Deconstructing Next Generation Transport: An Industry, Technology and Services Overview

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Agenda

- Industry Dynamics
- Ethernet Trends and Convergence
- Standards Overview
- Service Mapping
- Summary
Industry Dynamics
Market Trends and Focus

- Ethernet at access for service aggregation
- Require service flexible architecture
- Capex and Opex efficient
- OAM and Network management key
- High availability and resiliency
- “Adaptation” of packet switching technologies to the transport domain
- Utilization of legacy strategy where ATM technology was used both as a “transmission” and a “switching” technology
- Migration to IP/MPLS and Ethernet based core switching
- Elimination of unneeded control plane capabilities and functionalities in transmission applications
- Multiple overlay and supplemental proposals and techniques, including T-MPLS,PBB-TE, to adapt IP/MPLS and Ethernet to the transport arena
Packet Transport Market Dynamics

- Traditional circuit switched transport systems are migrating toward packet based technologies

- SDH/SONET platforms provide low speed bandwidth granularity network services and high speed long haul transmission services

- IP adoption and convergence simplifies packet transport networks in the access/aggregation and metro domains to reduce CapEx and OpEx in next generation networks
Where we are today!!

Physical Layer

L3 Services

ATM / FR

SONET/SDH

Physical Layer

Physical Layer

Physical Layer
Characteristics and issues

- Network centric
  Circuit orientated

- Multiple networks
  OPEX and CAPEX inefficiencies
  Provisioning and service assurance complexities
  Complexity between layers

- ATM and F/R technology is tailing off
  Service capabilities
  Bandwidth concerns

- NG SDH/SONET days numbered
  TDM and circuits not well suited for packet transport
  Acknowledged by transport vendors and SPs
  Discussion is now about high performance packet networks

- Service capability may still be required
  Regulation
  Evolution may not be possible
Next Generation Transport Requirements

Policy Plane (per Subscriber)

- Portal
- Monitoring
- Billing
- Subscriber Database
- Identity
- Address Mgmt
- Policy Definition
- Presence
- Mediation

Access
- Residential
- Business
- Mobile
- AG
- DSL/PON
- Ethernet
- FR/ATM
- E1/ATM

Aggregation
- Single Tier Hub & Spoke or Ring

L3 Service edge

L3 Core

Ethernet
- Point to Point
- Point to MP
- Multi-point

Legacy Services
- ATM
- Frame
- TDM

NGN application
- Efficient IP multicast
- Efficient VoD delivery
- Call Admission Control

Others
- Standards based
- Cost Effective
- QoS, TE and recovery
- Fast provisioning

Mandatory
- Mandatory
- Optional
- Optional
- Mandatory

MPLS Japan 2007 8
Ethernet Transport And Convergence
Existing roles and responsibilities

- Organisational lines drawn based on networks
- Cross charging between groups
  - Transport to ATM, Transport to IP, ATM to IP
  - Creates considerable friction
  - Can cause organisational breakdowns (IP department buys dark fibre, dWDM gear)
Characteristics

- Multiple networks
  Different services, different capabilities
- Complex interaction between layers
- Layer 3 components tend to be fairly centralised in nature
- Most SPs believe the number of networks has to be rationalized
- New services are demanding more bandwidth
  Existing transport and ATM networks will not scale
  All see the need to build a high speed packet transport networks
Service Requirements

**Consumer**
- Internet
  - Voice / Video / data
- Voice
  - PSTN / Multimedia
- Video
  - Over the Top
  - Walled Garden
- Mobility

**Business**
- TDM/ATM → Ethernet
- L2 VPNs
  - Pt2Pt
  - Pt2MPt
  - MPt2MPt
- L3 VPNs
  - Connectionless
- Value-add Services
  - Based on L3 visibility

