Business Data Communications and Networking

11th Edition

Jerry Fitzgerald and Alan Dennis

John Wiley & Sons, Inc

Dwayne Whitten, D.B.A
Mays Business School
Texas A&M University

Copyright 2011 John Wiley & Sons, Inc

Chapter 11

Network Design

Copyright 2011 John Wiley & Sons, Inc

Outline

- **11.1 - Introduction**
  - **Traditional Network Design**
  - **Building Block Network Design**
- **11.2 - Needs Analysis**
- **11.3 - Technology Design**
- **11.4 - Cost Assessment**
- **11.5 - Designing for Network Performance**
- **11.6 - Implications for Management**

Copyright 2011 John Wiley & Sons, Inc

11.1 Introduction

Copyright 2011 John Wiley & Sons, Inc

Traditional Network Design

- **A structured systems analysis and design process**
  - **Network analysis phase**
    - **Meeting with users to determine the needs and applications**
    - **Estimating data traffic on each part of the network**
    - **Designing circuits needed to support this traffic and obtains cost estimates**
  - **Implementation phase:**
    - **Building and implementing the network**
    - **Takes place a year or two later**
- **Works well for static and slowly evolving networks, although costly and time consuming**

Copyright 2011 John Wiley & Sons, Inc

Inadequacy of Traditional Design

- **Three forces make the traditional design approach less appropriate for many of today's networks:**
  1. **Rapidly changing technology of computers, networking devices and the circuits**
     - **More powerful devices, much faster circuits**
  2. **Rapidly growing network traffic**
     - **Difficulty of estimating demand and growth requires shorter planning periods of 3 years or so**
  3. **Dramatic change in the balance of costs**
     - **Before: Equipment was costly; now: staff**
     - **Design goal: Minimize the staff management time to operate rather than the hardware costs, such as using standardized equipment**

Copyright 2011 John Wiley & Sons, Inc

Building Block Network Design

- **Building block design is simpler than traditional**
- **Key concept is to use a few standard components to reduce long run costs by simplification**
  - **Use few types of devices, over and over, narrow product choice but deep throughout organization**
  - **Simpler design process yields easily managed network**
- **Phases of design**
  - **Needs analysis, technology design, and cost assessment**
  - **Cycles through, refining the outcome of each phase**

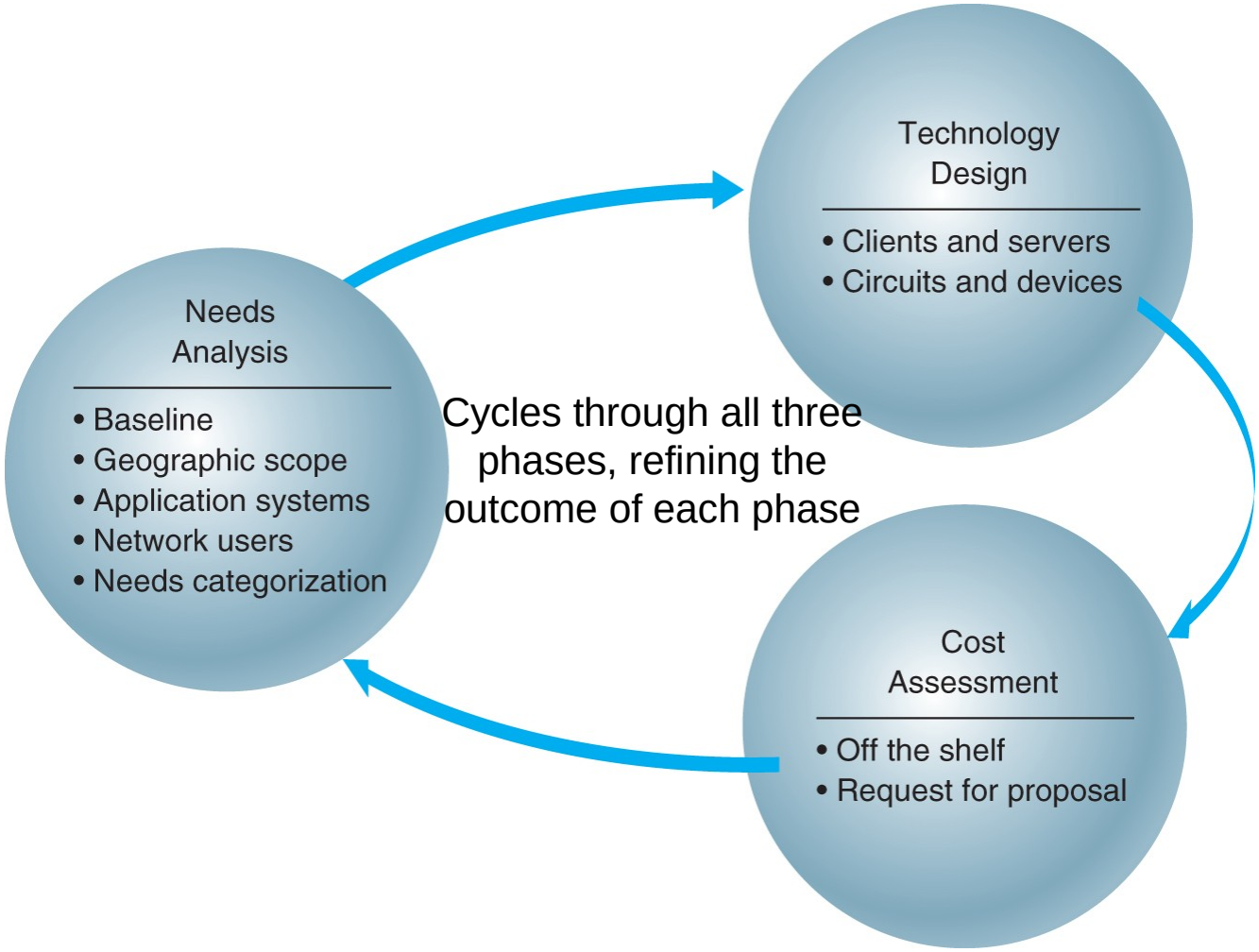
Copyright 2011 John Wiley & Sons, Inc

Phases of Building Block Design

- **Needs analysis**
  - **Understand current and future needs**
    - **Classify users and applications as typical or high volume**
    - **Identify specific technology needs**
- **Technology design**
  - **Examine available, off-the-shelf technologies and assess which ones meet the needs of user needs**
  - **In case of difficulty in determining traffic needs, provide more capacity to keep ahead of growth**
- **Cost assessment**
  - **Consider the relative cost of technology**

Copyright 2011 John Wiley & Sons, Inc

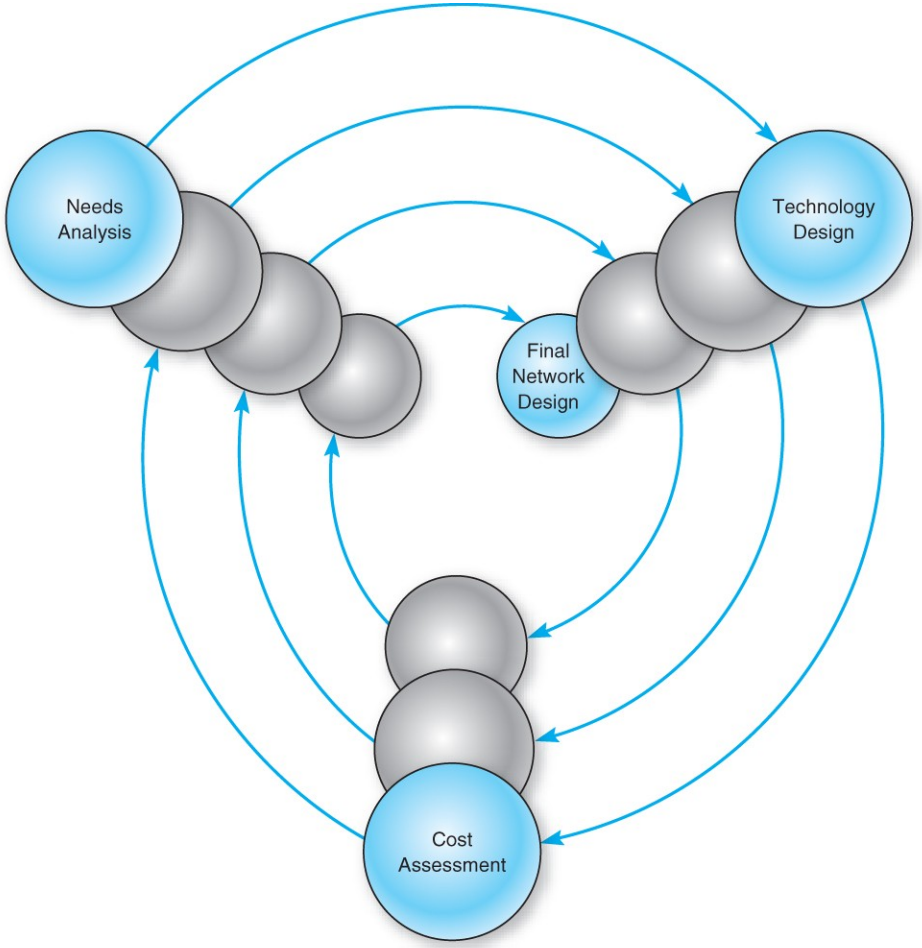
Building Block Network Design



Copyright 2011 John Wiley & Sons, Inc

Reaching a Final Network Design

Process of cycling through all three design phases is cyclical and repeated over time.



