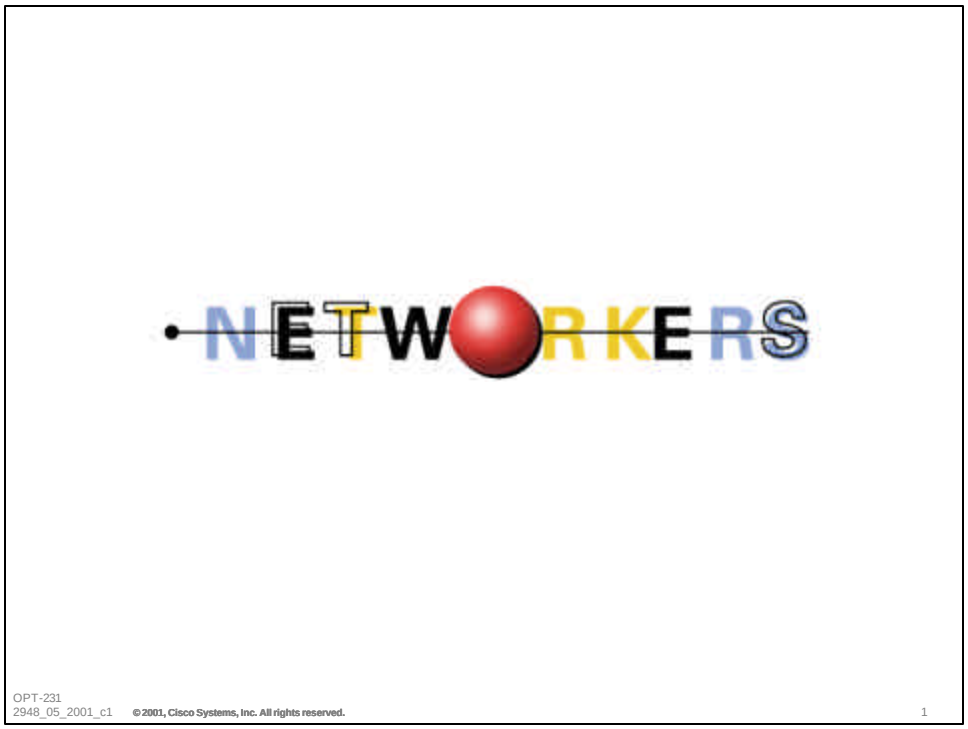
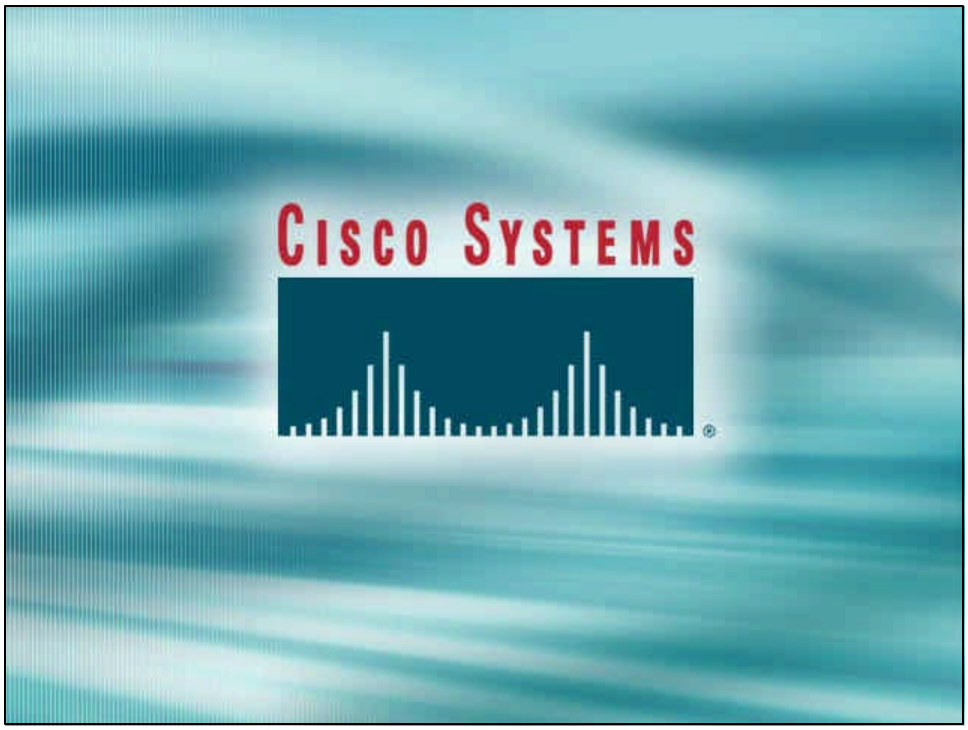




Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Cisco.com

Designing Optical Infrastructures for IP Networks

Session OPT-231

 © 2001, Cisco Systems, Inc. All rights reserved.

Market Trends

Cisco.com

- Fiber everywhere
- Decreasing costs of bandwidth
- Optical infrastructure
- New services

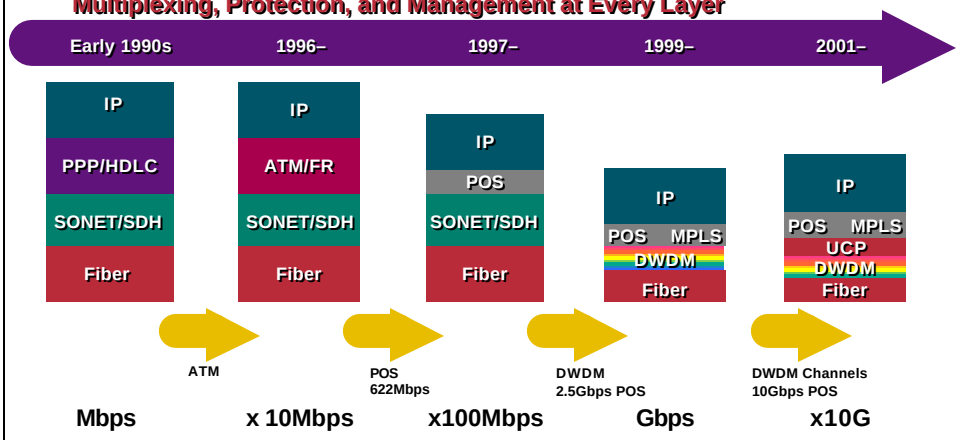
 © 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Evolution of Internet Backbone Architecture

Cisco.com

Multiplexing, Protection, and Management at Every Layer



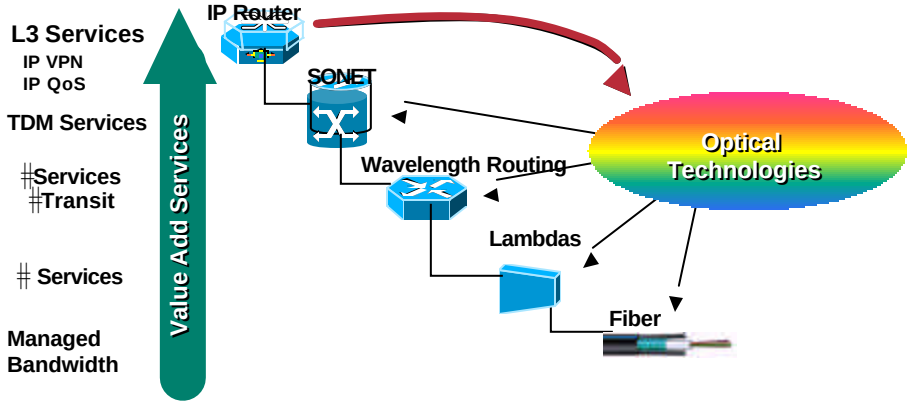
PPP	Point to Point Protocol
POS	Packet Over SONET/SDH
DWDM	Dense Wave Division Multiplexing
MPLS	Multi-Protocol Label Switching
UCP	Unified Control Plane

Architecture Has Been Evolved at Every Two Years to Increase the Capacity by Ten(10)

© 2001, Cisco Systems, Inc. All rights reserved.

