Business Data Communications & Networking:

12th Edition

Chapter 6: Network Design

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NETWORK DESIGN

- We now learn how to design networks.
- We usually design networks in **seven network architecture components**:

1. Local Area Networks (**LANs**)
2. **Building Backbone Networks**,
3. **Campus Backbones** that connect buildings,
4. **Wide Area Networks** (WANs) that connect campuses,
5. **Internet access**,
6. **e-commerce edge**, and
7. **Data Centers**.

Network design is an ***iterative*** process in which the designer examines users' needs, develops an initial set of technology designs, assesses their cost, and then revisits the needs analysis until the final network design emerges.

OBJECTIVES

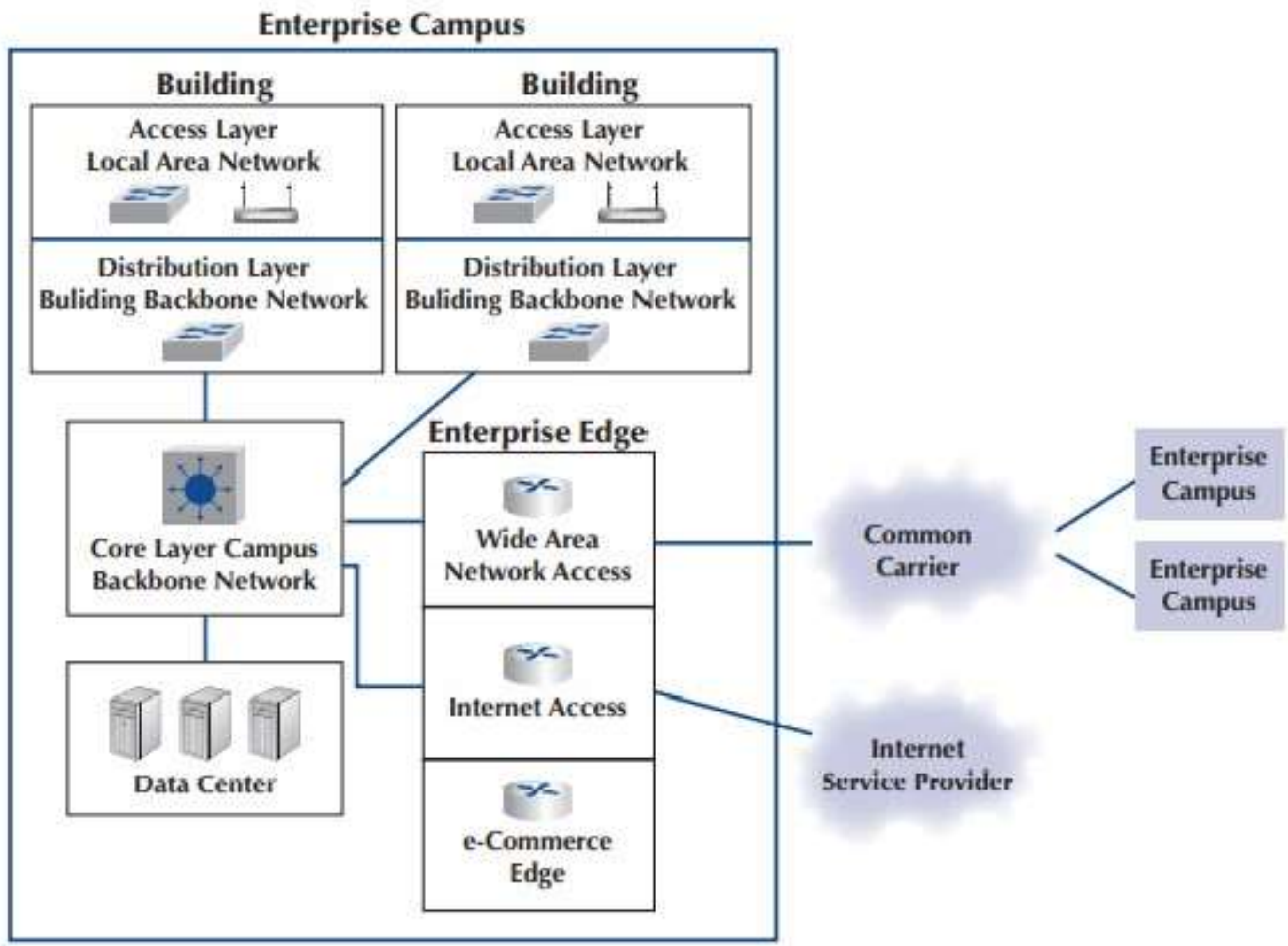
- **Understand** the seven network **architecture components**
- **Describe** the **overall process of designing** and implementing a network
- Describe **techniques for developing a logical network design**
- Describe **techniques for developing a physical network design**
- Understand network design principles

