Paving the Way to the Internet

NYSCATE
NEW YORK STATE CURRICULUM
for Advanced Technology Education

Integrated MST Design Activities for High School and Community College Students

Partners in New York State Curriculum for Advanced Technology Education
Hofstra University
New York State Education Department

Project Co-Principal Investigators
Linda Hobart
Finger Lakes Community College

John E. Jablonski, Vice President and Dean of the College
Fulton-Montgomery Community College

Margarita Mayo, Director of Education, Training and Quality
New York State Business Council

Godfrey I. Nwoke, Ph.D.
New York City College of Technology

Jean Stevens, Assistant Commissioner, Office of Workforce Preparation and Continuing Education
New York State Education Department

Management Team

Project Co-Directors
M. David Burghardt, Ph.D.
Michael Hacker
Hofstra University

Project Coordinator
William Peruzzi, Ph.D.
Hofstra University

Project Administrative Assistant
Lois Miceli
Hofstra University

Project Advisory Council
Stuart Field (Chair), Manager, Saratoga Division
Slack Chemical Company

Dr. James C. Dawson, Member
N.Y.S. Board of Regents

Nancy Bryan, Past President
New York State Technology Education Association

James Cimino, Executive Director
Association of Career and Technical Education Administrators

Dr. Lorraine Hohenforst, Coordinator of Instructional Services
Hamilton-Fulton Montgomery BOCES

Dr. Elaine, A. Johnson, Director
Bio-Link (ATE) Center, City College of San Francisco

Dr. James V. Masi, Retired Executive Director, Northeast (ATE) Center for Telecommunications Technology
Professor Emeritus, Western New England College

Mr. Bernard McInerney, Statewide Tech Prep Coordinator
New York State Education Department

Mr. Gordon Snyder, Executive Director
National Center for Telecommunications Technology

Project Evaluation Team
Bert Flugman, Ph.D. Director
Deborah Hecht, Ph.D.
Center for Advanced Study in Education
City University of New York

Principal Writer: Badreddine Oudjehane
Contributing Author: Josephine Braneky
Consultant/Writer: Barry Borakove

Copy Editor: Barbara L. Kelly
Publications Designer: Lesa Clark, Liz Scott

NYSCATE modules and ancillary materials such as the NYSCATE Pedagogical Framework may be downloaded from http://www.nyscate.net or www.hofstra.edu/nyscate

This material is based upon work supported by the National Science Foundation under Grant 0053269. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

The University of the State of New York
The State Education Department

NYSCATE MODULE GUIDE
PAVING THE WAY TO THE INTERNET

TABLE OF CONTENTS

I. INTRODUCTION AND OVERVIEW

ABSTRACT

This NYSCATE module provides second-year community college students with an opportunity to investigate various Internet addressing protocols and schemes. The Design Challenge requires students to design a network that will provide full Internet access for several clients/companies that have different network requirements. Routing fundamentals are investigated by students as are the data (routing tables) that they generate. Students optimize network design with the use of newer, more efficient addressing schemes such as variable length subnet mask (VLSM) and classless interdomain routing (CIDR). Students design networks using a variety of IP Internet addresses and classes, and they use the TCP/IP communications protocol.

GRADE LEVEL

This module is appropriate for students enrolled in the third semester of community college.

TIME ALLOCATION

Eight to nine class/lab sessions will be needed to complete this module. Class/lab sessions as described run for two class/lab hours; each class/lab hour is 50 minutes long. Total approximate time is 16–18 class/lab hours in a setting where computers are available for student use.

EXISTING COURSES ENHANCED BY THE MODULE

Examples of course offerings enhanced by this module at New York City Technical College are provided here:

Computer Systems Technology Department, Microcomputer Business Systems program:

- MS 307 Local Area Networks
- MS 405 Microcomputer Operating Systems

Electromechanical Technology Department, Computer Engineering Technology program:

- EM 360 Data Communications

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction

The "information superhighway" is by no means the smoothly paved road we all hoped it would be. We regularly encounter bumps and sharp curves along the way in our travels through cyberspace. It is the access to the multitudes of information available on the Internet that makes the process worthwhile.

Much of our active time on the Internet is spent searching for information that we need or for which we have only a passing interest. Time spent in the library 20 years ago can now be used more efficiently by accessing the same sources through the Internet. The same can be said for online purchasing (e-commerce), e-mail, and online banking.

