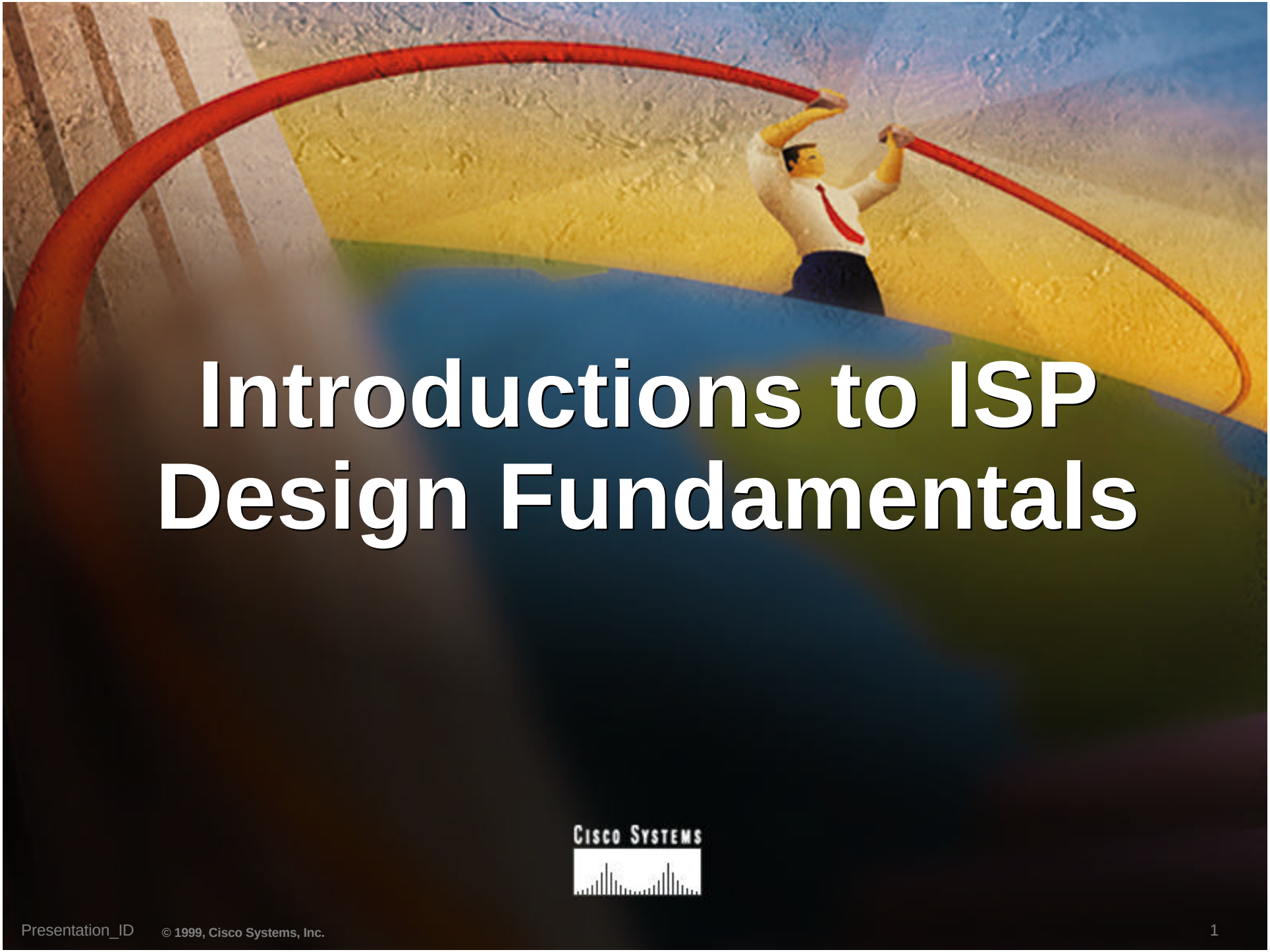
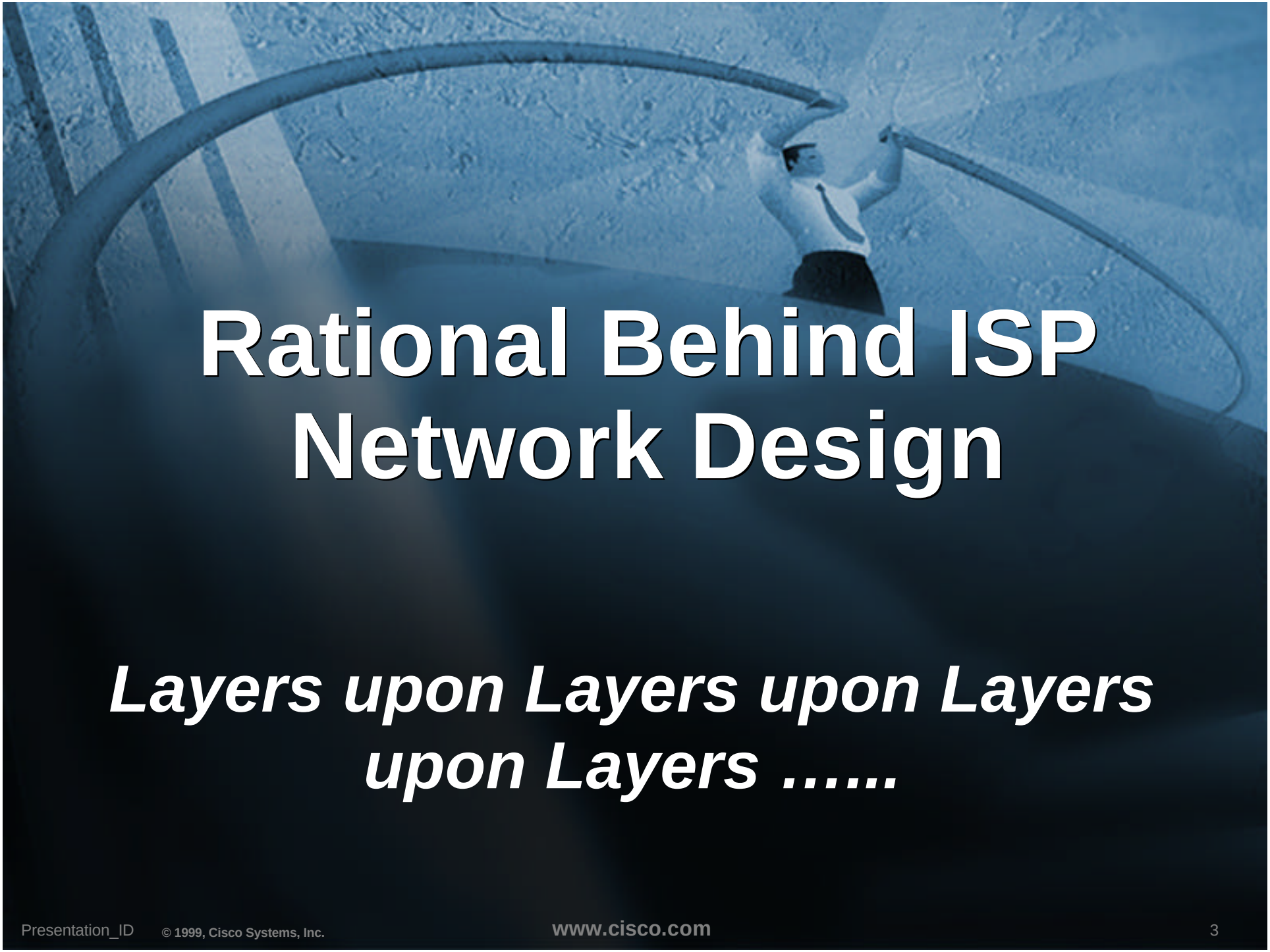


# Introductions to ISP Design Fundamentals

Cisco Systems

# Agenda

- Rational Behind ISP Network Design
- Point of Presence Topologies
- Adding Services to the Architecture
- Impact of Services on the Network



# Rational Behind ISP Network Design

***Layers upon Layers upon Layers upon Layers ……***

# The Free On-line Dictionary of Computing

**Architecture:** Design; the way components fit together; it may also be used for any complex system, e.g. “software architecture”, “network architecture”

# Network Design and Architecture…

- … can be critical
- … can contribute to the success of the network
- … can contribute to the failure of the network

# Ferguson's Law of Engineering

"No amount of magic knobs will save a sloppily designed network"

**Paul Ferguson—Consulting Engineer, Cisco Systems**

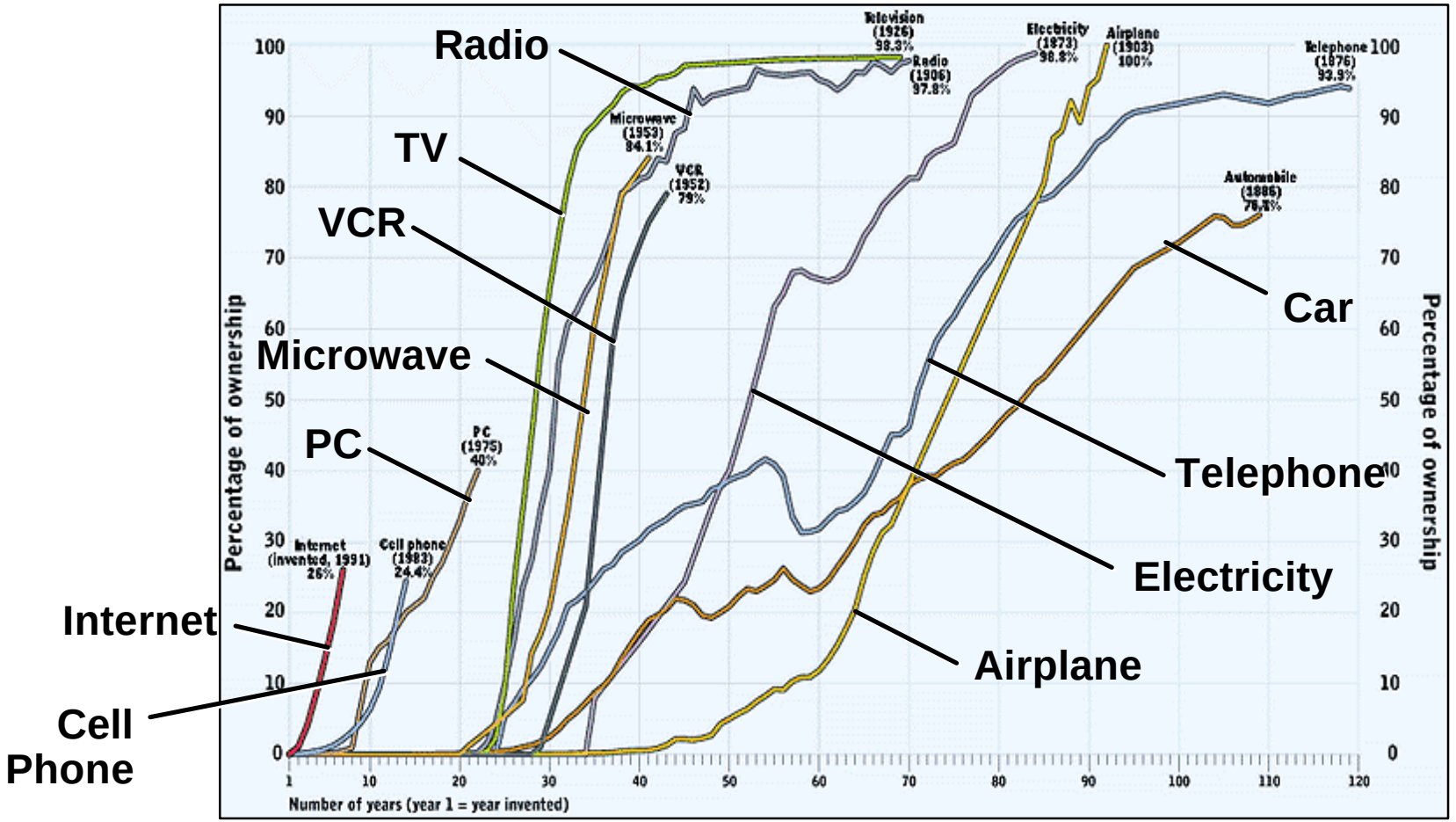
# What Is a Well-Designed Network?

