Deploying Wide Area Network Technologies (FR, ATM, Serial)

Session 2304
Agenda

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

Case Study

- Think about this:
  - International corporation
  - Distribution sites
  - Partners, Internet, sales sites
  - Remote access requirements
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

Initial Dilemma—Own or Outsource

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
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...

Cost Elements

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

• Planning for new applications
  Mobile services, extranets, and telecommuting, etc.

Planning Check List

• Business/application requirements
• Availability objectives
• Network resiliency
• Manageability, service levels, and metrics
• Scalability objectives
• Performance objectives
• Cost-benefit analysis
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
- Pilot the Solution
- Test and Validate in Laboratory
- Design With Vendor: Review
- Review Product Specifications
- Define and Refine Requirements

Potential Points of Failure

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

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

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
- Seamless integration

At Lowest Cost!
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, price

What Services?

- Low speed/legacy data
- Critical data applications
- Voice and video
- Differentiated services

And what are the requirements to support these services?
Legacy Data Service Requirements

- Bisync/async/VISA/ALC 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.)
- IP not a valid option today for circuit emulation

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
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
- VoATM 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

QoS

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

Services Delivery—Challenge for WAN Devices

Flexibility

User Interfaces

Network Interfaces

Efficiency

Low Delay and Low Variability

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

- X.25
- TDM
- ISDN
- Frame Relay
- ATM
- SONET
- DPT
- Fixed Wireless

Each Has Strengths... and Weaknesses

Different Services, Markets, and Network Deployments Require Different Solutions

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?
**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?

**ISDN—Pros and Cons**

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

**Questions to Ask**

- Do I Want to Pay Dialup Charges?
- Can I Afford to Give Up Flexibility?
- Do I Want to Invest in the Necessary TA and Infrastructure?
Frame Relay—Pros and Cons

- Dynamic allocation of bandwidth
- QoS is improving
- Ubiquitous service offering
- Limited multiservice performance
- High delay and high variability in delay possible
- Data-centric

Questions to Ask

- What Advantage Does It Buy Me Over ATM or MPLS?
- Do I Need an Inflexible VPN Solution?
- Future Evolution?

ATM—Pros and Cons

- Dynamic allocation of bandwidth
- Guaranteed performance
- Low delay and low variability in delay
- Layer 2 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?
**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?

**Wireless—Pros and Cons**

- Performance increasing (< 45 Mbps)
- Non-licensed spectrum available
- Non-recurring leased line expense
- Limited range (< 30 miles)
- Metropolitan technology (short distance)
- Not always available

**Questions to Ask**

- Do I Have a Cable or Fiber Option?
- Are There Bandwidth Limitations?
- Are There Environmental Obstacles?
### Services/WAN Technologies Support Matrix

<table>
<thead>
<tr>
<th></th>
<th>Low Speed Data</th>
<th>SNA</th>
<th>IP</th>
<th>Voice</th>
<th>QoS</th>
<th>Bandwidth Efficiency</th>
<th>Life Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>X.25</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Low</td>
<td>End</td>
</tr>
<tr>
<td>TDM/ISDN</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Low</td>
<td>End</td>
</tr>
<tr>
<td>FR</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Medium</td>
<td>Middle</td>
</tr>
<tr>
<td>ATM</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Medium</td>
<td>?</td>
</tr>
<tr>
<td>SONET/IDPPT</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>High</td>
<td>?</td>
</tr>
<tr>
<td>Wireless</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Medium</td>
<td>?</td>
</tr>
</tbody>
</table>

### Agenda

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

<table>
<thead>
<tr>
<th>Transport</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>X.25</td>
<td>2.4 Kbps</td>
<td>2 Mbps?</td>
</tr>
<tr>
<td>TDM</td>
<td>64 Kbps</td>
<td>45 Mbps</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>64 Kbps</td>
<td>45 Mbps</td>
</tr>
<tr>
<td>ATM</td>
<td>1.5 Mbps</td>
<td>2.5 Gbps</td>
</tr>
<tr>
<td>SONET/SDH</td>
<td>45 Mbps</td>
<td>&gt;9.6 Gbps</td>
</tr>
<tr>
<td>Fixed/Wireless</td>
<td>1.5 Mbps</td>
<td>45 Mbps</td>
</tr>
</tbody>
</table>

### Network Scale for X.25

- Supported by Cisco routers—ubiquitous and well-defined user interface—WAN transport immaterial but usually only up to 2 Mbps
- 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)
Network Scale and Frame Relay

- Point-to-Point PVC structure can lead to scale issues on large implementations (n^2 problem)
- Hotspots possible by poor planning (e.g., 1000 PVCs in one box)
- Need for many DLCI for some service profiles can be cost prohibitive
- No Layer 3 intelligence
- Pure transport option—very carrier friendly (oversubscription)

