Reinventing the

NETWORK

The only constant is change.

Packet Optical 2.0: Enhancing Video and Gigabit Services

Mano Nachum, Product Line Manager, Packet Optical Solutions

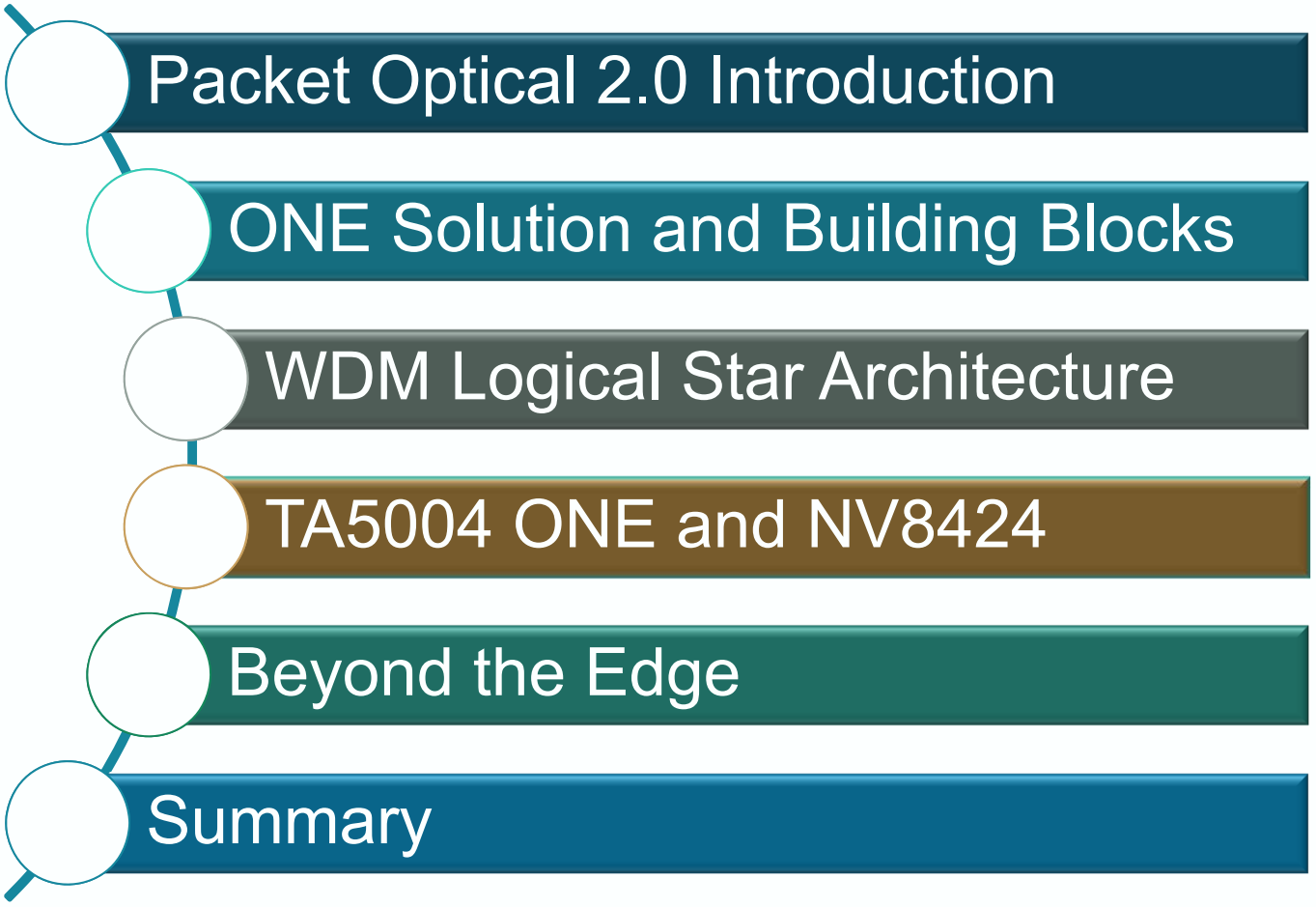
ADTRAN

Access-Edge-Core Perspectives

- What is access speed?
  - 64K?
  - T1?
  - 10M?
  - 1G?
  - 10G?
- 2.5G/10G used to be core technology not long time ago …
  - Now used in access/edge networks
- Transport speeds and BW moving to access/edge quickly

The Key:
Right-Sizing Core Speeds for Access, Aggregation, Tier 2/3 Markets

Outline

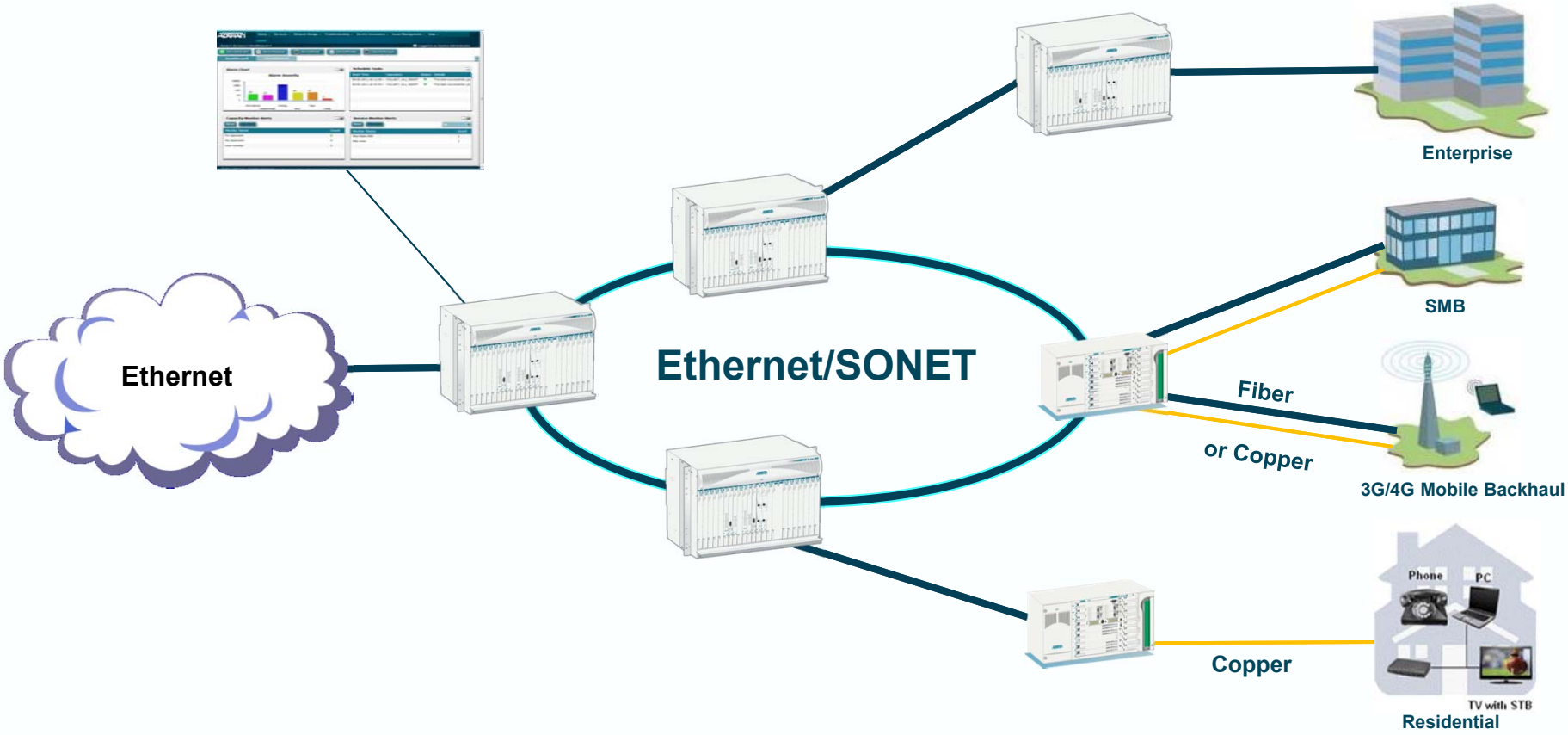


Drivers for Network Transformation
BW at the Edge/Metro

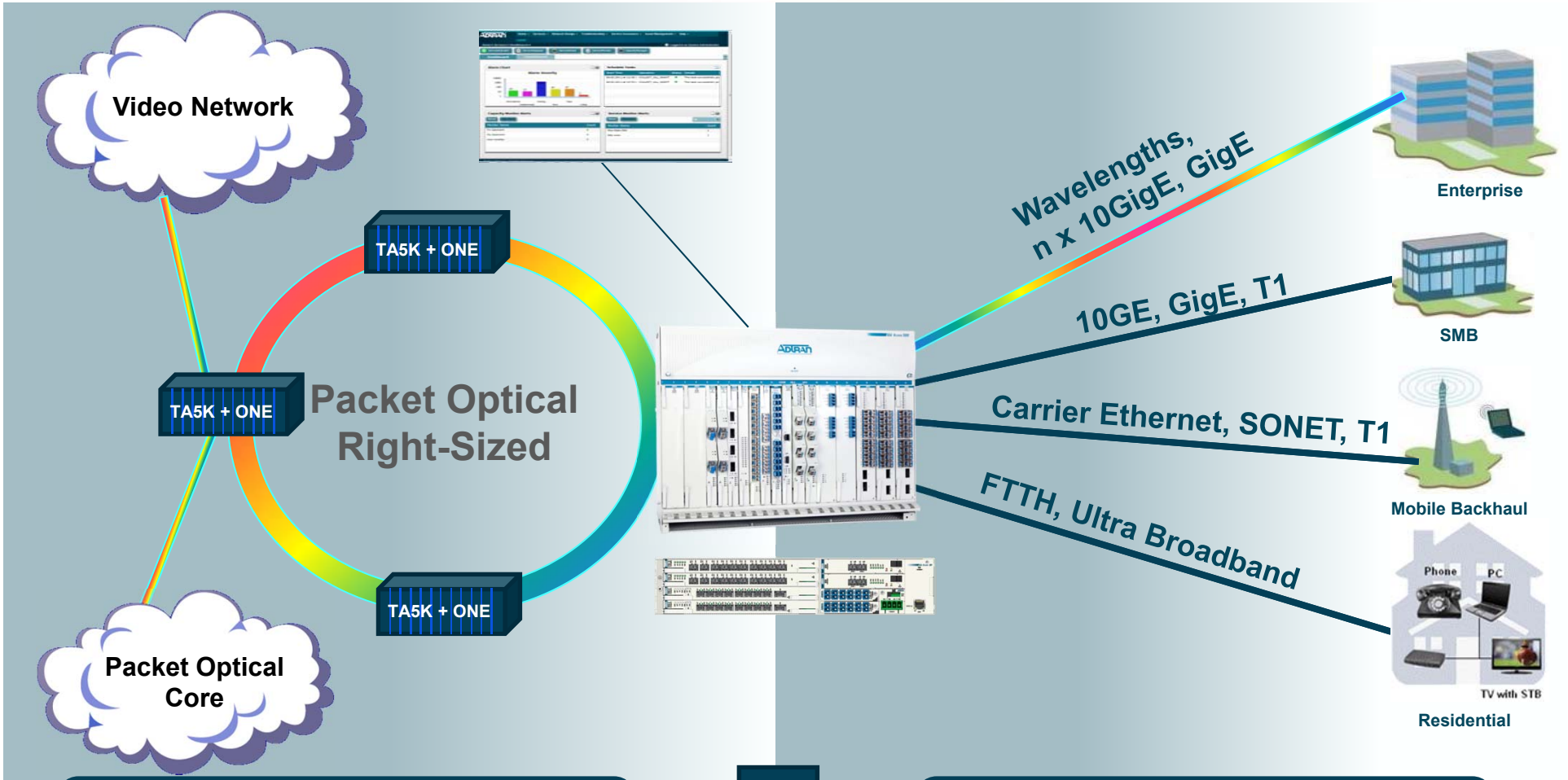
- Residential Broadband
- Mobile Backhaul
- Large Enterprise
- SME/Distributed
- Cloud Architectures
- Data Center/SANs