- **One that takes into consideration some main factors**
  - ✓ **Topological/protocol hierarchy**
  - ✓ **Redundancy**
  - ✓ **Addressing aggregation (IGP and BGP)**
  - ✓ **Scaling**
  - ✓ **Policy implementation (core/edge)**
  - ✓ **Management/maintenance/operations**
  - ✓ **Cost**

# One Must Acknowledge that…

- **Two different worlds exist**
  - ✓ **One world revolves around private organizational networks and another concerns the global Internet**
- **Growth in the Internet is faster than any other technology introduced to the public-at-large**

# Technology Adoption



# Scaling is the #1 Problem on the Internet

***If you're not scared yet, you don't understand the problem!***

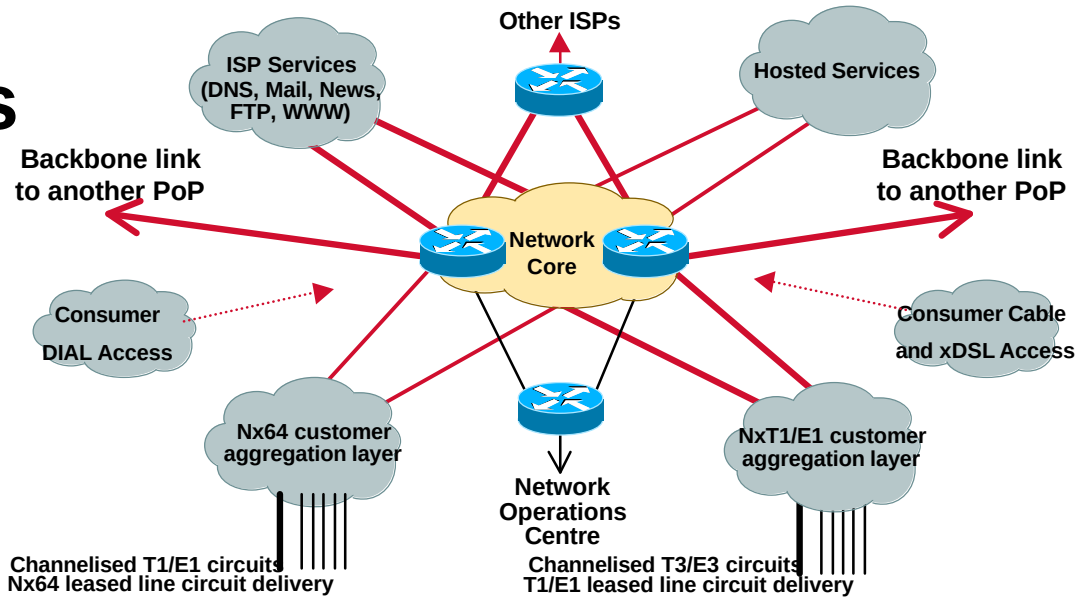
# Core Influences to ISP Design

- **Modular Design**
- **Functional Design**
- **Tiered/Hierarchical Design**
- **Multiple Levels of Redundancy**
- **Routing Protocol Hierarchy**
- **Build for IP Forwarding First - then add services**

# Modular Design

## Organize the Network into separate and repeatable modules

- ✓ Backbone
- ✓ POP
- ✓ Hosting Services
- ✓ ISP Services
- ✓ Support/NOC

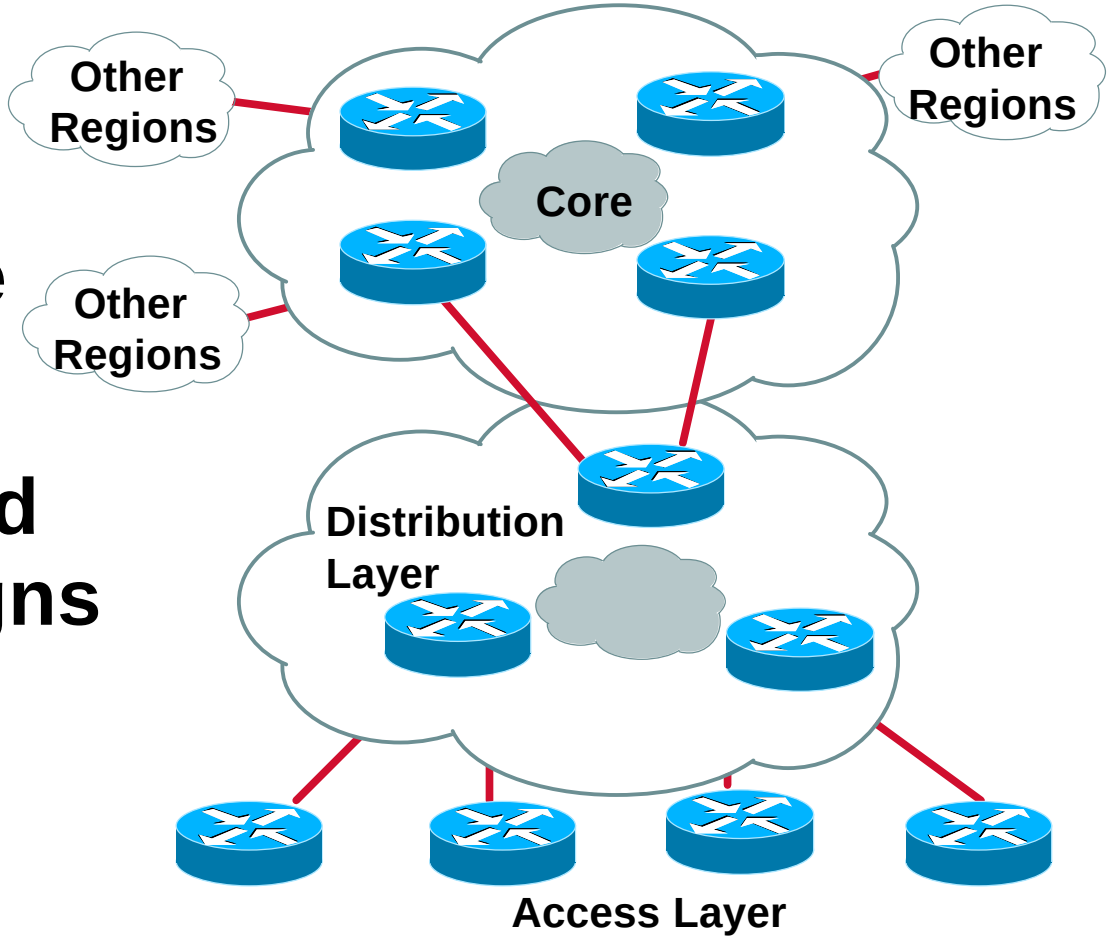


# Functional Design

- **One *Box* cannot do everything!** (no mater how hard people have tried in the past)
- **Each router/switch in a network has a well-defined set of functions.**
- **The various *boxes* each with a function interact with each other.**
- **ISP Networks are a *systems* approach to design.**

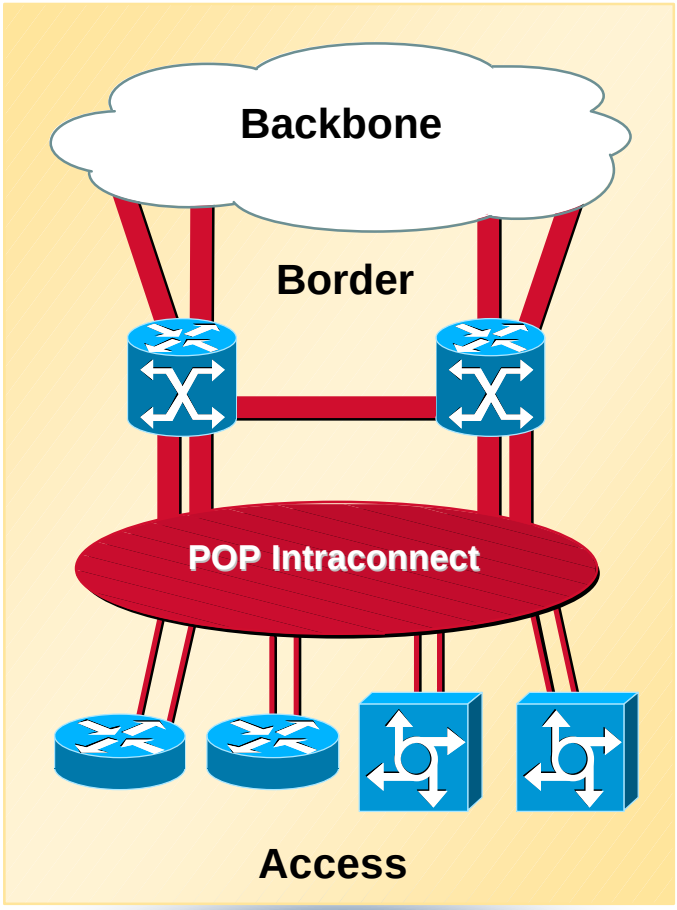
# Tiered/Hierarchical Network Design

- **Flat - Meshed Topologies have not scaled.**
- **Hierarchy is used in network designs to scale the network.**