Moving up the Services Value Chain

Cisco.com



© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Complex Core Network Management

Cisco.com

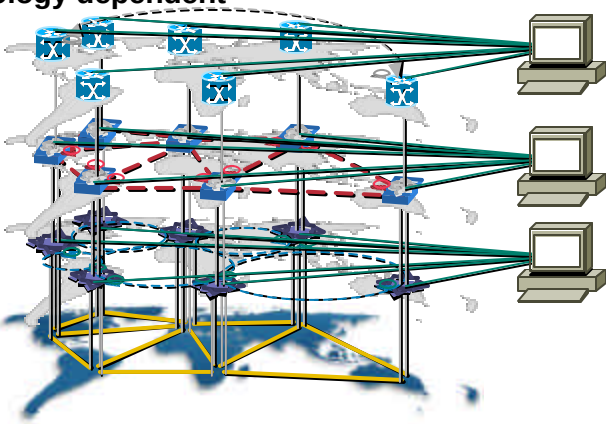
- Many EMS layers, and technologies
- Service introductions synchronized with each layer
- Service topology dependent

IP Router Mesh

ATM Mesh

SONET Rings: Add/Drop Multiplexers, Digital Cross Connects

Point-to-Point DWDM

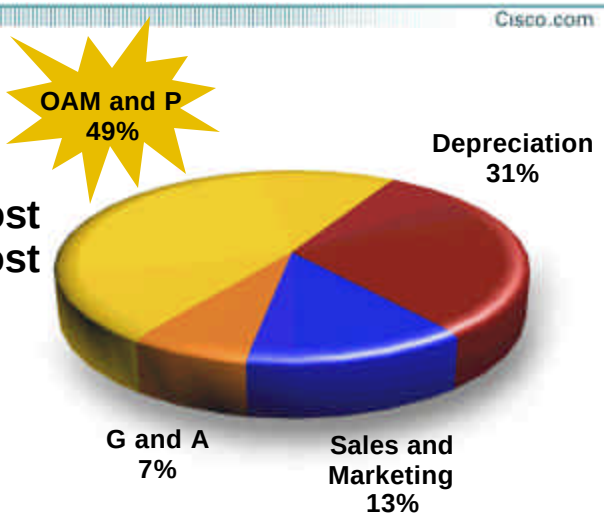


© 2001, Cisco Systems, Inc. All rights reserved.

How to Build Better and Cheaper Optical Internet?

Cisco.com

- OAM and P cost dominates most Service Provider's budgets



Source: ARMIS 43-01 Reports and Probe Research, Inc.

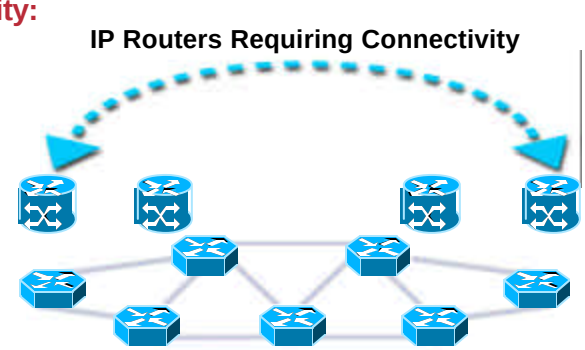
© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Service Velocity

Cisco.com

- Create **service velocity:**
  - Intelligent network elements, and simplified OSS
  - Distributed network database
  - Circuit-routed, Ethernet-like
  - Inherent scaling
  - Service-driven topology



© 2001, Cisco Systems, Inc. All rights reserved.

Cisco.com

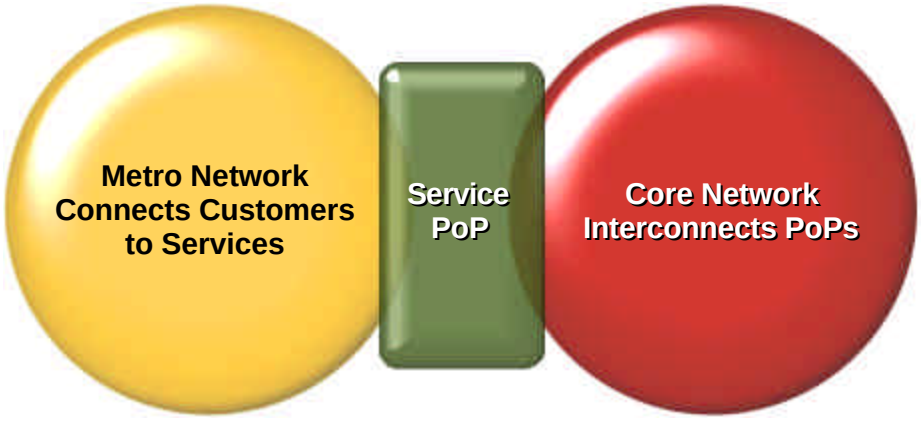
Optical Technologies

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

IP+Optical Metro/Core Architecture

Cisco.com



Physical Rings
Logically Hub and Spoke
Fragmented Market
Rapid Change

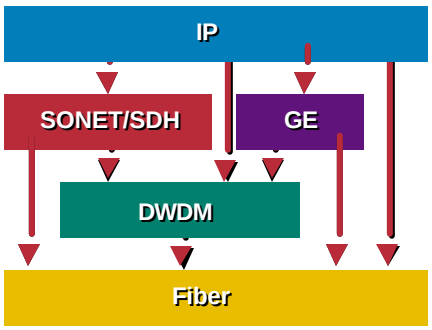
Physical Point-to-Point
Logically Peered
Established Market
Change Emerging (Ring-Mesh)

© 2001, Cisco Systems, Inc. All rights reserved.

Optical Transport Options

Cisco.com

- Dark fiber
- SONET/SDH
- DWDM



© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Dark Fiber

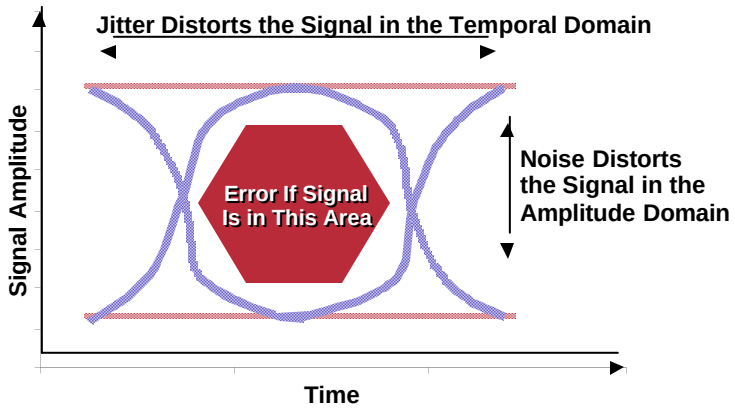
Cisco.com

- Effective alternative if fiber plant capacity is not limited or there is no need for bandwidth multiplication
- Modest distance (80 Km or less)
- No statistical gain
- Considerations when deploying IP infrastructures over dark fiber
  - Fiber plant—capacity and topology
  - Power budgets—optics reach
  - Signal loss (due to attenuation and dispersion)—optics reach
  - Network design must address protection

© 2001, Cisco Systems, Inc. All rights reserved.

Effects of Jitter and Noise

Cisco.com



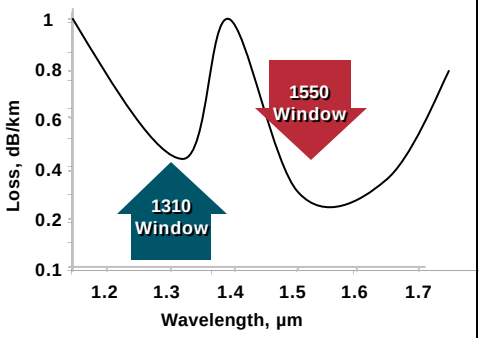
© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Optical Attenuation

Cisco.com

- Specified in loss per kilometer (dB/km)
  - 0.40 dB/km @ 1310 nm
  - 0.25 dB/km @ 1550 nm
- Loss due to absorption by impurities
  - 1400 nm peak due to hydroxyl (OH) ion absorption