Copyright 2011 John Wiley & Sons, Inc

11.2 Needs Analysis

- **Goal is to understand why the network is being built and what users and applications it will support**
  - **improve poor performance?**
  - **enable new applications?**
  - **upgrade, replace old equipment?**
  - **standardize equipment based on vendor or protocol?**
- **Goals differ depending on the network**
  - **LAN and BN typically are built with organizational ownership, best to design in over-capacity**
  - **WAN rely more on leased equipment and circuits, best to design at capacity, and then lease additional circuits as required**

Copyright 2011 John Wiley & Sons, Inc

Baselining

- **Gain an understanding of the current operations in terms of applications systems and messages**
  - **Most projects today involve upgrades and not new network designs. Often, a good understanding of the needs already exist.**
  - **Provides baseline against future needs**
- **Baseline provides a clear picture of**
  - **Sequence of operations, processing times,**
  - **Work volumes**
  - **Current network**
  - **Existing cost**
  - **User/management needs**

Copyright 2011 John Wiley & Sons, Inc

Objective of Needs Analysis

- **Objectives**
  - **Define the geographic scope of the network**
  - **Define applications and users that will use the network**
- **The goal:**
  - **To produce a logical network design that**
    - **Describes what network elements will be needed to meet the organization's needs**
    - **Does not specify technologies or products at this stage**
    - **Focus is on functionality (e.g., high speed access network)**

Copyright 2011 John Wiley & Sons, Inc

First Step in Needs Analysis

- **Break the network into three conceptual parts (based on their geographic and logical scope):**
  1. **Access layer**
     - **Lies closest to the user; often a LAN**
  2. **Distribution layer**
     - **Connects the access layer to the rest of the network; often a backbone network**
  3. **Core layer**
     - **Connects the different parts of the distribution layer together; often a WAN**
- **Not all layers present in all networks**
  - **Small networks may not have a distribution layer**

Copyright 2011 John Wiley & Sons, Inc

Next Step in Needs Analysis

- **Goal is to produce a logical network design, describing network elements to meet needs of organization**
- **Identify some basic technical constraints**
  - **Examples: If access layer is**
    - **LAN; no need to use T1 lines**
- **Identify constraints imposed by the current network infrastructure**
  - **Example: adding a new building to an existing office complex that use 100Base-T, probably choose the same for new building**

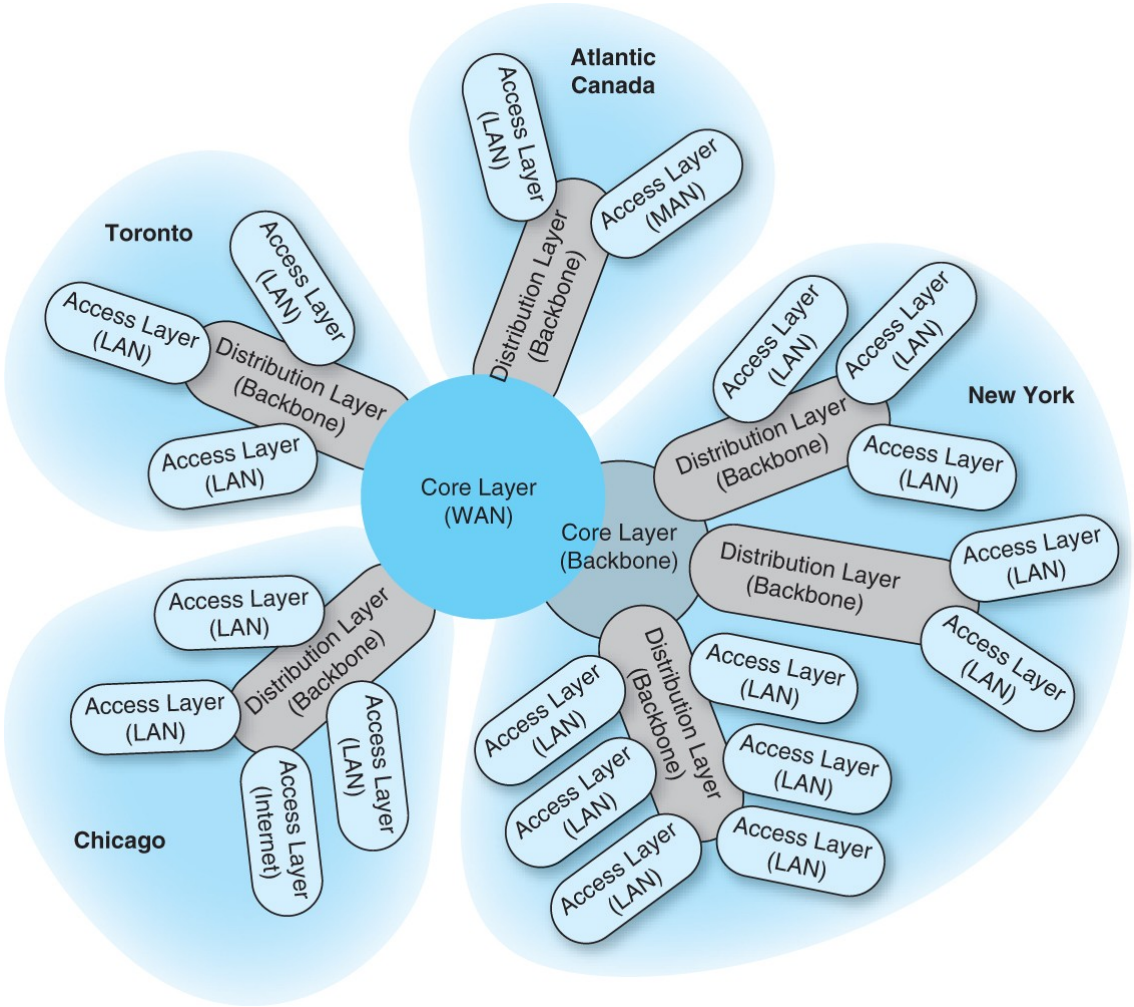
Copyright 2011 John Wiley & Sons, Inc

Design Process

- **Start with the highest level**
  - **Begin by drawing a WAN connecting locations**
- **Next draw individual locations connected to WAN**
  - **Usually a series of diagrams, one for each location**
- **Gather information and characteristics of the environment**
  - **Legal requirements, regulations, building codes**

Copyright 2011 John Wiley & Sons, Inc

Geographic Scope



Copyright 2011 John Wiley & Sons, Inc

Application Systems

- **Baselining**
  - **Review the applications currently used on the network and**
  - **Identify their location so they can be connected to the planned network**
- **Include applications expected to be added to the network**
  - **Review long and short range plans, goals, development plans, strategic directions for organization that will impact network**
- **Also identify the hardware and software requirements and protocol type for each application**
  - **HTTP over TCP/IP; Windows file access**

Copyright 2011 John Wiley & Sons, Inc

Network Users

- **Assess the number and type of users that will generate network traffic**
  - **Much network traffic comes from Internet use (i.e., e-mail and WWW)**
    - **In the past, application systems accounted for the majority of network traffic**
  - **Future network upgrades will require understanding of the use of new applications**
    - **Effect of video on network traffic**

Copyright 2011 John Wiley & Sons, Inc

Categorizing Network Needs

- **Assess the traffic generated in each segment (for each application and user)**
  - **Based on an estimate of the relative magnitude of network needs (i.e. typical vs. high volume)**
  - **Can be problematic, but the goal is a relative understanding of network needs. For example multimedia applications have high volume**
- **Organize network requirements into**
  - **Mandatory, desirable, and wish-list requirements**
  - **Enables development of a minimum level containing mandatory requirements if cost is a constraint vs. merely desirable requirements**

