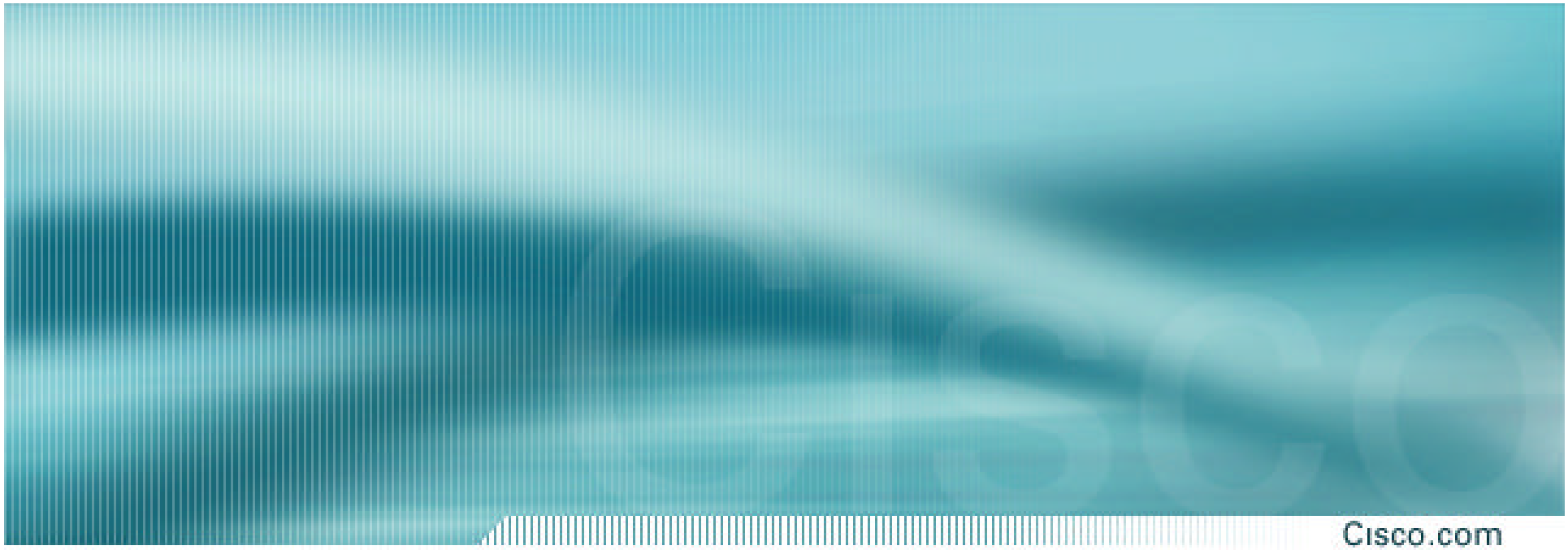


Metro Ethernet Architectures & Case Studies

What is a Network Architecture?

"The term 'architecture' is of great importance for system engineering and software development, but often defined very vague and often used different."

[Leist 2002]

"What is an architecture?: Objects, which are representing/defining the structure of a System."

[Foegen/Battenfeld 2001; Bass/Kazman 1999; Bass/Clements/Kazman 1998; Clements 1999]

"A network architecture is a structure or structures of a system, which comprises network components, their externally visible properties and the relationship between them."

[Bass/Clements/Kazman 1998]

Multilayer Service Portfolio
One Architecture – Many Services

ETTB

Enterprise/Business: Layer 1 to 7 focussed

Residential/Consumer: Layer 3 to 7 focussed

ETTx

Storage Web Hosting

Directory Service

Business Continuance

Secure Email

Instant Messaging

Hosted Telephony

ecurity; CCTV

Streaming (Audio, Video)

Corporate Access

Content Screening

Home Device Mgmnt

Enter-tainment

Service Revenue

Layer 3+

Managed Services / CDNs etc…

Layer 3

IP VPNs | **Business Class Internet Access** | **Always-On Internet Access**

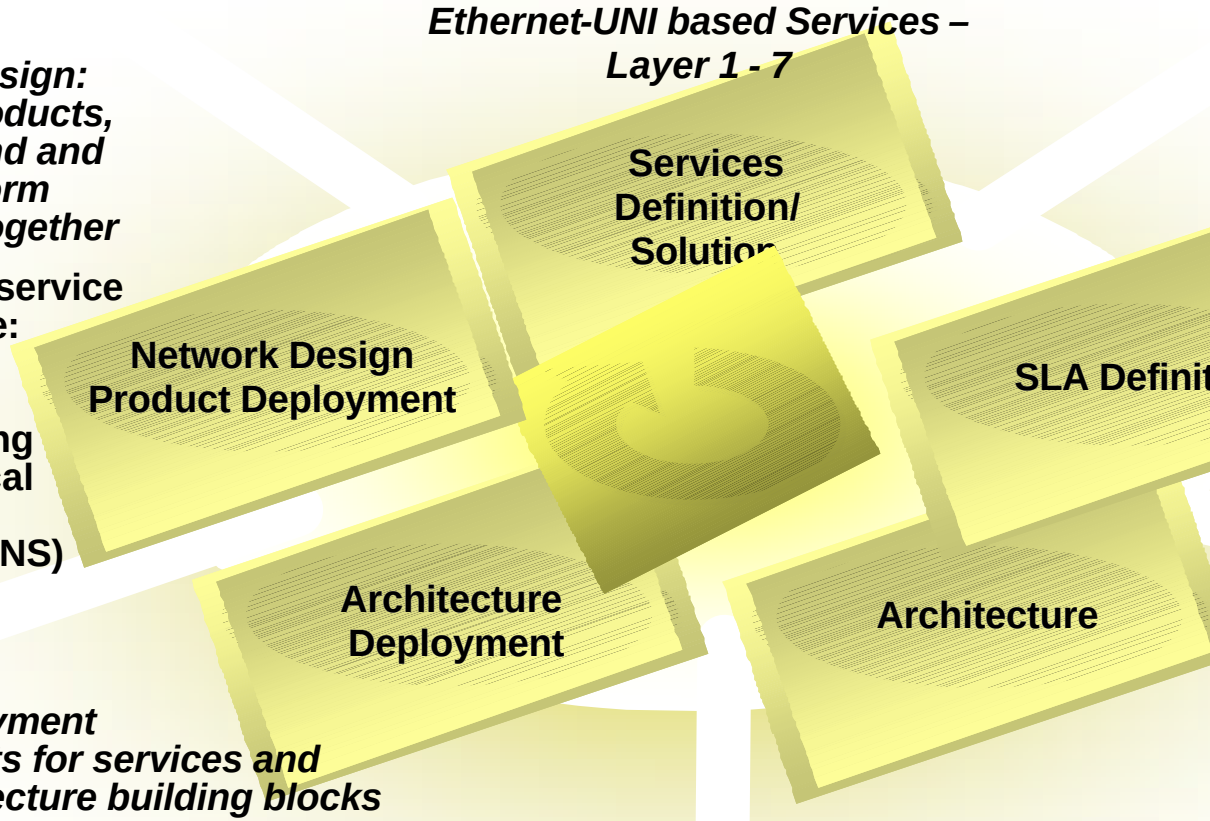
Layer 2

Ethernet Layer 2 Services: P2P, MP2MP, Hybrid

Any-to-Any Service Interworking | **Storage Services**

SONET/SDH services | **Wavelength services**

A Service Driven Metro Network Architecture



Ethernet-UNI based Services – Layer 1 - 7

Network Design: Glueing Products, Features and and closs-platform functions together

Delivery of service architecture: Catalyst switching, Cisco routing Cisco Optical Networking Systems (ONS)

SLA Definition SLA Models

focus on the business aspects

Deployment aspects for services and architecture building blocks

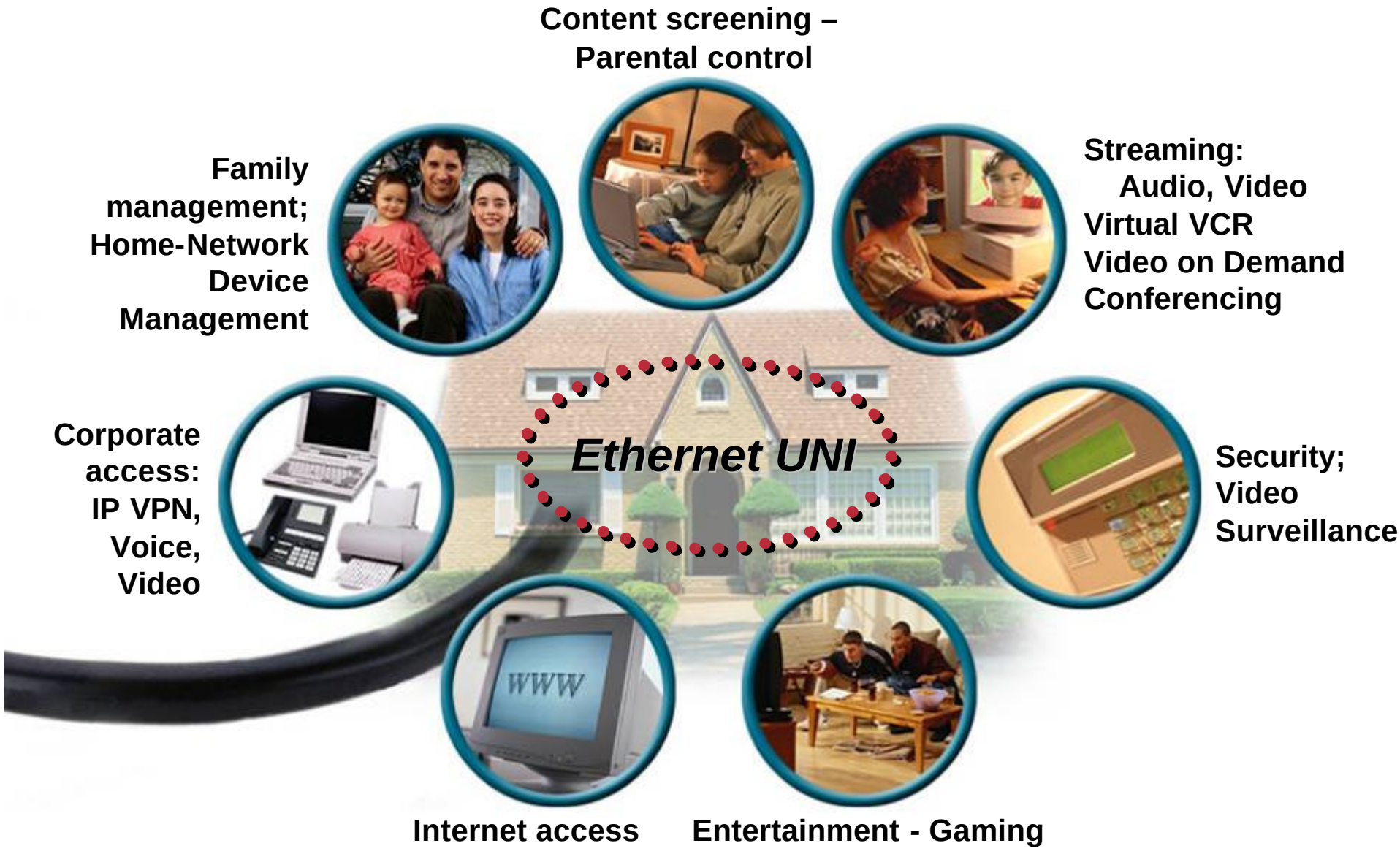
Service Interworking; Availability; Multicast; QoS for SLA delivery; Ethernet access rings; Redundancy

Technology Agnostic Architecture

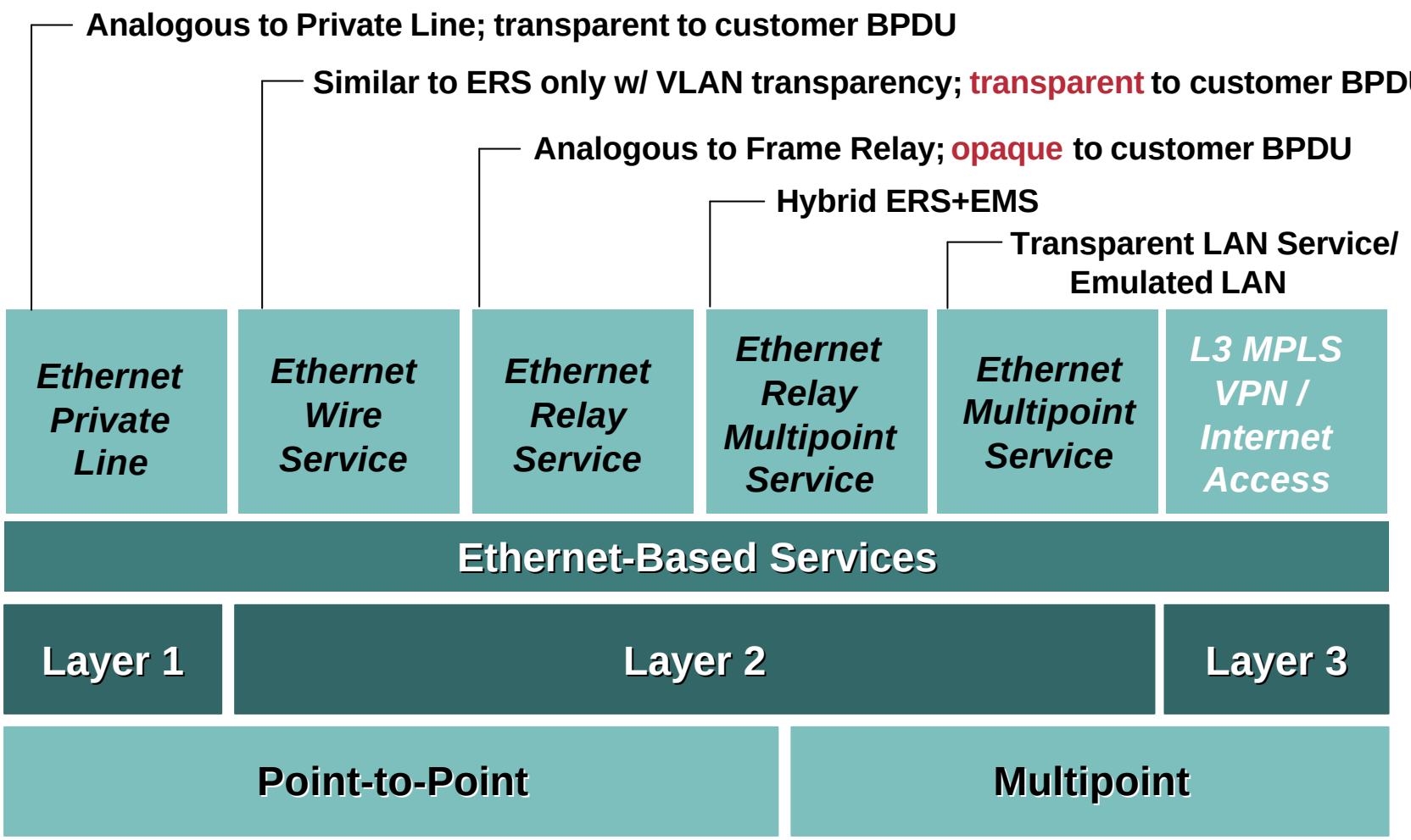
Scalability, Cost identification and control, Integration of transmission and transport, end-to-end capabilities for service delivery, Roles Definition

Broadband Consumer Services
Experience Focused – Beyond Connectivity

Cisco.com



Summary of Business Ethernet-based Services



Business Services Delivery using Metro Ethernet

End User Metro Services	Connectivity Options (Service Delivery Mechanism)		
	E-Line (P2P)	E-Line (P2MP)	ELAN MP2MP
Direct Internet Access	✓	✓	✓
Access to L3 VPN	✓	✓	✓
VPN with Frame/ATM Interworking		✓	
Voice	✓	✓	
Video	✓		✓
Storage Transport	✓	✓	✓
Data Center	✓	✓	
Security	✓	✓	✓

P2P – Point to Point
P2MP – Point to Multipoint
MP2MP – Multipoint to Multipoint

Layer 3 and Layer 2 VPN Service Characteristics

Layer 3 VPNs

- SP devices forward customer packets based on Layer 3 information (e.g. IP addresses)
- SP is involved in customer IP routing
- Support for any access or backbone technology
- IP specific
- Foundation for L4-7 Services!
- Example: RFC 2547bis VPNs (L3 MPLS-VPN)

Layer 2 VPNs

- SP devices forward customer frames based on Layer 2 information (e.g. DLCI, VPI/VCI, MAC)
- Enterprise stays in control of L3 policies (Routing, QoS)
- Access technology is determined by the VPN type
- Multiprotocol support
- Example: FR—ATM—Ethernet

Service Level Agreements: *Defining the Nature of the Service*

- **Service Level Agreements define:**
  - **Attributes about a service, e.g.**

    Availability – 99.99%, 99.999%,…?

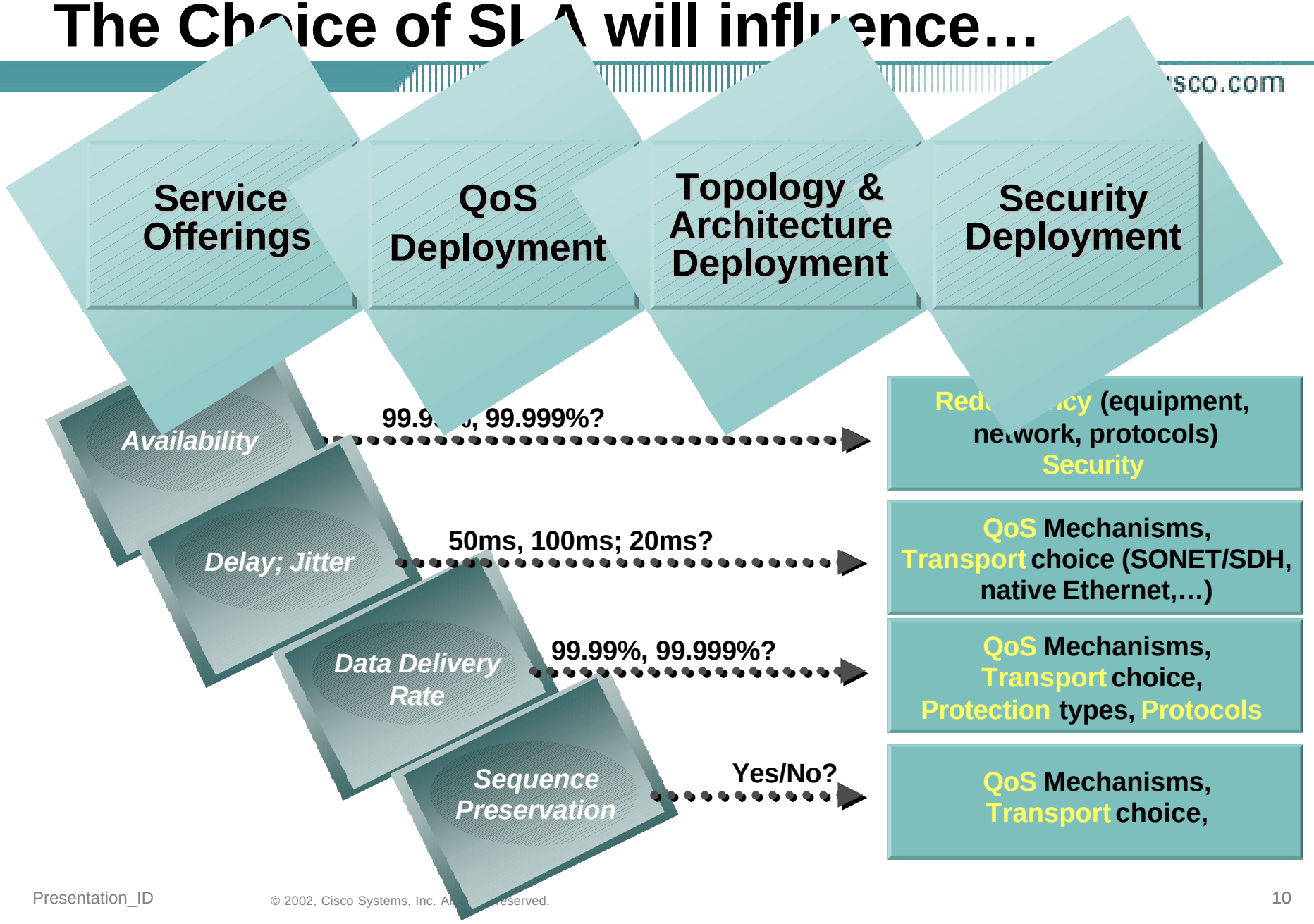
    Drop – 0.01%, 0.1%?

    Delay – 50ms, 100ms?

    Jitter – 20ms, 30ms?

    Sequence preservation – yes, no?
  - **Penalties if the attributes / performance parameters are not within defined boundaries**

The Choice of SLA will influence…



Ethernet SLA *Approaches*

Cisco.com

Phase 1

Bandwidth Profiles - Ingress Policing only

Two-Rate, Three Colour Metering - trTCM (RFC 2689)

Similar to common Frame Relay offerings (CIR, CBS, PIR, MBS)

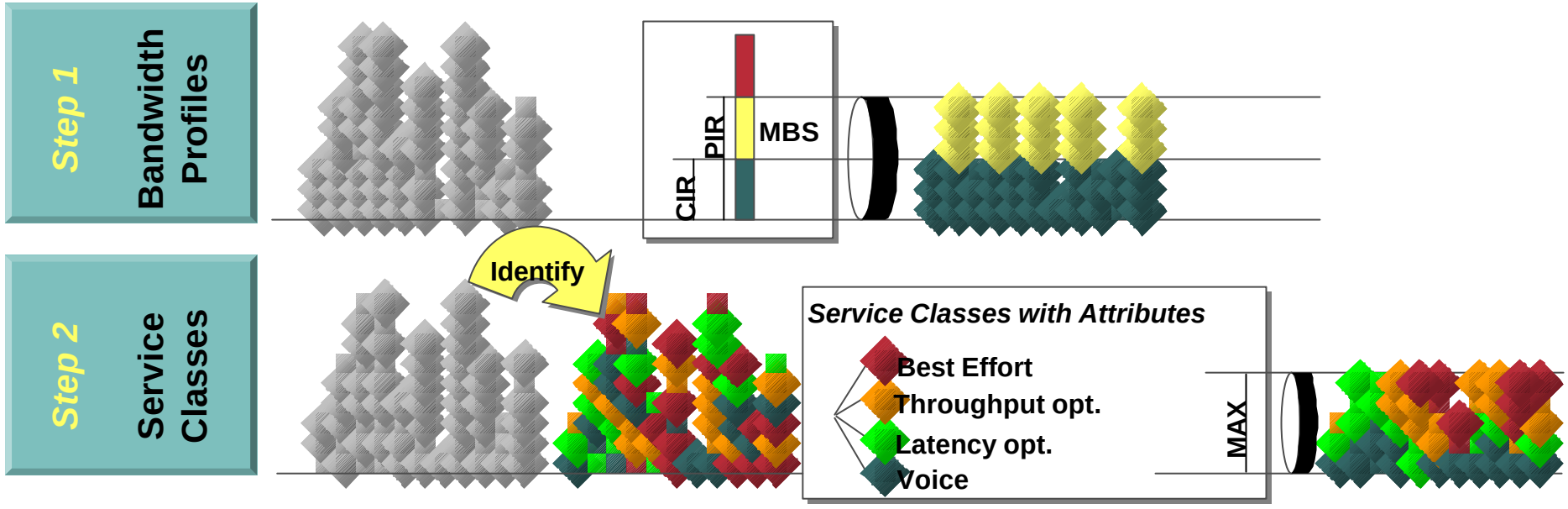
Phase 1 according to MEF - 

Phase 2

Service Classes - Application Performance Requirements based

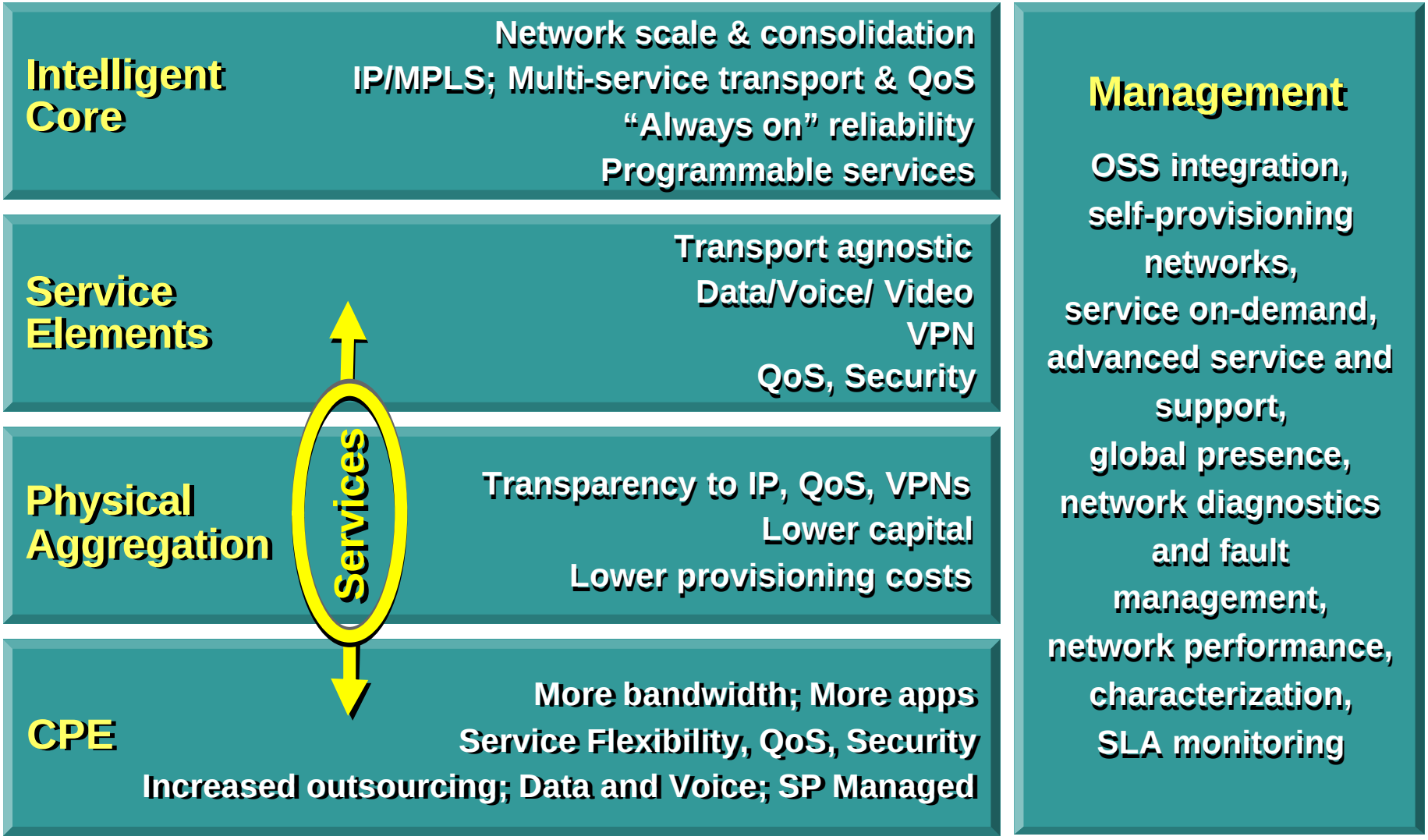
- **SLA definition based on: Delay, jitter, loss, bandwidth/throughput, sequence-preservation, availability**
- **Service-class based SLAs – e.g. VoIP, Business latency optimized**
- **Similar to *enhanced* Frame Relay offerings**

