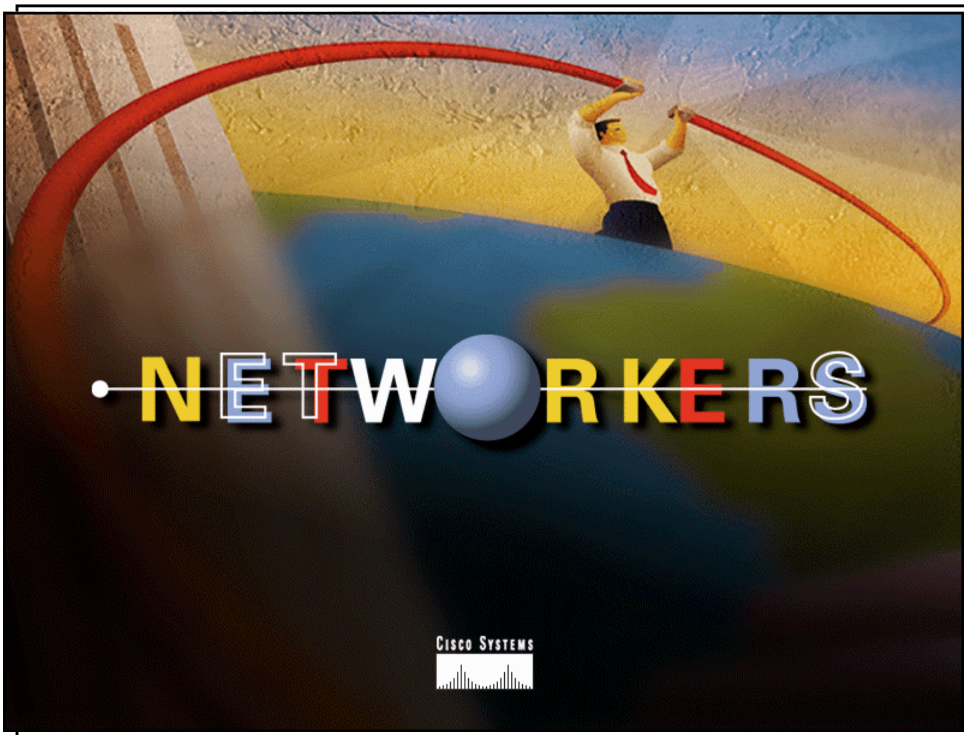
NETWORKERS
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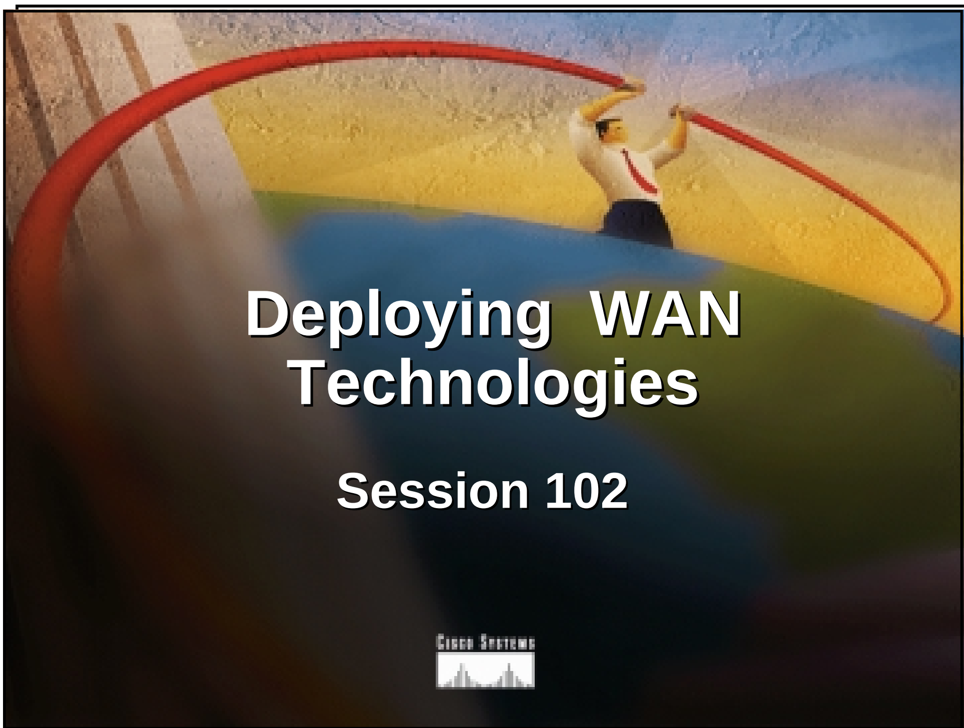
Deploying WAN Technologies
Session 102
Cisco Systems

Agenda

- Drivers, Costs, Planning,
- Requirements, Services, Transport Options
- Scalability, Availability, Reliability
- Enterprise WAN Network Architectures
- WAN Routing Methodologies
- Design and Performance
- Specific Implementations

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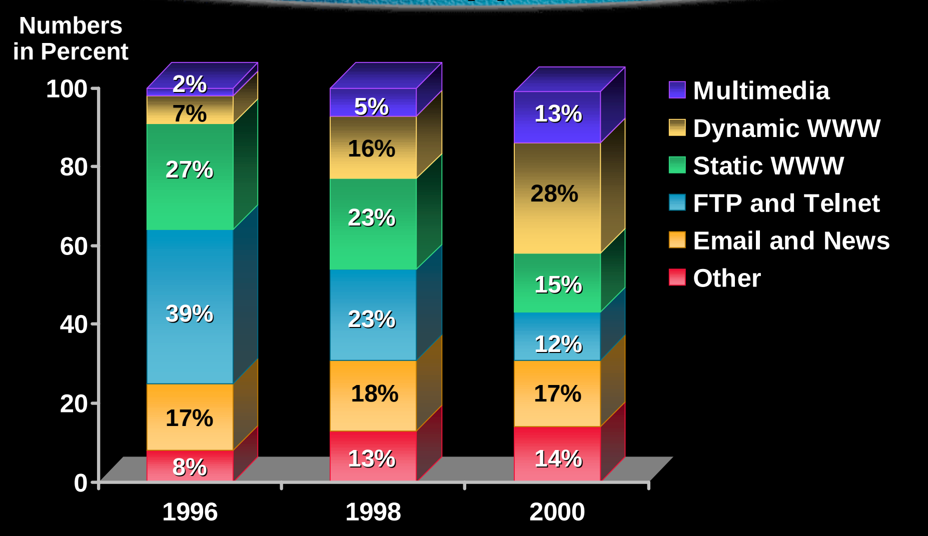
WAN Drivers: Bandwidth-Intensive Applications



Source: The Yankee Group, 1997

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WAN Drivers: New World Services

- Emerging Applications are IP centric (mobile remote access, etc.)
- Consolidation of multiservice applications requires a minimum set of protocols
- Performance and QoS guarantees are appearing as part of IP feature set
- MPLS in the core enables robust service offering over current Layer 2 infrastructures
- IP-VPN enables privacy/security, low cost and minimal management

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Initial Dilemma—Own or Outsource

Control Meter

Solution

- Own the WAN infrastructure
- Lease bandwidth, own facilities and equipment
- Lease a WAN VPN service (Frame Relay or IP)
- Outsource the total solution to the desktop

Issues

- Network Control
- Price
- Recurring Costs
- Flexibility
- Availability
- And…

CONTROL

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Costs and Core Business Issue

- Simple but effective cost benefit analysis: How important is the network to your core business?
- If your network goes away, can you still:

  Function?

  Compete?

  Survive?

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Cost Elements

- Equipment including DSU CSU
- Installation costs
- Rack space, wiring closet, DSLAM, etc.
- Operation, administration, monitoring
- Transmission
- Maintenance and upgrades
- Continued capacity planning
- Personnel—organizational/training

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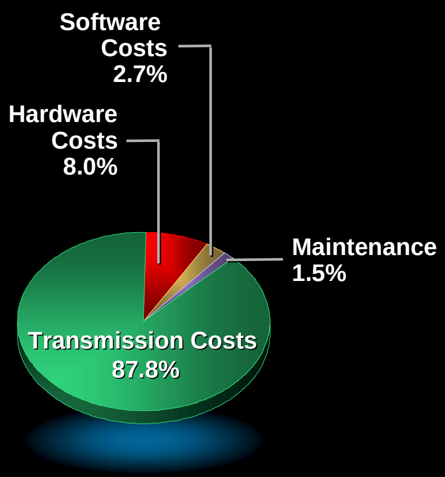
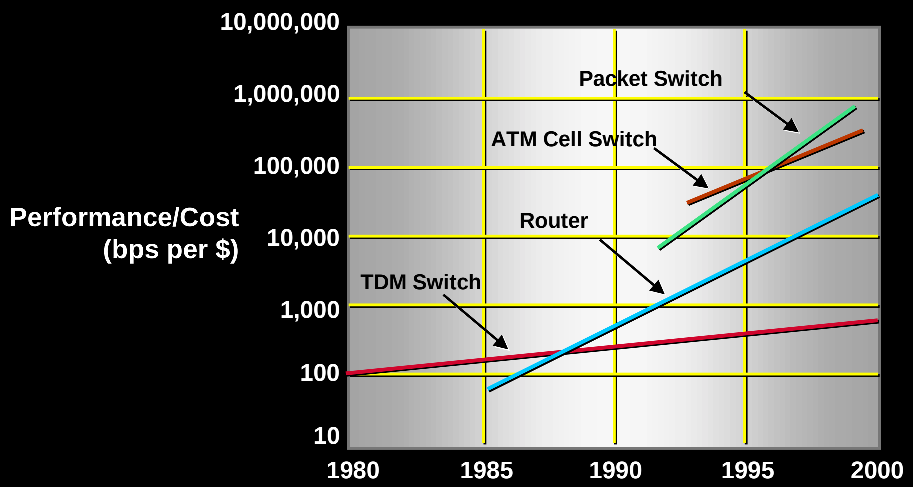
Cost Breakdown

- Capital costs (hardware)—non-recurring
  - Written off over three to five years
- Operations and management costs—recurring
- Bandwidth rental costs—recurring
  - One to five year contracts
  - Penalties for cancellation
  - Highest month recurring expense



Source: Data Communications

Economics of Alternative Infrastructures



Source: Peter J. Sevcik, NCRI

Change Management

- Change is expensive

  Deploying a new network infrastructure always has heavy associated (hidden) costs

- Planning for new technologies

  Includes line speeds, training, ancillary equipment, maintenance

- Planning for new applications

  Mobile services, extranets, telecommuting, etc.