All Segments Services are Scaling: Demands Packet Optical Edge

Voice/Low Speed Data Networking



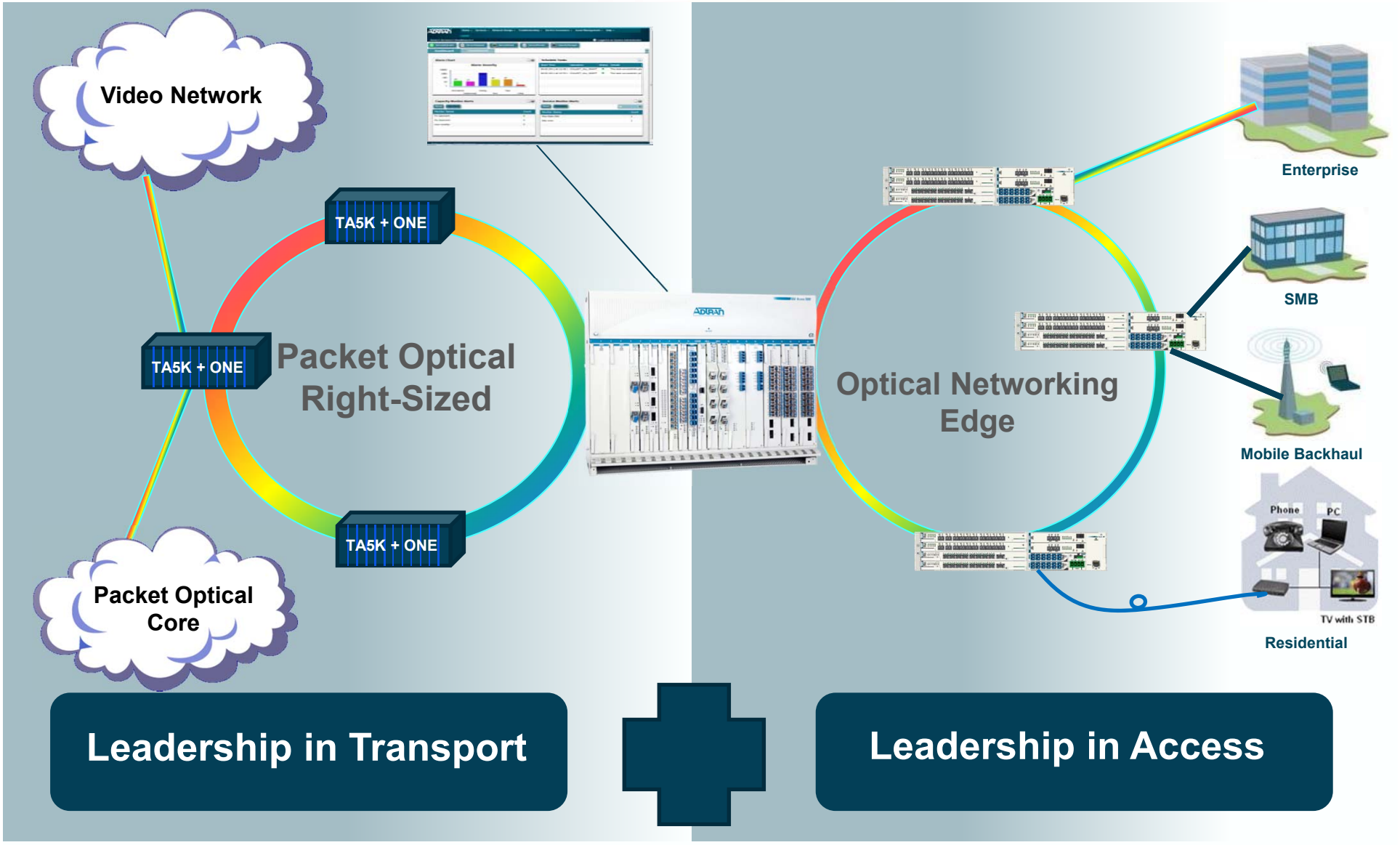
Video / Cloud Centric Networking



Leadership in Transport

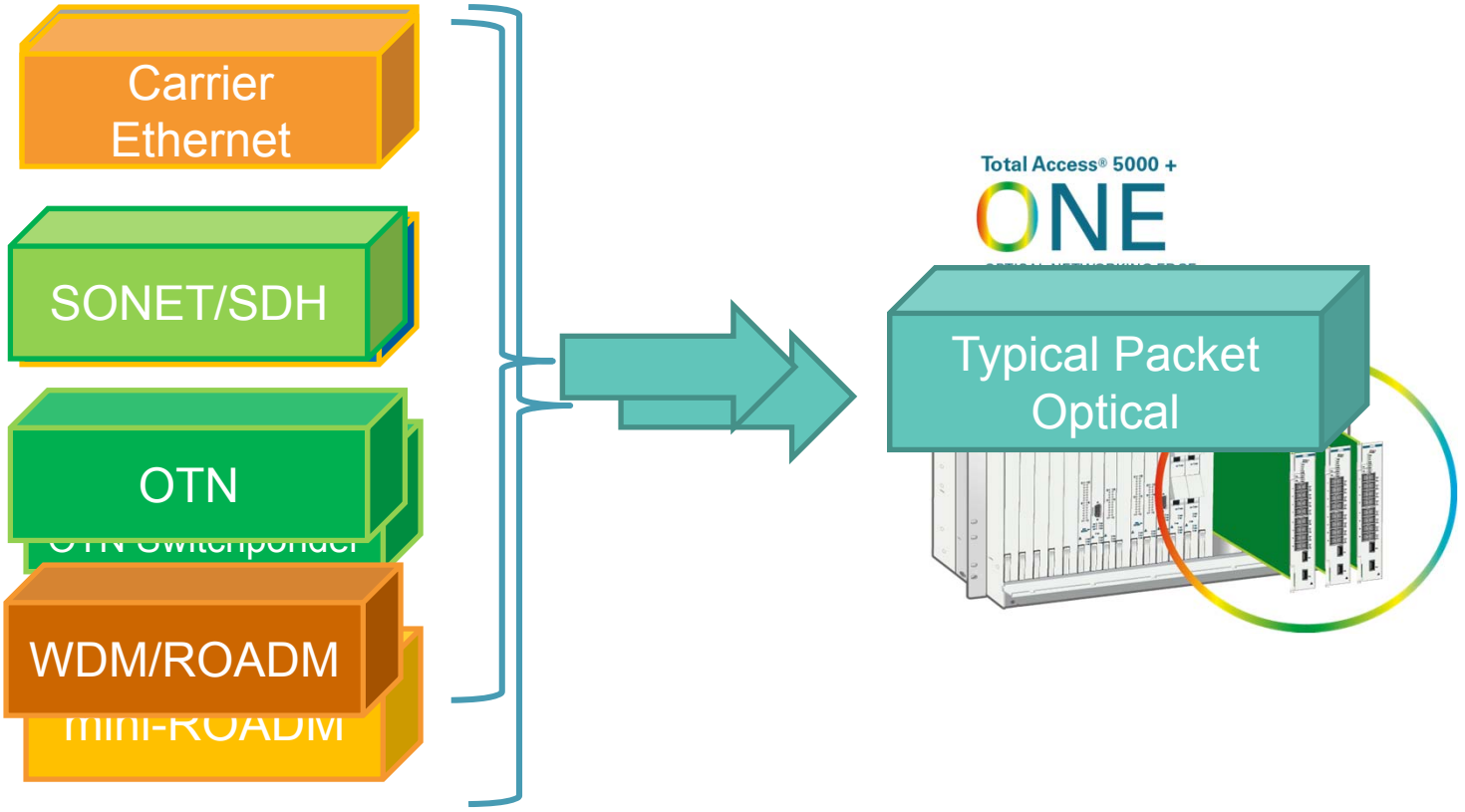
Leadership in Access

ONE 2.0: Enhancing IPTV & Gigabit Services



How Do We Do This?