Ethernet Service Level Agreements *Approaches*



- **Bandwidth Profiles**
  - **Similar to Frame-Relay – PIR/CIR/MBS** MEF Metro Ethernet Forum
  - **Well known, simple –limited traffic differentiation and per application network capacity planning**
- **Service Classes**
  - **Differentiate and traffic-engineer accordingly**

The Network Architecture Abstract



Metro Network Architecture
Roles and Objects

Core Device (P)
Fast Packet Forwarding, Suppor
Congestion manag

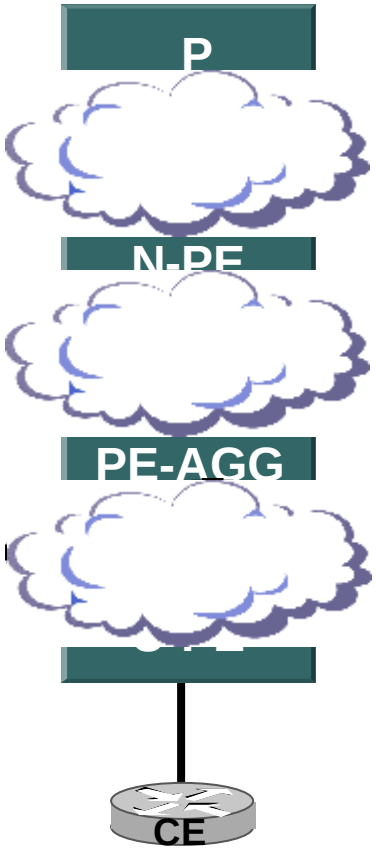
Service Application Layer – Network facing PE (N-PE)*
MPLS, L2TPv3, VPWS, VPLS
IP Service Application layer: L3VPN, Internet Access
Value Added Services: Content, Managed IDS, Firewall, U
Telephony, L2 Service Inter-working

Aggregation Devic
Traffic aggr

Edge Device – User facing PE (U-PE)*
Admission control, Security Policy Enforcement, Classification, Policing and Marking
Mapping function: "VPN Mapping" to a VLAN to SONET/SDH circuit, VLAN to EoMPLS tunnel, VRF lite to MPLS VPN, VC-ID translation
Service Enforcement layer; E2E SLA monitoring and reporting
L2VPN, L3VPN Services

* draft-ietf-ppvpn-l2-framework-03.txt

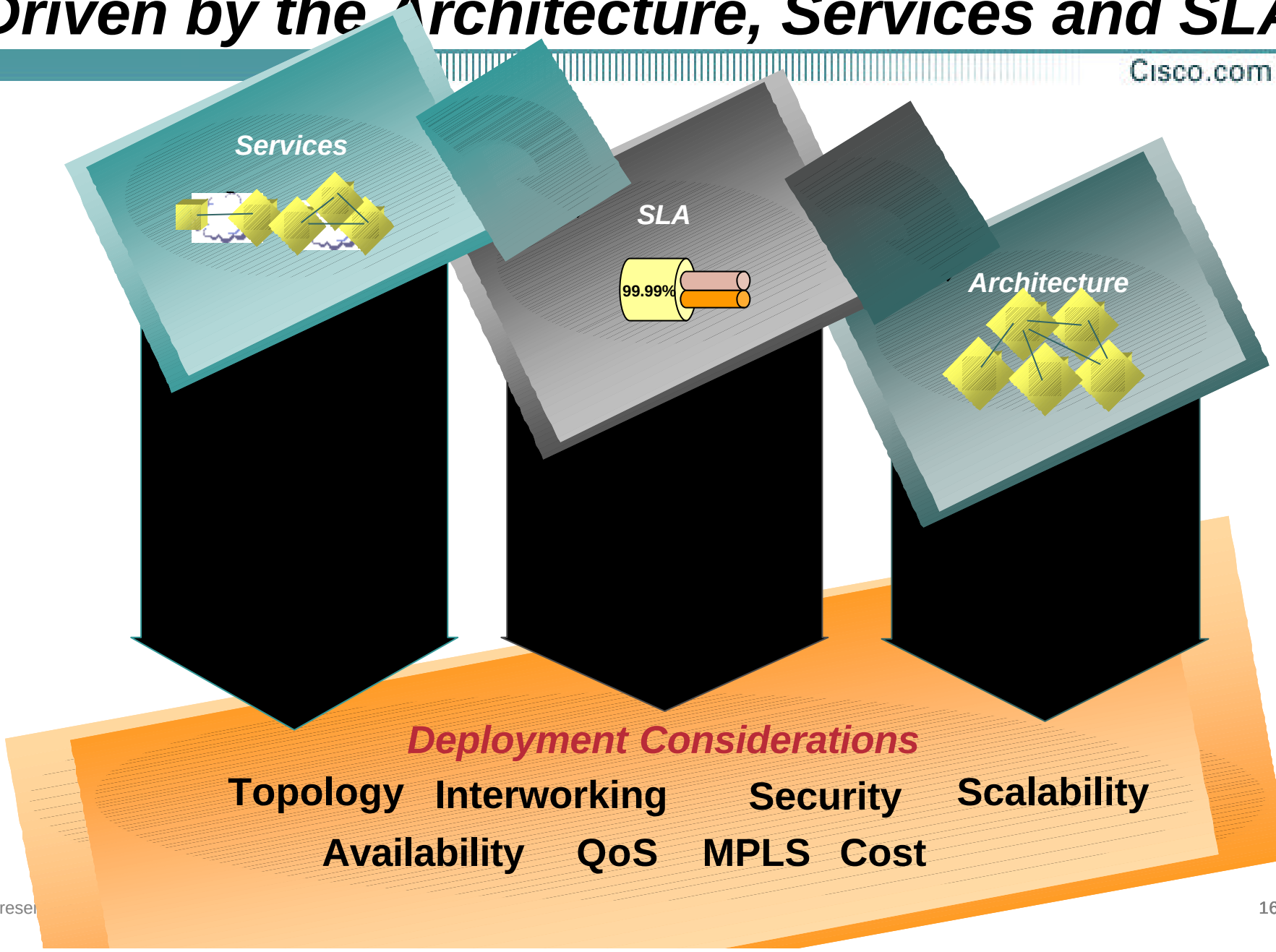
Metro Ethernet Network Architecture
Connectivity Options – Behind the clouds



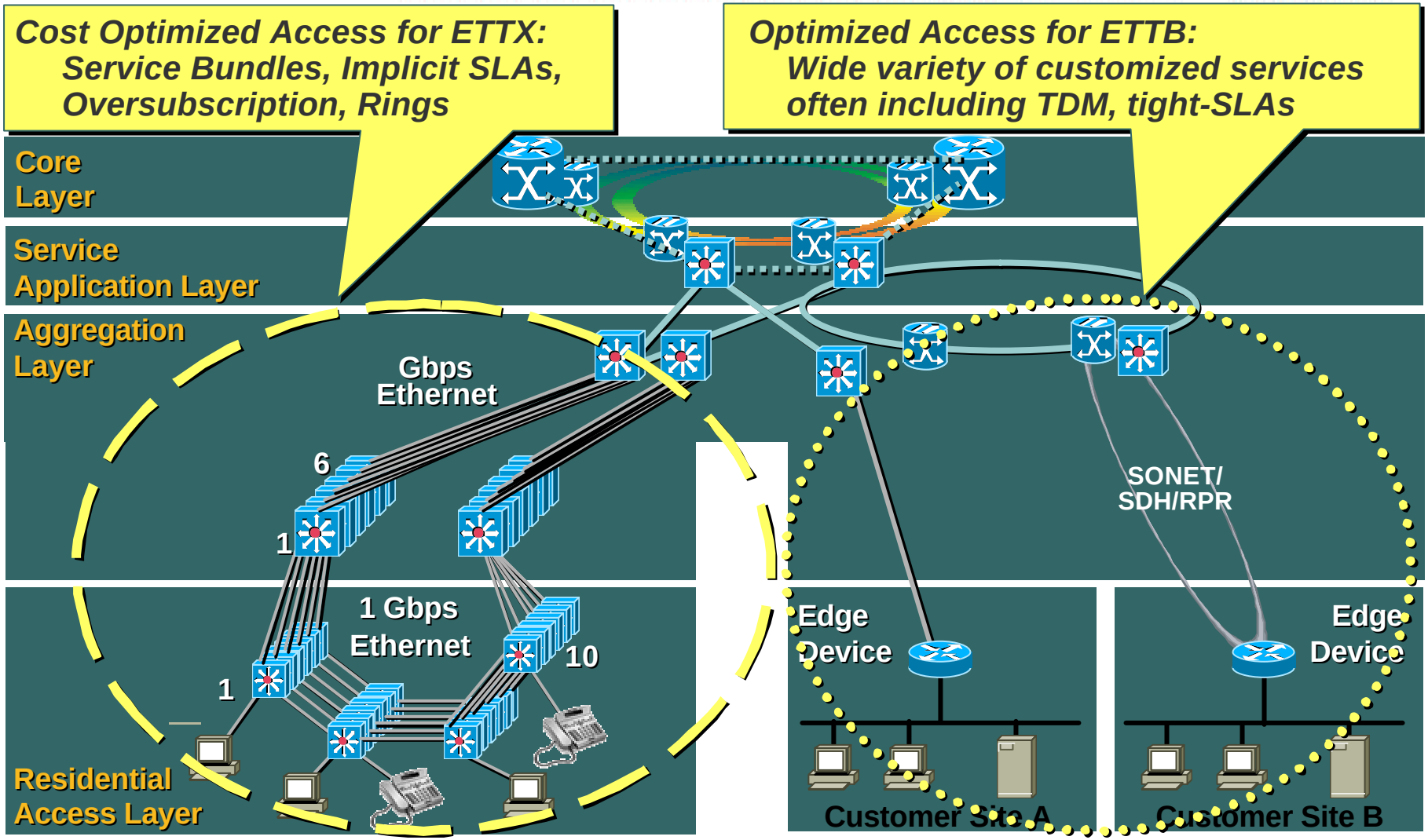
Relationship between layers/functional elements and components defines Protocols, Topologies and their deployment

- **Scalability**
  - **Topology – Ring vs. Hub&Spoke**
  - **Cost – fibre consumption, interface costs**
- **Availability**
  - **STP convergence vs. SONET/SDH/RPR**
  - **Dual-Homing / Redundancy**
- **SLAs**
  - **Fair and secure access, consistent SLA – e2e QoS**
- **Service Ubiquity – access over any technology/protocol**

Deployment Considerations
Driven by the Architecture, Services and SLA

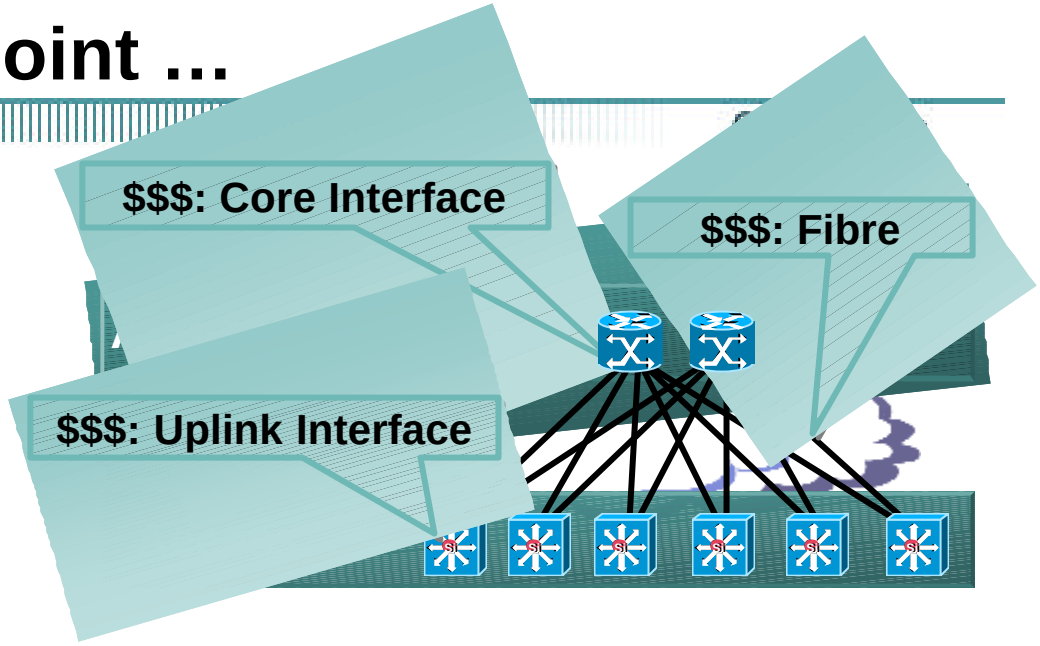


Architecture: Different Service & SLA models lead to different Network Deployments

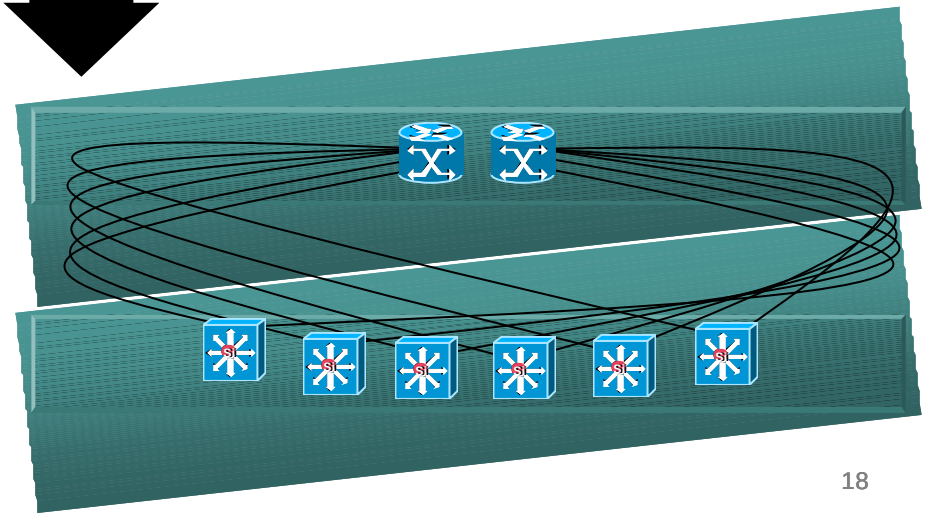


Topologies: Point-to-Point …

- Limited scalability if deployed over dark-fibre
  - # of fibres scales linearly with # of devices
  - # of Interfaces scales linearly with # devices
  - Fibre capabilities may make migration from 2.5G to 10G challenging (attenuation, dispersion management)
  - Cost of Optics Predominates at >2.5G
  - xWDM incurs penalties also

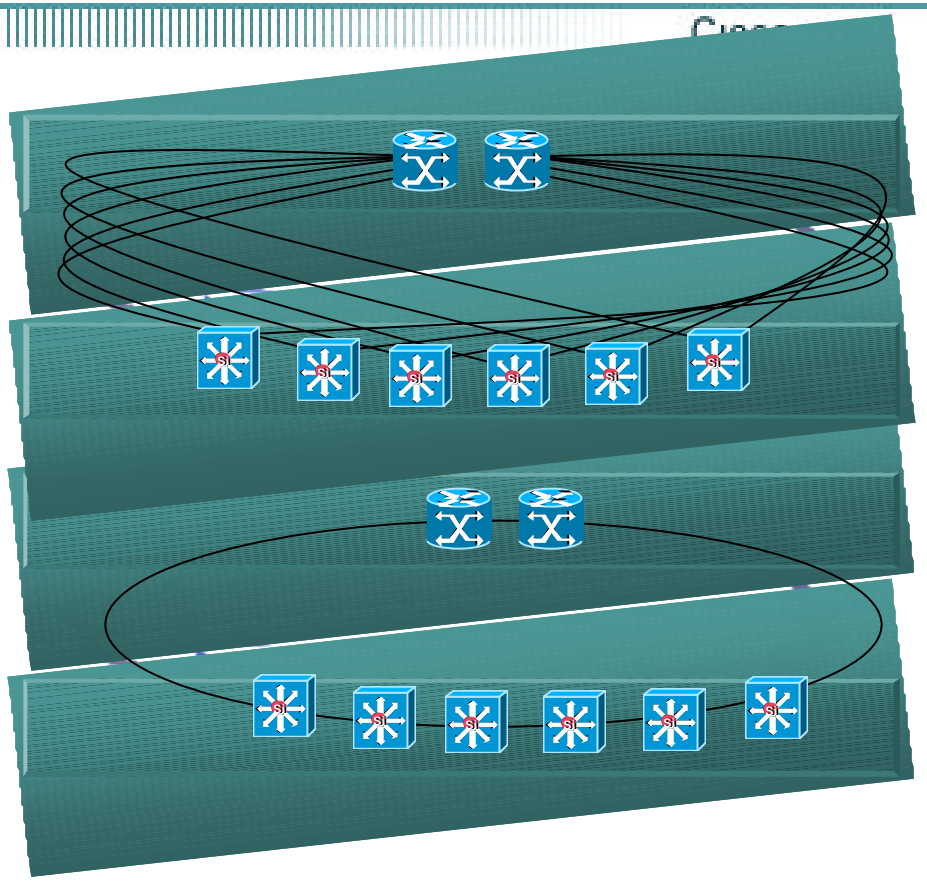


Fibre rarely runs point-to-point



Topologies: … or Ring

- **Fibre-consumption reduced (compared to p2p fibre)**
- **Reduced # of core interfaces N:1 vs 1:1**
- **Fibre-length reduced – 10G deployment feasible**
- **Rapid provisioning – provision additional bandwidth on the ring (compared to physically add fibre and interfaces)**

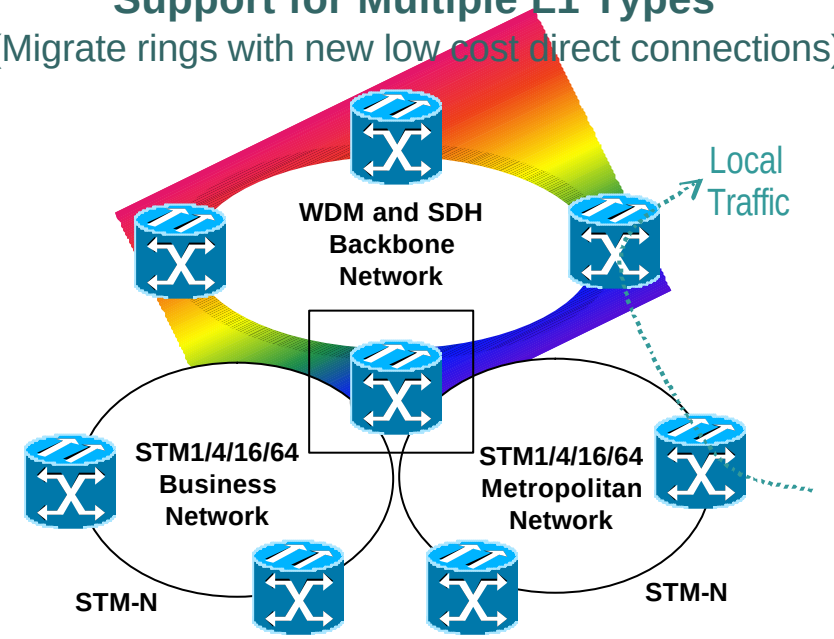


- **Layer 2/3 and/or Layer 1 rings? depends on traffic pattern (local vs. on-ring) and service mix –**
  - **Ethernet-PL best delivered via EoS or WDM**
  - **Effective and Fair use of Ring Bandwidth RPR or EoS – STP Ethernet-Rings more interesting if CAPEX is main issue**

Rings may be deployed with different technologies….

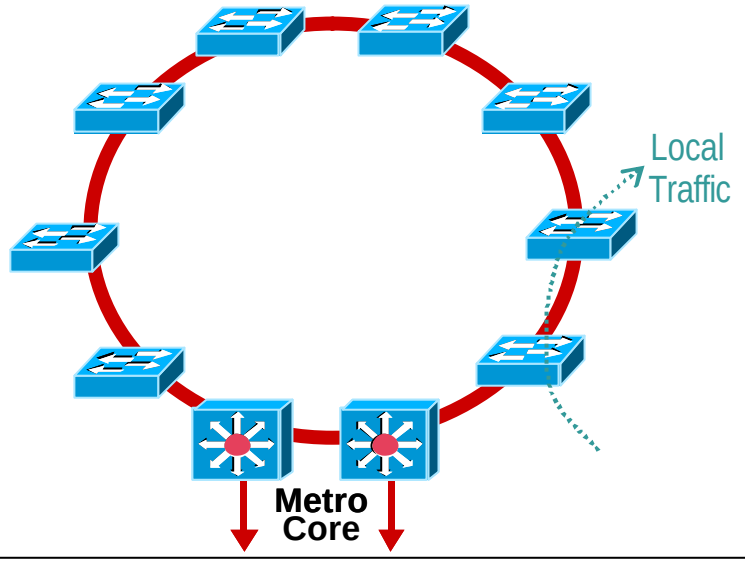
Support for Multiple L1 Types

(Migrate rings with new low-cost direct connections)



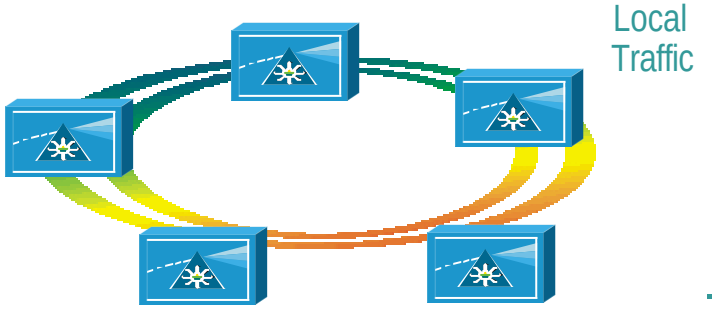
Ethernet using Spanning Tree

(Inexpensive interfaces)



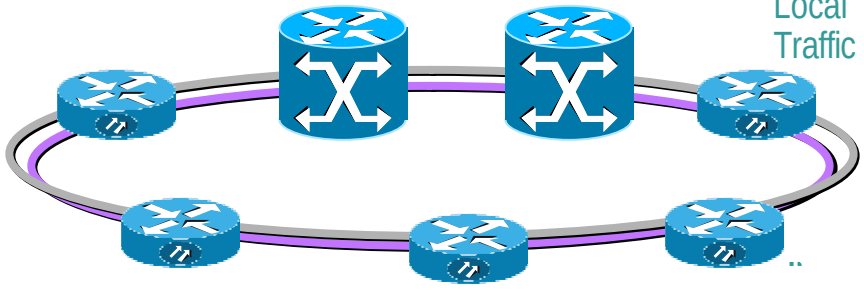
DWDM/CWDM

(point to point behavior without new fiber)



DPT/RPR

(Spatial Reuse for Local Traffic)



Rings – Transport Options

SONET/SDH

Multi-service capability
Installed base in service providers
TDM Services
Hierarchical bandwidth
50 ms convergence
Very (cost-) effective for E-PL
Foundation for all L1/2/3 VPN services

Switched Ethernet using Spanning Tree

Lower cost solution
Perceived simplicity of Ethernet switching
Easy to deploy over dark fiber
Flexible Bandwidth
Sub-second convergence
Foundation for Ethernet/IP L2/3 VPN

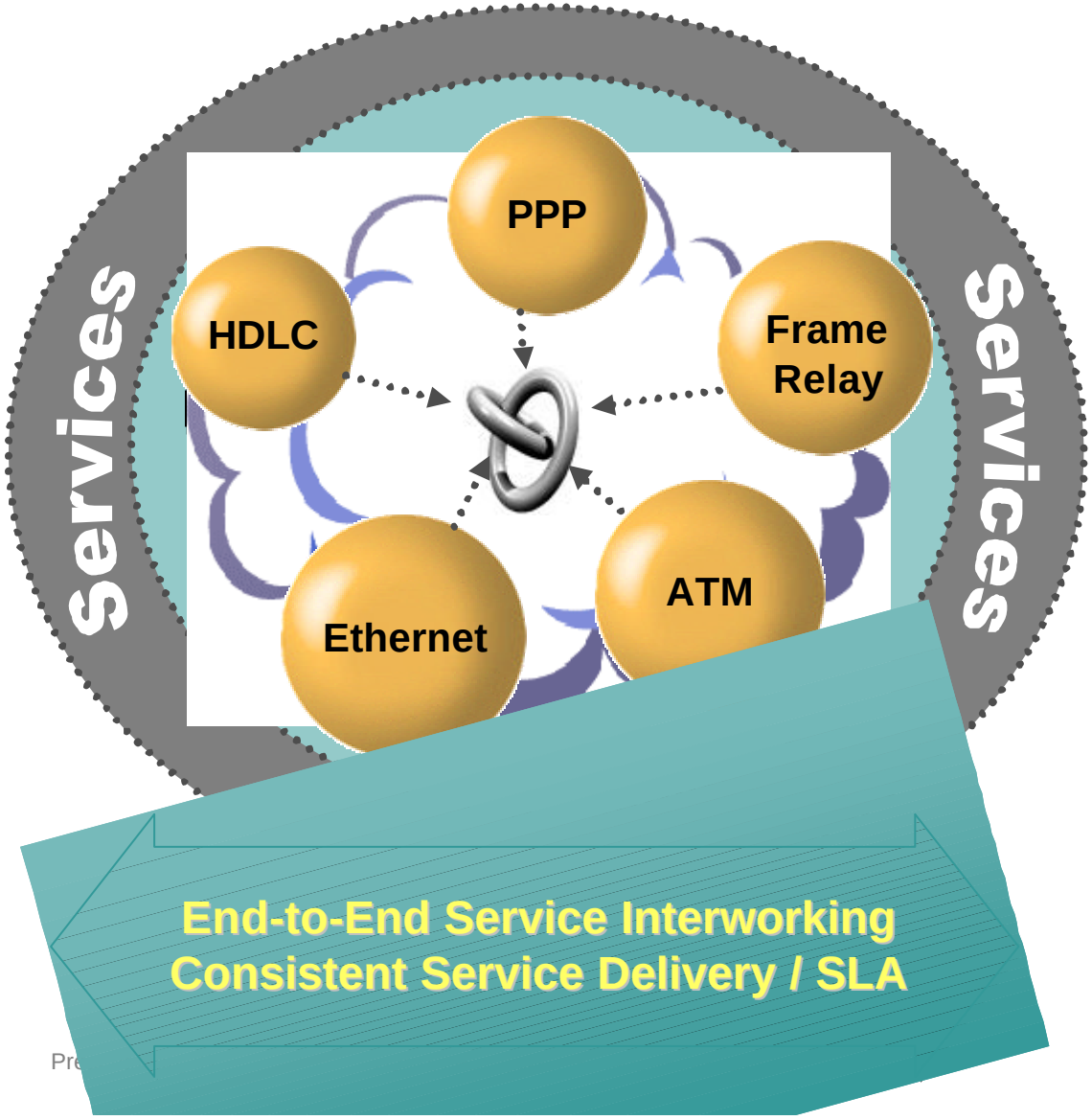
DWDM/CWDM

Scales Fibre Capacity
8Gbps, 320Gbps, 800Gbps
Convergence dictated by xWDM solution
Cost effective
Easy to deploy
Foundation for all Services – enables Storage etc. as well