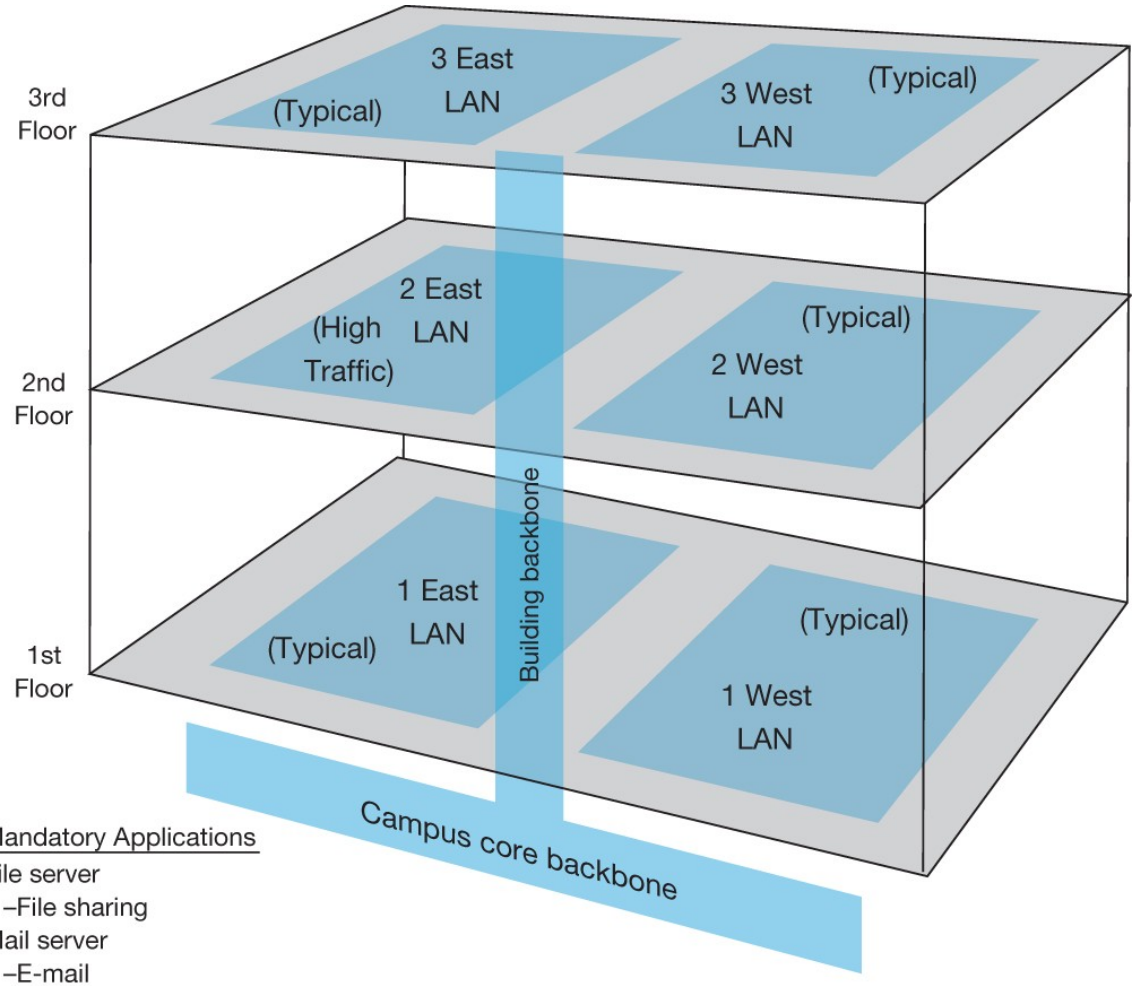
Copyright 2011 John Wiley & Sons, Inc

Deliverables

- **A set of logical network diagrams showing**
  - **Applications**
  - **Circuits**
  - **Clients**
  - **Severs**
- **Categorized as “typical” or “high volume”**
- **Logical plan conceptual plan for the network**
  - **No physical elements specified**

Copyright 2011 John Wiley & Sons, Inc

Sample Needs Assessment



Mandatory Applications

File server
–File sharing
Mail server
–E-mail
Web server
–Web applications for internal and external use

Wish-List Applications

–Desktop videoconferencing (2 East and 2 West)

11.3 Technology Design

- **Development of a physical network (or set of possible designs)**
- **Specify the computers (Clients and servers) needed to support applications and users**
    - **New computers**
    - **Upgrades**
- **Specify circuits and devices (routers, gateways) to connect the computers**

Copyright 2011 John Wiley & Sons, Inc

Designing Clients and Servers

- **Building block approach requires the specification of the computers needed in terms of standard units**
  - **Allocate “base level” client computers to “typical” users**
  - **Allocate “base level” servers to typical applications**
  - **Assign “advanced” computers to “high volume” users and servers**
  - **Beware of the definition for a “typical” unit**
    - **Keeps changing as hardware costs continue to fall, and capabilities/capacities continue to increase**

Copyright 2011 John Wiley & Sons, Inc

Designing Circuits and Devices

- **Deciding on the fundamental technology and protocols**
  - **e.g., Ethernet, T1, TCP/IP**
- **Perform capacity planning, estimating the size and type of the standard and advanced network circuits for each type of network (LAN, BN, WAN)**
  - **e.g., 10 Mbps, 100 Mbps, 1000 Mbps**
  - **Assess current and future "circuit loading"**
    - **Amount of data to be transmitted on a circuit**
    - **Focus on either average or peak circuit traffic**
  - **Estimate size and type of "standard" and "advanced" circuits for each LAN, BN, WAN**
    - **Should "standard" LAN circuit be shared or switched, 100Base-T,**
    - **or 1 Gbe (1 Gbe is transmitting Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second),**

Estimating Circuit Traffic

- **Average traffic:**
  - **Estimate total characters transmitted per day per circuit**
- **Peak traffic**
  - **Estimate maximum number of characters transmitted per two second interval, hope to design to peak**
- **Estimating Message volume**
  - **Count messages in a current network and multiply it with a growth rate**
  - **Use analyzers if an existing network**
    - **For example use Quest Messaging Stats tool to calculate number of mails sent and received by an exchange server and also their size**
- **Precision not a major concern**
  - **Stair step nature of communication circuit (lease another line, or upgrade to 1Gbe)**
  - **Uncertainty of project future needs**