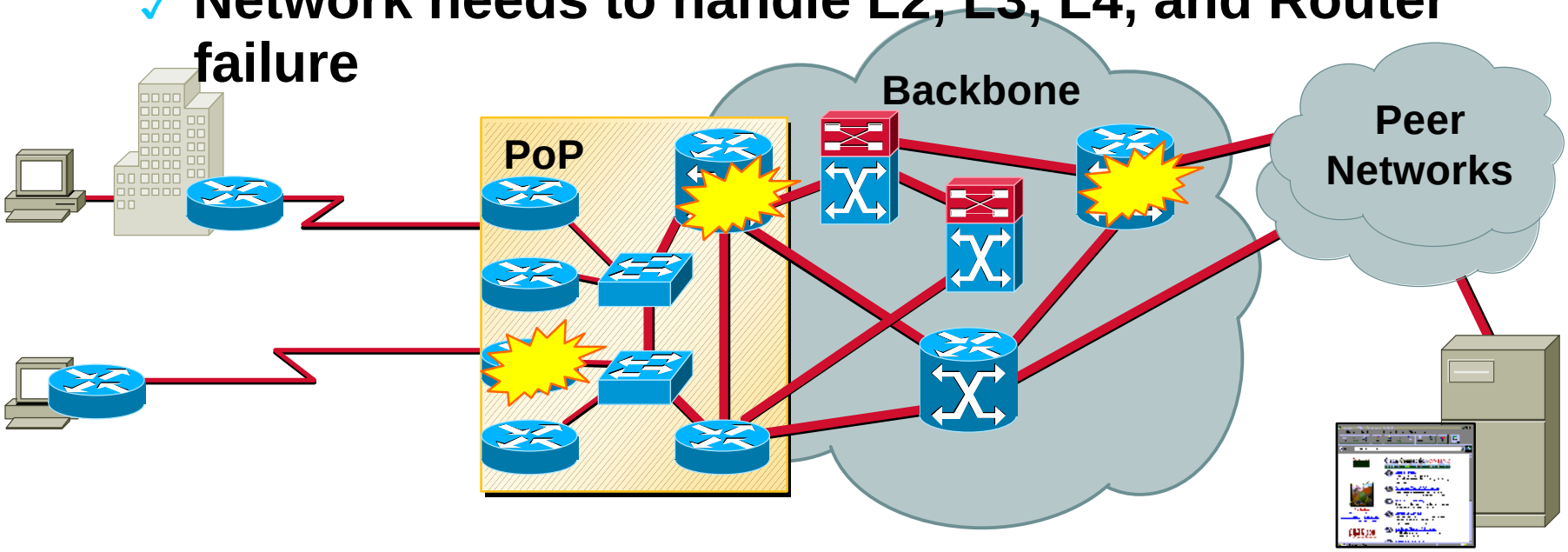
# Multiple Levels of Redundancy

- **Triple Layered POP Redundancy**
  - ✓ **Lower-level failures are better**
  - ✓ **Lower-level failures may trigger higher-level failures**
  - ✓ **L2: Two of everything at**
  - ✓ **L3: IGP and BGP provide redundancy and load balancing**
  - ✓ **L4: TCP re-transmissions recovers during the fail-over**

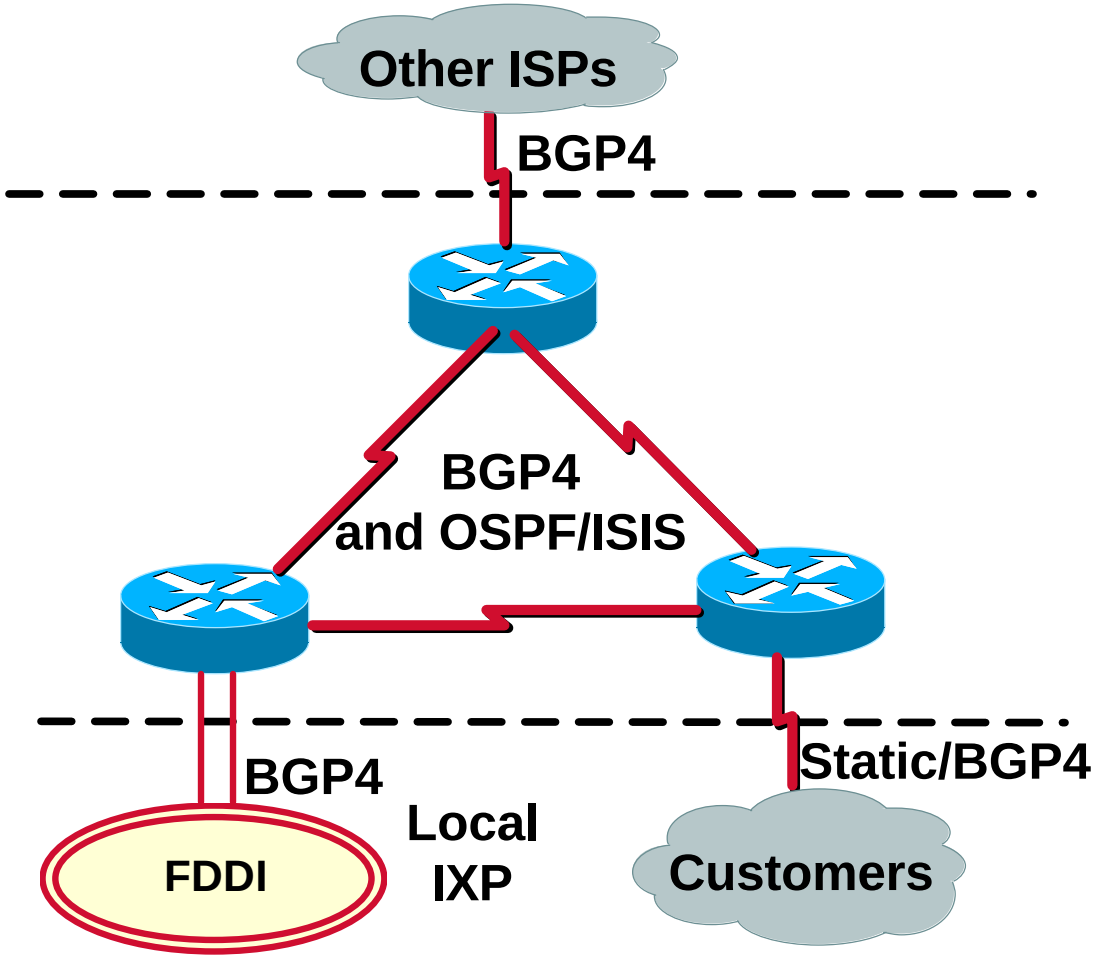


# Multiple Levels of Redundancy

- **Objectives -**
  - ✓ **As little user visibility of a fault as possible**
  - ✓ **Minimize the impact of any fault in any part of the network.**
  - ✓ **Network needs to handle L2, L3, L4, and Router failure**