DPT/RPR

Shared packet ring scales bandwidth up to 5 Gbps today
SONET/SDH framing provides insertion point for many providers
Large number of nodes per ring
50 ms convergence
Foundation for Ethernet/IP L2/3VPN

Layer 2/3 Service Interworking

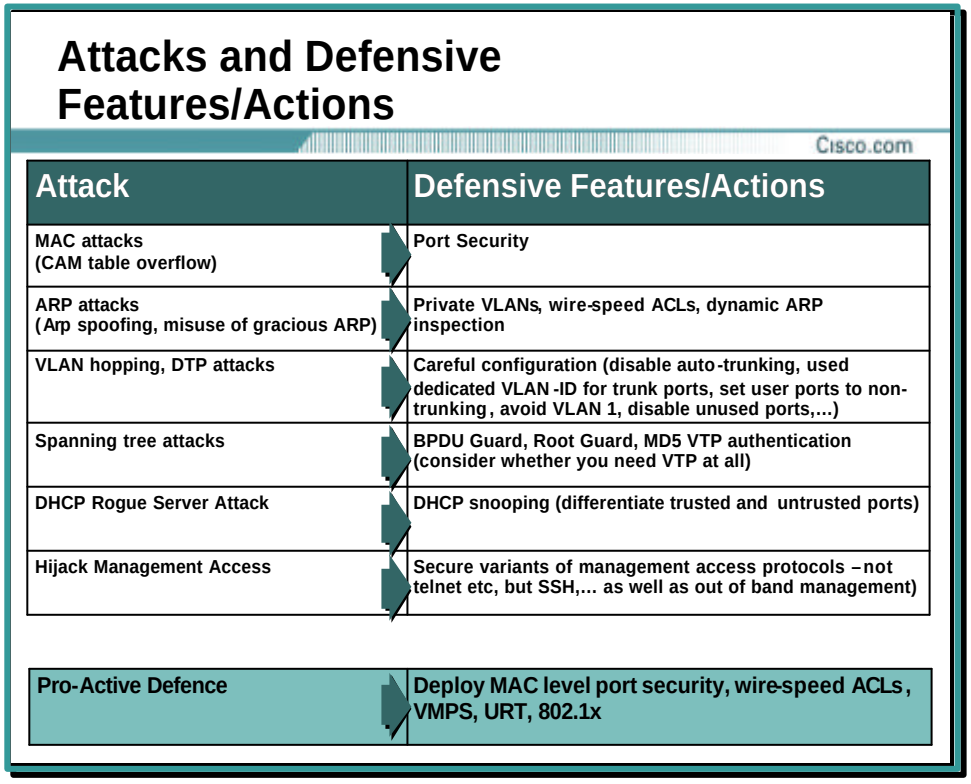


- Add Ethernet to Existing Service Portfolio
- Protocol-Interworking for ubiquitous service delivery
- Layer 2 and Layer 3 Solutions required – Solutions are protocol specific

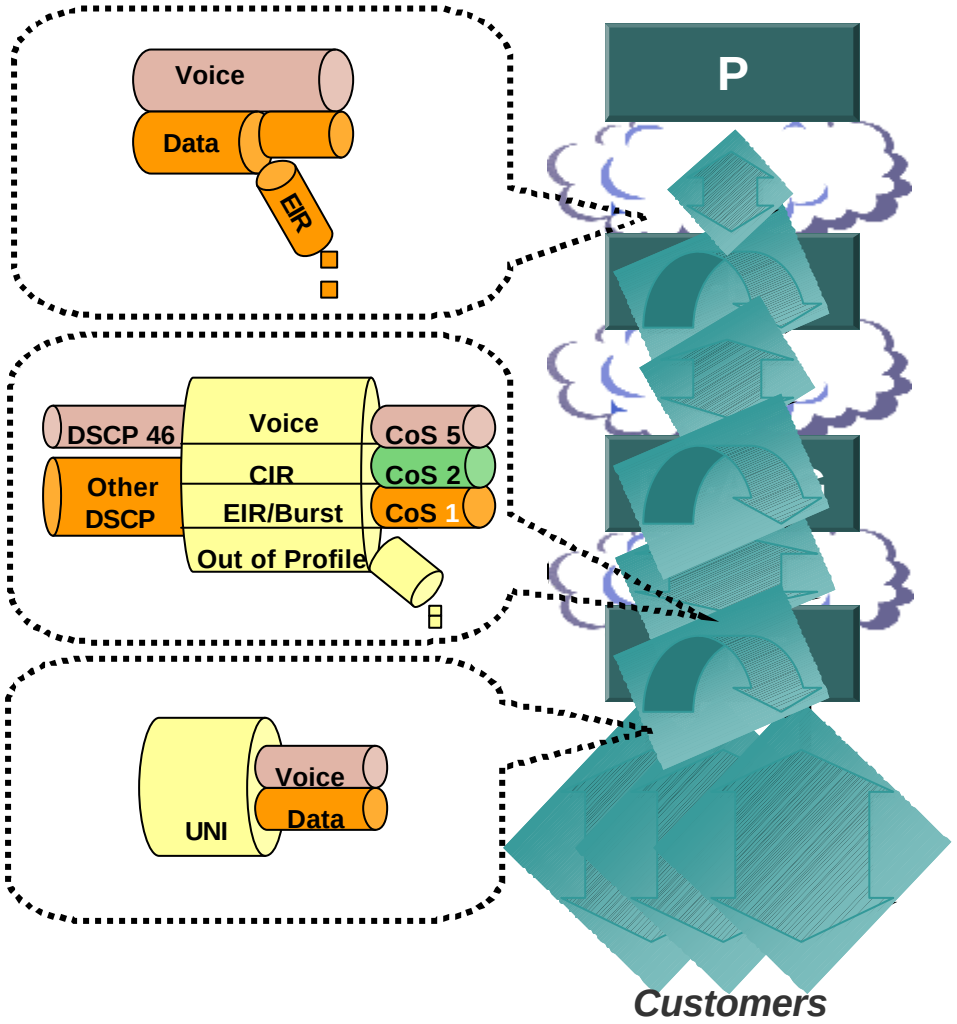
Security

Cisco.com

- **Service-Variety / enhanced Service-Attributes result in possibly new security threats**
  - **Layer2/3 different from simple Layer1**
  - **E.g. Denial of Service attack can impact SLA (availability)**
- **Ethernet-centric attacks**
  - **MAC, ARP, VLAN-Hopping, SPT, CDP, DHCP,…**
  - **Pro-Active and Re-Active Defence required**



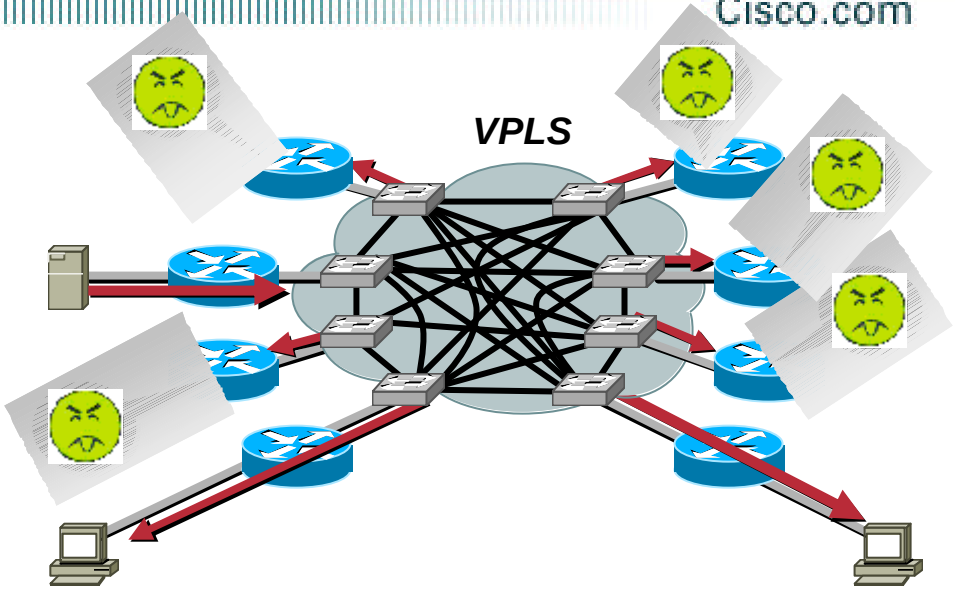
Consistent end-to-end QoS

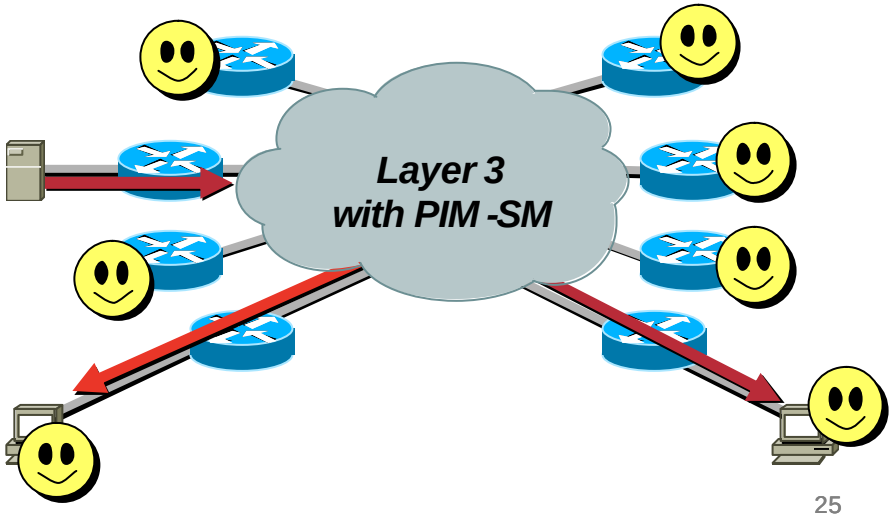


- **Enable tight SLA – PIR/CIR – latency, loss, jitter,…**
- **P2P and MP2MP differences**
- **Transport Efficiency – engineer and reduce traffic, avoid frequent equipment upgrades**
  - **leverage statistical mux'ing through Over-subscription at each layer**
  - **Keep local traffic local – leverage local switching at each layer**

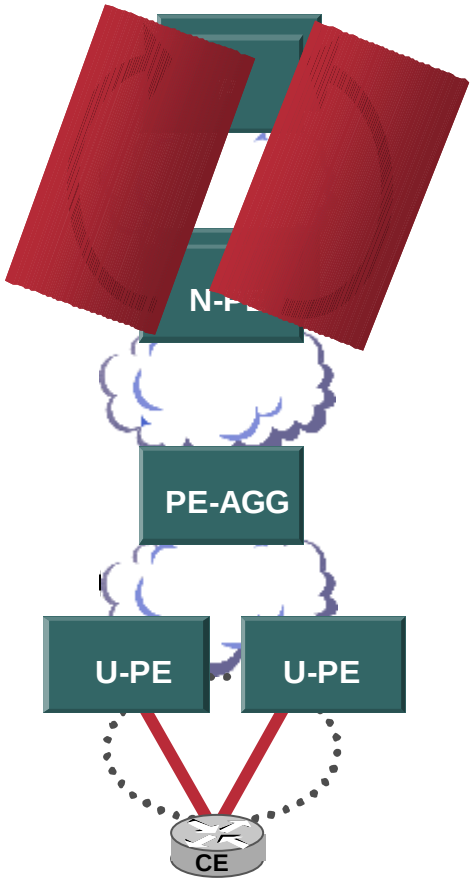
Multicast Deployment

- **Multicast Applications**
  - Voice/Video-Conferencing, Gaming, News-Channel / Information-bus
- **Multicast Deployment**
  - Multicast as Layer-2 Broadcast --- e.g. VPLS
    - inefficient distribution
  - Layer 3 Multicast (with PIM SM) over P2P pseudo wires
    - controlled distribution
  - Native L3VPN Multicast enabled core
    - controlled distribution





Redundancy/Availability



- **Equipment Redundancy Options**

  High Availability OS, redundant components

- **Security**

  Denial of Service Attacks could impact SLA

- **Protocols / Architectures**

  Redundant Access to Layer 2 Service Domains required but unresolved

  IEEE 802.1ad (Provider Bridges) to provide a standardized solution for a redundant ethernet access network for VPLS – Idea by Norm Finn (Cisco)

- **Topology / Transport**

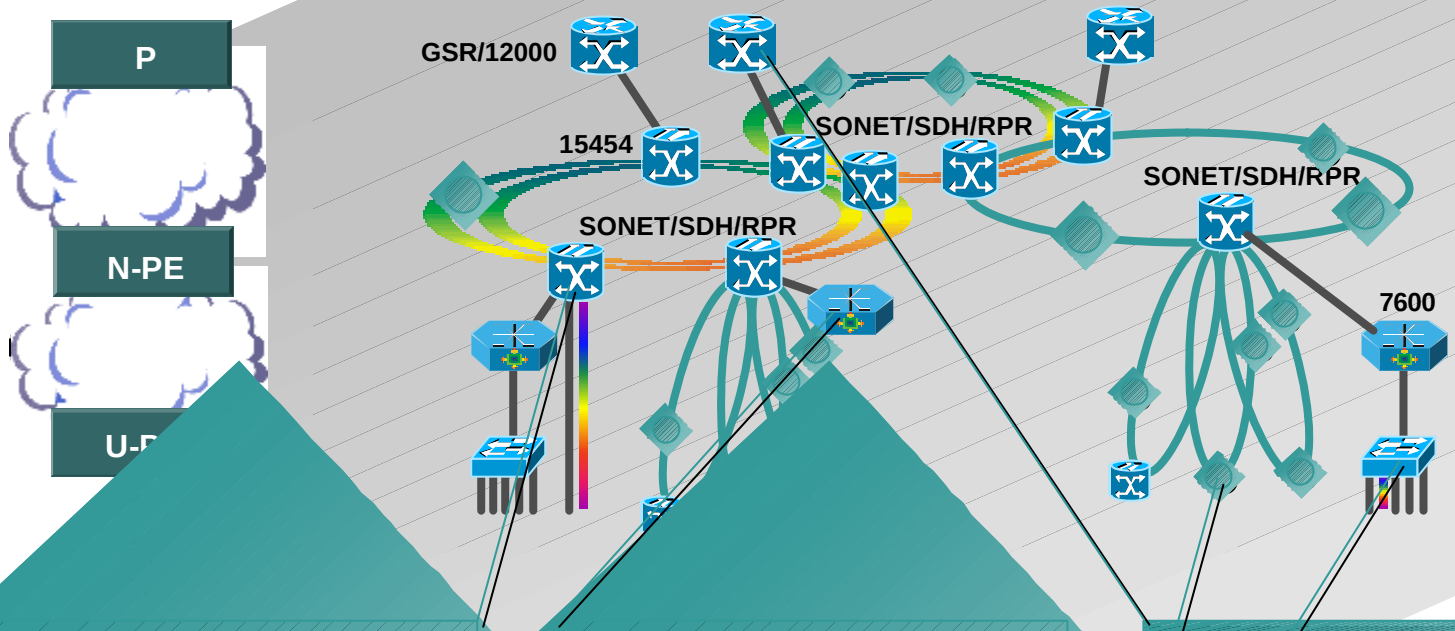
  Rings to provide dual paths – different protocols will have different characteristics (STP vs. SONET/SDH/RPR convergence)

Cisco Ethernet Innovations

Driving Industry Standards

Cisco Feature	Industry Feature
Ethernet Switching	Created industry standard
10Gb Ethernet	802.3ae 10Gb Ethernet
Gigabit Ethernet	802.3z Gigabit Ethernet
Fast Ethernet	802.3u - Fast Ethernet
EtherChannel / PAgP	802.3ad - LACP (Link Aggregation)
ISL	802.1q - Trunking Encapsulation
VTP	GVRP
Multi Instance Spanning Tree	802.1s - Shared STP Instances
Portfast UplinkFast, Backbone Fast	802.1w - RSTP
Cisco Inline Power	802.3af - Inline power
Tag Switching	MPLS
QinQ/Tag-Stacking	802.1ad – Provider Bridges

Example: Products to enable hybrid, highly scalable Networks



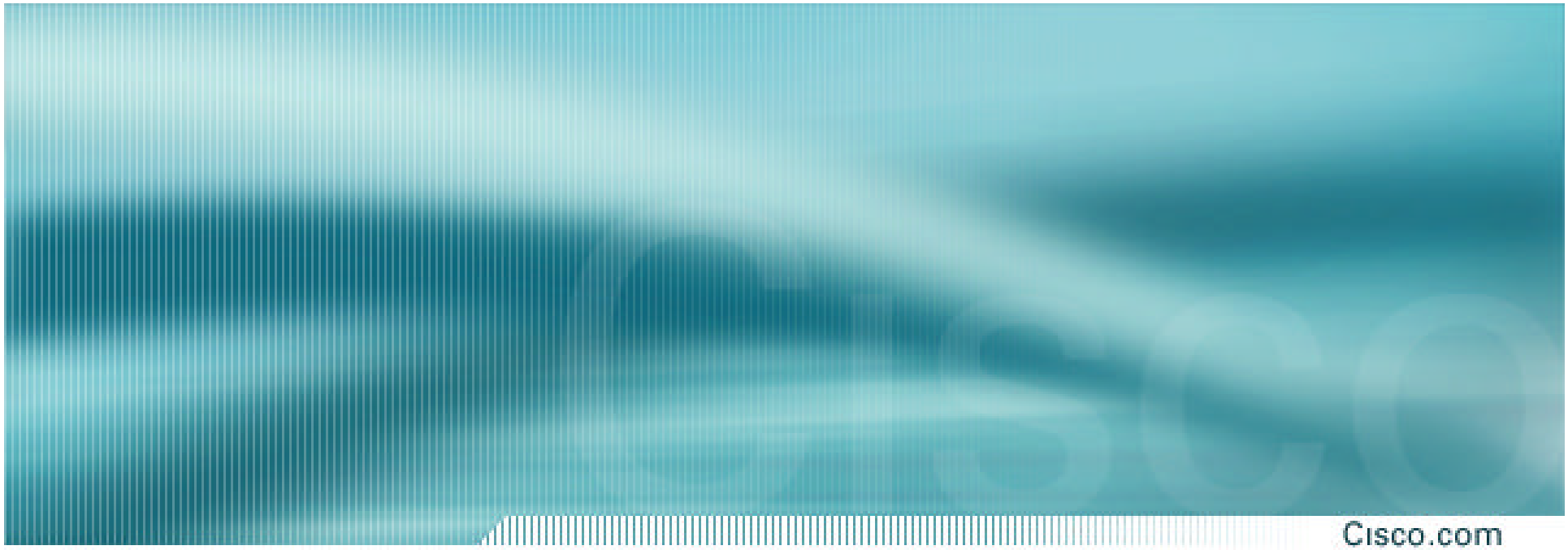
ONS 15454
- E1 to STM-64/OC-192
- Integrated DWDM Opti
- DWDM Transponder
- Integrated Ethern Ethernet-Private-L
- Integrated Layer2/3 Capabilities – QoS Traffic Shaping, Policing
- Integrated RPR

Cisco 7600/SUP720
- High-Density Ethernet,…, 10Gigabit-Ethernet
- Colored Interfaces/CWDM
- QoS, MPLS, AToM, VPLS
- Service Modules (Firewall, Service-Selection, IDS,..)
- Interworking (RBE, BRE,...)
- Interoperate with ONS 15454 Ethernet

Cisco 12xxx
- MPLS, QoS

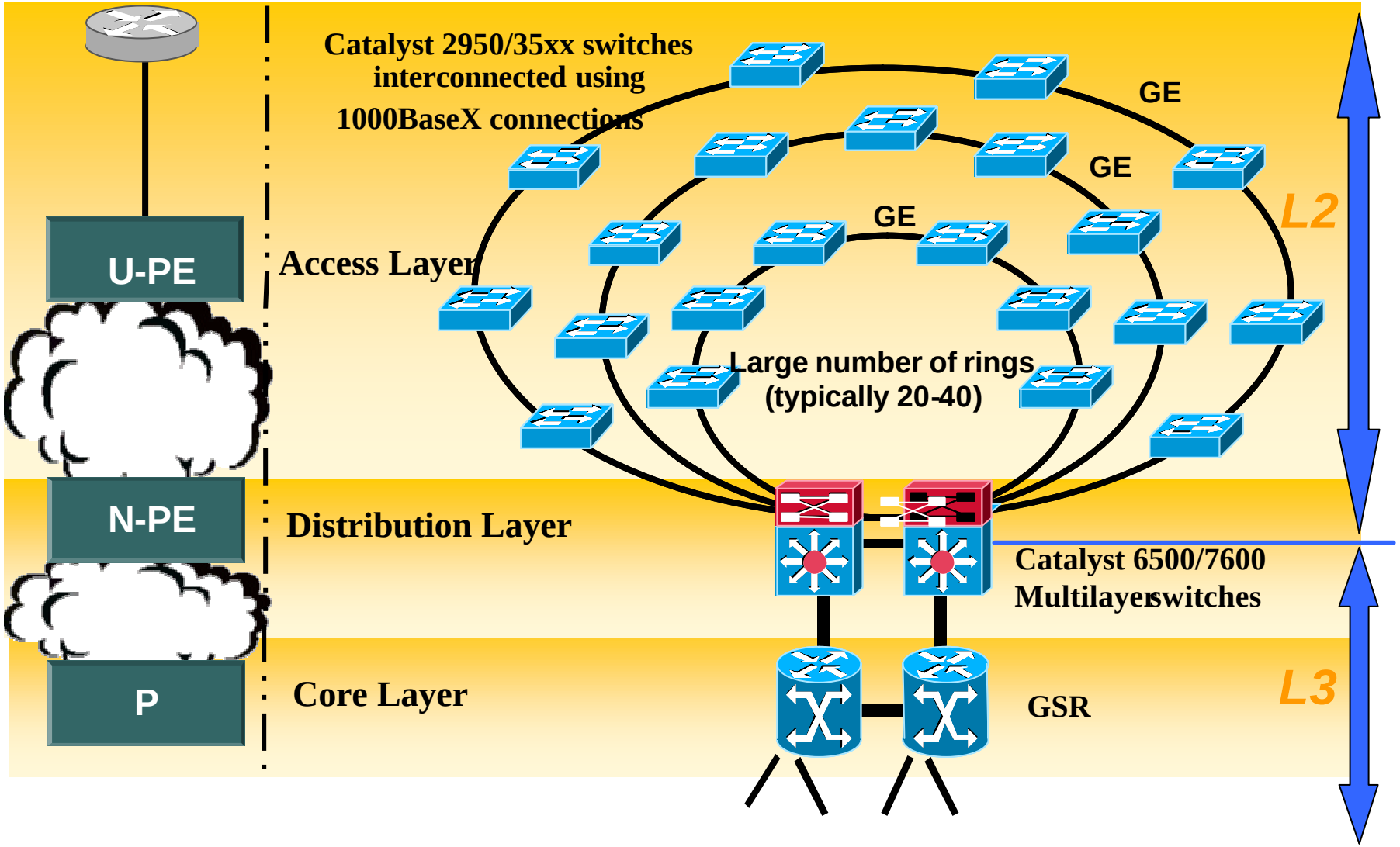
ONS 153xx
- EoSDH, E1, SNCP,…

Catalyst 3550
- QoS, QinQ, 802.1s/w,….
- Security features – Port Security, PVLAN, …

