

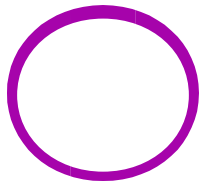
# Optical Networking Services



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Some slides and most of the graphics are taken from other slides



# Research Direction

- The research topic that I'm looking after is [Applications and Services Infrastructure for Optical Networking](#)
- What is a service composition and how we build a service? What building blocks are needed and how cooperating and brokering should work in optical infrastructure and among providers?
- A good starting point can be to look into some applications and pick few (2-3). We can look into the TeraGrid and SAN, and we should see how the dynamic behavior of emerging optical networking technologies could benefit the applications
- We need to look all the way from the problem, solution, application, architecture, services, and how this is implemented and what services are needed in each layer

# Agenda

## Optical Networking

Three networks: LAN, MAN and WAN

Leading technologies: ASTN, Smart ! , ASON, MPLS, OE,

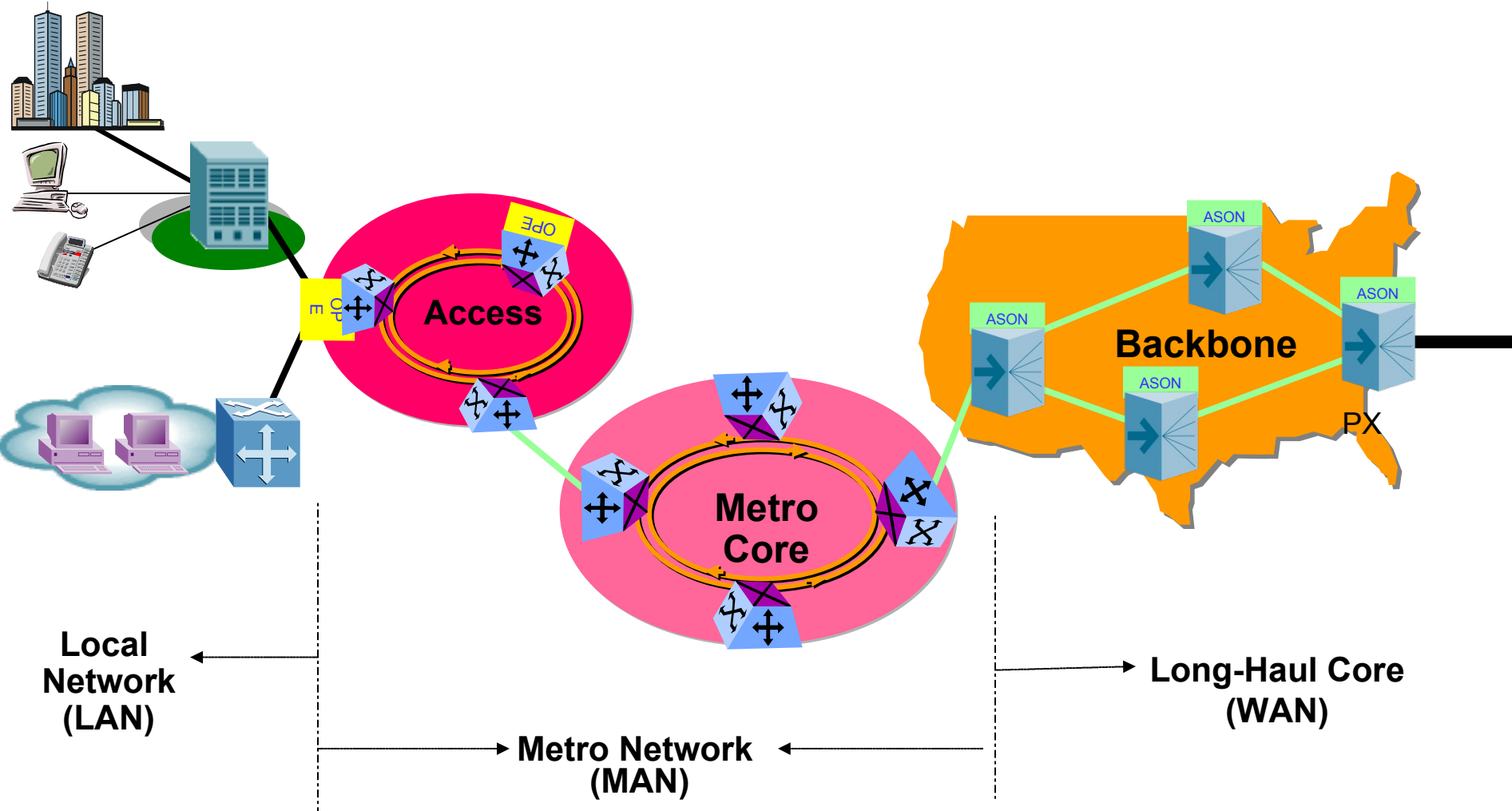
## Challenges

## Service Solutions

## Killer Applications

## Summary

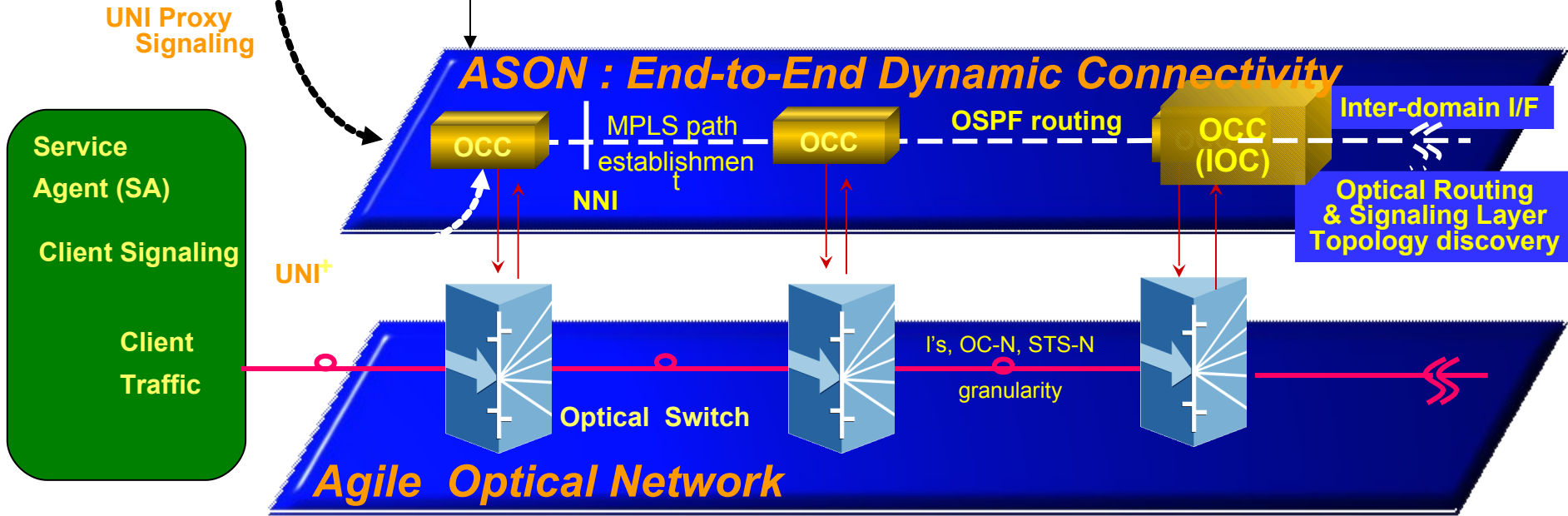
# Three networks in The Internet



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# Optical ASTN (Automatic Switch Transport Network)

## 3. Applications (SA Servers)



# Optical Ethernet (OE)

## Goal

Ethernet Transport (L2) over Optical networks (L1)

## Benefits

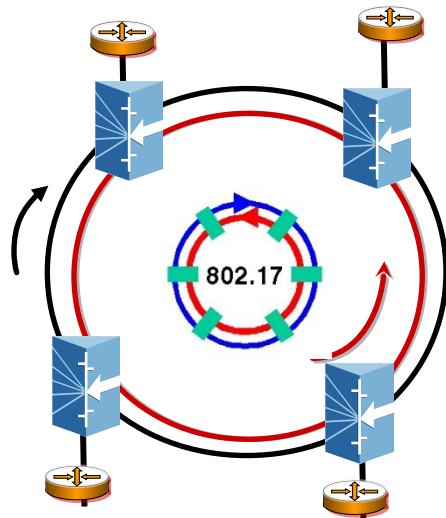
Optical agility and reliability

Ethernet simplicity and efficiency

Seamless transport from LAN to MAN and to WAN

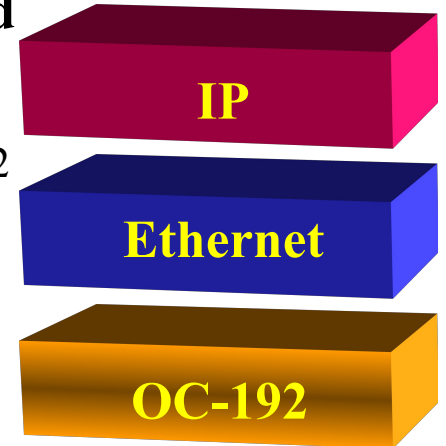
### RPR Standard (Resilient Packet Ring)

