Carrier Ethernet – Cisco’s Future Vision and the Alignment with the IP NGN

Istvan Kakonyi
Consulting Systems Architect
Agenda

1. Introduction
2. Architectural Evolution of the IP NGN
3. Technology Alternatives
4. Carrier Ethernet Aggregation System Reloaded
   Service Delivery Models
   Foundation Technologies
   Cisco EVC
   QoS and admission Control
   Multicast delivery for Video
5. Product Update
6. Q and A
Introduction
Carrier Ethernet Evolution
Towards a Combined L2-Services & Transport Layer

1st wave
Carrier Ethernet used to provide high bandwidth business services
Happened: Niche application

2nd wave
Carrier Ethernet employed in consumer broadband services / aggregation
Happening: Mainstream application replacing ATM solutions

3rd wave
Carrier Ethernet replaces SDH/SONET transport infrastructure
Beginning but long term: 10–20 Year transition
Example

Multi-Site WAN Market Changes in the Netherlands

Data Source: KPN quarterly reports
http://www.kpn.com/kpn/show/id=965927/contentid=20417
The Next Horizon—Video

- Broadcast Television
- Video Phone / Video Conferencing
- Video Streaming
- Video On Demand
- TV On Demand / nPVR
- Gaming / Interactive TV
- Video to Other Devices

Managed Video Applications
Video Communications Services
“Over the Top” Video
The Goal: Service-Optimized Access & Aggregation

NGN Access & Aggregation networks move from circuit-based to packetized transport.
Architectural Evolution of the IP NGN
Overall IPNGN Network Requirements

- **Access**
  - Residential: DSL/PON, Ethernet, TDM, E1/ATM
  - Business: DSL/PON, Ethernet
  - Mobile: TDM, E1/ATM

- **Aggregation**
  - Hub & Spoke or Ring
  - Portal, Monitoring, Billing, Subscriber Database, Identity, Address Mgmt, Policy Definition, Presence, Mediation

- **L3 Service Edge**
  - L3 Core

- **NGN Operations**
  - End-to-End OAM
  - Tight SLAs
  - Simple Operations
  - Fast Provisioning

- **Ethernet**
  - Point-to-Point
  - Point-to-MPt Multipoint
  - Mandatory

- **Legacy Services**
  - ATM
  - TDM
  - Optional

- **NGN Applications**
  - Optimal IP Multicast
  - Efficient VoD Delivery
  - Admission Control

- **NGN Design**
  - Standards Based
  - Cost Effective
  - Deterministic QoS
  - Fast Svc Recovery

  Mandatory
IPNGN Approaches Based on MPLS [1]

- **Common IP/MPLS control plane for L1, L2 and L3 Services**
- **Integrated L1/L2/L3 Service Model**
  - L3VPNs, VPWS and VPLS
- **Yesterday**
- **L2 Service Model**
  - VPWS and VPLS
IPNGN Approaches Based on MPLS [2]

Services
- Residential: BTV/VoD, VoIP, HSI
- Ethernet VPN: E-Line
- Ethernet VPN: E-LAN/-Tree
- IP and IP-VPN

802.1ad (Q-in-Q) Ethernet
- L2 MPLS Aggregation Service Model
- MST/LAG/REP
- L2+L3 MPLS Aggregation Service Model

- EoMPLS
- 802.1ad
- IP or IP-VPN
- EoMPLS
- H-VPLS
- VPLS
- EoMPLS
- 802.1ad
- IP or IP-VPN
- IP or IP-VPN
- EoMPLS
- H-VPLS
- VPLS
- IP or IP-VPN
- IP or IP-VPN
- IP or IP-VPN
Cisco Converged IPNGN Architecture

### RAN Backhaul
- PWE3 or IP based
- Per Service QoS
- Distribution of Clock

### FTTX Aggregation
- High density Fibre
- Per Service QoS
- Session awareness

### High Speed Internet (HSI)
- L2 EoMPLS Backhaul
- Per subscriber QoS
- Central L3 and services
- PPPoE & DHCP

### Video and Voice
- L3 edge distributed for efficient multicast and resiliency
- Virtualization options
- Per service QoS