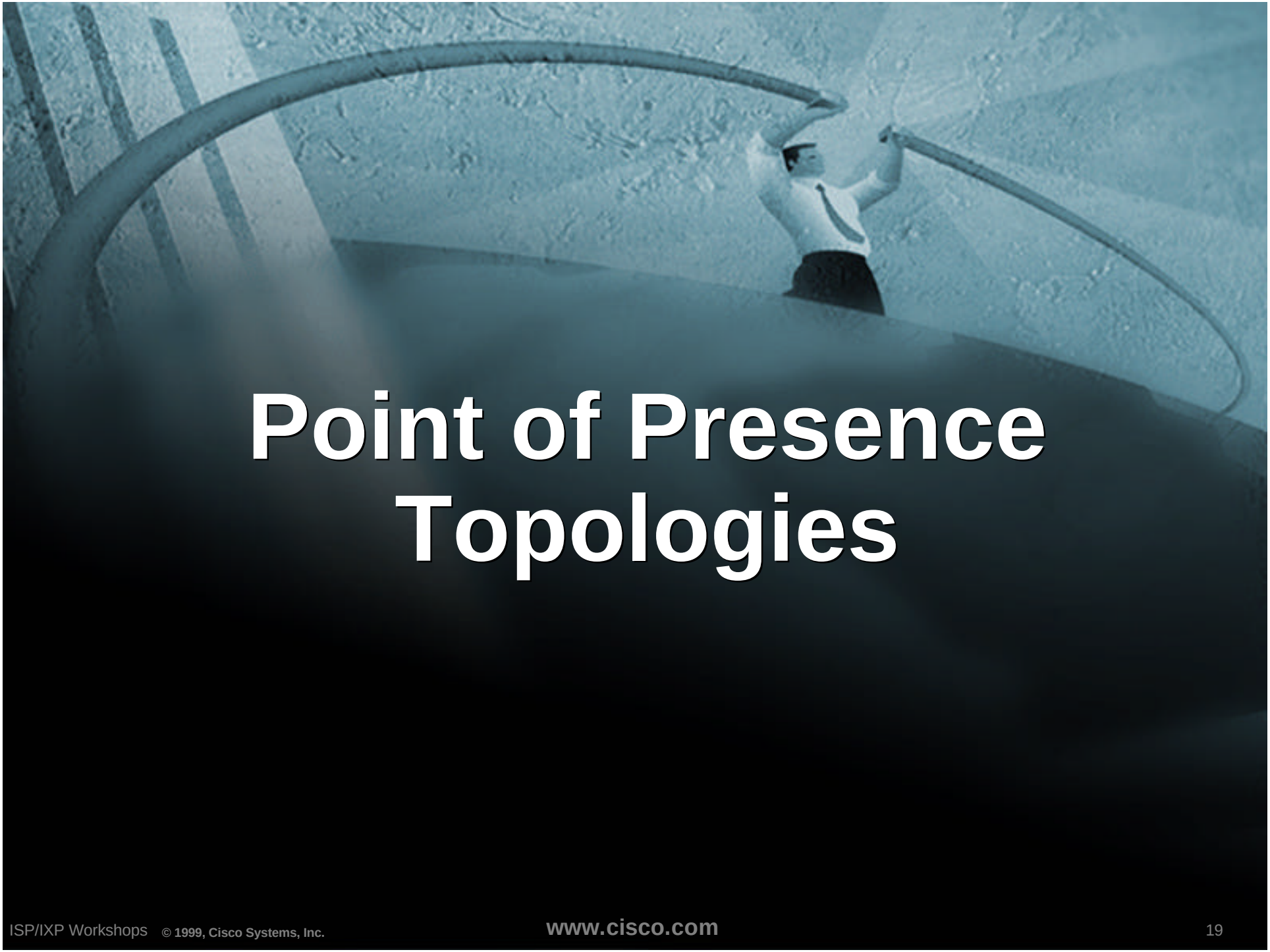


# Hierarchy of Routing Protocols



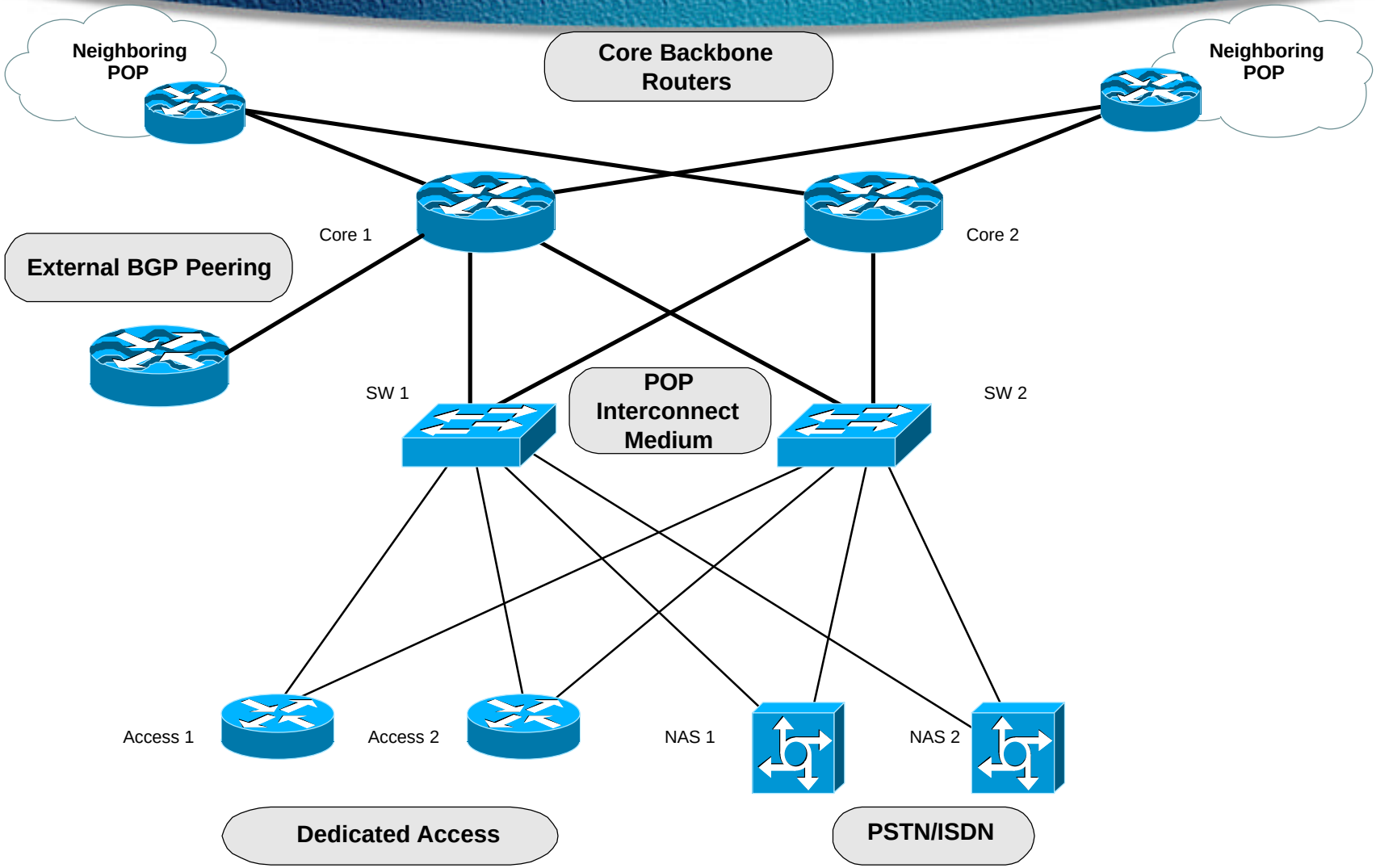
# Warning

**Beware Block Diagram/Slideware *Design Gurus!* They have gotten people and networks into trouble - including Cisco**



# Point of Presence Topologies

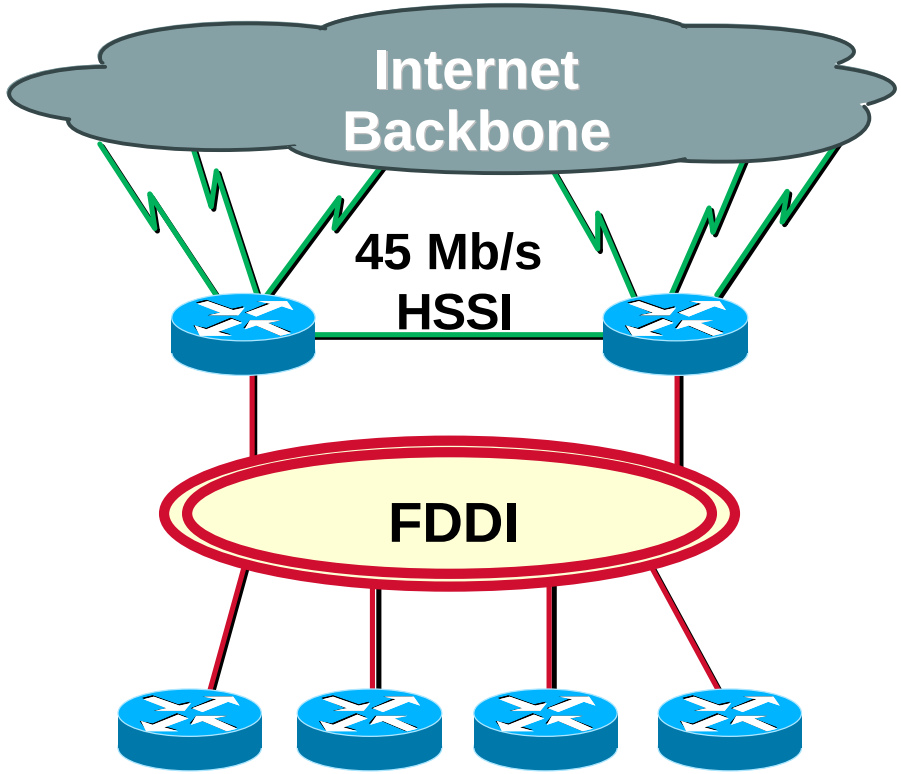
# PoP Design



# Early Internet POP Architecture - NSP

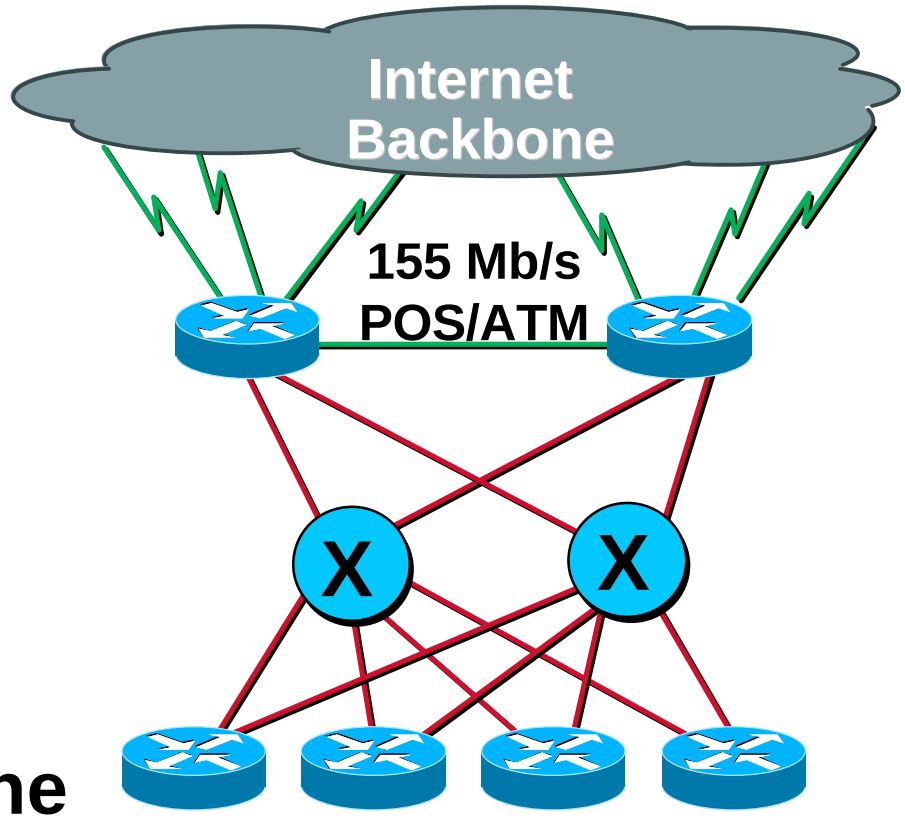
- ✓ Backbone trunks at 45 Mb/s
- ✓ Shared media interconnect within POP:

  FDDI, Ethernet, Switched Ethernet
- ✓ Conventional T3 backbone Internet router



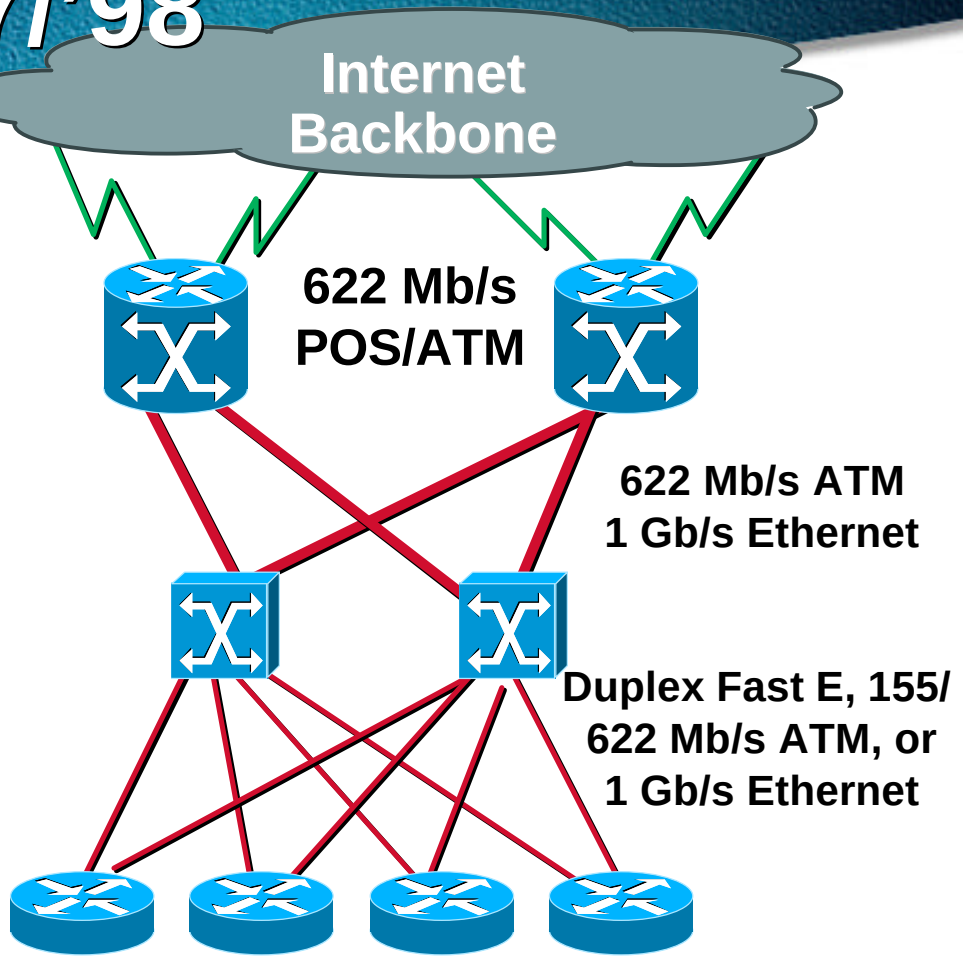
# Internet POP Architecture - '96/'97

- ✓ **Backbone trunks at 155 Mb/s**
  - **Packet over SONET OC3**
  - **ATM OC3**
- ✓ **Switched interconnect within POP:**
  - **Switched FDDI/Fast Ethernet**
  - **ATM OC3**
- ✓ **Advanced OC3 backbone Internet router**