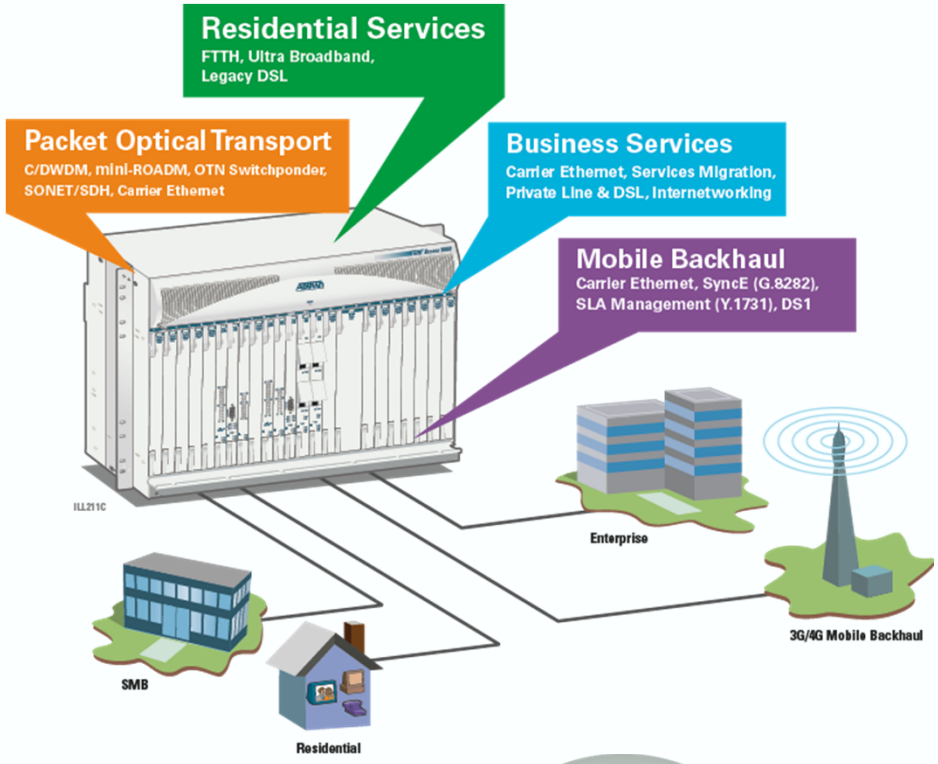
Reinventing Right-Sized Packet Optical

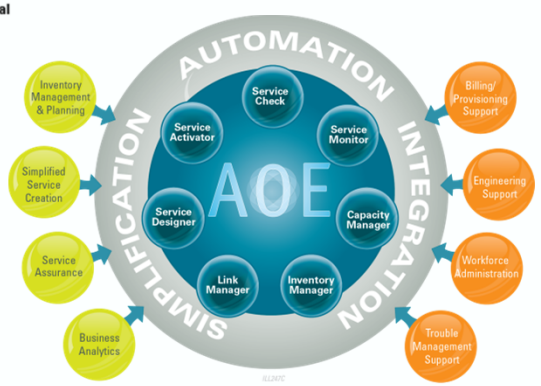


Right-Sized Packet Optical with Integrated Multi-Service Delivery

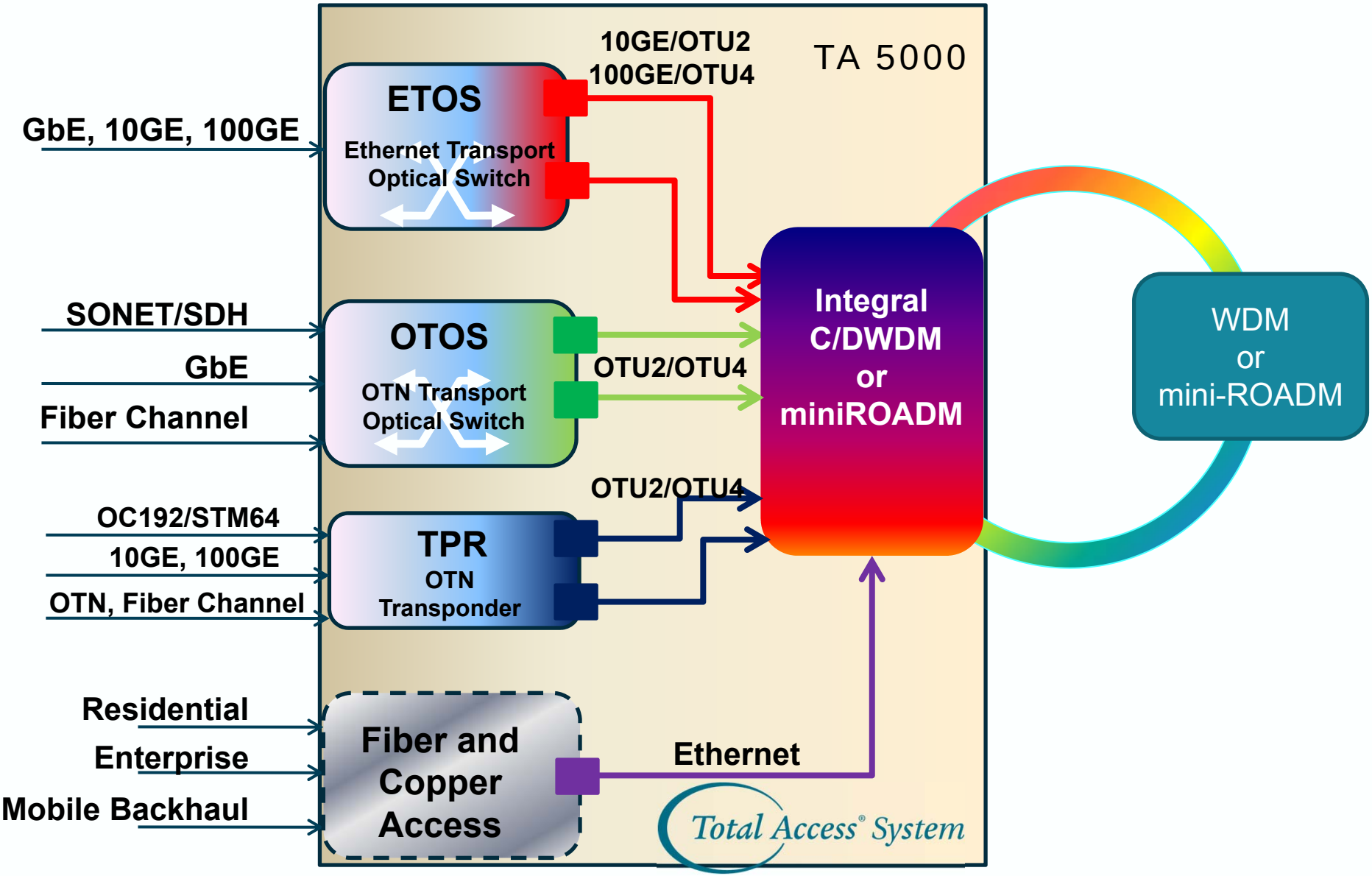
Right-Sized Packet Optical Differentiation

- Edge optimized scalability
  - Tier II/III offices/markets
  - Cell sites/Backhaul
  - Highest 10GE density on the market
  - Optimized, pluggable 100G
- Multi-service aggregation
  - Broadband Access
  - Business Services
  - Mobile Backhaul
- Temperature hardened
  - Transport and service aggregation in outside plant
- Service Velocity
  - Service aware provisioning and management
  - Agile networking



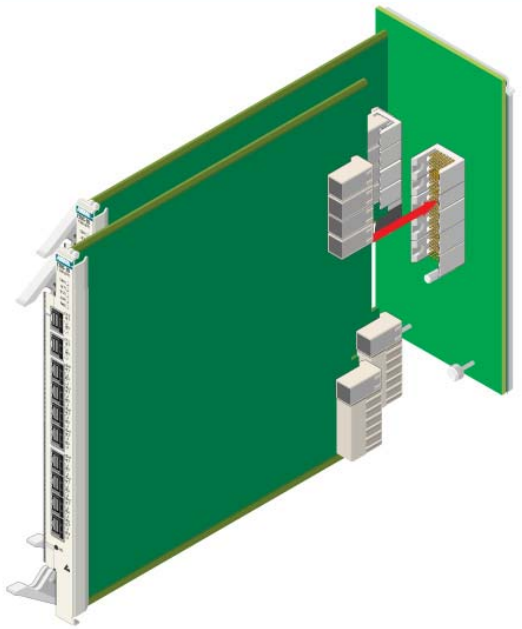


TA5000 ONE:
Integrated Access, Aggregation & Transport



Scalable, Reliable Carrier Ethernet/OTN

- Carrier Class, Non-Blocking Redundancy
  - Backplane Cross Copy BW for all faceplate ports
    - ETOS-1: 48G Backplane Cross Copy
    - ETOS-10: 85G Backplane Cross Copy
    - OTOS-2-16: 40G Backplane Cross Copy
    - OTOS-1-8: 20G Backplane Cross Copy
  - Facility and Equipment Protection
    - Client ports, Line ports, Switch
  - Cross slot ERPS protection
  - Cross Slot LAG
  - All faceplate ports usable for services or network connections



- Highest 10GE density on the market
  - 168 x 10GE in 9RU TA5000 shelf
    - 19 x 10GE in 1 RU equivalent
      - Plus 42 x 1G/2.5G
      - Total 1.8T per shelf – Available Today
  - 36 x 10GE in TA5004 (2RU) + 8 x 1G/2.5G + WDM modules

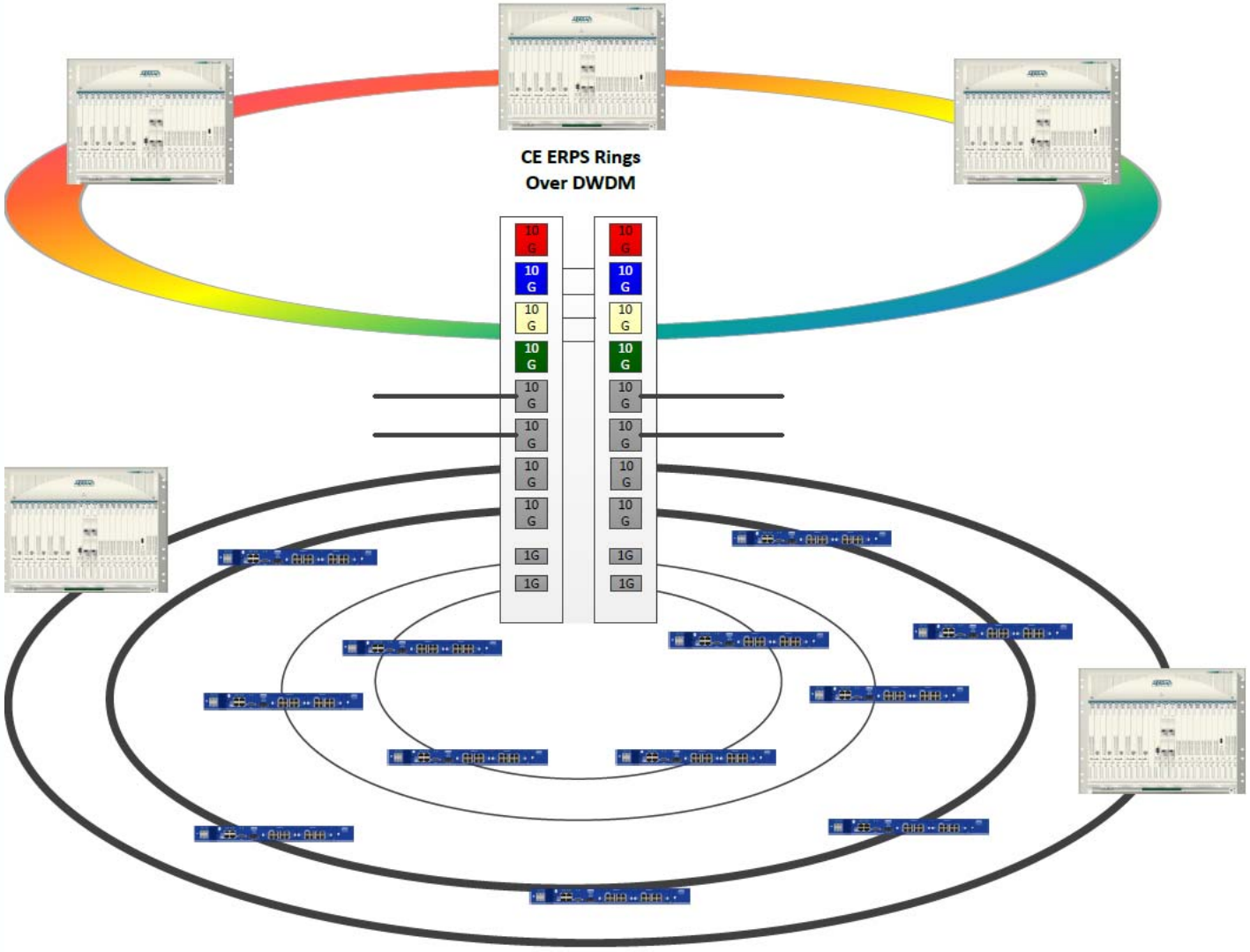
Most Scalable, Most Reliable Carrier Ethernet on the Market

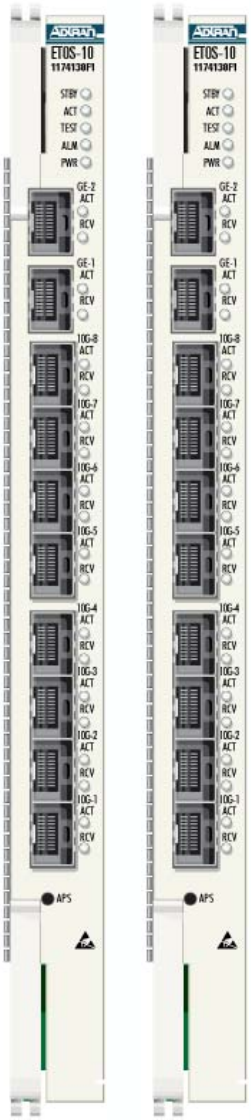
Ethernet Transport Optical Switch (ETOS-10)

- 8x10GE/2.5GE/1GE and 2x1GE/2.5GE in a single slot
  - Up to 168 x 10G in 23” TA5000 shelf
  - Up to144 x 10G in 19” TA5000 shelf
- Non-Blocking Layer 2 Ethernet Switch
- Optimized for 10G aggregation and Nx10G transport solutions
- E-LINE, E-LAN
- IGMP Snooping
- Up to 10 ERPS Rings (8x10G/2.5G/1G, 2x1/2.5G) in redundant mode (2 cards) and 5 ERPS rings with a single module
- Y.1731 support
- Integrated RFC 2544 traffic generator
- More than 200G throughput per slot
  - 80G front access
  - 80G backplane for equipment redundancy
  - 40G backplane connection to shelf switch module (SM) for BB service agg