### Mobile Edge
- GGSN
- PDN, MME, Serving GW
- LTE/SAE Evolution

### Business VPN
- L2 EoMPLS backhaul
- Per subscriber QoS
- Central or distributed services (L3 VPN, L2 VPN, VPLS)
Technology Alternatives
New Kids on the Block
Emerging and Revisited Ideas

1. 802.1ay Provider Backbone Bridging – Traffic Engineering (PBB-TE) / PBT
2. Transport MPLS (T-MPLS) – ITU G.8110
3. These are initiatives by „traditional” telecom vendors
4. Common characteristics are:
   - their goal is leveraging the installed base of SDH / L2 gear
   - force customers towards proprietary solutions
   - the rely on NMS / OSS systems (no dynamic control plane in the network)
   - No multi-service capabilities
1. In a sentence:
   Basically using 802.1ah data-plane functionality with OSS/NMS provisioning in lieu of IEEE control protocols (MSTP, GVRP, etc.) to setup P2P VCs.

2. It Consists of the following three components:
   Data-plane based on 802.1ah
   OAM based on 802.1ag
   A protection switching mechanism similar to MPLS TE Path Protection (protection path switching between two edge switches)
How Does It Work?

1. Use OSS to configure B-MACs and B-VLANs manually in the bridge along both primary and backup paths.

2. Use CFM Continuity Check Messages to monitor the primary and the backup paths.

3. Upon failure of the primary path, configure the edge switches (BEB1 & BEB2) to switch to the backup path.

BCB: Backbone core bridge  BEB: Backbone Edge bridge

Network Provisioning and Management System

Primary
SA: BEB1
DA: BEB2
B-VLAN: 10

Backup
SA: BEB1
DA: BEB2
B-VLAN: 20

CE

BEB1

BCB

BCB

BCB

BCB

BCB

BEB2

CE
Some Pending Questions Regarding PBT

1. What is the applicability?
2. Does it satisfy the requirements of a wide range of services?
3. If multipoint transport requires 802.1ah, what is the operational complexity of running PBB and PBT simultaneously?
4. What is the protection scalability? What are the target restoration times? For how many trunks?
5. What are the real benefits compared to other existing Ethernet transport alternatives?
T-MPLS (which is ended up in MPLS-TP by IETF)

Network Provisioning and Management System

Client Network

CE1

Client Virtual Circuit

Ethernet Frame

Adaptation Layer

MPLS LSP Stacks

Layer 1

T-MPLS network

T-MPLS Primary LSP

PE1

T-MPLS Backup LSP

PE2

Client Network

CE2

Client Virtual Circuit

Ethernet Frame

Adaptation Layer

MPLS LSP Stacks

Layer 1

T-MPLS between PEs

Adaptation layer on the PEs to enable transport of specific payload

Ethernet connection between CEs
T-MPLS

1. Connection oriented packet switched transport over an optical transport network
   Architecture based on ITU-T G.805

2. Its main characteristics are:
   - Data plane: Ethernet (today), no load balancing, same EtherType as MPLS
   - OSS/NMS based model: Static assign label, no control plane
   - OAM: Complete framework need to be review by IETF and ITU-T
   - Protection switching and Survivability based on ITU-T Y.1720/G.8131 (end-end protection) and Y.mrps (ring protection switching)

3. No or difficult interworking with MPLS Suite
IETF MPLS transport draft

Client Virtual Circuit, Adaptation layer on the PEs to enable transport of specific payload
Ethernet, IP, MPLS, ATM, FR, Circuit Emulation connection between CEs

AC Frame
Adaptation Layer
MPLS LSP Stacks
Layer 1

Service Provisioning and Management System
IETF based MPLS (GMPLS)
pseudowire LSP
Local & end-end protected LSP

PW between PEs
Adaptation layer on the PEs to enable transport of specific payload

Ethernet, IP, MPLS, ATM, FR, Circuit Emulation connection between CEs
IETF MPLS transport draft

1. Connection oriented packet switched transport over an optical transport network

   IETF draft-bryant-pwe3-mpls-transport
   Based on ITU requirements and IETF pseudowire definitions

2. Its main characteristics are:

   Data plane: Multi-protocol, load balancing in option.
   Integrated or OSS/NMS based model:
      External/Static configuration
      Dynamic control plane (GMPLS, MPLS TE, …)
   OAM: Two VCCV profiles
      BFD without IP/UDP headers
      BFD with IP/UDP headers
   Protection:
      Local and End-to-end repair
      Proactive repair

3. Interworking with MPLS protocol suite
Control Plane Comparison

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

PBT / T-MPLS : Simply moves complexity to the Network Management layer (and leads into disaster if NMS fails...)