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Planning Check-List

- Business/application requirements
- Availability objectives
- Network resiliency
- Manageability, service levels and metrics
- Scalability objectives
- Performance objectives
- Cost-benefit analysis

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Pre-Deployment Planning Process

- Define and refine requirements
- Review product specifications
- Design with vendor: Review
- Test and validate in laboratory
- Pilot the solution
- Train support, maintenance, and operations personnel
- Deploy

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Potential Points of Failure

- Hardware fault
- Link failures
- Power failures
- Equipment capacity issues (CPU UTIL)
- Software quality issues
- Inadvertent changes (manual intervention)

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Enterprise Requirements: Cost vs. Control

Minimize Cost

- Use statistically shared WAN

  (Frame Relay, ATM)
- Link consolidation (data, voice, and video)
- Minimize equipment and labor needs

Maximize Control

- Quality of service for:

  Traffic prioritization

  Efficient use of bandwidth

  Congestion management
- Control security
- Ensure availability for end users

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Enterprise Requirements: Services and Sophistication

- Multiple service classes
- Multiple service options
  - ATM, FR, private IP, public IP
  - Multiple VPN options
- Lower cost managed services
- Any-to-any traffic
- Extranets, CUGs
- Seamless integration

At Lowest Cost

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Generic WAN Requirements

- Scalability
- Reliability
- Availability
- Flexibility
- Efficiency
- Longevity
- Manageability

- Priority depends on:
  - Core business
  - Implementation
  - Current service requirements
  - Past experience
  - Skill set of personnel
  - Cost, price, cost, and price

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Service Mix Determines Choice of WAN Technology

- Reality-most networks are a mixture of legacy and new technologies and will stay so
- Each end-user service requires a slightly different approach to WAN deployment strategies
- The challenge

  How to deploy the right technology for the required service mix and traffic profiles

  How to future proof this investment to remain competitive and cost effective

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What Services?

- Low speed/legacy data
- SNA (critical data applications)
- Voice and video
- IP applications

And What Are the Requirements to Support These Services?

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Legacy Data Service Requirements

- Bisync/async are still common branch access protocols—especially in EMEA, Latin America and Asia
- Legacy data requires low-speed access and TDM like QoS (SLA) for deterministic transport
- Low delay and low variability essential
- Appropriate interfaces (RS 232, 449) and appropriate access devices (V110 DTU, etc.)
- Cisco IGX can provide native interfaces (but not for small branch offices)
- IP not a valid option today

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SNA Service Requirements

- SNA requires some edge intelligence or a highly deterministic transport infrastructure
- Support for total SNA protocol suite (APPN, B-STUN, PU-PU flavors, bisync, etc.) has WAN implications
- Currently TDM or X.25 are the prime options—low-speed and error prone links
- SNA over Frame Relay/Frame Forwarding an option
- SNA over IP more common as link speeds and reliability improve and specialized router protocols (DLSw, APPN) and interfaces appear

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Voice Service Requirements

- Voice transport normally requires deterministic transport—but this is changing fast
- WAN technology of choice is TDM or ATM for CE, G711 PCM, and classical compression algorithms
- VOFR is well understood/applicable if deployed on private network—public FR = high delay/variability
- VTOA is well understood but AAL2 is not generic yet—AAL1 is too expensive to implement on most private networks
- VOIP has challenges—will be solved in the short to medium term but deployment will depend on usage model and cost-benefit of new infrastructure

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Voice Service Requirements

- QoS
- Low variability and delay
- Lowest possible bandwidth use
- Signaling integrity/seamless global interoperability
- Value-add functionality (call waiting, music on hold)
- Zero downtime in some business models

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IP Service Requirements Are "Agnostic"

- No specific WAN line speed requirement
- Ethernet physical media access on site
- Network knowledge base shifts to data centric (IT) personnel for "internal" network value add
- Any protocol across the WAN—but must understand implications of interworking
- Deployment/knowledge of routing protocols and address schema gain importance
- Different security and management considerations implicit in IP

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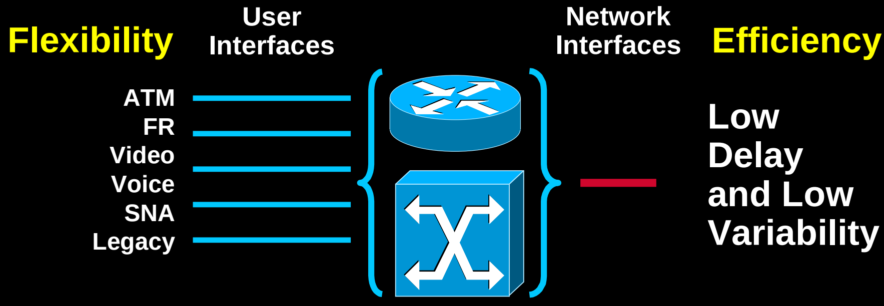
Services Delivery: Challenge for WAN Devices



Mission:
To Pack as Many Differentiated Services with Maximum Value Add Usage into Minimum Amounts of Trunk Bandwidth While Retaining the Highest QoS

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The WAN Transport Options

- X.25
- TDM
- ISDN
- Frame Relay
- ATM
- SONET

- Each has strengths
- ...and weaknesses
- Different services, markets and network deployments require different solutions

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X.25: Pros and Cons

- Excellent in highly error prone environments
- WAN protocol-independent
- Can guarantee delivery
- Unable to guarantee performance
- High delay and variability in delay
- Data only
- A technology in stasis

- Questions to ask:
- Do I have X.25-centric data applications—especially financial transactions?
- Do I have low-speed, low-quality lines?
- Is it the primary service offering?
- How do I migrate if and when I need to?

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TDM: Pros and Cons

- Predictable performance
- Protocol-independent
- Low- or high-speed links
- Inefficient/static bandwidth allocation
- A technology in decline

- Questions to ask:
- Do I have low-speed, legacy-data apps?
- Can I afford to waste bandwidth?
- Can I afford to trade off predictability against efficiency or flexibility?
- What voice quality service do I need?

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ISDN: Pros and Cons

- Predictable performance
- Protocol-independent
- For SOHO or back-up
- Complexity
- PRI or BRI service only
- Relatively expensive
- Static bandwidth
- Spotty availability
- What future?

- Questions to ask:
- Do I want to pay dial-up charges?
- Can I afford to give up flexibility?
- Do I want to invest in the necessary TA and infrastructure?

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Frame Relay: Pros and Cons

- Dynamic allocation of bandwidth
- Technology of choice for non-multiservice access lines
- Acquiring limited QoS
- Ubiquitous service offering
- Poor multiservice performance
- High delay and high variability in delay
- Typically data only

- Questions to ask:
- What about multiservice applications?
- What advantage does it buy me over ATM or MPLS?
- Do I need an inflexible VPN solution?
- Future evolution?

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ATM: Pros and Cons

- Dynamic allocation of bandwidth
- Guaranteed performance
- Low delay and low variability in delay
- L2 multiservice solution
- Ubiquitous service offering
- T1 and above
- Cell overhead

- Questions to ask:
- Do I need a multiservice solution?
- Do I trade overhead for QoS?
- Do I need an interworking solution?
- Can I use MPLS instead?
- Can I use POS instead?

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SONET: Pros and Cons

- Very high performance
- Guaranteed low delay
- Excellent Layer 1 resilience
- Dynamic allocation of bandwidth (SRP and DPT)
- For OC-3c/OC-12c and above
- High cost (but prices falling)
- Not always available

- Questions to ask:
- Do I need a high-speed optical core?
- Can I use an MPLS solution?
- Can I trade cost for resiliency?
- How do I integrate with my edge devices?

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Services/WAN Technologies Support Matrix

	Low Speed Data	SNA	IP	Voice	QoS	Bandwidth Efficiency	Life Cycle
X.25	✓	✓	✓			Low	End
TDM / ISDN	✓	✓	✓	✓	✓	Low	End
FR	✓	✓	✓	✓		Medium	Mid
ATM	✓	✓	✓	✓	✓	Medium	?
SONET			✓	✓	✓	High	?

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WAN Transport Scalability

Transport	Minimum	Maximum
• X.25	2.4 Kbps	2 Mbps?
• TDM	64 Kbps	45 Mbps
• Frame Relay	64 Kbps	45 Mbps
• ATM	1.5 Mbps	2.5 Gbps
• SONET SDH	45 Mbps	>9.6 Gbps

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Network Scale for X.25

- Supported by Cisco routers—ubiquitous and well-defined user interface—WAN transport immaterial but usually only up to 2Mbps
- Interaction between routing protocols OSPF, IS-IS, EIGRP and X.25 well known but:
- X.25 windowing protocol and IP services TCP/IP can conflict in some circumstances leading to network/connection scaling issues for X.O.T (P2P configuration)

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Network Scale and Frame Relay

- Point-to-point PVC structure can lead to scale issues on large implementations (n2 problem)
- FR VPN are complex and expensive to set up and provision
- Need for many dlci for some service profiles can be cost prohibitive
- No Layer 3 intelligence
- Pure transport option—very carrier friendly (oversubscription)

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Network Scale and ATM

- Scalability not really an issue for enterprise deployments
- No Layer 3 intelligence—except with IP+ATM
- VPN and PVC structure also has n2 problem for routing peers—SVC may help
- Can offer native services to some applications—but then has other issues with MPOA/LANE behavior, encapsulation, signaling, and equipment costs

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Network Scale and SONET/SDH

- Only really for large-scale deployment or highly mission-critical traffic
- MAN implementations tend to use Campus ATM switches or routers—SONET routers now an option with ISR 3303
- Availability and cost are currently issues
- Pure transport solution but IP over optical layer is the future direction for bandwidth intensive applications and infrastructures

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WAN Routing Protocol Scalability

