Cisco Pluggable Transceiver Modules

Leading the Industry to Enable Next Generation Networking

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TMGBU
Cisco Systems
Agenda

- Market Drivers
- Traffic Growth
- Moore’s Law Enabling the Growth in Traffic
- A Brief History Lesson
- CMOS Photonics
- CPAK
- 40G BiDi
The Internet of Everything
Exponential Growth

**Video, Mobile & Cloud** is Driving Traffic Growth

Content & traffic patterns are becoming more dynamic and distributed

The **Internet of Things** will accelerate traffic beyond recognition:
- Radically increase volume
- Dramatically change traffic patterns
- Challenge traffic engineering and management
- Demand new service definitions (SLAs)

To keep pace, **Service Providers** need **agile solutions** that reduce complexity and TCO
Changing Business Environment

Network Transformation levels the playing field – Emergence of SP Network+Cloud

IP Traffic
Global IP traffic will grow 3X to 1.4 zettabytes annually by 2017

Cloud
Global cloud traffic will grow 6X by 2016

Video
By 2017, the world will reach 3 trillion Internet video minutes per month

4G Mobile Adoption
4G will account for 45% of global mobile data traffic

M2M
Trillions of new “connected events” will occur over IP networks throughout the next decade
Cisco Open Network Environment (ONE)
Examples of Products and Solutions by Layer

- **Applications**
  - End User and Service Provider

- **Evolved Services Platform**
  - Policy and Automation

- **Evolved Programmable Network**
  - Virtualized Infrastructure
    - Programming and Managing Virtual Network Functions

- **Physical Infrastructure**
  - Programming and Managing of Physical Resources

**Cisco’s Open Network Environment**

- **Open APIs**
  - Prime Suite
  - InterCloud
  - nLight (IP+Optical)
  - onePK, OpenFlow, PCEP, Netconf/YANG, BGP-LS, GMPLS
  - Quantum WAVE
  - openstack

**Cisco’s Open Network Environment Environment**

- **Consumer**
- **Business**
- **Mobile**
- **M2M**

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  - VM

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The Need for Speed & Efficiency

- As traffic grows, data centers (DC) grow
- Switches, routers and servers must manage higher capacity
- EPA estimates that ~2% of power generated in the US is consumed by data centers
- As much as 50% of the DC power is used to cool the facility
- In’07 the EPA set guidelines for DC efficiency to manage carbon emissions from power generation

Router & Switch Capacity and Efficiency Must Keep Pace
Industry Trends are Enabled by CMOS Technology

What has CMOS evolution done?

- **Internet Transit - Price**: 3 orders of magnitude of cost reduction in 15 yrs
- **Compute - Price/Performance**: 10 orders of magnitude of cost reduction in 30 yrs
- **Wafer Scale Manufacturing**: ~2M wafer starts per week, $300B per year

Moore’s Law has reshaped our industry models (Web, Public Cloud players). CMOS technology through increased integration and speed and efficiency has enabled these markets changes.
Cisco nPower™ Silicon
New Cisco Network Processor Family

• Functionality and Optimization
  – High-scale, multiservice IPv4/IPv6/MPLS forwarding
  – LSR for label switching
  – Integrated Ethernet MACs and OTN framers
  – ZPL/ZTL smart support

• Flexibility
  – Fully programmable with 336 on-chip packet processors
  – Support for a wide range of Ethernet interfaces (10 GE, 40 GE, 100 GE)
  – Support for OTN framing

• Integration and Low Power Consumption
  – High integration (MAC, NPUs, OTN) provides low power consumption and reduced footprint
  – Helps enable highest power efficiency in terms of Watts and Gbps in the industry

CMOS Technology Providing Efficient Routing Solutions that Scale

4 Billion Transistors
Routing BW Demands 25X per Slot in 10 yrs

BW Growth Requires Optical Innovation

- 2004: CRS-1 = 40G/slot
- 2010: CRS-3 = 140G/slot B2B & MC
- 2013: CRS-X = 400G/slot B2B & MC
- 2014: NCS6K = 1Tb/slot B2B & MC

CFP – 100Gb/s, 24W
XFP – 10Gb/s, 2.5-3.5W

In almost 10 years optical technology did not become significantly more efficient to keep up with the advances in CMOS.