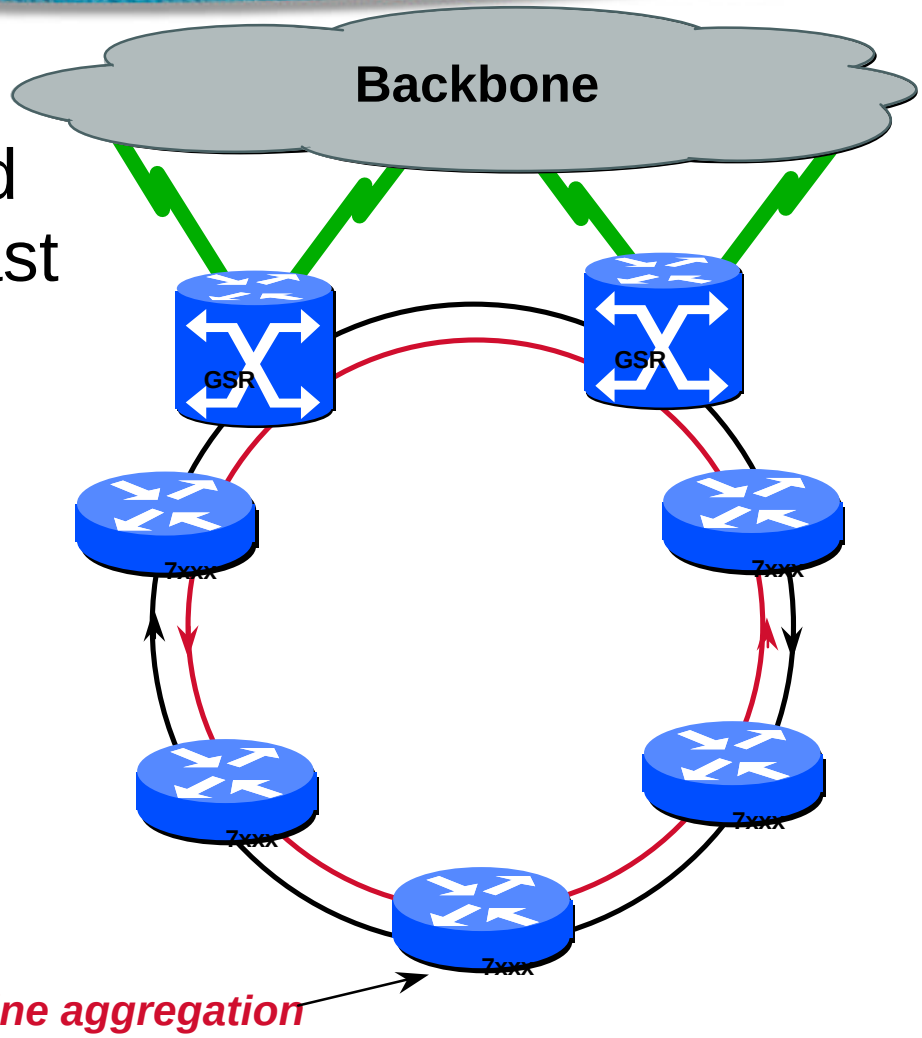
# Internet POP Architecture - '97/'98

- **Backbone trunks at 622 Mb/s**
  - Packet over SONET OC12
  - ATM OC12
- **Switched interconnect within POP:**
  - ATM at OC3 AND OC12
  - Ethernet Channel
  - Gigabit Ethernet (early '98)
  - POSIP (late '98)
- **Gigabit OC12 backbone Internet router**



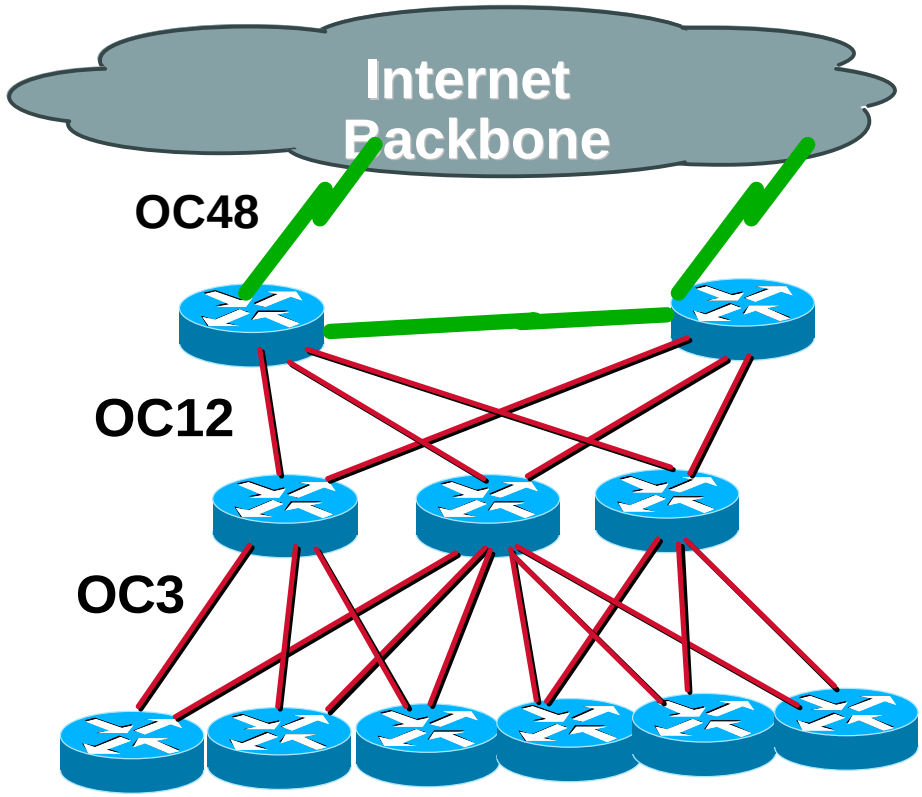
# Internet POP Architecture - '99/'01

- **SRP Rings -** High Speed of SDH combined with fast failover and redundancy
  - ✓ High bandwidth
  - ✓ Reduced port counts
  - ✓ Reduced complexity
  - ✓ Proactive self healing

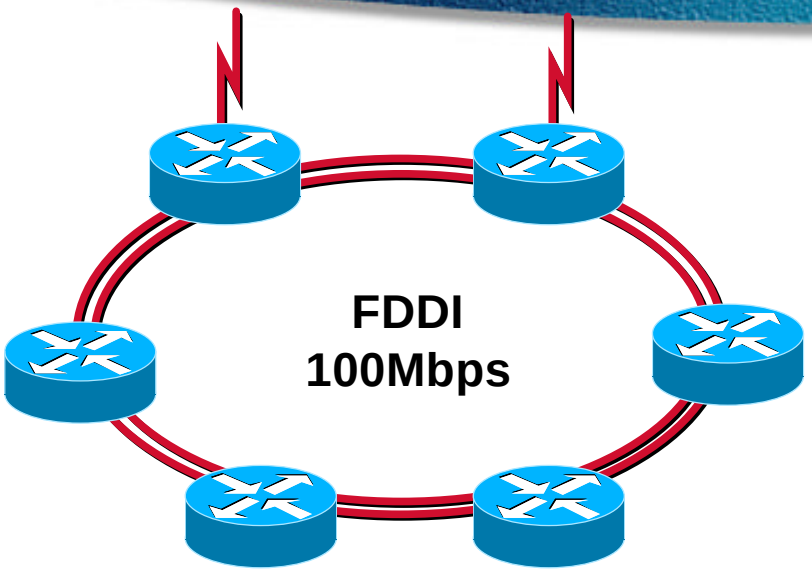


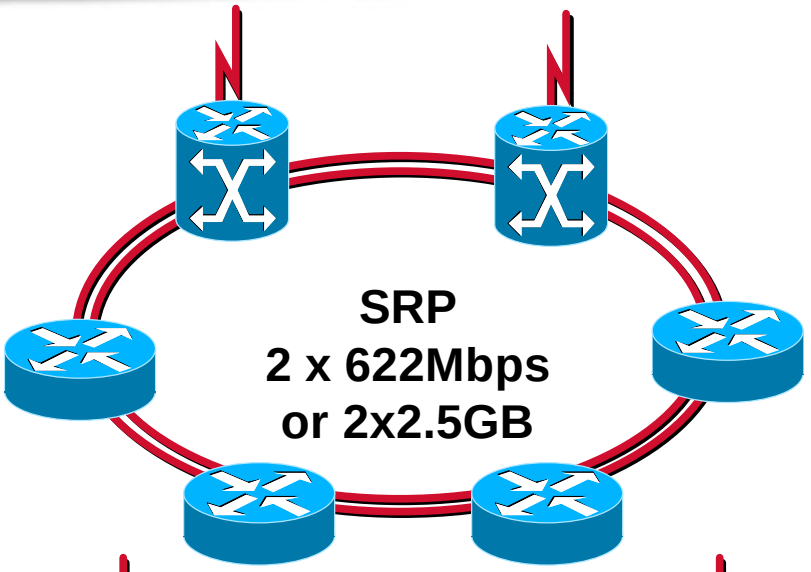
# Large POPs - add a 3rd layer

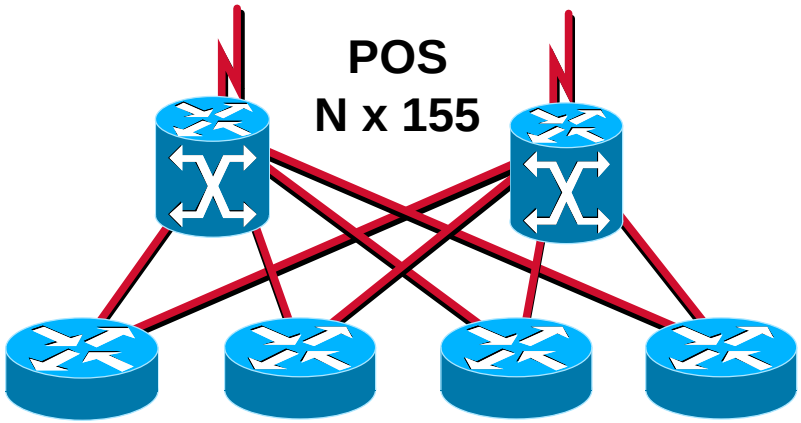
- ✓ Problem: port density!
- ✓ Solution: buy more routers!
- ✓ Customer routers connect to aggregation routers
  - Packet over SONET OC3
  - ATM OC3
- ✓ Aggregation routers connect to backbone routers
- ✓ Scales nicely
- ✓ X CRs to Y ARs to Z BRs
  - ✓ ...where X>Y>Z
  - ✓ Be careful not to oversubscribe!