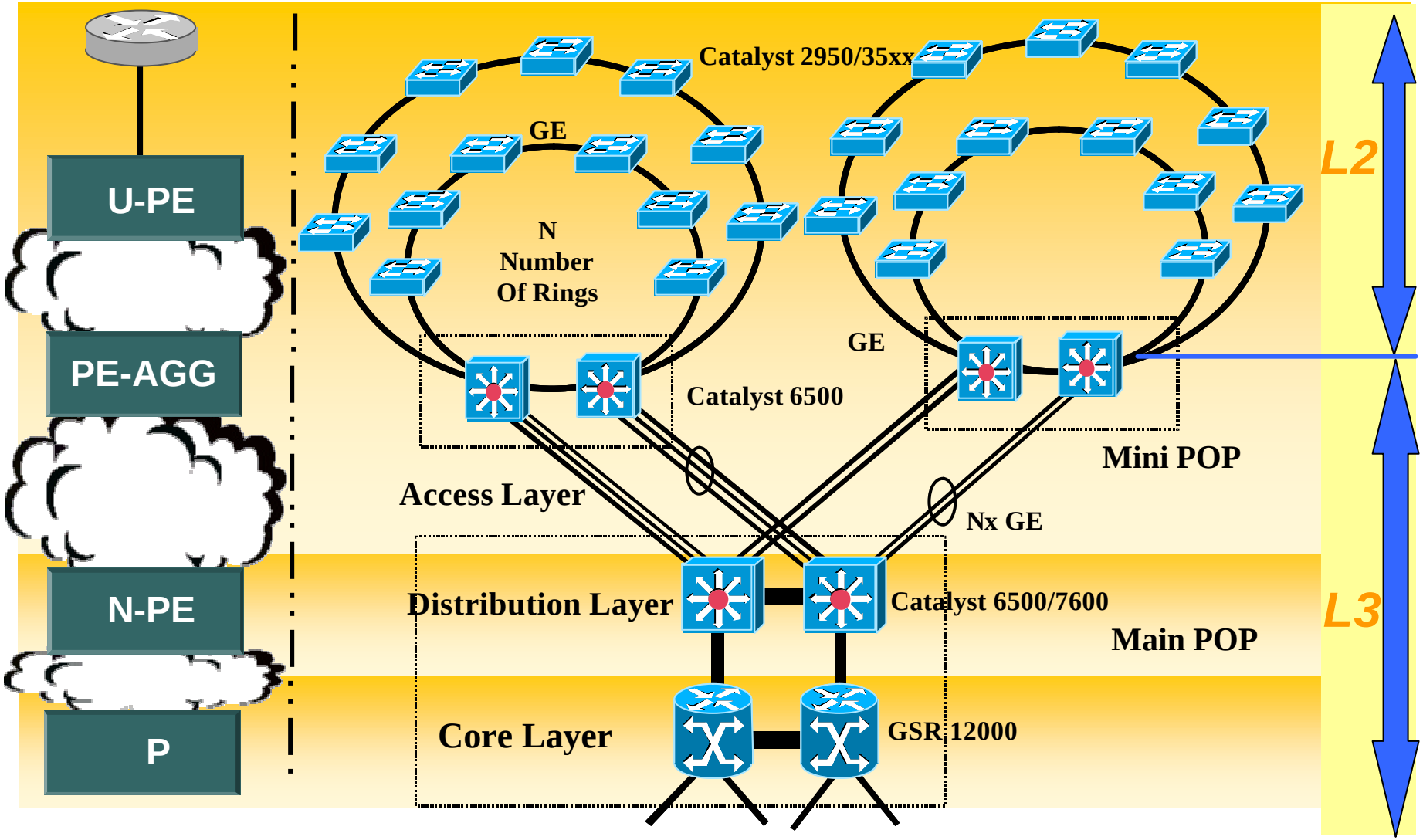


A look at popular Metro Ethernet Architectures

Option 1 - Layer 2 Ring Configuration



Option 1 variant – L3 Mini-POP with L2 Ring



On er 2 Ring on

com

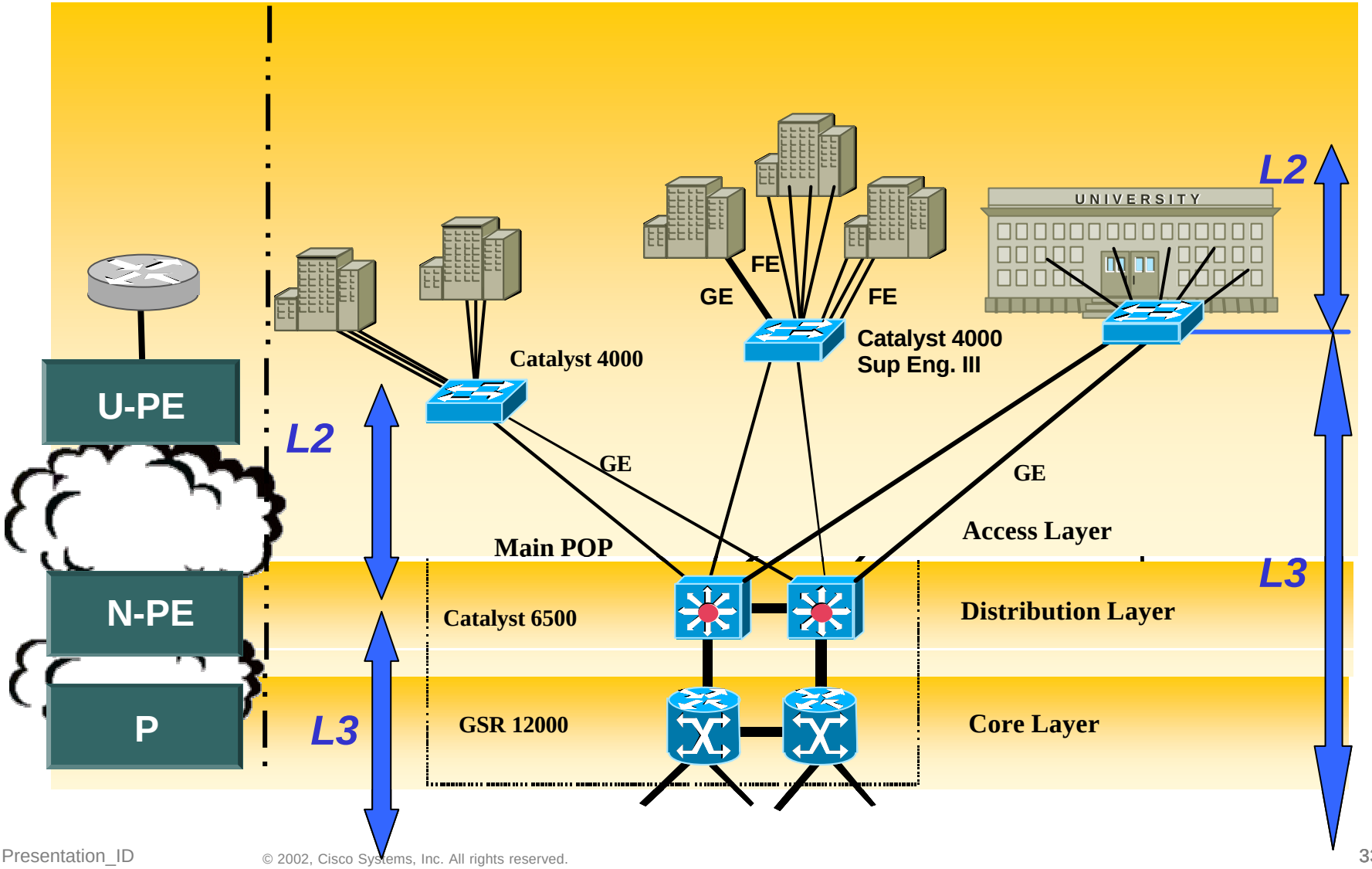
Pros

- Efficient use of fiber ring architecture
- More or less efficient use of IP addressing
- Efficient distribution of multicast traffic
- Access Device relatively low cost
- Uses 1 fiber pair

Cons

- Over subscription in the distribution layer likely
- Difficulty in mixing Business customers and residential services
- Relies on SPT for convergence (not really a disadvantage)
- Security issues (needs careful design and features)
- Troubleshooting / Fault detection
- Large number of VLANs need to be supported/terminated

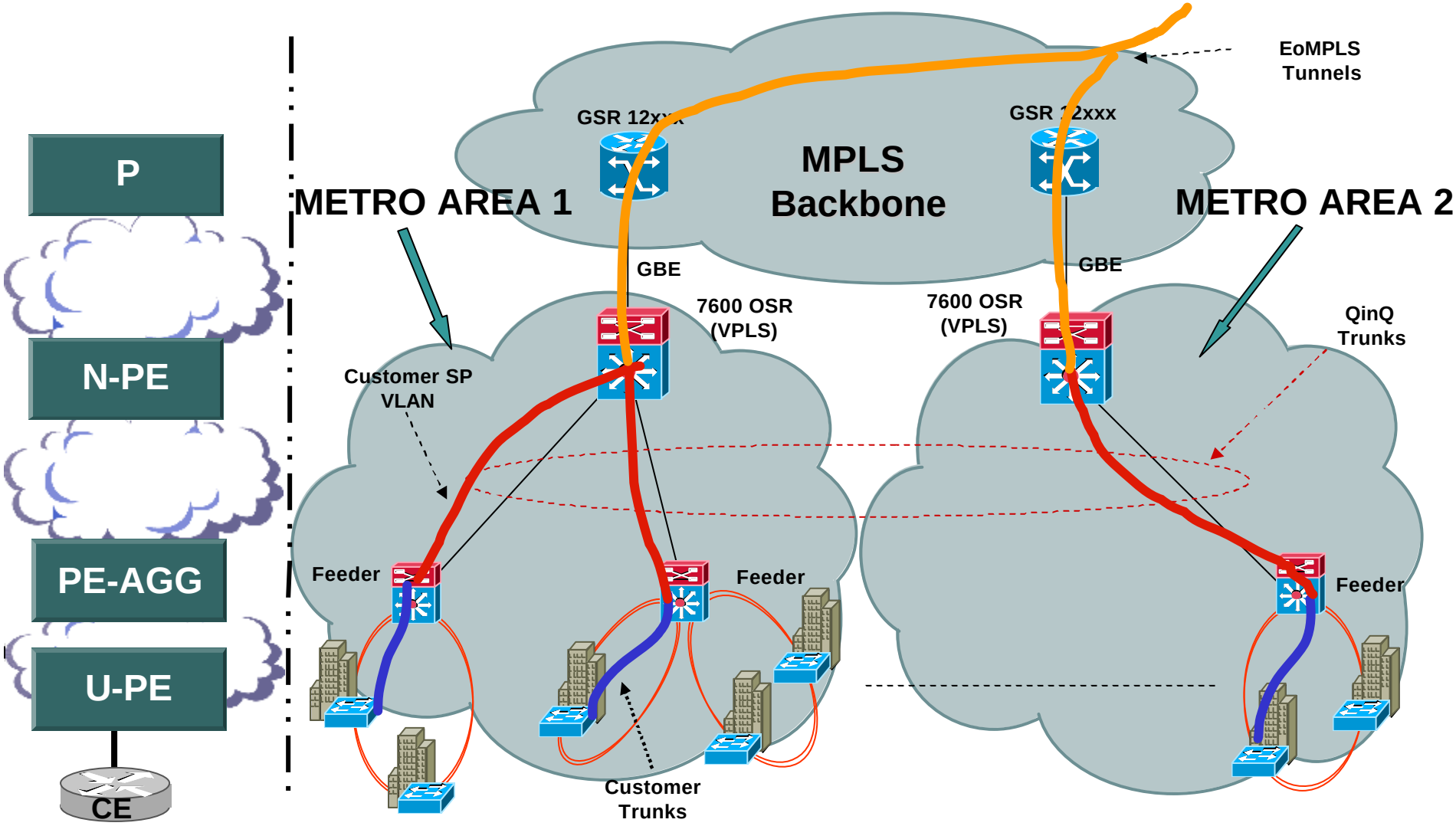
Option 2 – Star Architecture



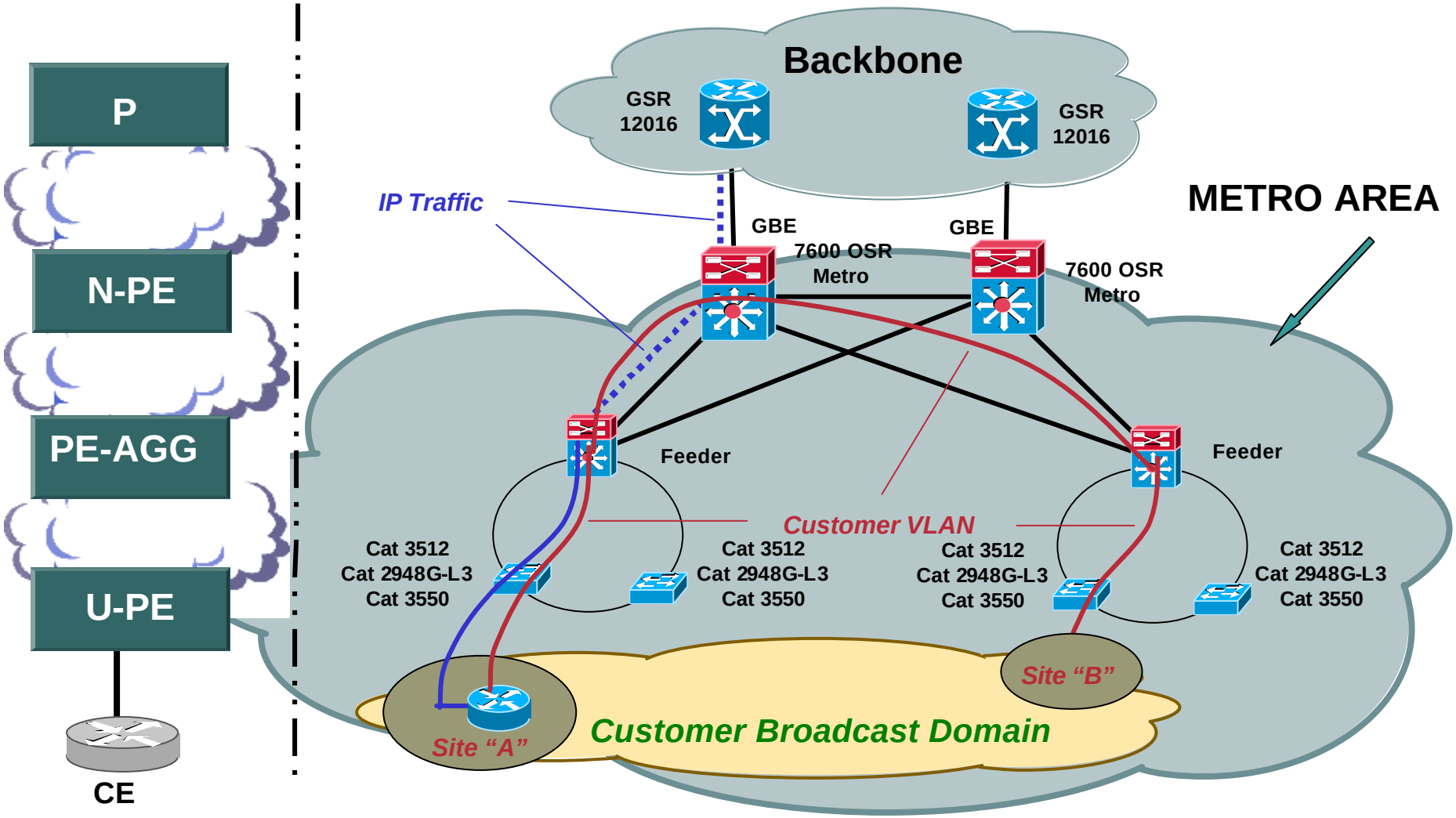
Option 2 – Star Architecture

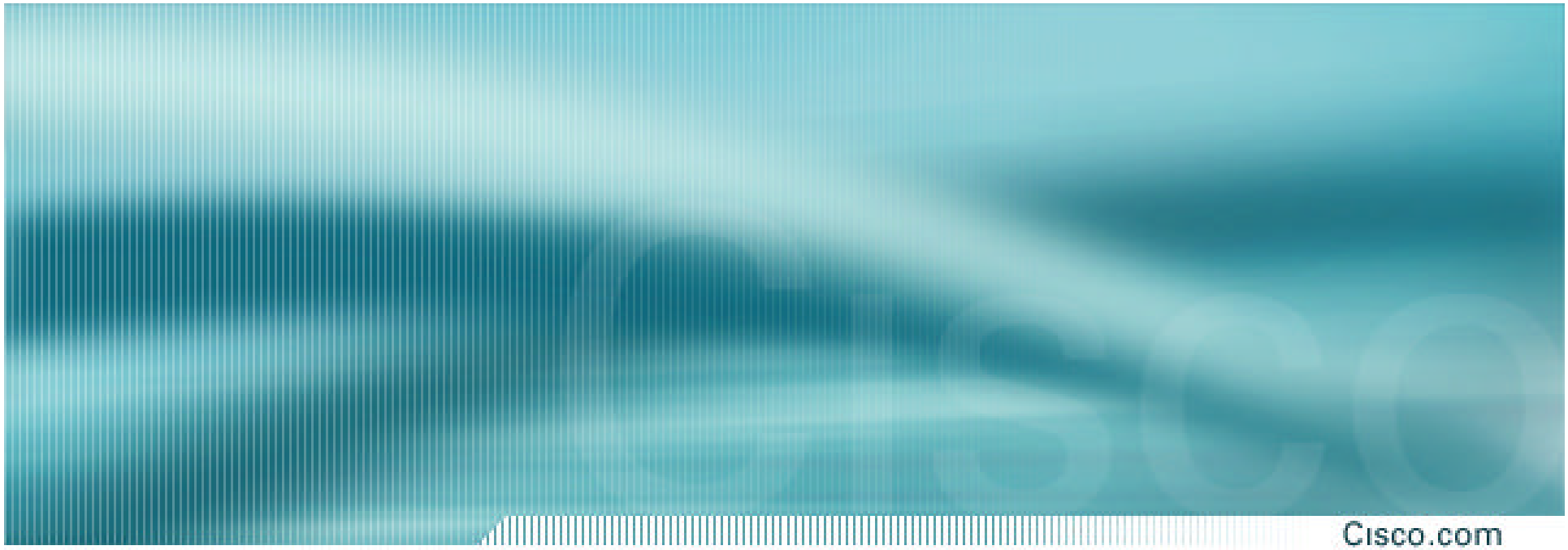
Pros	Cons
• Dedicated bandwidth for each user • Relatively simple to implement broadcast video services • Easy troubleshooting and fault detection • High resiliency and fast convergence • High density of used ports at Hub site	• Cost of deploying fiber in the access • Requires a higher-end platform to aggregate the users (potentially located at customer premises) • Security issues may still exist

ETTB solutions
Current Service offers – L2VPNs



ETTB solutions
EMS and L3 Access





Fastweb ETTx Rings Case Study

Metroweb and *Fastweb*

- **Start-up *city-carrier* located in Italy (spin-off of AEM - municipal power supply company)**
- ***Metroweb*:**
  Very large optical infrastructure in the metropolitan area (using AEM tubes and ducts)
- ***Fastweb*:**
  Communication services on top of Metroweb fiber optics rings infrastructure.

Fastweb service offering

- **High speed multimedia communication capabilities for both business and residential customers**
- **Data/Voice/Video integration on top of the unified IP infrastructure**
- ***Business customers (Large: 1,000; SMB: ~45,000)*: Fast Internet, VoIP, MPLS VPN, VoIP, *LAN-to-LAN (VPN)* and application hosting, Video surveilance**
- ***Residential customers (currently ~250,000)*: Fast Internet, VoIP, Digital TV and VoD (MPEG2), Video Phone, Internet Pay Per Use**

Residential Services Example: FASTWEB
Broadband Services and Revenue Streams

Cisco.com

	Monthly Prices
Activation fee (one time)	$53
Always on Internet at 10 Mbps 5 Mailboxes Unlimited on-net voice Calls, Local (4h), National (2h) calls	$53
Flat Voice (excluded mobile, intl)	$9
VoD per movie	$2-5
Digital TV Broadcast.	$35
Set top box rental	$5
Set top box DVD rental	$10
Pay Per Use	$X

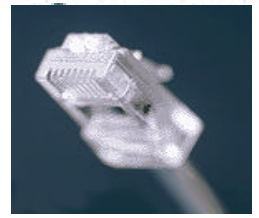
STREAM TV
LA TV DELLE GRANDI PASSIONI

TELE +

Rai Click

VIVENDI UNIVERSAL

SMB Customers
Broadband Services & Revenue Streams



SMB Bundle **(activation fee: 225 $)**

	Monthly Prices
Always on Internet at 10 Mbps	
5 Mailboxes	
5 Internet Access	
Unlimited on-net voice call	
Local (40h) National (20h) calls	140 $

Hard Disk Storage (250 Mb)	68 $ act. + 45 $
Additional 250 Mb	45 $
+ voice traffic	x+ $

SHOPs & PROFESSIONALS

Video Surveillance	225 $ act. + 45 $
Camera and Encoder rental	45 $
Day Recording retrieval	23 $
+ voice traffic	x+ $

ONE SOLUTION (SMB)

IP Phone activation fee	32 $
IP Phone monthly rental	32 $
Switch monthly rental	72 $
+ voice traffic	x+ $

FASTWEB

Top Enterprise Customers
Broadband Services and Revenue Streams

IP VPN (MPLS)

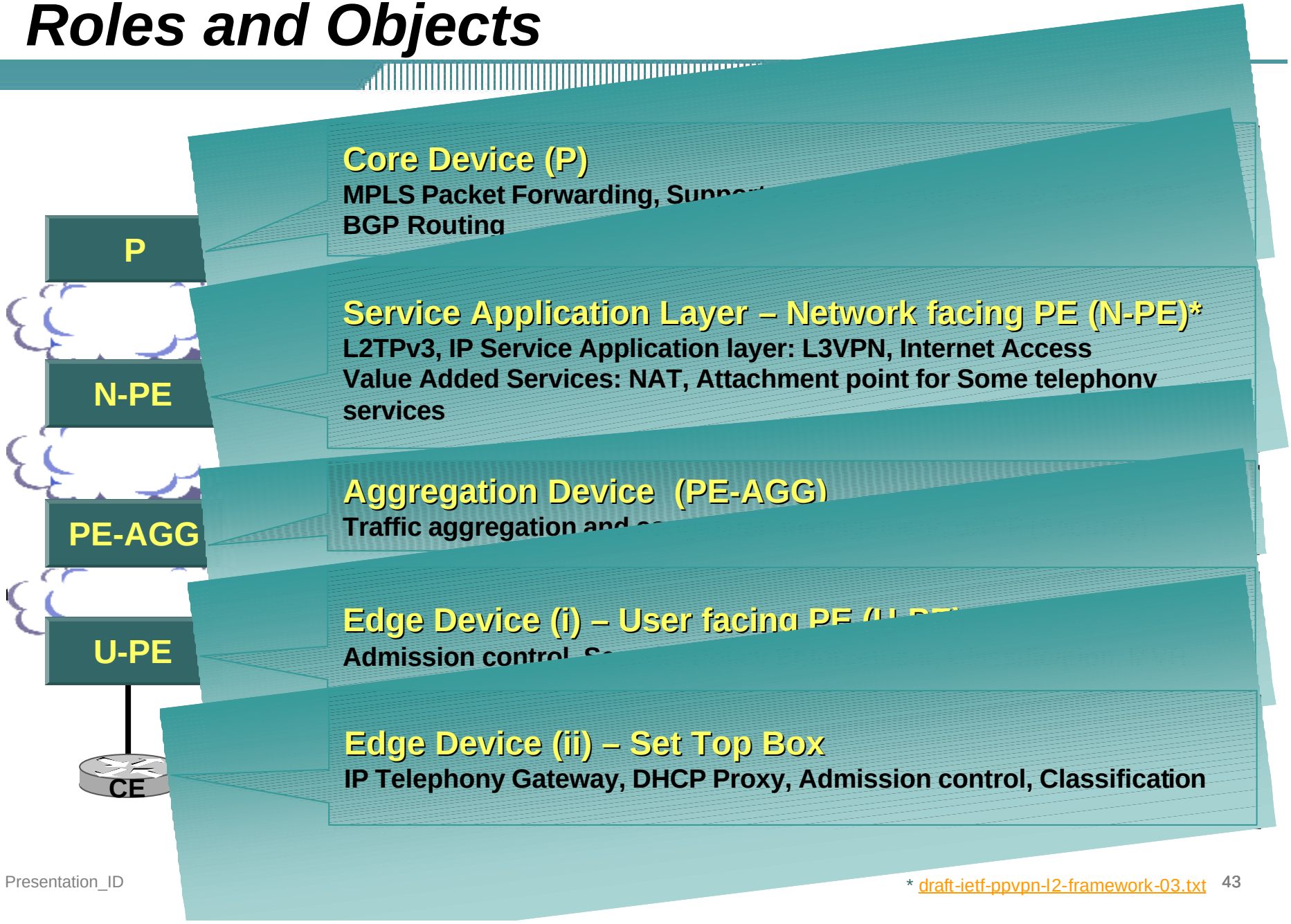
10 Mbps	$1,000 $ month / site
100 Mbps	$5,500 $ month / site
1 GE	"per project" priced

SLA: 99.97, 25ms round trip, 4 hours recovery

Video Application for Business (NEW)

- Exec. Management Business TV broadcasting
- 24 hour Business TV channel → Managed Storage/Encoding
- High Quality Multi video-conferencing