---

1. Integrated Control Plane
2. Multi-service Control Plane
   - L1, L2, L3
   - Pt2Pt, Multipoint
Carrier Ethernet Technologies
Forwarding Plane Comparison

1. IP/MPLS
   - Customer packet encapsulated in an MPLS label stack
   - Forwarding based on a label switch

2. PBT / PBB-TE
   - Customer packet encapsulated in 802.1ah
   - Forwarding with modified Ethernet switching

3. VLAN-XC
   - Customer packet encapsulated in 802.1ad dot1q or QinQ
   - Forwarding with VLAN tag Swapping

4. T-MPLS (now aligned with IETF!)
   - Customer packet encapsulated in MPLS label
   - Forwarding based on a label switch

**Strong Similarities, Hence Associated Costs Should Be Similar (Assuming Edge Functionality Is Similar!)**

- **Service Instance mapping functions (VLAN acrobatics)**
- **Security/anti-spoofing functions**
- **QoS/Shaping/Scheduling functions (often hierarchical)**
- **Provisioning/Policy Enforcement functions**
CE Aggregation Reloaded – Recent Additions
Retail Residential Services Architecture

Distributed Edge

Service

Internet, VoIP, VoD, Mobile
Backhaul, PSTN migration

N:1, 1:1 VLAN models

IP service subnets

IP Model
IPTV-mcast
N:1 VLAN model

IP-VPN, VPNv6
(incl. half-duplex)

Access Node UNI and connectivity models:
• Trunk (Multi VC) UNI, N:1 Service VLAN
• Trunk (Multi VC) UNI, 1:1 Internet Access VLAN
These models are the baseline in TR-101 and present in existing Access Nodes implementations

PIM / BGP / IGP / LSM control plane
IPmc / mVPN / LSM data plane

Access

Aggregation/Edge

Core

Access Domain

Carrier Ethernet Node

Carrier Ethernet Node

DSL, WiMAX, Ethernet

IP/MPLS

IP/MPLS

IP/MPLS

Presentation_ID © 2008 Cisco Systems, Inc. All rights reserved. Cisco Confidential
## Retail Residential Services Architecture

### Centralized Edge with L2 MPLS Backhaul

**Service**

<table>
<thead>
<tr>
<th>HSI, VoIP, VOD</th>
<th>N:1, 1:1 VLAN models</th>
</tr>
</thead>
<tbody>
<tr>
<td>N:1, 1:1 VLAN models</td>
<td>VPWS PW</td>
</tr>
<tr>
<td>HSI / IP service subnet</td>
<td>Single PW per Aggregation Node</td>
</tr>
<tr>
<td>IPTV-mcast</td>
<td>VPLS with IGMP Snooping</td>
</tr>
<tr>
<td>N:1 VLAN model</td>
<td>Single PW per Aggregation Node</td>
</tr>
</tbody>
</table>

**Access**

- DSL, WiMAX, Ethernet

**Aggregation**

- MPLS / IP

**Edge**

- PPP, IP, MPLS

**Core**

- MPLS

**Access Node**

- Ethernet I-NNI

**Aggregation Node**

- Ethernet I-NNI

**Distribution Node**

- Ethernet I-NNI

**Access Node UNI and connectivity models:**

- Trunk (Multi VC) UNI, N:1 Service VLAN
- Trunk (Multi VC) UNI, 1:1 Internet Access VLAN

*These models are the baseline in TR-101 and present in existing Access Nodes implementations.*
L3 Business Services Architecture
Centralized and Distributed