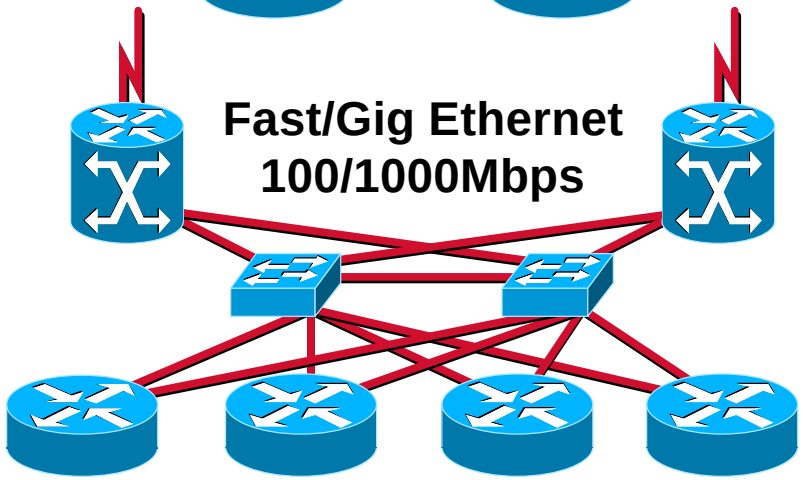


# POP Interconnect Summary



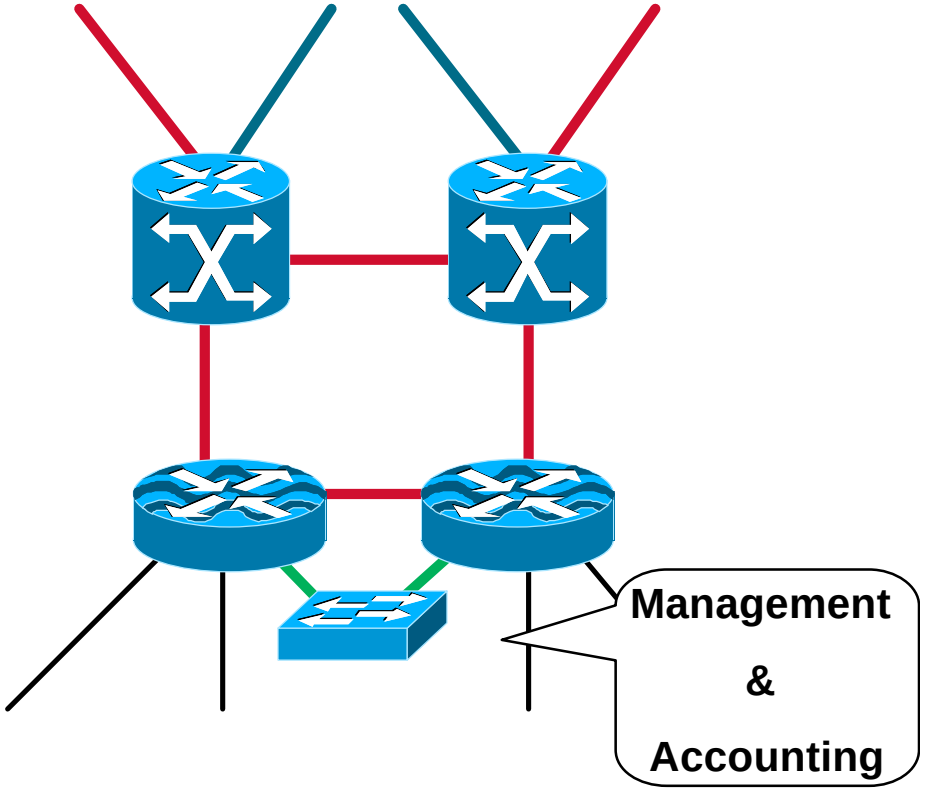



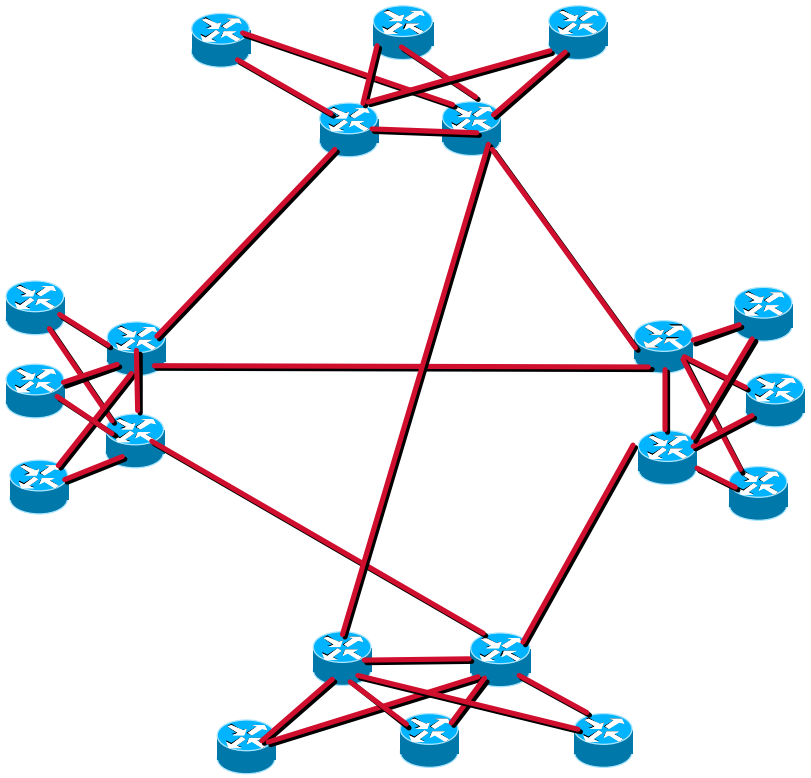
# Key Design Principles

- **Interconnection for Management, Security, and Accounting services**
  - ✓ Netflow Devices - FlowCollector
  - ✓ Syslog collector for all network devices
  - ✓ SNMP collector (PC Based UNIX)
  - ✓ Security Auditing Tools (NetSonar)



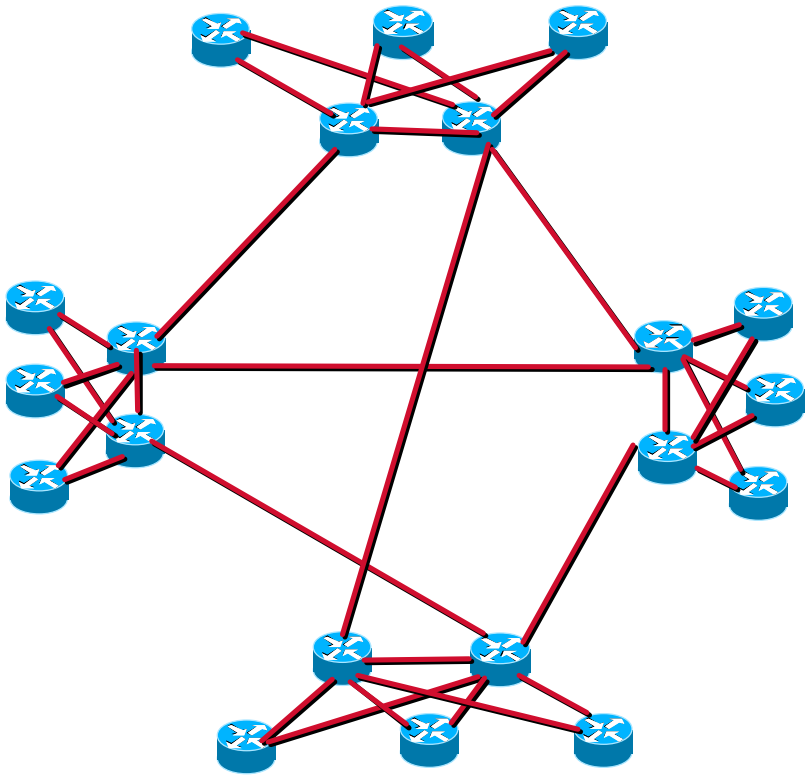
# ISP routing Architectures - IP

- IGP = EIGRP, IS-IS,or OSPF
  - ✓ *almost always* IS-IS or OSPF
  - ✓ IS-IS, single level (usually L2)
  - ✓ OSPF, either single area or BB/POP areas
- BGP = all routers in full mesh
  - ✓ mesh accomplished with route reflectors, confederations, actual full mesh
- All routers have all routes, so services could go anywhere



# ISP routing Architectures - IP+MPLS

- IGP = EIGRP, IS-IS,or OSPF
  - ✓ *must* be IS-IS or OSPF to use MPLS TE
- BGP = only edge routers need full routes
  - ✓ full-mesh of edge routers using aforementioned mechanisms
  - ✓ packets are forwarded via LDP labels, not IP destination address
- Where to put your services?
  - ✓ cannot hang a cache service off of a router that doesn't have full routes!



# Adding Services to the Architecture

## Cause and Effect

# Services?
# How many *Services*?

**Most network services are applied at the edge!**

**Edge (one-time) services**

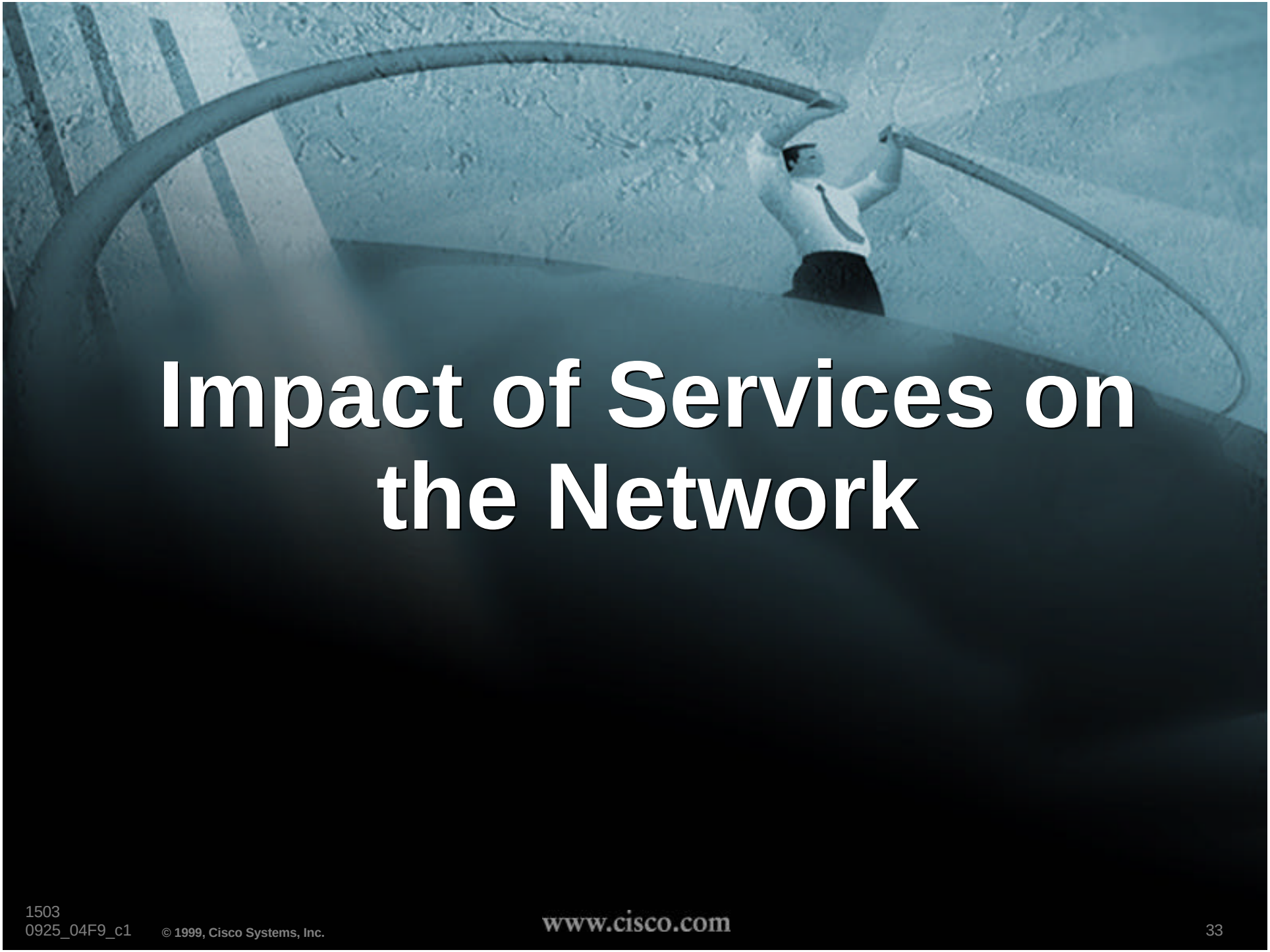
- **Voice over IP**
- **MPLS VPNs**
- **CDNs**
- **VPDNs**
- **Managed services**
- **Dial—DSL—cable**