- Ring MAC protocol
- Ethernet over rings
- IEEE 802.17



### 10GigE Standard

- GigE extension
- Ethernet over OC-192
- IEEE 802.3ae



# Agenda

## Optical Networking

### Challenges

Bandwidth provisioning

Data transport

Enterprise Networks

QoS

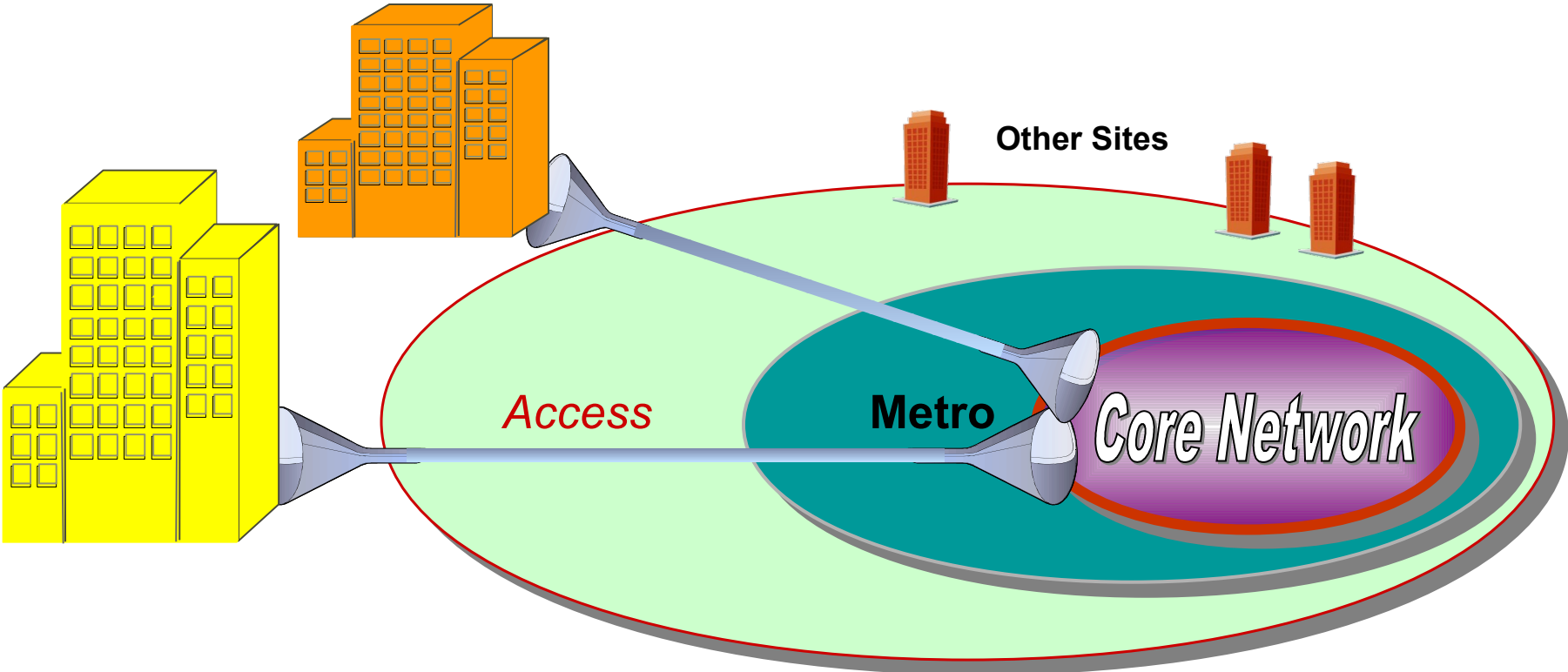
Network Heterogeneity

## Service Solutions

## Killer Applications

## Summary

# The Metro Bottleneck



**End User**  
 Ethernet LAN  
 IP/DATA  
 1GigE

**Access**  
 DS1  
 DS3  
 LL/FR/ATM  
 1-40Meg

**Metro**  
 OC-12  
 OC-48  
 OC-192  
 10G

**Core**  
 OC-192  
 DWDM n x  
 !  
 06/28/18  
 40G+



# Challenge 1: Bandwidth Provisioning

## Network congestion

LAN access to MAN

## Fibers in MAN and WAN

Insufficient use: <50% on lighting

Inefficient use: wavelength under load

## Lack of mechanisms

Dynamic setup

User intelligence

# Challenge 2: Data Transport Connectivity

## ***Packet Switch***

### **data-optimized**

Ethernet