Example t

- Figure shows a typical network for a large enterprise
- This organization has three enterprise campuses in different cities that are connected by a WAN provided by a common carrier such as STC or AT&T.
- Each **campus has several buildings that are connected by a backbone network**.
- The **first** network architecture component is the Local Area Network (**LAN**), which enables users to access the network (**ACCESS LAYER**)
- The **technologies** we use in the LAN are:
  - **network hubs, switches, and wireless access points**.
- The **second** network architecture component is the building **backbone network**, **which some vendors call the distribution layer**
- The building backbone uses the same technology as LANs (a network switch), but **usually faster** switches because the building backbone carries more network traffic than a LAN.
- The **third** network architecture component is the **campus backbone** (sometimes called the **CORE LAYER**), which connects all the buildings on one campus.
  - The campus backbone is usually faster than the backbones we use inside buildings because it typically carries more traffic than they do.

6.1.1 Network Architecture Components

- Network designers think about networks as 7 network architecture components.



Example (contdd).

- We use routers or layer 3 switches that do routing when we design the campus backbone.
- The **fourth** network architecture component is the data center, which contains the organization’s servers (e.g., database servers, email servers).
  - **The data center is essentially a LAN**, but because so much traffic goes to and from the data center, it is typically designed and managed very differently than the LANs intended for user access.
    - The data center is usually located centrally on the enterprise campus, with a **very, very high-speed connection to the campus backbone**.
  - There is usually one primary data center for the organization, typically found on its main headquarters campus.
  - ***It is common for large organizations to have several data centers spread around the world*** **(Why?).**
  - Many enterprise campuses have their own smaller data centers that store data just for that campus.
  - **The last three components of the network architecture make up the enterprise edge**, the parts of the network that **are at the edge of the enterprise campus and connect that campus to the rest of the world**.

Example (cond).

- A **WAN** is a private network that connects its different campus locations, usually leased from a **common carrier** such as AT&T or STC.
- **The WAN is for the private use of the organization and only carries its network traffic from one campus to another, unlike the Internet.**
- **The circuits used in the WAN are *traditionally very different* than the Ethernet we use in the LAN.**
- Another network architecture component is the **Internet access component**, which enables the organization to connect to the Internet.
- **Large organizations use the *same technologies* to connect to the Internet as they use in the WAN.**
- Small companies and individuals like us typically use ***cable modem or DSL***.
- The final network architecture component is the **e-commerce edge**.

Example (cond).

- **The e-commerce edge** is a special LAN with a group of servers that enables ***electronic data exchange between the organization and the external entities*** with which it does business (such as its ***customers or suppliers***).
- **For example, the organization's *primary Web server is located* in the e-commerce edge.**
- Like the data center, the **design of the LAN for the e-commerce edge is *specialized*; because the e-commerce edge often requires different security.**
- Network design usually **begins at the access layer, not the core layer**.
  - The **needs of the users** drive the network design (as well as **the applications in the data center**).
  - Most organizations put the last five components in the same building: The switches and routers that compose the **campus backbone**, the **data center**, and the **enterprise edge** are usually placed in one central building on campus so that data move very quickly between the enterprise edge, the **campus backbone**, and the data center.