- Distance vector protocols limited by potential message propagation (flooding) problems
- Link state protocols—peering domains subject to usual engineering restrictions and some implementations have flooding problems
- PNNI—128 nodes per domain no limit to domains
- Hierarchical PNNI—thousands of nodes per network
- MPLS uses standard routing protocols (OSPF, IS-IS) and iBGP for VPN

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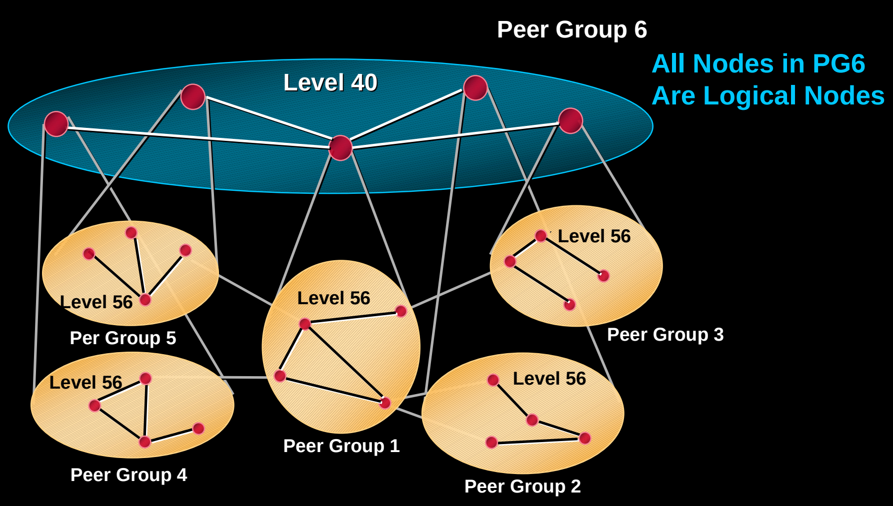
PNNI Hierarchical Network



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Principles of Availability Management

- Good capacity planning, use “what-if” design procedures, aggressive testing and validation
- Manage change and risk evaluation, plan maintenance—budget for spares
- Design for redundancy and resiliency
- Monitor network performance continually—use fault management tools—enforce service level agreements

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Measuring Availability

- Available user minutes less impacted user minutes
- Link status up percentage
- Successful end-to-end (FTP) response percentage
- If Switch goes down but network available then this impacts product level MTBF but not necessarily network availability

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WAN High Availability

- Carrier connectivity options: local loop, SONET, DACS, and channel banks
- Where is the DMARC—is there operations support for the CSU/DSU?
- Are there multiple facilities?
- Is there site diversity?
- Is there (genuine) link physical path diversity?

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Availability Parameters

	Availability Requirement	Unplanned Downtime	Redundancy	H/W MTTR Replacement	Service Mgmt	Cost
Reliable Network	99.9 %	8 Hours 46 Mins	No	Up to 24 Hours	No	$
High Availability Network	99.99 %	53 Minutes	Yes	Up to 4 Hours	Yes	$$
Non-Stop Network	99.9998%	32.6 Sec	Yes	2 Hours	Yes	$$$

Switched WAN Typically Aims at 99.9998 or More

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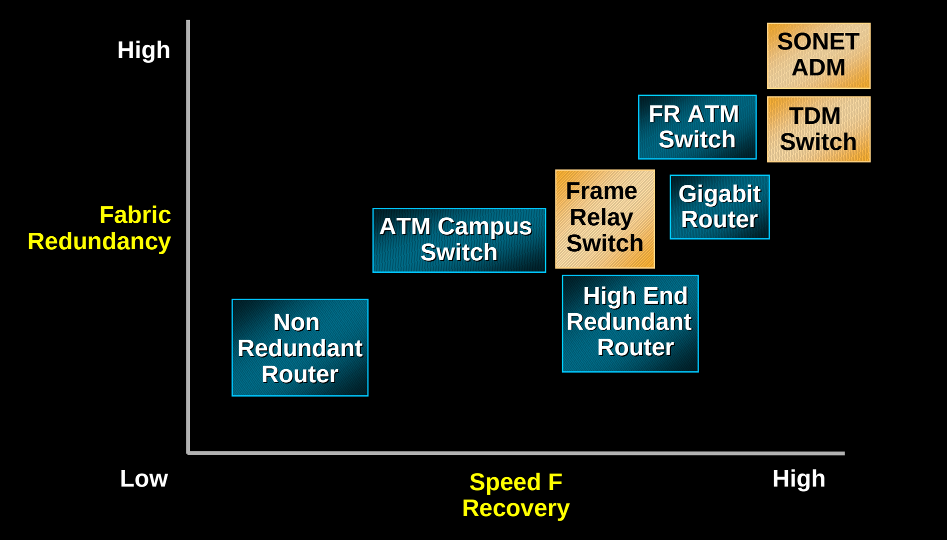
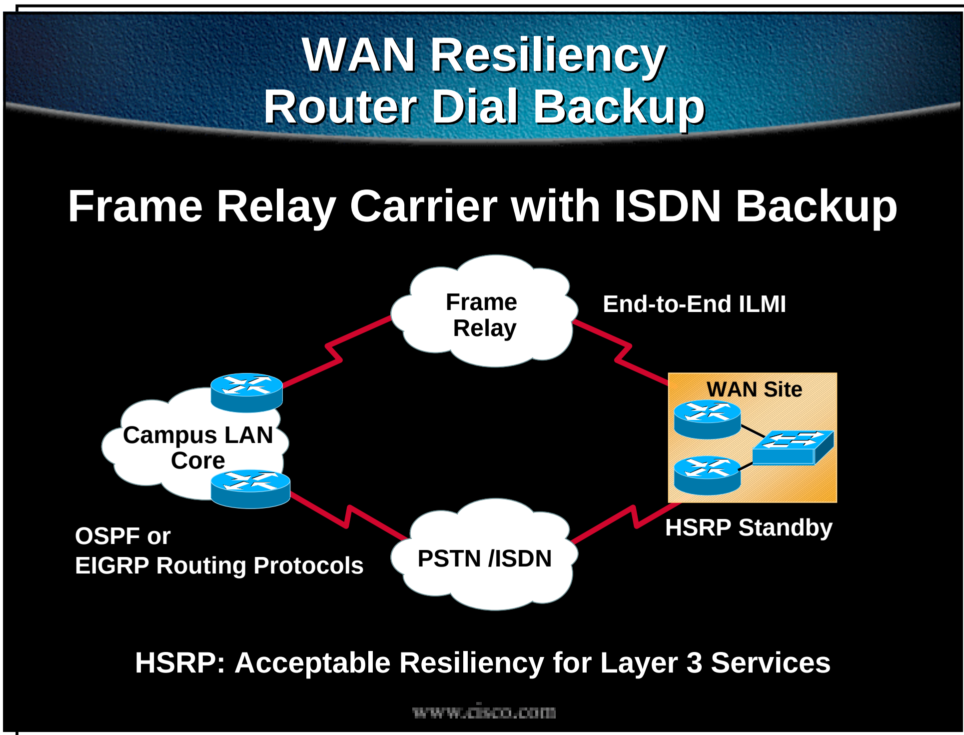
Equipment Level Redundancy

- Router redundancy typically HSRP—hot standby only implemented for very high performance routers
- Campus switches typically seconds to minutes of downtime on critical fabric failure
- ATM WAN switch typically “hitless” (microseconds) on most failures

Equipment Level Resiliency




WAN Resiliency
Router Dial Backup
Frame Relay Carrier with ISDN Backup
Frame Relay
End-to-End ILMI
WAN Site
Campus LAN Core
OSPF or
EIGRP Routing Protocols
PSTN /ISDN
HSRP Standby
HSRP: Acceptable Resiliency for Layer 3 Services
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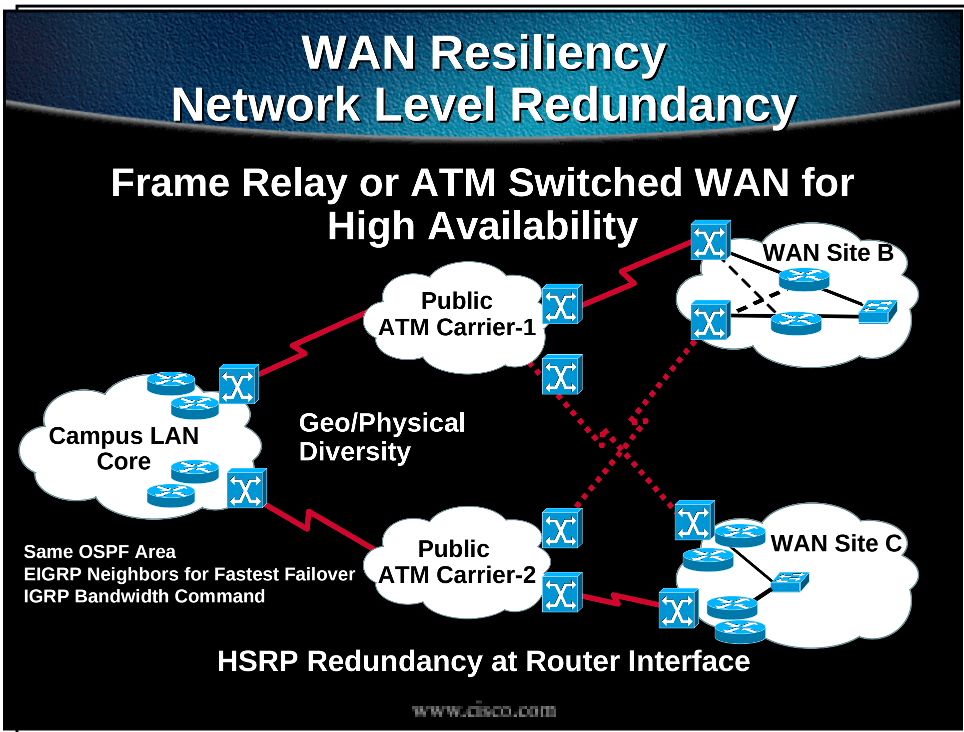
WAN Resiliency
Network Level Redundancy
Frame Relay or ATM Switched WAN for
High Availability
WAN Site B
Public
ATM Carrier-1
Campus LAN
Core
Geo/Physical
Diversity
Public
ATM Carrier-2
WAN Site C
Same OSPF Area
EIGRP Neighbors for Fastest Failover
IGRP Bandwidth Command
HSRP Redundancy at Router Interface
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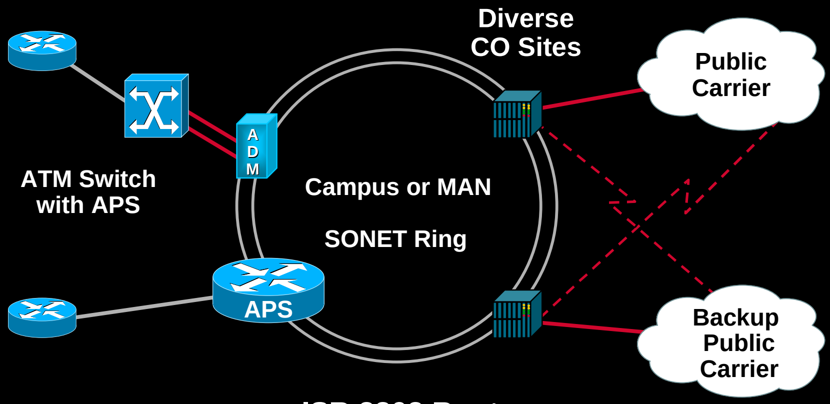
WAN Resiliency
Layer 1: SONET