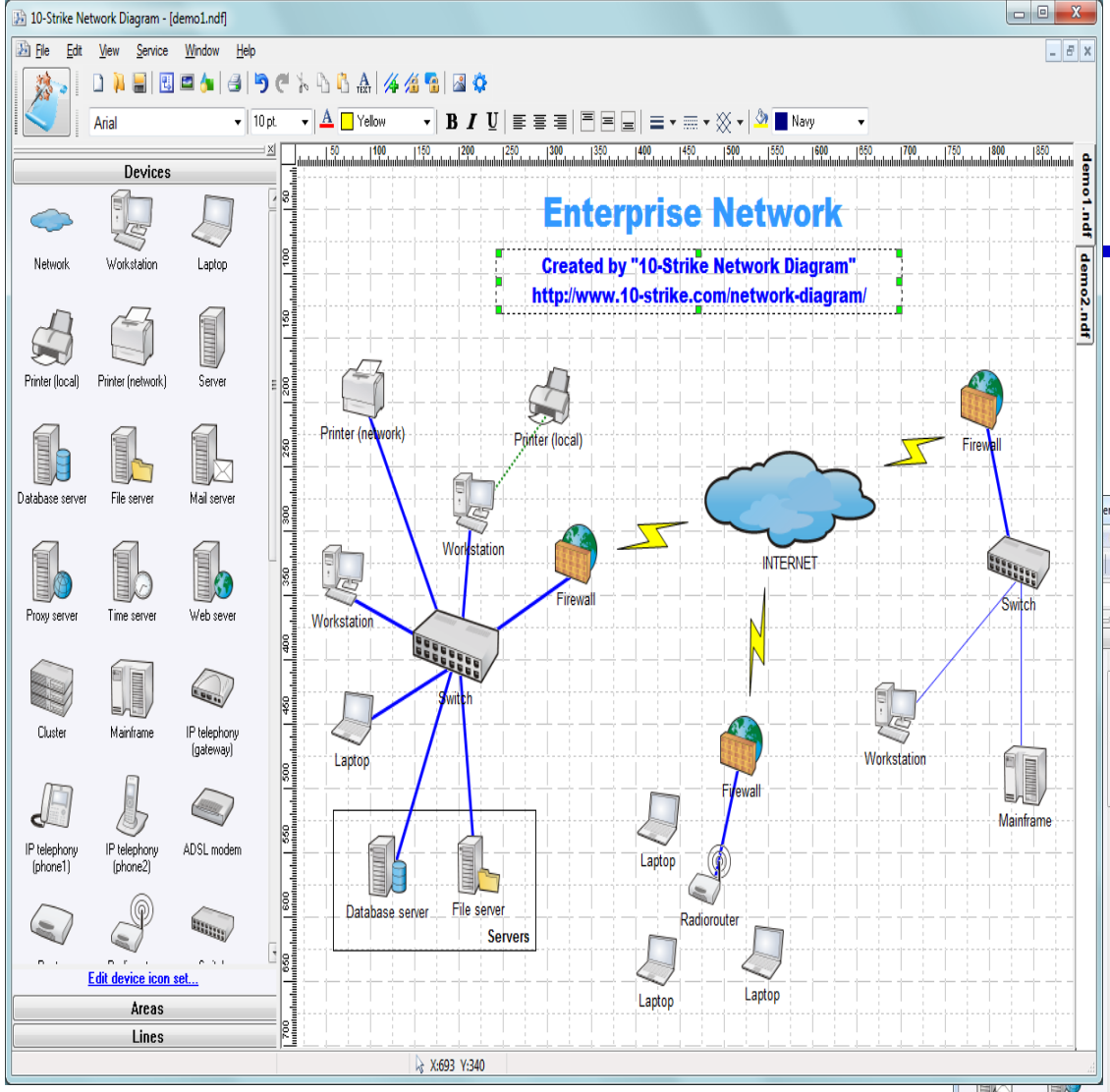
Capacity Overbuilding Dilemma

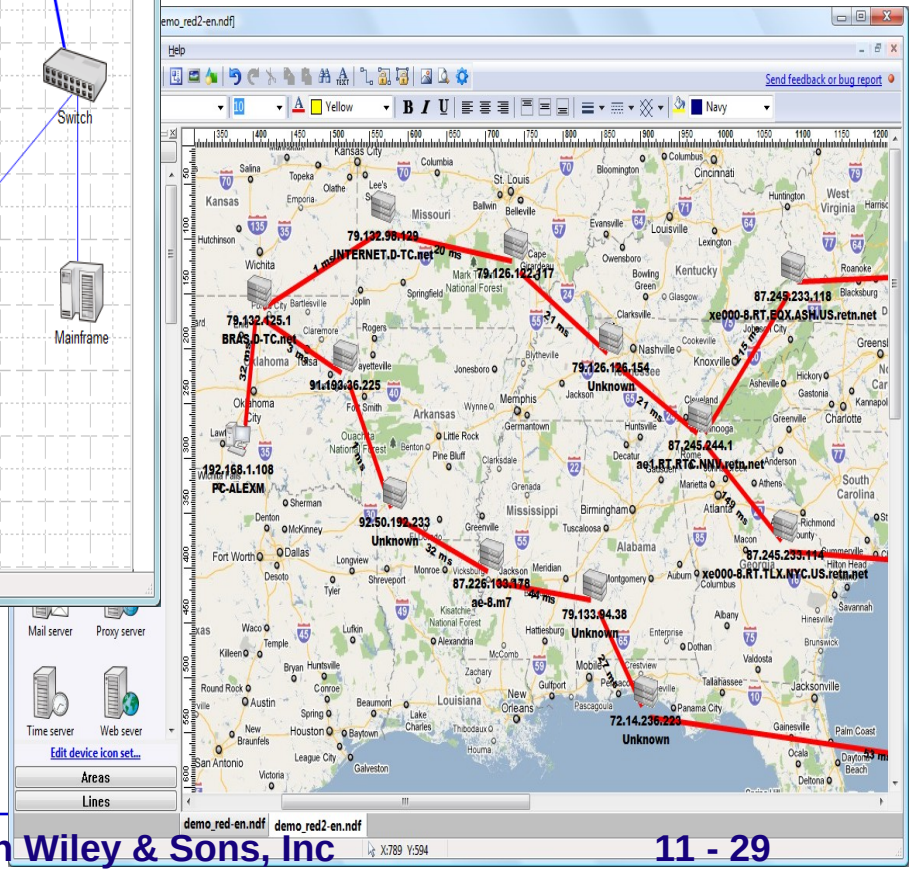
- **Cost of extra capacity vs. Cost of upgrading a network**
  - **Upgrading costs 50-80% more (than building it right at the first time)**
  - **Majority complains about being under capacity, not over capacity**
- **Most organizations intentionally overbuild**
  - **Rapid growth in demand, 5-50% annual growth factor, sometimes 100%**
  - **Difficulty in accurate prediction**
- **Most end up using overcapacity within 3 years**
  - ***Turnpike effect*: when the network is efficient and provides good service, it becomes heavily used**

Copyright 2011 John Wiley & Sons, Inc

Network Design Tools

- **Used mostly in the technology design process**
- **First step: Enter a diagram of the existing network**
  - **Created from scratch (as required by some tools), or**
    - **ie. 10-Strike Network Diagram**
  - **Discovered automatically (by some tools)**
    - **LanHelper is a powerful Local Area Network (LAN) management, discovery and monitoring tool for office network and home network.**
- **Once the diagram is complete**
  - **Add information about the expected network traffic and**
  - **See if the expected level of traffic can be supported**
  - **May be accomplished through simulation models**
- **Once simulation is complete**
  - **Examine results to see estimated delays and throughput**
  - **Change the design if necessary and rerun simulations**


10-Strike Network Diagram - [demo1.ndf]
File Edit View Service Window Help
Devices
Network
Workstation
Laptop
Printer (local)
Printer (network)
Server
Database server
File server
Mail server
Proxy server
Time server
Web sever
Cluster
Mainframe
IP telephony (gateway)
IP telephony (phone1)
IP telephony (phone2)
ADSL modem
Edit device icon set...
Areas
Lines
Enterprise Network
Created by "10-Strike Network Diagram"
http://www.10-strike.com/network-diagram/
Printer (network)
Printer (local)
Workstation
Workstation
Firewall
INTERNET
Firewall
Switch
Switch
Laptop
Firewall
Workstation
Mainframe
Laptop
Database server
File server
Servers
Radiorouter
Laptop
Laptop
demo1.ndf
demo2.ndf
X:693 Y:340


Help
Send feedback or bug report
79.132.96.129
INTERNET.D-TC.net
79.126.122.217
79.132.125.1
BRAS.D-TC.net
87.245.233.118
xe000-8.RT.FOX.ASH.US.retn.net
91.193.36.225
79.126.126.154
Unknown
192.168.1.108
PC-ALEXM
87.245.244.1
ae1.RT.RTC.NNV.retn.net
92.50.192.233
Unknown
87.245.253.114
xe000-8.RT.TLX.NYC.US.retn.net
87.226.183.178
ae-8.m7
79.133.94.38
Unknown
72.14.236.223
Unknown
demo_red-en.ndf
demo_red2-en.ndf
X:789 Y:594

Simulation

- **A mathematical technique used to model the behavior of a network**
  - **Once modeled, the network behaves as it would under real conditions**
    - **Simulates applications and users generating traffic and responding to messages**
  - **Can track: Number of packets, delays experienced at each point in the network**
  - **May be tailored**
    - **Enter parameter values specific to network at hand (e.g., Computer A generates 3 packets per second)**
- **May also highlight potential trouble spots**
  - **Offer design suggestions in overcoming problems**
    - **Increase a circuit speed from T1 to T3**

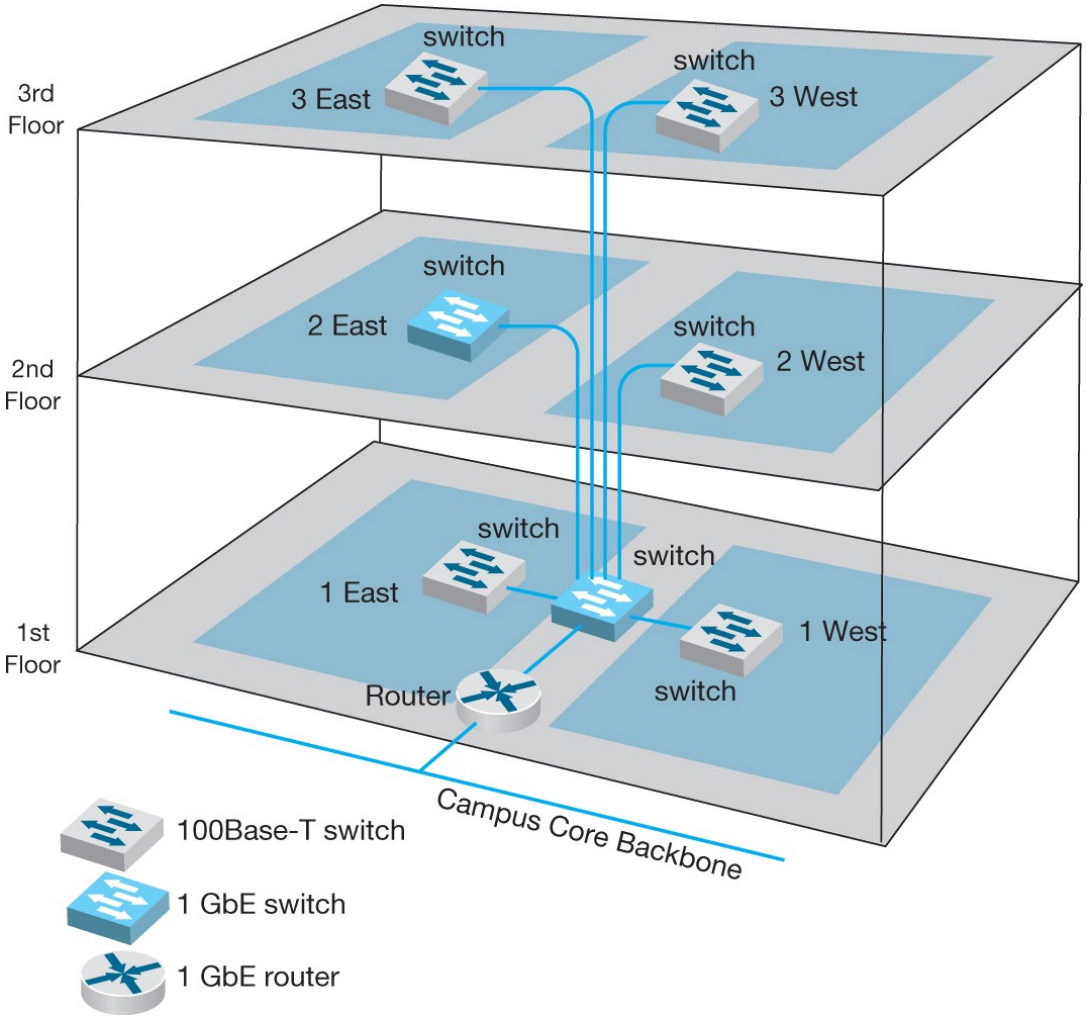
Copyright 2011 John Wiley & Sons, Inc

Deliverables

- **A set of physical network designs**
  - **General specifications for the hardware and software required**
  - **Several alternative designs to do analysis of cost versus performance**
- **The crucial issue is the design of the network circuits and devices**
- **Mostly new network is an upgrade of an older network**
- **In case of a completely new network designed from scratch,**
  - **It is important to define clients' computers with care due to large portion of total cost**