Service

Centralized Business IP-VPN
Port, 1:1 VLAN
EoMPLS PW
Ethernet QinQ

Distributed Business IP-VPN
Port, 1:1 VLAN
Ethernet QinQ

Access
Access Node
DSL, WiMAX, Ethernet

Aggregation
Aggregation Node
MPLS / IP

Edge
Distribution Node
MPLS / IP

Core
MSE
MPLS NNI
IP, MPLS
MPLS

Ethernet I-NNI
IP/MPLS NNI
MPLS-VPN
IP-VPN, VPNv6, mVPN
Ethernet I-NNI
IP/MPLS NNI
MPLS-VPN
IP-VPN, VPNv6, mVPN

Centralized and Distributed
IP-VPN, VPNv6, mVPN

Presentation_ID
© 2008 Cisco Systems, Inc. All rights reserved.
Cisco Confidential
Presentation_ID
L2 Business Services Architecture

E-LAN and E-Line

Service

Business E-LAN

Port, 1:1 VLAN

VPLS Spoke PW

VPLS PW

VPLS PW

H-VPLS

MPLS NNI

VPLS

MPLS NNI

Business E-LINE

Port, 1:1 VLAN

VPLS PW

VPLS PW

MPLS NNI

MPLS NNI

Port, 1:1 VLAN

VPWS PW

MPLS NNI

Port, 1:1 VLAN

VPWS PW

S

Access

Carrier Ethernet Node

Carrier Ethernet Node

Access Domain

IP/MPLS

IP/MPLS

DSL, WiMAX, Ethernet

Aggregation/Edge

Core
Wholesale Services Architecture
L3 and L2 Models

Service

L3 Wholesale
Port, 1:1 VLAN
IP-VPN, VPNv6, mVPN
IP/MPLS NNI

L2 Wholesale
Port, 1:1 VLAN
VPWS PW
IP/MPLS NNI

Access
Carrier Ethernet Node
DSL, WiMAX, Ethernet

Aggregation/Edge
Carrier Ethernet Node
IP/MPLS

Core
Carrier Ethernet Node
IP/MPLS
Carrier Ethernet – Foundation Technologies

1. Flexible Ethernet UNI with Cisco EVC
2. Quality of Service and Admission Control
3. Unicast and Multicast Video Delivery
## Flexible Ethernet Edge Requirements

### Adaptable Ethernet UNI

1. Support all Ethernet Encapsulations
   - 802.1Q, 802.1ad, Q-in-Q, 802.1ah
2. Flexible VLAN tag manipulation and translation
3. Flexible frame to service mapping
4. Multiple services on the same port (multiplexed UNI)
5. Local VLAN significance (per-port)

### Service functions

1. In/out H-QoS
2. Security
3. High Availability
4. OAM and SLA monitoring
5. Flexible connectivity models
6. Service instance scalability
7. Standards based
Cisco’s Approach to the Ethernet UNI

Ethernet Virtual Connection

One service instance can match one or multiple or range of VLANs at a time

Per service features

Service Instance

EVC (Ethernet Virtual Connection)

L3
VPLS
EoMPLS

Local connect (P2P)
Local Bridging (MP)

Flexible L2/L3 service mapping, one or groups of EFPs can map to the same EVC

Flexible VLAN tag matching, pop/push/translate
Simple configuration

- VLAN local port significance
- Two VLAN tag aware
- Flexible VLAN tag matching (combination of up to two tags)
- 802.1ah (future)

- Flexible VLAN tag manipulation,
- H-QoS per VLAN
- Security

Service Instance

Flexible VLAN tag matching

H-QoS per VLAN

Flexible VLAN tag rewrite

Security

Per service features
Cisco EVC Infrastructure

Overview

- EVC infrastructure
  - Provides most flexible classification of L2 flows on Ethernet interfaces
  - Supports dot1q and Q-in-Q, 802.1ad
  - Supports VLAN list, ranges & combinations
  - Coexists with routed subinterfaces
  - Flexible VLAN acrobatics (translate, pop, push)
  - Full H-QOS support

EFP – Ethernet Flow Point
EVC – Ethernet Virtual Circuit
Flexible Ethernet Edge Applied
Carrier Ethernet – Foundation Technologies

1. Flexible UNI with Cisco EVC
2. Quality of Service and Admission Control
3. Unicast and Multicast Video Delivery
End-to-End QoS Requirements

