Chapter 4 *Enterprise Network Design*

Topics covered:
Enterprise Network Design Model. Backbone design concepts. Structured cabling systems.

Definition

An enterprise network consists of a group of local area networks (LANs) interconnected using wide area networks (WANs). An enterprise network contains a number of internetworking devices (e.g., switches, routers, gateways, etc) and is under the control of one big organization.

4.1 Enterprise Network Design Model (Hierarchical Model)

Two design options:

- Design a network infrastructure from the ground up.
- Meld the new technologies into an existing infrastructure.

A model is vital for analyzing large, complex internetworks.

→ Use of guidelines or rules.

Internetworks are generally implemented in a hierarchical manner.

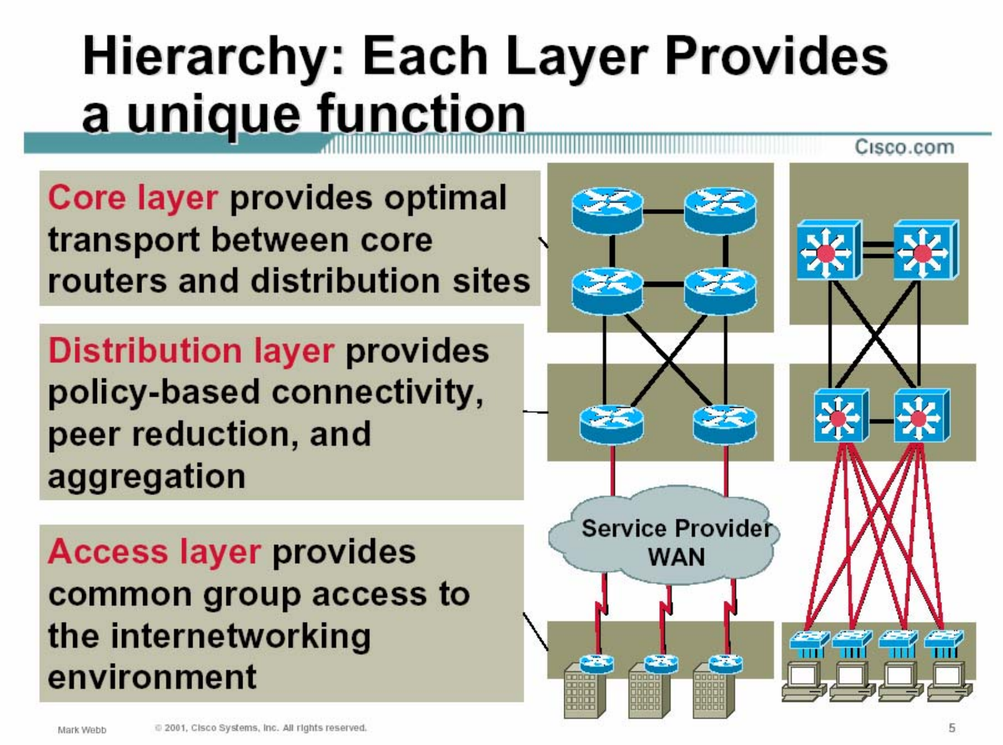
4.1.1 Three-tier hierarchical model

It consists of:

-
-
-

Each level provides a backbone for the level below.

Definition: A backbone is a network whose primary purpose is the interconnection of other networks.



Hierarchy: Each Layer Provides a unique function

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Core layer provides optimal transport between core routers and distribution sites

Distribution layer provides policy-based connectivity, peer reduction, and aggregation

Access layer provides common group access to the internetworking environment

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(Slide taken from http://www.cisco.com/warp/public/cc/so/neso/meso/uentd_pg.pdf)

4.1.1.1 Core tier

- Provides optimal wide-area transport between geographically remote sites.
- Connects campus networks in a corporate or enterprise WAN
- Services are typically leased from a telecom service provider
- May use the public Internet as enterprise backbone.
- Focus on redundancy and reliability
- Need to efficiently use bandwidth because of provider tariffs.
- End Stations should not be put in the core

Design Rule:

4.1.1.2 Distribution tier

- Connects multiple networks (departments) within a campus network environment.
- Includes campus backbone network, based on FDDI, Fast Ethernet, Gigabit Ethernet, or ATM.
- Acts as a concentrator points for many of its access tier sites.
- Links usually owned and/or controlled by the organization.
- Network policy is often implemented in this tier.