Copyright 2011 John Wiley & Sons, Inc

Physical Network Design



Copyright 2011 John Wiley & Sons, Inc

11.4 Cost Assessment

- **Assessment of the costs of various physical network design alternatives**
- **Complex process that requires analysis of many factors:**
  - **Circuit costs (leased circuits and purchased cabling)**
  - **Internetworking devices (switches and routers)**
  - **Hardware costs (servers, NICs:Network Interface Cards & UPSs:Uninterruptible Power Supply)**
  - **Software costs (network operating systems, application software and middleware)**
  - **Network management costs includes training needed for network management**
  - **Test and maintenance costs for monitoring equipment and supporting onsite repairs**
  - **Operations costs to run the network**

Copyright 2011 John Wiley & Sons, Inc

Request for Proposal (RFP)

- **Typically used before making large network purchases**
  - **Detailed specification of equipment, software, and services desired from vendors**
  - **Items may be categorized as mandatory, important, or desirable**
  - **Some RFPs may simply list requirements with no specific equipment**
  - **Ask vendor to provide their proposed design (if asked), specific items, and best prices**
  - **Allows apple to apple comparisons of numerous vendor responses**

Copyright 2011 John Wiley & Sons, Inc

Outline for Request for Proposals

- **Background Information**
  - **Organizational profile; Overview of current network; Overview of new network; Goals of the 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**

Copyright 2011 John Wiley & Sons, Inc

Vendor Selection Process

- **Evaluate submitted proposals against specific criteria**
- **Select winner(s) based on criteria**
- **Multi-vendor selections**
  - **Provide better performance**
    - **Unlikely that one vendor makes the best in all categories**
  - **Tend to be less expensive**
    - **Unlikely that one vendor has the cheapest in all categories**
  - **More difficult to manage**
    - **If not working properly, each vendor blames each other for the problem**

Copyright 2011 John Wiley & Sons, Inc

Selling the Proposal to Management

- **Obtaining the support of senior management for the proposed design**
- **Keys to gaining acceptance**
  - **Speak their language and present the design in terms of easily understandable issues**
    - **Make a business case by focusing on organizational needs and goals such as**
      - **Comparing the growth in network use with the growth in the network budget**
    - **Avoid focusing on technical issues such as upgrading to gigabit Ethernet**
    - **Focus on network reliability**
      - **Mission critical applications must be always available**

Copyright 2011 John Wiley & Sons, Inc

Deliverables

- **An RFP (Request For Proposal)**
  - **Issued to potential vendors for their reply**
  - **Can be tied to contract with selected vendor**
- **Revised set of physical network diagrams**
  - **Done after the vendor(s) selected**
  - **Final technology design**
  - **Selected components (exact products and costs)**
- **Business case**
  - **To support the network design**
  - **Expressed in terms of business objectives**

Copyright 2011 John Wiley & Sons, Inc

11.5 Designing for Network Performance

- **Several higher level concepts used to design network for the best performance**
  - **Managed networks**
    - **use managed devices that assist with network management through monitoring**
    - **Policy-based management**
  - **Network circuits**
    - **Traffic analysis**
    - **Service level agreements**
  - **Network devices**
    - **Device latency and device memory**
    - **Load Balancing**
  - **Minimizing network traffic**
    - **Content caching and content delivery**

Copyright 2011 John Wiley & Sons, Inc

Managed Networks

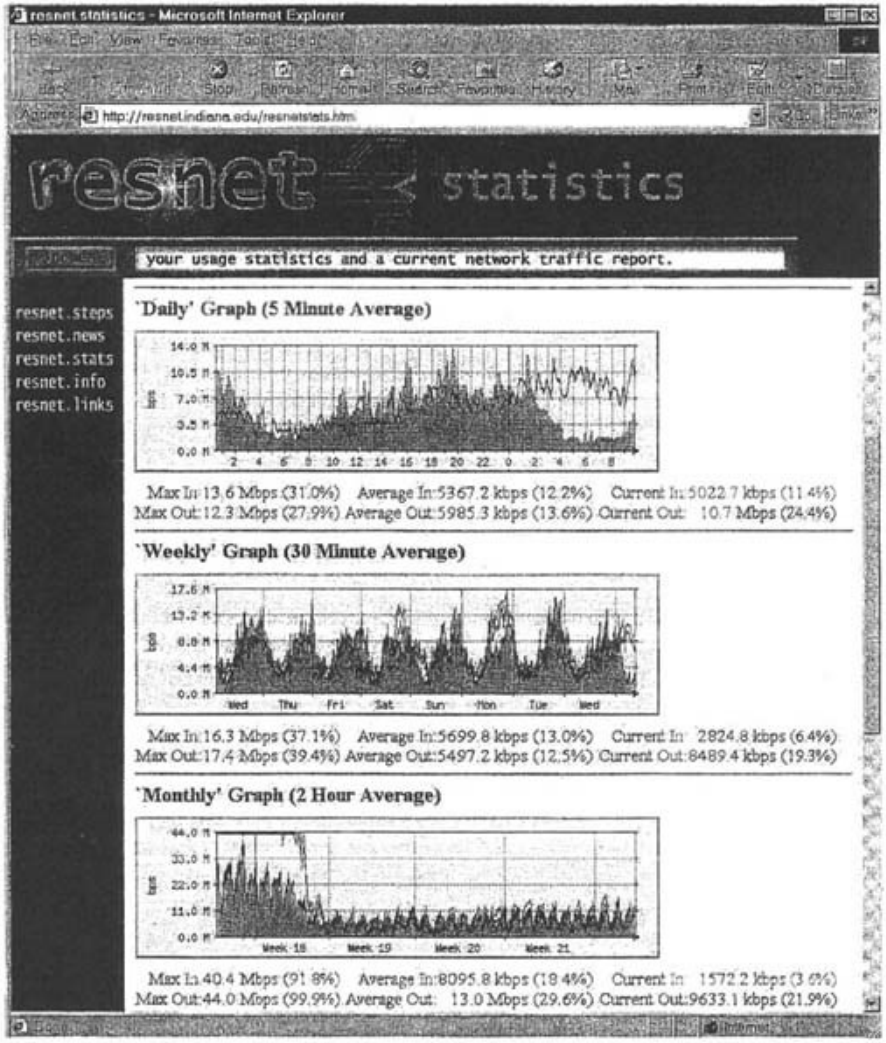
- **Network that uses managed devices**
  - **Managed device:**
    - **Switches and routes**
    - **Monitors traffic flows**
    - **Monitors its status and other devices connected**
    - **Records various data on messages it processes**
    - **Sends these data to manager's computer (on a request)**
    - **Sends alarms if a critical situation detected (such as a failing device, or unusual increase in traffic)**
  - **Problems detected and reported by devices themselves before problems become serious based on thresholds**
- **Requires both hardware and software**
  - **Hardware: monitor, collect, transmit**
  - **Software: store, organize, analyze**

Copyright 2011 John Wiley & Sons, Inc

Network Management Software

- **Device management software and**
  - **Provide specific information about a device**
  - **Analyzes patterns of configuration, traffic, error conditions, etc.**
    - **ie. resnet and NetDMZ network management software**
      - **using a server to monitor all LAN clients.**
- **System management software, or, enterprise management software**
  - **Analyzes device information record for diagnosis**
  - **Prevents alarm storms (for a failure on a circuit, many connected devices sending alarms)**
  - **Allows pinpointing source of problems quickly**
- **Application management software**
  - **Monitor applications based on device info**
  - **Focus on delays and application layer packets**