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 n^2 problem for routing peers—SVC may help
- VC merge improves scalability
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
- Availability and cost are currently issues
- Pure transport solution but IP over optical layer is the future direction for bandwidth intensive applications and infrastructures

Network Scale and Wireless

- Point-to-multipoint limited
- MAN applications by limited range
- RF licensing required
- 25 miles with 802.11b—70 ft. tower LOS
- 10 miles NLOS/LOS 25 miles
  - MMDS
  - Requires license
- Rapid deployment
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 multidomain capability
- Hierarchical PNNI—thousands of nodes per network
- MPLS uses standard routing protocols (OSPF, IS-IS) and iBGP for VPN

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
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 is available then this impacts product-level MTBF, but not necessarily network availability

WAN High Availability

- Reduce complexity, increase modularity and consistency; is there (genuine) link physical path diversity?
- 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?
- See Session—2609: High Availability Networks
Switched WAN Typically Aims at 99.9998 or More

<table>
<thead>
<tr>
<th>Availability Requirement</th>
<th>Unplanned Downtime</th>
<th>Redundancy</th>
<th>H/W MTTR Replacement</th>
<th>Service Management</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable Network</td>
<td>99.9%</td>
<td>8 Hours 46 Minutes</td>
<td>No</td>
<td>Up to 24 Hours</td>
<td>No</td>
</tr>
<tr>
<td>High Availability Network</td>
<td>99.99%</td>
<td>53 Minutes</td>
<td>Yes</td>
<td>Up to 4 Hours</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-Stop Network</td>
<td>99.998%</td>
<td>32.6 Sec</td>
<td>Yes</td>
<td>2 Hours</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Availability Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Level Redundancy</td>
</tr>
</tbody>
</table>

- Diversify termination points (router, CO, carrier, etc.)
- Router redundancy typically HSRP
- Campus switches typically seconds of downtime on critical fabric failure
- ATM WAN switch typically hitless (microseconds) on most failures
WAN Resiliency
Router Dial Backup

Frame Relay Carrier With ISDN Backup

- Campus LAN Core
- OSPF or EIGRP Routing Protocols
- PSTN/ISDN
- End-to-End ILMI
- WAN Site
- HSRP Standby

HSRP: Acceptable Resiliency for Layer 3 Services

WAN Resiliency
Network Level Redundancy

Frame Relay or ATM Switched WAN for High Availability

- Campus LAN Core
- Same OSPF Area
- EIGRP Neighbors for Fastest Failover
- IGRP Bandwidth Command
- Geo/Physical Diversity
- HSRP Redundancy at Router Interface
WAN Resiliency Layer 1—SONET

Agenda

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

Enterprise Multilayer Model

- WAN backbone
- Distribution
- Access

Enterprise Network—Evolution to Specialized Platforms

- Campus
  - Catalyst® 8500
  - Cisco 7100
- Distribution Layer
  - Cisco 7500
  - Cisco 2600, 3600, 3810
- WAN Backbone
  - Cisco 7500
  - Catalyst 8500
- International Offices
- Suppliers and Buyers
- (Extranet)
- Internet
- Regional and Branch Office
  - Cisco 7100
  - Cisco 2600, 3600, 3810
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, and QoS
- Highly cost effective

WAN Gateway Options

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

The Access 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 Layer 3 Services
- Homing to Cisco IGX 8540
  - Low-Speed Campus Link
  - High-or Low-Speed WAN Link
  - Legacy Data and Voice Services

The Distribution Layer

- Reduce cost
- Reduce management complexity
- Reclaim rack space
- Simplify sparing
- Manage WAN link costs
WAN Backbone Options—Routed WAN

- Classic Cisco 7200/7500 Routed WAN Backbone
  - Layer 3 services
  - Multiprotocol support
  - Multiservice
  - Layer 2 options
  - QoS improving (CBWFQ)
  - Flexible interfaces

WAN Backbone Options—Campus MAN

- Classic Cisco 7200/7500 routed WAN backbone
  - Multiservice
  - ATM switched backbone using 8540 MSR
  - ATM centric
  - High performance
  - Layer 3 services
  - Router ATM connectivity
  - High-speed interfaces
WAN Backbone Options—Frame Relay or ATM Switching

- Multiservice Switched Frame Relay or ATM backbone using Cisco IGX 8400 or Cisco 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
  - Layer 2 QoS

WAN Backbone Options: Packet Over SONET

- Uses Cisco GSR 12000, 7500, or Cisco 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
WAN Edge Options—Wireless

- Combination of cable Cisco UBR 7200 platform with wireless-based technology
- Up to symmetrical 44.4 Mbps serial PPP link