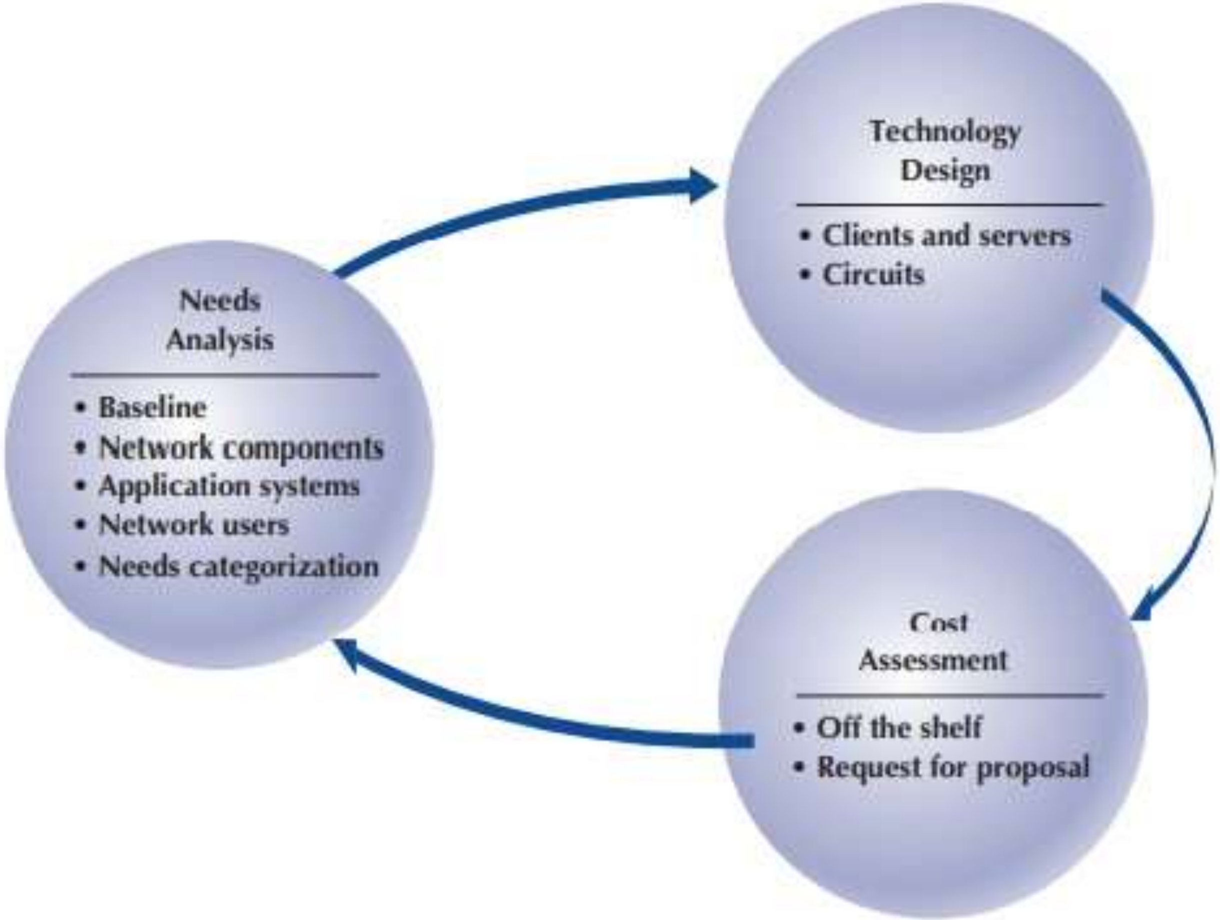
6.1.2 The Traditional Network Design Process (***)

- **Starts** **with the network analyst meeting with users** to identify user needs and the application systems planned for the network.
- **Second**, **the analyst develops a precise estimate of the amount of data that each user will send and receive** and estimates the total amount of traffic on each part of the network.
- **Third, the circuits needed to support this traffic plus** a modest **increase** in traffic are cost is estimated (obtained from vendors).
- Finally, 1 or 2 years later, the network is built and implemented.
- This **traditional** process, although expensive and time-consuming, **works well for static or slowly evolving networks**.
- **Unfortunately, networking today is significantly different.**
- **Three forces are making the traditional design process less appropriate for many of today's networks.**
  - First, the underlying **technology** of the client and server computers, networking devices, and the circuits themselves is **changing very rapidly**.
  - Second, the **growth in network traffic** is **immense**.
  - **Finally, the balance of costs has changed dramatically over the years**. In the early 1990s, the most expensive item in any network was the hardware (circuits, devices, and servers). **Today, the most expensive part of the network is the staff members who design, operate, and maintain it.**