ETOS-10: Carrier Ethernet 10GE Scalability

200G+ Throughput in a Single Slot

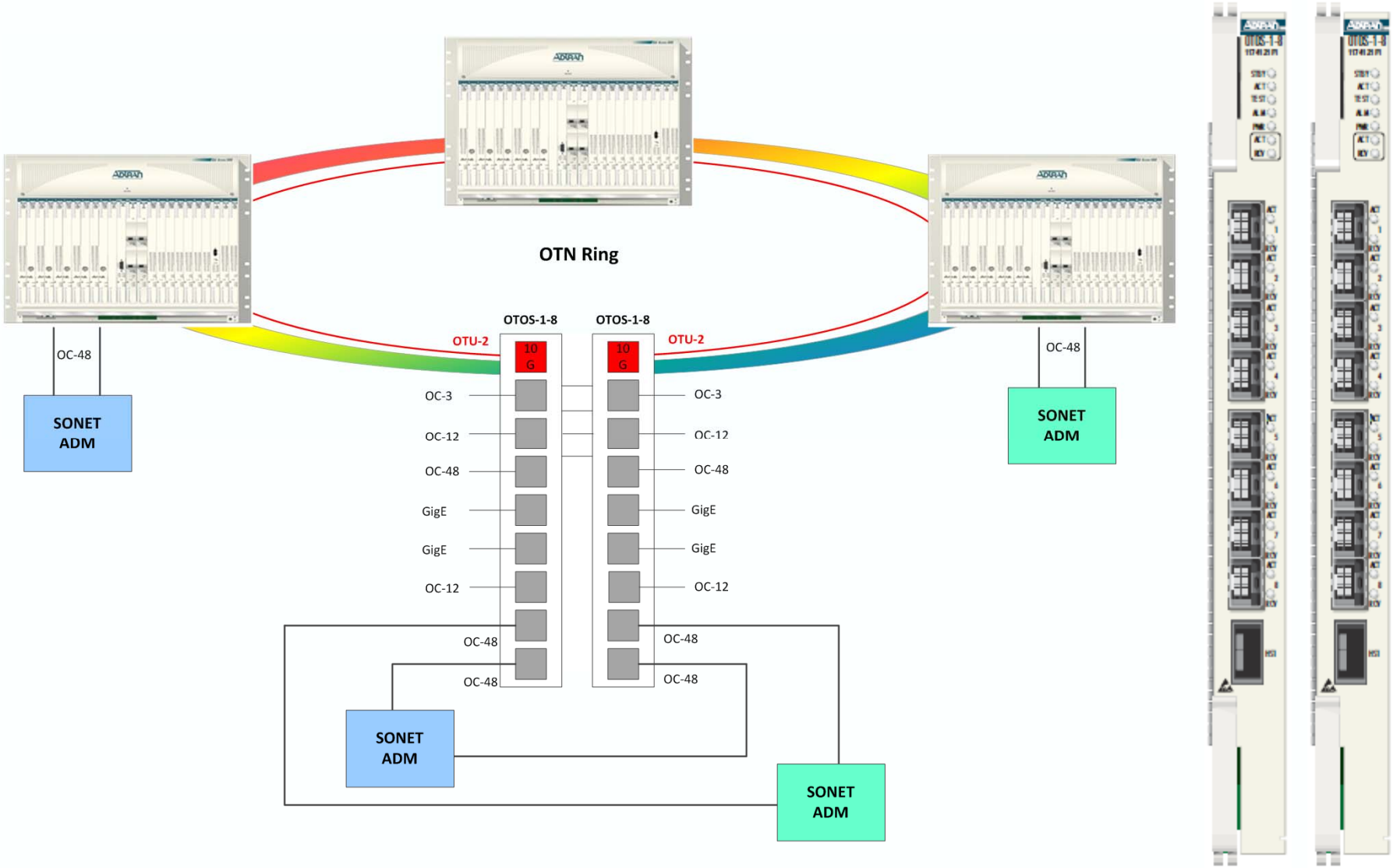




OTOS-1-8: Right-Sized Multi-Service OTN Switching and Transport

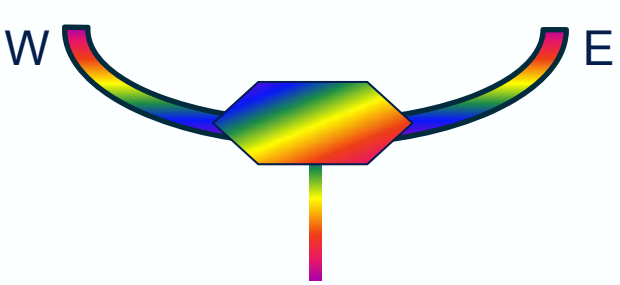
- Single slot card
- 8 provisionable client ports
  - SONET/SDH – OC-3/ 12 / 48, STM-1 / 4 / 16
  - GigE
  - OTN – OTU-n
  - Fibre Channel
- Service mapping onto OTN
- OTN cross connect
  - Add and Drop, grooming capabilities
- Equipment redundancy
- Various network topologies including ring, linear, mesh
  - SNCP protection – UPSR like ring topology and protection

OTOS-1-8: Right-sized OTN with Equipment Redundancy



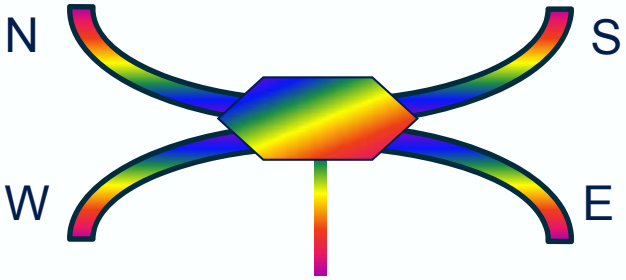
ROADM Degree Attributes

2 Degree (1x2) Ring App



Multi Wavelength Port

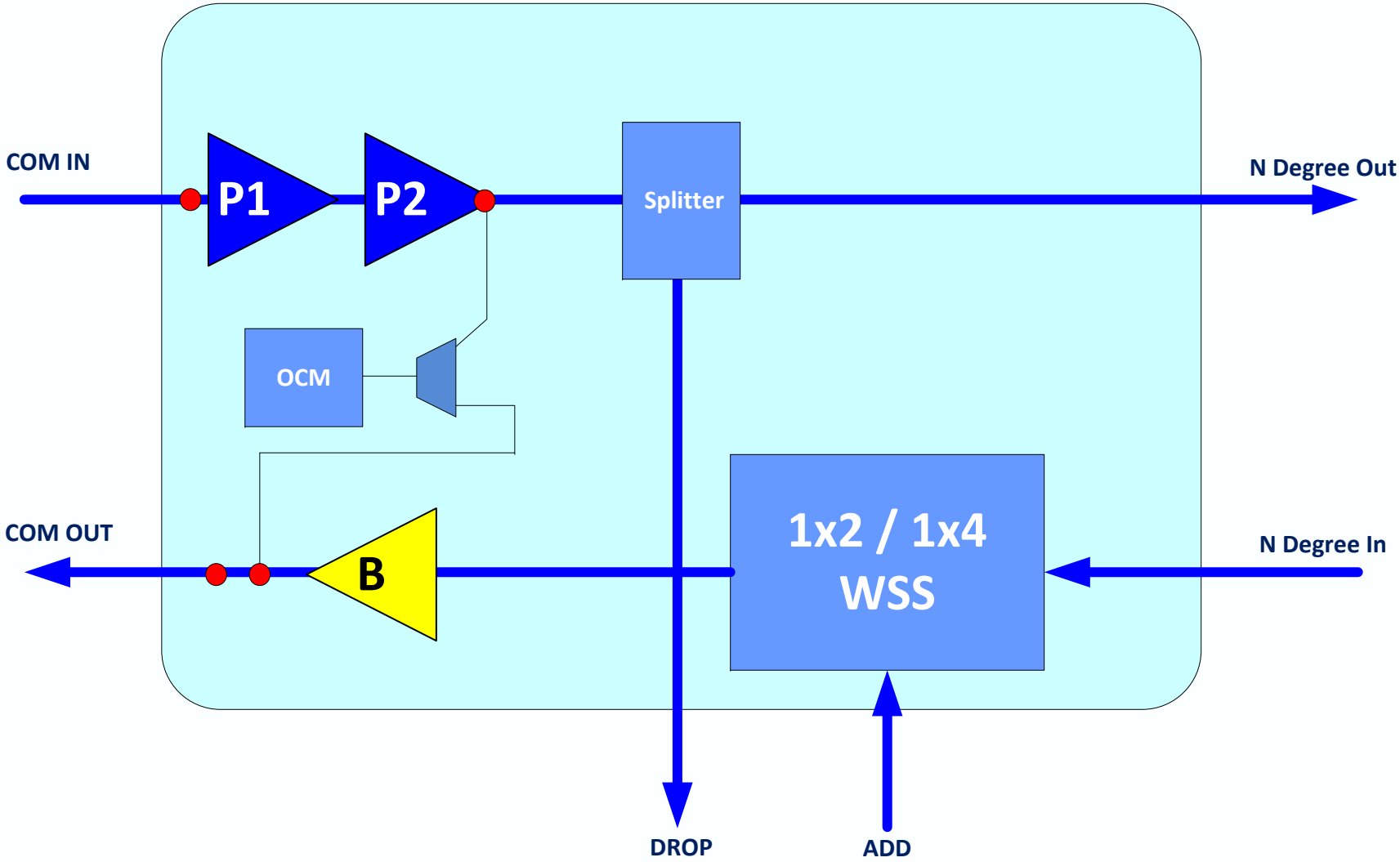
4 Degree (1x4) Dual Ring or Mesh Apps



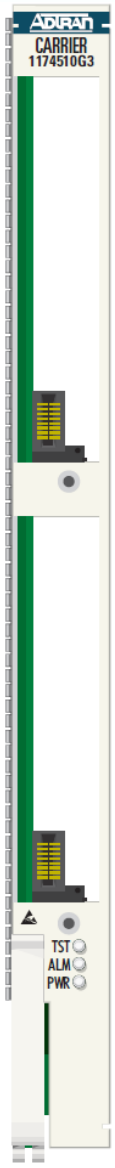
Multi Wavelength Port

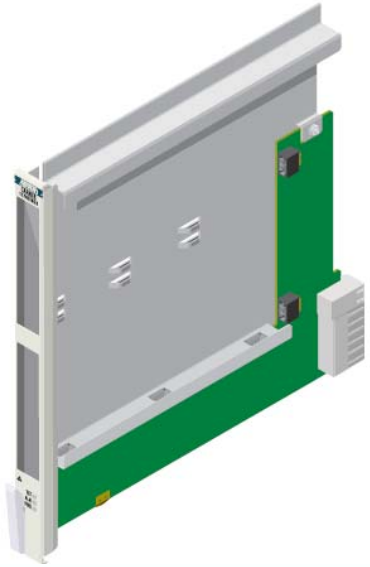
MARS-2/4: mini Amplified ROADM System

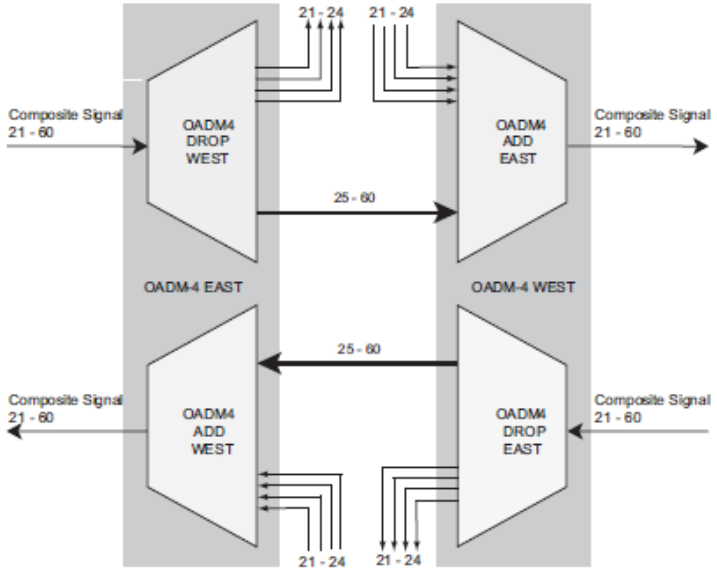
Integrated. Modular. Flexible.
Optimized Cost-Performance for Edge, Metro, Middle Mile Applications