CSU DSU Not Shown



ISR 3303 Router

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Network Architectures

Enterprise Multilayer Model

- Access
- Gateway
- Distribution
- WAN backbone

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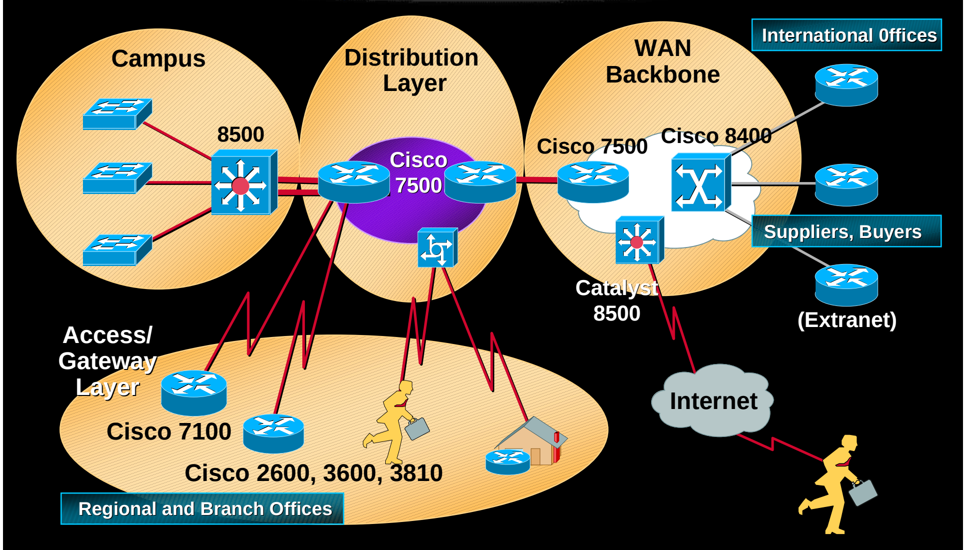
Enterprise Network: Evolution to Specialized Platforms



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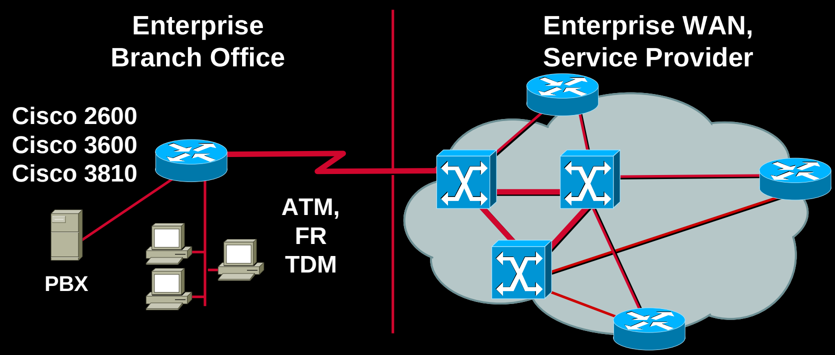
WAN Branch Access



- Low- to high-speed links depending on product (64 k–OC-3)
- Mixed LAN/WAN media flexibility with varying voice options (VoIP, VoFR)
- Full Cisco IOS functionality for security, traffic management, QoS
- Highly cost effective

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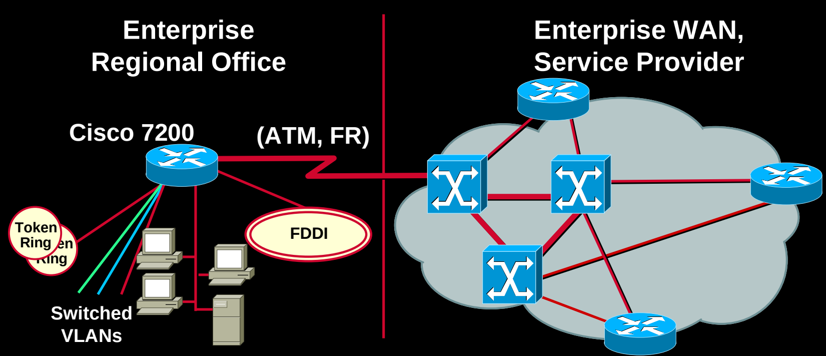
WAN Gateway Options



- High-performance Layer 3 engine (150 Kpps)
- Mixed LAN/WAN media flexibility
- Full Cisco IOS functionality for security, traffic management, QoS
- Cost effective solution via Cisco 7200 bundles—ATM, POS, DS3/E3 T1/E1

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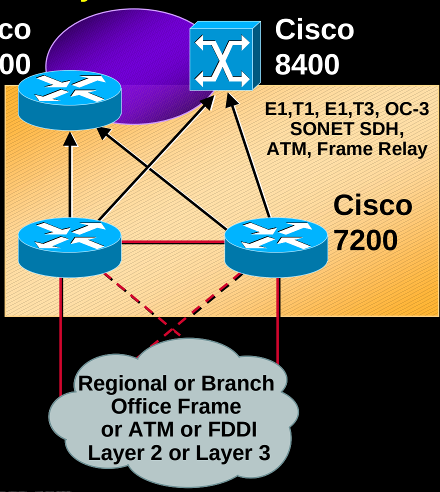
WAN Access/Gateway

The Access/Gateway Layer Can Home Either to Distribution Layer, or Directly to WAN Backbone

- Requirements:
- Homing to Cisco 7500
  - High-speed campus link
  - High-speed WAN link
  - High-speed L3 services
- Homing to Cisco IGX 8540
  - Low-speed campus link
  - High- or low-speed WAN link
  - Legacy data and voice services



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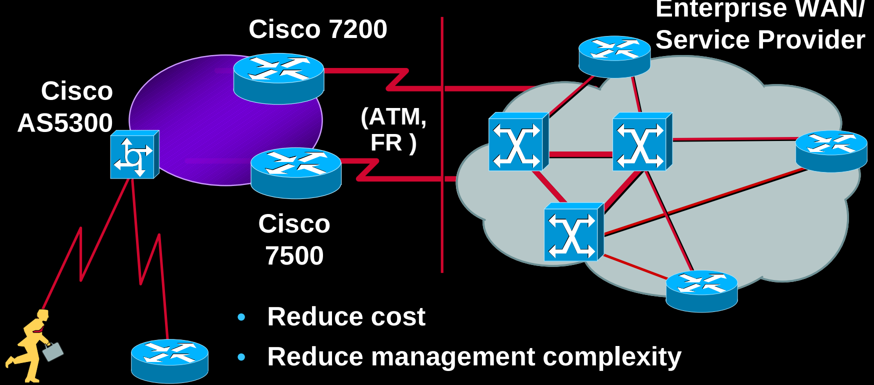
The Distribution Layer



- Reduce cost
- Reduce management complexity
- Reclaim rack space
- Simplify sparing
- Manage WAN link costs

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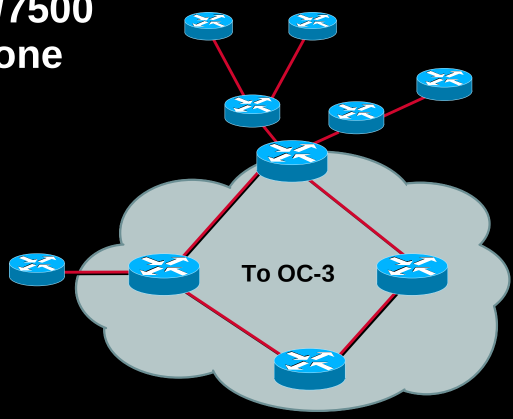
WAN Backbone Options: Routed WAN

- Classic Cisco 7200/7500 routed WAN backbone
  - L3 services
  - Multiprotocol support
  - Multiservice
  - Layer 2 options
  - QoS support limited
  - Flexible interfaces



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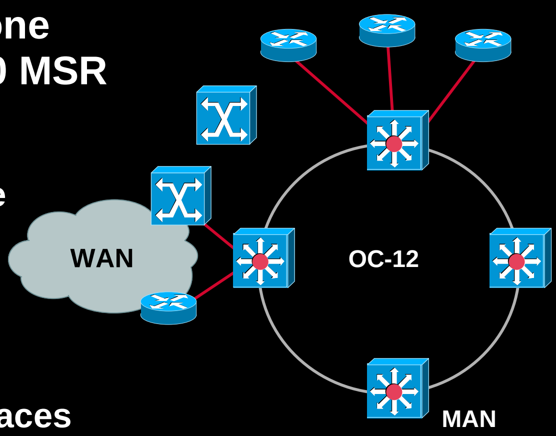
WAN Backbone Options: Campus MAN

- Multiservice ATM switched backbone using Cisco 8540 MSR
  - ATM centric
  - High performance
  - L3 services
  - Router ATM connectivity
  - High-speed interfaces