Design Rule:

4.1.1.3 Access tier

- Usually a LAN or a group of LANs.
- Typically uses Ethernet, Token Ring, or FDDI.
- Can be divided into two levels (workgroup level & desktop level)
- Where hosts are attached to the network.
- Connects workgroups
- Usually within a single building (or single floor)

- Provides logical network segmentation, traffic isolation and distributed environment

- Remote (dialup) users are connected at this tier.

Design Rule:

4.1.2 Benefits of a Hierarchical Design Model

Network designs can be: mesh or hierarchical. In a mesh structure, the network topology is flat.

1. Scalability

2. Ease of implementation

3. Ease of troubleshooting

4. Predictability

5. Protocol support

6. Manageability

4.1.3 Variations on the three-tier model

4.1.3.1 One-tier Design – Distributed

- Remote networks connect to a pseudo-core

- Good for small networks with no centralized server location.

4.1.3.2 One-tier Design – Hub and Spoke

- Servers are located in central farms.

4.1.3.3 Two-tier Design

- A campus backbone interconnects separate buildings

4.1.3.4 Redundant Two-tier Hierarchy

- Core LAN backbone is duplicated for total redundancy.

4.1.4 Hierarchical Design Guidelines

- Choose a hierarchical model that best fits your requirements

- Do not always completely mesh all tiers of the network

- Do not place end stations on backbones

- Workgroup LANs should keep as much as 80% of their traffic local to the workgroup

- Use specific features at the appropriate hierarchical level.
- Control the diameter of a hierarchical enterprise network topology (in most cases, 3 major layers are sufficient)
- Avoid chains at the access layer
- Avoid backdoors (i.e., connection between devices in the same layer)
- Design the access layer first, then the distribution layer, and finally the core layer.

4.1.5 Mesh vs. Hierarchical-Mesh Topologies

- In full-mesh topology, every router or switch is connected to every other router or switch. It provides complete redundancy

- A partial-mesh topology has fewer connections

- Mesh networks can be expensive to deploy and maintain

- A classic hierarchical and redundant enterprise design uses a partial-mesh hierarchy rather than a full mesh.

4.2 Redundant Network Design Topologies

Redundancy:

- Provides network availability by duplicating network links and interconnectivity devices
- Eliminates the possibility of having single point of failure on the network
- Helps you meet the availability goals for users accessing local services (in campus networks)
- Helps you meet overall availability and performance goals (in enterprise networks)
- Adds complexity to the network topology and to network addressing and routing

4.2.1 Backup Paths

- A backup path:
  - Consists of routers and switches and individual backup links between routers and switches.
  - Maintains interconnectivity even when one or more links are down
- Two aspects of the backup path to consider:
  - How much capacity does the backup path support?
  - How quickly will the network begin to use the backup path?
- Use a modeling tool to predict network performance when backup is in use:

→ It can be acceptable that the performance of the backup path is worse than that of the primary path.

- Backup path usually have less capacity than primary path, e.g., a leased line with a backup dial-up line. However, requirements may state that both must provide the same performance.

- Automatic failover is necessary for mission-critical applications.

- Backup path must be tested

- Some backup links are used for load balancing as well as redundancy

4.2.2 Load Balancing

- Redundancy improves performance by supporting load balancing across parallel links.

