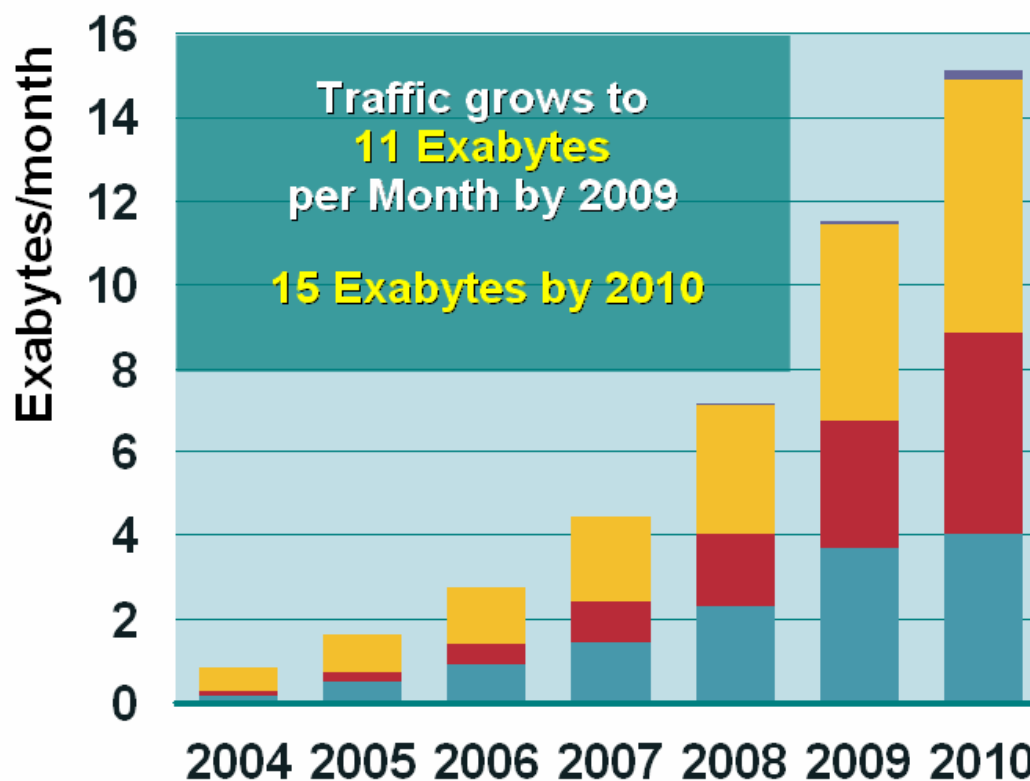# Routers

and

"Advanced Optical Modulation"

Gary Nicholl
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Overall Traffic Growth Is Straining All Known Network Architectures

Global IP Traffic—By Segment

■ Cable ■ Wireline Consumer ■ Wireline Business ■ Wireless Data

For Perspective:

1 Exabyte = 5 X All the World's Printed Matter

5 Exabytes = All Words ever Spoken

Traffic grows to
11 Exabytes
per Month by 2009

15 Exabytes by 2010

Exabytes/month

16
14
12
10
8
6
4
2
0

2004 2005 2006 2007 2008 2009 2010

*Source: Cisco Estimates, Ovum, Gartner, IDC, Merrill Lynch, MRG, MPA, Public Company Data

Growth is driven exclusively by Data

- **Legacy applications moving to IP**
  - Video – SD, HD, Broadcast Cable
  - Voice

- **New applications exclusively IP**
  - Video - On Demand, DVRs, Switched Digital, Video conferencing …
  - Audio – Streaming audio, Internet radio, Digital juke boxes,etc.…
  - High-Speed Data, Internet
  - Over-the-Top Content providers—i.e., YouTube

- **Household Bandwidth Needs in 2010 (U.S.):**
 - Applications: HDTV + SDTV + PVRs + HSD + VoIP-Phones
  - **Twenty such homes would generate more traffic than traveled the entire Internet backbone in 1995**

Where does this take us ?

- **Higher bandwidths** are needed to address this growth:

    10 Gig networks beginning to feel the strain

    Cannot rely on L2/L3 aggregation: LAG **4 X 10G ≠ 40G**

    Cannot rely on L1 aggregation: DWDM ports are not unlimited

- **Increase wavelength** capacity as soon as viable:

    Move to higher data rates per lambda, i.e. 40G and 100G

    BUT must operate over existing infrastructure

    AND ideally with equivalent performance to 10G

    Requires advanced optical modulation schemes

- **Remove** all unnecessary network layers leaving only:

    – **Service layer (IP)**

    – **Transport layer (DWDM)**

- **Integrate** DWDM technology on Router: IPoDWDM

IPoDWDM

- IPoDWDM vs. PMO

  – IPoDWDM reduces CAP EX

    • Less components, shelves, processor cards, etc…

  – IPoDWDM reduces OP EX

    • Less shelves, less rack space, less power, simplifies trouble shooting, etc…

  – IPoDWDM enhances Resiliency

    • Less Opto Electonic Components, enhanced fault recovery features, etc…
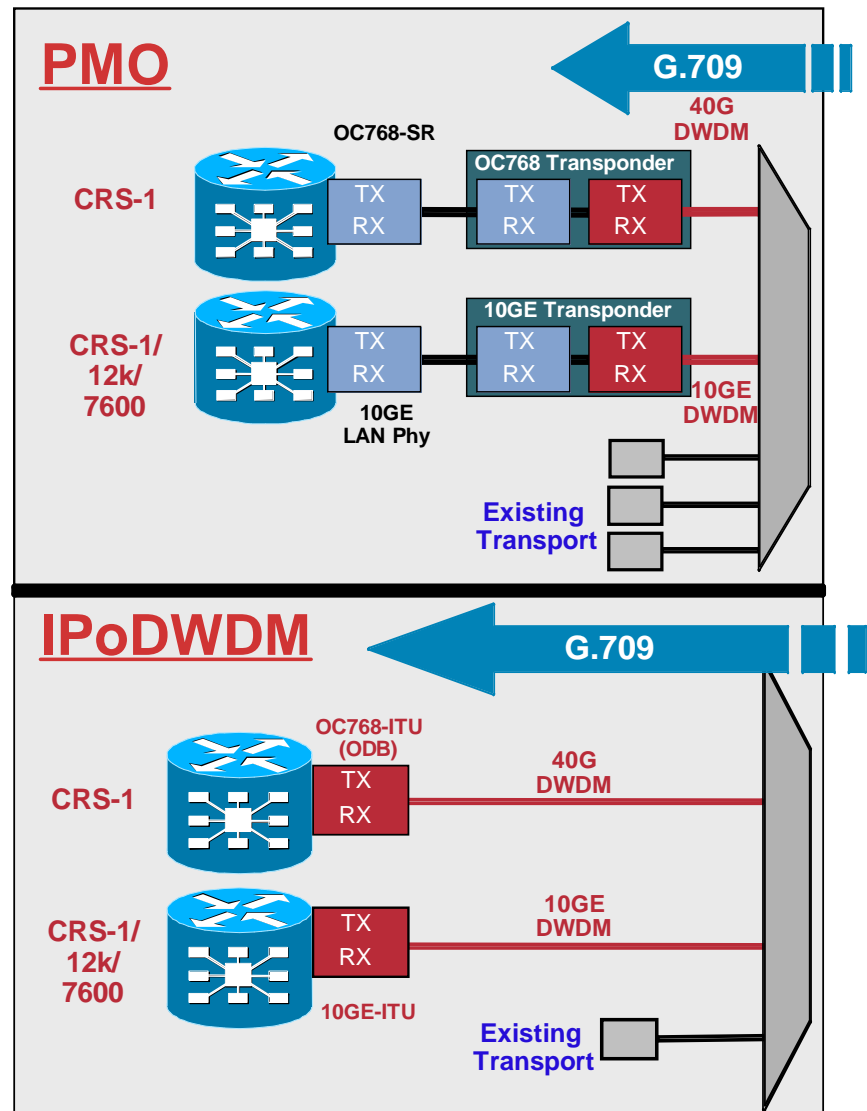
IPoDWDM - Integration

Three Key Levels of Integration

1. Hardware Integration

   – 40G and 10G serial interfaces on Cisco CRS-1

   – Serial 40Gig over existing 10Gig networks

   – Links of up to 900+km deployed

2. Control Integration

   – A to Z provisioning of services across entire network, both L1 and L3

   – Multiple standards defined

3. Management Integration

   – Management as two models:

     – Separate   (respect PMO)

     – Integrated   (IP+Transport)

Industry First

Tunable 40G compatible with 10G DWDM + SONET OAMP

Industry First

Tunable 10GE with SONET OAMP

40Gb/s Interfaces

- Routers Prefer single serial 40Gb/s interface
  - LAG / Load Balancing limitations

- Customers prefer single 40Gb/s interfaces
  - DWDM transport gear do not have unlimited ports
    - DWDM is view as fixed (and sunk) asset
    - 1 X 40Gb/s Port is better then 4 X 10Gb/s Port
    - Network capacity becomes 80ch X 40Gb/s = **3.2Tb/s**

- Modulation technology is advancing rapidly
  - ODB > DPSK > Coherent (DP-QPSK)
  - 40 Gb/s can be run over existing DWDM infrastructure
  - 40Gb/s approaching 10Gb/s performance

40 Ch DWDM System	400Gb/s 40Gb/s/CH	400Gb/s LAG / inv. M
40 ports	30 ports	0 ports

40 Gb/s DWDM Technology can be integrated on the Router

100Gb/s Interfaces

- 100Gb/s is Real!

  Customers Requesting Today!!

- IEEE and ITU have taken up the standard

- Routers Prefer single serial 100Gb/s interface

  LAG / Load Balancing limitiations

- Customers prefer single 100Gb/s interfaces

  DWDM transport gear are not unlimited ports

  1 X 100Gb/s Port is better then 10 X 10Gb/s Port

  Network capacity becomes 80ch X 100Gb/s = **8.0Tb/s**

- 100Gb/s must operate over existing 10Gb/s infrastructures

  Advanced modulation schemes will achieve this level of performance

  Leverage the work started on 40Gb/s

40 Ch DWDM System	400Gb/s 100Gb/s/CH	400Gb/s LAG / inv. M
40 ports	36 ports	0 ports

100 GB/s DWDM Technology can be integrated on the Router

Summary

- **IP Traffic Continues to Grow**

  All applications converging on IP

  15 Exabytes per month by 2010

- **Need fatter pipes, not more pipes**

  Service Layer (IP) - Router - overcome LAG / Load Balancing limitation

  Transport Layer (DWDM) - DWDM systems do not have unlimited ports

- **Advanced modulation required**

  Fatter Pipe (40G, 100G, etc..) needs to match performance of Skinny Pipe (10G)

- **Network is consolidating into two layers**

  Service (IP) & Transport (DWDM)

  IPoDWDM is the next obvious step in Network Evolution

- **Advanced Modulation Technology can be integrated on Router**

  CRS-1 has integrated 10G and 40G DWDM interfaces on the router