**Per-hop services**

- **MPLS packet forwarding**
- **DiffServ, other QoS**
- **Multicast Services**

# Ask the Right Questions

- **What is the value of the service?**
  - ✓ **Technical merit**
  - ✓ **Cost savings**
  - ✓ **Marchitecture**
- **What is the cost of the service?**
  - ✓ **Equipment?**
  - ✓ **Training people to support it?**
  - ✓ **Network buildouts/topology changes?**



# Impact of Services on the Network

# Who Knows?

- **What will be the impact on existing traffic loads/patterns?**
- **Can the network deliver the performance that your customers/applications desire? delay? jitter (delay variation)?**
- **Make sure to add capacity as you add services - bandwidth is a must.**

# Deployment of New Services

- **Is more of a business decision**
- **The technical aspect is to ensure continued network performance—scalability and stability**
- **Try to keep services within your AS**
  - ✓ **end2end control**
  - ✓ **less likelihood of failure/flaps**

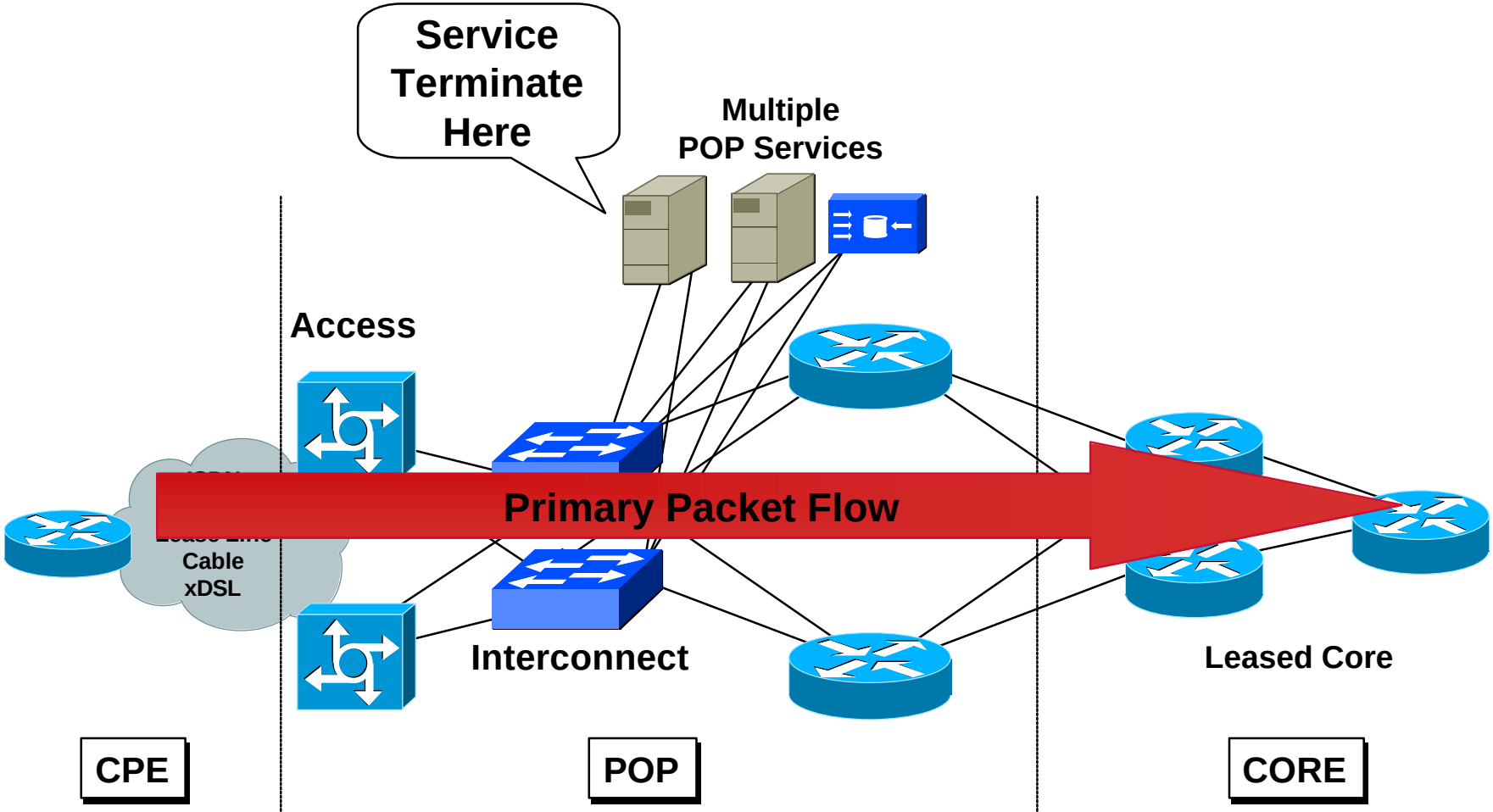
# Deploying New Services

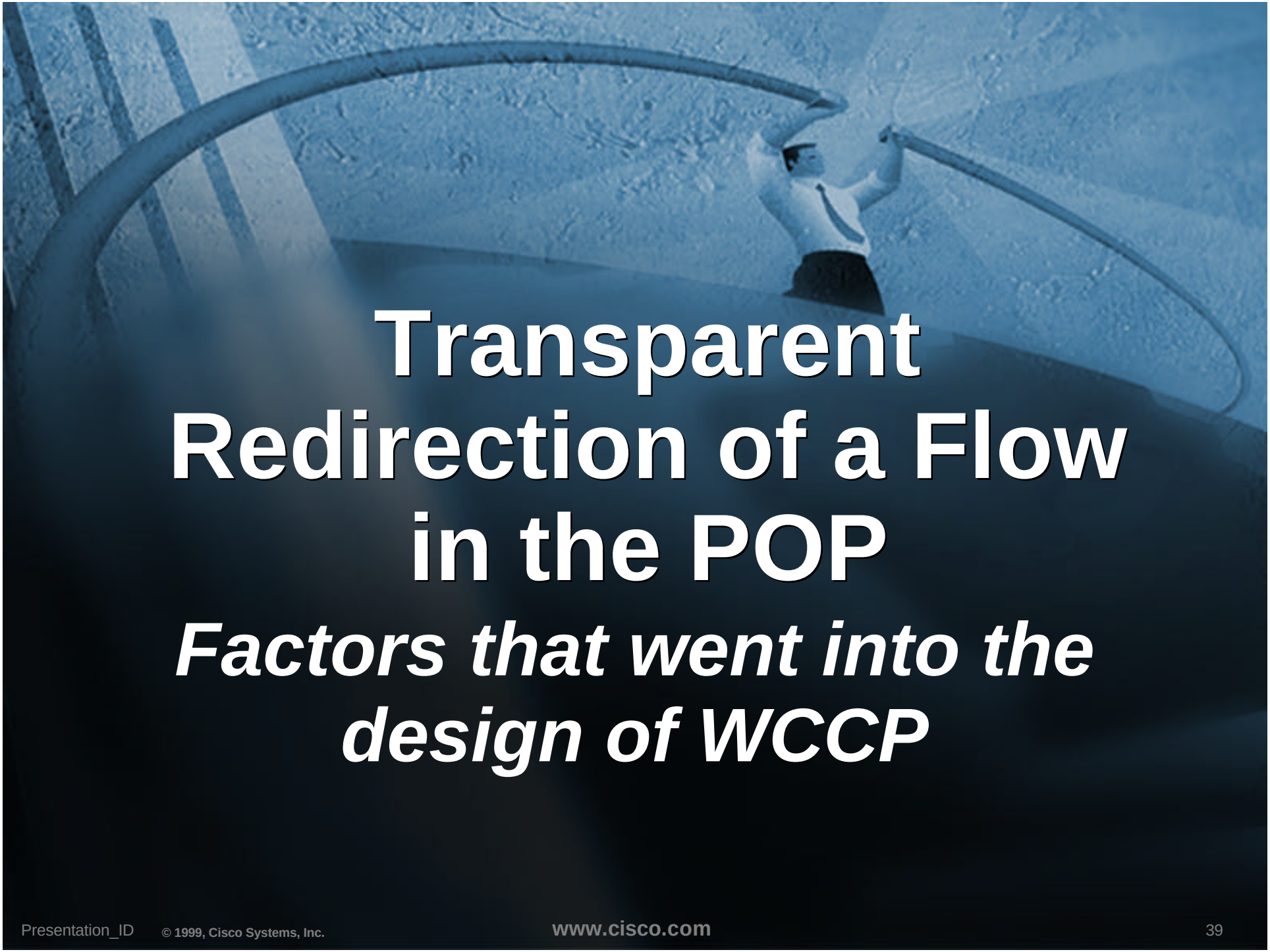
- **Don’t feed the hype fire**
- **Look *before* you leap!**
- **Don’t deploy new technologies and services just for the sake of it; have valid business and technical reasons**

# Deploying New Services

- **Usually a Service requires a TCP/UDP termination (I.e. TCP's three way handshake)**
- **Termination should happen out side of the *primary flow path***
- **Otherwise, the network is then designed around the single service.**