4 (8) ch WDM OADMs







Parameters		Unit	-	Specification
D4A2124 DWDM OADM Ch21 - 24		nm		1560.61, 1559.79, 1558.98, 1558.17
D4A2528 DWDM OADM Ch25 - 28		nm		1557.36, 1556.55, 1555.75, 1554.94
D4A2932 DWDM OADM Ch29 - 32		nm		1554.13, 1553.33, 1552.52, 1551.72
D4A3336 DWDM OADM Ch33 - 36		nm		1550.92, 1550.12, 1549.32, 1548.51
Center Wavelength		nm	-	ITU Grid, C-Band
Channel Spacing		GHz	-	100
Express Wavelength Range		nm	-	1500 ~ 1620
Number of Channels		-	-	4
Number of Ports		-	-	12
Insertion Loss (w/o Connector)	λ_1(Add/Drop)	dB	Max	1.2/1.8
	λ_2 (Add/Drop)	dB	Max	1.4/1.6
	λ_3 (Add/Drop)	dB	Max	1.6/1.4
	λ_4 (Add/Drop)	dB	Max	1.8/1.2
	Expansion (MUX/DMX)	dB	Max	1.0/1.0 (Exp. Optimized)
Insertion Loss (Add +Drop)		dB	Max	3.0
Isolation Loss Thermal Sensitivity		dB/C	Max	0.005
Wavelength Thermal Sensitivity		nm/C	Max	0.002
Channel Alignment @-0.5dB		nm	Min	$\lambda_{ITU}^{\pm 0.11}$
Channel Passband @-0.5dB		nm	Min	0.3
Passband Ripple		dB	Max	0.5
Isolation	Adjacent Ch	dB	Min	30
	Non-Adj Ch	dB	Min	50
	Express Ch	dB	Min	15
PDL		dB	Max	0.2
PMD		ps	Max	0.1
Return Loss		dB	Min	45
Directivity		dB	Min	55

The Packet Optical Networking Portfolio for IPTV and Gig Services

Chassis Systems

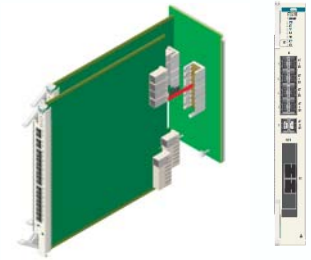
- Total Access 5000: 9RU, 21 access slots
- Total Access 5004: 2RU, 4 access slots
- Any service in any slot: optical transport, broadband access, Carrier Ethernet or service migration

Network Management

- Advanced service activation, monitoring and troubleshooting for access, aggr. and transport
- Web services API for end-to-end service provisioning and monitoring

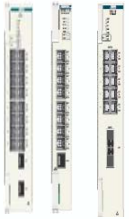
Carrier Ethernet Gateways

- CE 2.0 1G and 10G gateways
- Integrated 1G/10G ERPS rings
- Optional NxDS1/DS3 PWE3
- Integrated Carrier Ethernet router options



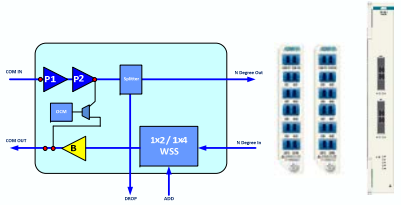
Ethernet Agg. and Transport

- Three module options:
  - 2x10G plus 16x1G
  - 8x10G plus 2x1G
  - Multiple 100GE, 10GE
- Full MEF CE 2.0 E-LINE/E-LAN/ E-Access capabilities
- Optional OTN uplinks
- Full cross-slot redundancy
- 802.1ag and Y.1731 OAM features



OTN Agg. and Transport

- Three module options:
  - 1x10G plus 8x1G
  - 2x10G plus 16x1G
  - Multiple 100G,10G *(future)*
- Transparent grooming of SONET and Ethernet services into higher order OTU-x interfaces
- Integrated OTN cross-connect
- Fully redundant deployment options

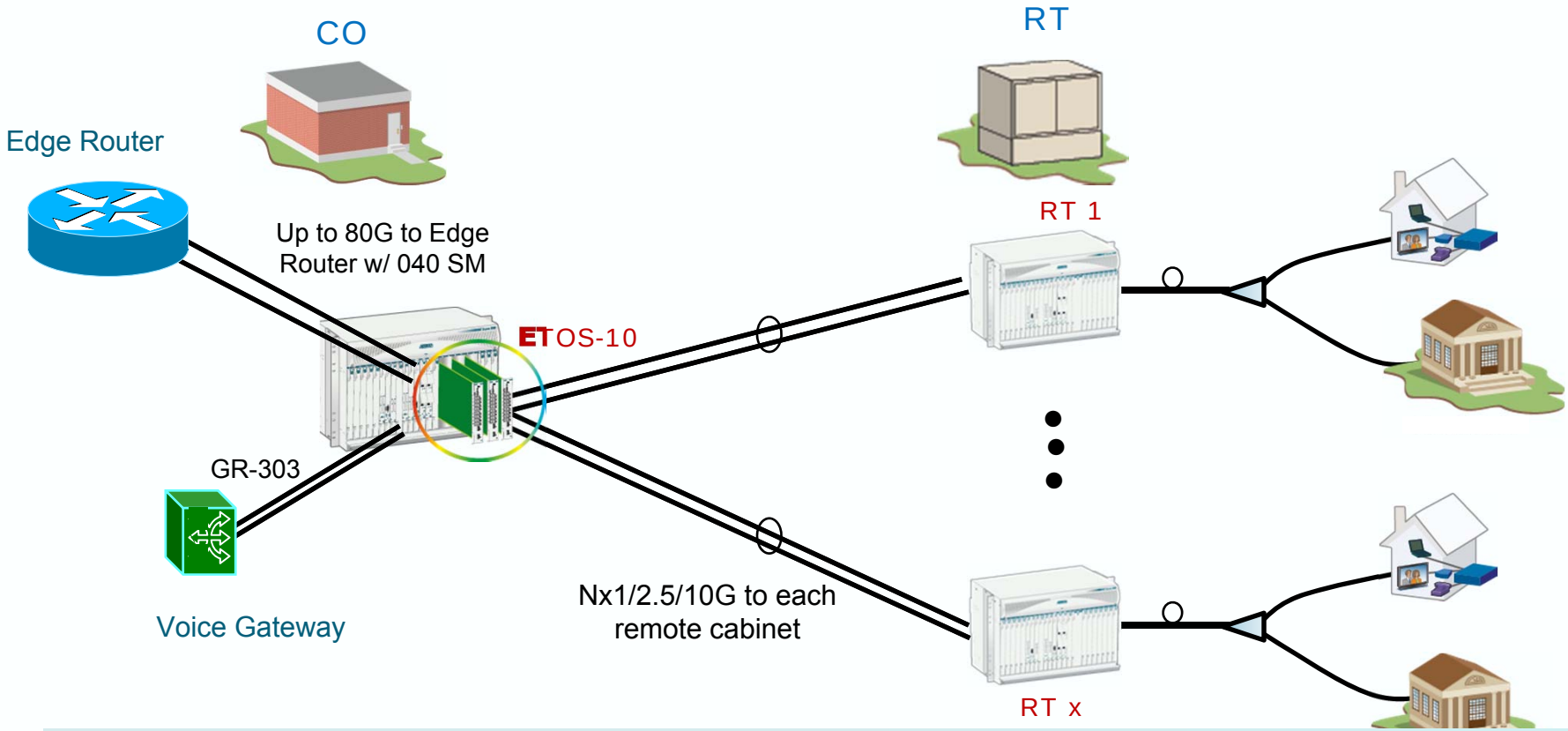


ROADMs/FOADMs/TPDRs

- 100G-ready 2D and 4D ROADMs optimized for metro networks
- Integrated pre-amp and booster circuit options
- Fixed-filter DWDM mux/demux/OADM options
- Nx10G and 100G (future) OTN transponders

Optimized 10G Aggregation of RTs

Enhancing the Video Experience

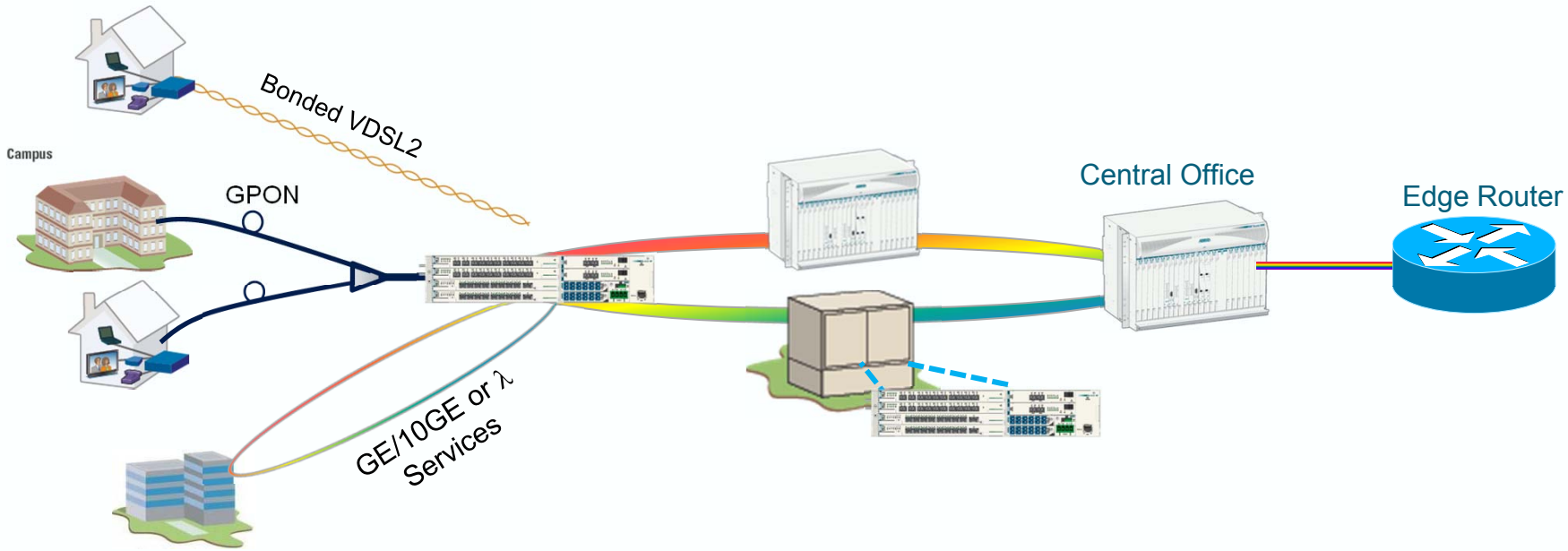


Solution Details:

- Redundant 10G connectivity to each RT, including cross-slot LAG = Total 20G
- Up to 80G uplink to edge router in COT
- Co-deploy with VG and other broadband services out of a common shelf

Increase Bandwidth to Remote Cabinets

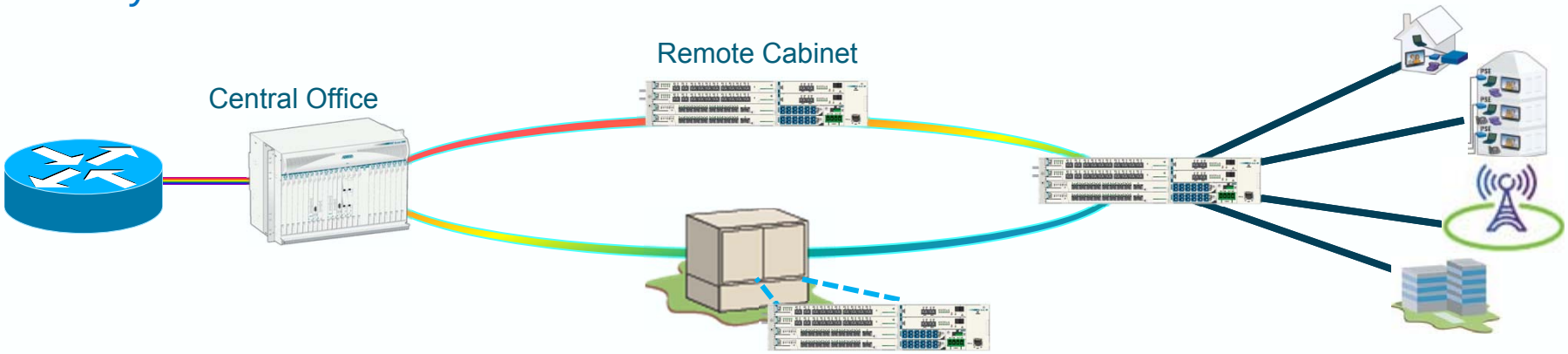
- Temperature-hardened WDM for remote cabinet deployments
- Physical ring topology, but each node connected as star topology with diverse routes by assigning a wavelength per node
- Multi-wavelengths per node to support a mix of residential, business, and mobility services out of fiber-constrained remote cabinet sites



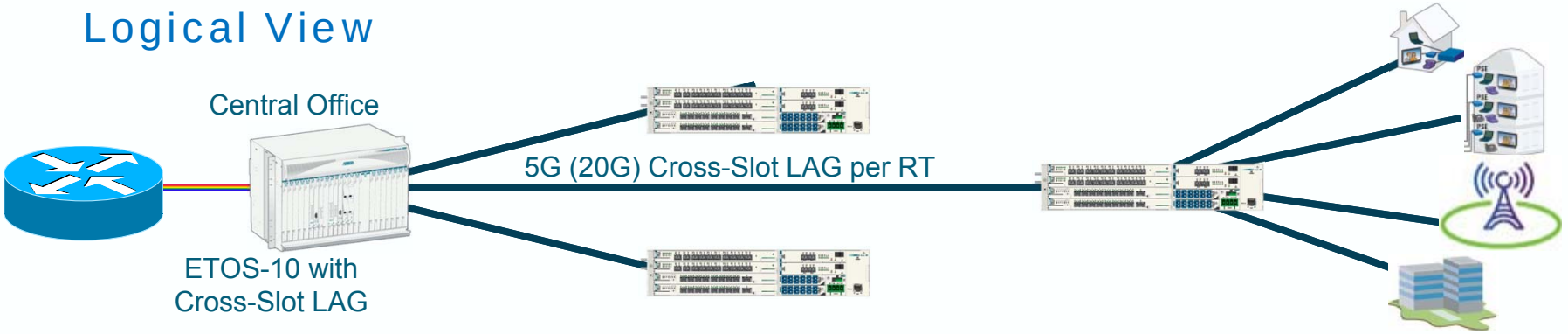
Only Integrated BB + P-OTS on the Market

ADTRAN Low-Latency, High-Bandwidth Aggregation Architecture

Physical View

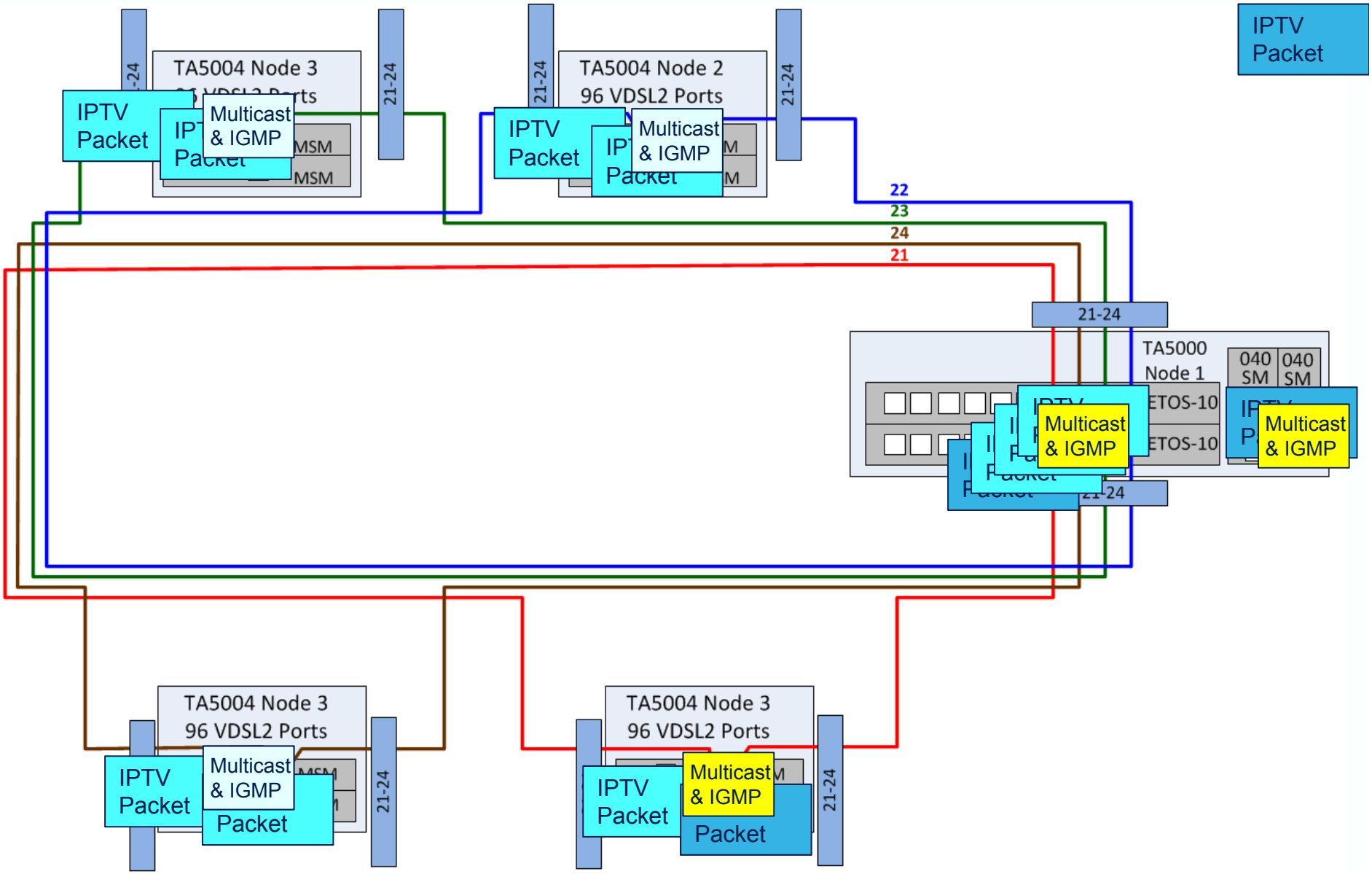


Logical View



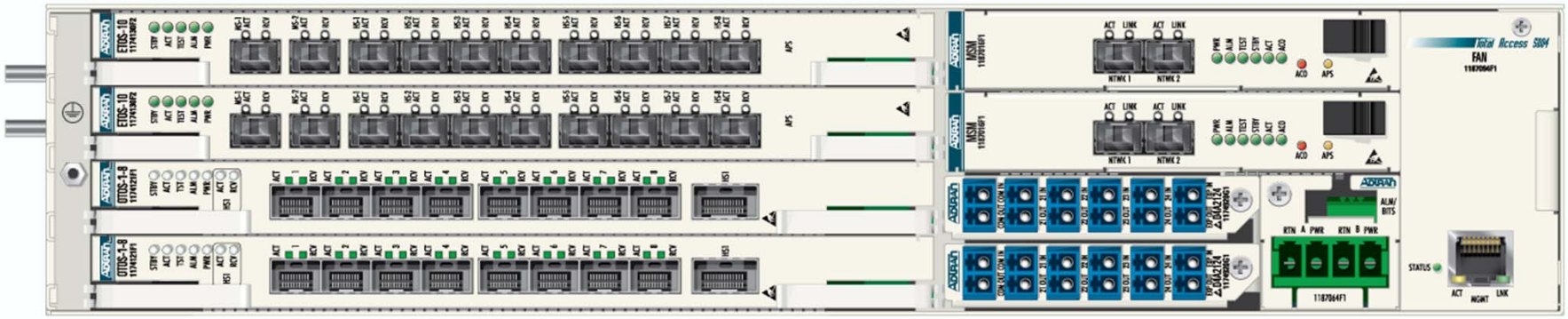
ADTRAN Aggregation Architecture: *Transition ERPS rings to logical star architectures with Cross-Slot LAG to ETOS-10 running at Nx1/2.5G/10G rates. Reduces latency and improves bandwidth per RT for fiber services.*