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A Little History
- Digital ICs leveraging CMOS process node evolution
- Primary motivation in data bus width is CMOS process node generation
- Ability to eliminate PHY/Retimers from modules depends on CMOS process node evolution
10GE has migrated from low port count to high port count applications...

CMOS technology migration enabled advances in CMOS SERDES technology
Optical technology moved much slower
Relative Cost of Optics & Electronics

Putting Optics on the Same Path as Electronics

Applying Moore’s Law to Optics
Why CMOS - Photonics?
Leveraging the 40yrs & $400B CMOS Industry Investment and Infrastructure

Scaling

Improved Performance & Cost

Industry Investment

• CM capital investment
• Standardized design tools
• Standardized manufacturing

Market Growth
(New Products and Applications)

This cycle of innovation is the power behind Moore’s Law, and the engine behind CMOS Photonics
CPAK 100G Form Factor

- **Standards Compliant**
  - IEEE standards compliant interfaces
  - 100GBASE-SR10 / LR4 / ER4
  - Supports OTN rates

- **High Density**
  - CPAK is 1/3 the size of CFP, ~20% smaller than CFP2
  - Enables 10+ Pluggable 100G Ports

- **Low Power Consumption**
  - CPAK LR4 max dissipation < 6.75W
    - <1/3 the power of CFP & 40% less than CFP2
    - Enabled by Cisco’s CMOS Photonics Technology for SMF applications
  - CPAK-10X10G-LR dissipates < than 4.5W
    - ½ the power of 10X SFP+ LR

- **Supports high density 10G breakouts w/ MPO-24**
  - CPAK-100G-SR10 compatible w/ 10GBASE-SR
  - CPAK-10X10-LR compatible w/ 10GBASE-LR

Cisco is Enabling Next Gen Switches & Routers in with CPAK
Cisco CPAK™ provides 20% more BW with 30% less power dissipation than CFP2.
CPAK™: 100G Transceiver Innovation
Breaking Through the Capacity Brick Wall

- Industry’s first CMOS Photonic Pluggable Transceiver
- CMOS Photonics – Light processing in Silicon!
- 70% size reduction, 70% power reduction
- IEEE Standards based
  OTU4 compliant

10 CPAKs = 1 Terabit
1 Terabit for <

CPAK is the smallest 100G form-factor capable of supporting the full range of IEEE reachs available.
## CPAK Product Portfolio

Providing a wide variety of reaches

- CPAK was introduced in 2013
- In production in 2013 with CPAK-100G-LR4 and now CPAK-100G-SR10
- Shipping in a variety of applications
- 2014 will Introduce CPAK-10X10G-LR & CPAK-100G-ER4-Lite
- Cisco will provide a full portfolio of industry standard reaches

<table>
<thead>
<tr>
<th>Cisco Product ID</th>
<th>IEEE Standard Compliance</th>
<th>Max Power Dissipation</th>
<th>Reach</th>
<th>Fiber Type</th>
<th>Optical Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPAK-100G-SR10</td>
<td>100GBASE-SR10, 2X 40GBASE-SR4, 10x 10GBASE-SR</td>
<td>&lt; 4W</td>
<td>&lt; 100m OM3, &lt;150m OM4</td>
<td>MMF</td>
<td>MPO-24</td>
</tr>
<tr>
<td>CPAK-100G-LR4</td>
<td>100GBASE-LR4</td>
<td>&lt; 6.75W</td>
<td>&lt; 10km</td>
<td>SMF</td>
<td>Duplex SC</td>
</tr>
<tr>
<td>CPAK-10x10G-LR</td>
<td>10x 10GBASE-LR</td>
<td>&lt; 4.5W</td>
<td>&lt; 10km</td>
<td>SMF</td>
<td>MPO-24</td>
</tr>
<tr>
<td>CPAK-100G-ER4</td>
<td>100GBASE-ER4</td>
<td>&lt; 7.5W</td>
<td>&lt; 40km</td>
<td>SMF</td>
<td>Duplex SC</td>
</tr>
</tbody>
</table>
Compare 75W’s of BW
What Does 75W’s of Power Dissipation Buy in Bandwidth?