1. Ensure deterministic network response to guarantee per class QoS SLAs
   Min and Max Bandwidth, Latency, Jitter
   Per class guarantees including under congestion

2. Simple and scalable engineering
   Rely on
   granular QoS conditioning at the edge and
   aggregate DiffServ in transit nodes

3. Streamlined operations
   Per class OAM-based measurements of SLA parameters
   Scalable monitoring and reporting
Ensuring QoS SLAs

UNI
- Ingress and Egress maximum/minimum bandwidth
- Ingress hierarchical shaping/scheduling
- (e.g. Port, S-VLAN, C-VLAN, Class)
- Ingress hierarchical policing
- Ingress and Egress DiffServ queuing per shaped max Bw priority levels
- 2 strict priorities
- 3 parameter scheduler (max, min, remaining)
- Service grouping for shared policies
- Classification on customer or provider marking
- Traffic stats per VLAN interface and per QoS class

MPLS Transport

CE-A

Ethernet Virtual Circuit (EVC) – Point-to-Point

CE-B

Ethernet Virtual Circuit (EVC) – Multipoint

NNI/Metro-Core
- DiffServ queuing
  - 4 priority levels
  - 2 strict priorities
  - 3 classes

Change priority levels to scheduling levels

Change to:
- Aggregate queuing

EVC - An association of two or more UNIs
- Connection between two or more devices
UNI SLA QOS Enforcement

1. Symmetric (ingress/egress) enforcement of max / min bandwidth and DiffServ behaviour per customer (VLAN)
2. Hierarchical scheduling & shaping
3. Dual Priority Queue for Voice and Video
4. Scalable (thousands of customers/VLANs)
Linecards with Scalable H-QoS
3-Level Hierarchy Example
Cisco’s Integrated Video CAC

1. Integrated Video CAC approach combines two methods
   
   **On-path RSVP-CAC**
   
   - Topology aware, handles dynamic topology changes
   - DSCP-based implementation eliminates scale challenges experienced with Intserv
   - Proven scale – tested to 50-100,000 sessions with 500 set ups per second
   - Layer 3 required at PE-AGG to implement path-based CAC

   **Off-path CAC** based on Policy Server for DSL line congestion

2. VOD stream will be denied if business rules of either fail

3. Prioritize blocking of Free VOD vs. Pay VOD in network failure scenarios
Carrier Ethernet – Foundation Technologies

1. Flexible UNI with Cisco EVC
2. Quality of Service and Admission Control
3. Unicast and Multicast Video Delivery
Video Delivery Requirements

1. Transport and Bandwidth Efficiency
   - Bandwidth scale - N x GE / 10GE -> N x 100GE
   - Optimal multicast distribution trees for available topology, incl. failure conditions
   - Load balancing for multicast and unicast Video
   - Admission control for multicast and unicast Video

2. Resiliency
   - Network level resiliency
   - System level resiliency
   - Video service level resiliency

3. (User) Quality of Experience
   - Service and user level QoS
   - Video monitoring
   - Video delivery management
Cisco IP/MPLS Solution – Benefits [1]

1. Optimal and Scalable Forwarding
   - PIM SSM optimal multicast distribution tree for all topologies and failure conditions
   - Dynamic Load Balancing on equal cost paths
   - Optimized ARP and IGMP tables scale through distribution
   - Flexible content injection, including localized content
   - Distributed L3 for network nodes and subscribers scalability in any topology
   - Allows for on-path Video Admission Control

2. Resiliency
   - Consistent IGP and PIM Fast Convergence in all failure cases: Source-, Node-, Link - Failures.
   - Anycast-Source model for Video Source redundancy
   - Fast ReRoute options also available: TE-FRR and MoFRR
   - PIM SSM Security & Address-Space Efficiency - Proven architecture in many large 3Play production networks today
Cisco IP/MPLS Solution – Benefits [2]

1. Simplified Operations
   - Standard PIM/IGMP setup, no snooping necessary in aggregation network – snooping contained in DSLAM
   - Seamless integration with IP/MPLS core
   - Stateful, fully traceable multicast distribution tree – easy to operate and troubleshoot
   - Single Point of L3 termination for IPTV (no VRRP required)

