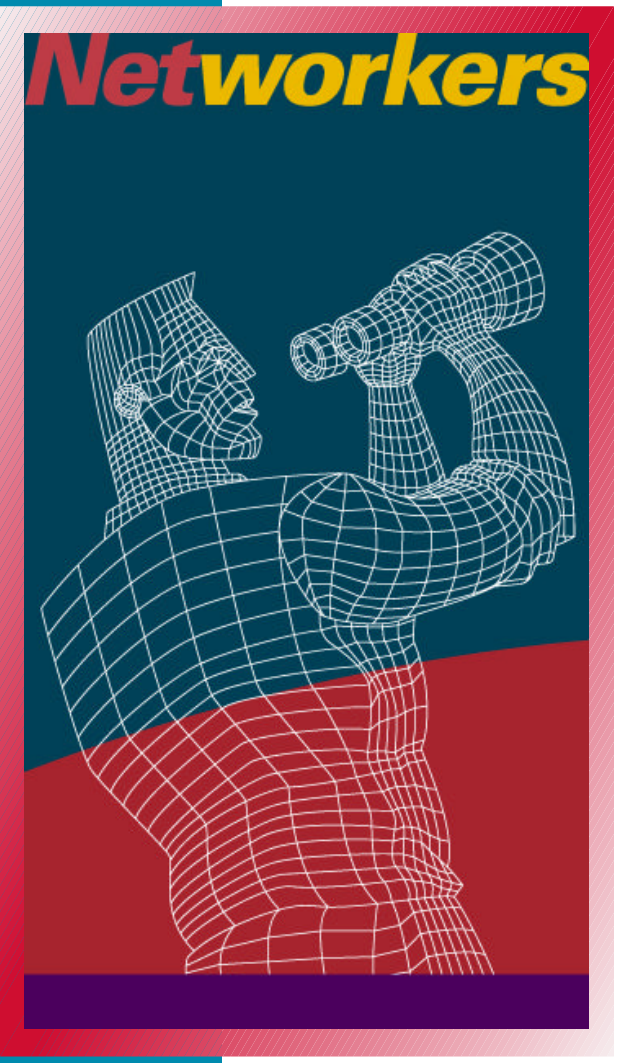

Packet over SONET for IP Transport

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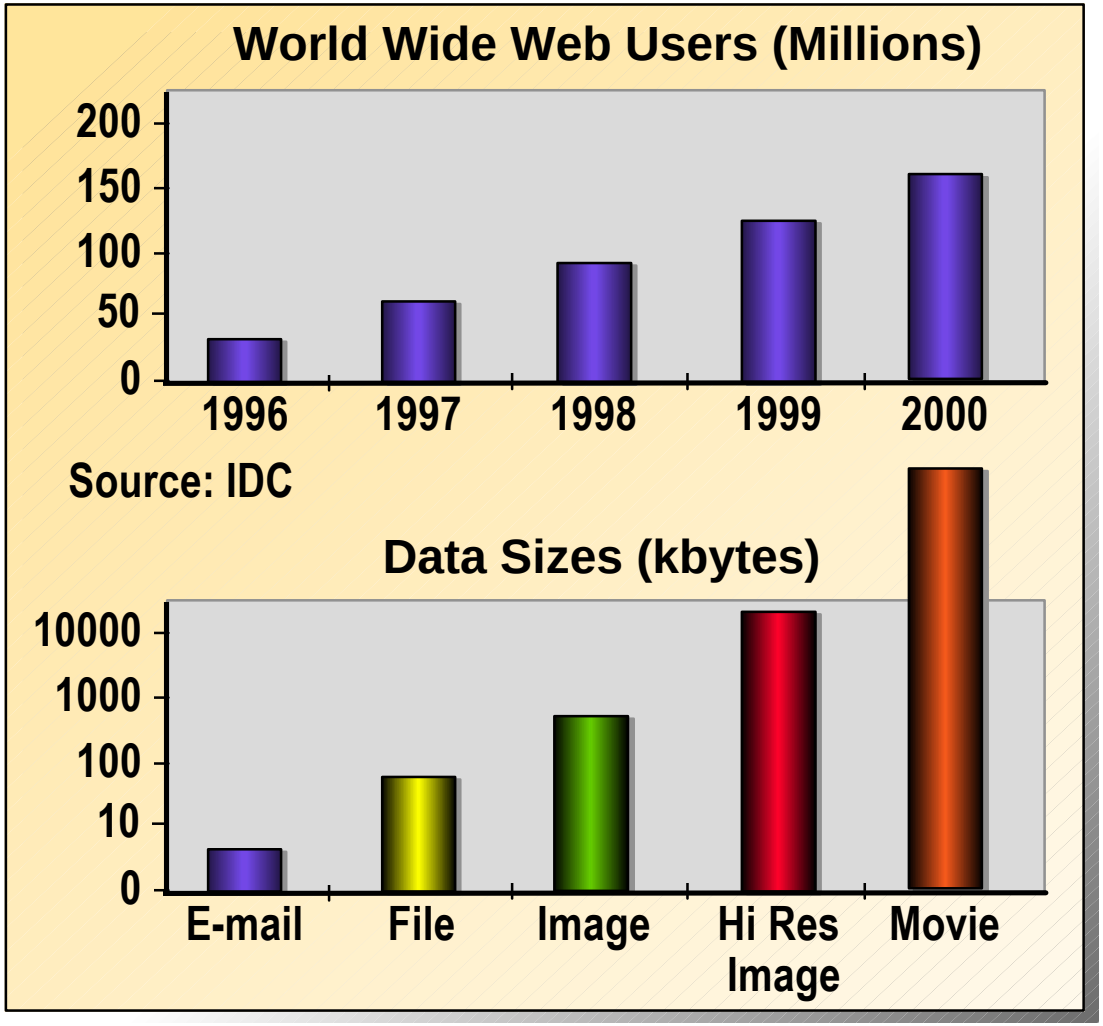
Agenda

- IP Growth
- Emergence of IP Transport Paradigm
- What Is Packet over SONET
- Packet over SONET vs. ATM
- Network Architecture
- Router “Sonetization”
- Packet over SONET Applications
- Summary

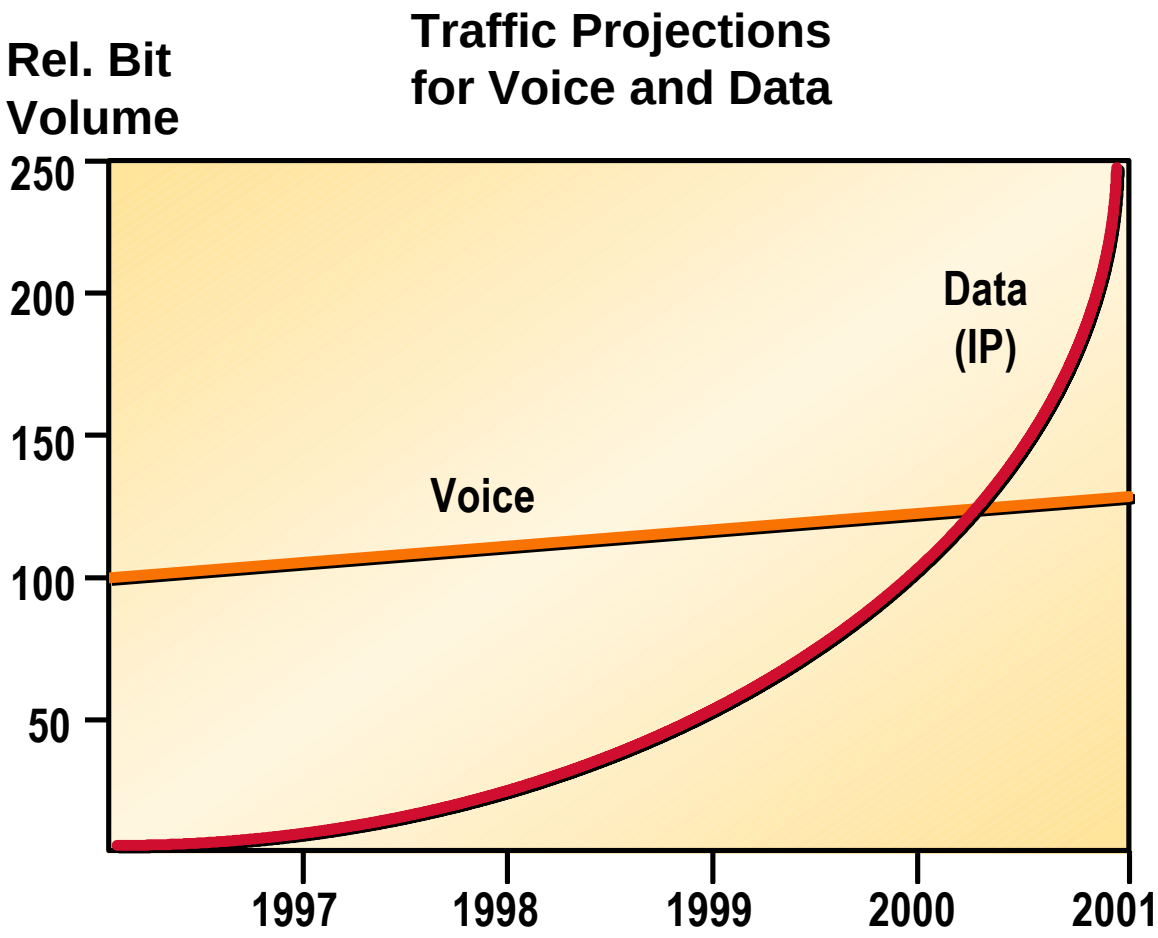
Internet Growth

- Data traffic exceeds voice—growing at 2-4x per year vrs 6%
- Internet hosts growing exponentially (16M in Jan ’97)
- Web users expected to reach 160M by 2000
- TCP-WWW now accounts for 75% of traffic
- Traffic type changing rapidly from text to image to video