Although we're very interested in the location of the information we are looking for, we never seem to be concerned about the path the information takes to reach us. If not for the ability to locate a remote information source, and initiate a data transfer from this source, we could not have an Internet as we know it today.

The Internet can only work if it has a method (or protocol) that enables it to identify users and direct information accordingly. The Internet protocol (IP) accomplishes this by assigning a unique address to each user. This process, which is similar in concept to the manner in which the U.S. Postal Service directs mail delivery, can suffer from the same kind of bottlenecks and congested resources. Although there are no ZIP codes (or ZIP + 4) on the Internet, strategies have been developed to optimize the process and increase the efficiency of data transfer.

Design Challenge

You and the members of your team will design a network that will provide full Internet access for four clients/companies. You will determine the requirements of each company and then design an optimal addressing scheme to serve them.

Specifications

- Full Internet access will be provided for the following four clients/companies:
  - Small company (real estate office): 50 nodes
  - Medium company (department store): 200 nodes
  - Medium-large company (university): 1,500 nodes
  - Large company (local ISP): 5,000 nodes
- The designed network must increase data performance (decrease router table size) of a traditional single class B address network.

Constraints

- ISP (Internet service provider) has access to a single class B IP address.
- Solution must use VLSM (variable length subnet mask) and CIDR (classless interdomain routing) in the addressing scheme.

III. GOALS AND LEARNING OUTCOMES

Tech Prep Information Technology Skill Standards

Network Technologies: Technical Learning Component
Learner Program Outcomes
- Demonstrate an understanding of the overall design and components of LAN and WAN systems.
- Demonstrate the ability to perform basic setup and configuration of network hardware and software.

Key Competencies
- Present and explain the design features of LAN and WAN systems.
- Install and configure a network server.
- Set up and configure a basic workstation connected to the network.
- Determine the type of network topology needed, such as peer-to-peer server based.
- Set up and configure TCP/IP services on workstation and server level.

Organization/Delivery of Presentations: Foundation Learning Component
Learner Program Outcomes
- Demonstrate the ability to select presentation technology, methods, and material appropriate to the audience and purpose of the presentation.
- Demonstrate the ability to organize and deliver the presentation material.

Key Competencies
- Select a technology delivery system and method appropriate to the size and nature of the audience and purpose of the presentation.
- Identify the requirements relating to the presentation space and environment.
- Organize the material so that it is complete and logically sequenced, and make sure it meets the presentation timelines.
- Deliver the presentation, using good speaking skills and appropriate technology to enhance the delivery of the content.

Teamwork: Foundation Learning Component
Learner Program Outcomes
- Demonstrate the ability to organize and work in a team setting.
- Demonstrate the ability to recognize expertise and to learn from others, and demonstrate collaborative decision making.
- Demonstrate the ability to work and communicate effectively with persons of different backgrounds.

Key Competencies
- Use effective communication skills when interacting in a team environment.
- Work collaboratively to set team goals, showing flexibility in accepting others' leadership.
- Manage conflicts that arise, and maintain and build on the team process.

IV. TIMELINE CHART

This module is designed to be completed within 16–18 class/lab hours. Each class/lab hour is 50 minutes in length. Instructional sessions as described are two class/lab hours long.

Session	FOCUS MODEL COMPONENT (for teachers)	INFORMED DESIGN LOOP COMPONENT (for students)	ACTIVITY
1	**Focus** discussion on Problem Context **Organize** for Informed Design	Clarify Design Specifications and Constraints	Begin discussion of Introductory Packet (Module Overview). Discuss the informed design cycle; finish packet.
2–5	**Coordinate** Student Progress	Research and Investigation	Conduct KSB 1: What Is an IP Address? Conduct KSB 2: Classical IP Addressing Schemes. Conduct KSB 3: Designing a Network IP Scheme. Conduct KSB 4: Implementing a Classful Design. Conduct KSB 5: Routing Fundamentals. Conduct KSB 6: VLSM and CIDR.
6–7	**Coordinate** Student Progress	Generate Alternative Designs Choose and Justify Optimal Design Construct and Test the Network Design	Create diagrams of alternative solutions. Select and defend choice of preferred alternative. Develop network diagram and plans for testing design solution.
8	**Unite** Class in Thinking about Accomplishments **Sum Up** Progress on Learning Goals	Test and Evaluate Network Design	Make group presentations of methods and results. Individuals submit reports. Assess student progress, instruction, and attainment of the goals for the mod.

