Cisco Knowledge Network:
Low Latency Transport Architecture
Cisco Knowledge Network

To view this session on VoD, please click here.

If you would like to get in touch with our technical experts or provide your feedback, please email us at globalckn@cisco.com.

Thank you.
Introduction

- Welcome – Moderator(s):
  
  **Dale Clark** - Strategic Account Manager

- Today’s Show: **Low Latency Transport Architecture**

  Speaker(s):
  
  **Abhishek Sharma** – PLM, Converged Optical Business Unit

- Q&A

- Survey
Cisco Low Latency Solution

Abhishek Sharma,
CORBU PLM.
Drivers for Low Latency

• High Frequency Trading - enable traders to grasp opportunities only available for fractions of a second.

• Cloud Services - interactive Web-based applications

• Business Continuity and Disaster Recovery - disk mirroring and synchronous replication of mission critical data between a primary and a remote, secondary data center

• Consolidated data centers - for processing power, storage, and IT staffing.
High Frequency Trading

- Regulation—Best Execution
- Regulation—More Data Source
- Result
- Created more

Electronic Trading

Created more

Inability of human trader to keep up

Trade and quote volume

Faster receipt, translation, and distribution of market data

Source: TowerGroup 2007
Latency in Electronic Trading

- Latency - key in SP/supplier decision making.
- Two components of Latency
  - Intra Server - Software and uP
  - Inter Server - Local and Access Network
- Good progress being made in reducing Intra-Server Latency
  - Multicore processors & custom HW/SW
- Network Latency - the emerging bottleneck
  - Fragmented Liquidity, Global distributed trading - any pool any time

"Every Millisecond of latency eliminated equates to $100 million annually in revenue opportunity"

A Network capable of delivering the lowest latency to any Liquidity pool is a disruptive weapon in the fight for position in the new era of Electronic Trading
End to End Latency

Many variables involved—key is to profile end-to-end trading process.
Elements of Latency

• Latency is the amount of delay a signal experiences in reaching its destination.

• Although Latency can be introduced at each layer of the TCP/IP stack, keeping transmission at L1 for as much as possible helps to lower latency.

• The primary elements that add latency at the physical layer:
  1. The Fiber.
  2. The Network Elements.
  3. The Line Rate.

• Among these the fiber contributes to more than 98% of the total latency.
Understanding Network Latency

• Three components of Network Latency:
  1. Propagation Delay - simple function of distance and speed of light
  2. Serialization Delay - simple function of packet size and link speed
  3. Queuing Delay - complex function of traffic, network speed mismatch, queue scheduling, and link speed
Low Latency Network Design

• Traditional network designs are generally optimized for cost.
• Managed service design will not work if lowest latency is desired.
• A low latency network design requires:
  - Direct connection from LAN port on server to WAN link.
  - Simplified network topologies – Point to point instead of hierarchical (traditional 3 tiered)
  - Shortest route, excellent slack management and novel dispersion management.
Poll Question #1
Low Latency Components

- Low Latency Transponders.
- Pluggable Transceivers.
- Passive Multiplexer/De-Multiplexer.
- Low Latency Amplifier.
- Regenerators.
- Low Latency Dispersion Compensation Units.
Low Latency Transponders
10x10G Multi-rate Card

- 10-ports SFP+ based and one 100G CXP based port.
- Each of the 10Gbps SFP+ based port can support – OC-192/STM-64, 10GE WAN PHY, 10GE LAN PHY, 8G FC, 10G FC and OTU-2.