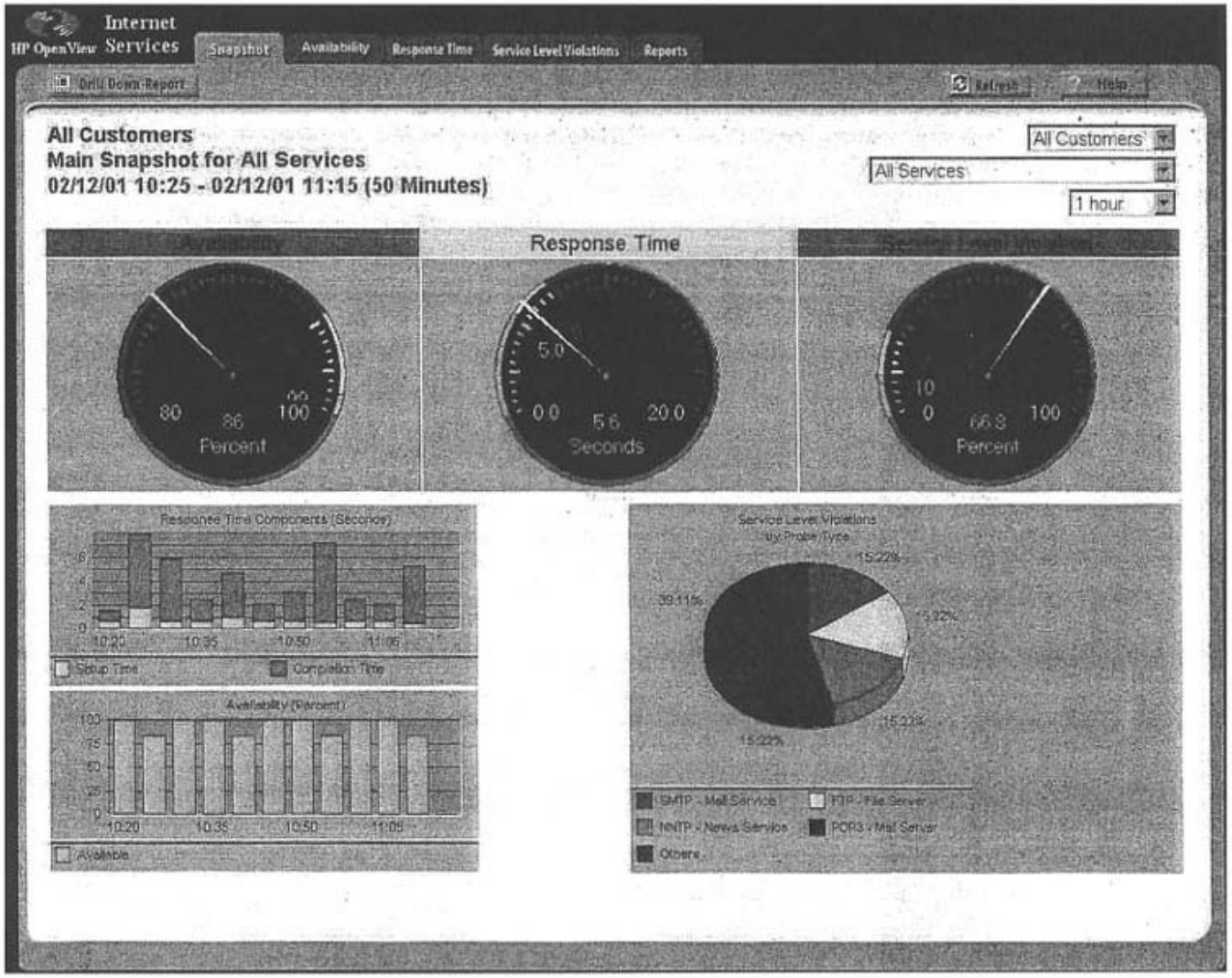
Device Management Software



Source: Alan Dennis

Copyright 2011 John Wiley & Sons, Inc

System Management Software



Source: HP OpenView

Copyright 2011 John Wiley & Sons, Inc

Network Management Standards

- **Application layer protocols defining type of information collected and format of control messages**
  - **Simple Network Management Protocol (SNMP)**
    - **Developed for Internet and LANs**
    - **Components of SNMP**
      - **Agent: collects device info and responds to requests from the manager**
      - **Management Information Base (MIB): database at device stored by the agent**
      - **Network Management Station (NMS): Access MIB, sends control messages to agent**
  - **Common Management Interface Protocol (CMIP)**
    - **Developed for OSI type networks**

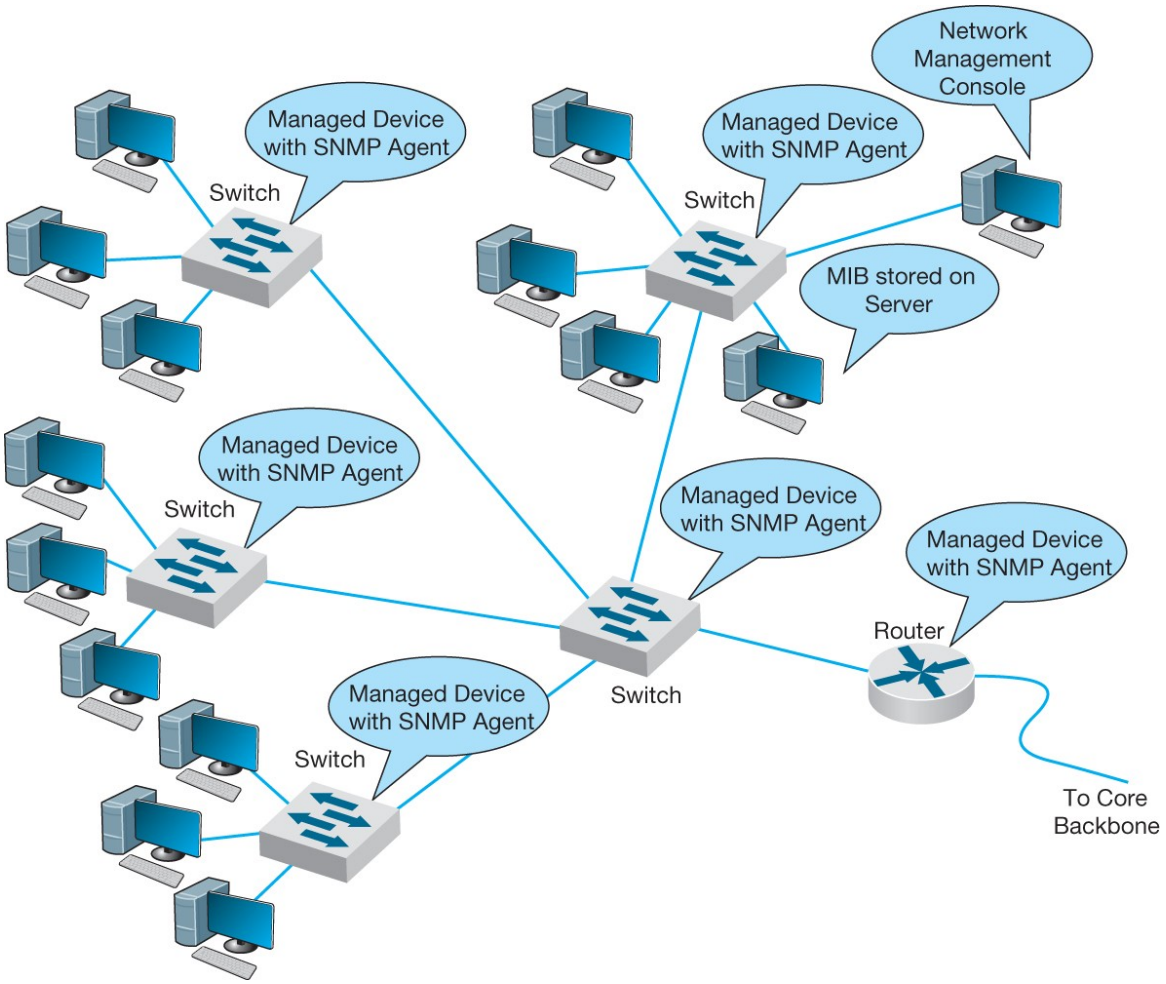
Copyright 2011 John Wiley & Sons, Inc

More on SNMP

- **Remote Monitoring (RMON)**
  - **Enables remote monitoring of SNMP devices**
  - **Provide network-wide monitoring info to the manager (rather than device-wide info)**
    - **No need to look at individual devices**
    - **Reduces network management traffic**
  - **Collects info on various layers (data link, network, application layer)**
    - **Provides a clear picture of types of traffic**
  - **Also collects statistics based on IP addresses**
    - **Enables manager to observe any host-host traffic**
- **Problems with SNMP**
  - **Limited functionality; security; vendor extensions**

Copyright 2011 John Wiley & Sons, Inc

More on SNMP



Copyright 2011 John Wiley & Sons, Inc

Policy-Based Management

- **Enables managers to set priority policies for traffic (to take effect when congested)**
  - **Example:**
    - **Manager: order processing to have the highest priority**
    - **Software: configure devices using QoS capabilities in ATM, TCP/IP, etc to give this application the highest priority**
- **Expected to become more important**

Copyright 2011 John Wiley & Sons, Inc

Network Circuits

- **Play a critical role in designing network for maximum performance**
- **Important to size the circuit and place them to match the traffic**
- **Areas of concern:**
  - **Circuit loading and capacity planning**
  - **Traffic analysis: why are some circuits more heavily used?**
  - **Service level agreements**

Copyright 2011 John Wiley & Sons, Inc

Traffic Analysis

- **Performed to pinpoint why some circuits are heavily used**



- **Example: Toronto-NY circuit overloaded**
  - **<u>Immediate reaction:</u> upgrade/add another circuit between Toronto-NY**
  - **<u>Reason for the overload</u>: NY-LA traffic**
  - **<u>Ideal solution</u>: new circuit directly between LA and NY**