Cisco WAN Product Matrix

<table>
<thead>
<tr>
<th></th>
<th>TDM</th>
<th>X.25</th>
<th>Frame Relay</th>
<th>ATM</th>
<th>SONET</th>
<th>Max Line Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco 3810</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>E1</td>
</tr>
<tr>
<td>Cisco 3600</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>OC-3</td>
</tr>
<tr>
<td>Cisco 7200</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>OC-3</td>
</tr>
<tr>
<td>Cisco 7500</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>OC-3</td>
</tr>
<tr>
<td>Cisco ISR 3303</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>OC-48</td>
</tr>
<tr>
<td>Cisco MSR 8500</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>OC-48</td>
</tr>
<tr>
<td>Cisco IGX 8400</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>OC-3</td>
</tr>
<tr>
<td>Cisco BPX 8600</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>OC-12</td>
</tr>
</tbody>
</table>

Location
- Branch
- Branch/Hub
- Hub/Core
Agenda

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

WAN Routing Methodologies

- Routed WAN
  Choice of routing protocol is a planning/design issue prior to building the WAN
  Main area to examine is Layer 2 design impact on Layer 3 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 Layer 2 network
WAN Protocol Issues

- Possibility of non-optimized routes at set-up
- Traffic and route determinism required
- 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

Factors Determining Protocol Convergence

- Network size
- Hop count limitations
- Peering arrangements (edge, core)
- Topology design
- Routing information compatibility
- Port and switch-level addressing
- Path selection
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 2204–2220**

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.)
Protocol Convergence: Factors to Consider

- Network topology, overall bandwidth availability, and 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

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!
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

Comparison of Routing Protocols

<table>
<thead>
<tr>
<th></th>
<th>Link State</th>
<th>Traditional Distance Vector</th>
<th>Advance Distance Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalability</td>
<td>Good</td>
<td>Low</td>
<td>Excellent</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Memory</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>CPU</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Convergence</td>
<td>Fast</td>
<td>Slow</td>
<td>Fast</td>
</tr>
<tr>
<td>Configuration</td>
<td>Moderate</td>
<td>Easy</td>
<td>Easy</td>
</tr>
</tbody>
</table>
Agenda

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

Classic Network Design

- Backbone
- Distribution
- Access

Holds True Whether LAN or WAN; In This Context the Enterprise WAN Can Be the Backbone, or the Backbone Plus the Distribution Layer
Design Problems

- Achieving homogenous design with heterogeneous media
- 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
- Regular validation of the ‘cookie cutter’

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
- Good decisions through multiple iterations and varying “what-if” analyses
- Baselining regularly enables design optimization and planning
LAN and WAN Modeling and Optimization

Design Progression

User Requirements ➔ NetSys + WANDL WANPRICER

Router and Switch Location and Traffic Matrix ➔ WANDL WANPRICER

Sites, Links, and PVCs ➔ NMT WSA
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
- Pro-active feedback and reaction time will be less critical
- Can portions of the Network be outsourced more cost effectively? SLAs?

Network Planning and Auditing

- Sophisticated network capacity planning is 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
QoS on the WAN

- **TDM:**
  QoS integral to the transmission technology

- **Frame Relay:**
  FR traffic-shaping
  FRF11, FRF12

- **ATM:**
  Integral to the transmission technology

- **SONET:**
  Classical SONET integral QoS
  POS IP QoS
IP/QoS Constituents

- IP precedence and BGP propagation
- **Committed Access Rate**
- **Weighted Fair Queuing**
- **Weighted Random Early Detection**
QoS Metering for SLA

- Source IP Address
- Destination IP Address
- Source TCP/UDP Port
- Destination TCP/UDP Port
- Next Hop Address
- Source AS Number
- Dest. AS Number

NetFlow Data Record (V5)

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
Agenda

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

Case Study

- Requirements:
  International enterprise
  HQ (2 campuses) + 2 distributions sites
  Multiple sales offices
  Internet (dual connection)
  Local and international remote access
  Multiple partners (critical, non-critical)
Metropolitan Area Network

Diversify the COs and Carriers
Possibly Leased Dark Fiber

Sunnyvale
Cisco GSR 12008
OC-12
Santa Clara

OC-3
CAMPUS or MAN
SONET RING
SNVACA01
SNTCCA11

Public Carrier
Backup Public Carrier

Metropolitan—Close-Up

hostname sunnyvale-gw
!
interface POS0/1
description OC3 to santacalara-gw
ip address 10.1.1.1 255.255.255.252
ip pim sparse-dense-mode
ip mrout-cache distributed delay 7
crc 16
clock source internal

hostname santacalara-gw
!
interface POS0/1
description OC3 to sunnyvale-gw
ip address 10.1.1.2 255.255.255.252
ip pim sparse-dense-mode
ip route-cache distributed
crc 16
ATM Wide Area Links