TCP/IP

### **Network use**

LAN

### **Advantages**

Efficient

Simple

Low cost

### **Disadvantages**

Unreliable

## ***Circuit Switch***

### **Voice-oriented**

SONET

ATM

### **Network uses**

Metro and Core

### **Advantages**

Reliable

### **Disadvantages**

Complicate

High cost

Efficiency ? Reliability

# Challenge 3: Enterprise Networks

## **Network security**

Encrypted communication

Selective routing

## **Network efficiency**

Fast transport

Extensible intranet and extranet

Dynamical connection and route setup

# Challenge 4: QoS Guarantee

**The Internet has rapidly increasing bandwidth**

With the help of optical transport

With high-speed router and switches

**However, it does not provide server guarantee**

Throughput

Delay

Jitter

Reliability

Priority

# Challenge 5: Network Heterogeneity

## **The Internet is fragmented in structure**

LAN, MAN and WAN in terms of area

Actual domains operated by network service providers

## **Network Service providers**

Support a variety of L1-7 protocols

Realize data transport in their own ways

Control network by different methods and technologies

## **Interface problems**

Device interface: UNI, NNI

Layer-to-layer: IP QoS to Ethernet CoS

Switching: Ethernet to MPLS, RPR to MPLS

# Agenda

## Optical Networking Challenges

## Service Solutions

Optics + Ethernet

Smart bandwidth

Flexible VPN

QoS

Network Coordination

## Killer Applications

## Summary

# Solution: Optics + Ethernet

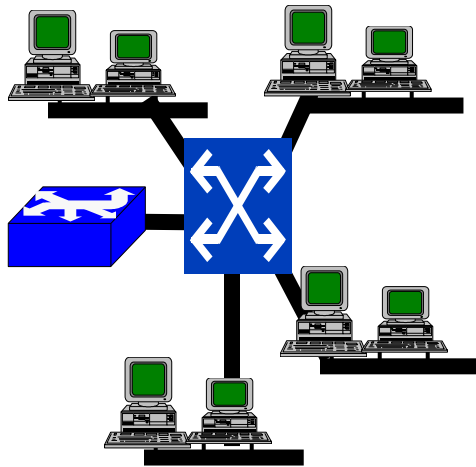
## Optical Networks

- Huge bandwidth
- Fast and reliable

## Ethernet Transport

- Data efficiency
- Simple and scalable

**LAN**

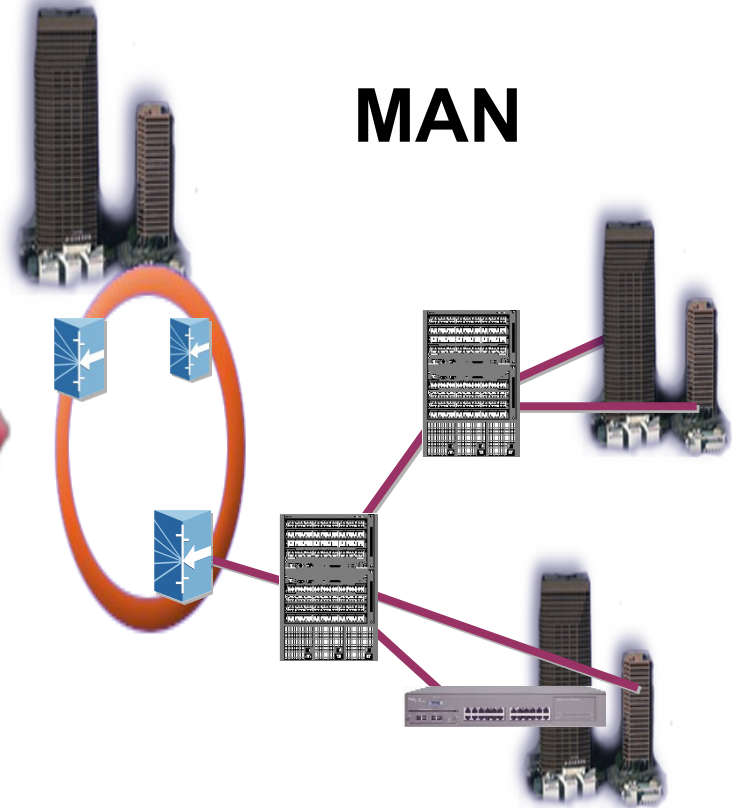


**Simple**

**O + E**

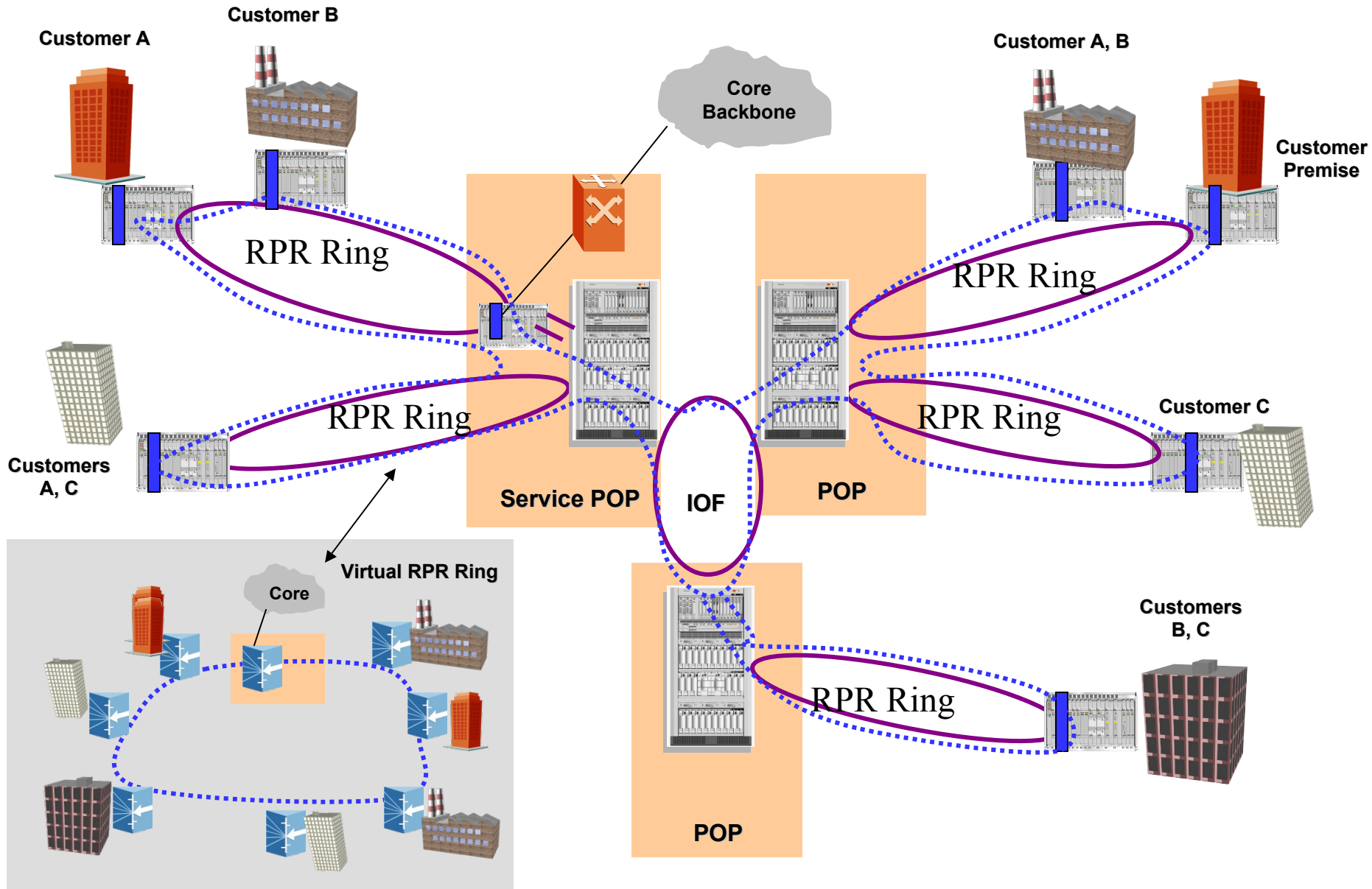
**Fast**

**MAN**



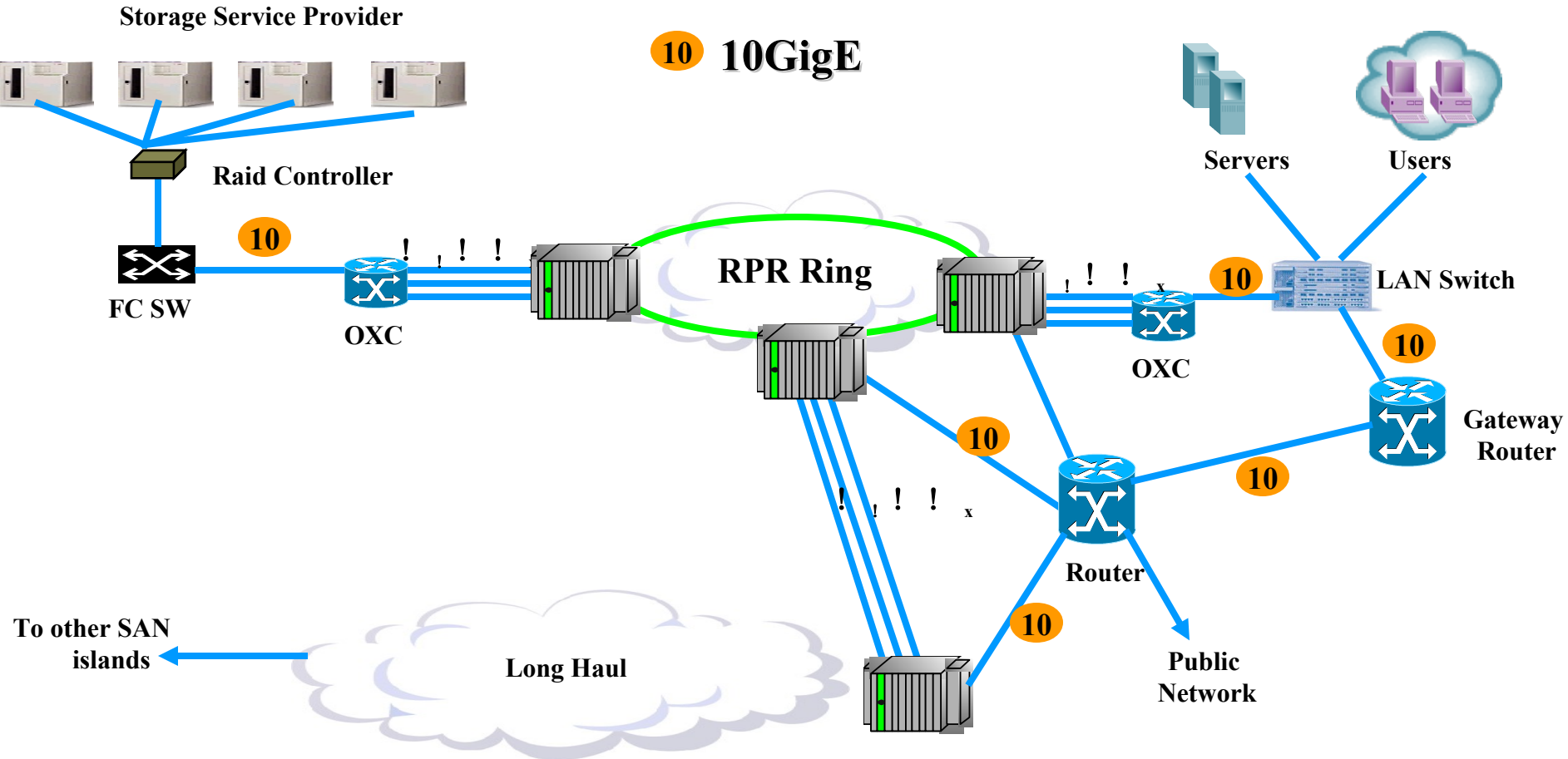