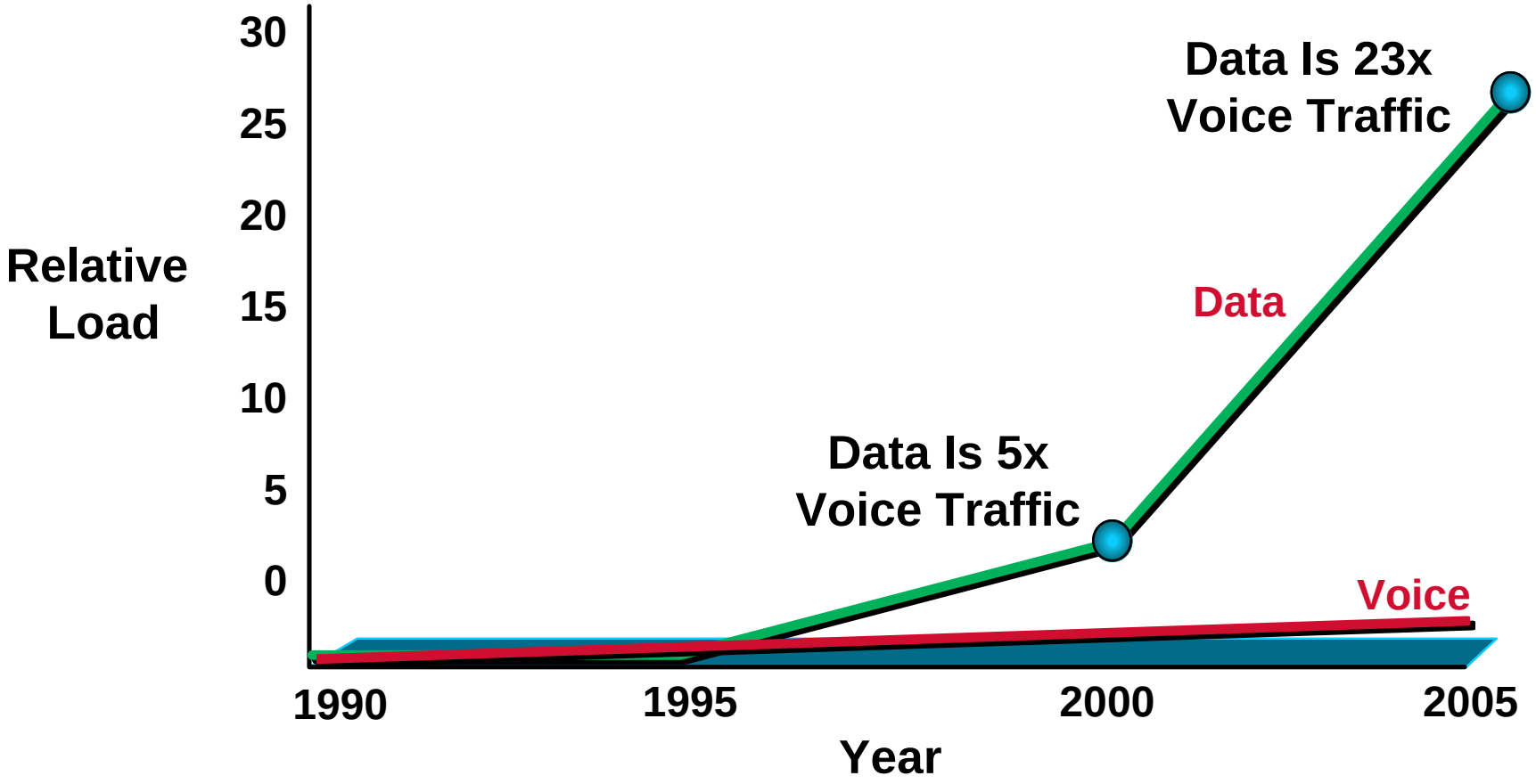
Growth of IP Traffic— A Paradigm Shift

- The Telcom market will grow from $195 B annual revenue to $260 B by year 2000, with data services accounting for the lion's share of this increase. (Yankee group)
- Construction of data infrastructure is outpacing voice three to one
- US/Japan commercial BW is twice the voice BW



Source: Multiple IXC Projections

Network Bandwidth Prediction



Source: Electronicast

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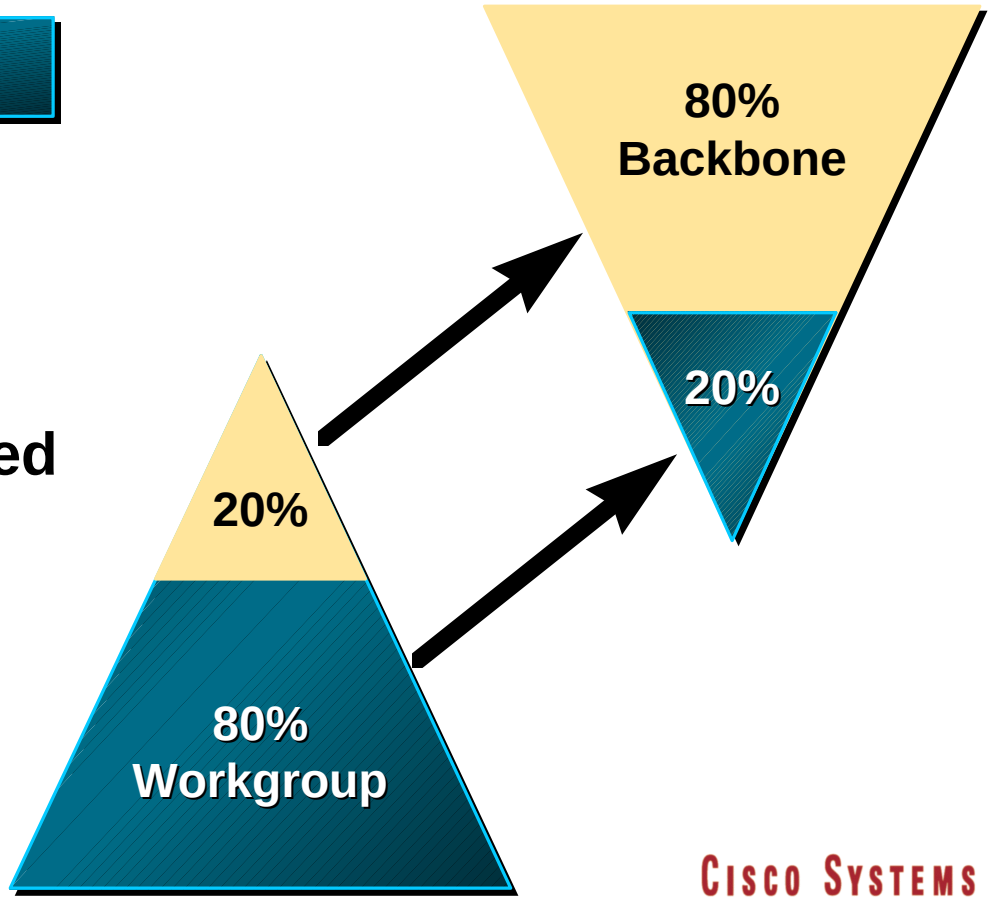
Network Traffic Pattern Turning Upside Down!

"The New 80–20 Rule"

- Server locations shifting
- Server bandwidth performance increase
- Latency reduction required
- Multimedia applications
- Multicast applications
- **Transport backbones will be stressed out**



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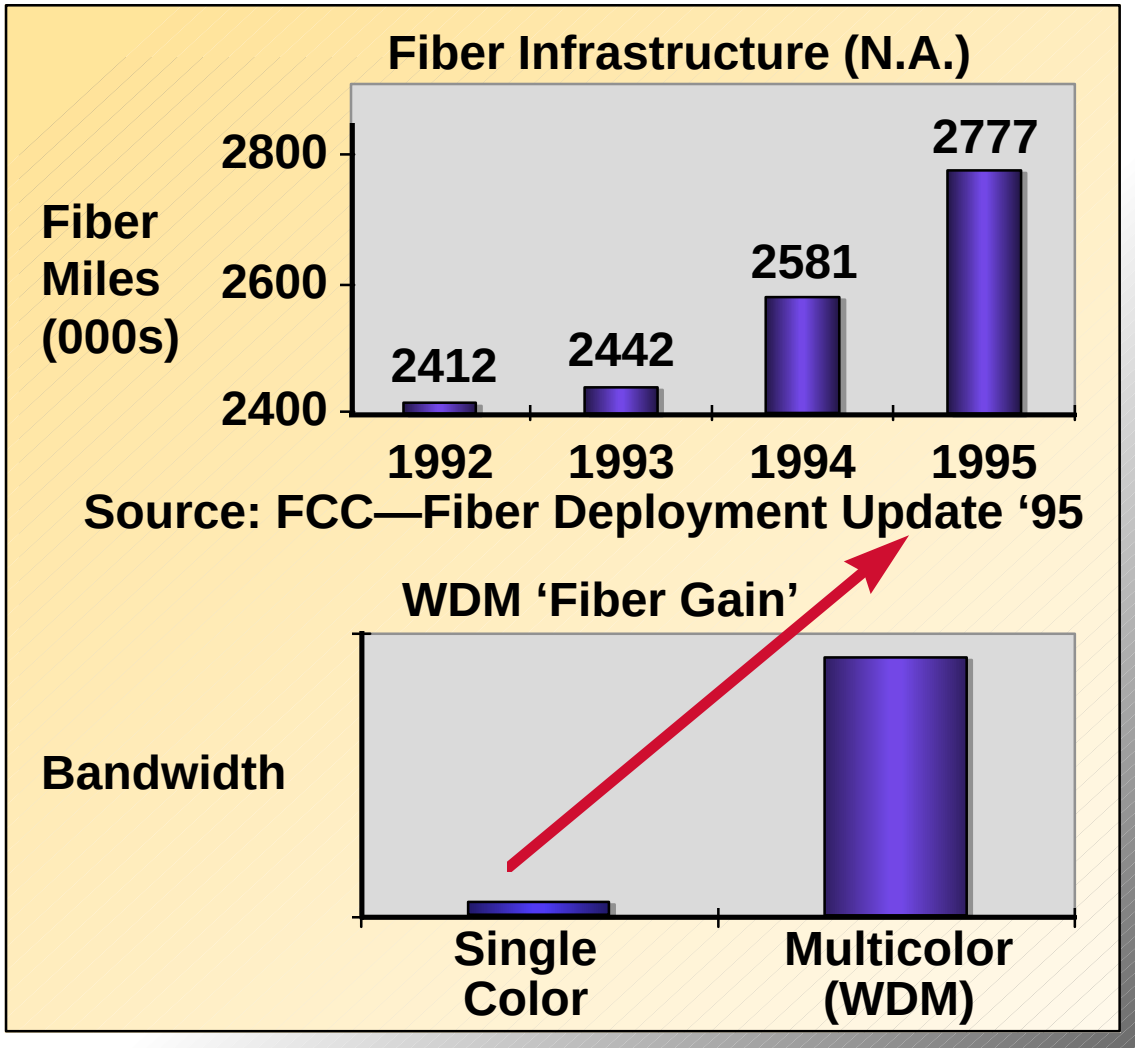
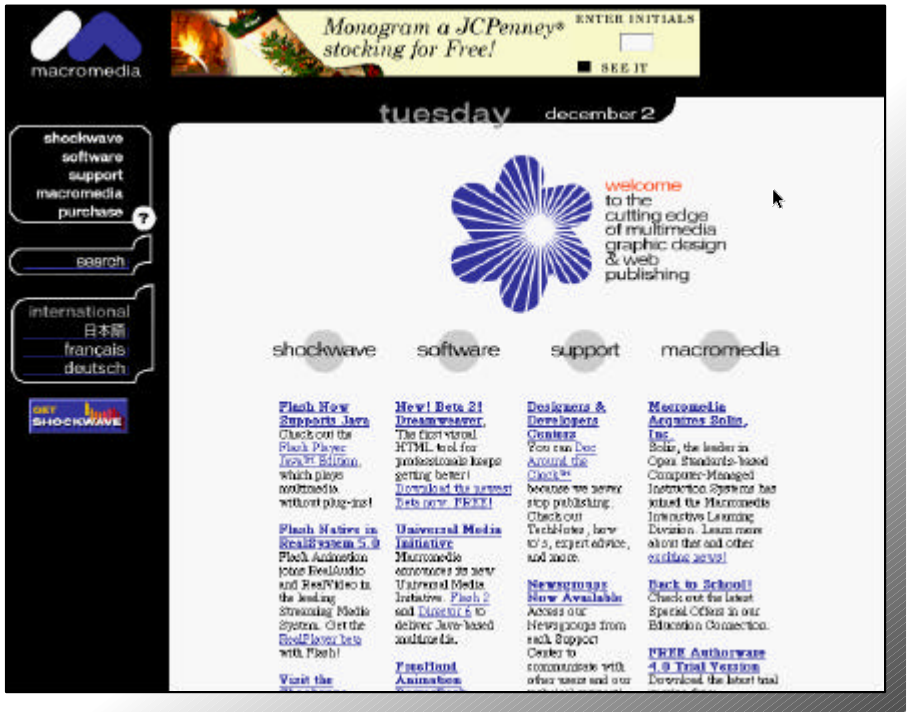
Bandwidth Supply

- New installation by traditional players
- WDM will provide “fiber gain” in the order of 8-32x for existing plant
- New providers of dark fiber—particularly in metropolitan areas
- Alternatives to fiber



Characteristics of Internet Traffic

- WWW accounts for 75% of Internet traffic
- “Average” packet size approximately 330 bytes
- Average WWW session duration is 13 seconds
- Average WWW flow is 15 packets long



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Emergence of a New Paradigm

- The explosive growth of data drives the emergence of a new era: the IP transport infrastructures based on packet over SONET technology
- Criteria: co-existence with existing transport SONET/SDH networks

What Is IP Transport?