V. MATERIALS AND RESOURCES

Materials Needed

(If routers are available, there is no need to have a PC act as a router.)

- Networked PCs:
  One to act as the Internet (outside the designed network) with a network interface (NIC) card
  One to act as the router server (Internet provider) with at least two NIC cards
  Additional computers to act as the companies (clients) to be served by the network, each with a NIC card
- Network HUBs or switches having at least 4 ports
- Network cables.

SOURCES

- Cisco Systems: OSI Model, ConfigMaker, ***http://www.cisco.com***
- Everything You Ever Wanted to Know, by Chuck Semeria ***http://www.3com.com/solutions/enUS/ncs/501302.html***
- Network Magazine ***http://www.networkmagazine.com/article/NMG20010226S0002***
- Network ICE, ***http://advice.networkice.com/Advice/default.htm***
- How to set Linux as a router:
  - ***http://www.geocrawler.com/archives/3/47/2003/5/0/10502321***
  - ***http://www.linuxquestions.org/questions/archive/3/2001/07/1/3938***
  - Ipmasq: ***http://www.linux.org***
  - ***http://www.freesco.org***
- How to set Windows as a router:
  - Exploring Windows 2003 Security: RRAS and IAS ***http://www.serverwatch.com/tutorials/article.php/3115701***
  - Routing and Remote Access (RRAS) ***http://computerperformance.co.uk/Litmus/rras.htm***
  - ***http://www.microsoft.com***

VI. PROCEDURAL SUGGESTIONS

PEDAGOGICAL FRAMEWORK **REFERENCE**

A separate document, the NYSCATE *Pedagogical Framework (www.nyscate.net)*, provides an in-depth understanding of the NYSCATE challenge statements, the FOCUS on Informed Design pedagogical model for teachers, student Knowledge and Skill Builders (KSBs), the informed design loop for students, and more.

SUGGESTIONS FOR TEACHERS

Pages within this section provide suggestions for preparing and teaching the KSBs and Design Challenge. The text boxes that appear represent the first pages only of the relevant student handouts. For the complete handouts, turn to the Student Handout section. The strategies presented are within the context of the NYSCATE FOCUS on Informed Design model, a pedagogical model for teachers. The FOCUS components are: **Focus** discussion on the problem context, **Organize** for informed design, **Coordinate** student progress, **Unite** the class in thinking about what has been accomplished, and **Sum** up progress on the learning goals (see NYSCATE *Pedagogical Framework* for more on this model).

Session 1: *Focusing discussion on the problem context*

The problem. In order to focus and engage your students, discuss with the class the Design Challenge.

INTRODUCTORY PACKET: Overview of the Module and Design Challenge

HERE IS WHAT YOU WILL DO

In the NYSCATE module ***Paving the Way to the Internet,*** you work ir a group to:

- Design a network to provide full Internet access for four clients/companies.
- Investigate the characteristics of the most current Internet protocol.
- Determine addressing schemes and calculations for multiple subnets.
- Create and test subnet addressing schemes using a variety of scenarios.
- Investigate routing fundamentals and protocols.
- Design networks using the more efficient classless addressing schemes.

PROBLEM CONTEXT

The “information superhighway” is by no means the smoothly paved road we all hoped it would be. We regularly encounter bumps and sharp curves along the way in our travels through cyberspace. It is the access to the multitudes of information available on the Internet that makes the process worthwhile.
Much of our active time on the Internet is spent searching for information that we need or for which we have only a passing interest. Time spent in the library 20 years ago can now be used more efficiently by accessing these same sources through the Internet. The same can be said for online purchasing (e-commerce), e-mail, and online banking.
Although we’re very interested in the location of the information we are looking for, we never seem to be concerned about the path the information takes to reach us. If not for the ability to locate a remote information source, and initiate a data transfer from this source, we could not have an Internet as we know it today.
The Internet can only work if it has a method (or protocol) that enables it to identify users and direct information accordingly. The Internet protocol (IP) accomplishes this by assigning a unique address to each user. This process, which is similar in concept to the manner in which the U.S. Postal Service directs mail delivery, can suffer from the same kind of bottlenecks and congested resources. Although there are no ZIP codes (or ZIP + 4) on the Internet, strategies have been developed to optimize the process and to increase the efficiency of data transfer.