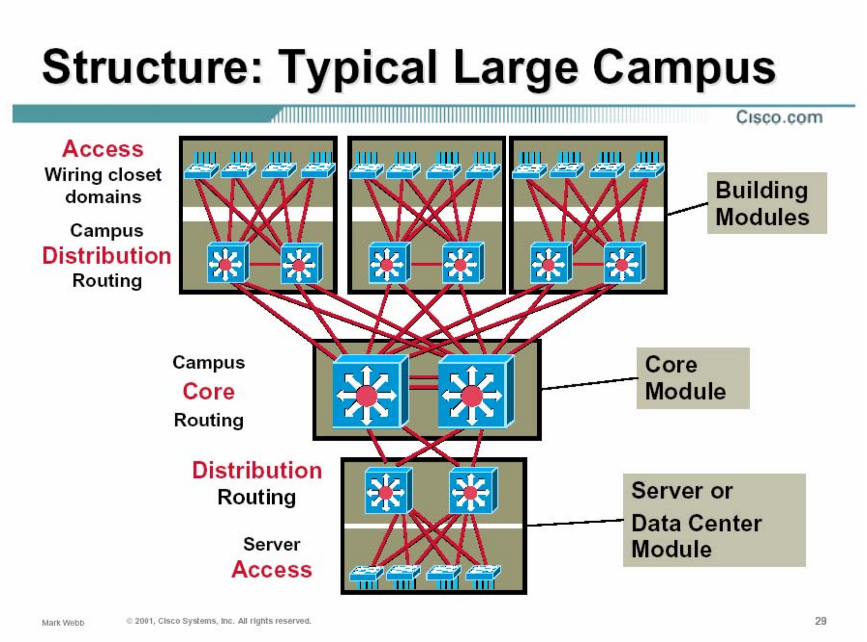
- Load balancing must be planned and in some cases configured.

- Cisco supports balancing across 6 parallel paths.

4.3 Designing a Campus Network Design Topology

- Redundant LAN segments
    - Design redundant links between LAN switches.
    - The spanning tree algorithm guarantees that only one path is active between two stations.

- Server redundancy
  - Depends on the customer's requirements
  - Services include: file, web, DHCP (Dynamic Host Configuration Protocol), name, database.
  - Use redundant servers when needed (e.g., DHCP). The servers should hold redundant (mirrored) copies of the DHCP database. DHCP servers can be placed at either the access or distribution layer.



Structure: Typical Large Campus

4.4 Designing an Enterprise Network Design Topology

- Enterprise network design topology should meet a customer's goals for availability and performance:
  - Redundant LAN and WAN segments in the intranet
  - Multiple paths to extranets and the Internet.

- Redundant WAN segments
  - Usually uses a hierarchical partial-mesh topology.
  - Circuit diversity: physical circuit routing of backup WAN links and primary WAN links should be different than each other.

- Multihoming the Internet connection: provides an enterprise network more than one entry into the Internet (i.e., redundancy and fault tolerance)

  - **Definition:** ***Multihoming*** - provide more than one connection for a system to access and offer network services

- Virtual Private Networks (VPNs): enables the use of a public network, such as the Internet, to provide a secure connection among sites on the organization's internetwork.

  - A public network is used as a backbone for the enterprise network.

  - Links remote offices together.

  - Inexpensive compared to private leased lines.

- Private data is encrypted for routing through the public network
- No permanent link is required.
- Can use Dial-on-demand routing (DDR).

4.5 Secure Network Design Topologies

- Planning for physical security: protection from unauthorized access, theft, vandalism, and natural disasters.
- Meeting security goals with firewall topologies:
  - **Definition:** ***Firewall*** – a system or combination of systems that enforces a boundary between two or more networks (according to the National Computer Security Association (NCSA)).
  - A firewall can be:
    - a router with access control lists (ACLs),
    - a dedicated hardware box, or
    - software running on a PC or UNIX system.

- A firewall should be placed in the network so that all traffic from outside the protected network must pass through the firewall.