- **An IP-based full service network taking advantage of natural IP capabilities :**

  Simplicity, scalability, multicasting

  IP layer three Quality of Service (QoS)

What Is an IP Transport Infrastructure?

- A network populated with SONET/SDH-smart routers, IP network elements (IPNEs),for seamless integration into the existing vast SONET/ SDH infrastructure

What Is Packet over SONET?

A high-speed WAN transport that leaves LAN traffic in its native format

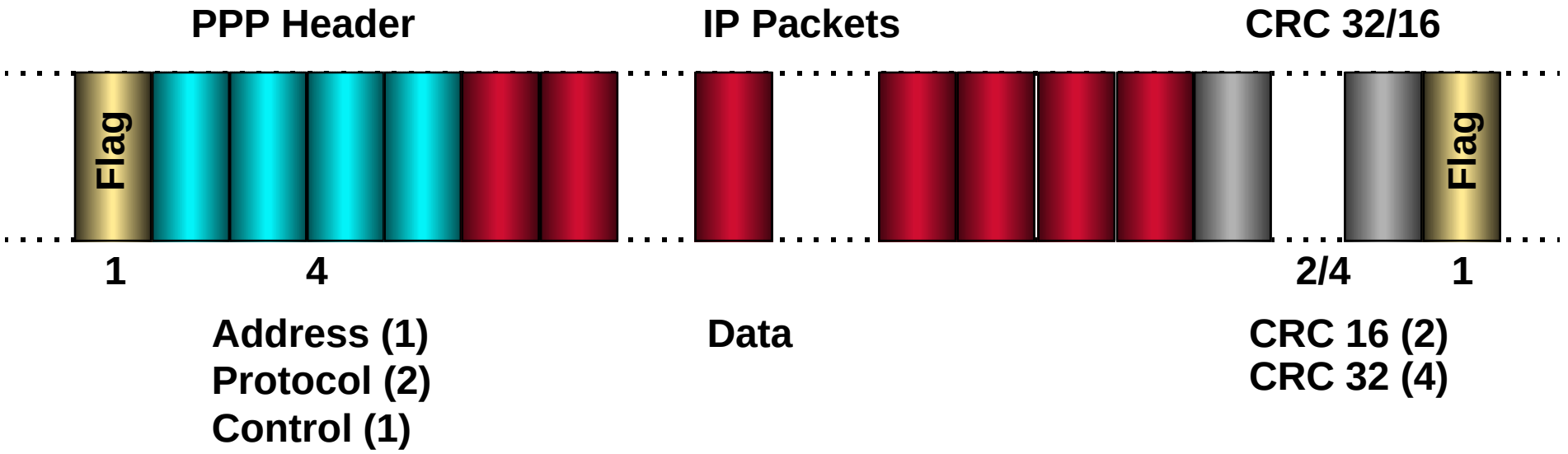
What Is Packet-Over-SONET/SDH?

- **Packet-Over-SONET/SDH is the serial transmission of data over SONET frames through the use of Point-to-Point Protocol (PPP)**

  RFC 1619, “PPP over SONET/SDH”

  RFC 1662, “PPP in HDLC-like Framing”

Format of Packets in SONET SPE



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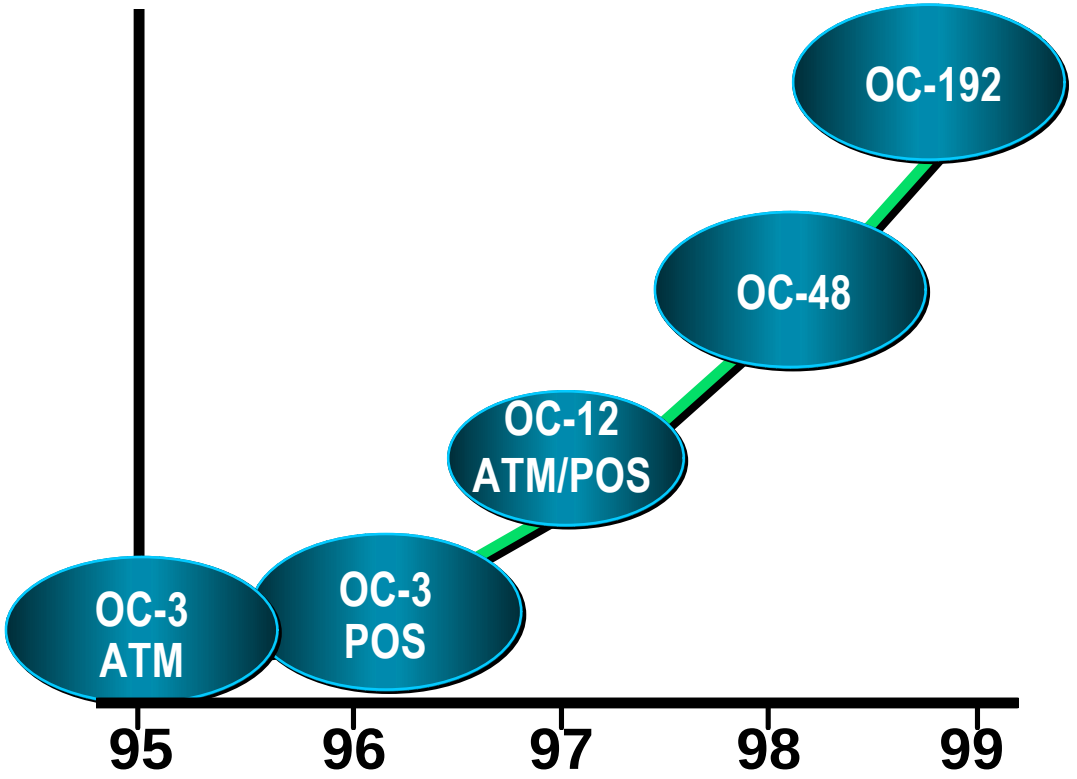
What Has Made IP over SONET Possible?

- Bandwidth is the driver
- New mapping schemes
- Employing architectures from switches not computers
- Good engineering and ASIC technology
- Early-adopter customers



Performance with Flexibility

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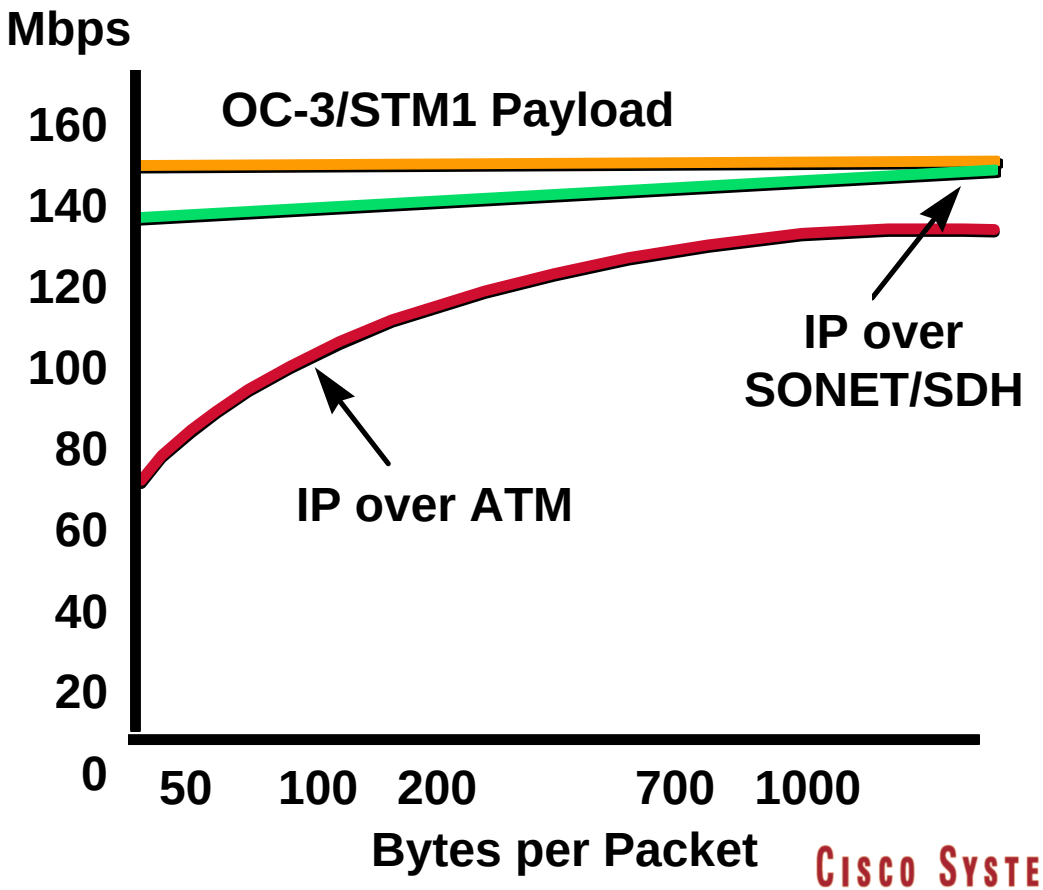
Benefits of Packet over SONET

- **High utilization of WAN bandwidth**
  - Packet over SONET provides 98% utilization
- **Goodput verses throughput**
  - Sufficient buffering for large TCP flows
  - Congestion avoidance
- **Traffic management**
  - Load balancing during steady-state and failure conditions