Design Challenge

You and the members of your team are to design a network that will provide full Internet access for four clients/companies. You will determine the requirements of each company, and then design an optimal addressing scheme to serve them.

Specifications

- Full Internet access will be provided for the following four clients/companies:
  - Small company (real estate office): 50 nodes
  - Medium company (department store): 200 nodes
  - Medium-large company (university): 1,500 nodes
  - Large company (local ISP): 5,000 nodes
- The designed network must increase data performance (decrease router table size) of a traditional single class B address network.

As users of the Internet, most people are not interested in how the information reaches them. Most users are only concerned with the speed at which the information arrives. From time to time, bottlenecks occur as a result of heavy traffic; thus we experience lengthy delays and heavy congestion in the delivery of data. This makes management of the routing of information very difficult. Four clients/companies have the problems of heavy traffic and congestion in delivery of data and difficulties in routing their information. These companies vary in size.

After providing “wait time” for the class to think, elicit and record (on chalkboard, flip chart, or whatever media is available) what kinds of problems have been encountered, what kinds of companies are to be served, how many nodes are required by each company, and what is their current network design.

Tell the class that they will focus on designing a new and improved network for each of the four companies, and then describe the Design Challenge. Distribute the Introductory Packet but have students put it aside until the following meeting. Introduce the informed design loop. Ask “KWL” questions to find out what the students **know**, what they **want to know**, and what they need to **learn**. Examples of such questions are “Why do we need to keep track of how data is transferred?” and “Why do we need to be efficient in data transferring?” Discover here and elsewhere through such questions the naïve conceptions individual students hold about network technology.

The challenge. Redirect students to the Introductory Packet. As you go through the packet’s contents together, present the challenge in a manner that will motivate them. Discuss briefly the Here’s What You Will Do, Problem Context, and Materials Needed sections.

Each company needs full Internet access. These companies have come to you for help in redesigning their network so that their company has full Internet access and increased data transmission performance.

Period 1: ***Organizing for informed design***

Informed design. (See the NYSCATE *Pedagogical Framework*, p. 10, for a more detailed discussion on focusing students on the process of informed design.) Elicit from students what they know about good design and who engages in design. Ask for examples of good design and poor design.

Tell the class that completing a series of KSBs will help prepare them for addressing the Design Challenge they face. Then introduce the student sheet describing the informed design cycle and provide time to read it.

The information sheet on the informed design cycle should be referred to often as groups work on the Design Challenge. The informed design loop can be particularly useful to the students as they chart their progress using a Design Journal. Like professional engineers, they will find themselves using the loop in an iterative way rather than in a linear way.

Discuss the informed design cycle and stress that although design is normally informed by the designer's current knowledge, completion typically requires access to new knowledge. Discuss the need to research what solutions exist to solve this Design Challenge, and how reaching an optimal design solution requires meeting specifications, working within constraints, and making trade-offs.

Student requirements. Discuss the student requirements (Introductory Packet); students are expected to maintain a Design Journal. (Information on this document is provided in the NYSCATE *Pedagogical Framework,* p. 15, along with guidelines for the individual Design Report and the group presentation.) Help students see that the Design Journal allows them to document progress as they complete literature searches, factor investigations, and Knowledge and Skill Builders (KSBs). Describe the requirement that each student submit a Design Report and each group make a class presentation at the conclusion of the module. Alert the students that the presentations are to be multimedia and should detail their design process and results. Help them see that such a presentation summarizes work completed in researching, collecting, and analyzing data; developing models; improving designs; and making refinements. Describe the multiple forms of media (e.g., presentation software, color overheads, videos, computer animation) that they might use to enhance their presentations. Assure them that when their classmates ask probing questions and challenge group findings at the end of presentations, they are mirroring proceedings that are common at science conferences.

Assigning groups. Talk with some of the students ahead of time to see how experienced they are at working in cooperative groups. Assign small working groups; a group of three students is often ideal (see "Forming and Facilitating Design Teams" in the *Pedagogical Framework*, p. 12). Monitor groups throughout the module.