- A firewall is important at the boundary between the enterprise network and the Internet.

- A basic firewall topology is simply a router with:
    - a WAN connection to the Internet,
    - a LAN connection to the enterprise network, and
    - software that has security feature.

- Firewall topology can include a public LAN that hosts Web, FTP, DNS, and SMTP servers (for customers who need to publish public data).
    - This public LAN is referred to as: ***demilitarized or free-trade zone***.

- Larger companies use a dedicated firewall in addition to a router between the Internet and the enterprise network.

4.6 Backbone Design

There are two types of backbone design:

- Distributed backbones
- Collapsed backbones

4.6.1 Distributed Backbones

4.6.1.1 Distributed Backbones in Buildings (Figure 5-3 in [1])

- Each floor's router is directly connected to a centralized backbone.
- The backbone is typically and FDDI ring. This provides maximum fault tolerance.
- Generally, do not contain a single point of failure
- Requires extra input and output ports for each component
  - Faults quickly corrected by isolation process
  - High cost
- **Drawbacks:**
  - Multiple IP network numbers → difficult to add, move, or change users.
  - More expensive
  - Migration to switching not easy.
  - Less-flexible approach to wiring a building.

4.6.1.2 Distributed Backbones on the Campus (Figure 5-4 in [1])

- More resource-efficient solution than in a building.
- **Drawback:**
  - Lack of flexibility in connecting to other buildings on the campus.

4.6.2 Collapsed Backbones (Figures 5-5 and 5-6 in [1])

- Has a single concentration point connecting all floors.
- All floor-to-floor connectivity passes through the backbone component.
- Problem isolation is simple, while finding problem's root cause is difficult.
- More flexible and cost-effective approach to wiring a building.
- Changes can be easily made.
- Single point of failure (Router)

  → **Solution:** Router with HSRP (Hot Standby Router Protocol).

- Can be extended to accommodate VLANs.
  - VLANs in a building
    - More flexibility in positioning of end stations and servers.
  - VLANs accross a campus
    - One switch acts as the backbone for the entire campus.
    - Assign stations to VLANs such that only 20% of their traffic is destined to other VLANs.

4.7 Structured cabling Systems (SCS)

4.7.1 SCS Principles

- Studies have shown that more than 50% of all network disruptions are related to cabling.

- IBM & AT&T developed generic cabling systems based on STP cables and UTP cables, respectively.

- SCS objectives:
  - Use a single common cable type that supports many applications
  - Remain cost effective (i.e., minimum additional equipment required)
  - Based on a "flood wiring" approach.
  - Ability to support any given application
  - Reliability of the system.

- SCS topology:
  - Based on "star" topology in a tree-like fashion.
  - Distribution point provides the administration (patching) points for the system
  - All systems must comprise at least the horizontal distribution level
  - At each distribution point, application specific equipment (e.g., computer systems, repeaters, switches, etc) are patched into the system for user connectivity.

- SCS standards:
    - EIA/TIA-568 standard: “Commercial Building Telecommunications Wiring Standard” (1990)
        - Included the use of both 10Base2 and 10Base5 media (i.e., coaxial)
        - EIA: Electronics Industry Association (www.eia.org)
        - TIA: Telecommunications Industry Association (www.tiaonline.org)

    - ANSI/EIA/TIA-568-A standard: provides ideal design platform
        - Different media is possible
        - SCS terminology in ANSI is different from ISO’s
            - ANSI: American National Standards Institute
            - ISO: International Standards Organization

4.7.2 Areas within a SCS System

- SCS comprises 3 cabling subsystems:
    - Horizontal cabling subsystem.
    - Building backbone subsystem.
    - Campus backbone subsystem.

- The work area cabling is also necessary but outside the scope of SCS standards.