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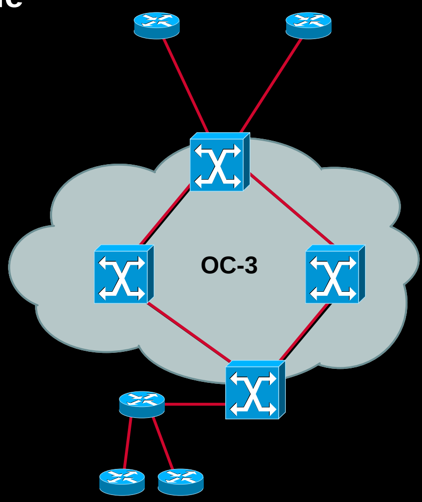
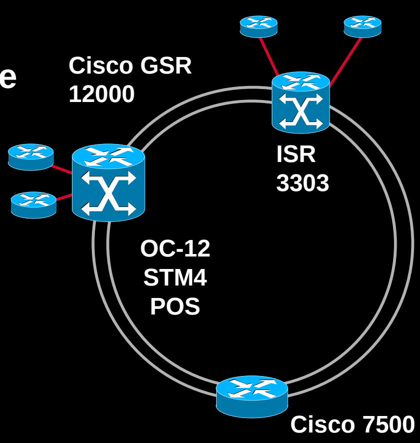
WAN Backbone Options: Frame Relay or ATM Switching

- Multiservice switched Frame Relay or ATM backbone using Cisco IGX 8400 or BPX 8600
  - Carrier class redundancy
  - Legacy voice and data
  - Low-speed links
  - ATM traffic management
  - Frame Relay congestion control (CLLM and eLMI)
  - ATM/FR interworking
  - L2 QoS



WAN Backbone Options: Packet Over SONET

- Uses GSR 12000, 7500, or ISR 3303 at the core
- Cisco 7200/7500 at the edge
- Optimized for IP traffic
- Excellent bandwidth, performance and network efficiency with SRP/DPT
- IP QoS/MPLS for multiservice support



Cisco WAN Product Matrix

	TDM	X.25	Frame Relay	ATM	SONET	Max Line Speed	Location
3810	✓	✓	✓	✓		E1	Branch
3600		✓	✓	✓		OC-3	
7200	✓	✓	✓	✓	✓	OC-3	Branch/ Hub
7500	✓	✓	✓	✓	✓	OC-3	
ISR 3303					✓	OC-48	
MSR 8500			✓	✓		OC-48	
IGX 8400	✓	✓	✓	✓		OC-3	Hub/ Core
BPX 8600			✓	✓		OC-12	

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WAN Routing Methodologies

- Router WAN
  - Choice of router protocol is a planning/design issue prior to building the WAN
  - Main area to examine is L2 design impact on L3 efficiency
  - For detailed comparisons of RIP, RIP2, OSPF, IS-IS, EIGRP, BGP, etc., see other Networkers presentations
- MPLS WAN
  - Uses the classical routing protocols initially and MPLS-specific traffic engineering for the L2 network

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WAN Routing Methodologies

- TDM and ISDN
  - Static or dynamic circuit-oriented
  - Uses proprietary mechanisms, often routed explicitly by external server (NMS)
  - Dynamic (switched) services, e.g., voice-use PSTN signaling infrastructure (SS7, ISUP)
- X.25
  - Connection-oriented but dynamic routed mechanism, defined at user interface
  - Uses either native X.25 or other WAN transport

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WAN Routing Methodologies

- Frame Relay

  Proprietary connection oriented or connectionless, static or dynamic (switched) services

- ATM

  Proprietary derivatives of, or precursors to PNNI and OSPF; moving to standards-based PNNI, AINI, B-ISUP

- SONET SDH

  Proprietary static or dynamic

  Optical interworking standard—SRP/DPT leverages SONET bandwidth

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WAN Protocol Issues

- Possibility of non-optimized routes at set-up
- Traffic and route determinism required
- Routing loops in some implementations
- Convergence time, and routing information conflicts when different protocols are interworked
- Goal—maintain WAN transparency and concentrate on more complex layer 3 issues
- With MPLS IP+ATM leverage layer 3 resiliency and layer 2 deterministic qualities

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Factors Determining Protocol Convergence

- Network size
- Hop count limitations
- Peering arrangements (edge, core)
- Topology design
- Routing information compatibility
- Port and switch level addressing
- How well do the WAN/LAN protocols interact?
- Path selection

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Convergence Issues on Routed WAN

- Standard router issues

  State change

  Table updates, etc.

- HSRP switchover

  Convergence equal to items mentioned above plus dead interval (40 sec.)

- See sessions 307–320, 1400–1407

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Convergence Issues on Switched WAN

- Link failure

  Convergence is time to re-establish link plus PVC/SVC re-route (tens to 100’s of ms depending on protocol used)

- Switch fabric failure

  Redundant ATM WAN switch—normally hitless

  Campus ATM switch—rapid rebuild

  FR switch—can be either of above

- I/O card failure

  Depends on redundancy implementation (y cable, APS, connection reprogramming, etc.)

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Protocol Convergence: Factors to Consider

- Cisco IOS version(s) installed for routers and MSR/LS1010
- Network topology, overall bandwidth availability, protocol-specific bandwidth requirements (compare OSPF with EIGRP)
- CPU and memory utilization—for a given protocol on routers, for switch software on ATM switches
- PNNI behavior for switched backbone
- AutoRoute or similar link-state PVC protocols on non-PNNI FR/ATM switches
- MPLS convergence and TE on IP+ATM networks

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Protocol Addressing

- Until now not a major issue for the WAN using TDM, FR, or ATM
- Typically a Layer 3 consideration for sophisticated routing protocol support
- Use of PNNI forces WAN design and planning engineers to consider address topology, structures, and address allocation
- Issues are similar to those raised in layer 3 addressing schema—plan, plan, plan

And Plan

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PNNI Addressing Considerations

- Flat multipeer group network model
- Hierarchical network model
- Number of hierarchies
- Number of nodes
- NSAP mapping and E164 addresses
- As with Layer 3 network, the topology determines address structure

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Comparison of Routing Protocols

	Link State	Traditional Distance Vector	Advance Distance Vector
Scalability Bandwidth	Good Low	Low High	Excellent Low
Memory CPU	High High	Low Low	Moderate Low
Convergence Configuration	Fast Moderate	Slow Easy	Fast Easy

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Agenda

- Drivers, Costs, Planning,
- Requirements, Services, Transport Options
- Scalability, Availability, Reliability
- Enterprise WAN Network Architectures
- WAN Routing Methodologies
- Design and Performance
- Specific Implementations

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Business Goals Drive Design

- Application derived requirements—e.g.:
  - Response time
  - Traffic volume and network profile
  - Availability requirements
- Budget
- Time to market/deadlines
- Trends (SNA to TCP/IP, X.25 migration, telecommuting, IP-VPN)

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Classic Network Design

- Backbone
- Distribution
- Gateway
- Access

Holds True Whether LAN or WAN—
In This Context the Enterprise WAN Can Be the
Backbone or the Backbone Plus the Distribution Layer

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Design Problems

- Each design presents unique problems
- The tools, plus “what-if” analyses constitute a dynamic environment
- Growth is often unpredictable and bursty depending on demographic shifts and changing service requirements
- Mergers, and acquisitions can destroy the best plan and necessitate constant re-evaluation

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Network Modeling

- A critical component of overall network management and planning
- Enables prediction and control of costs
- Assure control and reliability of network configuration and network services
- Ensure informed network decisions through multiple iterations and varying “what -if” analyses
- Enables design optimization

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Cisco Modeling and Design Tools

- **NetSys**

  Routers and ATM campus switches for LAN-WAN integration

- **Concord Health**

  For capacity planning—pre- and post-installation

- **NMT**

  WAN switch configuration verification

- **WANDL**

  Optimization of backbone design for routers and switches, campus and WAN

- **WSA**

  Used as ongoing live network monitoring tool

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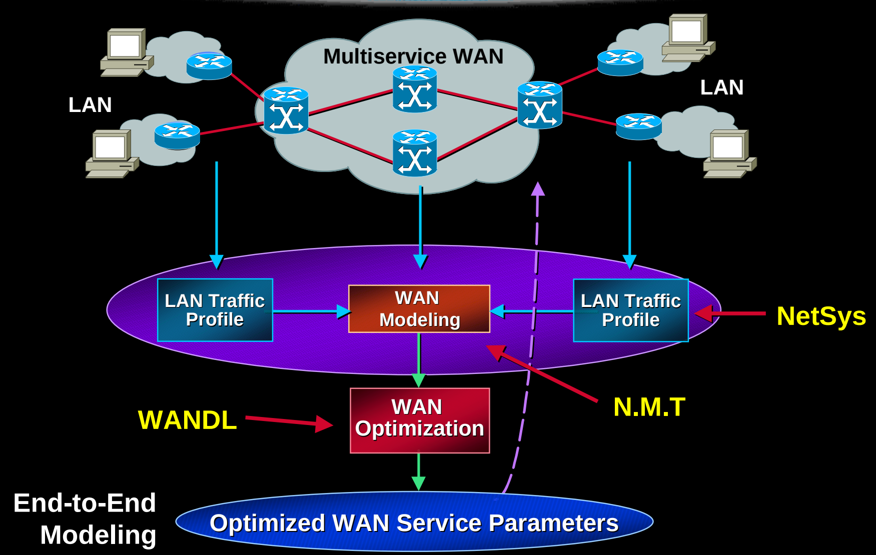
LAN and WAN Modeling and Optimization



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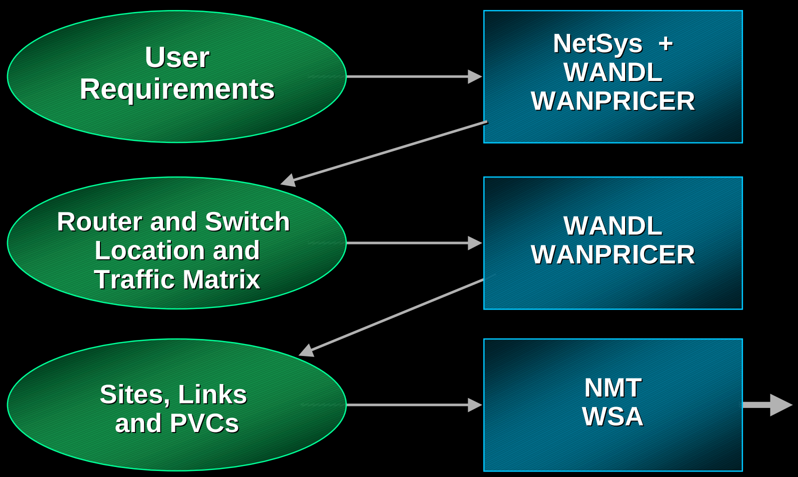
Design Progression...