DWDM Ring with Star Architecture IPTV Traffic

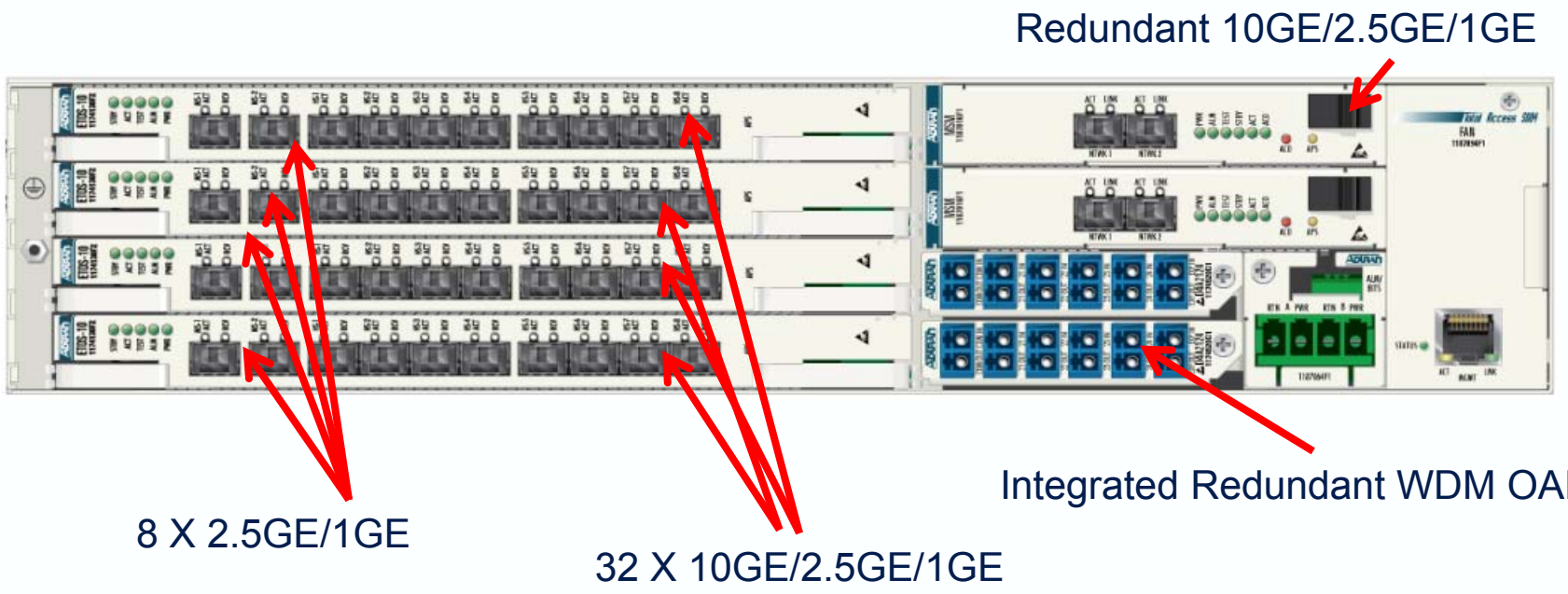


TA5004 ONE – Highest Density Packet Optical Networking Edge Solution

- 2RU, 19” rackmount solution
- 4 standard access slots for ONE modules
- 2 half-height passive module slots
- MSM management module (optionally redundant)
- Support all ONE modules: ETOS/OTOS and xWDM/ROADM modules
  - 36x10GE + 4 channel DWDM OADM
  - Or combination of CE + OTN + DWDM
- Ideally suited for migration from SONET/SDH based transport applications to Packet Optical Networking



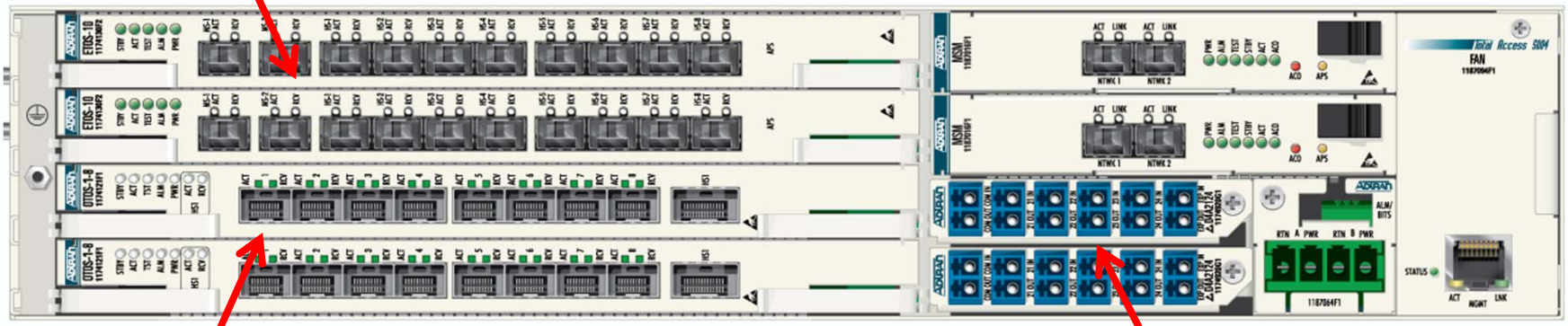
Compact Redundant High Density CE + WDM



- Unmatched flexibility – modular, scalable, redundant
- Ideal for multi 10GE CE applications

Compact Multi-Service OTN +CE Solution

Redundant Multi 10GE CE (16x10GE, 4x1GE)
Or Additional OTN blades



Redundant Multi-Service
OTN Switchponder

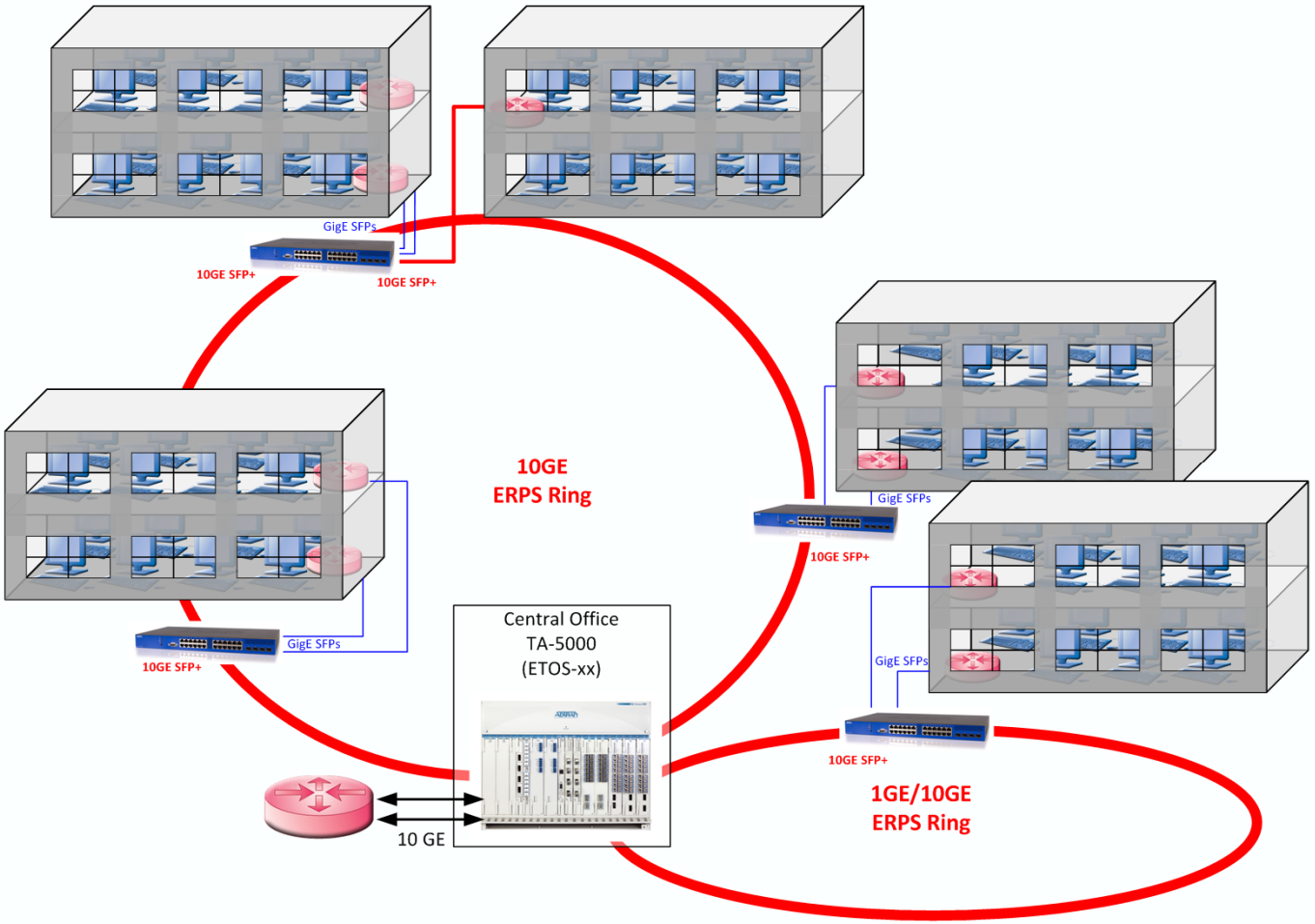
Integrated Redundant WDM OADM

- Unmatched flexibility – modular, scalable, redundant
  - 16 multi-service interfaces
  - 2 OTU-2
  - 16x10GE/2.5GE/1GE (8 support OTN)
  - 4x2.5GE/1GE
- Ideal for SONET replacement with OTN and CE

Nx10GE Multi-service Edge Switch (NV8424)

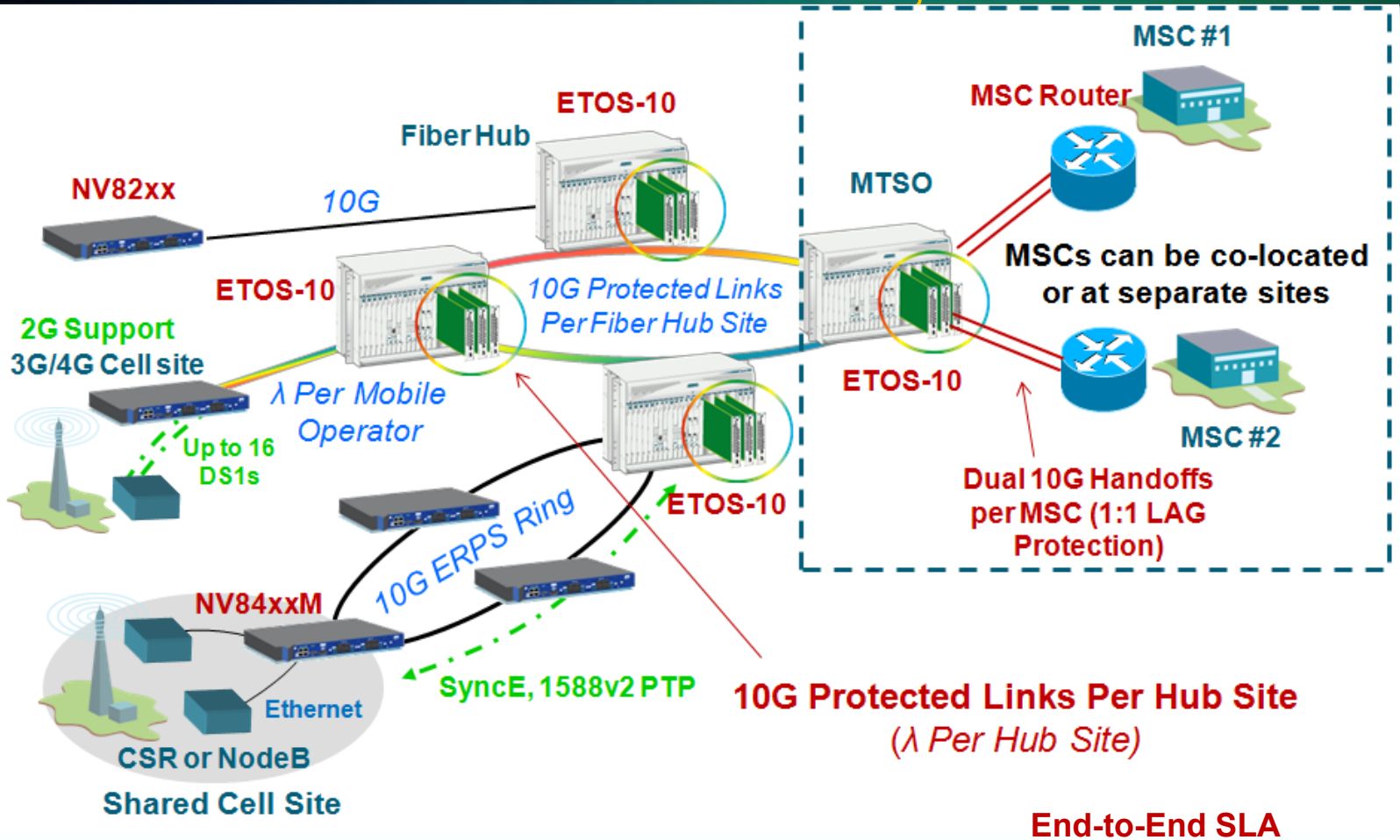
- **MDU Switch:**
  - 4x10G SFP+, 24x1G RJ45 Gigabit switch ideally suited for delivering gigabit services in MDUs
  - Residential IPTV features
  - 1RU, 19” rack mount or wall mount solution (temperature hardened)
- **Business and MBH Services:**
  - 4x10G SFP+, 24x1G SFP version w/ redundant DC PS
  - CE2.0
  - RJ45, DC PS option
  - NV8212 version with lower number of ports