- Working modes:
  a. 5 x 10G Transponder equipping client card with SFP+ DWDM
  b. Fan-Out for 100G into 10x10G signals coming from external device
  c. Ultra Low latency Transponder using Grey / DWDM SFP+

- Latency is 2.48 us with G.709 wrapping and <4ns in low latency mode.
Coherent Solution (DCU less)

- 4-Port 10-Gbps Full-Band Tunable DQPSK Muxponder Card.
  - Can transport four OC-192/STM-64/10GE LAN/10GE WAN/8G FC/10G FC/OTU2 payloads.
  - Latency:
    - G.709 On - Standard FEC – 5 us
    - G.709 On - Enhanced FEC – 50 us

- Can transport SONET OC-768, SDH STM-256, OTU3, 40 GbE WAN and 40GbE LAN PHY signals.
  - Client OTU3:
    - G.709 On - Standard FEC – 11.5 us
    - G.709 On - Enhanced FEC – 52.9 us
  - Client OC768 / STM256:
    - G.709 On - Standard FEC – 6.6 us
    - G.709 On - Enhanced FEC – 47.9 us
  - CD Tolerance – 29,000 ps/nm

- 10 port SFP+ Muxponder coupled to 100G DWDM Line card
  - Muxponding Latency - **12.41 us** (with Std. FEC)

- Can transport 100GbE LAN-PHY and OTU4 signal over a 50-GHz spaced, 50-GHz stabilized, ITU-compliant wavelength.
  - Latency:
    - G.709 - Standard FEC – 1 us
    - G.709 – HG-FEC 7% - 44 us
    - G.709 – UFEC 20% - 74 us
  - CD Tolerance – 70,000 ps/nm

© 2011 Cisco and/or its affiliates. All rights reserved.
Transceivers

• It contains three parts, Transmitter, Receiver, I2C Management interface.

• The SFP+ transceiver has a latency of less than 900 ps.

• The same interface is used on both the client and trunk side of the 10x10G card.
Passive multiplexer/De-multiplexer

- 40 / 48 channels at 100GHz on the “Odd” and on the “Even” ITU grid.
- 40 / 48 bi-directional LC-LC ports and one trunk port (plus monitor ports)
- Slot for interleaver module for upgrade to 80 / 96 channels at 50GHz via the “even” channel version
- Cost-effective for DWDM terminal / hub applications and also simple point to point Data Center Interconnections.
- Very low latency through the patch panels.
Low Latency Amplifier

- Erbium Doped Fiber Amplifier (EDFA) add latency due to the photons traveling along the erbium doped fiber path.
- The latency optimized Mal-less EDFA can be used in place of the regular EDFA wherever applicable.
- Wherever possible, one should leverage RAMAN Amplifiers which have the lowest latency (10’s on ns) as the amplification occurs along the length of the fiber.
The Cisco 100-Gbps Full-Band Tunable CP-DQPSK DWDM Trunk Card supports OTU4 Regeneration capabilities.

Two cards can be configured to work in Back-to-Back mode connecting through the backplane in the same shelf, and perform the OTN O-E-O Regeneration of the Frame.
Low Latency Dispersion Compensation Units

- Latency below 25 ns which is three orders lower than the alternative DCF.
- Insertion loss less than 4.5 dB.
Cisco Optical Low Latency Timeline

2010
Ultra Fast 40G TXP & MXP

2011
Low Latency Amplifiers

Mar 2012
96 ch. Passive filters

Ultra Fast 100G TXP & MXP

May 2012
96 ch. SFP+ pluggable transceivers

Jul 2012
Low Latency DCU

* ULL 10G TXP

* Available in hardware today
Poll Questions #2
Low Latency point to point architecture

- Router/Switch pluggable interface produces WDM signal
- Transceiver is cabled directly into passive mux/demux
- No active intermediate devices
Low Latency Ring / Mesh architecture

- Services require Transponding, Muxponding, or Xponding
- Physical Network Topology is a Ring (3+ nodes) or a Mesh
- Distance and/or loss is too high for passive
Latency optimized design

• Analysis of a network between Washington and Chicago:

• The existing network had a combination of 10G and 40G CP-DQPSK MUX w/E FEC. Also fiber based DCUs were used at sites for CD compensation. EDFA-C and RAMAN amplifier were used at OLA sites.