**Wholesale**
- TDM/ATM → Ethernet
- L2 VPNs
  - Pt2Pt
  - Pt2MPt
  - MPt2MPt
- L3 VPNs
  - L2TP
  - Connectionless

**Evolved services**
- PSTN
  - Migrate
- Mobile
  - RAN backhaul
  - IP transition
- TDM
  - Migrate and evolve to Ethernet
- ATM
  - Migrate and evolve to Ethernet
- F/R
  - Evolve to Ethernet
Moving forward

- **Service Oriented Architecture**
  Functionality placed where it makes sense for optimal service delivery
  Infrastructure and demographics
  Traffic flows

- **IP is the service protocol**
  Not Ethernet, Not optical, Not MPLS
  Other than dumbest optical transport all NGN networks need IP disciplines
  So do the organisations running them

- **Network convergence**
  CAPEX and OPEX reduction
  Ease of provisioning and service assurance
Control Plane Comparison
Provider Backbone Transport and T-MPLS

- NMS based Control Plane
- Long term support integrated control plane?
  - PBT and T-MPLS → G-MPLS
  - G-MPLS – Link state Protocol, RSVP etc
- Single Service Control Plane
  - Pt2Pt Only

PBT / T-MPLS : Simply moves complexity to the Network Management layer
Packet Transport forwarding and control plane

- **IP/MPLS (EoMPLS and VPLS):**
  - Lot of initial success: - but mainly sold as next generation ATM
  - Based on the encapsulation customer traffic in two or more labels
  - Label forwarding within the core based on provider label
  - IP/MPLS control plane

- **Provider Backbone Bridge-Traffic Engineering:**
  - Emerging Ethernet solution
  - Based on encapsulation of customer traffic in backbone mac address
  - Ethernet forwarding within the core based on provider backbone mac address
  - NMS based control plane (discussing the use of G-MPLS)

- **PBT:**
  - Vendor proprietary

- **T-MPLS:**
  - Emerging
  - Based on the encapsulation customer traffic in two or more labels
  - Label forwarding within the core based on provider label
  - NMS based control plane (discussing the use of G-MPLS)

- **Arguments over which option**
  - CAPEX cost: - Ethernet and transport solutions are cheaper than IP solutions
  - Complexity of IP control plane: - OPEX associated with operating the solution
Technology Uncertainty / Forecasting

IPv6
~7 years

MPLS
~7 years

802.1ah
~1 Year

PBB-TE/PBT
Less than 1 Year

Acceptance of Idea
Standard Work Initiated

First large-scale deployments
Standards Overview
T-MPLS and IETF MPLS

- T-MPLS supporter’s claim it is a subset of IETF MPLS
  - Pseudo-wire concept, same Ethertype
  - T-MPLS simplifications are covered by the IETF MPLS RFCs

- Inter-operability will be challenging
  - Different OAM mechanisms
  - Different signaling protocols for pseudo-wires
  - Different control planes using same Ethertype (label management)

- SG 15 Q.12 September 2007

Agreement to use IETF Standards Process for T-MPLS future work and to examine the existing ITU-T Recommendations by IETF to resolve any issues (inconsistencies, incompatibilities or omissions) with the use of IETF MPLS by amending already approved (or consented) ITU-T Recommendations.

- draft-ietf-pwe3-mpls-transport-01
IEEE 802.1Qay Provider Backbone Bridges Traffic Engineering

- New work item to define traffic engineering extensions for 802.1ah
- IEEE 802.1 Project Authorization Request (PAR) approved in November 2006
- Standardization expected to take at least 2-3 years
- Motivated by provider backbone transport (PBT) discussion
- How similar/different PBB-TE and PBT will look is unknown
802.3ah

- Link Level OAM
- Operates on point-to-point link, not propagated beyond a single hop.
- Slow Protocol (Max rate of 10 frames per second)
- Functions:
  - OAM discovery – Discover OAM capabilities on peer device
  - Link monitoring – Event notification when error thresholds exceeded
  - Remote MIB Variable Retrieval – Polling and response (but not writing) of 802.3ah MIB
  - Remote Failure indication – Inform peer that receive path is down.
  - Remote Loopback – Puts peer in (near-end) intrusive loopback state. Statistics can be collected while testing link.
802.1ag Connectivity Fault Management (CFM)