2. Compatibility with all Video distribution architectures
   - Easy to add / distribute advanced Video service functions, incl. Video error repair, rapid channel change, targeted advertisement insertion and monitoring
   - Simple integration of Video monitoring and management functions
   - Flexible placement of Video streaming functions
Video optimised Diffserv Schedulers

1. Cisco leads the industry in the development and support of multi-priority schedulers implementations

2. Enables differentiation between premium services, requiring bounded delays

Diagram:
- Classifier
- Per-class policy
- Scheduler
- EF #1
- EF #2
- AF #1
- AF #n
- RED
- Tail Drop
- Strict priority queue
- Bandwidth queue
- Policer
- Classifier
- Scheduler
Quality of Subscriber Experience

Video Quality Monitoring*

- **Video quality problem** detected & Reported to Video Mgmt System
- **Compute Video Quality** at each system between receiver and source
- **Troubleshoot** location where Quality first degrades
- **Correct the problem and restore** video quality

* Some functions subject to future availability. Please check for platform specific support.
Video SLA Requirements
Managing Loss

1. A number of technological approaches to achieve required SLA
   - Network approaches to reduce loss: fast convergence, fast reroute
     - Application approaches to recover from loss experienced: FEC, Temporal Redundancy, Spatial Redundancy
     - Network approaches for engineering spatial redundancy: MoFRR, MTR, MPLS TE

2. Number of network deployment models to support each approach

3. Application level approaches may also impose requirements on the network

4. Different combinations of models and approaches have different pros / cons and cost vs. complexity trade-offs
Fast Convergence - MPEG Video Example
Real vs. Perceived Requirements

1. <1 or 2 seconds: humans do not bother
2. <200msec: humans do not notice
3. <50msec: humans have a perception of being better off

Requirements often dictate complexity of the design
Towards Lossless IPTV Transport

Possible Deployment Scenarios

What are relative positions of these technologies in the loss vs. cost/complexity matrix?
Multicast (PIM SSM) Fast Convergence
Convergence Time for All Channels Following a Network Failure

Prefix prioritisation allows important groups (e.g. premium channels) to converge first

No more than one I-frame loss even in the worst case

Tested with 2500 IGP prefixes and 250k BGP routes
Impact of multicast convergence on unicast convergence is negligible

Developments with IP optical integration can further reduce the outage to sub 20ms in many cases (lossless in some cases)
Multicast only Fast Reroute (MoFRR)
How It Works – Key Concepts

- **Automated Diverse Routing**: deliver two disjoint branches of the same IPTV PIM SSM tree to the same PE

- **Target <50msec**: the PE locally switches to the backup branch upon detecting a failure on the primary branch
  
  IPTV Inter-packet Gap is 0(1msec). Upon not receiving any packet from the primary branch for 50msec, switch-over to the backup feed.

  Initial implementation based on IGP FC trigger – targeting O(100msec) recovery

- **Hitless**: the PE uses the two branches to repair losses and present lossless data to its IGMP neighbors
  
  Leverage RTP sequences to repair losses

- **Simple approach**: from a design, deployment and operations perspective
MoFRR in Two-Plane Network Design
Engineering and Operational Benefits

1. MoFRR needs to be deployed only on PEs

2. No additional capacity demand

3. Path diversity is a native property of the design – no need for explicit routing techniques

4. Relies on standard-based IP multicast routing – leverage the operational experience

Operational Simplicity a Fundamental Property of the Solution
Towards Lossless IPTV Transport

Deployment Scenarios

Increasing Cost and Complexity

Options where a lossless solution is required and the topology does not support path diversity with MoFRR
- Option where multicast is delivered over L2/VPLS pseudowires over TE LSPs. Also applicable to LSM deployments. More complex to operate vs. MoFRR, bandwidth inefficiencies in failure cases.
- Recommended approach where some loss is tolerable and topology supports MoFRR
  - Lowest bandwidth used in working and failure cases
  - Lowest solution cost and complexity
  - Constrained impact of network failures on video

Options where no network re-engineering is required
- Recommended where lossless approach is required and topology supports path diversity with MoFRR
  - Lowest bandwidth used in failure cases
  - Low solution cost and complexity
  - Does not apply to all topologies