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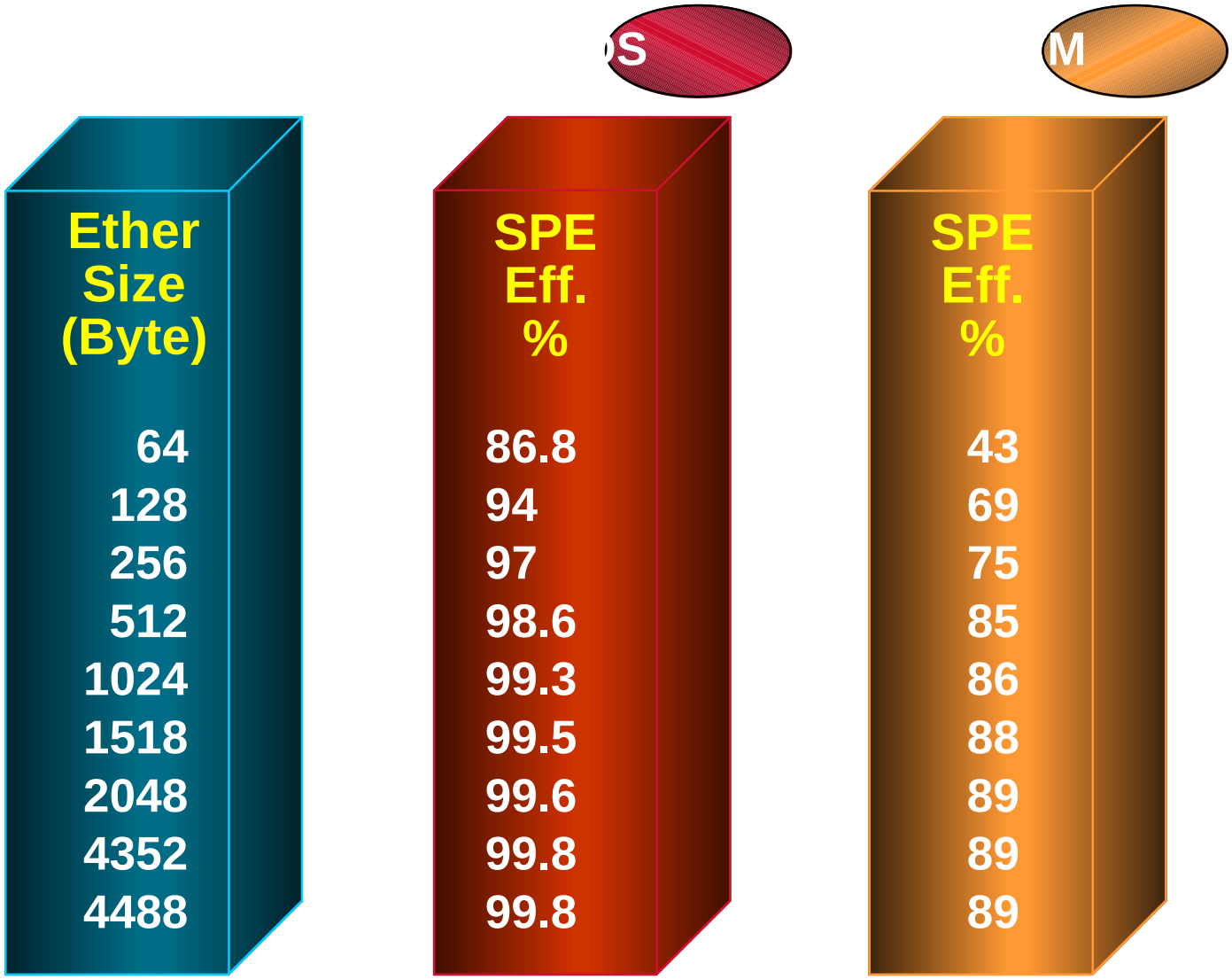
SPE Efficiency

Packet-over-SONET vs. ATM-over-SONET



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Consider IP over SONET/SDH when business model or majority of traffic is IP Centric

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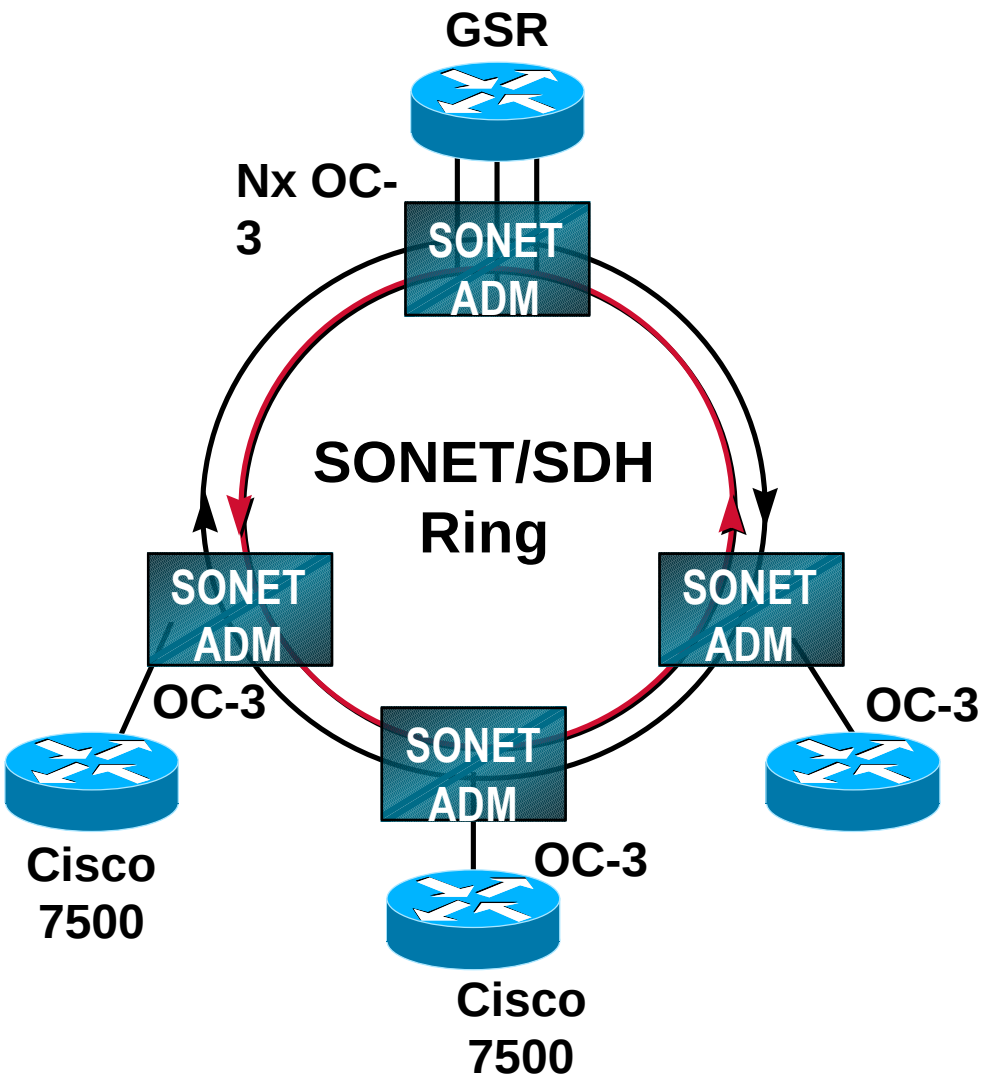
Consider ATM for aggregation of multiple services on a common transmission infrastructure

SONET/SDH-Based TDM Transport

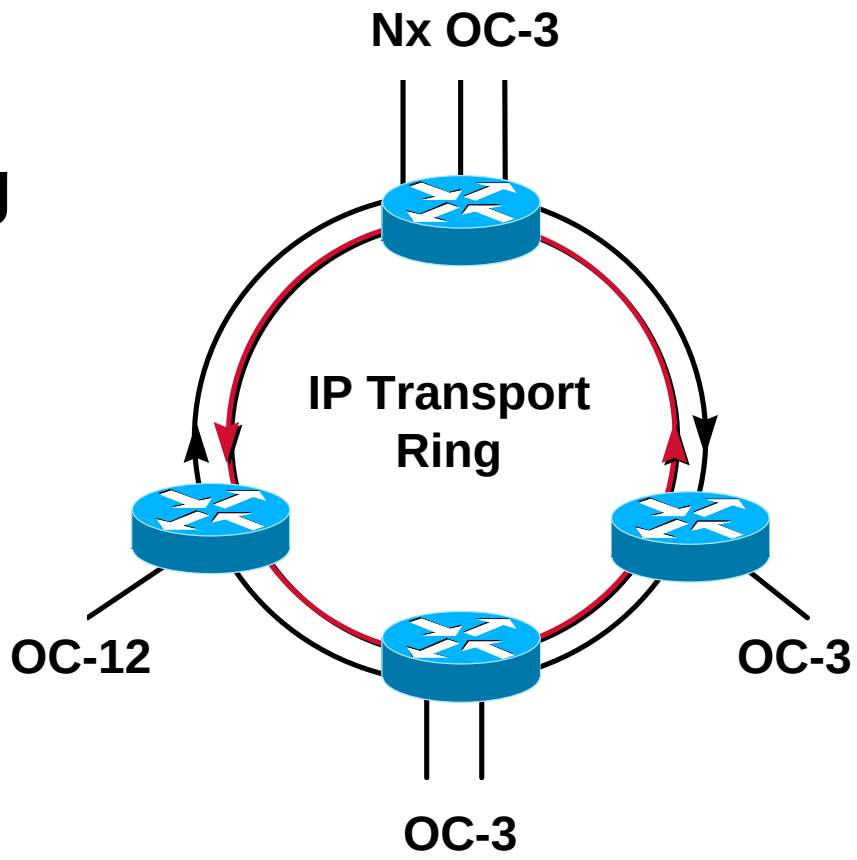
- Accepted transport architecture
- Performance monitoring
- Logical pt-pt over physical ring
- Multiservice via TDM, but expensive in bandwidth for data
- Good protection, but expensive in bandwidth



Optimized for TDM Voice,Not Data

SONET/SDH-Based IP Transport

- Retain basic transport architecture and performance monitoring
- Logical IP rings with multicast, oversubscription and priority
- Protection done at the network layer for greater efficiency



Optimized for IP

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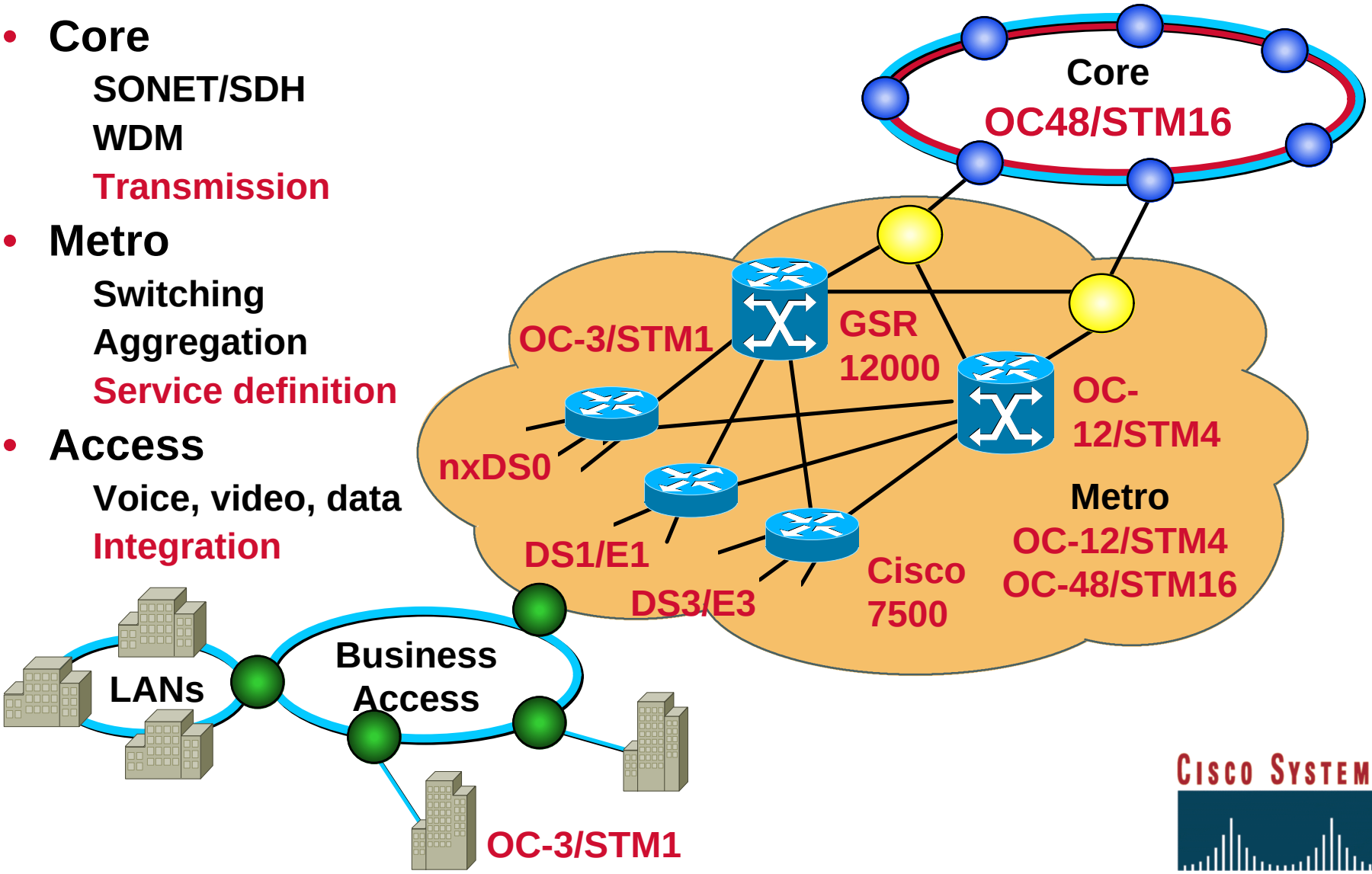
Network Architecture—Today