Fastweb Network Architecture
Roles and Objects

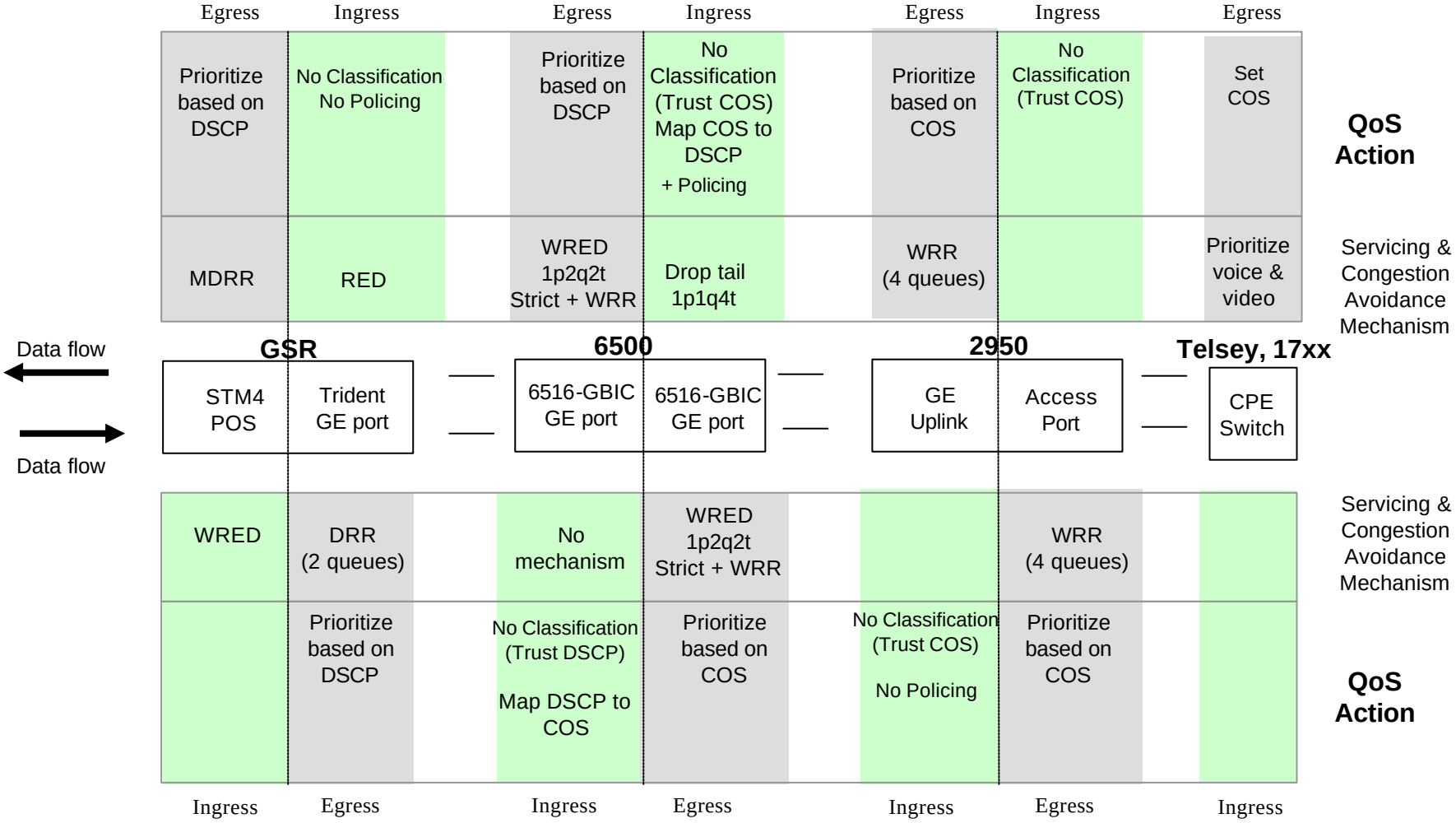


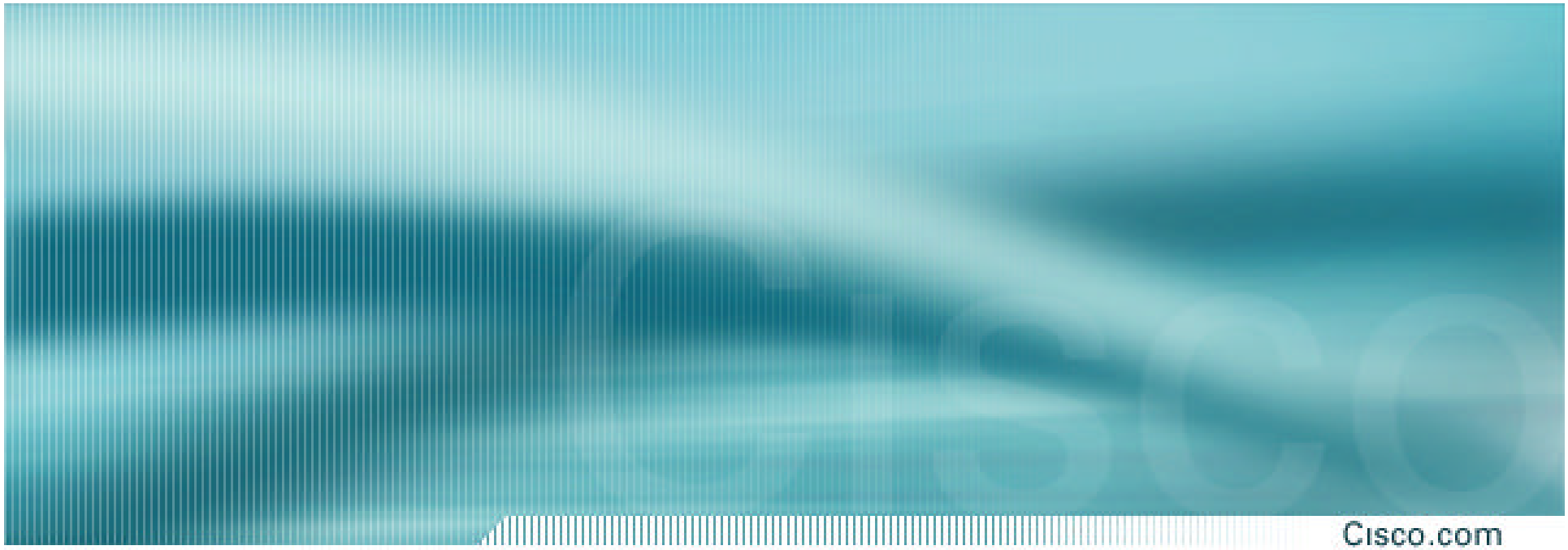
* draft-ietf-ppvpn-l2-framework-03.txt

QoS Strategy

- **Residential Users – Rate limited Best Effort traffic**
- **Business Users – Priority Gold and silver traffic**
- **Multicast (TV) – Own traffic class**
- **Signalling (H323) – Equivalent to Gold**
- **E2E QoS based on DiffServ model**
- **Traffic Marking**
  - **Relies on CPE device in combination with Classification capability of Access Switch**
- **COS to/from DSCP mapping at first L3 switch**

End-to-End QoS

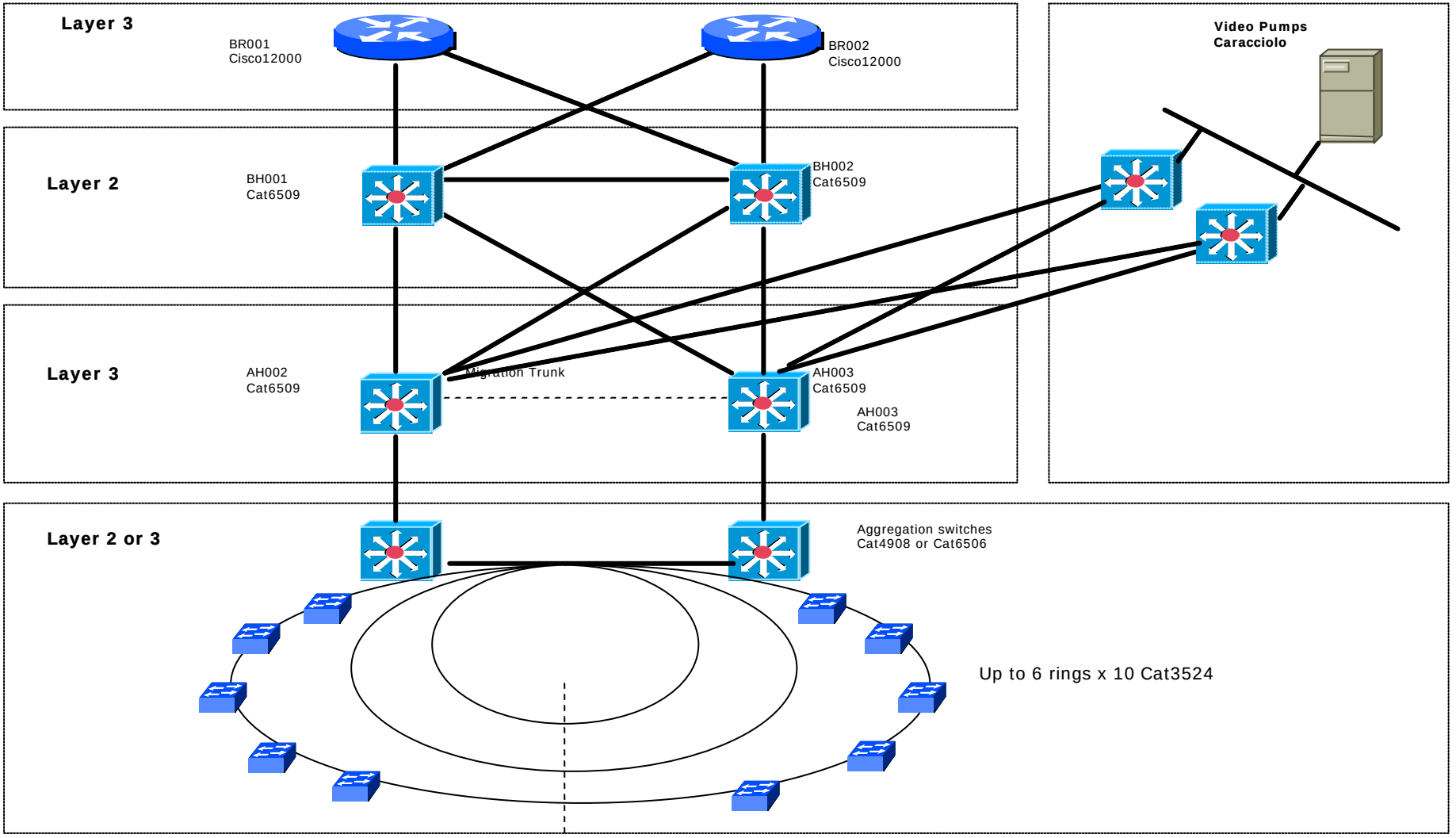




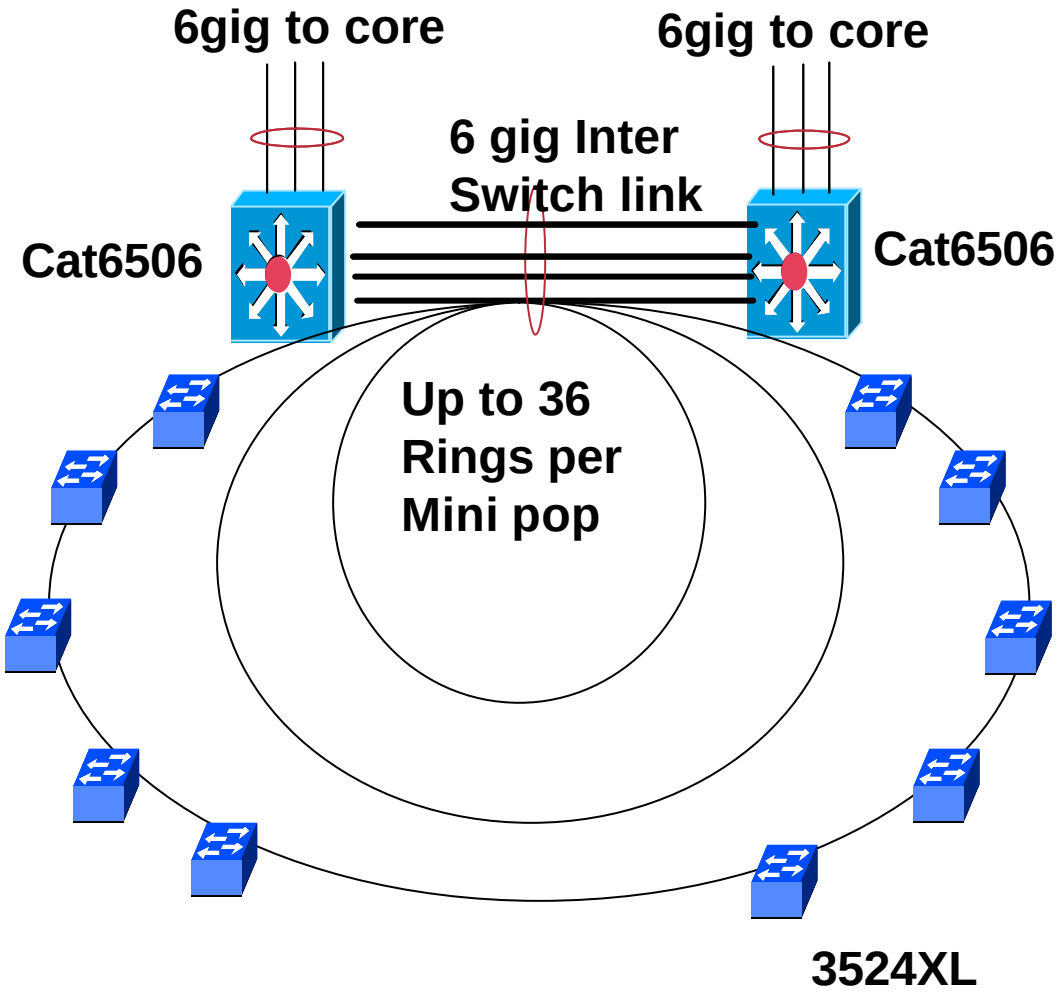
Ring Topology Overview

Fastweb case

Fastweb Pop

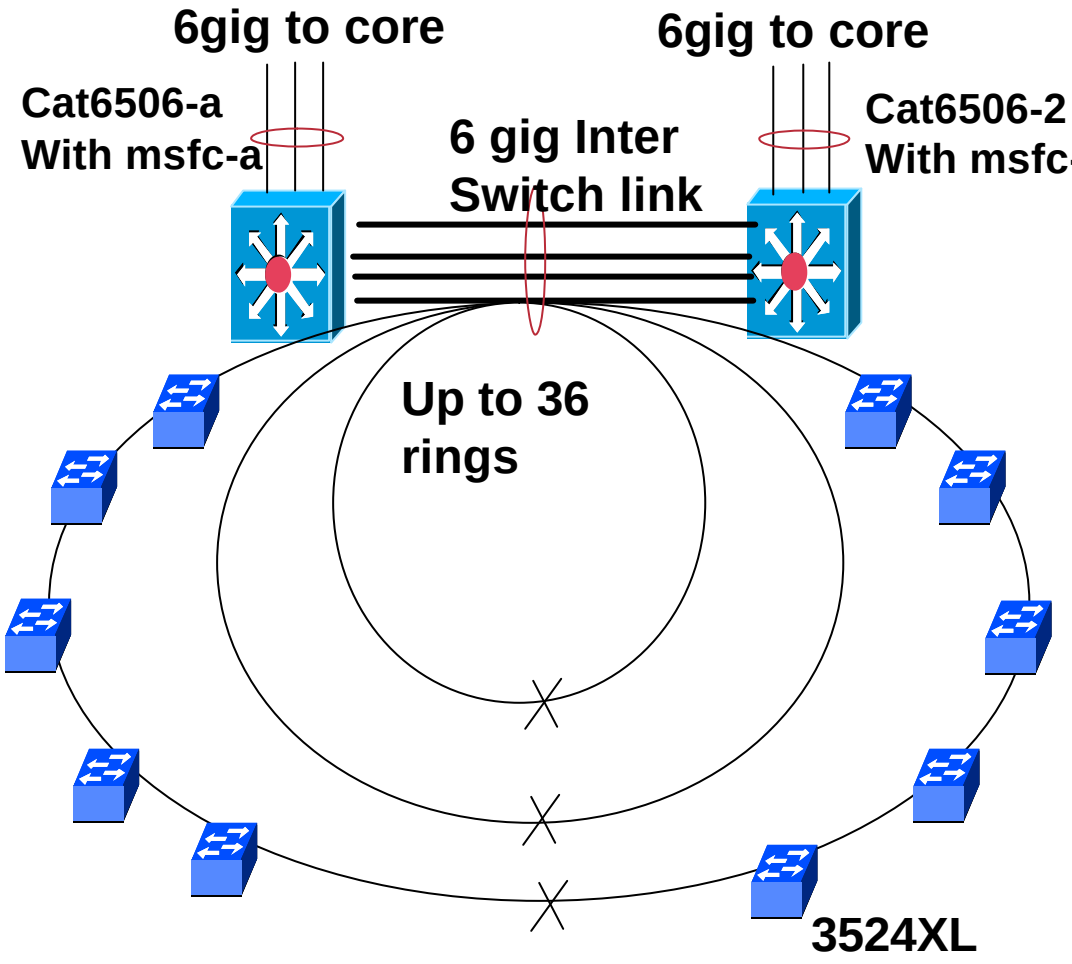


FastWeb Mini Pop topology



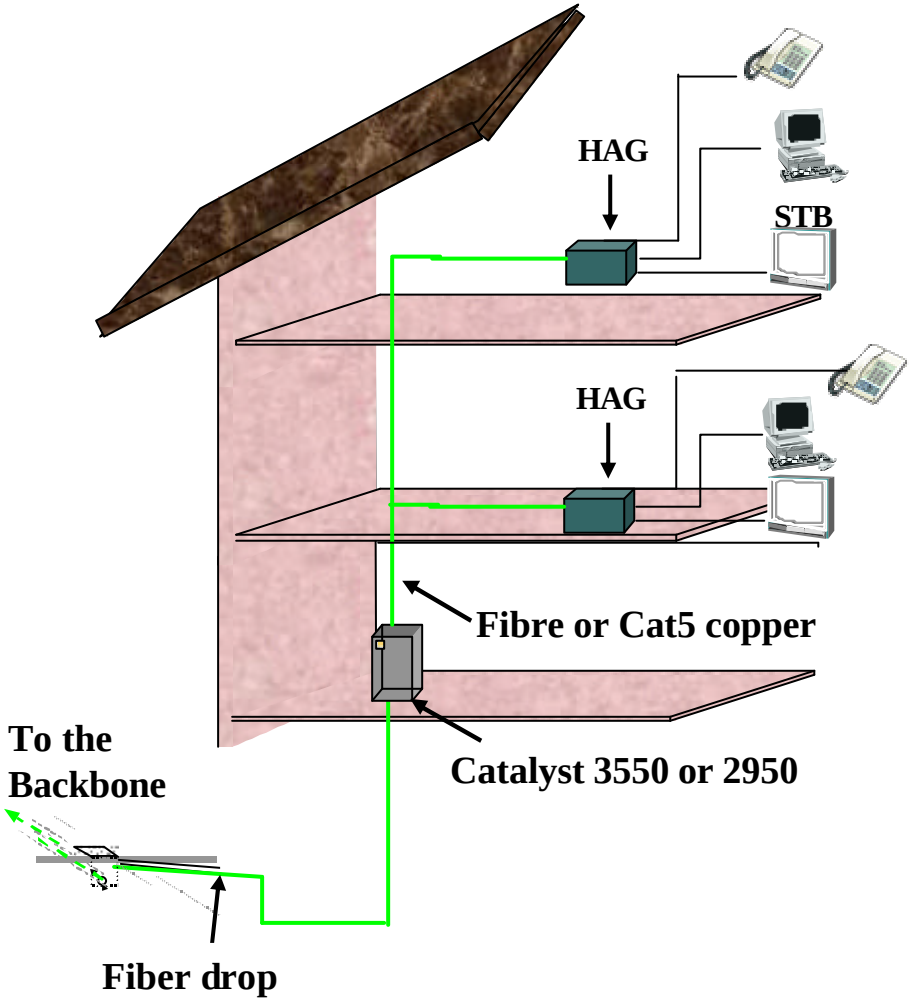
- All links in the rings are gigabit dot1q trunks
- 6 GEC between the two 6506
- 6 GEC uplink to PoP
- One VLAN per Access switch
- Up to 10 switches per ring
- Up to 36 rings per pair of 6506
- Each users on XL at 10M HD
- Each rings carries :
  - 10 users VLAN (one per switch)
  - 1 mgmt VLAN
  - The multicast VLAN

FastWeb Mini Pop topology (cont.)

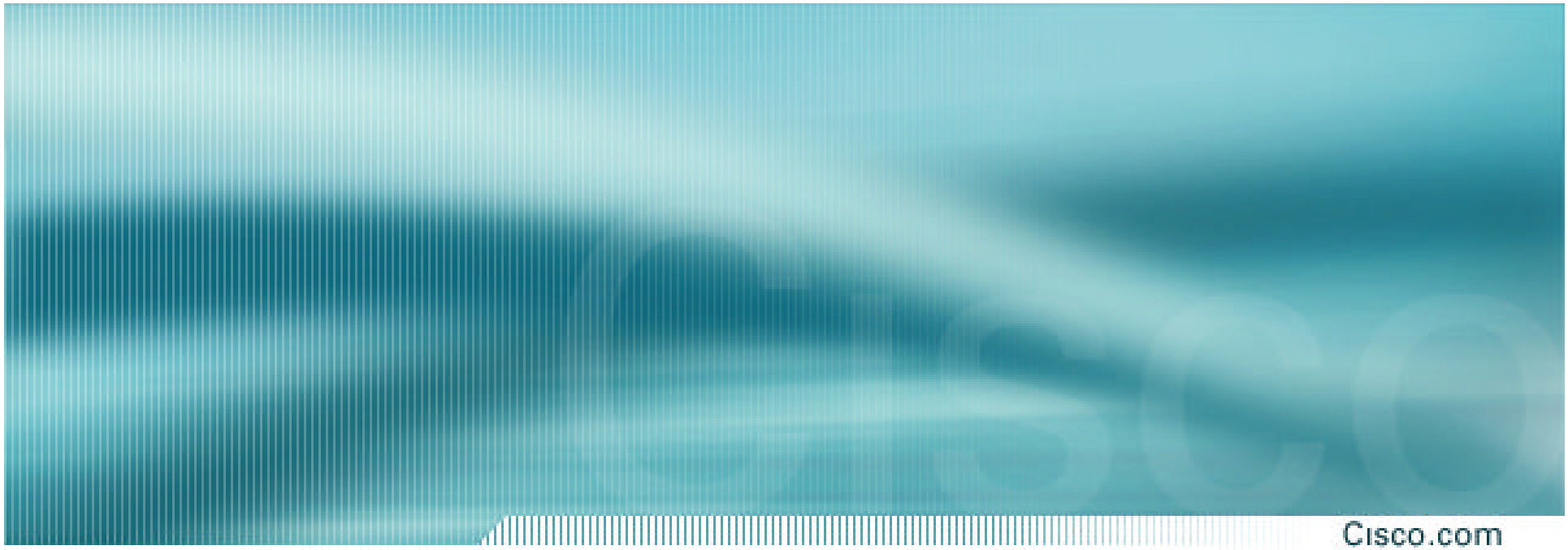


- Each vlans is terminated on msfc-a and msfc-b both running HSRP
- Each rings are purely L2 and root and backup root are located on 6506-a and 6506-b → each VLAN is blocked in the middle of the ring

The last few meters – Building connection



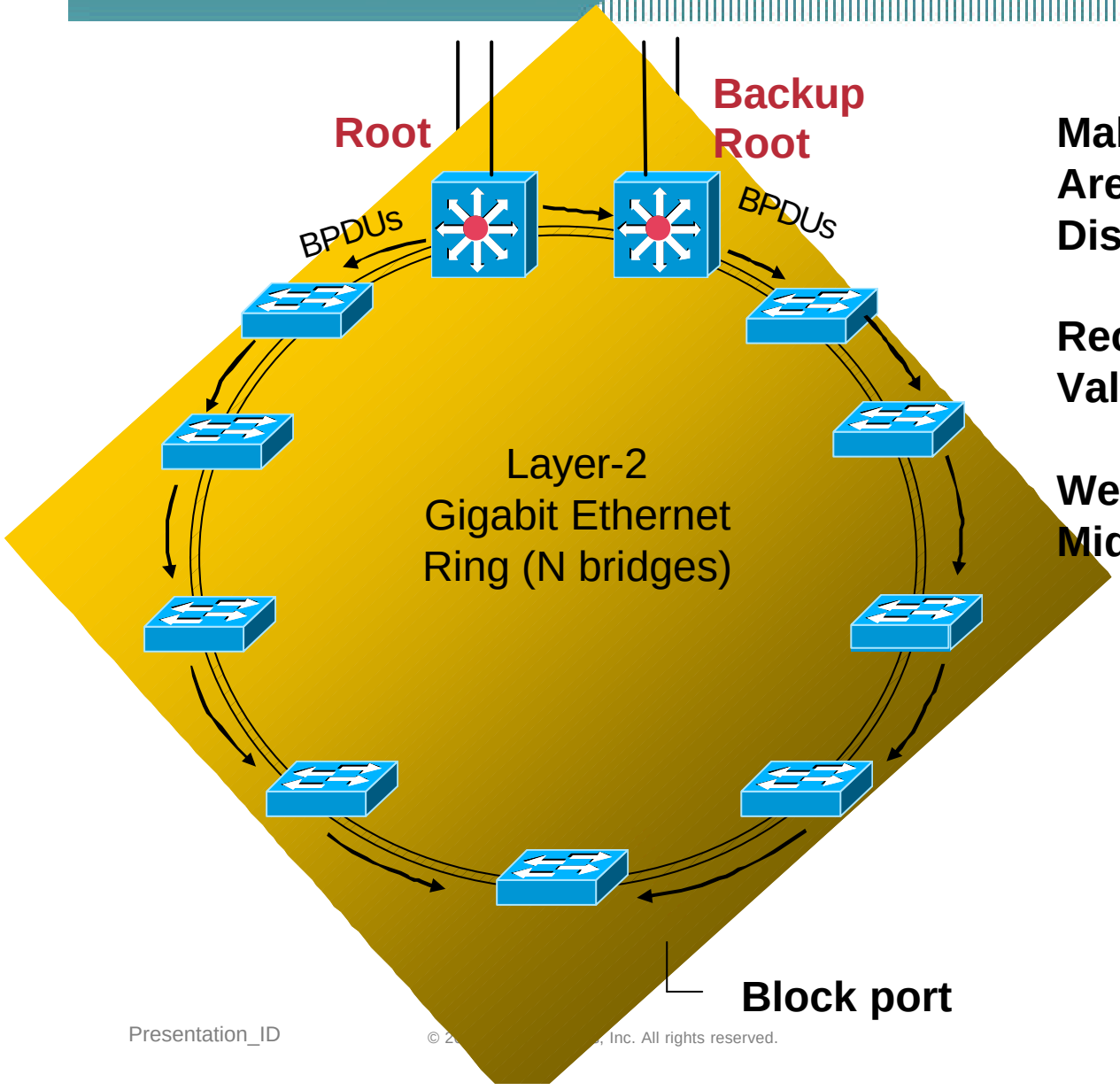
- There is a 3550 or 2950 switch in the basement of each building.
- A Ethernet connections to each of the flat is set. It can be copper or fiber (with optical converters)
- Each of the switches has two GigEth links towards the backbone.



