic Provisioning & Service Activation
  - Traffic Engineering
  - Protection & Restoration
- **Fully Automated End-To-End Optical Network**

Control Plane Enabled SONET Mesh



- **Lower Cost**
  - Better Utilization with Mesh vs. Rings
  - Improved Survivability & Resiliency
  - Simplified & Rapid Service Activation
- **Network**
  - GFP, VCAT and LCAS
  - Full link diversity with best effort node diversity
  - Access to CP via GigE, OCn, …
- **Enhanced Services**
  - 'Just-in-Time' Service Activation
  - Dedicated Broadband Bandwidth on Demand (BBoD)
  - STS-1 Granularity, BBoD scales from 50Mb/s to 10Gb/s
  - Protection Choices – 1x0 Unprotected, 1+1 Protected, Dynamic Reroute, …
  - Customer Portal for self-service

Control Plane Initiatives

- **Verizon Interoperability Forum (VIF)**
  - E-NNI, I-NNI, UNI Interface Testing
    - Driving Definitions & Implementation
  - OSS Integration
  - Service Formulation
- **VzBusiness Trans-Atlantic Mesh Network**
  - Control plane based protection & restoration capabilities
- **VzTelcom – Wholesale/Verizon Partner Solutions (VPS) Deployment for JiT**
  - Just-In-Time (JiT) provisioning trial in New York City concluded successfully in 2006
  - JiT service rollout in NYC in 2007
  - Implement CP in metro SONET network for JiT

Verizon's End-to-End All Optical Network

- **Embraces Evolution**

  Residential, Enterprise, Government, Wholesale, and Internal needs

  - Verizon Interoperability Forum (VIF) reduces time to market
  - Wavelength Centric Network, WSS/ROADM, P-OTP, …
  - Driving towards 40G applications and 100G introduction
- **Becomes Dynamic**
  - Control Plane Enabled (Topology, Element And Capacity Aware)
  - Routing, Bandwidth Allocation, And Protection/Restoration Functional
- **Remains "X"able**
  - Accessible (Protocol Agnostic, Industry Based Interfaces)
  - Scalable (Nodes, Rates, Ports, Bandwidth, …)
  - Predictable (Throughput, Latency, ...)
  - Reliable/Survivable (Protected: Node, Link, Route, Port, Service, …)

Thank You!

Access – FTTP Architecture