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 15

Calculating Link Loss Budget

Cisco.com

Link Loss Budget =	Optical Power Budget— Design Margin— Power Penalties

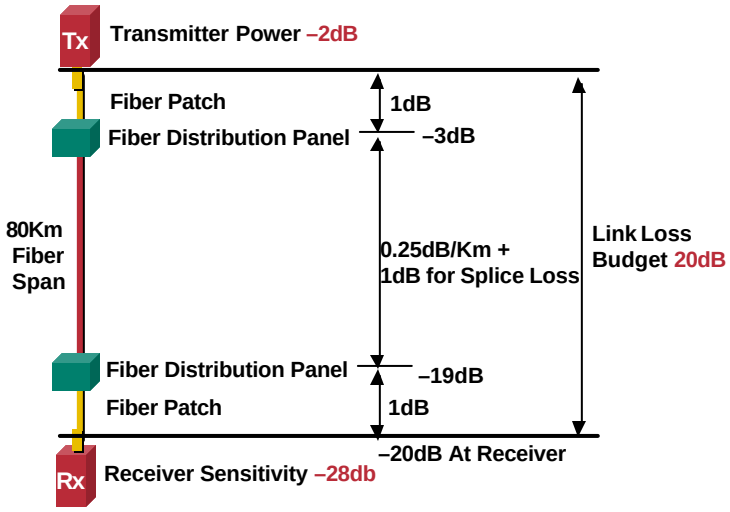
Optical Power Budget	26dB (OC-48c POS [1550nm])
Design Margin (EOL)	–1dB
Power Penalties	–2dB (OC-48c POS [1550nm])
Connector and Splice	–3dB
Link Loss Budget	20dB

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 16

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Link Loss Budget Example

Cisco.com



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 17

Cisco.com

SONET/SDH

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 18

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

SONET

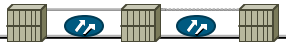
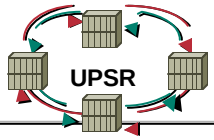
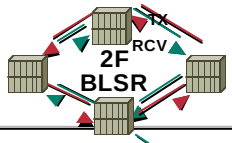
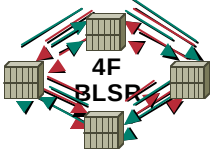
Cisco.com

- Widely deployed optical transport technology
- TDM transmission
- Optimized for voice traffic
- Proactive fault and performance monitoring capability
- Fast restoration
  - ? 50 msecs

 © 2001, Cisco Systems, Inc. All rights reserved.

SONET/SDH Network Configurations

Cisco.com

Point-to-Point		Two Nodes, Terminal Mode
Linear		Up to 16 Nodes, ADM
Unidirectional Path Switched Ring		All Traffic Homing to a Central Location
Two Fiber Bi-directional Ring		Traffic with Neighboring Pattern, Reusable Bandwidth
Four Fiber Bi-directional Ring		Traffic with Neighboring Pattern, Reusable Bandwidth

 © 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Cisco.com

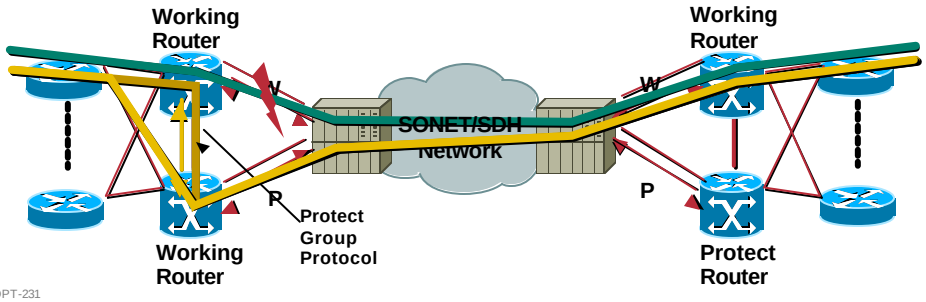
Packet Over SONET (POS)

 © 2001, Cisco Systems, Inc. All rights reserved.

POS APS/MSP

Cisco.com

- APS—Automatic Protection Switching (APS)
- SDH—Multiplex Switching Protection (MSP)
- Uses K1 and K2 byte; 1 + 1 Protection



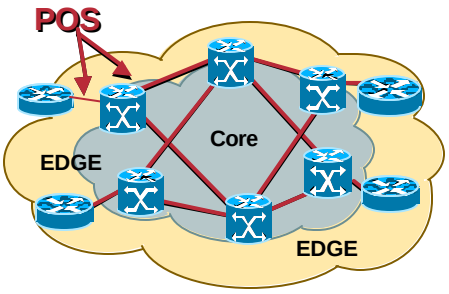
 © 2001, Cisco Systems, Inc. All rights reserved.

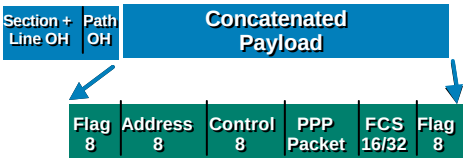
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

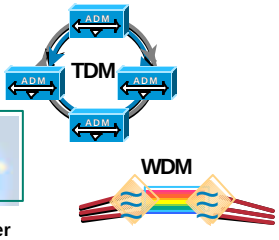
POS Applications

Cisco.com

- PoS Packet-over-SONET/SDH
- Runs over dark fiber, SONET, or WDM
- Enables transport “mix and match”
- Provides efficient evolution path for incumbents
- Provides optimized transport for greenfield builds
- Standards based







Dark Fiber

© 2001, Cisco Systems, Inc. All rights reserved.

Cisco.com

Dynamic Packet Transport DPT

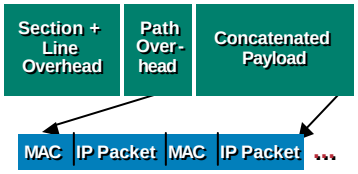
© 2001, Cisco Systems, Inc. All rights reserved.

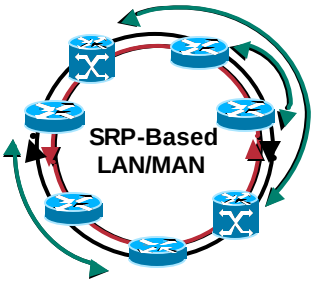
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

DPT Overview

Cisco.com

- New Layer 2 MAC protocol
- Uses SONET/SDH framing
- Bandwidth efficient
- Fairness (SRP-fa)
- Scalable
- Fast protection switching and service restoration
- Multicasting and priority



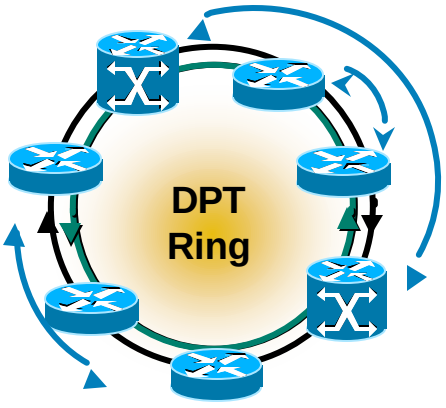


© 2001, Cisco Systems, Inc. All rights reserved.

Dynamic Packet Transport

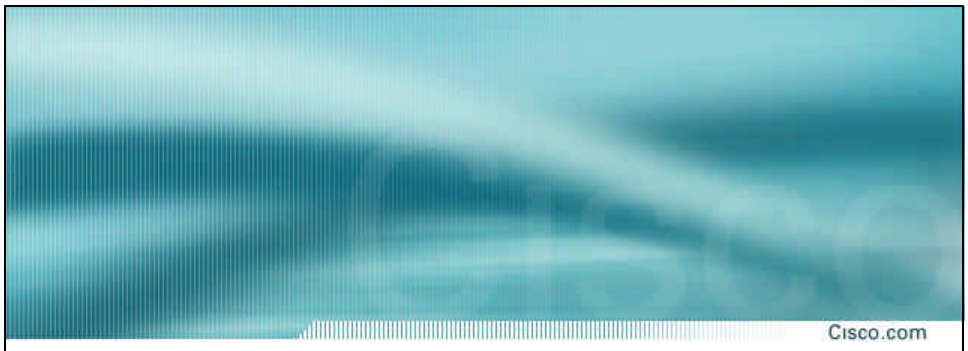
Cisco.com

- Maximize bandwidth efficiency
- Bandwidth consumed only on traversed segment
- Multiple nodes transmit concurrently
- Fairness via SRP-fa
- Self-healing through IPS
- Minimize provisioning and configuration



© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr



Dense Wave Division Multiplexing DWDM

 © 2001, Cisco Systems, Inc. All rights reserved.