- **Core**
  - SONET/SDH
  - WDM
  - Transmission
- **Metro**
  - Switching
  - Aggregation
  - Service definition
- **Access**
  - Voice, video, data
  - Integration



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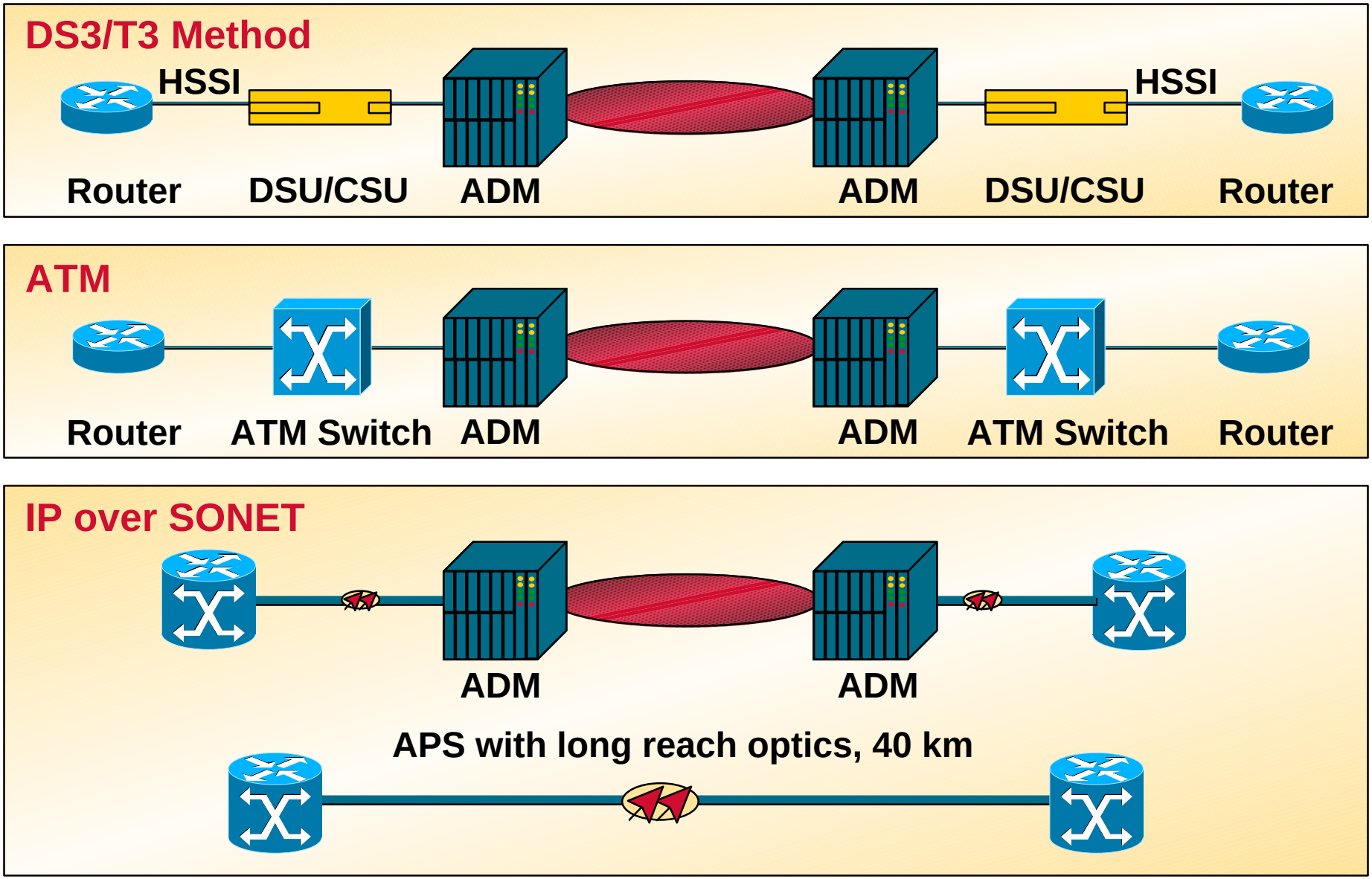
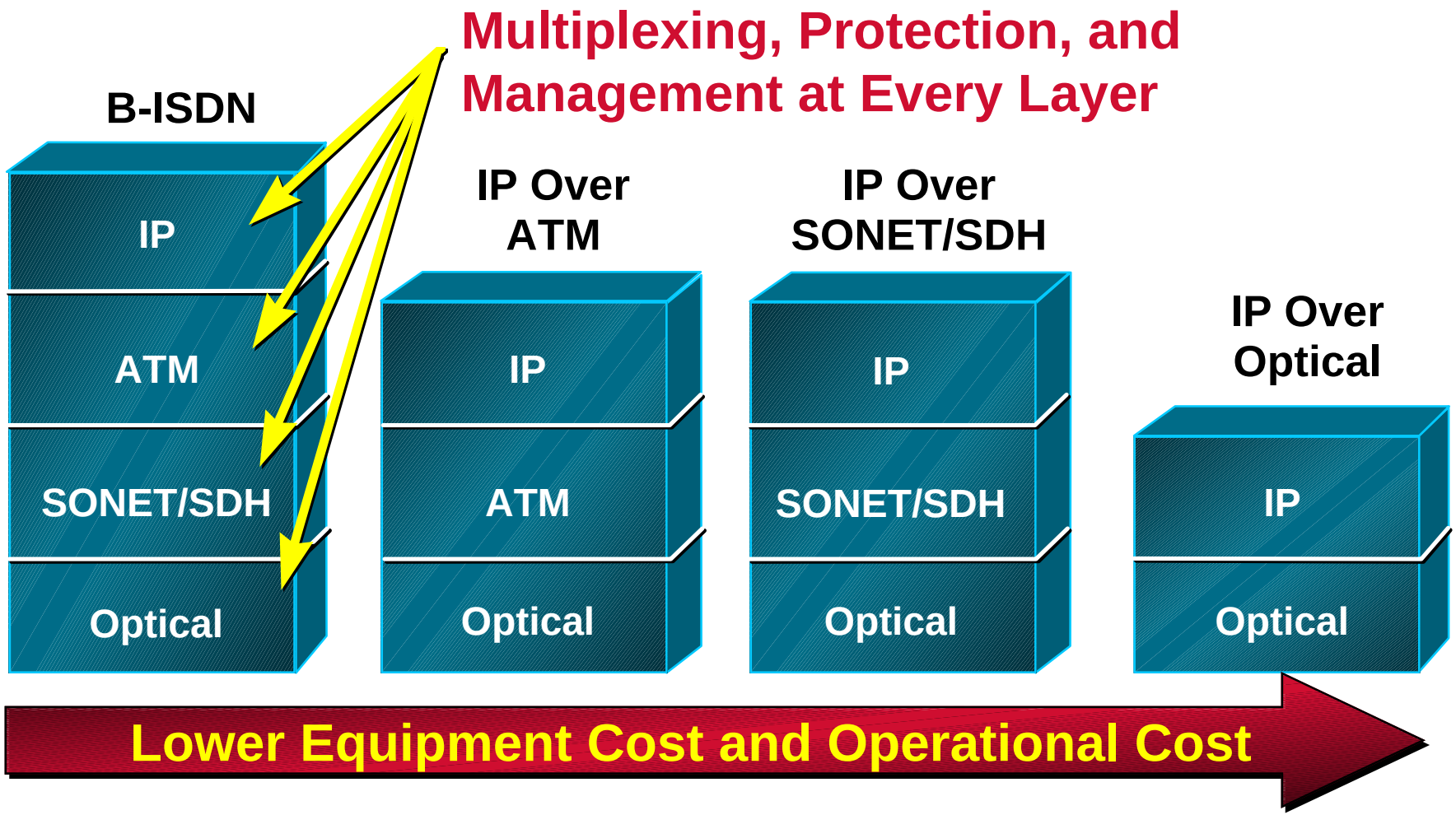
Packet over SONET role in helping the LAN/WAN transition and lowering the cost of ownership



IP Transport Alternatives



Criteria for Moving Forward

- **Co-existence with the existing transport SONET/SDH networks**

Leveraging the SONET/SDH Technology

- Worldwide infrastructure
- High capacity/performance
- Resilient/highly available
- Proactive fault detection
- Synchronization
- Scalability to OC-48/192
- High utilization of WAN bandwidth for IP
- Differentiated services through L3 QoS
- High-performance multicast

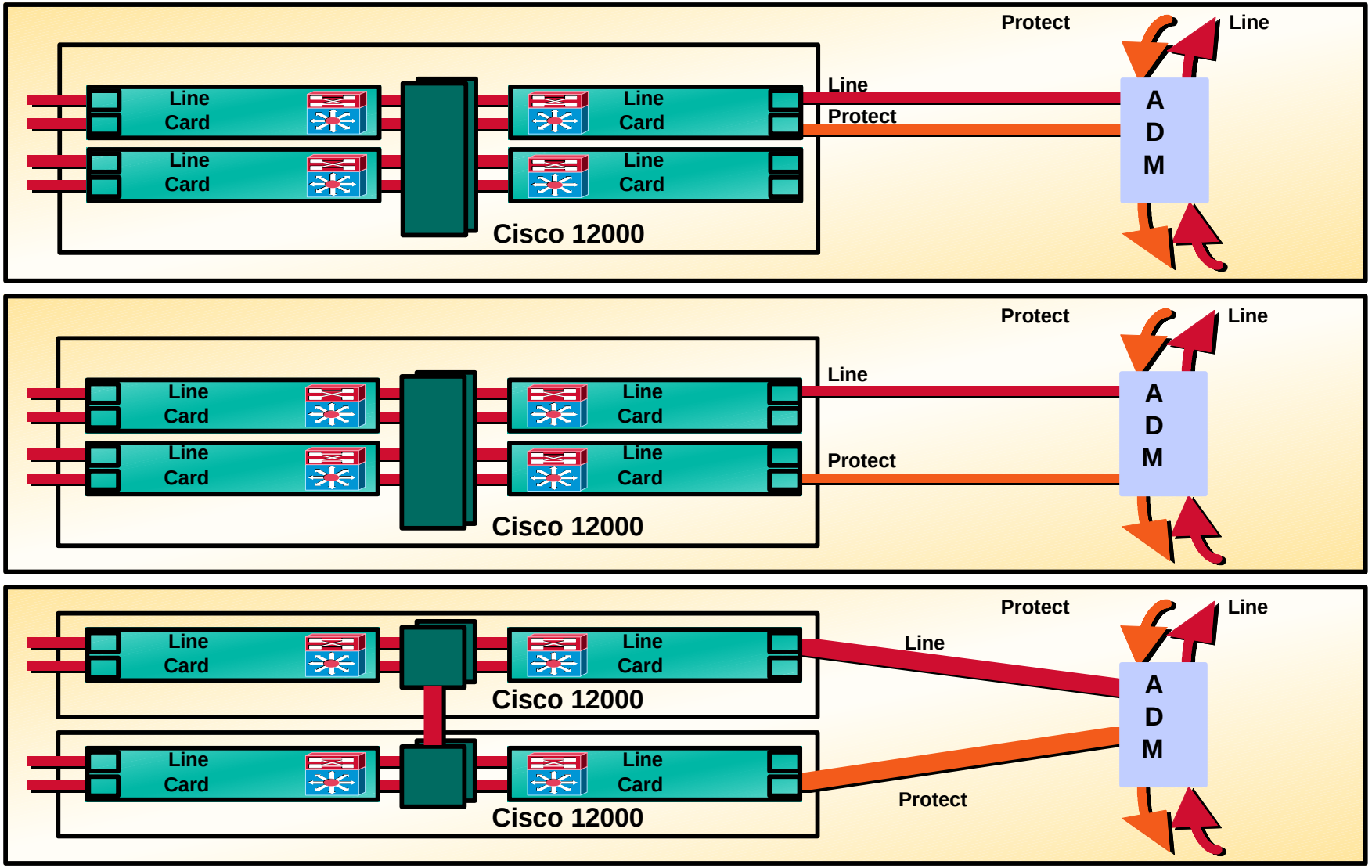
SONET Transport and Path Overhead byte Designations