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WAN Modeler Features

Network Modeling Tool

- Actual network configuration
- Accurate switch and router configuration designs
- Geographical display
- Configuration verification
- Routing and alternate routing verification

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Optimizer Features

WANDL

- Accurate transmission topology designs
- Least cost designs via tariff DB's
- Robust/diverse backbone designs
- Network and failure simulations
- Discrete event simulation
- "What if" design scenarios

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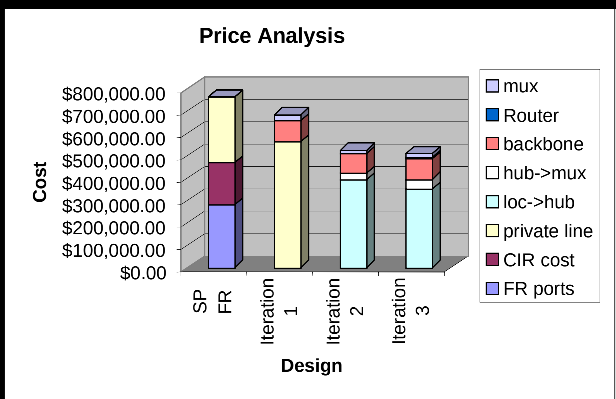
Multiple Iterations = Cost Reductions

Case 1—Service Provider FR	$760,154.22
Case 2—Iteration 1 (One level Concentration)	$682,112.00
—Iteration 2 (LEC FR Second Level)	$523,382.00
—Iteration 3 (LEC FR/ Router 2nd Level)	$507,801.00



Data Taken From a Case Study Executed in 1998—50 IGX WAN Switches Spread Across the USA

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Operational Issues

- The lower the skill level of personnel the more robust the design required
- Design for a low-stress operation for both personnel and equipment to avoid continual tuning
- Low stress = low maintenance costs
- Pro-active feedback and reaction time will be less critical

Modeling: Conclusions

- Modeling is critical part of overall network management and thus facilitates efficient network deployment
- End-to-end modeling is strategic, can form basis for new, value-added applications

  Network auditing

  Service capacity modeling

  End-to-end integration

Network Planning and Auditing

- Sophisticated network capacity planning critical as services expand
- Reduce provisioned network resources being misused, not billed, or not used
- Can ensure services and resources are available, especially in areas with long service activation periods
- Cost effective end-to-end modeling and planning is a strategic differentiator and enables tactical advantage by facilitating cost reduction

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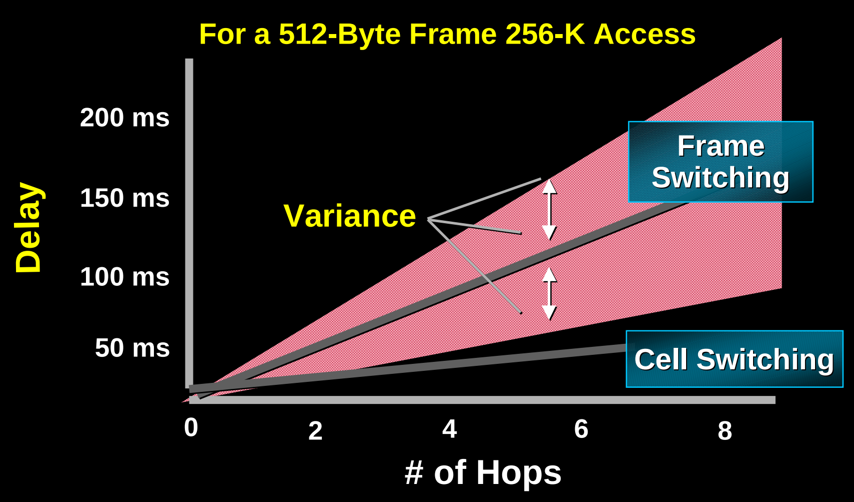
QoS Challenge for WAN Devices



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QoS on the WAN

- TDM
  - QoS integral to the transmission technology
- Frame Relay
  - Not easily engineered on top of the transmission technology
- ATM
  - Integral to the transmission technology
- SONET
  - Classical SONET integral QoS
  - POS IP QoS

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QoS Building Blocks

- Backbone speed and scale
- Packet classification
- Bandwidth management and admission control
- Congestion management
- Queue management
- Granular measurements

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IP/QoS Constituents

- IP precedence and BGP propagation
- Committed access rate
- Weighted fair queuing
- Weighted random early detection

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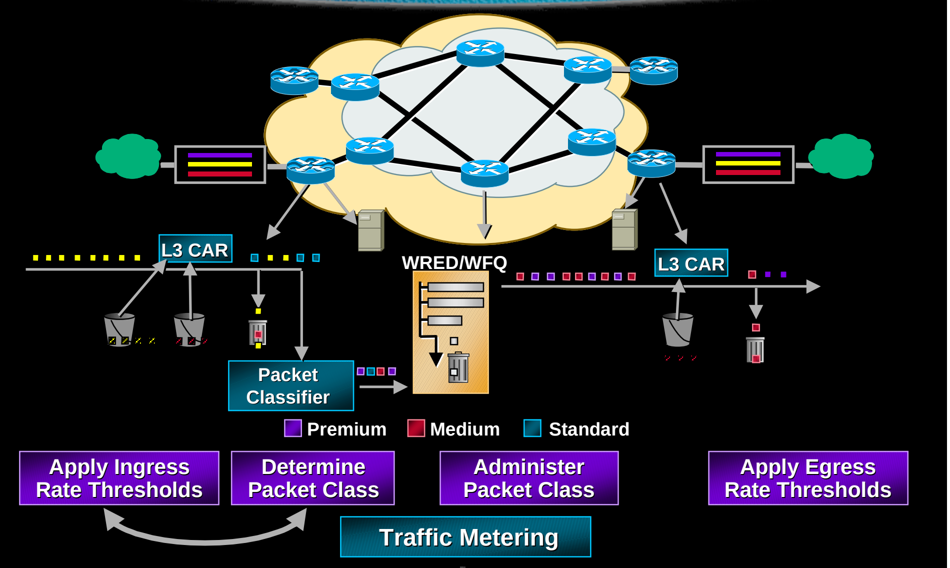
IP Quality of Service



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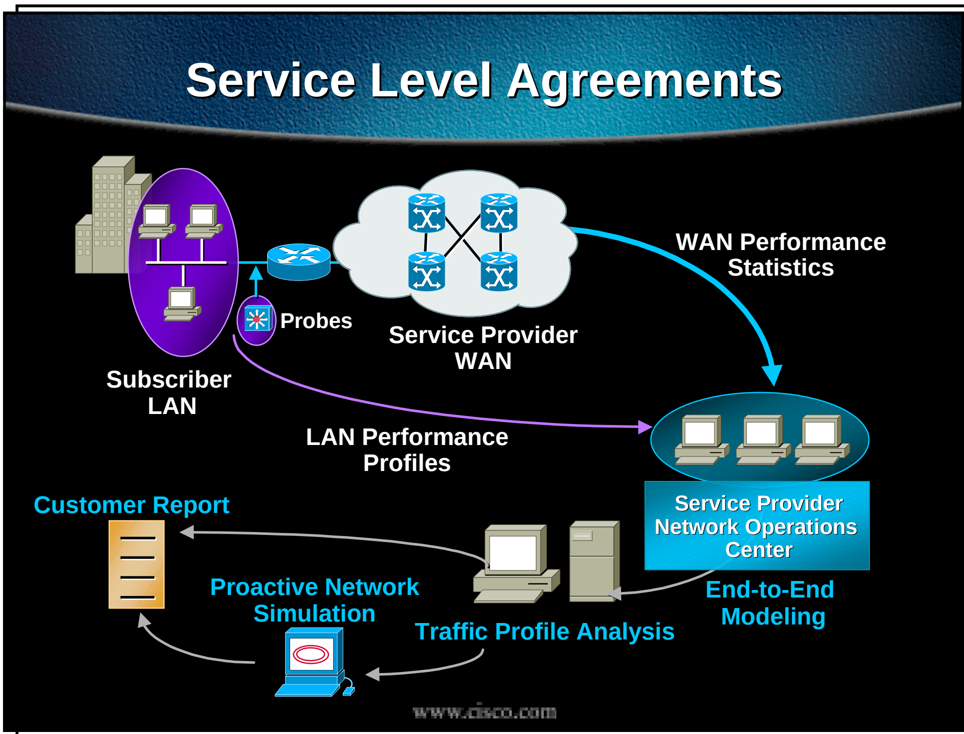