DWDM

- Used to provide bandwidth multiplication where fiber plant capacity is scarce
- No protection on tributary side
- Network design must address protection

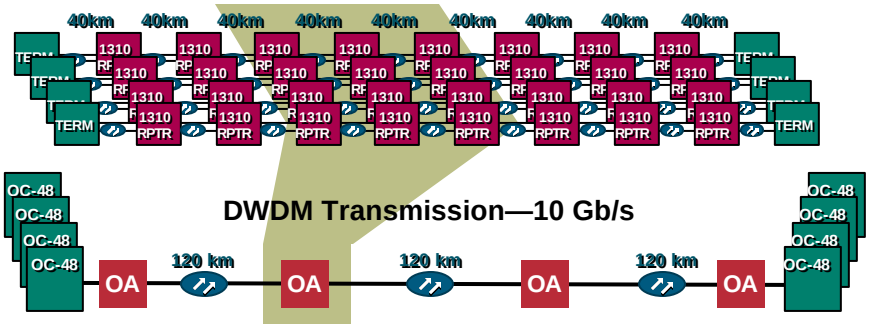
 © 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

DWDM for Fiber Gain

Cisco.com

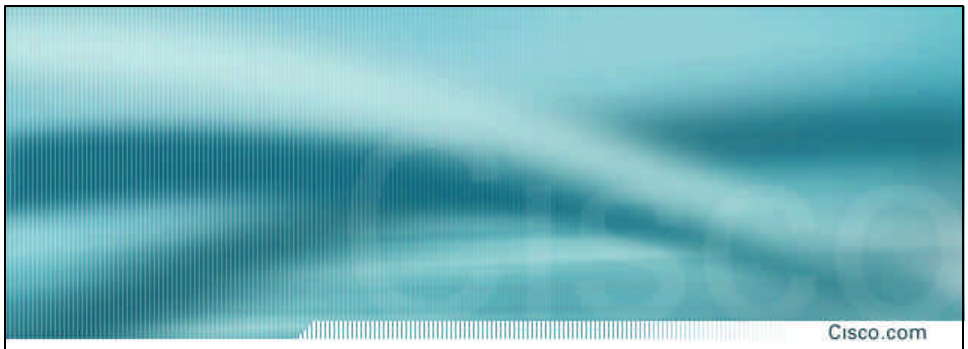
DWDM Offers Compelling Economics



DWDM Transmission—10 Gb/s

4 fibers → 1 fiber
32 regenerators → 4 optical amplifiers

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 29



Cisco.com

Optical Networks

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 30

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Design Considerations (Backbone)

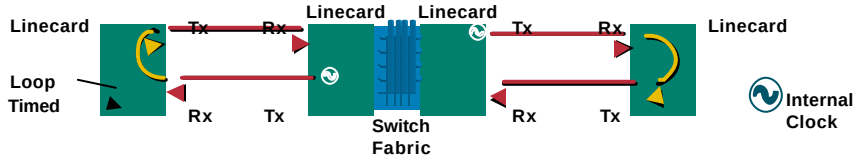
Cisco.com

- Infrastructure redundancy
  - Routers
  - Links
  - No single point of failure
- Path redundancy
  - Load sharing
  - Protection
- Capacity planning and traffic engineering
- Topology

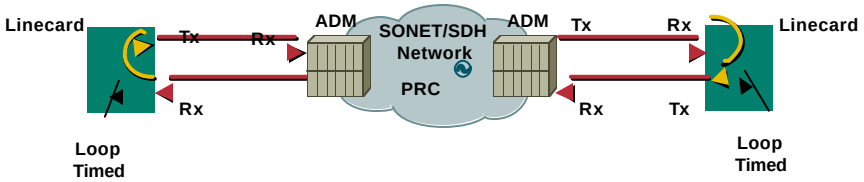
© 2001, Cisco Systems, Inc. All rights reserved.

Clocking and Synchronization

Cisco.com



- Set clock source internal for back to back connections, dark fiber and DWDM



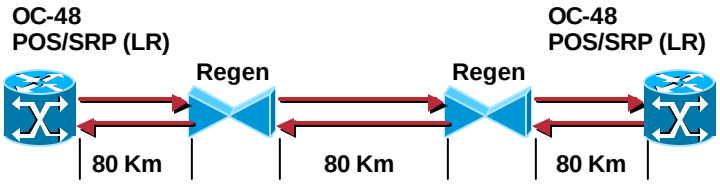
- SDH ADM or term—clocking derives from the Stratum 1 source in the SDH network
- Applies to both POS and SRP
- Clock the router from Line Always!

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Extending the Distance

Cisco.com

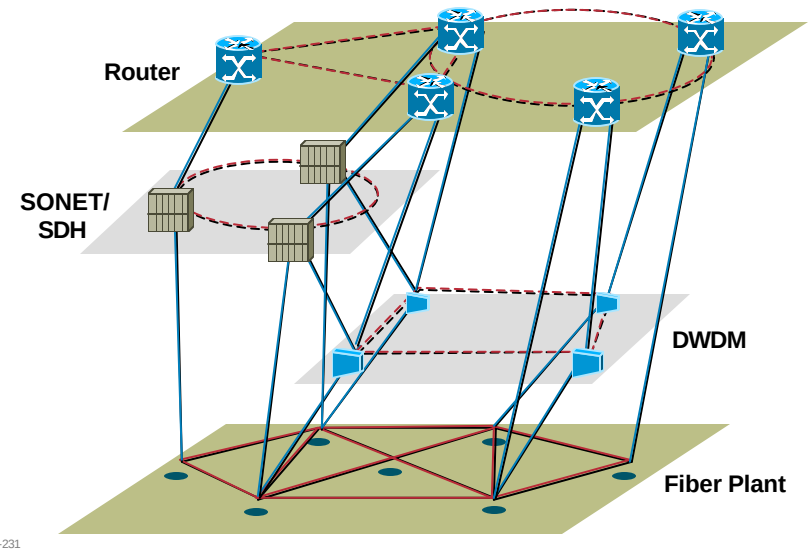


- Use regenerator
  - 3R—Re-amp, Re-shape and Re-time
- Can be used for both POS and SRP
- Cisco regen supports IP over DCC for management
- 30 regens can be cascaded to get a distance of 2400 Km (? 1500 miles)

© 2001, Cisco Systems, Inc. All rights reserved.

Optical Network Infrastructure

Cisco.com



© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Topology Options (Backbone)

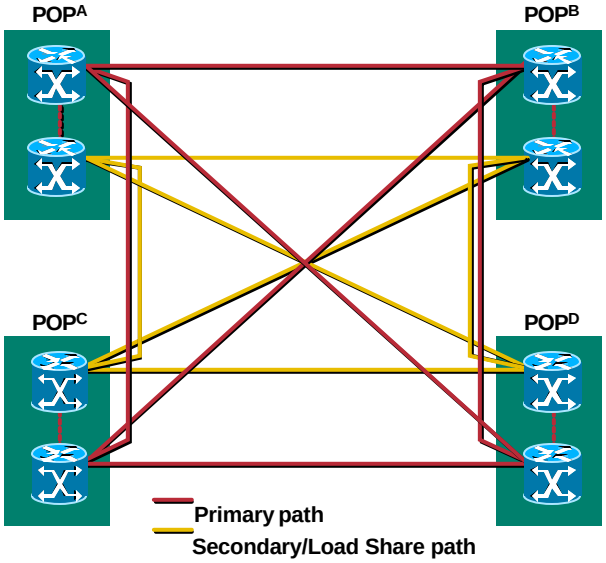
Cisco.com

- **Mesh**
  - **Full or partial**
- **Point-to-point**
  - **POS**
- **Ring**
  - **POS or SRP**

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 35

Full Mesh

Cisco.com



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 36

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Full Mesh

Cisco.com

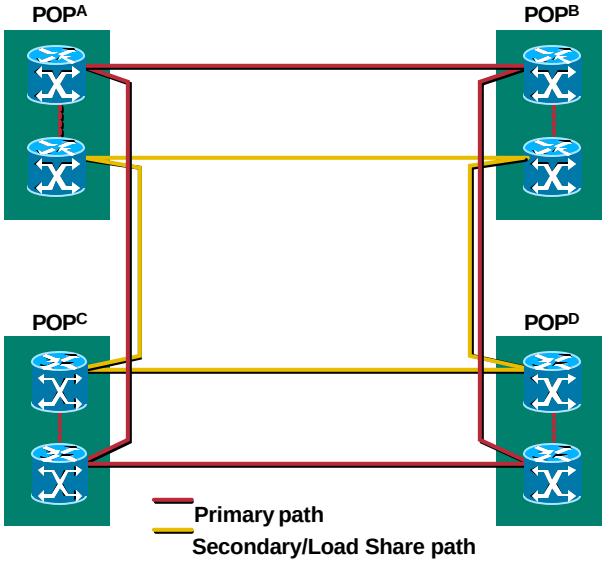
- All the backbone routers are connected to each other
- Single hop from any backbone router to the other
- Depending on the number of routers in the backbone, may require a lot of slots/ports

  n(n-1)/2 ports

© 2001, Cisco Systems, Inc. All rights reserved.