Sessions 2–7: *Coordinating student progress*

Coordinate work by individuals. Plan opportunities within this module for students to revisit their initial understandings by providing experiences with new phenomena that contradict their stated perceptions. Unless individuals get to actively process such contradictions, they may fail to grasp the new concepts and then may revert to naïve conceptions.

Help individual students make the connection between carefully documenting information as they proceed and well-written reports and presentations at the end.

Note that a student displaying unacceptable behavior may be doing so because other members of the group do not value that student's contribution to the project. Get to know the strengths of such a student and try assigning roles for all members of his or her group. Give the student a role that features a personal strength and inform the group ahead of time that this person is known to do that task well.

As the work becomes more technical and cerebral, some students will begin to complain that they are doing all the work while others loaf. Citing examples from your own experience, explain to such individuals that the best way to learn something is to teach it to others. Remind the group that it is essential that *all* members of a cooperative group understand all ideas and steps along the way. Conduct frequent verbal checks to see that each student has adequate understanding before the group moves on in its work.

Group research and investigation through KSBs. Have students complete:
KSB 1: What Is an IP Address? The students are to learn the advantages of using an IP number, check connectivity, and learn about different classes (A, B, C, and D).

Knowledge and Skill Builders (KSB 1)
What Is an IP Address?

This KSB introduces you to the concept of Internet protocol (IP) addressing. A host (or node) that is on the Internet must be connected to a network as well. The Internet can be defined as the interconnection of many networks. An IP address has two parts: a network identifier and a host identifier within that network.

You first check to determine whether your station is actually connected to the Internet. If it is connected, you identify your assigned IP address. You are to compare your IP address to that of your classmates and use the network mask to identify the net ID of your network. Since numbers can be difficult to remember, you are to explore the usage of names for nodes instead of IP numbers. Networks have different network IDs; you compare several of them from different classes (classes A, B, and C).

Develop your understanding

1. What are the advantages of using names instead of IP numbers?
1. Check the connectivity with your classmates; are the net IDs different?
2. Connect to www.cisco.com. Identify and record the path and networks your packet crossed.
3. Run the traceroute utility. Describe the output obtained.
5. Check the network mask and use your IP to determine your network ID. Is your IP class A, B, or C?

KSB 2: Classical IP Addressing Schemes – Students develop an understanding of subnetting and calculating special ID addresses.

Knowledge and Skill Builders (KSB 2)
Classical IP Addressing Schemes

In this KSB you are introduced to the mathematical tools and fundamental IP calculations needed to create a single network address. An IP address is used to reach a host on the Internet; an IP address is broken down into two components. The first portion of the IP address is used to access the correct network, and the second portion of the IP address is used to reach the host. A subscriber (a company or an individual) can have only one physical network; therefore, all hosts are at the same hierarchical level. See figure 1 below.

Different hierarchical levels are introduced by creating *logical networks*. These logical networks are produced by subdividing network addresses into subnetworks. These subnetworks (sets of smaller networks) are derived from the single IP network address given to the (subscriber) "company." Unless it is advertised, the rest of the Internet is not aware of the existence of these subdivisions.

Knowing the different IP classes, do the mathematical operations needed to effectively design a subnetted network. Doing so helps you learn how to determine:

- The network ID given a network mask.
- Whether a subnetted scheme is used.
- How to calculate the number of subnets in the schemes as well as the number of hosts and range of IP addresses for each subnet.
- How to calculate some special addresses such as subnet ID loopback and broadcast addresses.

Develop your understanding

1. Describe two situations in which subnetting can be a solution, using the printed/electronic resources provided by the instructor.
2. List and explain the advantages/disadvantages of rewiring a physical network and creating a subnetted network.

Describe the differences and similarities between a network and a subnetwork. If we have two subnetworks, do they belong to the same network?

3.
   i. Describe the differences and similarities between a network and a subnetwork. If we have two subnetworks, do they belong to the same network?
   ii. Subnet the following class C 192.168.10.0 into at least 6 subnets. You and your partner are to select an IP address from the same subnet and change the IP. Connect your PC with that of your partner using the provided network hub. You and your partner are to change the IP address of your PC to one from the same subnet.
      a. Test the IP connection with your partner.
      b. Present and explain the results.
   iii. Repeat the previous exercise, but now you and your partner select an IP address from different subnets.
      a. Test the IP connection with your partner.
      b. Present and explain the results.
      c. Compare these results to the previous exercise.
4. If a company has two buildings, 20 departments per building, and each department has two networks, how many class C

KSB 3: Designing a Network IP Scheme – Through the use of several Cisco websites, students become familiar with layer-2 and layer-3 devices. In addition, students establish network connectivity using routers.