**Reliable**

# Scenario 1: City Network





# Scenario 2: Storage Area Network (SAN)



# Smart Bandwidth

## **Bandwidth on Demand**

- Schedulable bandwidth provisioning
- Tunable bandwidth allocation
- Dynamic optical links and wavelength establishment

## **Load Balance**

- Bandwidth fairness
- Traffic re-route

## **Use differentiation**

- Traffic: sources and destinations
- User: how much you pay, privilege
- Application: medical, science computing
- Content: video streaming, 3D games

## **Base Technologies**

- OE: RPR, 10GigE
- ASON
- MPLS/GMPLS
- Content networking

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# Flexible VPN

## Various needs

- L1: Optical VPN
- L2: Ethernet 802.1Q VLAN
- L2: Ethernet Transparent LAN
- L2+: MPLS-based VPN
- L3: IP VPN
- L4+: Content VPN

## Intelligent Control

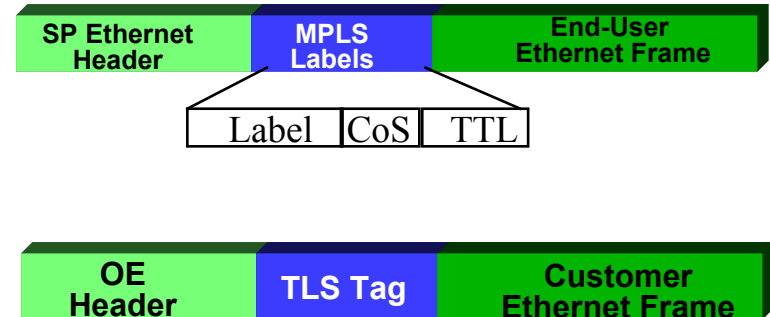
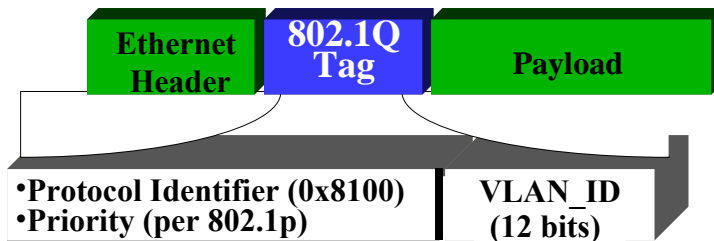
- VPN on demand
- Dynamic join/drop
- Route adjustment