Partial Mesh (1)

Cisco.com



© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Partial Mesh

Cisco.com

- Each backbone router is connected to two or more backbone routers
- Multi-hop to some backbone router
- Uses less slot/port and fiber compared to full mesh topology
- Cost effective

© 2001, Cisco Systems, Inc. All rights reserved.

Point to Point—POS

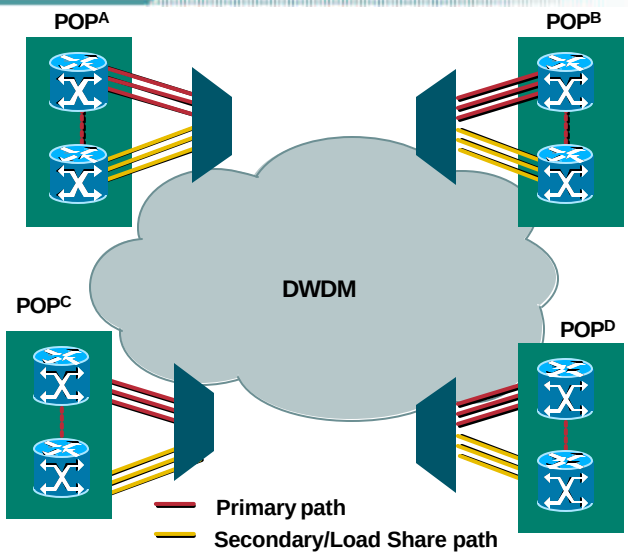
Cisco.com

- Point to point connection using POS
  - OC-3/STM-1—OC-192/STM-64c
- Encapsulation—HDLC/PPP
- Connecting to SONET/SDH
  - APS/MSP for protection
- Connecting to DWDM or Dark fiber
  - Multiple links for load sharing and protection

© 2001, Cisco Systems, Inc. All rights reserved.

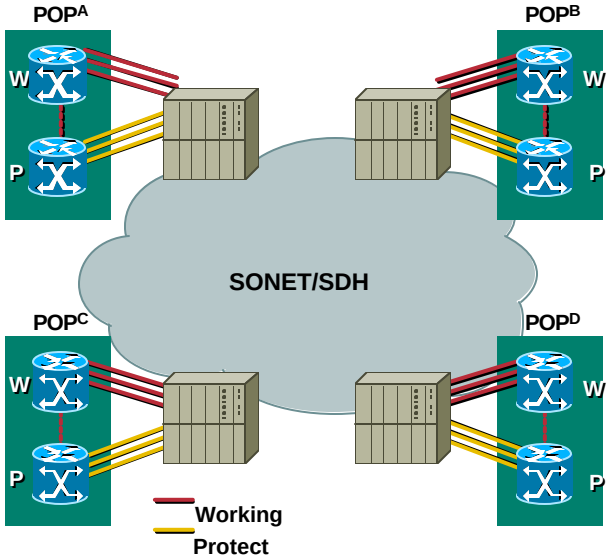
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Connecting to DWDM



OPT-231
2948_05_2001_c1
© 2001, Cisco Systems, Inc. All rights reserved.
41

Connecting to SONET/SDH

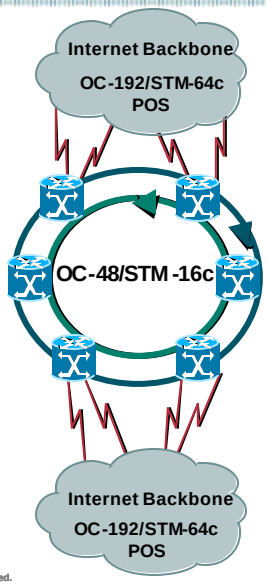


OPT-231
2948_05_2001_c1
© 2001, Cisco Systems, Inc. All rights reserved.
42

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

DPT PoP Design

Cisco.com



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 43

Cisco.com

MPLS

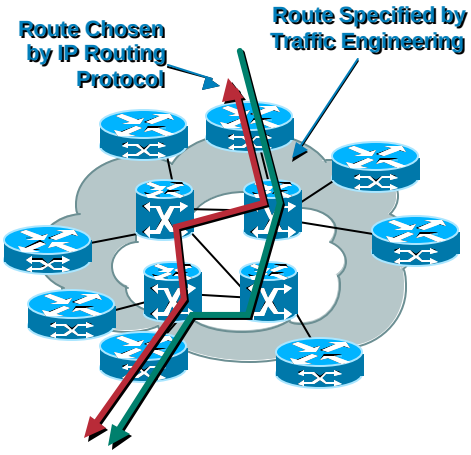
OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 44

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Traffic Engineering with MPLS

Cisco.com

- Why traffic engineer?
  - Optimize link utilization
  - Specific paths by customer or class
  - Balance traffic load
- Traffic follows pre-specified path
- Path differs from normally routed path
- Controls packet flows across a L2 or L3 network infrastructure



© 2001, Cisco Systems, Inc. All rights reserved.

Cisco.com

Unified (Optical) Control Plane Overview

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Existing Control Planes

Cisco.com

Network Element	Standard Body	Routing	Signaling	Available
Optical Cross Connect	None	Proprietary	Proprietary	Future
Optical Cross Connect	ATM Forum	PNNI	PNNI	Deployed
MPLS IP-LSR	IETF	Constraint Based	LDP/ RSVP	Deployed

- Separate control planes exist for L1/2/3
- Limited communication creates isolation
- Results in an overlay network model

Source: John Drake—MPLS Conference 1999

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 47

UCP Protocols Standards Summary

Cisco.com

Function	MP # S/GMPLS	O-UNI	G.ASON
Routing Protocol	IGP TE Extensions	N/A	N/A
Signaling	RSVP/CR-LDP Extensions	RSVP/CR-LDP Extensions	Out-of-band Client UNI
Link Management, Verification, Neighbor Discovery, Etc.	LMP	LMP	Central Control, IP/ATM/ SONET Clients
Model	Peer/Overlay	Overlay to Peer	Overlay
Standards Body	Peer/IETF	OIF	ITU-T

Overlay Is a Subset of the Peer Model

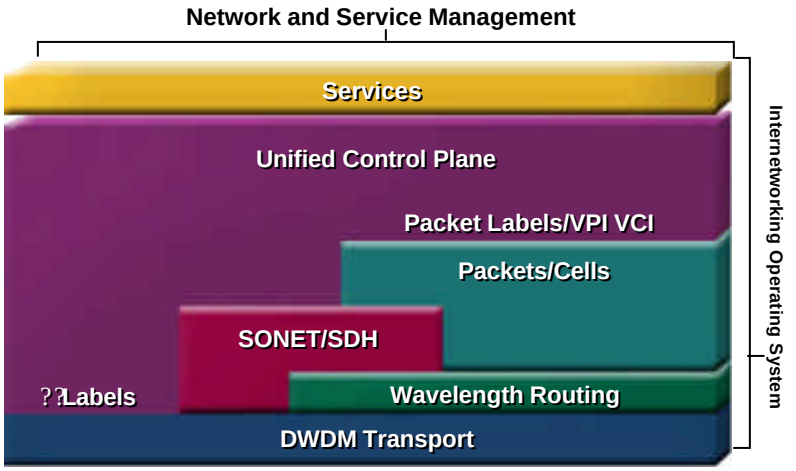
Drafts as of January 2001

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 48

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Unified Control Plane

Cisco.com

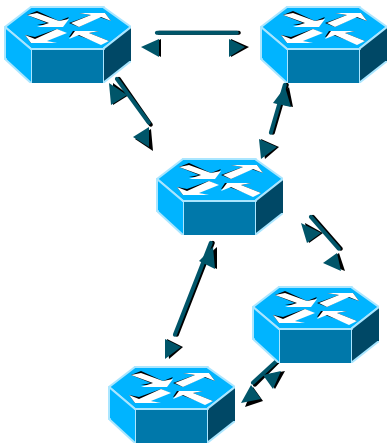


OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 49

Control Plane Functions

Cisco.com

- Resource discovery
- Connection management
  - Path set-up/tear down
  - Maintenance and monitoring
- Topology/state dissemination
  - Reliable broadcast/Flooding
- Path Selection
  - Constraint-based routing