Recommended where some loss is tolerable and topology does not support MoFRR
- Lowest bandwidth used in working and failure cases
- Lowest solution cost and complexity
- Constrained impact of network failures on video

Lossless

1 GOP Impact
IP NGN Product Update
Cisco IP NGN Infrastructure in FY ’09

Access
- Cable
- DSL
- Wireless
- CE Access
- ME3400E

Carrier Ethernet Aggregation
- ME4500 with EVC & MPLS support
- C7600 with ES+ linecards

IP / MPLS Core
- CRS-1

IP / MPLS Edge
- ASR 1000 (BNG)
- 10000 (BRAS)
- 12000 (MPLS PE)

SP Data Center
- Nexus 7000 (DC Switch)
- CRS-1

Presentation_ID © 2008 Cisco Systems, Inc. All rights reserved. Cisco Confidential
Cisco 7600: functional enhancements

Network and Node Resiliency

**MPLS Access**

**Dual Homed Access**

**Ring Access**

**Cisco 7600**

**Access Resiliency Mechanisms**
- EoMPLS PW Redundancy
- Resilient Ethernet Protocol (REP)
- Spanning Tree (MST, PVRSTP)
- Single and Multi-Chassis (SRE) 802.3ad (mLACP)

**Node Resiliency Mechanisms**
- Protocol Inclusive NSF/SSO
- EFSU/ISSU
- Fully Redundant Commons

**Core Resiliency Mechanisms**
- 2-way PW Redundancy (SRE)
- MPLS TE/FRR
- Hot Standby PW (SRE)
- MAC withdrawal for VPLS
- Static MAC for EVC
- Single and Multi-Chassis (SRE) 802.3ad (mLACP)
Cisco 7600: **ES+ Linecard Architecture**

1. 40 Gbps throughput with features enabled
2. Better QoS capabilities (MQC, 128K queues, 4 hierarchies)
3. Feature Richness via Network Processors
   - IEEE 802.1 ah PBB, BEB functionality – over VPLS
   - Video Monitoring by hw.
   - Distributed Single Edge BRAS solution (ISG)
4. Different hardware flavours
5. IPoDWDM
Cisco 7600: DWDM Solution
IPoDWDM linecard with pluggable optics

Transponder Integrated into 7600

7600
ROADM

IPoDWDM 40G with Ethernet Services:
- 4x10GE and 2x10GE based on ES+40
- G.709/FEC/OAM Capability
- DFC Version – 3CXL
- Supported on all existing 7600 chassis
- XFP Pluggable DWDM Optics
Cisco IP NGN Infrastructure in FY ’09

Carrier Ethernet Aggregation

- ME4500 with EVC & MPLS support
- C7600 with ES+ linecards
- C7600/ASR9000

Access

- Cable
- DSL
- Wireless
- CE Access

ME3400E

IP / MPLS Edge

- ASR 1000 (BNG)
- 10000 (BRAS)
- 12000 (MPLS PE)

Carrier Ethernet Aggregation

- ASR 1000 (BNG)
- 10000 (BRAS)
- 12000 (MPLS PE)

IP / MPLS Core

- CRS-1

SP Data Center

- Nexus 7000 (DC Switch)
- CRS-1

ME3400E

Cisco Confidential

Presentation_ID  © 2008 Cisco Systems, Inc. All rights reserved.
ASR 1000 Overview

1. Next-generation of Midrange router family
   - 2RU / 4RU / 6RU chassis
   - 5 / 10 / 20+ Gbps forwarding with services
   - Simple scale: 10-20-(40G) just by changing FP [5G-10G in 2RU]
   - Dual AC or DC power supplies

2. Differentiators
   - Designed for High Availability
   - HW redundancy for 6RU (RP and FP) with ISSU
   - SW redundancy for 2RU/4RU: In-service software upgrade, even with one RP
   - State of the art H-QoS (3 level, 128K+ queues)
   - Integrated services (no service blades), software-licensed based features (SBC, FW, NBAR, etc.)
   - Powerful control plane in RP –Route Reflector apps