75W will light a room
With 75W, Cisco CPAK will light up a 1Tb/s network

Cisco CPAK Provides the Industry’s Most Efficient Bandwidth
CMOS Photonics Circuit

Highly Integrated and Highly Repeatable in Performance and Production

Integrating over 32 optical elements in a single CMOS chip
Wafer scale manufacturing
Wafer scale repeatability

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CPAK is Everywhere
Providing High Density & Efficient 100G Connectivity

**Data Center**
Massive bandwidth, low latency, encryption, lowest cost-per bit focus. CPAK’s low power consumption and density will enable the transition to 100G in the DC

**Metro / Edge**
Regional rings collect and aggregate traffic to the SP core. CPAK provides low power client side interfaces for metro applications.

**Long Haul / Core**
High data rates, massive scale, long distances. Mesh core switch / router interconnect and leased line transport. CPAK provides high density client side interface for core routing and coherent line cards.

Nexus 7700 Switch
NCS4000 Router
NCS2000 Coherent Transport
NCS6000 Router
CRS-X Router
Fixed Port Line Cards

The Old Way
Separate Line Card per Rate

- What is the port requirements when you initially deploy a platform?
- How will you network evolve over the next few years?
- How many type of line cards will you need to spare?
- How many of these ports will be left unfilled?
CMOS Photonics Based **CPAK-10X10G-LR**

The Highest Density / Lowest Power 10G Single Mode Module Available

10x SFP+ LR
130mm = 10x 10Gb/s
10W

1 – CPAK-10X10G-LR
< 35mm = 10X 10Gb/s
3W

Saves > 70% of the power dissipation and front panel space over SFP+
"Anyport" 100 Gb CPAK Line Card Solution
Breaking the Fixed-Port Paradigm with CPAK

One CPAK Line Card Can Support 100G, 40G & 10G

- 10G Ports Router/ Switching Platform
- MPO-24 to 10x Duplex LC SMF or MMF
- 40G Ports Router/ Switching Platform
- MPO-24 to 2x MPO-12 SMF or MMF
- SR10
- 10X10G-LR

Extend the investment of a single line card to manage migration from 10G and 40G to 100G
"Anyport" 100 Gb CPAK Line Card Solution

<table>
<thead>
<tr>
<th>CPAK 100 GE ER4</th>
<th>CPAK 100 GE LR4</th>
<th>CPAK 100 GE SR10</th>
<th>CPAK 10x10-LR</th>
</tr>
</thead>
</table>

**Future CPAK Options**

**Investment Protection**
Start with 10 GE and upgrade to 100 GE in the future

"Anyport" CPAK Card Capability
Supports 10 GE, 40 GE, and 100 GE on the same card

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Cisco CPAK™: Portfolio of Innovation
Delivering the Industry’s Highest Density, Lowest Power & Flexible Solutions Today

• With the flexibility of the CPAK portfolio in one line card:
  • 100G: CPAK-100G-SR10, CPAK-100G-LR4, CPAK-100G-ER4
  • 40G: CPAK-100G-SR10 w/ breakout cable to 2X 40G-SR4
    CPAK10X10G-LR w/ breakout cables to 2x QSFP-4X10G-LR
  • 10G: CPAK100G-SR10 w/ Breakout cables to 10X 10G-SR
    CPAK-10X10G-LR w/ Breakout cables to 10X 10G-LR