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 50

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

OCP/UCP Technology Scenarios

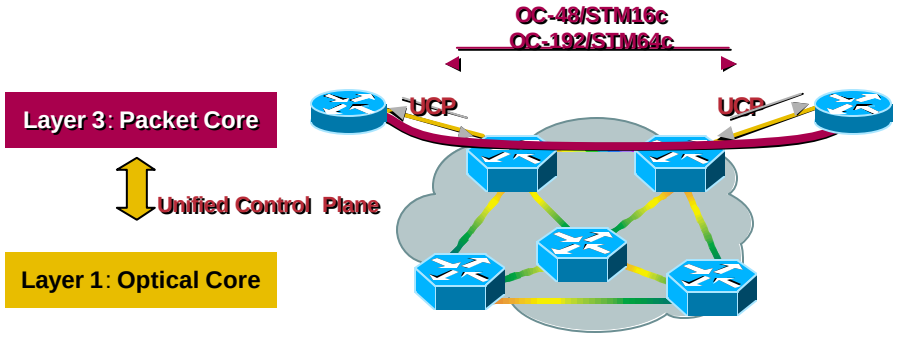
Cisco.com

- **UNI**
  - Used to build point-to-point 'SVC-Like' circuit set-up mechanism
  - Used to accelerate service delivery of IP or other service definitions across an optical overlay network topology
- **GMPLS**
  - Used to enable standard protocol based circuit provisioning and restoration technique node by node within the interior of an optical transport network
  - Used to construct a multi-vendor optical transport network
  - Enables scalable node to node peering and full-mesh topologies
  - Allows for the administrative boundary of a UNI
  - Leverages existing IP network layer service definitions
- **Miscellaneous others**
  - Pure IP Control Plane, Central Server Provisioning, GSMP (VSI)

© 2001, Cisco Systems, Inc. All rights reserved.

Evolution of Optical Core (IP over ?) with Unified Control Plane

Cisco.com



Benefits:

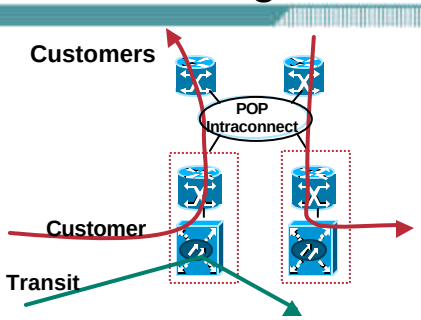
- Network simplification: common framework for packets and wavelengths
- Reduced provisioning costs
- Increased service velocity
- Fast path restoration

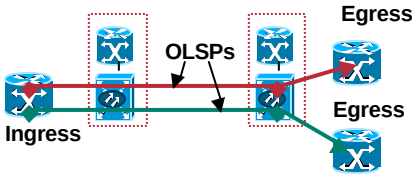
© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Router + OXC: Optical Pass-through for IP Traffic

Cisco.com





- Transit Traffic forwarded thru OXCs
  - Offloads core routers of per-packet transit processing
  - Frees up IP router resources for handling customer traffic
- One-hop O-LSPs across core network
  - No intermediate per-packet processing lower latency and jitter

Improved Network Performance

© 2001, Cisco Systems, Inc. All rights reserved.

Cisco.com

Deploying IP Services

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

What's the Problem?

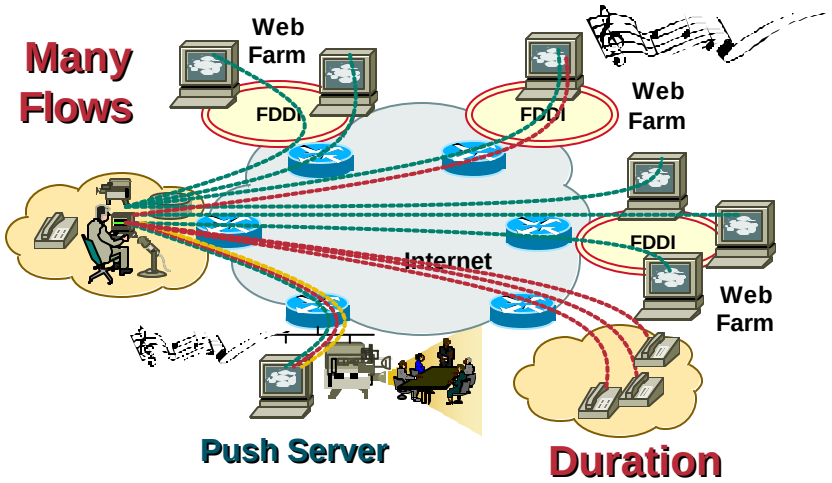
Cisco.com

- API to API service creation
- Requirement for mobility
- Full IP network services

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 55

Complexity's an Issue

Cisco.com



OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 56

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

IP Services: Essentials

Cisco.com

- Open standards
- Scalability
- Reliability
- Manageability
- Low latency
- Network services

  DNS, DHCP, hosting, caching, AAA, number translation, SCP, firewall, NAT, etc…

- IP QoS
- IP traffic Eng
- IP VPN
- IP any-2-any
- IP multicast
- IP security

© 2001, Cisco Systems, Inc. All rights reserved.

Services: The Challenge

Cisco.com

- The optical IP network needs to meet the requirements of the applications
- Different services have different requirements:

  Voice, videoconferencing, distance learning-low latency, low jitter

  Bulk data transfer-high bandwidth

  Email-no demanding requirements

© 2001, Cisco Systems, Inc. All rights reserved.

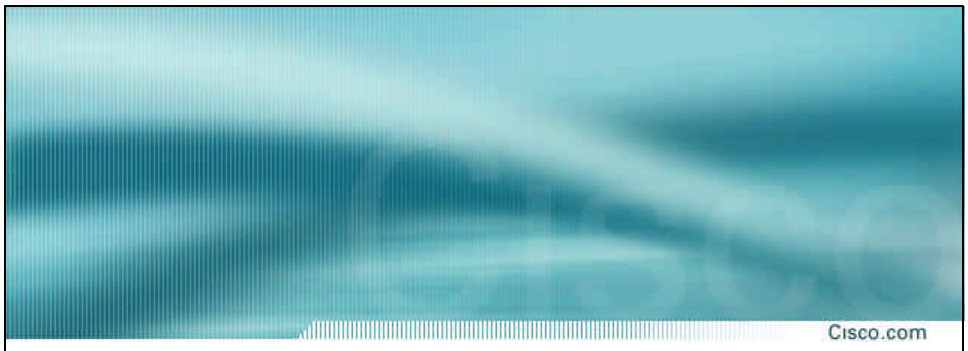
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Services: The Challenge

Cisco.com

- To ensure service quality, each application or flow, needs to be differentiated from one another
- Non time critical applications, e.g. www, could impact time sensitive applications, such as voice or video

© 2001, Cisco Systems, Inc. All rights reserved.



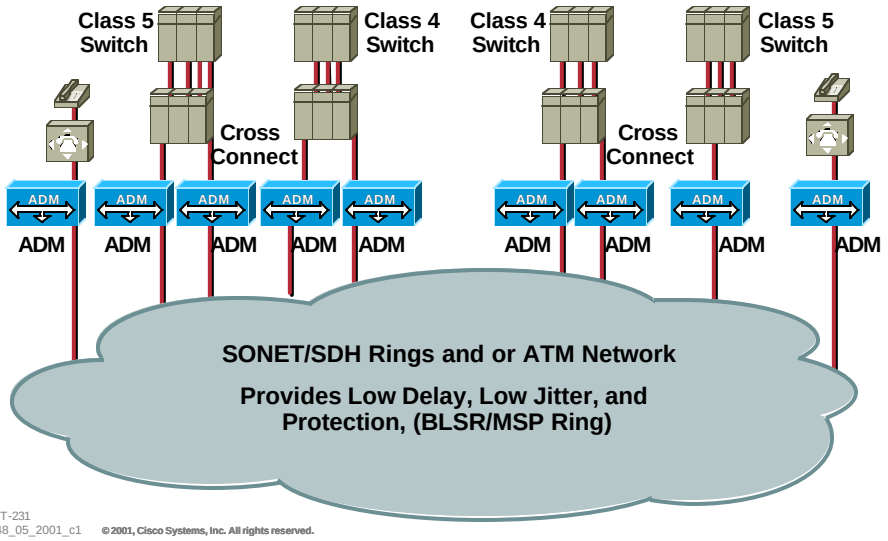
The Need for QoS in IP Networks

Consider Voice...