	Transport Overhead			Path Overhead
Section Overhead	Framing A1	Framing A2	Trace/ Growth STS ID J0/Z0	Trace J1
	BIP-8 B1	Orderwire E1	User F1	BIP-8 B3
	Section Data Communication Channel D1	D2	D3	Signal Label C2
Line Overhead	Pointer H1	Pointer H2	Pointer H3	Path Status G1
	BIP-8 B2	APS K1	APS K2	User F2
	Line Data Communication Channel D4	D5	D6	Indicator H4
	D7	D8	D9	Growth Z3
	D10	D11	D12	Growth Z4
	Sync Status/ Growth S1/Z1	REI/ Growth M0 or M1/Z2	Orderwire E2	Tandem Connection Z5

Cisco Packet over SONET—A Table of SONET Features

• Timing	• Looped or internal
• Maintenance	• Local or distant loopback signals
• Automatic Protection Support	• Support of K1/K2 bytes
• C2 signal label	• Setting and display of the SPE content
• J1 path trace	• Inserts and monitories a repetitive message
• BIP 1/2/3 parity bytes	• Inserted and monitored
• Provisioning of the SS bits in the H1 byte	• Interfacing various brands of SONET NEs
• M1 and path (in G1) REI	• Inserted and monitored
• Section, line, path alarm and performance monitoring	• Aid in trouble shooting

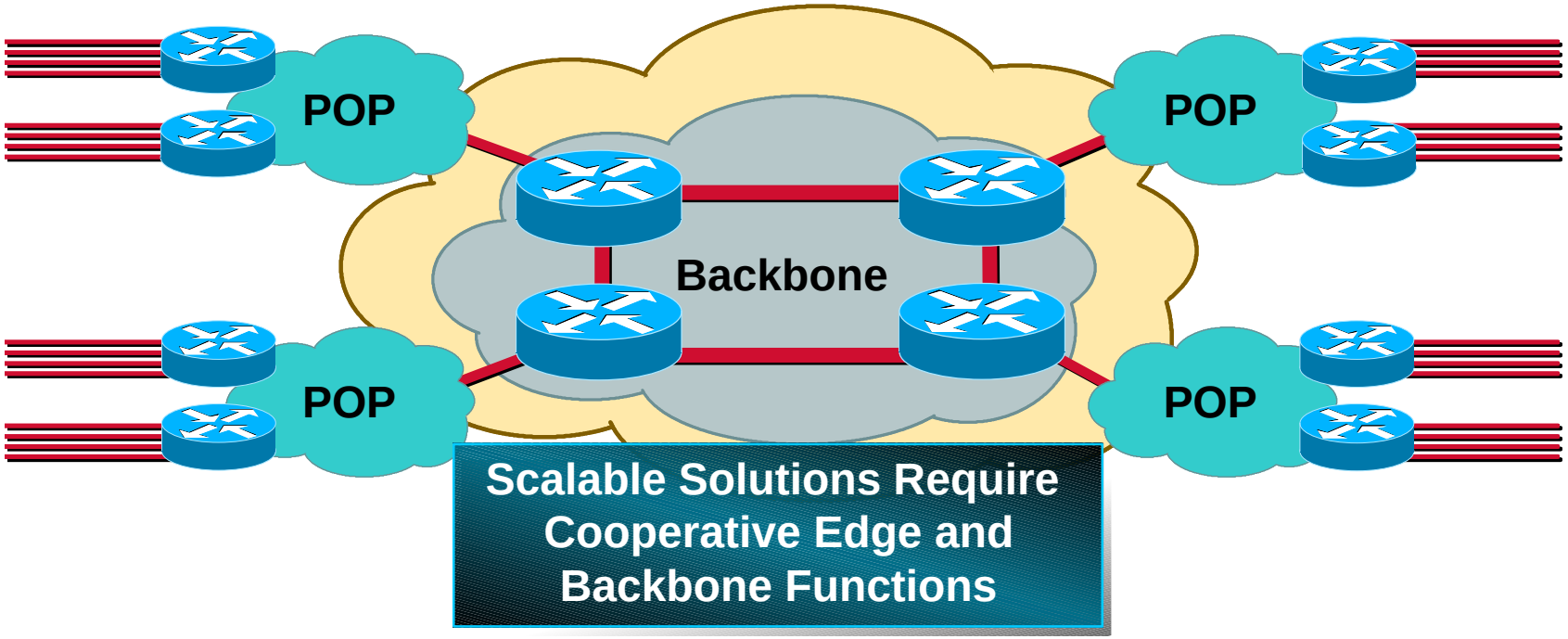
Cisco 12000 Automatic Protection Switching Support, Bellcore GR-253



Why L3 QoS?

- Deregulation of the industries
- In-region competition
- Mission critical applications
- VoIP
- Need for guaranteed and differentiated services
- Need to increase revenue/earnings

Network Architecture



Edge Functions

- Packet classification
- Bandwidth management
- L3 metering
- Security filtering
- Access aggregation

Backbone Functions

- High-speed switching and transport
- QoS enforcement
- QoS interworking

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L3 QoS on Packet over SONET

- **Committed Access Rate (CAR)**

  Used at the edge of the network for rate-limiting, controls the amount of traffic going through a given interface, i.e, DS3 interface with T1 throughput

- **Random Early Detection (RED)**

  RED is a congestion avoidance mechanism which controls the packet flow before congestion takes place. That is TCP operates based on closing and opening of its window. RED manipulates flow through the TCP sessions before the actual congestion takes place. RED is typically supported at the core of the network

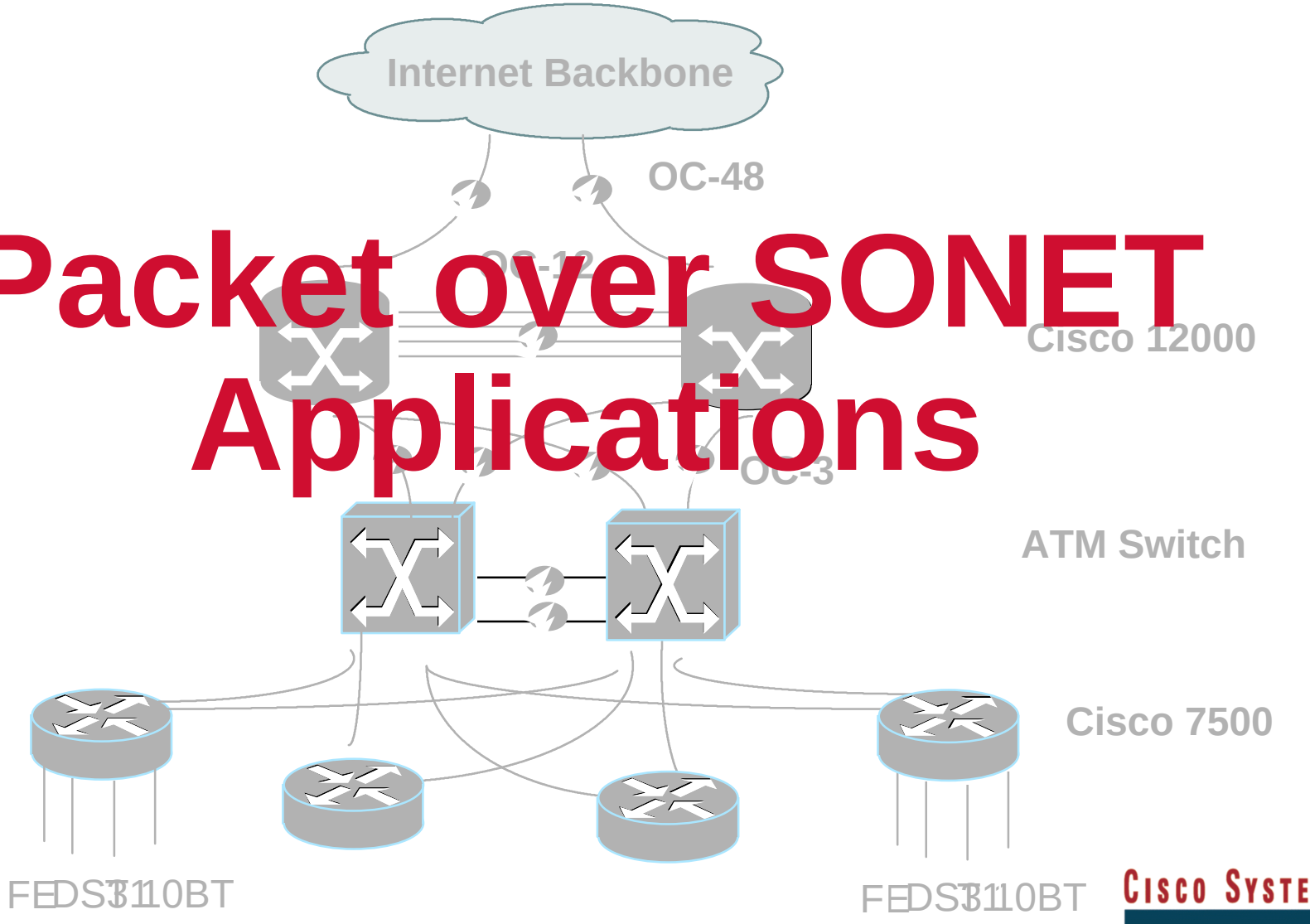
- **Weighted RED**

  WRED is a congestion avoidance mechanism designed to provide preferential treatment for premium-class traffic under congestion situations while concurrently maximizing network throughput and capacity utilization and minimizing packet loss and delay. The network operator may define up to six classes of service

Cisco Packet over SONET Platform Support

	OC-3/STM-1	OC-12/STM-4	OC-48/STM-16
Cisco 7200	✓		
Cisco 7500	✓		
Cisco 12004	✓	✓	
Cisco 12008	✓	✓	✓
Cisco 12012	✓	✓	✓