CPAK - Breaking through the fixed port paradigm
CPAK to CFP2 Adapter

Allows you to take advantage of CMOS Photonics in CFP2 platforms

- Allows CPAK modules to operate in CFP2 ports
- Take advantage of CMOS Photonics for all 100G applications
- Reduce inventory
Cisco Innovations for 10G to 40G DC Transition
Innovative Data Center Transition to 40G: BiDi Technology

10GBASE-SR

- Replace duplex infrastructure fiber with multi fiber cable
- Additional cost of fiber
- Additional cost of installation

40GBASE-SR4

- Stay with 10G infrastructure
- First short reach duplex 40G Duplex module
- Exclusively available from Cisco
- Supported on all Cisco QSFP-Based Platforms

Cisco QSFP-40G-SR-BD

Which path to 40G would you rather take?

Duplex Fiber

Multi-Fiber Cable

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# 40G QSFP SR4: Cost Analysis

## Fiber infrastructure pricing with QSFP 40G SR4 optics

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit price (Manufacturer’s List Price)</th>
<th>Qty</th>
<th>Extended price (Manufacturer’s List Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Fiber MPO-MPO trunk cabling (90m): (only 8 fibers needed for QSFP SR4)</td>
<td>$1,844</td>
<td>0.67</td>
<td>$1,229</td>
</tr>
<tr>
<td>12 fiber MPO / MPO Panel</td>
<td>$150</td>
<td>0.5</td>
<td>$75</td>
</tr>
<tr>
<td>12 fiber MPO jumper</td>
<td>$340</td>
<td>2.00</td>
<td>$680</td>
</tr>
<tr>
<td><strong>Pro-rated fiber pricing, per 40GE 100m link</strong></td>
<td></td>
<td></td>
<td><strong>$1,984</strong></td>
</tr>
</tbody>
</table>

### Notes:
1. Using OM4 fiber; OM3 fiber is ~10% less expensive
2. Cost does not include Optics
### 40G QSFP BiDi: Cost Savings Analysis

#### Fiber infrastructure pricing with QSFP 40G BiDi optics

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>12 Fiber MPO-MPO trunk cabling (90m): (only 8 fibers needed for QSFP SR4)</td>
<td>$1,844</td>
<td>0.17</td>
<td>$307</td>
</tr>
<tr>
<td>12 fiber MPO / LC Trunk Module</td>
<td>$525</td>
<td>0.17 x 2</td>
<td>$178</td>
</tr>
<tr>
<td>12 fiber LC jumper</td>
<td>$75</td>
<td>2.00</td>
<td>$150</td>
</tr>
<tr>
<td>Pro-rated fiber pricing, per 40GE 100m link</td>
<td></td>
<td></td>
<td>$635</td>
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**Savings in cable costs:** $1,349

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Note1: Using OM4 fiber; OM3 fiber is ~10% less expensive
Note2: Cost does not include Optics
Seamless Migration to 40G

Optics Savings  ▪ Fiber Savings  ▪ Time Savings

> 50% savings on Optics) ▪ (~75% less Fiber needed) ▪ (Zero Fiber Installation Time)

If every 10G Data Center Adopted Cisco QSFP BiDi for 40G migration

> $3Billion Saved
(On Fiber cable and Installation Labor)
Enough to buy 9 new data centers for the largest cloud providers

> 300,000km Fiber Saved
(Enough to wrap around the Earth 7 times)
Summary

• Traffic is expanding at a terrific rate
• That traffic is the result of applications for video, mobility and communications that can be manage cost effectively
• CMOS technology is enabling this economy
• A brief summary of the evolution of optical modules
• Optics had the bottle neck in the infrastructure of managing this traffic
• By applying CMOS technology to optical modules, Cisco has been able open up the bottle neck with Cisco CMOS Photonic technology
• CPAK is the first implementation of CMOS Photonics in pluggable transceivers
• Cisco Innovations for Data Center transition from 10G to 40G over duplex fiber with BiDi
Questions
Thank you.