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
• 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
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
Video / Cloud Centric Networking

Packet Optical Right-Sized

Leadership in Transport

Leadership in Access

Video Network

Packet Optical Core

Wavelengths, n x 10GigE, GigE

10GE, GigE, T1

Carrier Ethernet, SONET, T1

FTTH, Ultra Broadband

Enterprise

SMB

Mobile Backhaul

Residential
ONE 2.0: Enhancing IPTV & Gigabit Services

Leadership in Transport

Packet Optical Right-Sized

Leadership in Access

Packet Optical Core

Video Network

TA5K + ONE

Optical Networking Edge
How Do We Do This?

ONE 2.0
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

- **ETOS**: Ethernet Transport Optical Switch
- **OTOS**: OTN Transport Optical Switch
- **TPR**: OTN Transponder
- **Integral C/DWDM or miniROADM**

**Ports and Formats**:
- **GbE, 10GE, 100GE**
- **SONET/SDH**
- **GbE**
- **Fiber Channel**
- **OC192/STM64**
- **10GE, 100GE**
- **OTN, Fiber Channel**
- **Residential**
- **Enterprise**
- **Mobile Backhaul**

**Networks**:
- **WDM or mini-ROADM**
- **Ethernet**
- **Fiber and Copper Access**
- **Total Access System**
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 to 144 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
• Single slot card
• 8 provisionable client ports
  – 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

- **P1**
- **P2**
- **OCM**
- **Splitter**
- **1x2 / 1x4 WSS**
- **COM IN**
- **COM OUT**
- **N Degree Out**
- **N Degree In**
- **DROP**
- **ADD**
## 4 (8) ch WDM OADMs

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4A2124 DWDM OADM</td>
<td>Ch21 - 24</td>
<td>1560.61, 1559.79, 1558.98, 1558.17</td>
</tr>
<tr>
<td>D4A2328 DWDM OADM</td>
<td>Ch23 - 28</td>
<td>1537.36, 1536.55, 1535.75, 1534.94</td>
</tr>
<tr>
<td>D4A2A924 DWDM OADM</td>
<td>Ch29 - 32</td>
<td>1554.13, 1553.33, 1552.52, 1551.72</td>
</tr>
<tr>
<td>D4A3386 DWDM OADM</td>
<td>Ch33 - 36</td>
<td>1530.92, 1530.12, 1529.32, 1518.51</td>
</tr>
<tr>
<td>Center Wavelength</td>
<td>GHz</td>
<td>ITU Grid, C-Band</td>
</tr>
<tr>
<td>Channel Spacing</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Express Wavelength Range</td>
<td>mm</td>
<td>-</td>
</tr>
<tr>
<td>Number of Channels</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Number of Ports</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Insertion Loss (w/o Connector)</td>
<td>dB</td>
<td>Min: 1.2/1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max: 1.4/1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min: 1.6/1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max: 1.8/1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min: 1.0/1.0 (Optimized)</td>
</tr>
<tr>
<td>Insertion Loss (Add/Drop)</td>
<td>dB</td>
<td>Min: 3.0</td>
</tr>
<tr>
<td>Isolation Thermal Sensitivity</td>
<td>dB/C</td>
<td>Min: 0.005</td>
</tr>
<tr>
<td>Wavelength Thermal Sensitivity</td>
<td>dB/C</td>
<td>Min: 0.002</td>
</tr>
<tr>
<td>Channel Alignment @ 0.5dB</td>
<td>mm</td>
<td>Min: 0.333</td>
</tr>
<tr>
<td>Channel Passband @ 0.5dB</td>
<td>mm</td>
<td>Min: 0.3</td>
</tr>
<tr>
<td>Passband Ripple</td>
<td>dB</td>
<td>Min: 0.5</td>
</tr>
<tr>
<td>Isolation Adjacent Ch</td>
<td>dB</td>
<td>Min: 30</td>
</tr>
<tr>
<td>Isolation Non-Adj Ch</td>
<td>dB</td>
<td>Min: 30</td>
</tr>
<tr>
<td>Isolation Express Ch</td>
<td>dB</td>
<td>Min: 15</td>
</tr>
<tr>
<td>PMD</td>
<td>ps</td>
<td>Min: 0.1</td>
</tr>
<tr>
<td>Return Loss</td>
<td>dB</td>
<td>Min: 45</td>
</tr>
<tr>
<td>Directivity</td>
<td>dB</td>
<td>Min: 55</td>
</tr>
</tbody>
</table>
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

**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

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

**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 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

- 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
**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

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

![Diagram of Scalable Access, Edge, Metro Networking](image)
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.