Packet over SONET Applications



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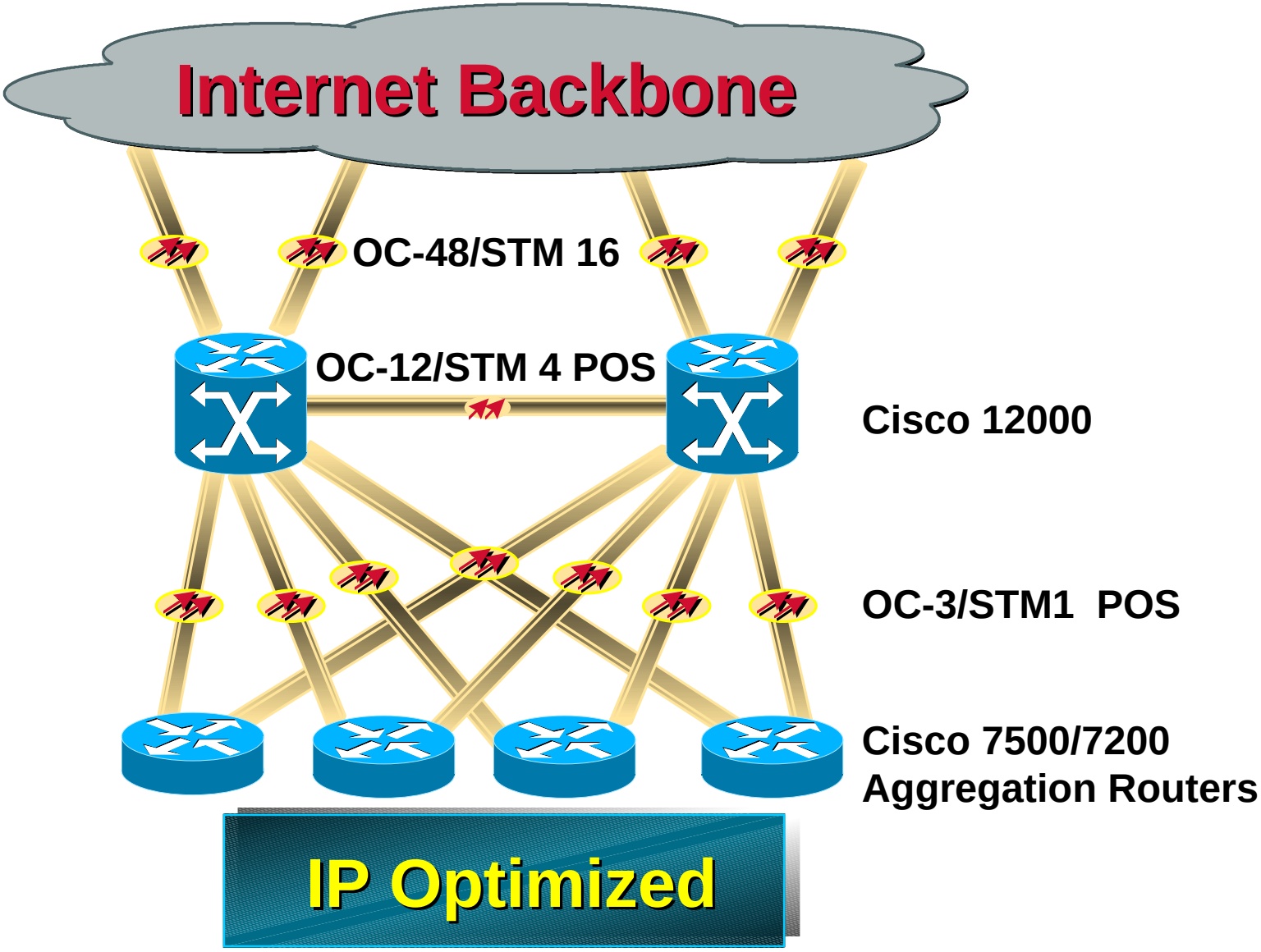
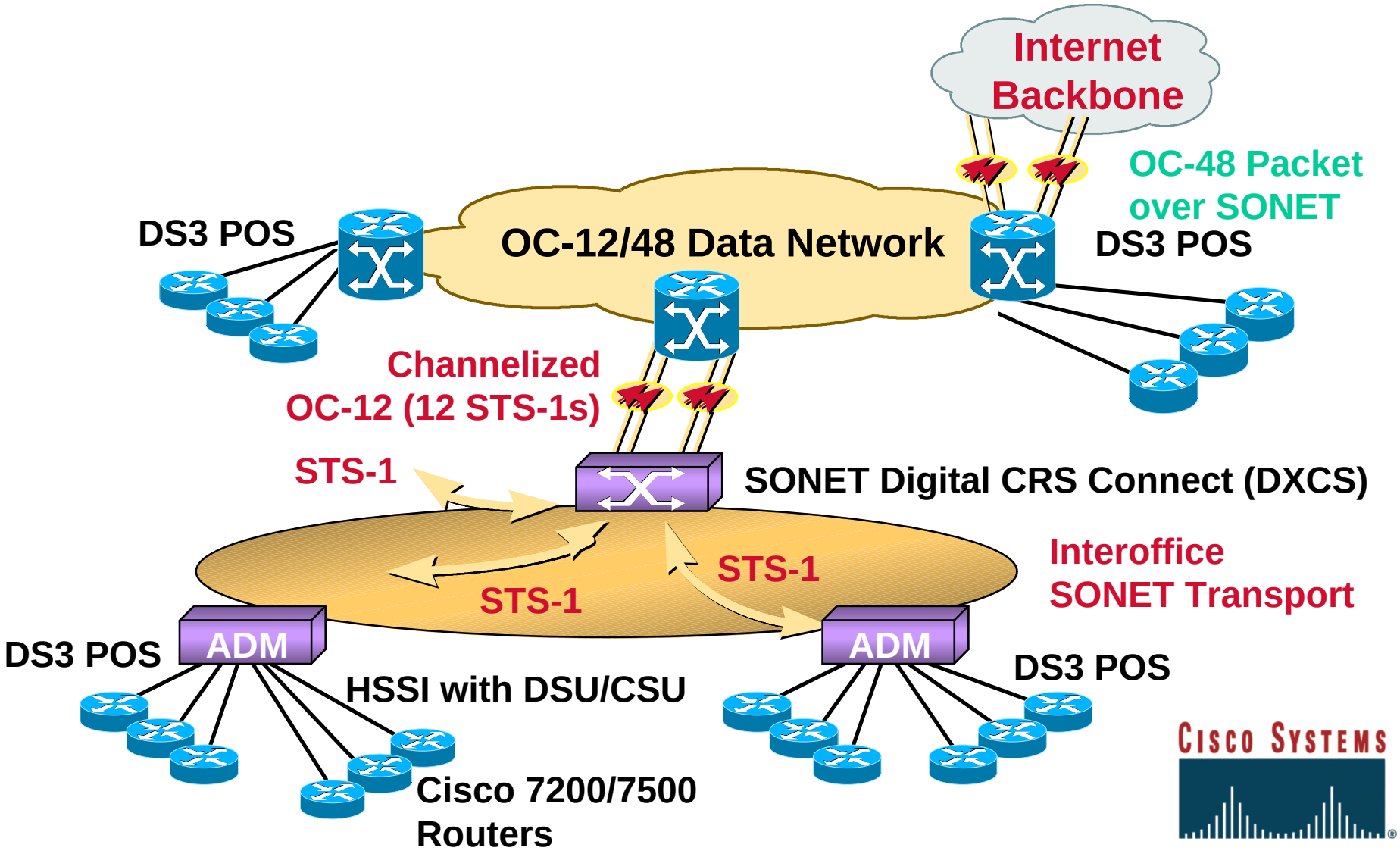
Packet over SONET Application in the Internet Service Provider Space



Aggregation and Backhauling of Packet over DS3 Services to the Internet Backbone by Utilizing Metropolitan SONET/SDH Ring Networks