6.1.3 The *Building-Block* Network Design Process

- The key concept in the building-block process is that networks that use a few standard components throughout the network are cheaper in the long run.
- Rather than accurately predicting user traffic and build networks to meet those demands, the building-block process instead starts with a few standard components and uses them over and over again, even if they provide more capacity than is needed. The goal is **simplicity** of design.
- This strategy is sometimes called “narrow and deep” because a very narrow range of technologies and devices is used (very deeply throughout the organization).
- The results are a **simpler design process and a more easily managed network built with a smaller range of components**.
- The building-block process to network design involves three steps that are performed repeatedly: **(i) needs analysis (mostly an educated guess), (ii) technology design, and (iii) cost assessment.**
- During needs analysis, the designer attempts to understand the fundamental current/future network needs of the various users, departments, and applications.
- In technology design, the available technologies and assessed/examined to determine which options will meet users’ needs. The designer makes some estimates (e.g., 1 Gbps Ethernet) and matches the needs to technologies. **Mostly building more capacity than needed and by designing networks that can easily grow**
- In the third step, cost assessment, the relative costs of the technologies are considered.

FIGURE 6-2
Network design



6.2.5 DELIVERABLES t

- The key deliverable for the needs assessments stage is a set of logical network diagrams, showing the applications, circuits, clients, and servers in the proposed network, each categorized as either typical or high traffic.
- The logical diagram is the conceptual plan for the network and **does not** consider the specific physical elements (e.g., routers, switches, circuits) that will be used to implement the network.
- Figure 6-4 shows the results of a needs assessment for a building that includes the access layer (LANs), the distribution layer (building backbone), and the core layer (campus backbone).
- This figure shows the distribution and access components in the building with the series of six access LANs connected by one building backbone, which is in turn connected to a campus core backbone.
- One of the six LANs is highlighted as a high-traffic LAN, whereas the others are typical.
- We normally would assume that the LANs need both wired and wireless access unless the requirements stated differently.
- Three mandatory applications are identified that will be used by all network users: email, Web, and file sharing. One wish-list requirement (desktop videoconferencing) is also identified for a portion of the network.
- **Once the needs have been defined in the logical network design, the next step is to develop a physical network design.**

FIGURE 6-4

Sample needs assessment Logical network design for a single building. LAN = Local area network