© 2001, Cisco Systems, Inc. All rights reserved.

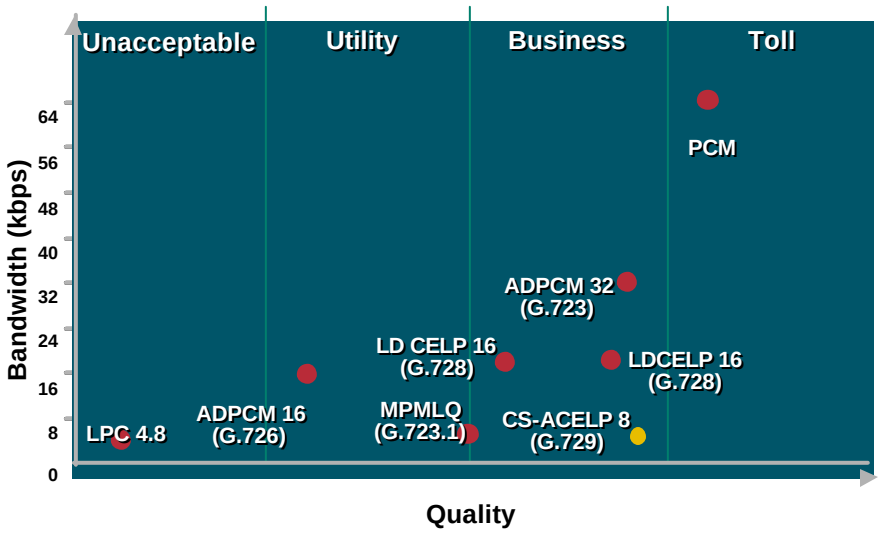
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Traditional Voice Networks



OPT-231
2948_05_2001_c1
© 2001, Cisco Systems, Inc. All rights reserved.
61

Voice Quality: Compression Standards

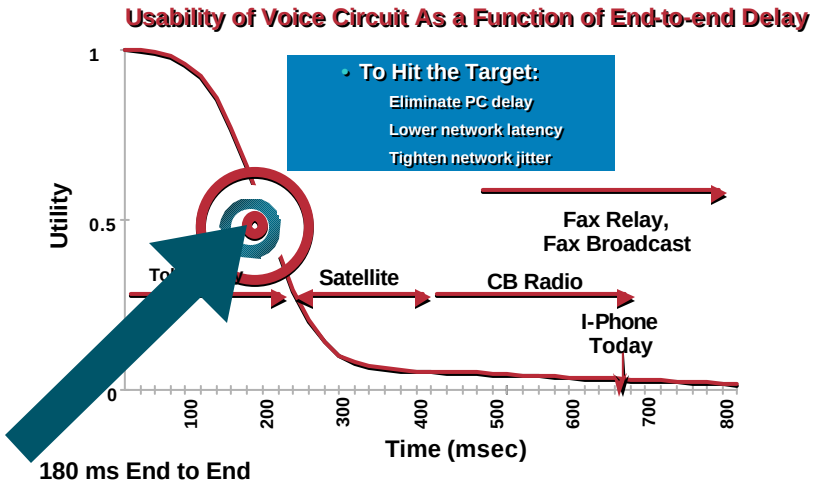


OPT-231
2948_05_2001_c1
© 2001, Cisco Systems, Inc. All rights reserved.
62

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Why Is It So Important to Minimise Delay?

Cisco.com



© 2001, Cisco Systems, Inc. All rights reserved.

Delay Considerations in IP Networks

Cisco.com

- Codec
- Packetization
- Output Queuing
- Access (Up) Link Transmission
- Backbone Network Transmission
- Access (Down) Link Transmission
- Input Queuing
- Jitter Buffer
- Codec

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Calculating a Delay Budget (G.729)

Cisco.com

Encoder/decoder Delay (Algorithmic Plus Processing and VAD)	30 ms
Waiting and Framing (10 ms Frames)	10 ms
Move to Output Queue	Negligible
Wait in Queue (Depends on Queuing and Congestion)	0–8 ms
Access up Link -Backbone-down Link (1 ms Per 100 Miles)	Variable
Move From Input Queue to DSP	Negligible
Jitter Buffer	4 Ms–40 ms
Coder Process Delay	
Total: (Excluding up Link, Backbone, and Down Link)	45 ms

© 2001, Cisco Systems, Inc. All rights reserved.

What Is Referred to as QoS?

Cisco.com

- The following parameters are usually equated with QoS:
  - Bandwidth guarantees
  - Admission control
  - Delay
  - Jitter

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

QoS with IP Class of Service

Cisco.com

- Implemented at network Layer 3
- Media independent
- Efficient use of available bandwidth through statistical multiplex
- Bandwidth guarantees, delay, and jitter limits via advanced queuing mechanisms
- Admission control only for applications that need certain guarantees (gatekeeper)
- Connectionless—no TDM

 © 2001, Cisco Systems, Inc. All rights reserved.