Service Level Agreements
WAN Performance Statistics
Probes
Service Provider WAN
Subscriber LAN
LAN Performance Profiles
Customer Report
Service Provider Network Operations Center
Proactive Network Simulation
End-to-End Modeling
Traffic Profile Analysis
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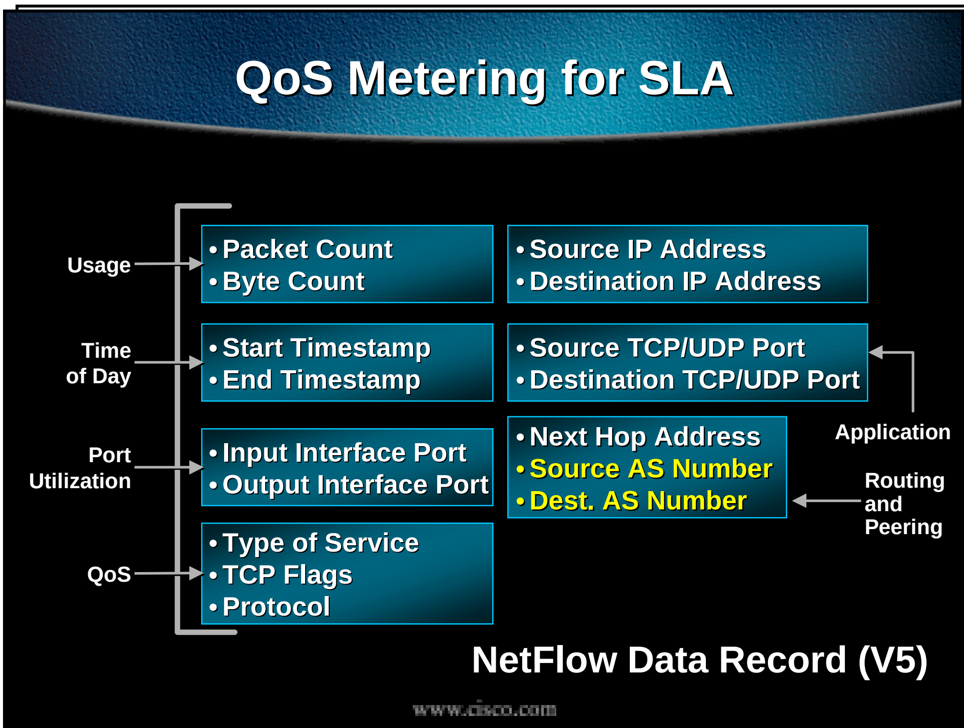
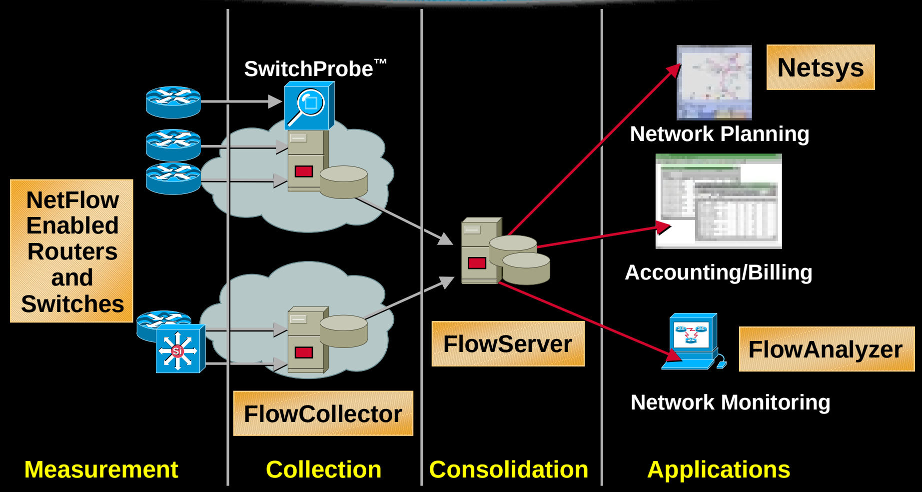


QoS Metering for SLA
Usage
Time of Day
Port Utilization
QoS
• Packet Count
• Byte Count
• Start Timestamp
• End Timestamp
• Input Interface Port
• Output Interface Port
• Type of Service
• TCP Flags
• Protocol
• Source IP Address
• Destination IP Address
• Source TCP/UDP Port
• Destination TCP/UDP Port
• Next Hop Address
• Source AS Number
• Dest. AS Number
Application
Routing and Peering
NetFlow Data Record (V5)
www.cisco.com

NetFlow Metering Infrastructure



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Performance Monitoring for Service Level Agreements

- Review hardware replacement processes
- Establish problem resolution processes
- Define performance measurement
- Agree availability measurements
- Install monitoring and error detection
- Continual pro-active capacity planning

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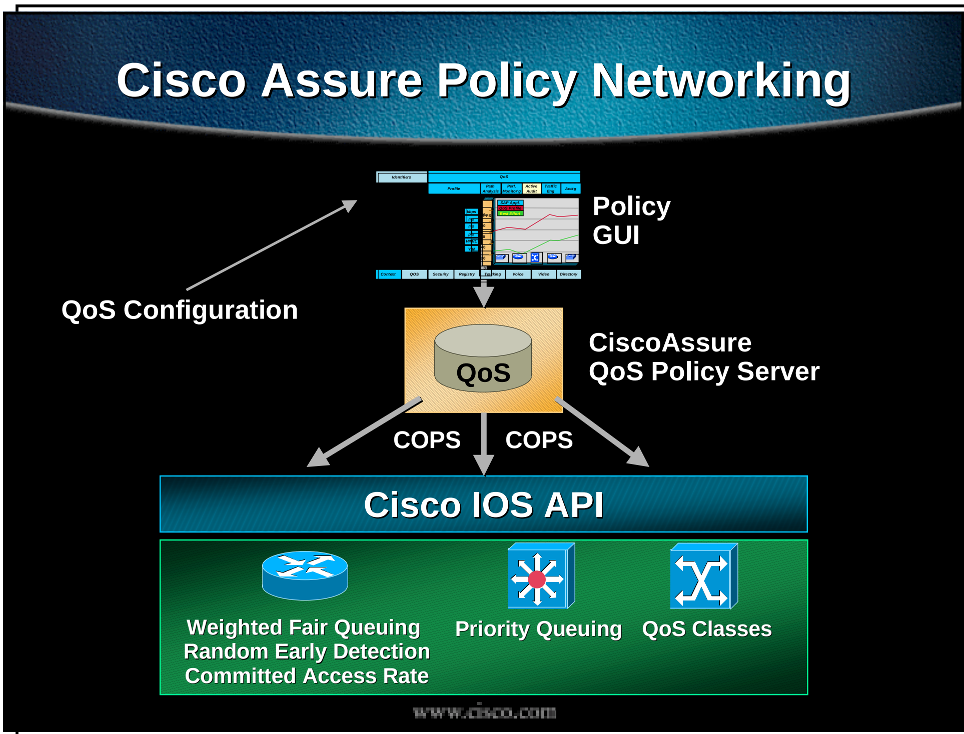

Cisco Assure Policy Networking
QoS Configuration
Policy
GUI
QoS
CiscoAssure
QoS Policy Server
COPS
COPS
Cisco IOS API
Weighted Fair Queuing
Random Early Detection
Committed Access Rate
Priority Queuing
QoS Classes
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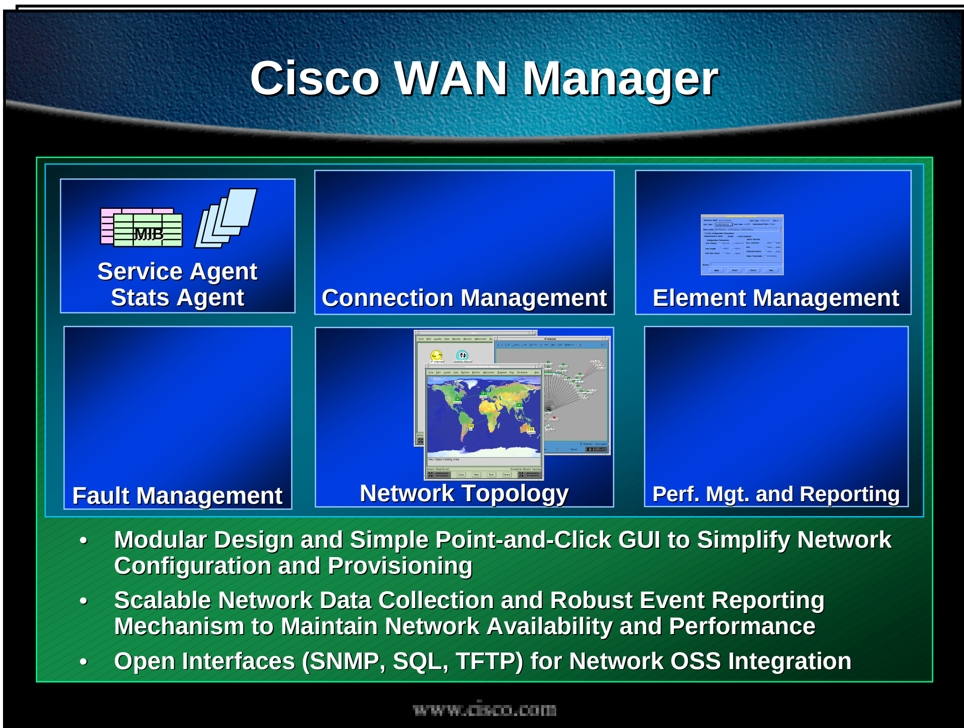

Cisco WAN Manager
MIB
Service Agent
Stats Agent
Connection Management
Element Management
Fault Management
Network Topology
Perf. Mgt. and Reporting
• Modular Design and Simple Point-and-Click GUI to Simplify Network Configuration and Provisioning
• Scalable Network Data Collection and Robust Event Reporting Mechanism to Maintain Network Availability and Performance
• Open Interfaces (SNMP, SQL, TFTP) for Network OSS Integration
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Agenda