## Use differentiation

- Enterprise: SBC, Sprint, AOL
- User group: discussion
- App content: games, video conference

## Base technologies

- ASON
- Ethernet
- MPLS/GMPLS
- IPVPN
- Content networking



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# Coordination of Network Controls

## Mapping

IP2OE: IP control to Optical Ethernet control

OE2M: Optical Ethernet control to MPLS control

NCIM: network interface mapping

- UNI
- NNI

## Use differentiation

Network providers: carriers

Service providers: ISP

## Base technologies

IP

ASON

Ethernet

MPLS/GMPLS



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# QoS (Quality of Service)

## Mechanisms

- L1: wavelength protection
- L2: Ethernet CoS
  - IEEE 801.p priority levels
- L2+: MPLS CoS
- L3: IP QoS
  - **Diffserv**
  - **Intserv**

## Use differentiation

Network providers: carriers  
Service providers: ISP  
Applications  
Content

## Base technologies

IP Intserv and Diffserv  
ASON  
Ethernet  
MPLS/GMPLS

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# Agenda

**Optical Networking**

**Challenges**

**Service Solutions**

**Killer Applications**

**Summary**

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# Large-volume Data Exchange

**Optical SAN**

**Backup on demand**

**Disaster Recovery**

Fast route to restore data after the disaster

Alternate routes to bypass the network in a disaster

# Content Networking

## Content enabling extensions

Content VPN

Content Caching

Content Multicasting

## Application scenarios

Video teleconferencing

Video on demand

Streaming media

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# Distributed Server Groups

## Servers grouped in the Internet

In SAN, data storage servers

In Web, HTTP servers

In Media, A/V media streaming servers

In Grid, super computing servers

## Application scenarios

Global Load Balance

- **Server load fair distributions**

Grid Computing

- **Media treatment: CT diagnoses**
- **CAD: fighter concurrent design**

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# Agenda

**Optical Networking**

**Challenges**

**Service Solutions**

**Killer Applications**

**Summary**

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# Summary

**Optical transport brings abundant bandwidth**

**Efficient use of bandwidth becomes crucial**

**Network Services enable**

Use network flexibly and transparently

Add customized intelligence

**Killer Applications might be OVPN or any other dynamic bandwidth provisioning**

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# Backup

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# Resilient Packet Ring (RPR)