Copyright 2011 John Wiley & Sons, Inc

Service Level Agreements

- **Established between organizations and common carrier and ISPs**
- **Specify the exact type of performance that the common carrier will provide**
  - **Availability**
    - **99% → can be down only 3.65 days per year with no penalty**
    - **99.9% → can be down only 8.76 hours per year with no penalty**
    - **"Five nines" is 99.999% uptime**
  - **Also includes maximum response time and other parameters**
- **Specify penalties if the desired performance is not provided**

Copyright 2011 John Wiley & Sons, Inc

Network Devices

- **Network devices from different vendors provide different capabilities**
  - **Some faster, some more reliable, etc,.**
- **Factors important in network performance**
  1. **Device latency is delay imposed by device in processing messages**
  2. **Device memory**
  3. **Load Balancing is capability in sharing the network load**
  4. **Capacity management**

Copyright 2011 John Wiley & Sons, Inc

Device Latency

- **Delay imposed by device in processing messages**
  - **High latency device; takes long time**
  - **Low latency device: faster**
  - **Wire speed: fastest device operating as fast as the circuits they connect (virtually no delays)**
- **Key element affecting latency:**
  - **Computer processor in the device**
- **More important for networks with heavy traffic**
  - **High latency devices may cause long traffic backups**
- **Less important in low traffic networks**
  - **Packets arrive less frequently and less backup delays**

Copyright 2011 John Wiley & Sons, Inc

Device Memory

- **Goes hand-in-hand with latency**
  - **If a high-latency device, backed-up packets to be stored in memory;**
    - **Otherwise they will be lost and to be retransmitted, causing more, unnecessary traffic**
    - **High-latency devices need more memory**
- **Also important for servers**
  - **More memory means more files can be stored in memory**
  - **Requests are processed more quickly, and is often faster than hard disks**

Copyright 2011 John Wiley & Sons, Inc

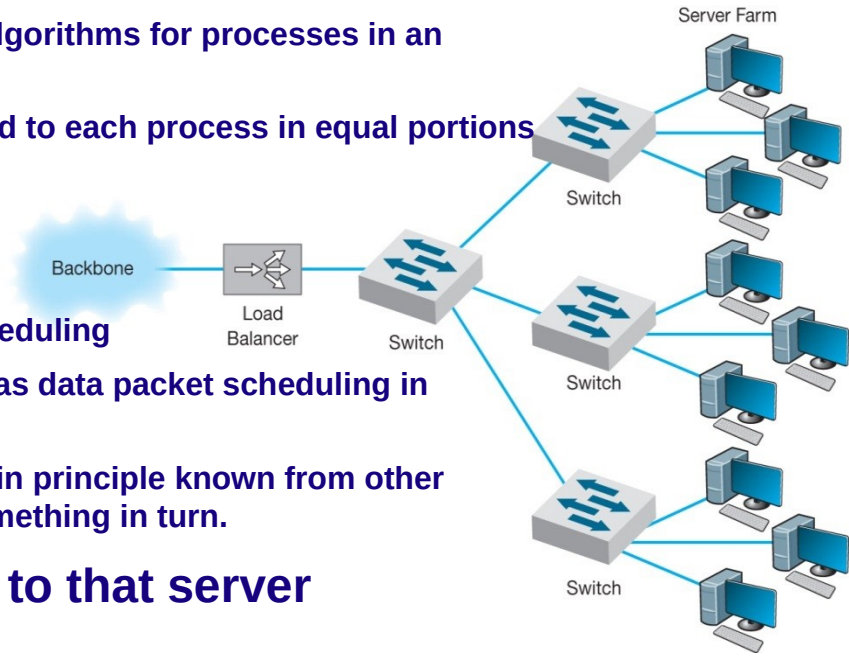
Load Balancing

- **To ensure that a request is handled immediately by a free server in the server farm or cluster**
- **Network's load balancer device:**
  - **Handles all requests; selects an appropriate server based on some sequence(round-robin, etc.,)**
    - **Round-robin (RR) is one of the simplest scheduling algorithms for processes in an operating system.**
    - **As the term is generally used, time slices are assigned to each process in equal portions and in circular order, handling**
    - **all processes without priority (also known**

    as cyclic executive). Round-robin scheduling is simple,

    easy to implement, and starvation-free. Round-robin scheduling

    can also be applied to other scheduling problems, such as data packet scheduling in computer networks.
    - **The name of the algorithm comes from the round-robin principle known from other fields, where each person takes an equal share of something in turn.**
  - **If server crashes, no requests are sent to that server**



Server Virtualization

- **Process of creating several logically separate servers on the same physical computer**
- **Provides better utilization of servers**
- **Decreases space and power**
- **May need virtualization software**
  - **Vmware, MS Virtual PC, Virtualbox**

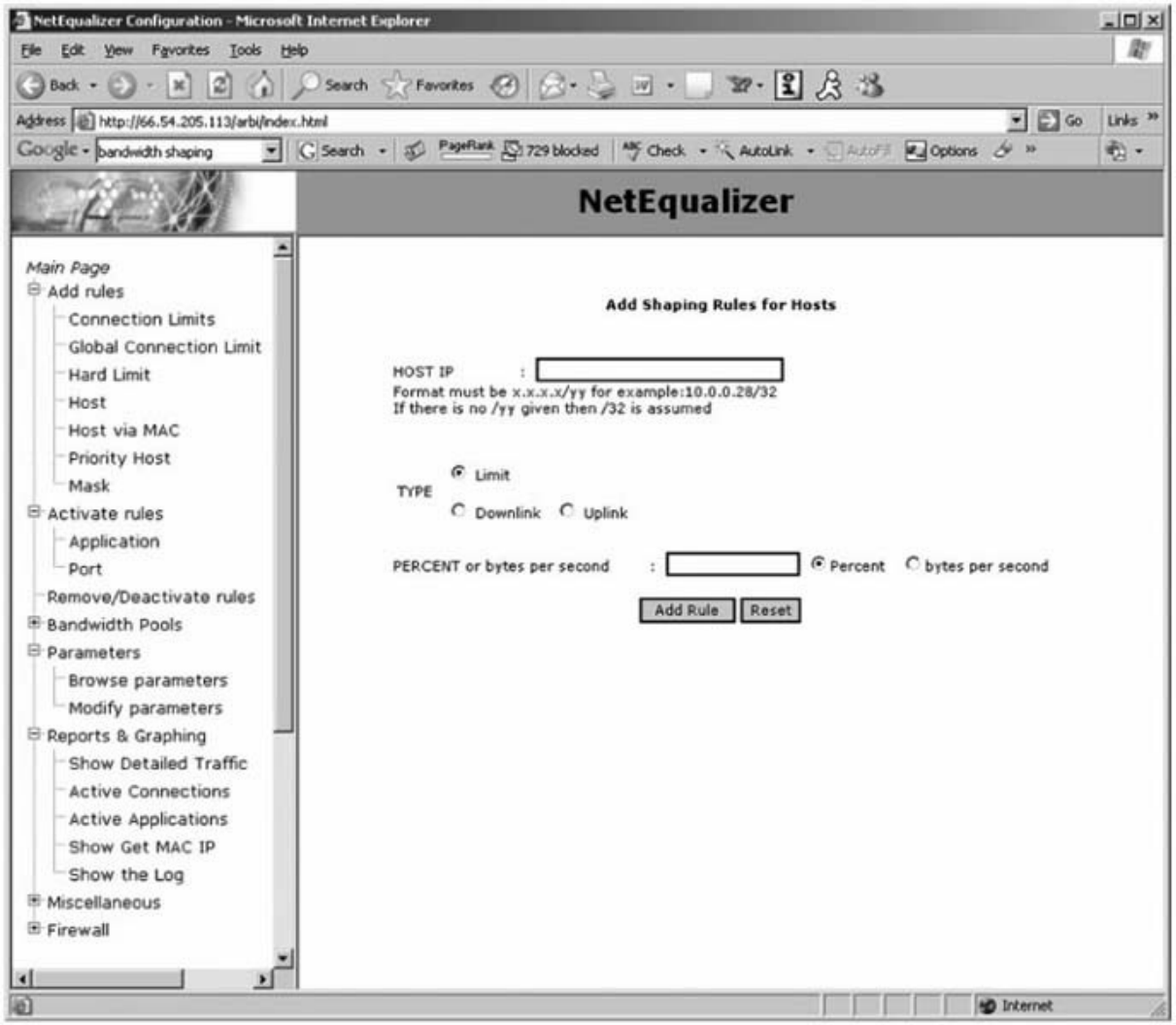
Copyright 2011 John Wiley & Sons, Inc

Capacity Management

- **Uses capacity management devices**
- **Also called bandwidth limiters or bandwidth shapers**
- **Slow down users who use too much capacity**
- **Installed at key points in network**
- **Limit capacity for unofficial use such as for MP3 file sharing**

Copyright 2011 John Wiley & Sons, Inc

Capacity Management Software



Copyright 2011 John Wiley & Sons, Inc

Minimizing Network Traffic

- **Another approach in improving network performance**
- **Attempts to move most commonly used data closer to user, thus reduces demand for traffic elsewhere**
  - **Providing servers with duplicate copies at points closer to users**
- **Approaches in reducing traffic**
  - **Content caching**
  - **Content delivery**