Spanning Tree

STP in Ring overview and Failure scenarios

Spanning Tree in Rings

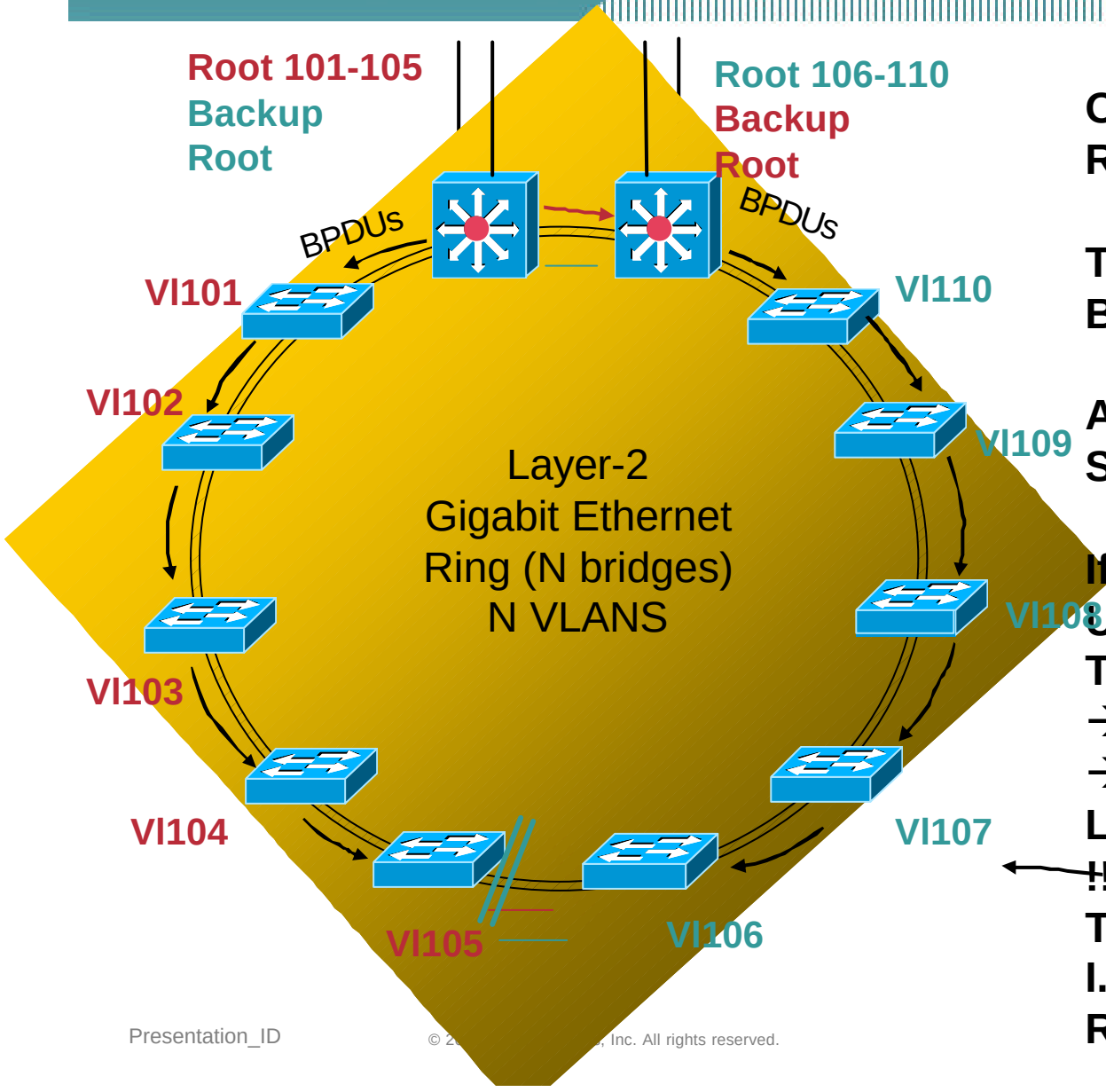


Make sure Root and backup Root Are statically configured on Distribution switches

Recommended to use low priority Value (0 and 1 for example).

We will block somewhere in the Middle of the ring.

Spanning Tree in Rings : one user vlan per switch.



One user VLAN per switch Restriction

Trying to load balance Root Between the two dist switch

Always Match HSRP active with STP root.

If provisioning permits try to Use to have HSRP active The closest switch
→Minimal path
→Avoid using the Inter switch Link between dist switch
!! Remember oversubscription of That links
I.E. : Fastweb uses 6Gig for 36 Rings.

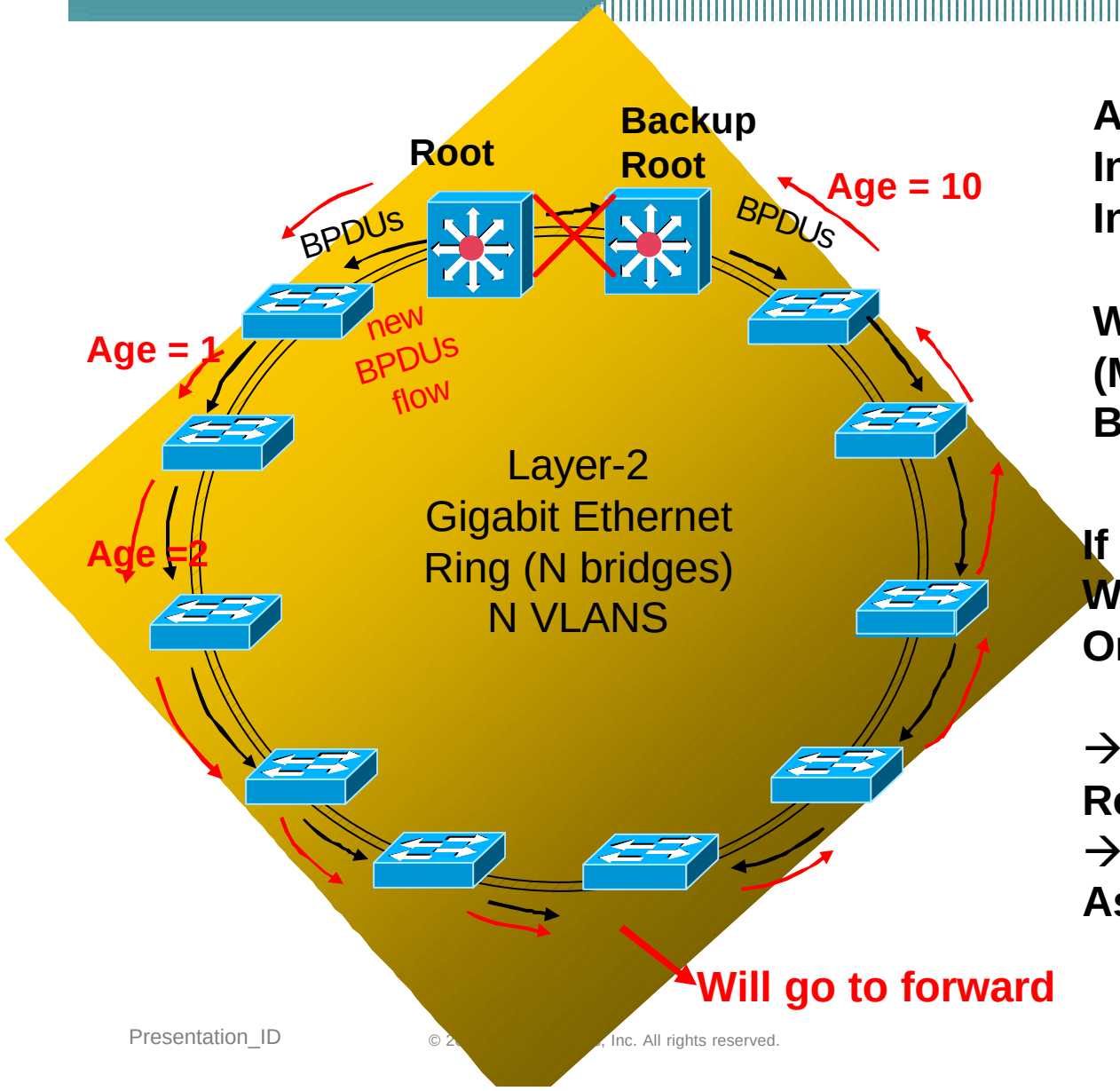
Diameter of the STP

- **IEEE default timers are :**
  - **Max age 20s**
  - **Fwd delay 15s**
  - **Hello 2s**
- **These timers consider :**
  - **Max Diameter N = 7**
  - **3 BPDUs can be lost without triggering recalculations**
  - **…**
- **See : http://www.cisco.com/warp/customer/473/122.html for detail on IEEE calculation to reaches these values.**
- **They suppose very conservative values (1 sec delay introduced per switch, ….)**
- **Some calculation done more recently usually allows more aggressive timer values (like the one used to calculate timers when macro commands are used in CatOS)**

Diameter of the STP

- **With 10 access switch in rings diameter would be up to 12 (longest L2 path between two switches)**
- **Far above L2 recommendation**
- **However, it has been tested in such ring architecture to be OK to go up to 12 access switches per ring (N=14) with default timers.**

Risks linked to high value of N (diameter)



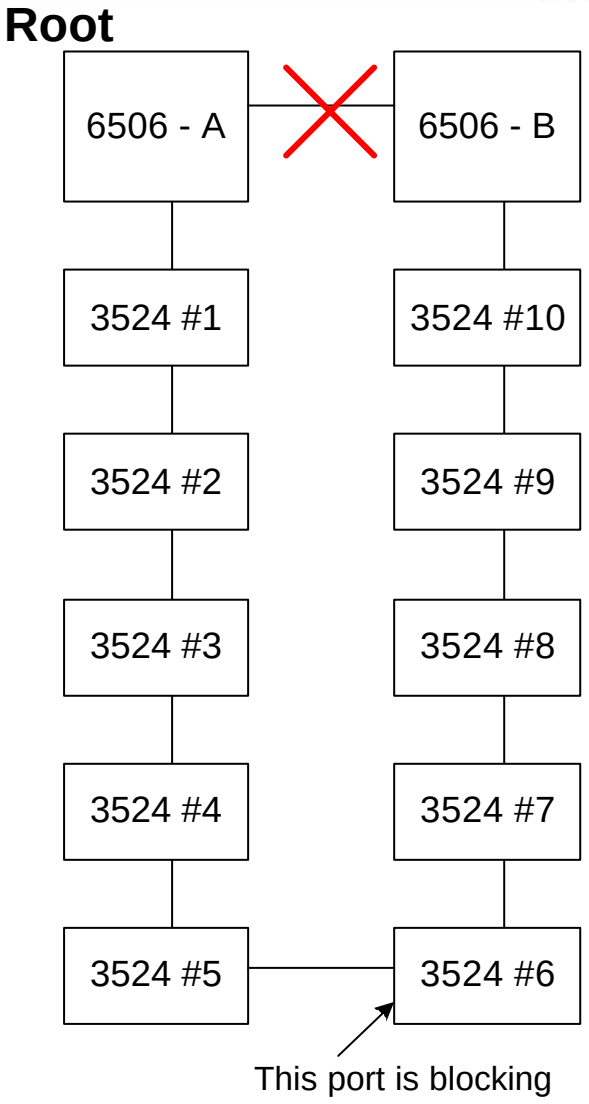
Age of BPDU is carried In each BPDU Increased by one by each switch.

We are aging received info (Max_age – age) sec without new BPDU

If BPDU receive with age 10, we Will age out that info after 10 sec On Dist switch backup root.

→Risk is potentially 2 different Root at the same time.
→Not good, but not catastrophic As there is no more blocked port

Failure and impact: Lost of the Inter switch distribution link



- **Break link between two distributions :**
  - **Not likely to happen as**
    - **It is a channel (6 gig in FW)**
    - **Channel between port in different module**
  - **Effect :**
    - **Recalculation of the blocked port to go to forwarding (new root port)**
    - **Switch 6, 7, 8, 9 and 10 all recalculate as**
      - **Root port → Designated port**
      - **Designated port → Root port**

→Half of all rings loses connectivity for about 50 sec.

Failure and impact: Root dies

- **Root is crashing or dying, effect :**

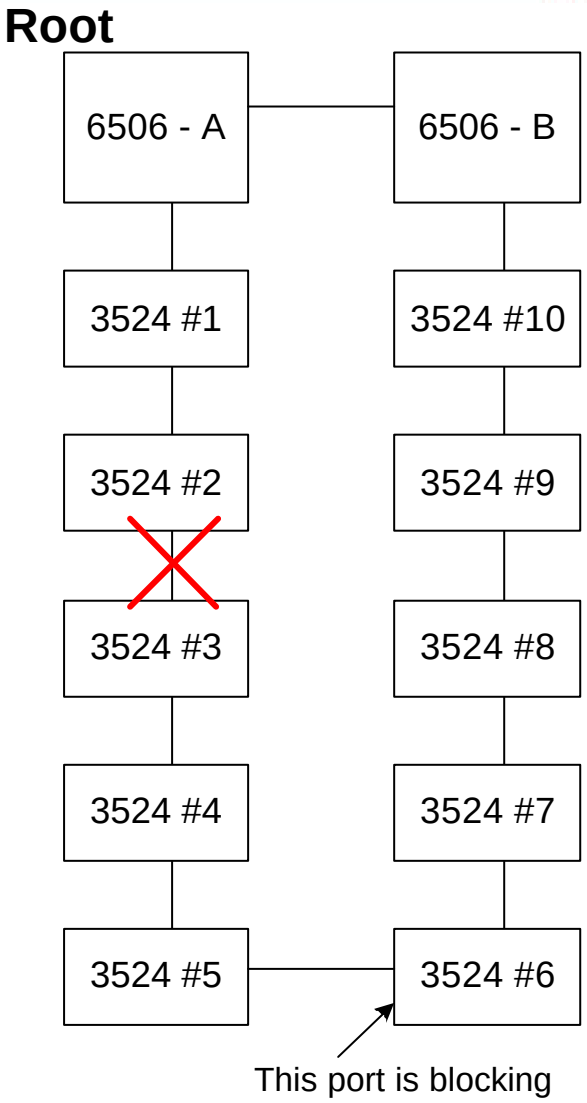
  Backup root detect it straight away (directly connected)

  Block links needs to recalculate (max_age + 2 Fwd delay = 50 sec) of downtime for half of one ring in worst case

  All switch in the half ring close to the former root recalculate.

  → Switches impacted are switches with user vlan having the failed root and located on the half side of the ring close to the failure.

Failure and impact: Lost of an inter access switch link close to the root



- **Break link between switch 2 and 3 :**

  Effect :

  Recalculation of the blocked port to go to forwarding (new root port)

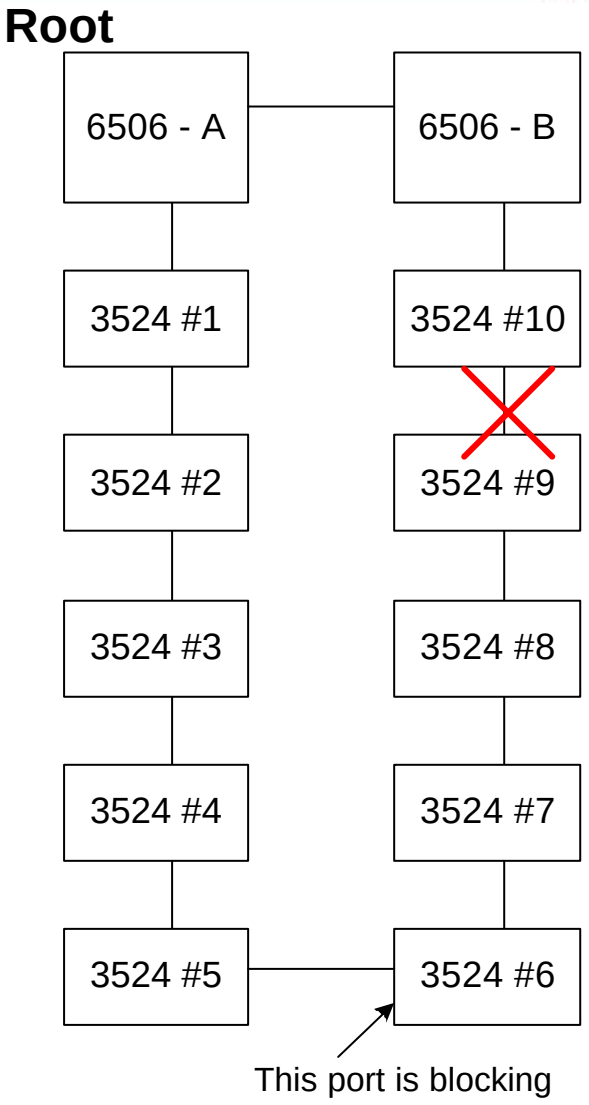
  Switch 3, 4, 5 all recalculates as

  Root port → Designated port

  Designated port → Root port

  → 3 switches loses connectivity for about 50 sec.

Failure and impact: Lost of an inter access switch link far from the root



- **Break link between switch 9 and 10 :**

  Effect :

  Switch 6, 7, 8 and 9 loses their root port and got a new root port

  → 4 switches loses connectivity for max 50 sec.

Timers Recommendation

- **It is however not recommended to tune timers to more aggressive values.**

Spanning Tree Portfast

- **It is obviously recommended to enable spanning tree portfast on all user port**
  - **Bypass listening learning state**
  - **Do not Generate TCN in case of port flapping**
  - **→More stable L2 table**
  - **→Less flooding**

Spanning Tree Root Guard

- **Root Guard is a spanning-tree feature that will make sure that a port with root guard enable will be put in blocked state whenever it is selected as root port :**
  - **I.E : if someone behind that port claim to be root**
- **Recommended to configure it on access port**

Spanning Tree BPDU skewing

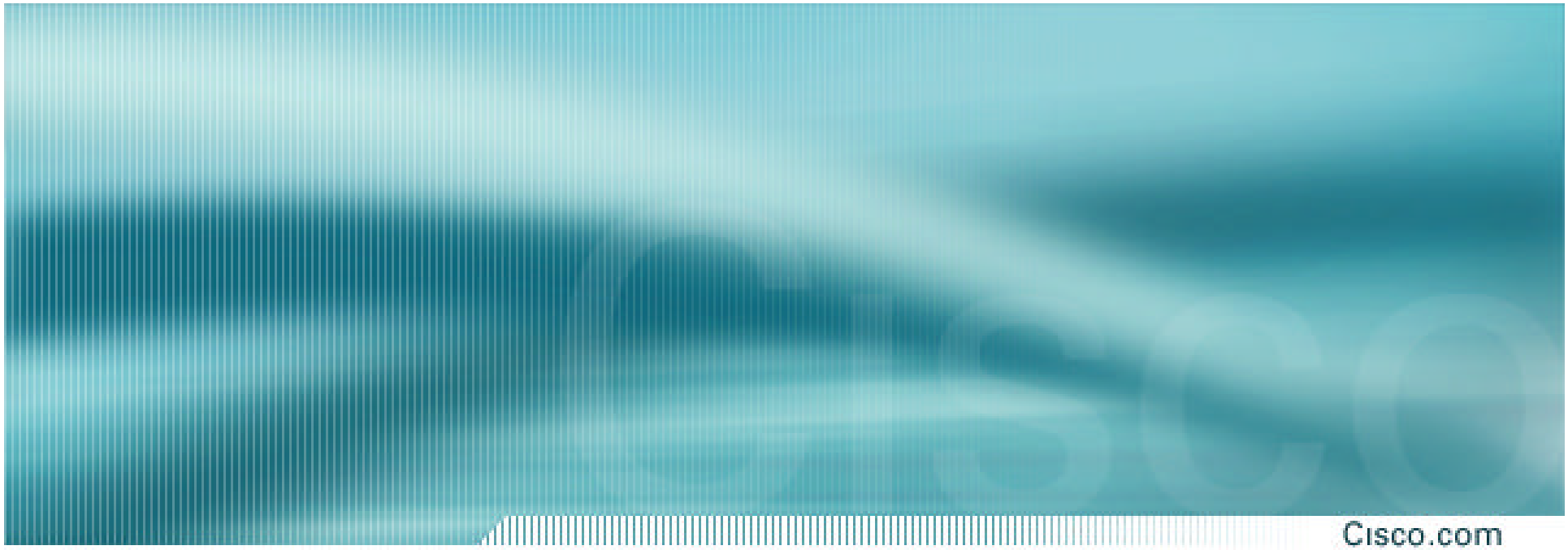
- **STP operation relies heavily on the timely reception of BPDUs.**

  BPDUs are sent by the root bridge at every *hello_time* message (2 seconds by default).

  Non-root bridges do not regenerate BPDUs for each *hello_time* message, but they receive relayed BPDUs from the root bridge.

  → Therefore, every non-root bridge is supposed to receive BPDUs on every VLAN for each *hello_time* message.

- **BPDUs can be lost or delayed (CPU too busy to relay timely)**
- **This potentially compromises the stability of the spanning tree topology.**
- **BPDU skewing should be monitored**



ETTx Rings Case Study

Multicast

Multicast video considerations

- **Multicast VLAN Registration (MVR) feature is used in layer 2 ring architectures… (use IGMP Snooping used for star architecture)**
- **PIM Sparse Mode used in the network today**
- **PIM Source Specific Multicast / IGMPv3 is desirable**
  - **Scalability and operability issue**
- **Set top box needs to support IGMP v2 / v3**

Problem to distribute multicast in L2 rings

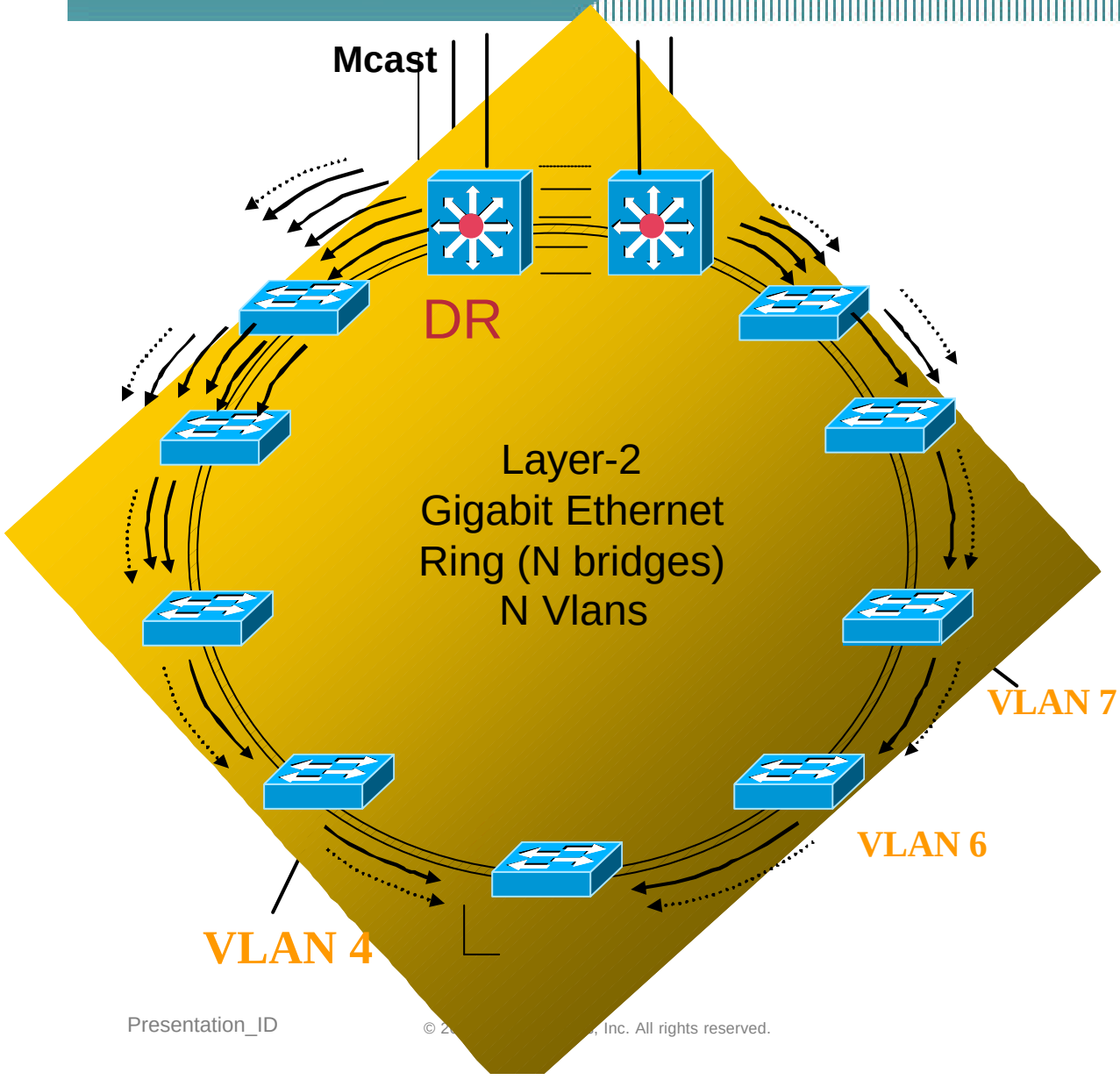
- We have one user VLAN per L2 switch in the ring and the 10 users VLAN are send over each trunk in the ring.
- We need to be able to send all multicast streams to each users
- In standard multicast the distribution 6k needs to replicate multicast streams to potentially 10 users VLANs

  →More heavy on 6k that needs to replicate to 10 output VLAN

  →10 copy of each multicast packet might travel over the ring

  → If we use 50 MPEG2 stream thus around 200M of Mcast traffic, that would make max 2Gig of traffic over the ring that has only a capability of 1 Gig

Problem to distribute multicast in L2 rings



One copy of each mcast Streams is coming from the Network to the 6500 DR

The 6500 needs to replicate The traffic N times

N copy of each frames are Going over the ring

→Solution is MVR (multicast VLAN Registration)

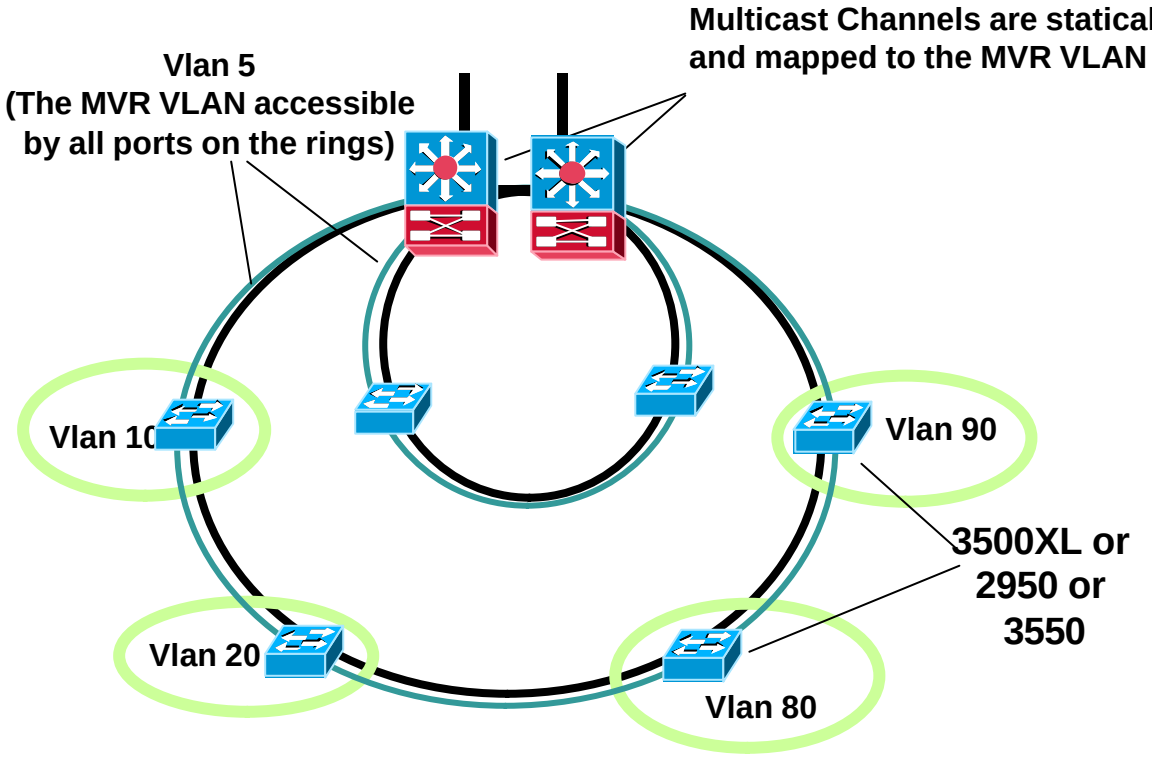
Multicast VLAN Registration (MVR)