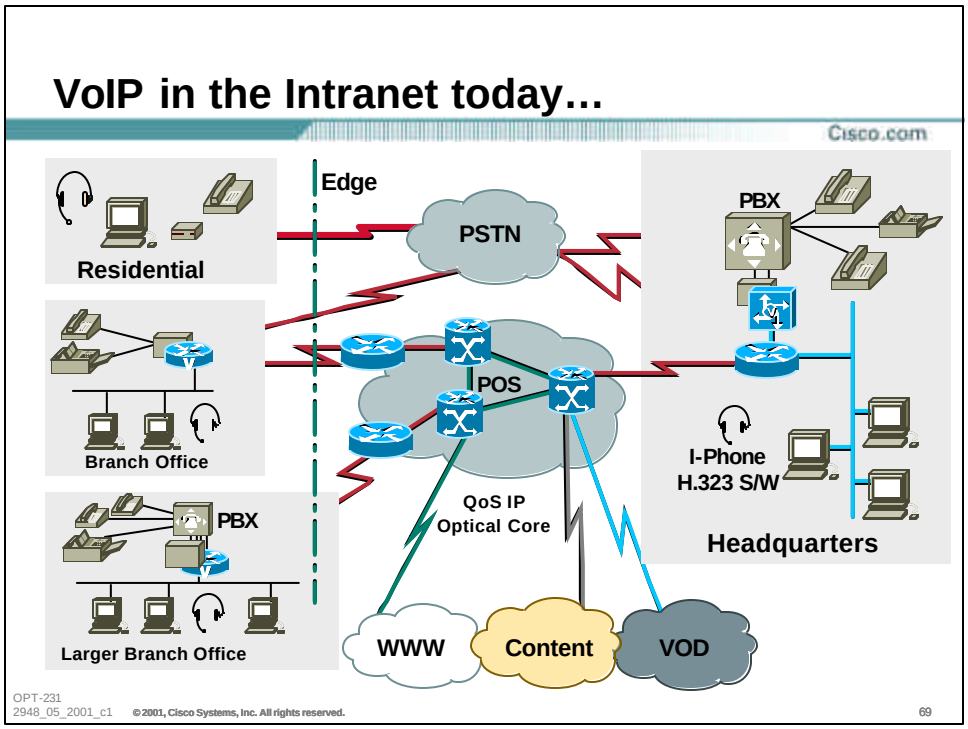
Changing QoS Requirements

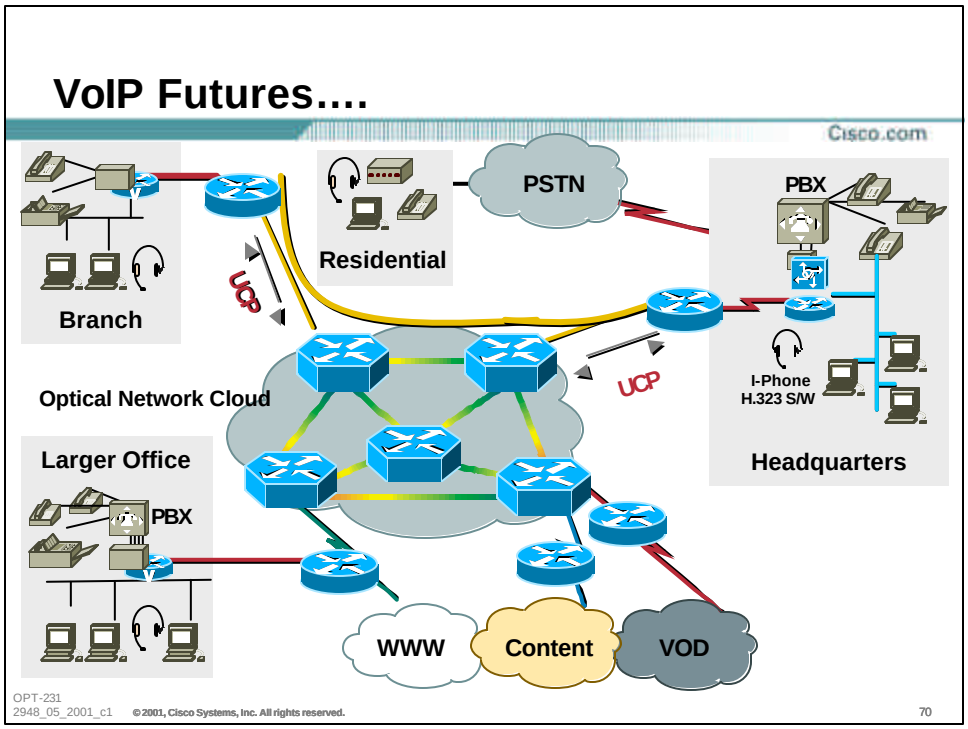
Cisco.com

- Changing applications change requirements
- Classic voice requires dedicated 64k channel in TDM network
- Voice over IP designed to work on IP transport networks, can tolerate delay and jitter within limits
- IP transport is inherently statistically multiplexed, but can limit delay and jitter to suit VoIP applications

 © 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr





Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Network Wide IP QoS

Cisco.com

- Packets are marked at the ingress or by the application and carry their classification throughout the network
- Core devices use this information to provide required services
- Easier to manage

© 2001, Cisco Systems, Inc. All rights reserved.

Congestion Issues

Cisco.com

- Routers by design can have congested links when an interface is offered more load than it can support for an extended period of time
- This can cause three things:
  - Packet loss due to output queue overflow—some traffic might be sensitive to it
  - Added and varying delay-real time applications impacted
  - Bandwidth for some important data is insufficient

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Dealing with IP Congestion

Cisco.com

- **Impact can be minimized the following way:**
  - **Drop less important traffic before high priority traffic**
  - **Handle delay sensitive traffic different than bulk data**
  - **Ensure bandwidth for specific traffic is managed**

© 2001, Cisco Systems, Inc. All rights reserved.

Edge Functions

Cisco.com

- **Packet classification**
  - **Precedence setting with CAR**
- **Bandwidth management**
  - **Rate limiting with CAR**
  - **Traffic shaping**
- **L3 metering**
  - **NetFlow data export**

© 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Backbone Functions

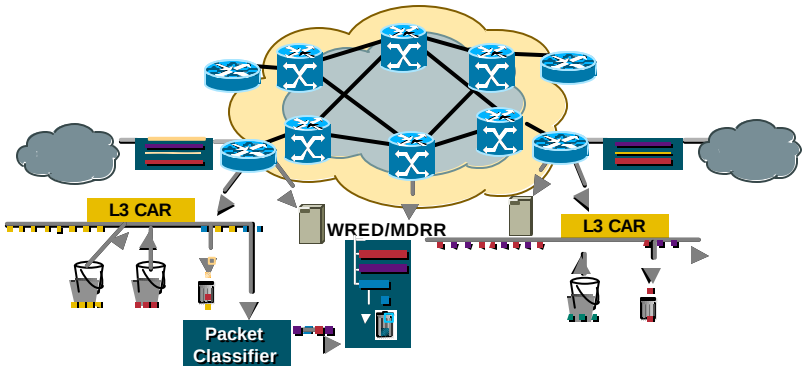
Cisco.com

- **High-speed switching and transport**
  - **Distributed switching (CEF)**
- **QoS enforcement**
  - **Congestion avoidance (WRED)**
  - **Congestion management (MDRR)**
- **QoS interworking**
  - **IP-ATM QoS interworking (VC per CoS)**

© 2001, Cisco Systems, Inc. All rights reserved.

Summary of Network IP QoS

Cisco.com



© 2001, Cisco Systems, Inc. All rights reserved.

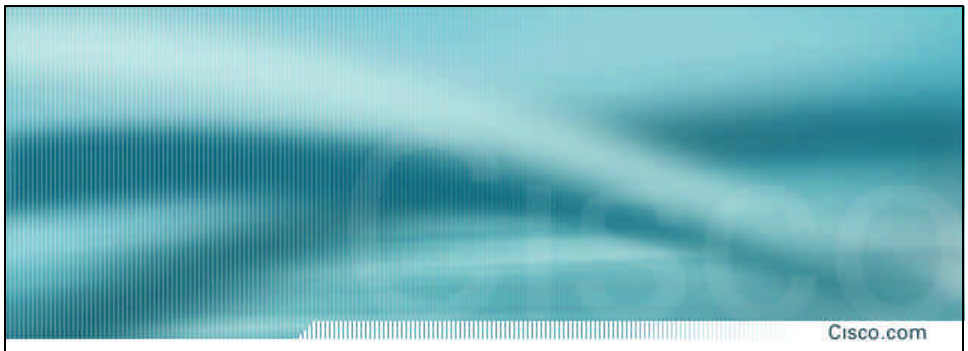
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

Summary

Cisco.com

- We have seen that it is very feasible with careful design to deliver differentiated IP services over an optical infrastructure
- Different service requirements; (Delay, Jitter Etc.) can be accommodated using the tools available, CAR,WRED,MDRR
- Different traffic flows can be effectively marked, and differentiated from each other, enabling, Service providers to Offer billable, robust, IP services to their customers
- In the future the unified control plane will allow for service velocity

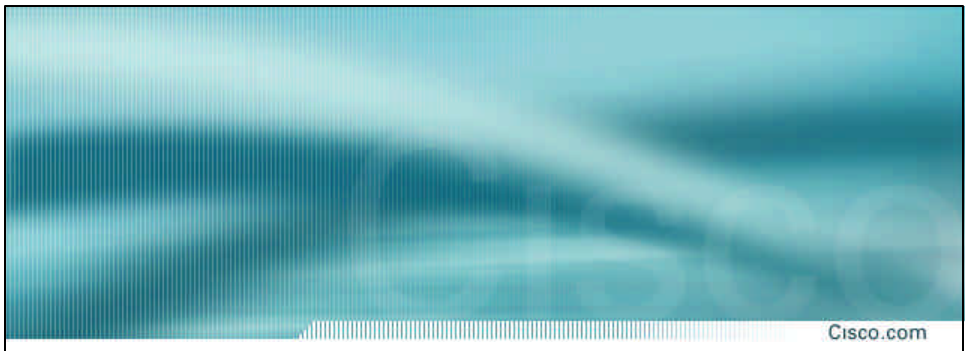
© 2001, Cisco Systems, Inc. All rights reserved.



Questions ?

© 2001, Cisco Systems, Inc. All rights reserved.

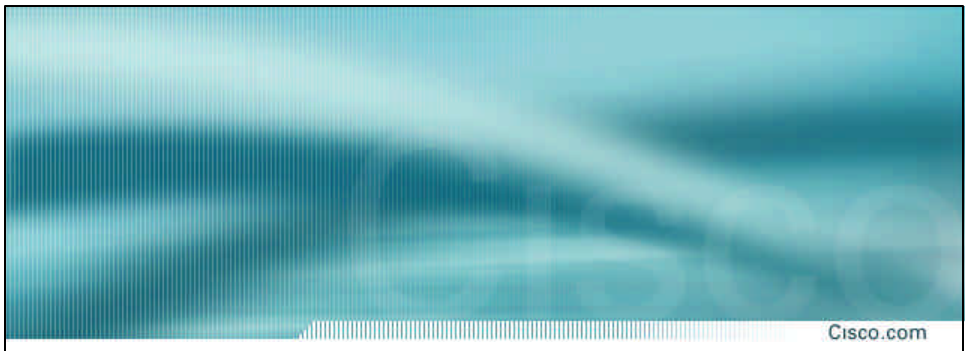
Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr



Designing Optical Infrastructures for IP Networks

Session OPT-231

 © 2001, Cisco Systems, Inc. All rights reserved.



Please Complete Your Evaluation Form

Session OPT-231

 © 2001, Cisco Systems, Inc. All rights reserved.

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr

OPT-231
2948_05_2001_c1 © 2001, Cisco Systems, Inc. All rights reserved. 81

Copyright © 1998, Cisco Systems, Inc. All rights reserved. Printed in USA.
Presentation_ID.scr