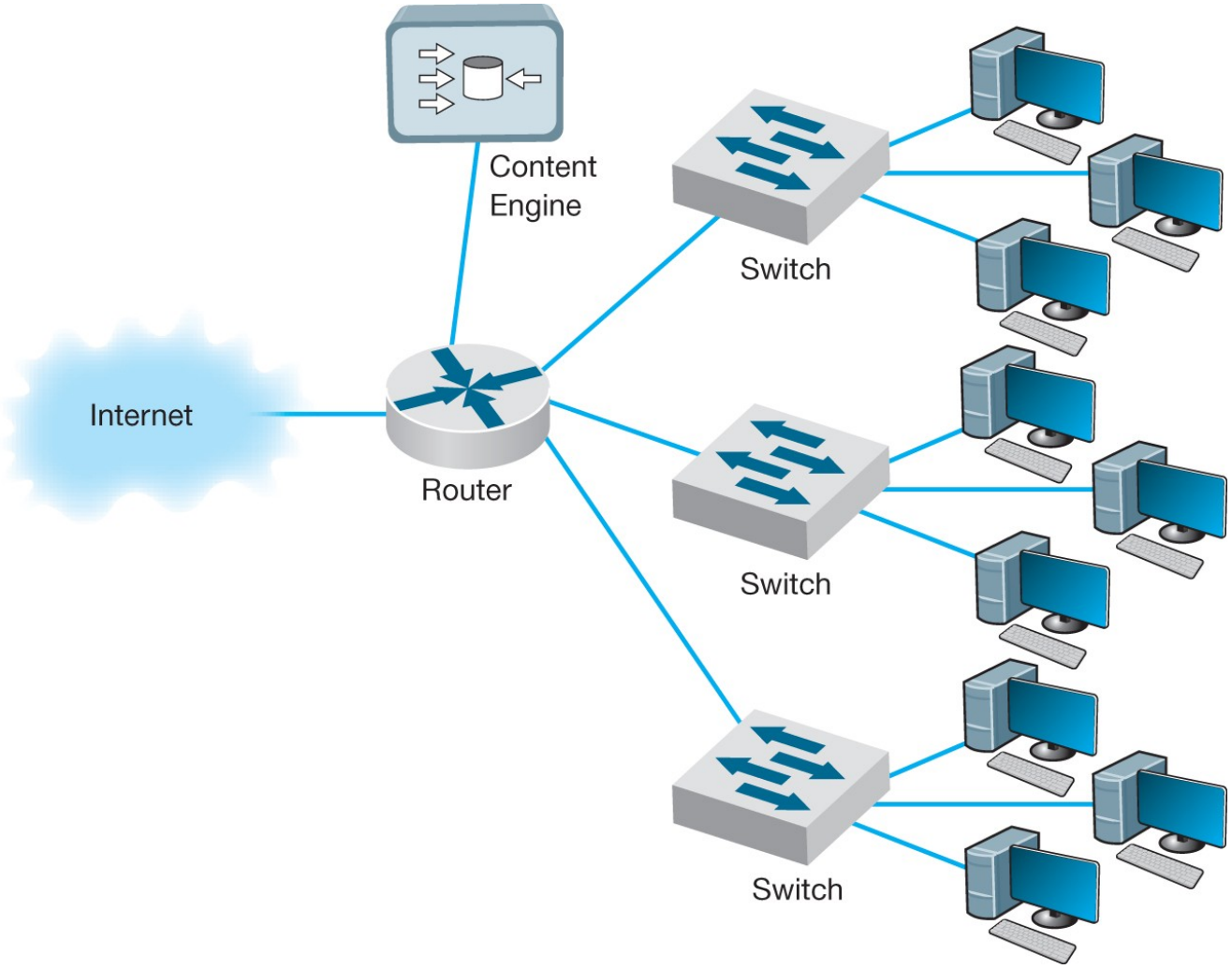
Copyright 2011 John Wiley & Sons, Inc

Content Caching

- **Store copies of other web based data closer to your users**
  - **Install a content engine (cache engine) close to your Internet connection**
  - **Install special content management software on the router**
- **Operations**
  - **Stores requests and responses (mostly static files)**
  - **Examines each outgoing request; if it requires a file already in cache, it responds immediately (without going to the requested site)**
- **Stores contents form most commonly accessed sites (updates them frequently)**
- **Must operate at wire speeds (otherwise degrade performance)**
- **Reduces traffic between Internet and organization → less circuits to lease**

Copyright 2011 John Wiley & Sons, Inc

Network with Content Engine



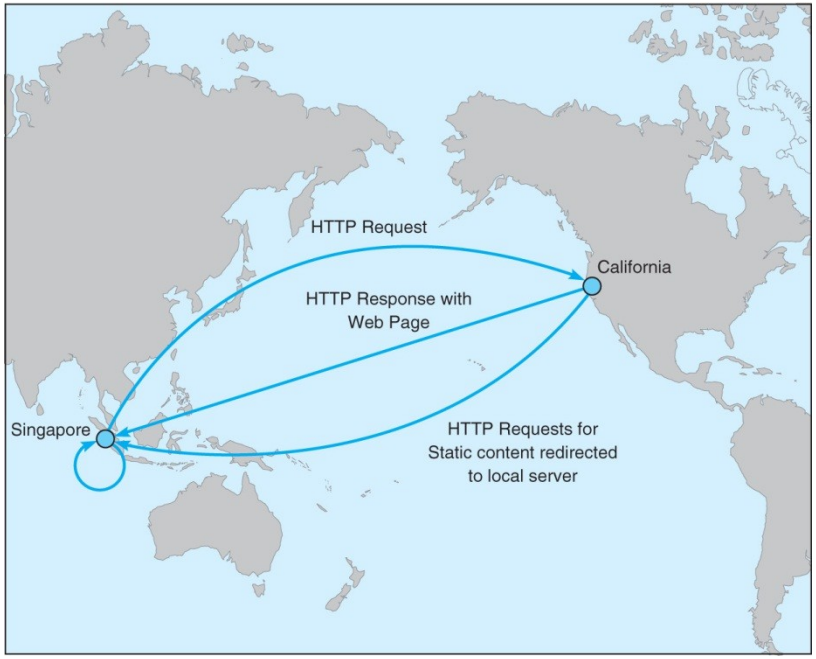
Copyright 2011 John Wiley & Sons, Inc

Content Delivery

- **A special type of Internet service provided by "content delivery providers (CDPs)"**
  - **A CDP stores Web files for its customers closer to the customer's potential web page users**
  - **Akamai, a CDP, operates 10,000 servers located near busiest NAPs and MAEs**
    - **Servers contain most commonly requested web info for some busiest sites like yahoo.com**
    - **When a user access a CDP's website, a software in user's server looks for an Akamai server (closer to the user)**
    - **Akamai server sends the user the static files, the Akamai's customer's server sends the user the dynamic files of the site**

Copyright 2011 John Wiley & Sons, Inc

Network with Content Delivery



- **User: in Singapore:**
  - **Requests a web page from yahoo.com**
- **Client: Yahoo.com server farm located in California**
  - **Responds with a dynamic HTML page with static graphic files**
  - **Static content is directed to be pulled form Akamai's server in Singapore**

Copyright 2011 John Wiley & Sons, Inc

Benefits of Content Delivery

- **Users of the web pages of customer subscribed to Akamai**
  - **Much faster response time because many parts of the requested page will come form a nearby Akamai server**
- **Customer organization subscribed to Akamai**
  - **Less traffic for its servers**
  - **Need not spend as much on its server farm**
  - **Need less capacity on its circuits to Internet**
- **ISPs providing service to users**
  - **Less traffic flows through their networks which is of benefit because much of this would be unpaid traffic due to peering**

Copyright 2011 John Wiley & Sons, Inc

Green IT

- **The design and use of IT to improve environmental sustainability.**
- **Focuses on reducing the amount of power consumed and hear produced**
- **Server virtualization aids in Green IT**
- **Software can turn off inactive components**
  - **NICs and switches using IEEE 802.3az**
- **Estimates indicate that 20% of energy in typical office building due to IT**

Copyright 2011 John Wiley & Sons, Inc

11.6 Implications for Management

- **Develop strong relationships with only few vendors**
  - **Use a building block approach in designing networks**
  - **Use a few common, standardized technologies everywhere in the network**
- **Purchase technologies that will provide strong network management capabilities**
  - **Cost to operate is now much more expensive than the cost to purchase**
- **Use powerful design and management tools**
  - **Saves money in the long run**

Copyright 2011 John Wiley & Sons, Inc

Copyright 2011 John Wiley & Sons, Inc.

All rights reserved. Reproduction or translation of this work beyond that permitted in section 117 of the 1976 United States Copyright Act without express permission of the copyright owner is unlawful. Request for further information should be addressed to the Permissions Department, John Wiley & Sons, Inc. The purchaser may make back-up copies for his/her own use only and not for distribution or resale. The Publisher assumes no responsibility for errors, omissions, or damages caused by the use of these programs or from the use of the information herein.