- Multicast VLAN – avoids channel replication on the ring
- Each multicast channel is sent only once via the Multicast VLAN
- IGMP joins and leaves from STB's are "intercepted" by the L2 switch
- The L2 switch modifies hardware forwarding behavior to allow m-cast traffic to be forwarded from the m-cast VLAN to the subscriber VLAN
- There is a one-to-one mapping relationship between IP-mc addresses and MAC multicast addresses

MVR overview (cont'd)

- **Second advantage of MVR against CGMP is that it provides faster channel swapping (zapping).**

MVR Configuration



http://www.cisco.com/univercd/cc/td/doc/product/lan/c3550/1214ea1/3550scg/swigmp.htm

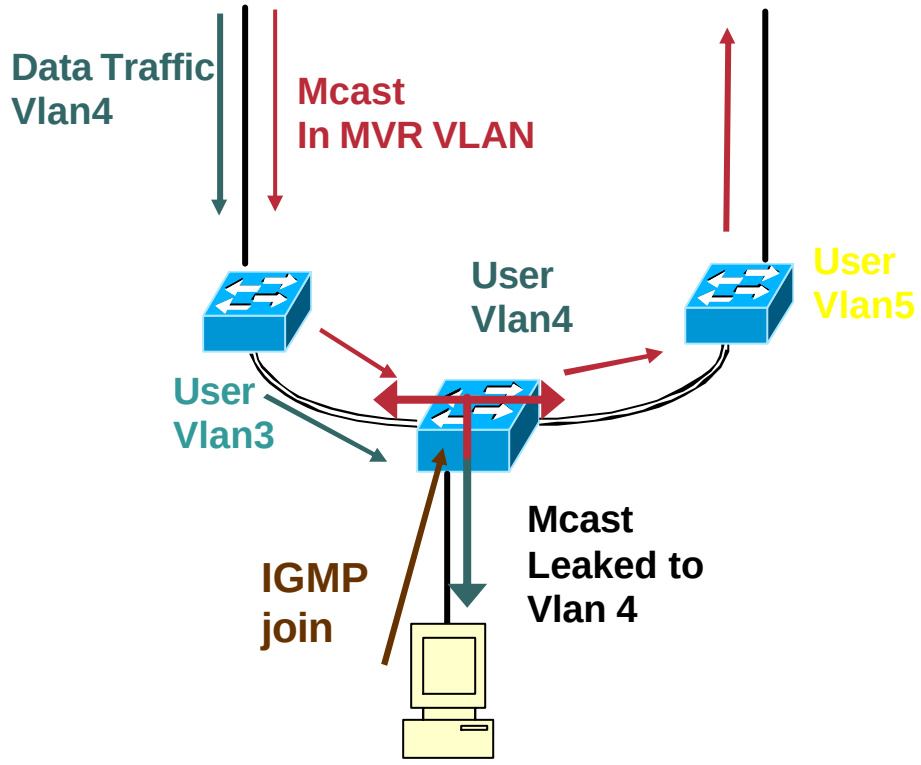
MVR Vlan

- **The MVR vlan is the only one that is present on all the rings.**
- **Note that there is no impact from failure within one ring for all the other rings**

  No recalculation in other rings

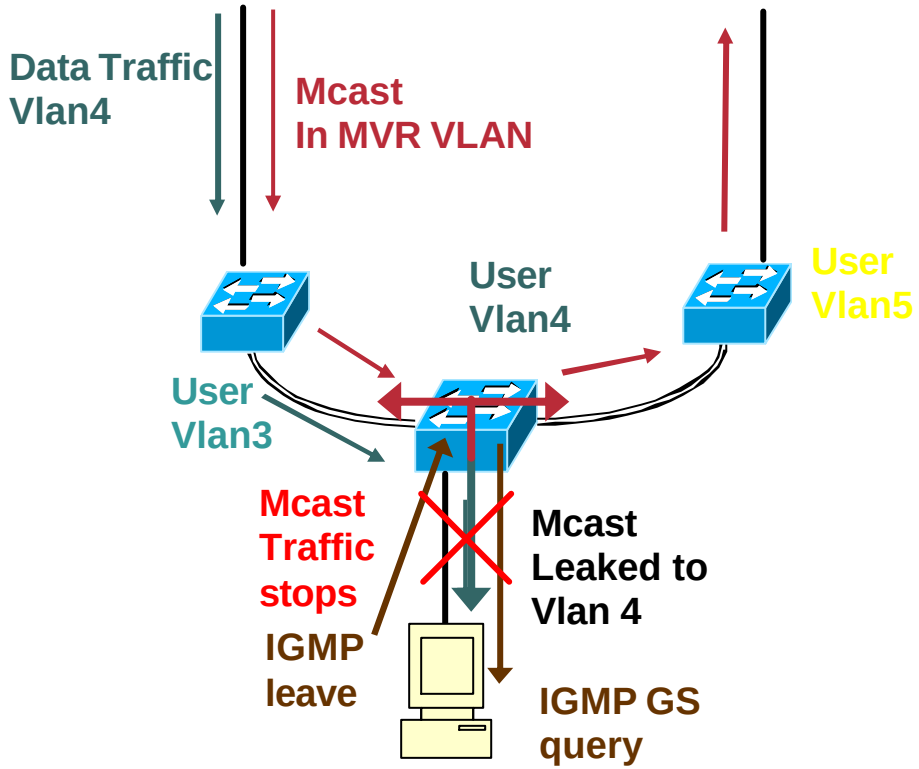
  Just TCN process and cam aging in mvr vlan, but it has no drawback as the MVR vlan do not hold mac address of users.

MVR operation : User joining a group



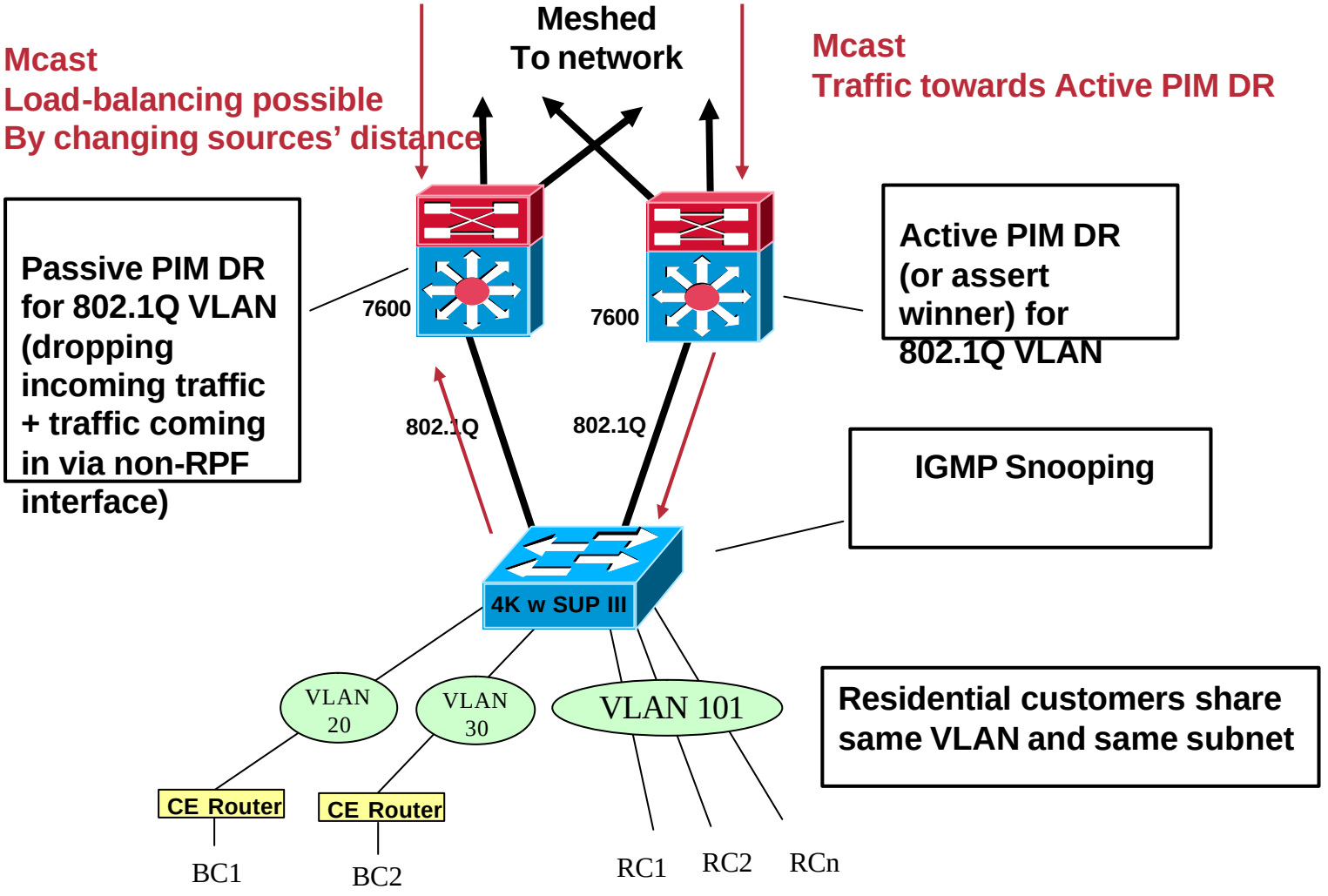
- 1. Original state : Data traffic in vlan4 to user, mcast traffic in MVR vlan. User did not join yet
- 2. IGMP rapport (join) sent by user is capture by L2 switch CPU
- 3. L2 switch starts to leak Multicast traffic from MVR vlan (red) to Data Vlan4.

MVR operation : User leaving a group

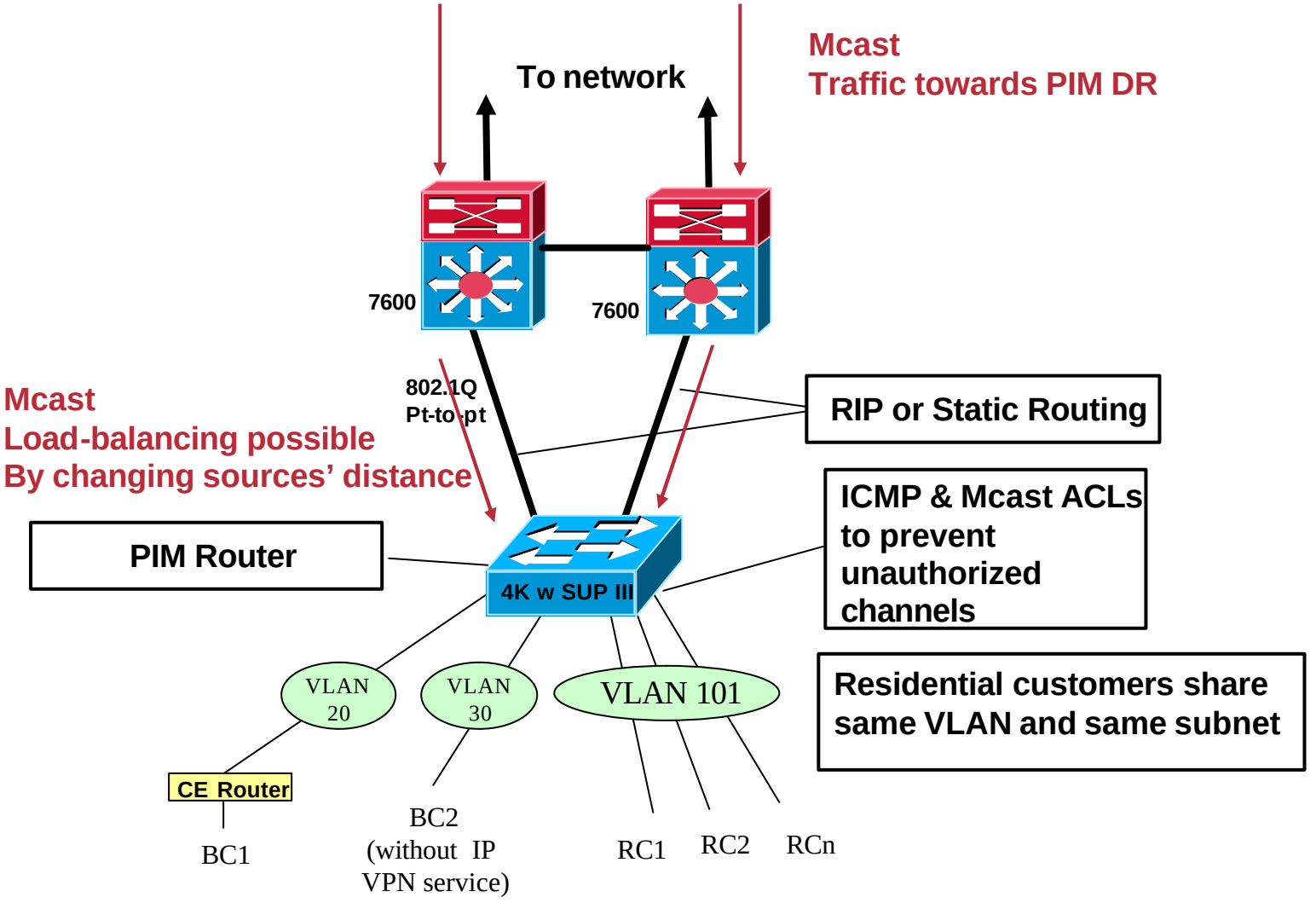


- 1. Original state : Data traffic in vlan4 to user, mcast traffic in MVR vlan. User has joined and multicast traffic is leaked from MVR Vlan to user vlan for the desired group.
- 2. User sends IGMP leave for the group, the leave is capture by the switch CPU.
- 3. Switch CPU sends an GS IGMP query to verify there is no more set top box interested by that traffic on that user port.
- 4. There is no IGMP report replying to the GS query and the switch stop to leak mcast traffic for that group to that user port.

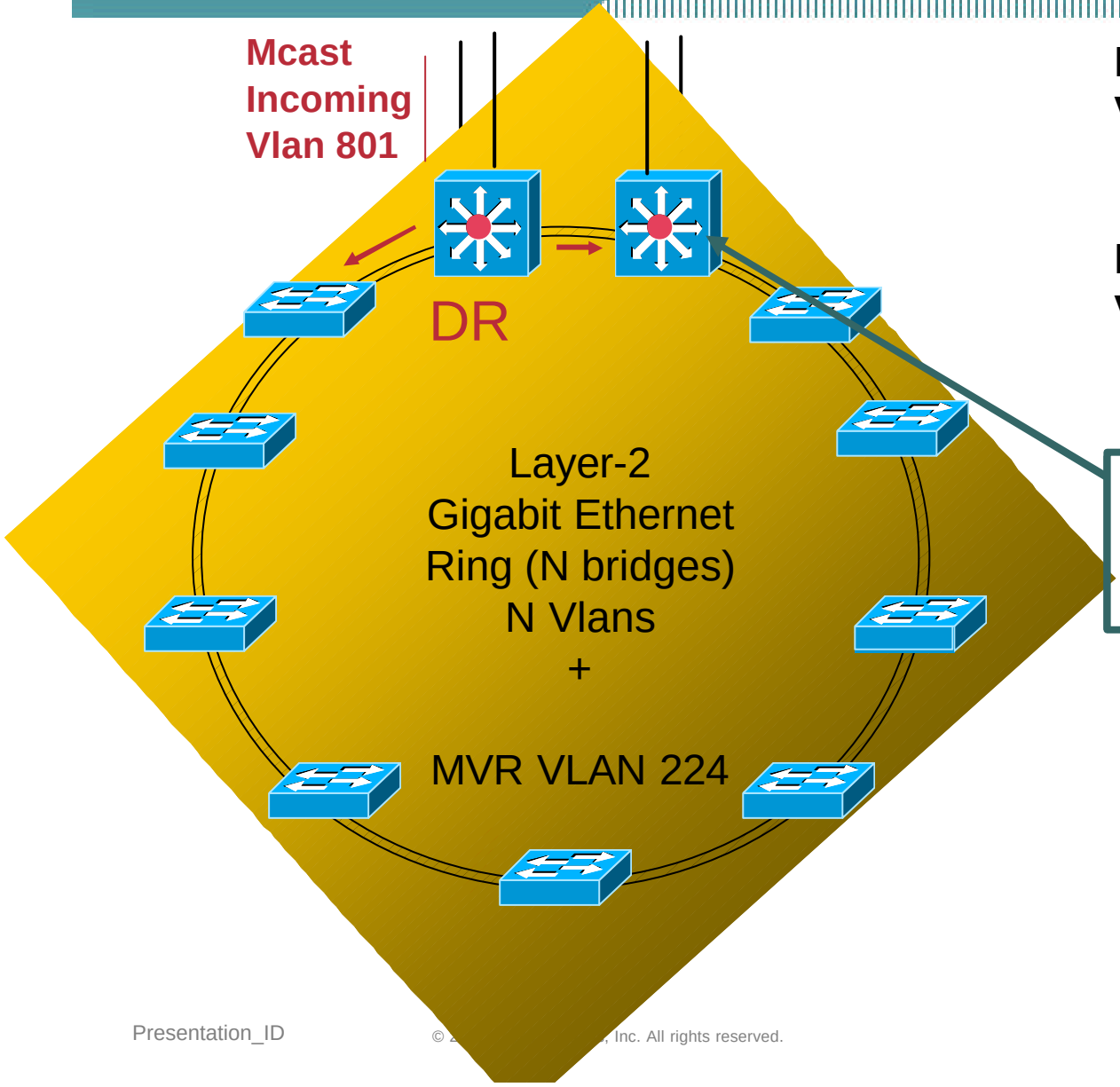
Multicast in L2 Star Configuration



Multicast in L3 Star Configuration



Non RPF in ring topologies

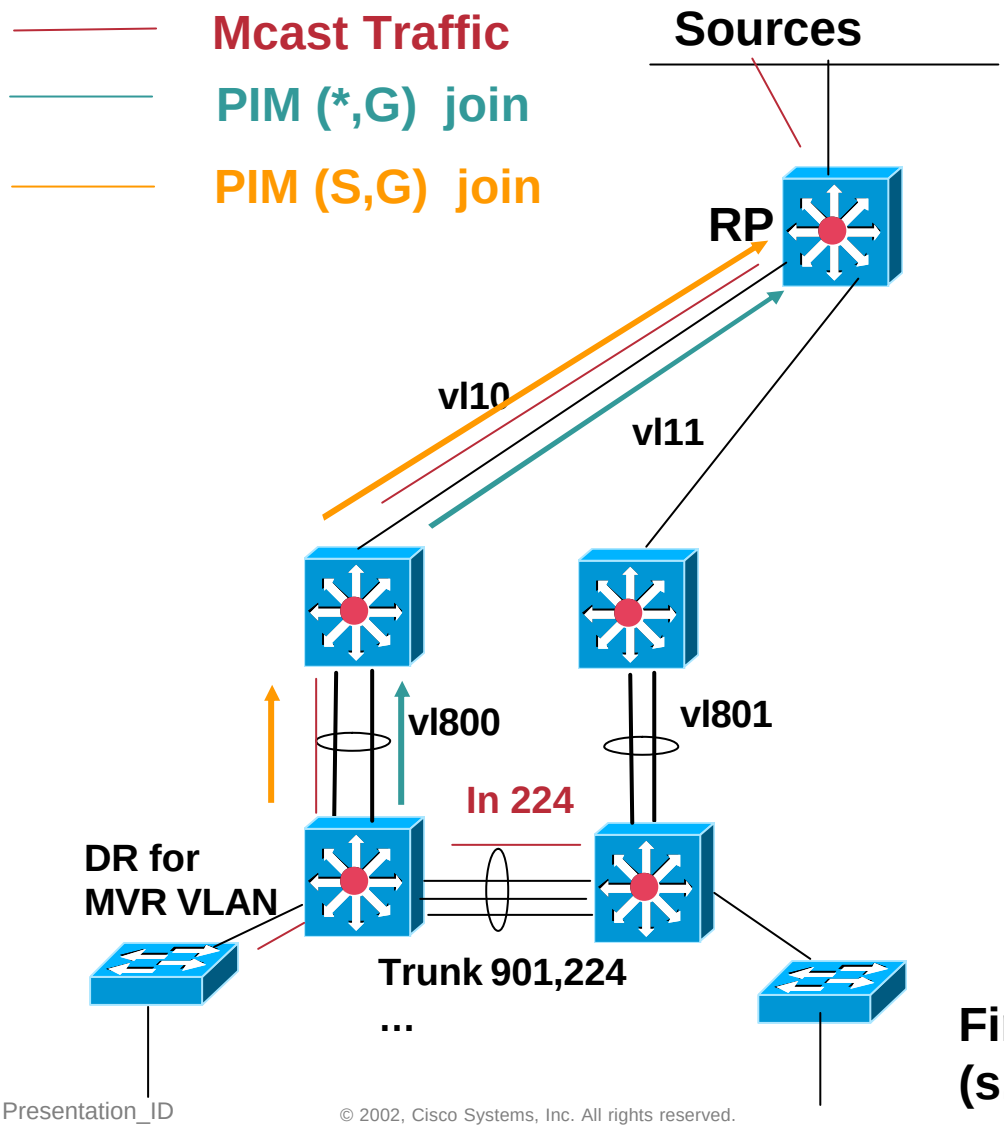


Incoming multicast traffic in Vlan 801 hitting the DR

DR route the traffic to the MVR VLAN 224

Mcast Traffic hits Non-DR 6500 In vlan 224 (non RPF vlan) → Drop this Non-RPF traffic

Mcast Data and PIM flow



On distribution switches PIM
Runs on :
-vlan 800 (801) to core
-vlan 224 (MVR vlan
-Vlan 901 : pt to pt vlan between distribution

IGMP Static-group created
→OIL modified on DR
→PIM (*,G) join sends on 800

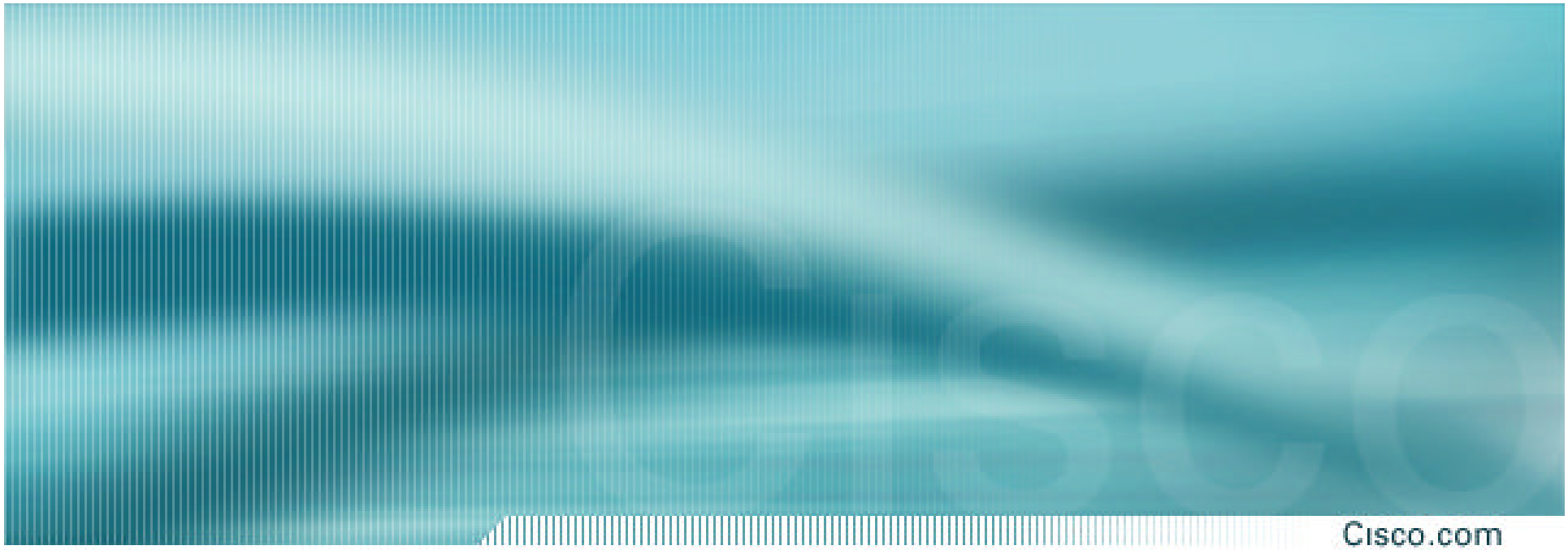
PIM join reaches RP, traffic flow
Through shared tree

DR creates (s,g) and joins
Source tree → PIM (S,G) joins
Towards the source

Final state : periodic pim joins sent
(s,g) created everywhere on the path

IGMP Filtering

- Controls at the port level which IP multicast group(s) can be joined
- Works with MVR
- Allows SP to sell individual video channels
- Prevents unsubscribed customers from illegally intercepting video streams
- There is a one-to-one mapping relationship between IP-mc addresses and MAC multicast addresses



ETTx Rings Case Study

Various issues

Address Management

- **Private IPv4 Addresses**
  - **-DHCP Server assigns the addresses as requested**
  - **-NAT is used**
  - **-Disadvantages of using NAT:**
    - **Applications may not work (peer to peer)**
    - **Possible Performance Hit**
    - **Management overhead and complexity**

Subscriber Identification

- **Subscriber needs to be identified for**
  - **Access control / Policy Enforcement**
  - **Security / Trace-ability**
  - **Billing**
- **This is done via MAC addresses of Set Top Box**
  - **manually**
  - **Automatically using features such as VQP or MAC address notification ….when the first DHCP request is sent, the MAC address is validated by the VLAN Server in a LDAP database**

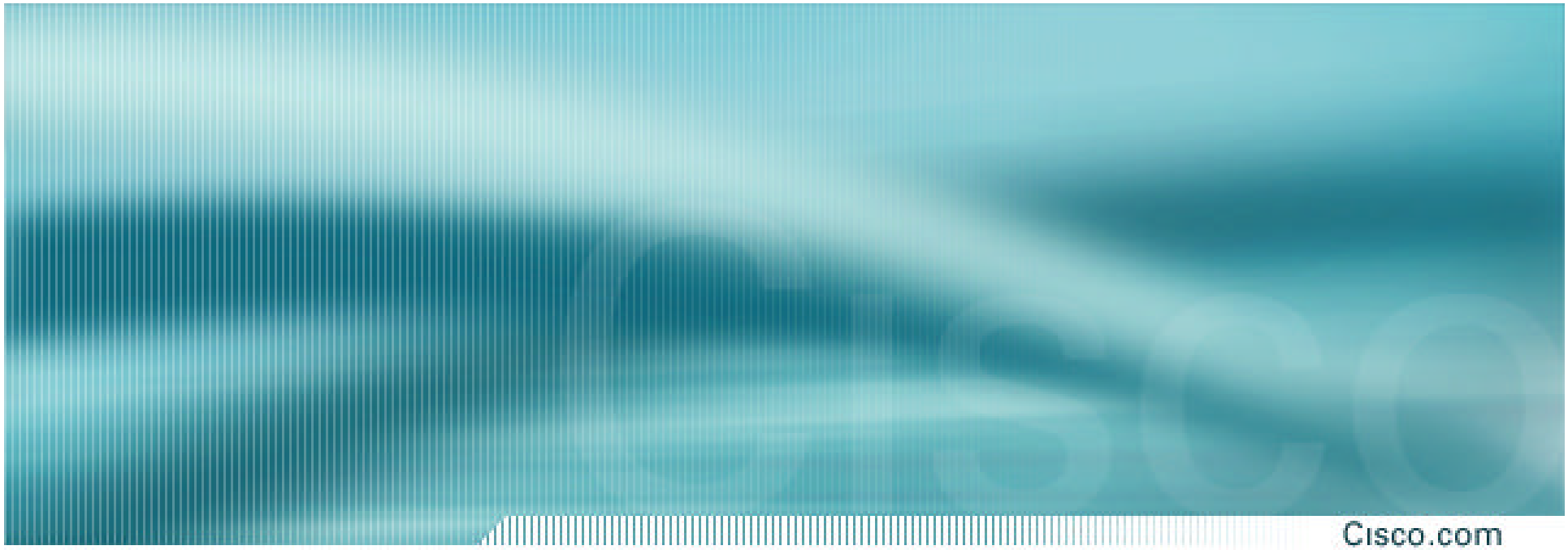
Dimensioning

Number of Rings and Access Ring Size

- **Engineering Guidelines**

Number of Switches in Ring	**<= 10-15**
Number of subscribers on a ring	**<= 200**
Number of L3 users (IP addr.) terminating on a C6500	**<=5000**
Bandwidth overbooking between Mini-POP and Main-POP	**Ratio 6:1**

(36 Rings on MiniPOP → 6 GE links from Main to Mini)



ETTx Rings Case Study

Fastweb's IPPU

Internet Pay Per Use (IPPU)

Cisco.com

- **Fastweb's IPPU –**
  - **Is a service providing usage based connection to the Internet to Ethernet Residential Users**
  - **Also Used to provide NAT functionality**
  - **Based on Cisco' Service Selection Gateway (SSG)…**

SSG ?