- End to End per EVC OAM
- Hierarchical Maintenance Domains
  MEPs/MIPs
- Standard Ethernet Frames (in-band)
  Continuity Check
  Loopback
  Link Trace
Y.1731

- CFM plus...
  - ETH-LCK (out of service diagnostics)
  - Multicast Loopback
  - AIS
  - TEST
  - Maintenance Communication Channel
  - Experimental OAM
  - Performance Management (Delay, Packet loss, Jitter)
E-LMI

- Asymmetric protocol, applicable on UNI only (uPE to CE)
- Specifies procedures & message formats exchanged and NOT how uPE collects OAM data – relies on Service/Network OAM running uPE to uPE
- Allows uPE to communicate to CE:
  - EVC Status
  - Remote UNI Status
  - CE-VLAN to EVC Map
  - BW Profiles
MPLS Evolution

IP + ATM Integration

- ATM Services
- IP Services
- IP+ATM Switch
- IP

Traffic Engineering:
Bandwidth Optimization of traffic

MPLS VPNs: Scalable Network based VPNs

Bandwidth Protection and Resiliency

Layer 2 Integration for a converged network

- Ethernet
- Frame Relay
- ATM

Optical Services
- IP Services
- IP+Optical Switch
- O-UNI
- MPLS

IP+Optical Integration
A pseudowire (PW) connects native Layer 2 attachment circuits.

Establishment of PWs is signaled between PEs using LDP.

LSP ultimately carries PW traffic between PEs.
Recent IP/MPLS Standards Published by IETF
In last 12-14 Months, Few of them..

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<td>4364</td>
<td>BGP/MPLS IP Virtual Private Networks (PS)</td>
<td>Feb-06</td>
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<td>4665</td>
<td>Service Requirements for Layer 2 Provider Provisioned Virtual Private Networks</td>
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<td>Framework for Layer 2 Virtual Private Networks (L2VPNs)</td>
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<td>4684</td>
<td>Constrained Route Distribution for Border Gateway Protocol/Multiprotocol Label Switching (BGP/MPLS) Internet Protocol (IP) Virtual Private Networks (VPNs)</td>
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<td>BGP-MPLS IP Virtual Private Network (VPN) Extension for IPv6 VPN</td>
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<td>OSPF as the Provider/Customer Edge Protocol for BGP/MPLS IP Virtual Private Networks (VPNs)</td>
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<td>Pseudowire Setup and Maintenance using the Label Distribution Protocol (LDP)</td>
<td>Apr-06</td>
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<td>Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN</td>
<td>Feb-06</td>
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<td>4197</td>
<td>Requirements for Edge-to-Edge Emulation of Time Division Multiplexed (TDM) Circuits over Packet Switching Networks</td>
<td>Oct-05</td>
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<td>Encapsulation Methods for Transport of Ethernet Over MPLS Networks</td>
<td>Apr-06</td>
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<td>4553</td>
<td>Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)</td>
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<td>Pseudowire Emulation Edge-to-Edge (PWE3) Fragmentation and Reassembly</td>
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<td>Encapsulation Methods for Transport of Frame Relay Over MPLS Networks</td>
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<td>Encapsulation Methods for Transport of PPP/High-Level Data Link Control (HDLC) over MPLS Networks</td>
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<td>Encapsulation Methods for Transport of Asynchronous Transfer Mode (ATM) over MPLS Networks</td>
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<td>A Path Computation Element (PCE) Based Architecture</td>
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<td>Path Computation Element (PCE) Communication Protocol Generic Requirements</td>
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<td>Requirements for Path Computation Element (PCE) Discovery</td>
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<td>Multiprotocol Label Switching (MPLS) Label-Controlled ATM and Frame-Relay Management Interface Definition</td>
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<td>Encoding of Attributes for Multiprotocol Label Switching (MPLS) Label Switched Path (LSP)</td>
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<td>Establishment Using Resource ReserVation Protocol-Traffic Engineering (RSVP-TE)</td>
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<td>Signaling Requirements for Point to Multipoint Traffic Engineered MPLS Label Switched Paths (LSPs)</td>
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<td>Definition of a Record Route Object (RRO) Node-Id Sub-Object</td>
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<td>Operations and Management (OAM) Requirements for Point-to-Multipoint MPLS Networks</td>
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<td>Generalized Multi-Protocol Label Switching (GMPLS) Signaling Extensions for G.709 Optical Transport Networks Control</td>
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<td>A Transport Network View of the Link Management Protocol (LMP)</td>
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<td>A Lexicography for the Interpretation of Generalized Multiprotocol Label Switching (GMPLS)</td>
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<td>Terminology within The Context of the ITU-T's Automatically Switched Optical Network (ASON)</td>
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<td>Recovery (Protection and Restoration) Terminology for Generalized Multi-Protocol Label Switching (GMPLS)</td>
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<td>4428</td>
<td>Analysis of Generalized Multi-Protocol Label Switching (GMPLS)-based Recovery Mechanisms</td>
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<td>GMPLS - Communication of Alarm Information</td>
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<td>Reoptimization of Multiprotocol Label Switching (MPLS) Traffic</td>
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<td>Engineering (TE) Loosely Routed Label Switch Path (LSP)</td>
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Apart from this list, there are many draft standards that were published in this period which will eventually become new standards in coming months.
Service Mapping and Applicability
Building Network Services