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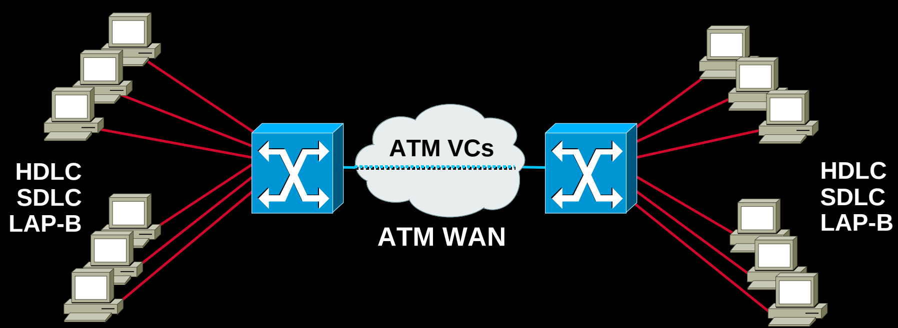
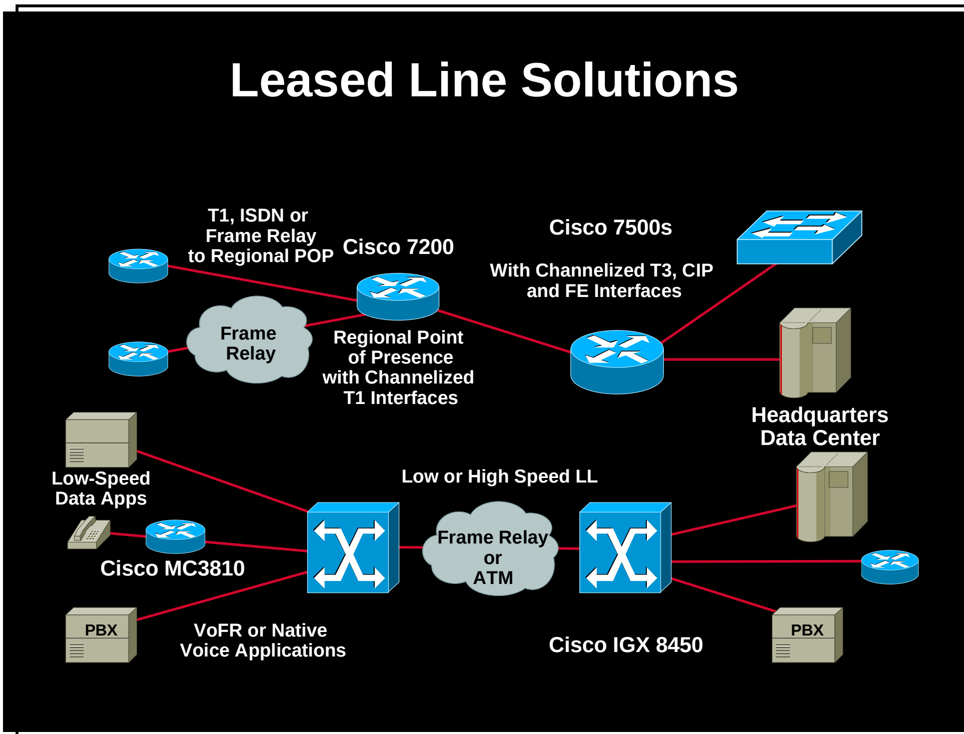
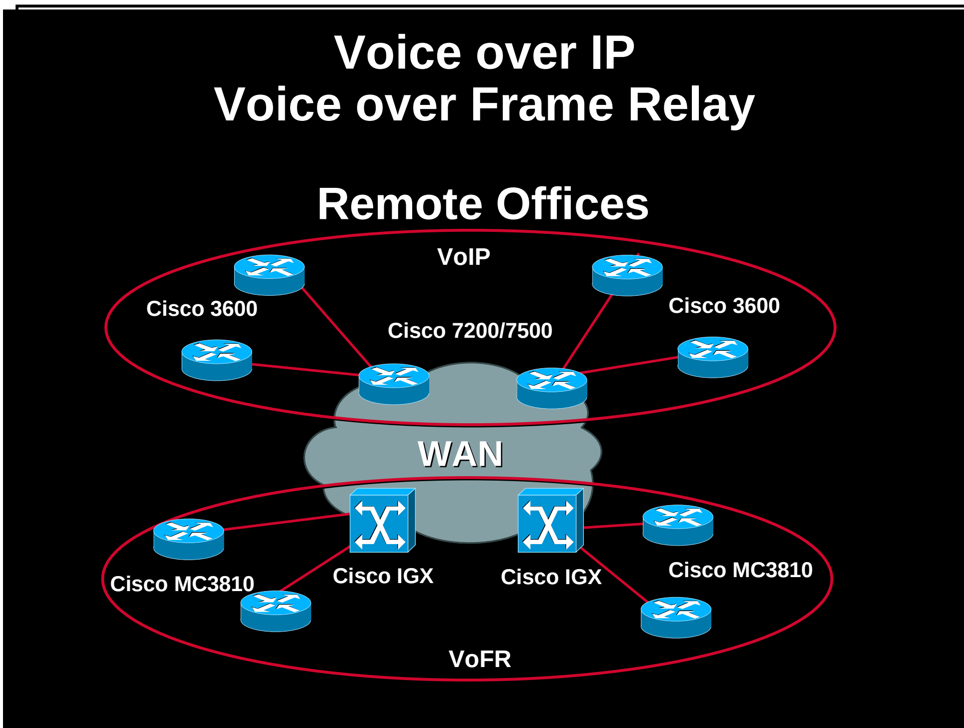
X.25 Frame Forwarding Solution

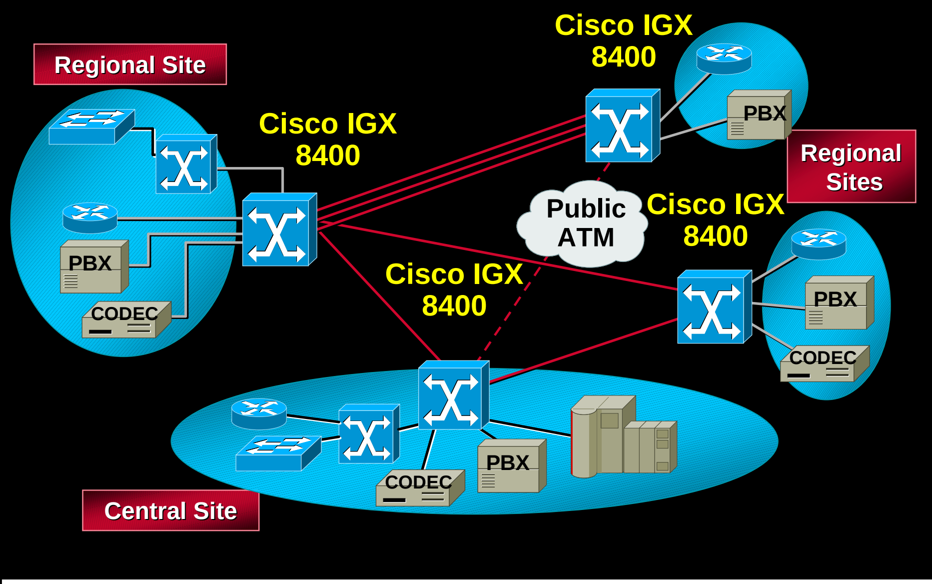
Transparently Carries HDLC/SDLC-Based Traffic Across the Network




Leased Line Solutions
T1, ISDN or
Frame Relay
to Regional POP
Cisco 7200
Cisco 7500s
With Channelized T3, CIP
and FE Interfaces
Frame
Relay
Regional Point
of Presence
with Channelized
T1 Interfaces
Headquarters
Data Center
Low-Speed
Data Apps
Low or High Speed LL
Frame Relay
or
ATM
Cisco MC3810
PBX
VoFR or Native
Voice Applications
Cisco IGX 8450
PBX

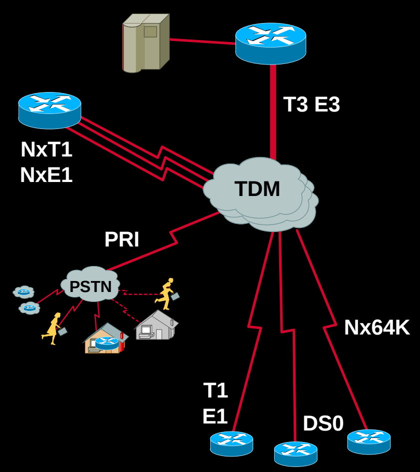

Voice over IP
Voice over Frame Relay
Remote Offices
VoIP
Cisco 3600
Cisco 3600
Cisco 7200/7500
WAN
Cisco MC3810
Cisco IGX
Cisco IGX
Cisco MC3810
VoFR

TDM Replacement—Cisco IGX 8450

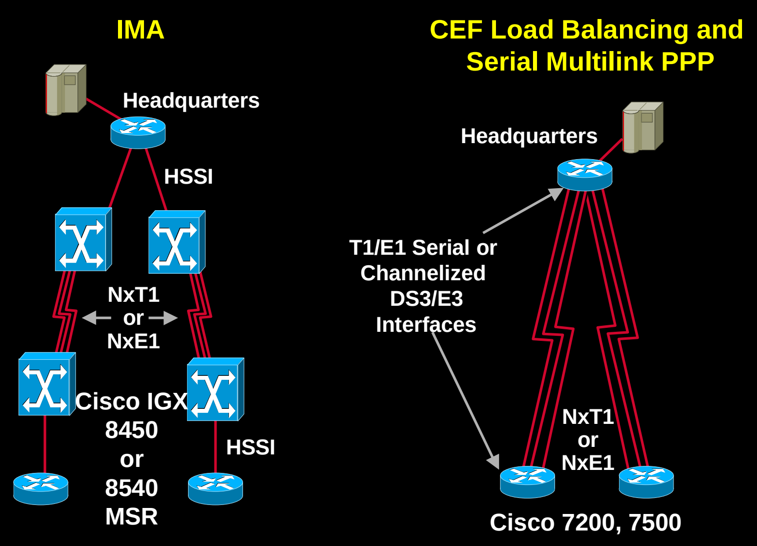


TDM Replacement Multichannel Router Interfaces

- Direct termination
- Built in T1 CSU/DSU
- Built in E1 G.703
- Up to 8 T1/E1 ports per card
- Multichannel
  - 64K, FT1/FE1, T1/E1
  - 128 connections per card
- Built in T3/E3 line interface
- Flexible channel management
- Onboard BERT



Inverse Multiplexing Options



Inverse Multiplexing: Software Solutions

- CEF load balancing
  - Balances load by distributing traffic across multiple IP addresses
  - Channelized and unchannelized interface support
  - Available on Cisco 7500/7200
- Serial multilink PPP
  - Creates one IP address for N T1/E1 lines
  - Preserves packet order
  - Standards-based software solution

Summary

- Careful planning
- In depth cost-benefit analyses of all technical options
- Vendor evaluation for the long haul
- Out-task and consolidate to focus on core business
- Select an integrated solution
- Monitor aggressively
- Keep control

Please Complete Your Evaluation Form

Session 102

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