4.7.2.1 Horizontal Cabling Subsystem

- Includes:
    - Horizontal distribution cables
    - Connecting hardware
    - Cross-connect patching at the Floor Distributor (FD)

- Media options: UTP, STP, optical fiber (multimode)

- Horizontal distribution cable should be continuous

    - However, a single transition point can be included between FD and TO.

        - Source of increased crosstalk.

- Maximum distance is 90 meters from FD to TO.

    - Maximum 5 meters for patch cords and work area fly leads.

→ Maximum 5+90+5=100 meters between equipment and end-user.
(100 meters is the maximum transmission distance for high speed data over twisted pair)

4.7.2.2 Building Backbone Cabling Subsystem

- Includes:
    - Building backbone cable
    - Termination hardware
    - Cross-connect patching at the Building Distributor (BD)

- Media options: UTP, STP, optical fiber (multimode and single mode)

- Transition points not allowed.

- Maximum distance is 500 meters.

- Maximum 20 meters for patch cords length.

4.7.2.3 Campus Backbone Cabling Subsystem

- Includes:
    - Campus backbone cable
    - Mechanical termination of backbone cable
    - Cross-connect patching within the Campus Distributor (CD)

- Media options: mainly optical fiber (for longer distances and electrical isolation)

- Maximum distance is 1500 meters.

    - Added to the building backbone maximum distance (i.e., 500 meters)

    → 2 km, that is the maximum supported distance for high speed data over multimode fiber optic.

- Maximum 20 meters for patch cords length.

4.7.3 Application Classes

- Applications must be taken in consideration when designing an SCS

<u>Example</u>: Ethernet maximum transmission limit is 100 meters over UTP cables.
→ Ethernet will not run over UTP backbone of 500 meters.
→ Backbone should be reduced to 100 meters or media changed to fiber optic

- Mapping of LAN applications onto SCS:
    - Ethernet is the easiest to map onto SCS because standards were written for twisted pair media.

4.7.4 SCS Patching

4.7.4.1 Inter-Connect (Direct) Patching

- Convenient when port presentation is the same on equipment and patch panel (e.g., RJ-45)

- Requires fewer connections.
  → Minimizes the amount of crosstalk

- **Problem:** Patch cables can become a tangled mess with cables going in all directions (bad presentation).

4.7.4.2 Cross-Connect (Indirect) Patching

- Involves the addition of extra patch panels where equipment are permanentaly terminated.

- Much neater cable presentation.

- **Problem:** More crosstalk on the link mainly if the full bandwidth of the cabling is being pushed to its limits over the maximum 90 meters distribution distance.

  → Can be avoided with good installation practices.

4.7.5 Design Guidelines

- Start from the edge (i.e., work area) and work back to the center.

  Example: sizing of work areas, media type of horizontal cabling, location of FD, cabling pathways, etc.

- System administration must start at the planning stage to maximize the potential of the cabling system.

  Example: outlet identification, numbering/naming, etc.

4.7.5.1 Work Area

- 1000 m^2 of floor space is the maximum area to be supported from one FD.
- Work area sizing: 2 m^2 → 10 m^2 (However, this is site specific decision)
- Number of TOs per work area: at least 2 (1 copper, and 1 fiber or copper).
- Design work areas to form logical "zones"
  - Some buildings may require multiple FDs to service all locations on a floor.
- Overlaying, or interleaving the cabling (multiple pathways are used) can provide a high degree of resilience when a pathway is damaged.
  - Much higher installation and material cost.

4.7.5.2 Distributor Layout

- Type of patch panel, FD housing (cabinet, rack, etc), sizing, location, etc.

- Each cabinet contains a proportion of all elements (e.g., some horizontal cabling, some equipment, etc.)
    - If a cabinet is lost (e.g., due to power failure), a proportion of users will not be affected.

4.7.5.3 The Backbone

- May need to provide two backbones: one for voice and one for data.

- Resilience: implement multiple backbones via multiple risers and have additional capacity in each backbone.

4.8 References

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