- What are the important services?
- What are the transport requirements?
  - Point to Point Transport
  - Multipoint Transport
  - Multicast for Video Delivery
  - Legacy Integration & TDM Circuit Emulation
Multi-vendor Interoperability

- Multi-Vendor Interoperability is key to ensure
  - No Proprietary Implementation is Deployed
  - No vendor Lock-in
  - Investment protection

- Crucial to test Multi-vendor interoperability for critical services/requirements of the network to ensure right selection of technology
  - Traffic protection
  - Services: Point-to-Point, Multipoint-to-Multipoint, Multicast
  - Legacy Integration (e.g. ATM Transport)
  - Quality of Service
  - OAM
Some Historical Background of Layer 3 vs. Layer 2

- In past 10 years, there have been at least 2 major attempts to “revolutionize” networking by introducing a Layer 2 approach with arguments that Layer 3 is either unnecessary, more complex and more expensive –
  - End-to-End Pure Layer 2 Switching
  - ATM LAN Emulation

- Both failed Miserably with time!

- IP/MPLS is revolutionary in a way since it unites the benefits of both Layer 2 and Layer 3 together!

Didn’t we finish the L2 vs L3 wars already?
Is a Layer 2 Based Solution Cheaper than a Layer 3 Based Solution?

Some considerations:

- Cost of overlay networks required for legacy integration
- Cost of network management system
- Cost of overlay network/intelligence required for supporting Multicast and Video
- Cost of manual provisioning & management since network doesn’t have intelligent control plane
- Cost of adding Intelligence (GMPLS) to the solution that has no control plane
- Cost of important features on network elements like Hierarchical-QoS (H-QoS), etc
Summary
Summary

Key Points to Consider Before Selecting Technology for Building your Next Generation Ethernet Network

- Technology State, Standardization, Maturity, Field Proven, Future Roadmap
- Network Intelligence: Integrated Control Plane or Proprietary NMS Control Plane
- Is Selected Technology agnostic of transport protocols so that it allows you to migrate smoothly
- Are All Required Services can be offered by the Technology or basic services itself requires workarounds.
- Is technology Multi-Vendor Interoperable
- Last but not the least, its combined capital & operational cost
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