NV8424 CE2.0 Business Services

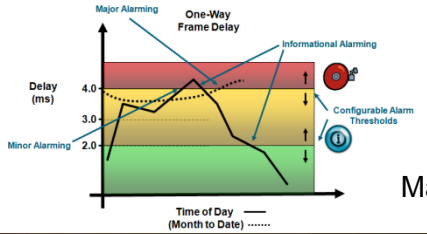


Beyond The Edge

Increased Scalability for Mobile Backhaul
ETOS-10, NV8424



End-to-End SLA Monitoring & Reporting



Service/Network Management System

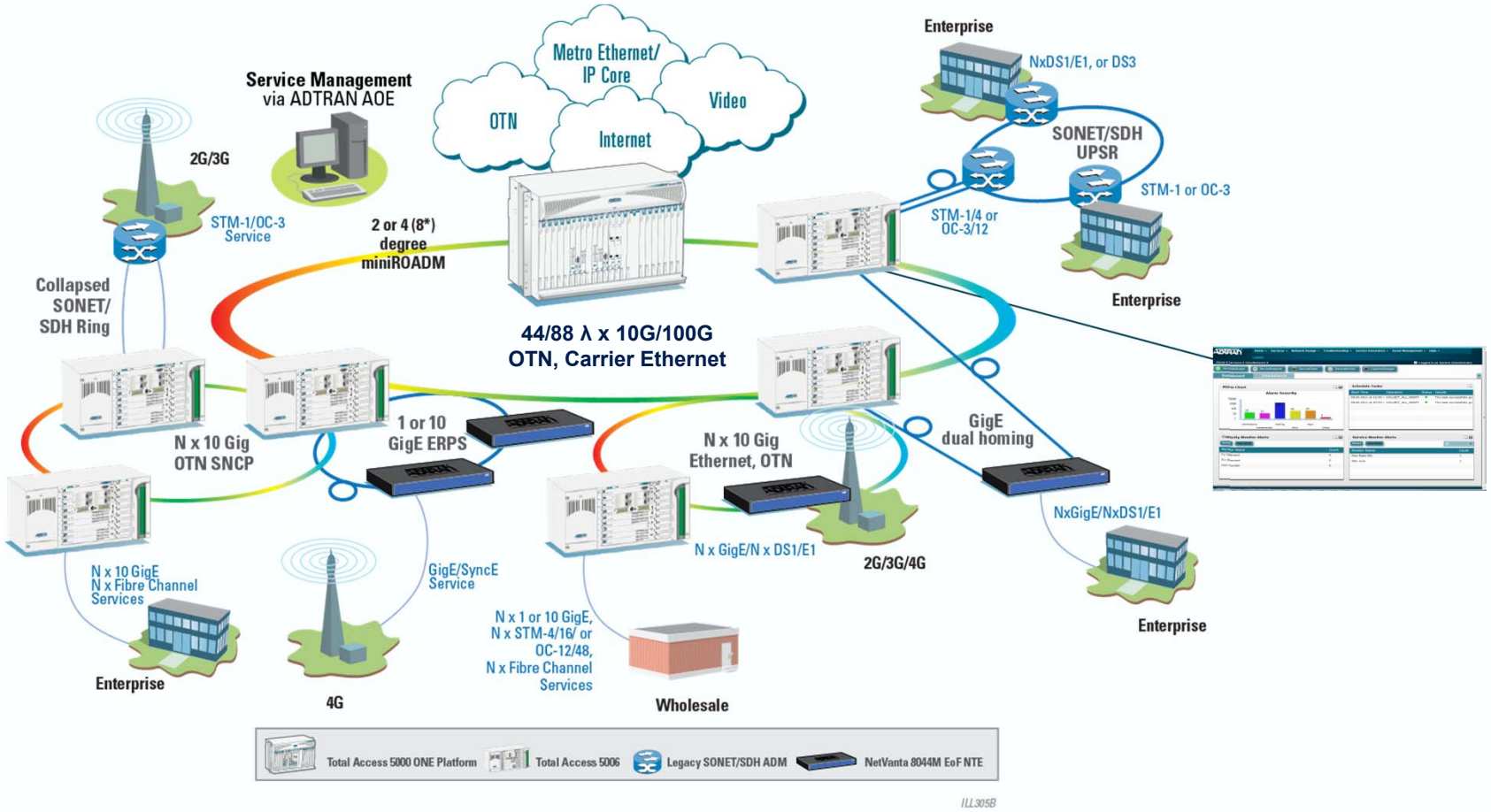
Mobile Operator Requirements:

- ✓ Timing synchronization
- ✓ Granular SLA monitoring & reporting
- ✓ Network resiliency

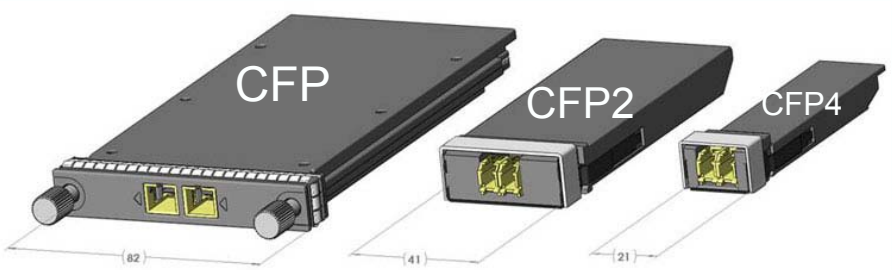
Packet Optical Scalability –
Right-sized Service Delivery, Aggregation, Transport

Scalable Access, Edge, Metro Networking

- Ethernet, OTN, ROADM Networking
- Simplified operations
- End to end service delivery & mgmt
- Accelerate time to revenue



100G Market Trends



5”x7” 100G Coherent LH Module

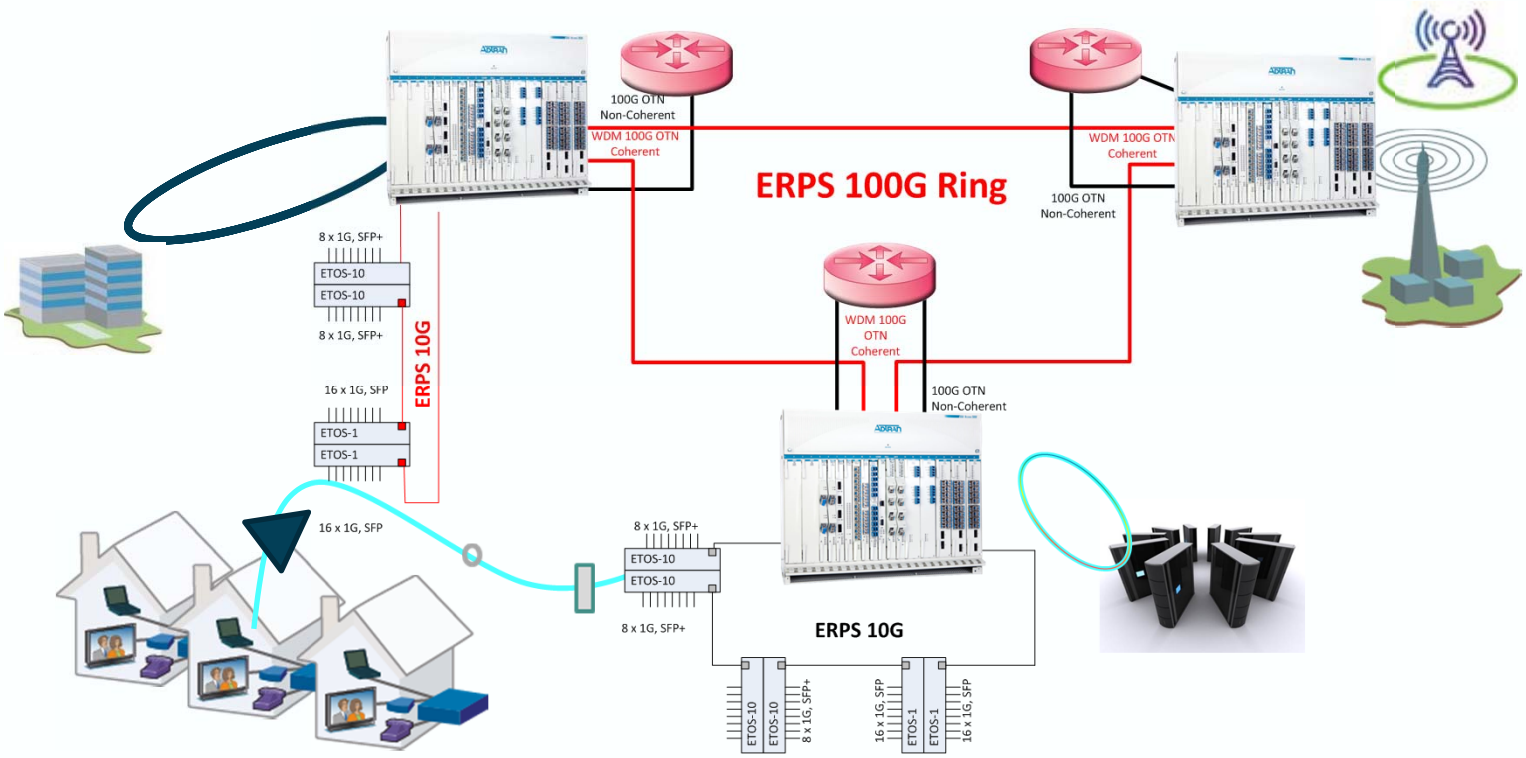
- 2” high (w/o heatsink)
- 100W power dissipation
- 3000KM reach
- >30-15x10G module
- Currently available

Pluggable 100Gbps Optics

- 30W (CFP) and 15W (CFP2)
- Optimized for metro distances (800KM).
- Roadmap to <7x10G price
- Available by the end of 2014

Right-Sized 100G+ Optical Networking

- Modular solution based on latest pluggable optics and Ethernet or OTN switching
- Optimized for edge, metro and regional networks (Coherent Solution)
- Comprehensive Packet Optical Networking solution with ONE (ETOS/OTOS, ROADM), NV8424 10G CE Switch, and other ADTRAN products



Summary: Reinventing Packet Optical

- ONE 2.0 Delivers Access/Edge scalability for enhanced IPTV and Gigabit Services
  - Cost effective extension of Packet Optical Networking
- Right-sized Packet Optical Networking:
  - Scalable, Reliable Carrier Ethernet
  - Multi-service OTN
  - mini-ROADM on a Blade
- Scalable metro and middle mile
- Unmatched multi-service scalability
- Pay-as-you-grow modularity

ONE: Packet Optical Right-Sized


Reinventing the
NETWORK
ADTRAN solutions enable
service providers and
businesses around the world
to evolve, change and grow.
ADTRAN®