3. Simple Migration
   - SPA support – same interfaces as 7600/12K/CRS-1
   - IOS features, CLI – simple migration from existing 7200 deployments

Initial target applications:
- Broadband (IPTV, Triple Play)
- IPSec Termination
- High-speed CPE/Managed Svcs
- BGP Route Reflector
Investment Protection
ASR 1000 Scale

Shared Port Adapters
Interface Flexibility

ASR 1002
ASR 1004
ASR 1006
RP-1
RP-2
Chassis

5G
10G
20G
40G+
Future
ASR 1000 in Service Provider IP Next Generation Networks

- High Speed CPE
- BRAS-PPPoE
- LAC, PTA, ISG
- IPSec Aggregator
- VoIP SBC
- PE (L3VPN PE)
- LNS
- Route Reflector
- Internet Peering
Cisco IP NGN Infrastructure in FY ’09

Access
- Cable
- DSL
- Wireless
- CE Access
  - ME3400E

Carrier Ethernet Aggregation
- C4500 with EVC & MPLS support
- C7600 with ES+ linecards

IP / MPLS Core
- CRS-1
- Nexus 7000 (DC Switch)
- SP Data Center

IP / MPLS Edge
- ASR 1000 (BNG)
- 10000 (BRAS)
- 12000 (MPLS PE)
ASR9K At a Glance

1. Optimized for Aggregation of Dense 10GE and 100GE

2. Designed for Longevity: Scalable up to 400 Gbps of Bandwidth per Slot

3. Based on IOS-XR & ANA for Nonstop Availability and Manageability

4. Enables Convergence with Integrated Layer 3 Services Intelligence
**ASR9K System Overview**

- Based on IOS-XR
- Managed by ANA 4.1
- FCS in Q3 FY ’09

<table>
<thead>
<tr>
<th>Linecards per Chassis</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 slots</td>
<td>8 LC + 2 RSP</td>
<td>12 LC + 2 RSP</td>
</tr>
<tr>
<td>6 slots</td>
<td>4 LC + 2 RSP</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linecard Density</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 slots</td>
<td>200 Gbps</td>
<td>200 Gbps</td>
</tr>
<tr>
<td>6 slots</td>
<td>200 Gbps</td>
<td>200 Gbps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bandwidth per Slot</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 slots</td>
<td>400 Gbps</td>
<td>400 Gbps</td>
</tr>
<tr>
<td>6 slots</td>
<td>400 Gbps</td>
<td>400 Gbps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bandwidth per Chassis</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 slots</td>
<td>6.4 Terabits</td>
<td>9.6 Terabits</td>
</tr>
<tr>
<td>6 slots</td>
<td>3.2 Terabits</td>
<td></td>
</tr>
</tbody>
</table>
ASR9K System Architecture

Distributed Basics of the Architecture

Forwarding Plane

Eight Line Cards (Independent Forwarding)
Highly programmable NPU LC Architecture, with Dual Core CPU
4 NPU’s per LC for line-rate 40G
Robust Queuing w/ 256K Q’s per LC

Integrated IOS-XR Control-plane & Switching Fabric
Redundant Route Switch Processors (RSP)

Non-blocking memory-less fabric
1:1 Redundancy
Service Intelligence with hi/lo priority uni-cast/multicast recognition & VoQ’s
IOS-XR Powers the Edge with ASR9K
A Fully Distributed, Microkernel-Based Architecture

Modular Components
- Routing Composite
  - MPLS
  - RIP
  - OSPF
  - BGP
  - ISIS
- Host Composite
  - Manageability
  - Security
  - Forwarding
  - Base
  - Admin
  - Line Card

Applications Architecture
- IS-IS
- Multicast
- Distributed Middleware
- QoS
- BGP

Distributed Service Separation
- LC1: OAM, MAC, VLAN, Subs
- LC2: OAM, MAC, VLAN, Subs
- LCn: OAM, MAC, VLAN, Subs

Next Generation Architecture
1. Microkernel-based design
2. Highly modular, highly extensible
3. ‘Service-enabled’ blade architecture

Designed for Scale, HA, and Performance For IP NGN Applications
1. Scale through distribution
2. Unique address tables per linecard
3. Process-level, stateful subscriber HA
Q&A