New Jersey

ATM

Brussels

SONET

Sunnyvale

Santa Clara

WAN Core—Close-Up

Cisco 7206—300/PA-A3

hostname hq-gw

! interface ATM5/0.1 point-to-point description to euro-gw : CID LLOOP : CID SP bandwidth 2000 ip address 100.10.1.5 255.255.255.252 pvc-bundle datapvc 100/100

hostname euro-gw

! interface ATM5/0.1 point-to-point description to hq-gw : CID LLOOP : CID SP bandwidth 2000 ip address 100.10.1.6 255.255.255.252 pvc-bundle datapvc 100/100

Other Considerations:
- Traffic Prioritization, Rate Limiting, and Classification
- Service Provider’s ATM Network for Maximum Redundancy
- ATM Chose for Scalability and Burst Capability
- At Least 2–3 Paths to Each Site
- Packet Over SONET (POS) in the MAN
- Disparate Central Offices for Physical Redundancy
**WAN Core—QoS**

```
class-map Gold
  match access-group 101
!
policy-map wan_policy
  class Gold
    bandwidth 512
    queue-limit 64
    random-detect
!
interface serial 0/0
  service-policy output wan_policy
!
access-list 101 permit ip any any precedence 5
```

**Internet Service Providers**

- Dual Attached for Regionalized Traffic
- Santa Clara Fatpipe for VPN Traffic, Bulk Users, Etc.
- BGP Peering with ISP and Brussels
ISP Close-Up

hostname internet-gw
interface Serial5/0
description To isp.net : CID LLOOP : SP
ip address 150.10.1.1 255.255.255.252
framing c-bit isp-gw
cablelength 50
dsu bandwidth 44210
router bgp 110
neighbor 150.10.1.2 remote-as 150

hostname isp-gw
interface Serial5/0
description To corp.net : CID LLOOP : SP
ip address 150.10.1.2 255.255.255.252
framing c-bit
cablelength 50
dsu bandwidth 44210
router bgp 150
neighbor 150.10.1.1 remote-as 110

Sales Office/Partner Sites

- Intranet—field sales offices
  Bandwidth by population, applications
  Common policy
  Trusted network

- Extranet—partners
  Bandwidth by business impact
  No autonomy/control
  Un-trusted network
US Field Sales Offices

- Channelized DS-3 in Santa Clara
- 128K–512K to Field Sales Offices
- PRI Homed to Sunnyvale
- ISDN DDR Backup to Each Site

European Field Sales Offices

- ATM
- Leased Line (HDLC)
- Frame Relay
Remote Access Networks

• Don’t get burned…
  In house, outsourced, or hybrid?
  Does the bandwidth scale?
  Should I own or lease equipment?
  Have I established a clear policy?
  Can I afford support and management?

Remote Access Networks

• Dense concentration should be leveraged (CLECs, etc.)
• Outsource moves, adds, and changes
• Sparse concentration should be flexible, IP based (VPNs)
• Mobile option needs to be provided
Remote Access Network

International Remote Access

Compulsory Tunneling Options:
- PPTP/MPPE (12.0(7)XE)
- Layer 2 TP/IPSEC (Win2000)
International Remote Access—PPTP Tunneling Example

```
aaa new-model
aaa authentication ppp [LISTNAME] radius local
!
vpdn enable
!
vpdn-group 1
accept-dialin
protocol pptp
virtual-template 1
!
interface Loopback0
ip address 20.0.0.1 255.255.255.0
!
interface virtual-template 1
ip unnumbered Loopback0
peer default ip address pool VPDN
compress mppc
ppp encrypt mppe auto
ppp authentication ms-chap
!
ip local pool VPDN 1.1.1.3 1.1.1.254
```

Summary

- Plan simple, redundant, and manageable networks
- Do a cost-benefit analysis of all technical options
- Monitor aggressively—SLAs are a two-edged sword
- Outsource where possible to focus on core business
- **KEEP CONTROL**
You Should See Sessions...

- 2204—Introduction to Routing Protocols
- 2209—Deploying BGP
- 2301—Deploying Traffic Management and QoS Technology
- 2307—Introduction to Wireless Technology
- 2401—Deploying Remote Access VPNs
- 2502—Deploying Secure Networks
- 2601—Introduction to Service Level Management
- 2609—Introduction to High Availability Networking

Deploying Wide Area Network Technologies (FR, ATM, Serial)

Session 2304
Please Complete Your Evaluation Form

Session 2304

Cisco Systems

Empowering the Internet Generation SM