## A winning combination

"SONET/DWDM" + Ethernet

## Ring MAC Protocol

Packet Add/Drop/Pass

Efficient Multicast/Broadcast

## Effective Use of Bandwidth

Spatial re-use

## Ring Protection

Fast and reliable layer 2 protection

## Topology Discovery

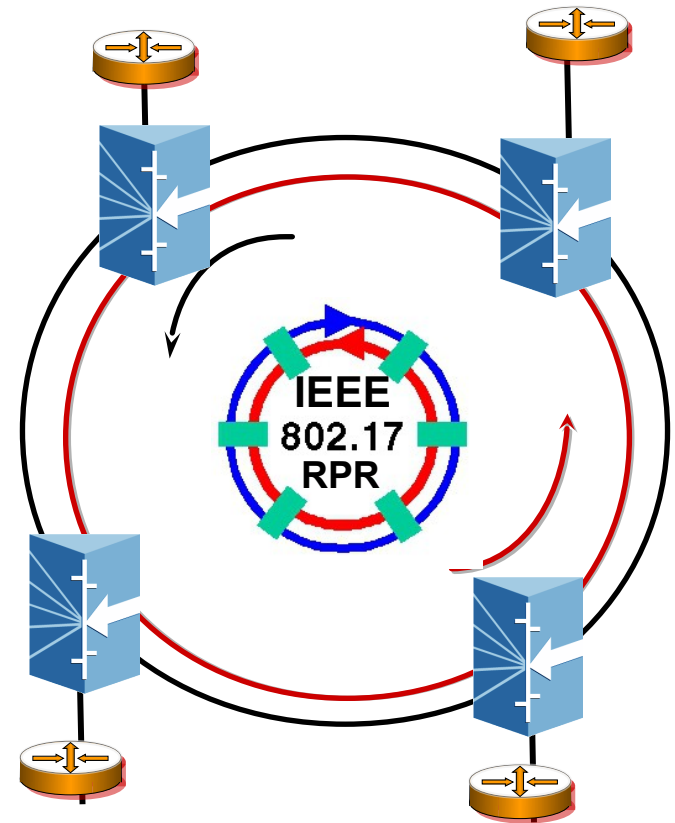
Connectionless route discovery

## Control Access Protocol

Ensures fair access to ring BW

## Class of Service

IEEE 802.1p



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# 10 Gigabit Ethernet (10-GigE)

An immediate extension of GigE from LAN to LAN and WAN

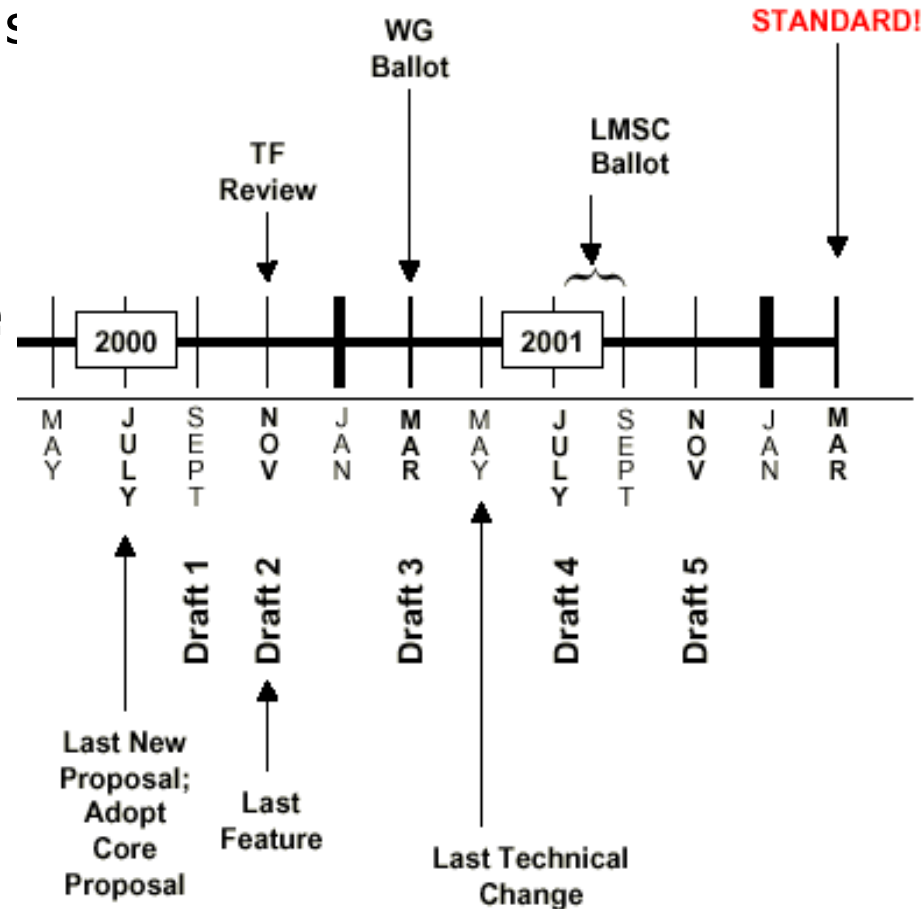
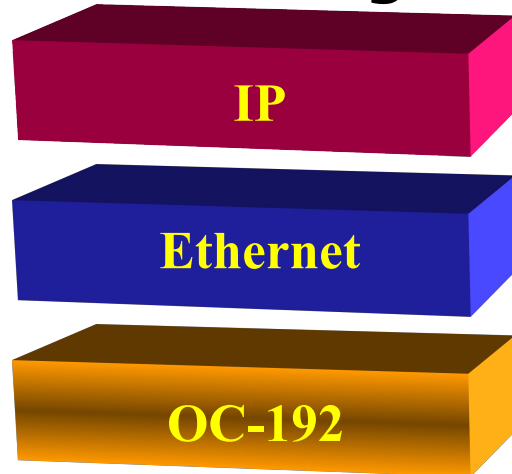
Same Ethernet MAC protocol

Same frame format with the s

Fiber-only

**IEEE 802.3ae Standard**

**10GEA: 10 GigE Alliance**



# MPLS and Long-range VPNs

- MPLS/GMPLS is the emerging switching protocol in optical core networks
- Long-range VPNs can be established by MPLS labels