• The network was redesigned for low latency for which the 10G wavelengths were multiplexed using 40G CP-DQPSK MUX w/E FEC. This design being completely coherent eliminated the need for DCUs. Also at some sites the EDFA-C were replaced with MAL-less EDFA.

• The same network was again redesigned using FBG DCUs in place of the Fiber based DCUs.
Latency and Cost Analysis

- Existing Network had an end to end latency of 9.2 ms.
- The redesign of the network using a completely coherent solution yielded an end to end latency value of 8 ms.
- Using FBG DCU the end to end latency of the network was 7.1 ms.
- Cost of building the network between Washington and Chicago with FBG DCU was marginally higher than the cost of the original network.
- Cost of building the network with a complete coherent solution was slightly lower than the cost of the original network.
- Thus for this particular case, an FBG DCU based solution is ideal in case lowest latency is desired whereas the coherent solution is ideal for a cost optimized design.
Drivers for Optical in Data Centers

• Increasing demand for bandwidth for applications like VoD, r.t video processing, financial services, medical imaging, storage and scientific computing.

• Multi-hop networks used in data-centers are based on Fat tree or Butterfly topologies use commodity switches that employ store-and-forward paradigm that incur high latencies and high power consumption.

• Low-latency networking for financial players has continued to evolve and innovate at such a relentless pace that today 250ns can make the difference between winning and losing a trade.
Design Requirements for HFT

- Network diversity with self healing topology.
- Support for ever increasing bandwidth and deliver guaranteed high performance data solution.
- Speed, reliability and security to receive and transmit volumes of critical data to market centers.
- Shortest routes between major exchange locations for point to point transmission.
- Specialized DWDM network with guaranteed round trip performance between key Data Center locations.
High Frequency Trading
Present Scenario

Customer A  Customer B  Customer C  Customer D

Exchange Server

Exchange Switch

Customer Switch

Customer Server
High Frequency Trading
Present Scenario

Customer A  Customer B  Customer C  Customer D

Exchange Server

Exchange Switch

Quickest Response Gets Trade

Customer Switch

Customer Server
High Frequency Trading
ULL Concept

Concept
• Reduce impact of buffering, microbursts, and multicast issues
• Use switch for order execution entry
• Bypass switch for near elimination of ingress Market Data traffic latency

Solution
• Passive Optical Switch almost totally eliminates receive traffic latency and inherent issues with ingress market data

Value
• Latency cut down drastically to less than 20 ns.

Exchange Owned
Firm Owned
High Frequency Trading using Optical
Latency Arbitrage
Present Scenario

HFT Servers
Require External
Information to Make
Smart Trades

Exchange Server

Exchange Switch

Is your WAN
Optimized for
Lowest Latency?

Info from
Other Exchanges

Info from
Financial Feeds

Customer A

WAN

WAN

WAN
Latency Arbitrage using Optical

Exchange X-Connect

1:8 Passive Optical Switch

Nexus 3064

ONS 15454

Exchange Owned

Firm Owned

Single fiber strands

1:8 Passive Optical Switches

Dual NIC HFT Servers

Optical WAN

Inbound fiber strands

One strand per server

Outbound fiber strands

One per server

© 2011 Cisco and/or its affiliates. All rights reserved.
Poll Question #3
Summary

- Owing to the wide portfolio encompassing all the layers of the TCP/IP stack, Cisco is today in a unique position to offer end-to-end architecture for low latency.
- In the Optical space too Cisco has products that boast of a feature for feature match with offerings from Adva, Ciena and Infinera.
- The low latency transponder has a latency below 4 ns which is the best in the industry.
- With the addition of FBG DCU, low latency amplifier and 96 channel passive filters to the portfolio, Cisco Optical now has a complete low latency solution suite thus distinguishing itself in the Low Latency Optical Networking space.
Q&A

Thank you.
Wrap-Up

• Survey
• Contact us: cisco-optical-sales@cisco.com
• Webinar playbacks and updates can be found at:
  www.ciscoknowledgenetwork.com/optical
• Please also click on www.cisco.com/go/optical for more information.