# Deploying New Services





# Transparent Redirection of a Flow in the POP

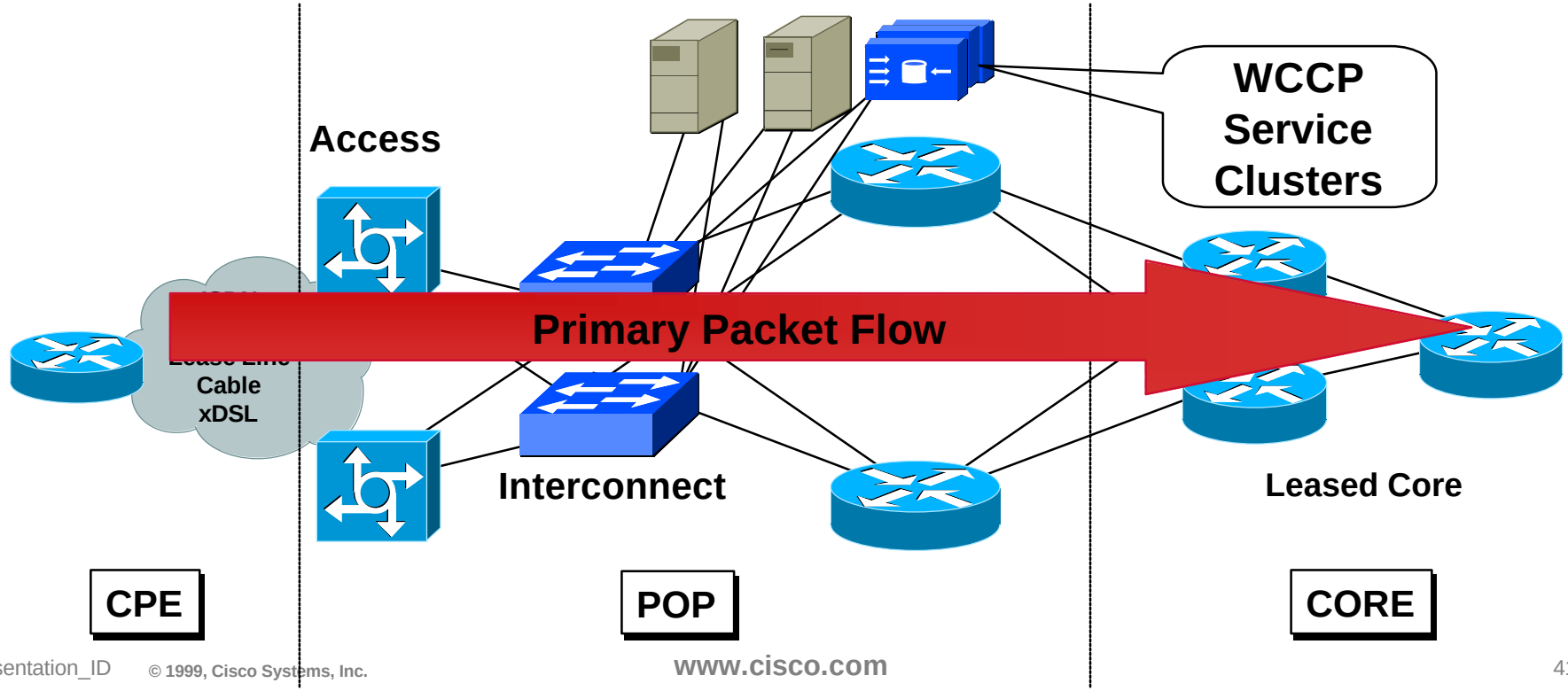
## *Factors that went into the design of WCCP*

# Design Objectives for the ISP

- **Transparent *Redirection* of a IP flow based on source, destination, and/or port number.**
- **Transparent *Integration* - no rebuilding the POP to add this service.**
- **Failed open - if the service fails, it should not effect the core IP service nor any other services.**

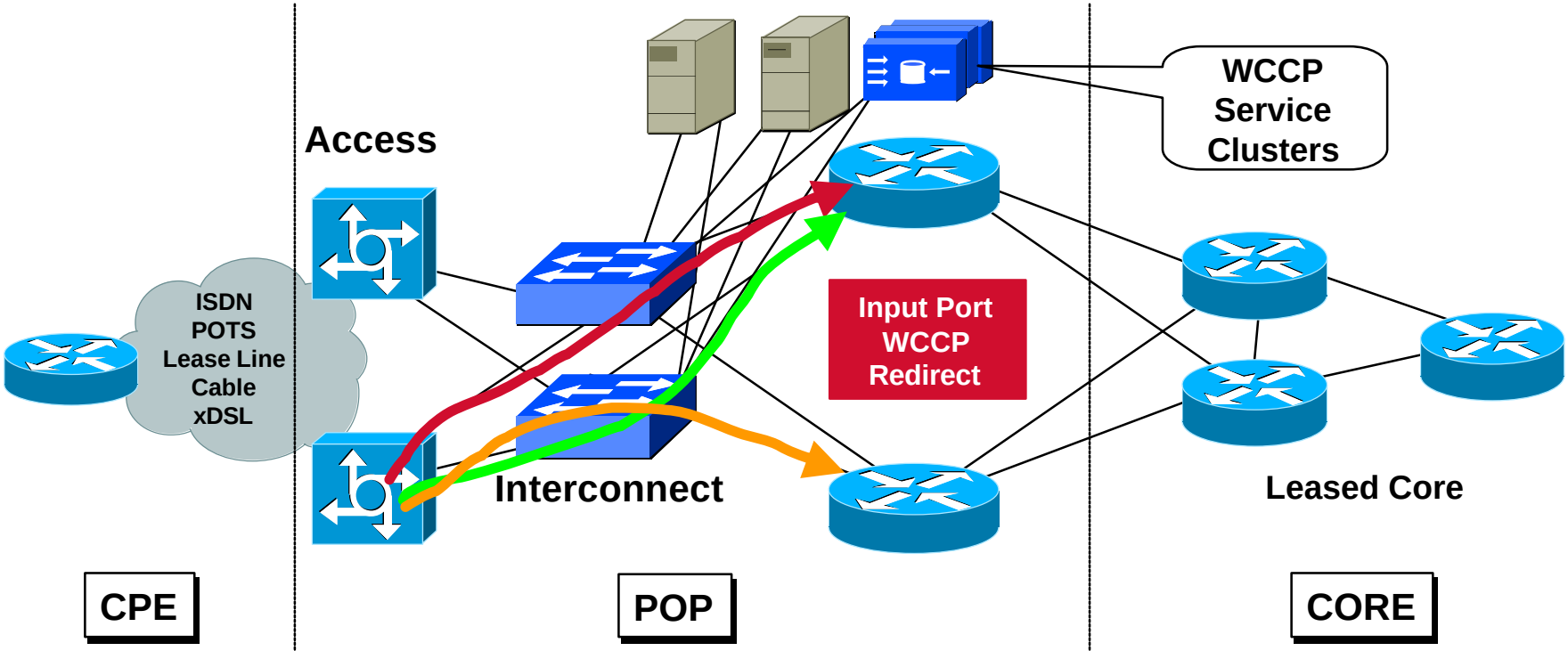
# Design Objectives for the ISP

- **Not to effect the primary packet flow of the POP - if not redirected - then is CEF/dCEF Switched!**



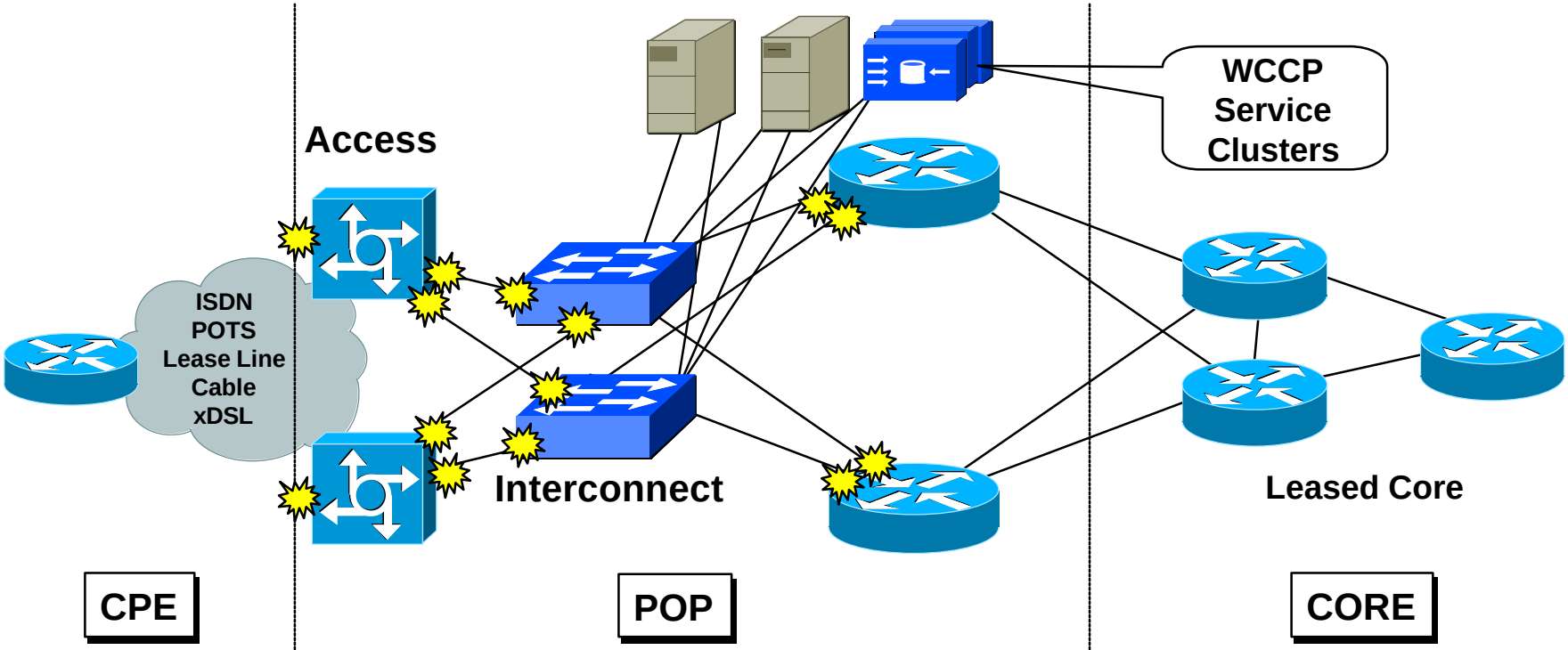
# Design Objectives for the ISP

- **Work with the multi-level L2/L3 redundancy of the ISP POP. Equal paths in the IGP + CEF leads packet asymmetry.**



# Design Objectives for the ISP

- **Provide the ISP with Flexibility on the point of redirection. Do not force an architecture on the customer.**



# Design Objectives for the Service Group

- **Linear Scalability with the Cache - minimize object replication.**
- **Fault Tolerance and Maintenance.**
- **“Joe Smith the Telco Tech” test.**