- **SSG – Service Selection Gateway – is a switching solution for Service Provider that provides**
  - Subscriber Authentication
  - Service Selection
  - Service Connection
  - Accounting

- **SSG works in conjunction with Cisco Subscriber Edge Service Manager (SESM) and AAA Radius server**

- **Current deployment include DSL, Public Wireless LAN, ETTx, an Wireless solutions**

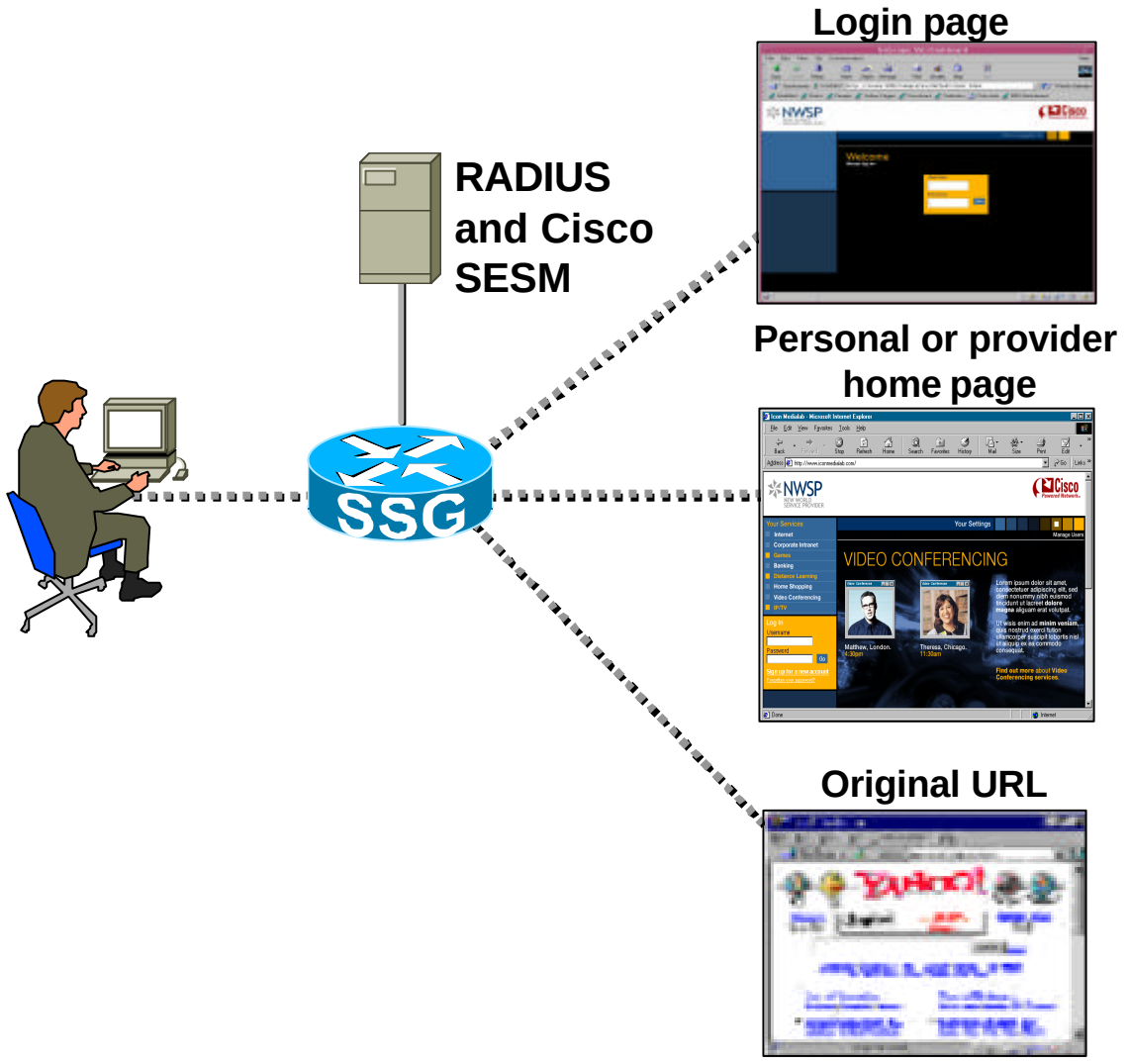
TCP Redirect and Captive Portal

Step 1
Unauthorized subscriber attempts to connect to a service on a TCP port, such as www.yahoo.com

Step 2
HTTP packet is redirected to the Cisco SESM (dest IP address and port rewritten)

Step 3
Subscriber logs into the Cisco SESM and is authenticated and authorized

Step 4
Subscriber is then presented with a personalized home page, the provider's home page, or the original URL (configurable)



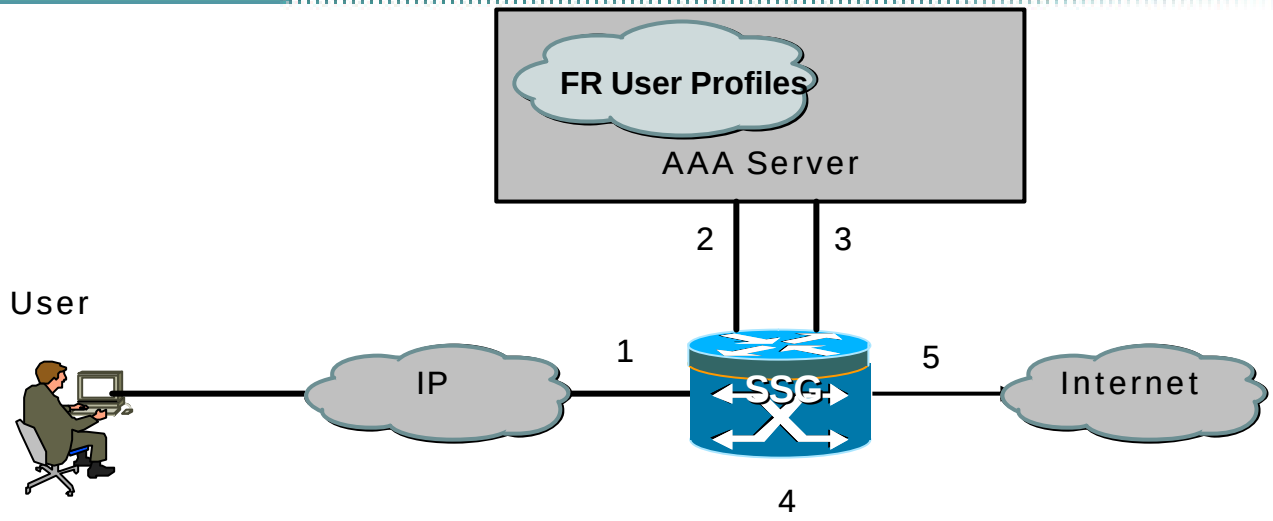
Two types of IPPU users

- **The solution allows two type of users:**

  Pay Per Use – using the “traditional” SSG architecture

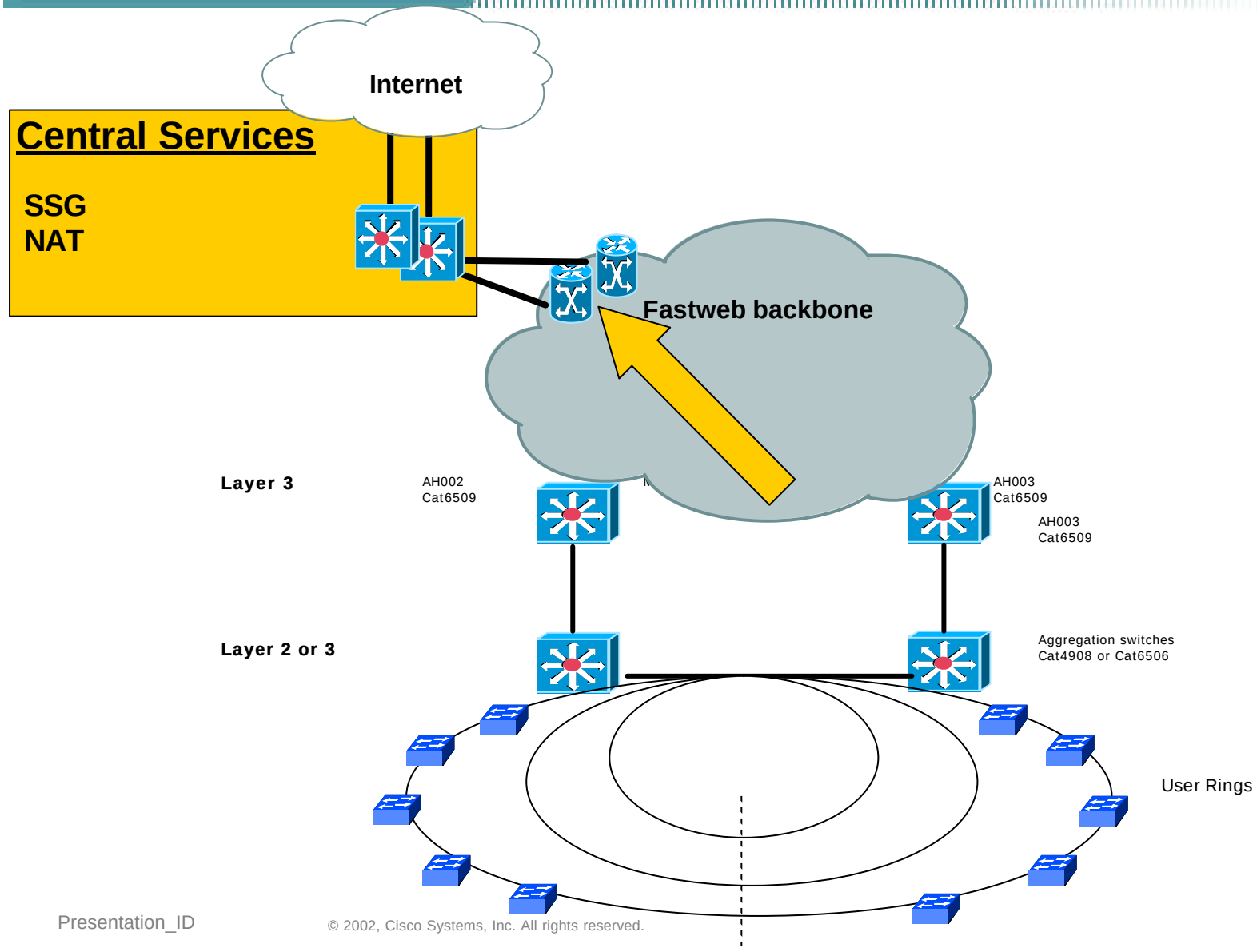
  Flat Rate User – bypassing the SSG architecture. It requires a new feature, called “Transparent Auto Logon (TAL)”

Transparent Auto Logon

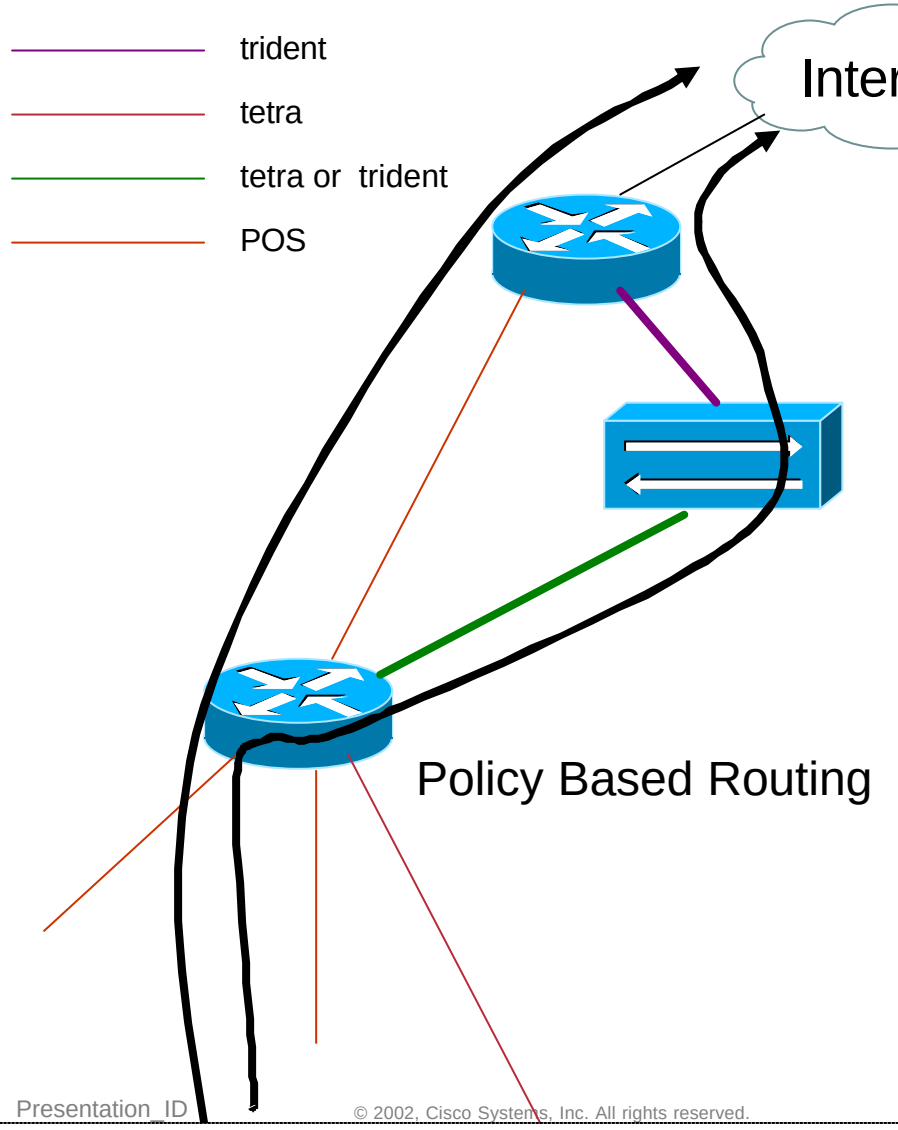


1. SSG gets a packet from an unknown user trying to access the Internet
2. SSG sends access-request to AAA server including user's IP address and Service Provider configurable Default Password
3. (a) AAA server responds with Access-Accept for FR users
   (b) Responds with Access-Reject for Un-authorized accesses, causing un-authorized packets to be dropped
4. SSG populates its local FR list based on response from AAA
5. Transparently Authenticated FR User traffic flows to Internet

Centralized IPPU – Fastweb Solution



Traffic is redirected to the IPPU Farm



Migration

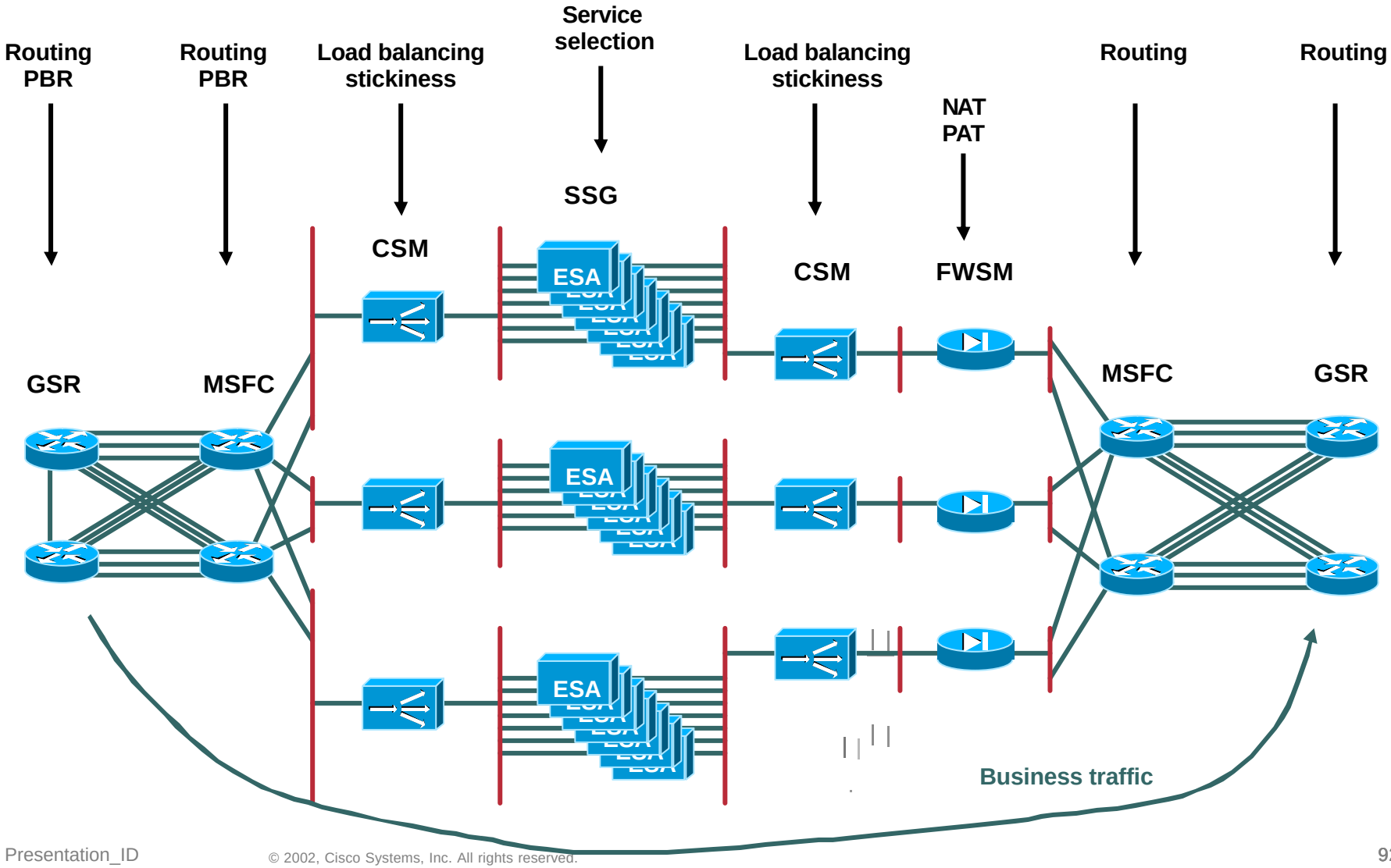
1- configure PBR on the GSR (engine 3 PoS and Gigabit Tetra Cards).

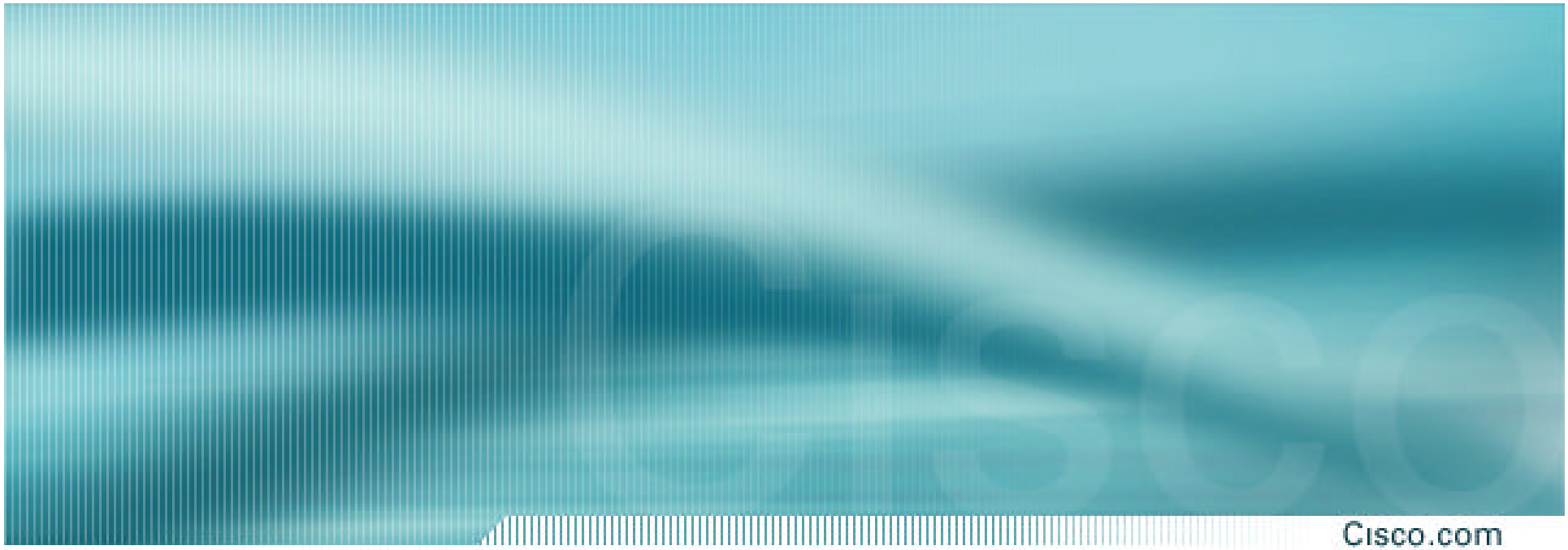
PBR will send PUBLIC address directly towards the internet and PRIVATE (residential user range) ones to the SSG farm.

Today NAT is done in the AH00X devices, therefore PBR will still send all the traffic directly to the internet.

2- remove the IP NAT INSIDE in a specific VLAN interface in the AH00X, and at that point all the traffic from that mini-PoP will be redirected to the SSG Farm.

IPPU Farm : simplified logical schema





Conclusion

Service Driven Project

- **Customized & Flexible Services – with SLA aligned to customers' business objectives**
- **Service Driven Transport rather than Transport Driven Service**
- **Combine IP, Ethernet and Optical-SDH/SONET – Ethernet as the UNI to profitable, future-proof Services**
- **Consistent Service Deployment – Scalability, Security, Management, QoS, Multicast, …**
- **No Service Silos – Save CAPEX and OPEX by building an architecture allowing diverse services**
- **Project Methodology required to go through this cycle**

The Challenges

- Metro Ethernet utilizes “simple” boxes (i.e. ethernet switches), but is a complex solution
- Metro Ethernet encompasses many protocols & technologies which are difficult to integrate as an end-to-end Solution on a shared infrastructure.
- Security is a big issue, since ethernet was originally designed to facilitate communication between local users.
- Operational complexity, provisioning, & management must not be underestimated
- The services “launch” can be slow & difficult if the network is not properly designed & implemented

Cisco *Advanced Services (AS)* can help - *The Expertise*

- **Cisco's Advanced Services has proven experience in Metro Ethernet**
- **We have a dedicated, Metro Ethernet team, plus highly experienced in-country resources**
- **We have designed & helped operate the largest Metro Ethernet networks in the world; therefore, we understand the pitfalls and the weaknesses in the solutions. We know how to make Metro Ethernet networks successful!**
- **We are highly experienced in balancing seemingly contradictory requirements in order to find the right architecture**

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