EVOLUTION OF PACKET / OPTICAL NETWORKING

Core Networks at a Crossroads

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PACKETS VERSUS CIRCUITS

Packet Switching

Multi-Protocol Label Switching (MPLS)

“Expensive”

Statistical Multiplexing

Circuit Switching

Optical Transport Network (OTN)

“Cheap”

Time Division Multiplexing (TDM)
“It is the nature of stochastic ‘bursty’ traffic that peak demand will be much larger than average demand. Providing for the peak would be very expensive, and certainly against good engineering economic principles.”

ATT Net Neutrality Comments, Jan 14, 2010
Option 1: Use the same architecture with bigger IP routers

1. Build the core with bigger IP routers
   - DWDM
   - IP Router
   - Edge Router

2. And expect higher CAPEX and OPEX
   - Cost-to-Buy
   - Cost-to-Run

3. Some industry voices express skepticism
   - “We need to fundamentally rethink how we interoperate, how networks are constructed, how routing is done and how we move content.”
   - Source: ATT CTO, October 2009

4. Because the problem is the architecture
   - Bigger IP routers in the same architecture means...
     - an increasingly cumbersome and expensive infrastructure
     - mismatched functionality of IP for simply and economically moving large numbers of packets
     - complexity that compromises ability to scale
     - escalating power and space consumption
     - can’t support convergence
Option 2: Use less expensive OTN circuits in the core and do routing at the edge

1. Put circuits in the core, packets at the edge

2. Which increases total cost

3. Some leaders advise an all-up view

   “Simply trying to lower the cost-per-bit isn’t enough to deal with the underlying challenge.”
   Source: ATT CTO, October 2009

   “Basing the network on OTN doubles the complexity of planning and modeling”
   Source: Global Service Provider, Dec 2010

4. As the basis for network architecture evaluation

   A core architecture based on OTN means...
   - one must provision for peak traffic
   - the core depends on OTN circuits ill-suited for bursty and dynamic traffic
   - complexity shifts to the edge and increases cost even more
   - MPLS-TP is not the magical solution some portray it to be
Option 3: Maintain separate OTN and packet layers. Have transit traffic bypass the routers

1. Bypass MPLS when possible
   - DWDM
   - OTN Switch
   - IP Router
   - Edge Router

2. Which adds both CAPEX and OPEX
   - Cost-to-Buy
   - Cost-to-Run

3. The industry experience is mixed
   - “If the OTN switch does all the channelization, then yes, it would minimize port count. If it doesn’t, then it would increase the port count.”
   - Service provider quote in ACG Research OTN Survey, June 2010

4. With respect to cost and bursty traffic
   - This two-layer approach...
     - Requires provisioning for peak traffic
     - Works only with highly static traffic
     - Requires dual, centralized network management systems that inhibit scale
     - Adds technical and operational complexity
Reduced complexity translates into higher switching capacity, improved density, lower power.

Dramatically reduce the number of network elements.

Which costs less to buy and run:

- **Cost-to-Buy**
  - [Cost-to-Buy Indicator]

- **Cost-to-Run**
  - [Cost-to-Run Indicator]

Build core on Juniper PTX Series: Which costs less to buy and run

Migrate to a super core. Combine MPLS switching with transport in a converged solution.

Cost-to-Buy

1. Build core on Juniper PTX Series
2. Which costs less to buy and run
3. Delivering the efficiency of MPLS
   - MPLS consumes up to 45-65% less network resources than OTN switching
   - MPLS supports flexible and dynamic aggregation of bursty traffic
4. AND the simplicity of switching
   - Switch LSPs rather than OTN circuits
   - Switch and multiplex OTN when appropriate
5. With unmatched scale
   - Reduced complexity translates into higher switching capacity, improved density, lower power
   - Dramatically reduce the number of network elements

Delivering the efficiency of MPLS

Announcing the PTX Series

Juniper Solution

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Acknowledgement: Dr. Pietro Belotti of Clemson University came up with this formulation of the problem and the solution methodology; first published in 2008 for $K = 1$, and generalized to $K > 1$ with robust optimization in 2010 (see http://myweb.clemson.edu/~pbelott/papers/robust-opt-network-design.pdf).
SIMPLE MODEL TO APPROXIMATE STATISTICAL GAIN

- **B** = Average bandwidth in a flow
- **α** = Ratio of peak to average to use as a “rule of thumb”
- **K** = A specified number of “simultaneous” peaks
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TRANSPORT NETWORKS AT THE CROSSROADS

Abstract:

- Traffic growth… Desire to Lower Costs… Some make the case for OTN switching as low cost alternative to IP/MPLS core networks.
- To compare and contrast the costs of OTN versus MPLS, we undertook multiple modeling exercises.
- The preliminary results show that the optimal network design depends on different parameters, such as: ratio of peak to average flow demands, number of simultaneous peak demands, ratio of MPLS to OTN port costs and size of core transport interconnects.

Summary:

- We presented the results of several modeling exercises that compare the costs of OTN versus MPLS under uncertainty in the traffic demand.
- Based on the outcome of this modeling exercise we argue that an optimal packet optical transport architecture is one that use packet switching as the foundation with OTN in a supportive role.
CONVERGED SUPERCORE ARCHITECTURE

Introducing a new architecture

Built on a new foundation

- Best-in-class MPLS switching
- Best-in-class optics
- Convergence built on packet layer
- JUNOS Express chipset
- Extending JUNOS to transport

And a set of industry firsts

- Industry’s fastest switching silicon
- Industry-leading scale and density
- Contentionless, colorless, directionless multi-degree optical switching

To enable what was previously not possible

- Service-driven optical layer
- Smart multi-layer modeling, planning, provisioning, protection and restoration
- One operating system running packet and optical layers
ENABLING THE FIRST CONVERGED SUPER CORE

CONVERGED SUPER CORE

PTX5000

PTX9000

TDM services

MX 3D

IP services

JUNOS Trio
• Subscriber Scale
• Services Scale
• Bandwidth Scale

JUNOS Express
• Speed
• Scale
• Cost

JUNOS Trio
• Subscriber Scale
• Services Scale
• Bandwidth Scale
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