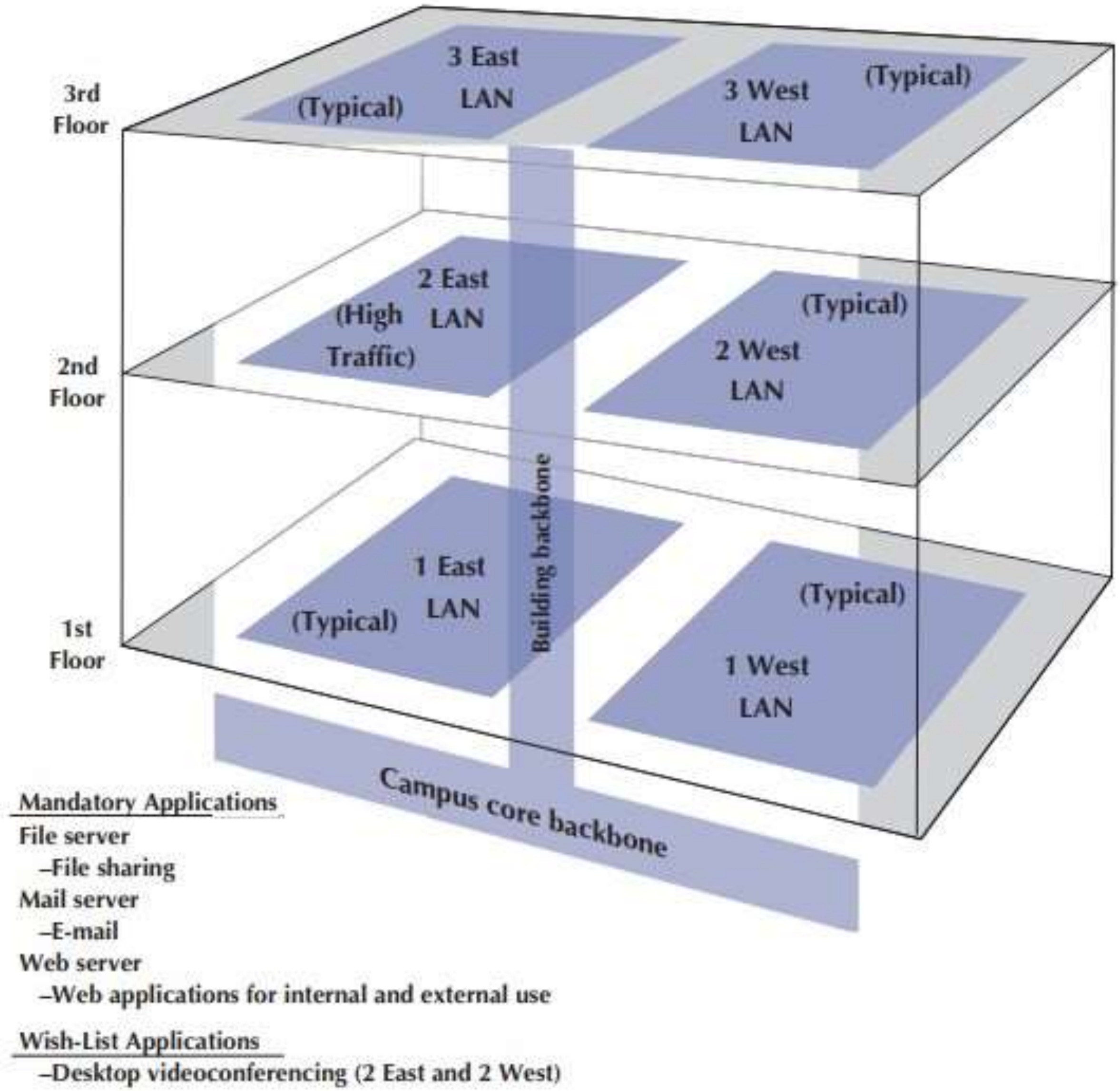
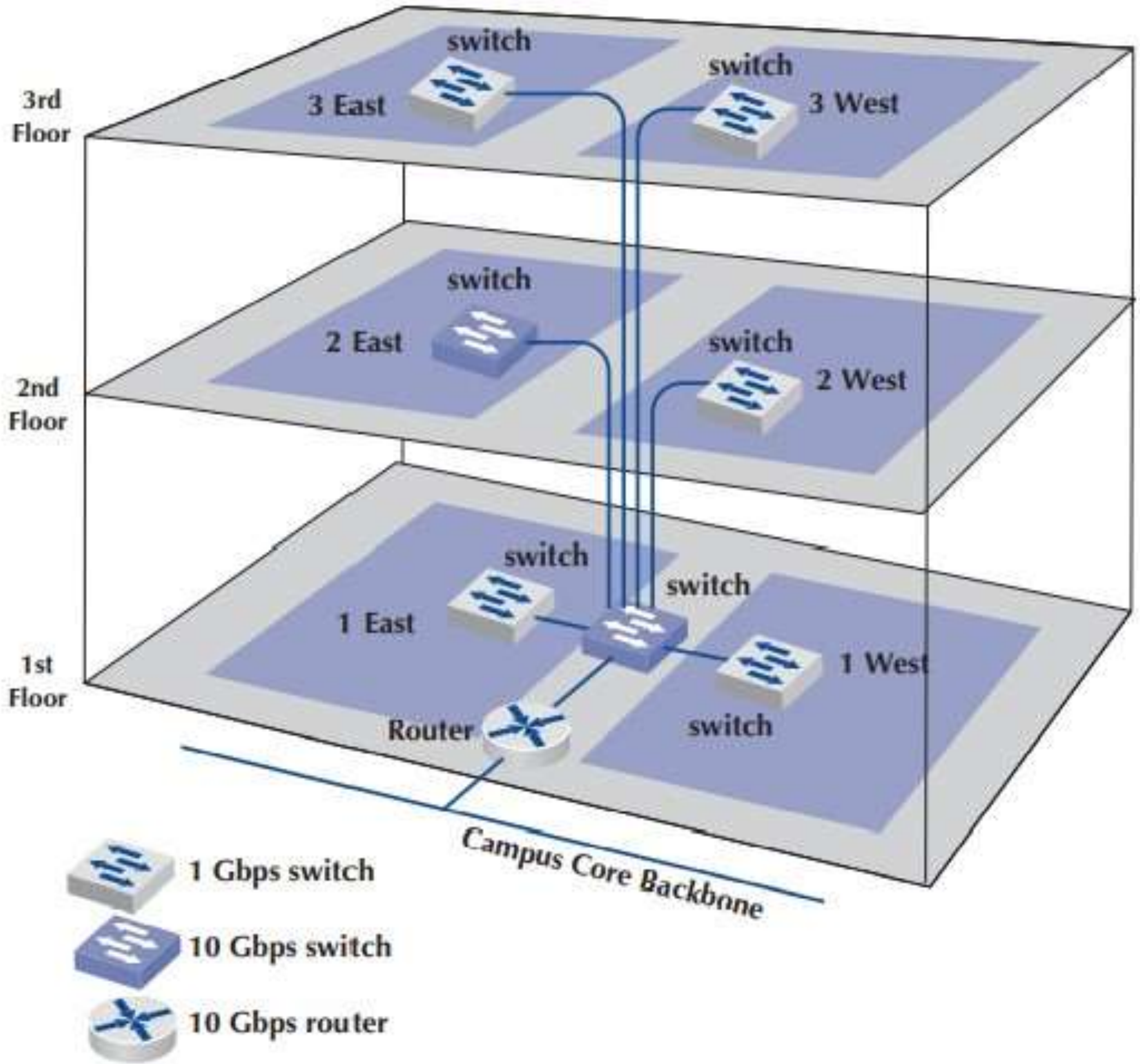