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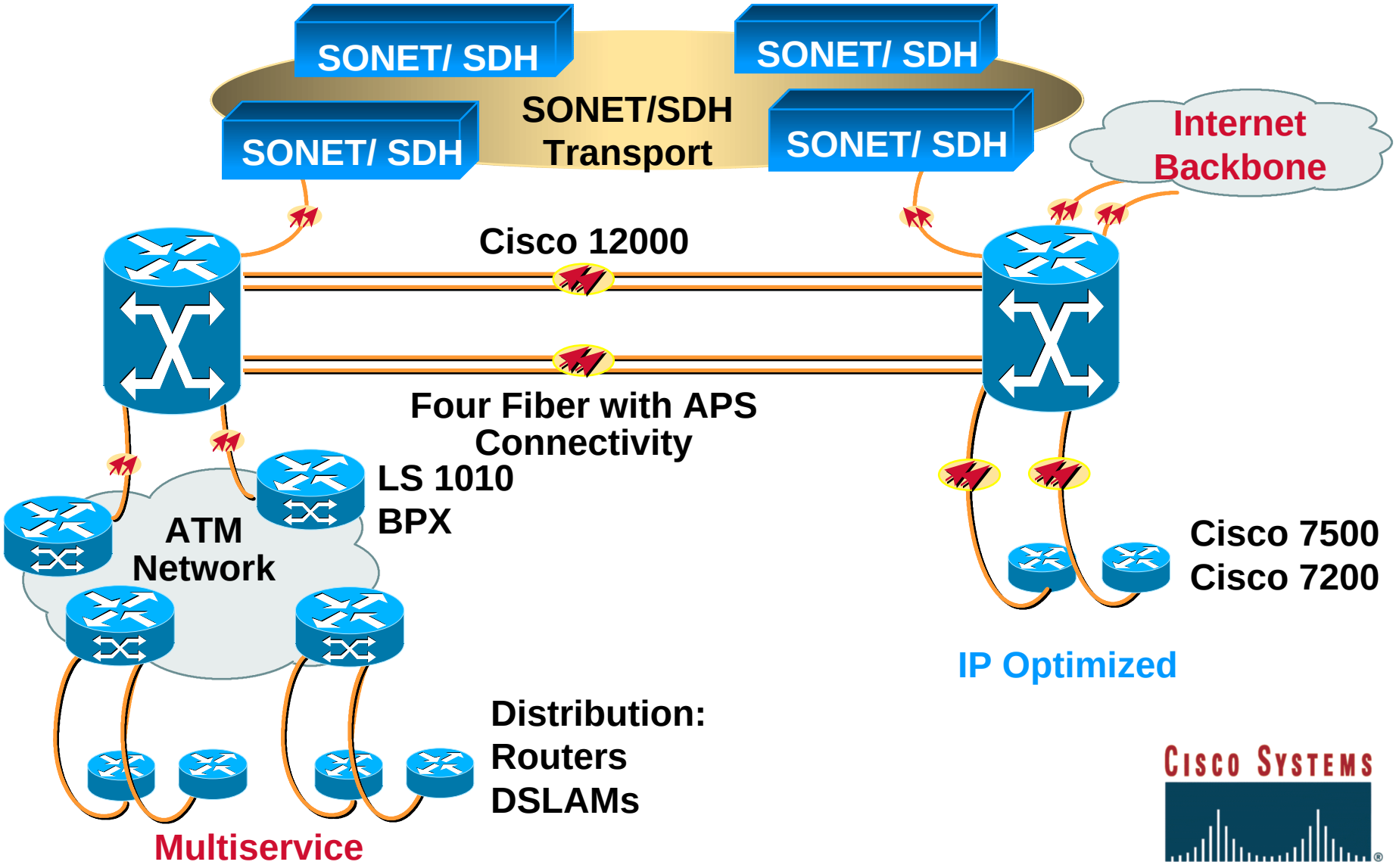
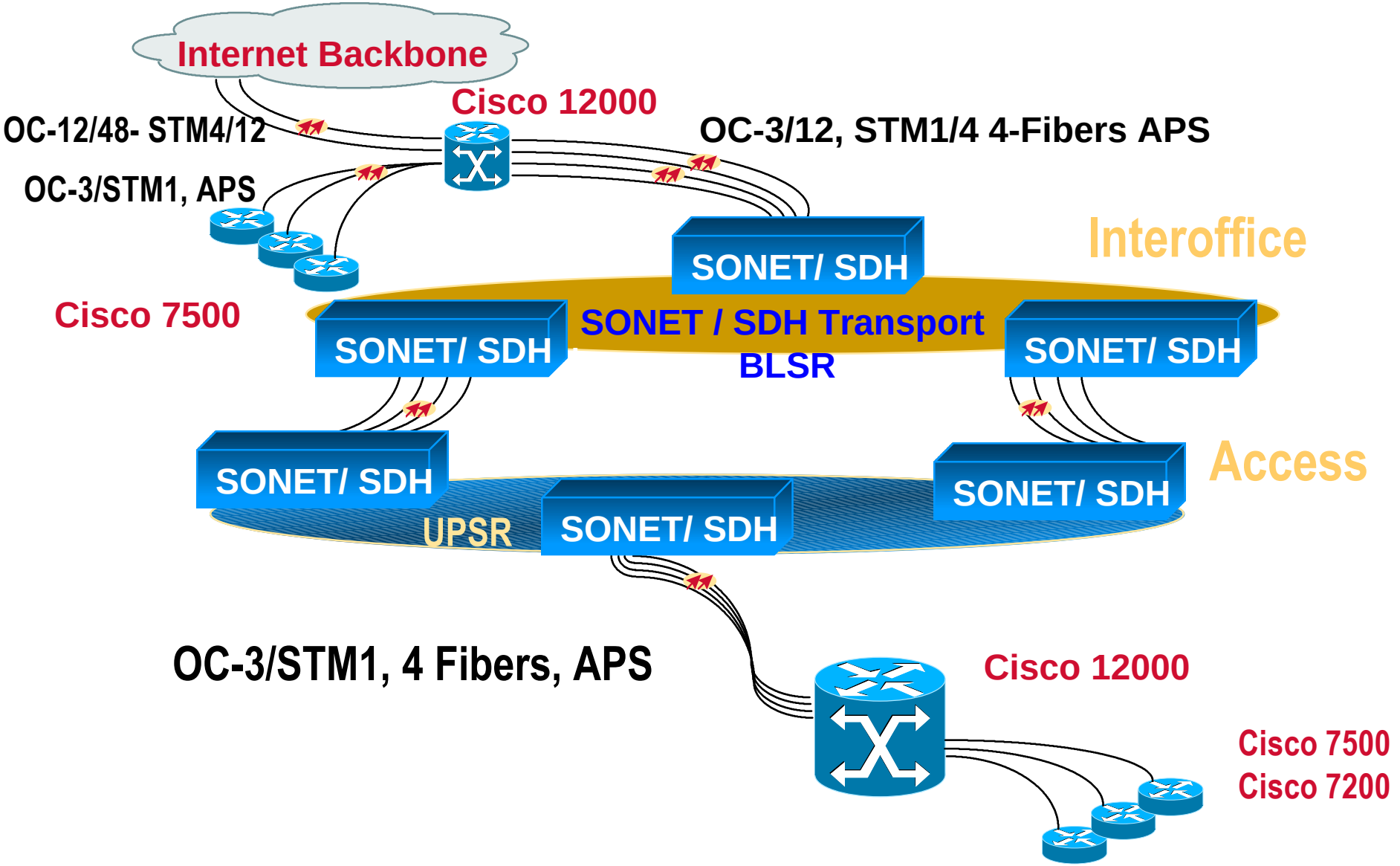
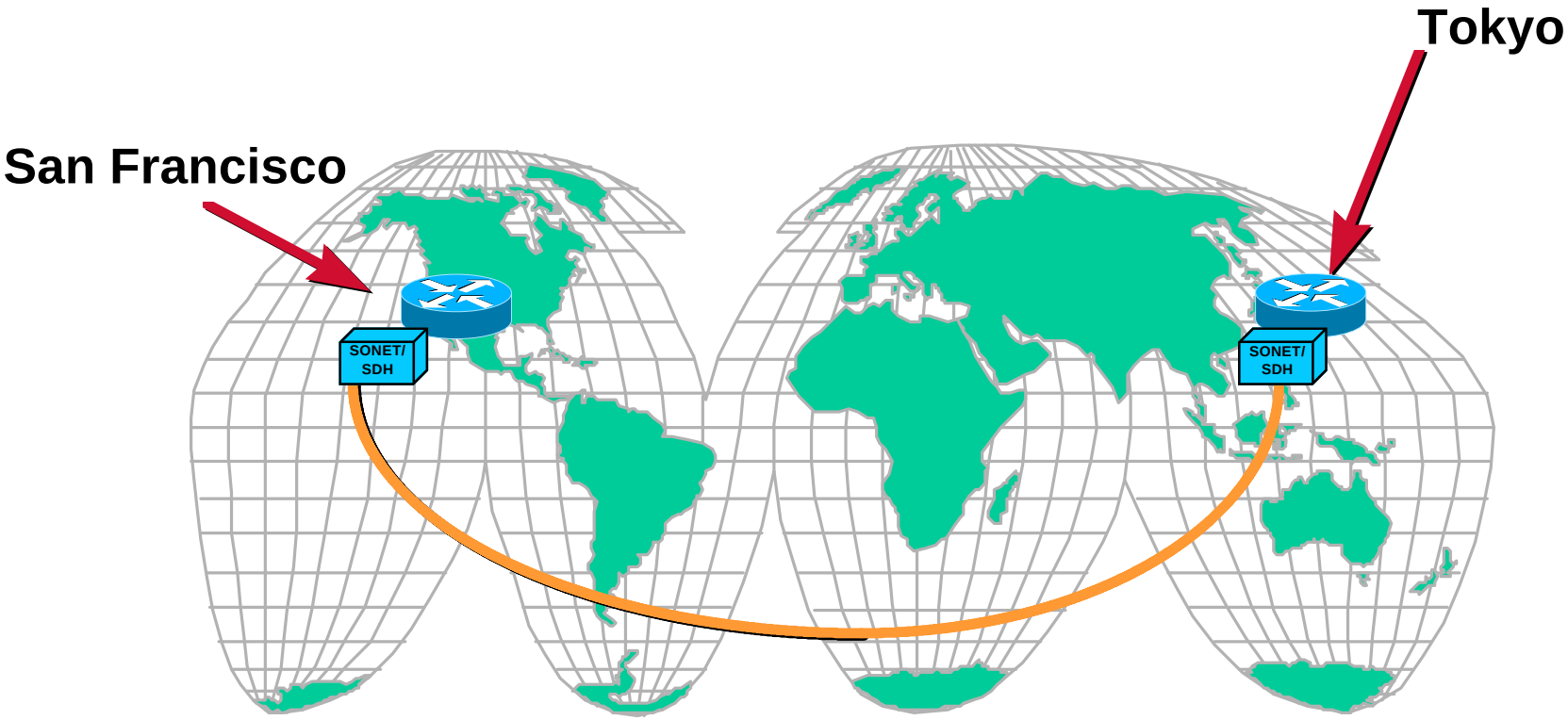
Private Peering and Route Diversification over SONET Interoffice Facilities



Carriers—Cisco 12000 Interconnection to the Transport Interconnecting Rings



Packet-Over-SONET Trans-Oceanic Application



Trans-Pacific Undersea Fiber Cable

San Francisco—Tokyo

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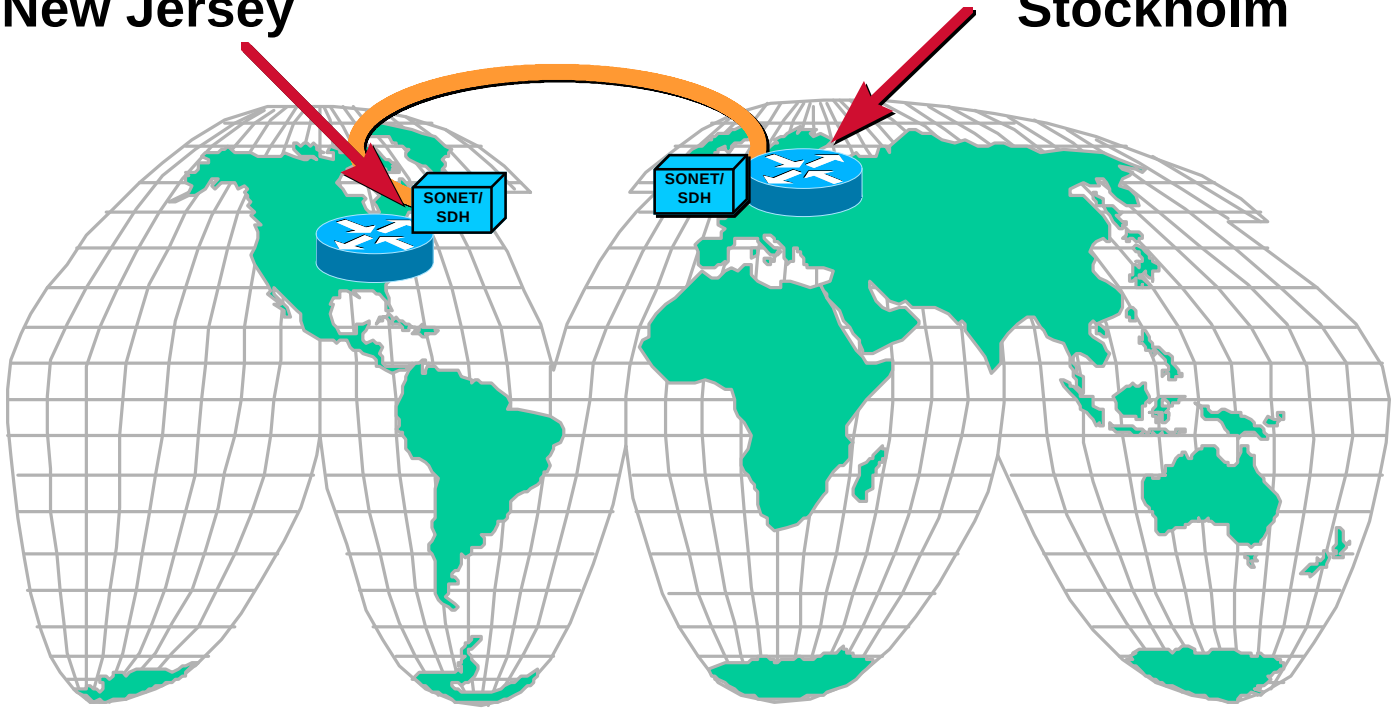
Packet-Over-SONET Trans-Oceanic Application

NY NAP, New Jersey

Stockholm



Trans-Atlantic Undersea Fiber Cable
Sprint Link and ICMnet

New Jersey—Stockholm

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Packet over SONET Worldwide Deployment

Summary

- **The need to optimize networks for the dominant protocol**
- **Co-existence between IP transport and the SONET transport networks**
- **Need to offer differentiated services through L3 QoS**

  Best effort mentality and throwing bandwidth at the problem is not competitive

Summary—No Religious War!

- **Net-heads vs bell-heads**

  Based on strength and weakness of each technology, the two can co-exist in their respective territories

Summary—Benefits

- Bandwidth savings
  - Less overhead
  - Channelization
- Scalability
- Simplicity
  - Configuration, management, trouble shooting
- L3 QoS
- Leveraging existing SONET/SDH infrastructure
- Reliability through the APS support
- No circuit provisioning by carriers
- Lower cost of ownership through elimination of the intermediate SONET NEs


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Empowering the
Internet Generation℠