FIGURE 6-5
Physical network design for a single building



6.3.3 Network Design Tools (Modeling & Simulation) t

- Network modeling and design tools can perform a number of functions to help in the technology design process.
- With most tools, the first step is to enter a diagram or model of the existing network or proposed network design.
- Some modeling tools require the user to create the network diagram from scratch.
- Other tools can "discover" the existing network; that is, once installed on the network, they will explore the network to draw a network diagram.
- Once the diagram is complete, the user can then change it to reflect the new network design.
- Obviously, **a tool that can perform network discovery by itself** is most helpful when the network being designed is an upgrade to an existing network and when the network is very complex.
- Once the diagram is complete, the next step is to add information about traffic and see if the network can support the level of traffic that is expected.
- **Simulation, a mathematical technique that tracks the number of packets in the network and the delays encountered at each point in the network.**
- Simulation models may be tailored to the users' needs by entering **parameter** values specific to the network at hand.
- **Good tools not only produce simulation results but also highlight potential trouble spots** (e.g., servers, circuits, or devices that experienced long response times).

6.3.4 Deliverables

- The key deliverable is a set of one or more physical network designs like that in Figure 6-5, which is the design for a single building.
- Most designers like to prepare several physical designs so they can **tradeoff** technical benefits (e.g., performance) against cost.
- In most cases, the critical part is the design of the **network circuits and devices**.
- In the case of a new network designed from scratch, it is also important to define the client computers with care because these will form a large portion of the total cost of the network.
- Usually, however, the network will replace an existing network and only a few of the client computers in the existing network will be upgraded

6.4.1 Request for Proposal

- Although some network components can be purchased off the shelf (with petty cash), most organizations develop an RFP for large network purchases.
- RFPs specify what equipment, software, and services are desired.
- Some RFPs are very specific about what items are to be provided in what time frame.
- In other cases, items are defined as mandatory, important, or desirable, or several scenarios are provided, and the vendor is asked to propose the best.
- In a few cases, RFPs specify generally what is required and the vendors are asked to **propose their own network designs**.
- Figure 6-6 provides a summary of the key parts of an RFP.
- Once the vendors have submitted their proposals, the organization evaluates them against specified criteria and selects the winner(s).
- Depending on the scope and complexity of the network, it is sometimes necessary to redesign the network on the basis of the information in the vendors' proposals.
- One of the key decisions in the RFP process is the scope of the RFP.
    - Will you use one vendor or several vendors for all hardware, software, and services?
    - Multivendor environments tend to provide better performance, are less expensive, but are difficult to manage.

Request for Proposal (RFP)

Information in a Typical Request for Proposal

- Background information
    - Organizational profile
    - Overview of current network
    - Overview of new network
    - Goals of new network
- Network requirements
    - Choice sets of possible network designs (hardware, software, circuits)
    - Mandatory, desirable, and wish-list items
    - Security and control requirements
    - Response-time requirements
    - Guidelines for proposing new network designs
- Service requirements
    - Implementation time plan
    - Training courses and materials
    - Support services (e.g., spare parts on site)
    - Reliability and performance guarantees
- Bidding process
    - Time schedule for the bidding process
    - Ground rules
    - Bid evaluation criteria
    - Availability of additional information
- Information required from vendor
    - Vendor corporate profile
    - Experience with similar networks
    - Hardware and software benchmarks
    - Reference list