Knowledge and Skill Builders (KSB 3)
Designing a Network IP Scheme

Given a set of specifications, you are to design a network scheme. Several examples are used to illustrate the differences between the IP classes and addresses. Determining the subnet mask also is one of the objectives.

You are given a network IP address from each IP class along with either the number of subnets to be created, or the number of hosts per subnet. You are to perform all the calculations for each of the networks presented to you. An interconnecting device called a *router* is needed to establish a link between different networks; the router allows hosts from one subnet to communicate with a host from another subnet. The router keeps track of the IP addressing scheme used and permits connectivity among the networks. You are to test and confirm the fact that a physical connection is not enough to provide Internet communication; a standard Internet protocol is needed as well. You are to use the TCP/IP communication protocol to explore various situations by changing IP addresses of your host and modifying protocols.

Develop your understanding

1. Define and explain the functions of a layer-2 device.
2. Select, using www.cisco.com, at least two layer-2 devices. Summarize the technical specifications for each of the layer-2 devices selected.
3. Define and explain the functions of a layer-3 device.
4. Select, using www.cisco.com, at least two layer-3 devices. Summarize the technical specifications for each of the layer-3 devices selected.
5. If we use the analogy that the Internet is equivalent to a superhighway, then what are routers equivalent to?
6. Explore and record the following issues:
   a. How many routes can you find from your current location to a specified NYSCATE site?
   b. How many routes can you find from your current location to your e-mail server?

KSB 4: Implementing a Classful Design – Students determine procedures and connectivity using an IP address.

Knowledge and Skill Builders (KSB 4)

Implementing a Classful Design

In this KSB you implement a network design using the computers that are available in your school. You become familiar with the functions and importance of routers and subnet masks. Connectivity is confirmed through the use of a variety of computer simulation tools.

You are given a set of specifications to be implemented in a network. You are to determine the network design that will best meet the specifications and implement the design. Each PC represents a member of each subnet and one PC represents a node located on the Internet outside your network. In addition, you are to set up one PC as a server that acts as a router. You are to test full connectivity by creating accounts and testing access to those accounts.

Develop your understanding

1. What kinds of specific difficulties did you encounter when designing your network and how did you overcome those difficulties?
2. Describe your reactions to your design and implementation.
3. Discuss the procedure used to have the server act as a router.

KSB 5: Routing Fundamentals – Students learn to use a protocol analyzer, browse different sites, and record locations.

Knowledge and Skill Builders (KSB 5)

Routing Fundamentals

Most processes in the network environment are designed to be transparent to the user; users usually do not need to be concerned with the network design and implementation. In this KSB you are concerned with the network design and you use a variety of tools to monitor network traffic and describe methods to route data. The data must be routed to its destination in the most efficient manner possible.

You are to view the routing table used in your network design. The routing table allows data to be routed from the source to the destination. In addition to specifying the best route, these tables provide additional information needed to establish a local map of devices that are involved in routing. You are to be introduced to a variety of tools (such as a protocol analyzer) that gather network traffic data and allow you to view and read the content of those packets as well as look at their structure.

Develop your understanding

1. What are the physical and IP addresses of your default gateway?
2. Launch the protocol analyzer and start recording. Then start your browser.
   a. Point started browser to www.cisco.com.
   b. Locate and download a document within that site.
   c. Stop the recording session of the analyzer.
   d. Locate, view, and record those packets/frames that contain the activity carried out in parts b and c.
   e. Select a packet that originated from your station. Decode the packet and locate the layer-3 header. Describe the values of the flags and items listed in the header. Specify the port used.
   f. Select a packet that was destined to your station that used the TCP transport protocol (layer 4) that contained the flag "syn" up in the transport (layer 4) header. Research the purpose of that flag and propose the likely purpose of that packet.

KSB 6: VLSM and CIDR – Students develop an understanding of variable length subnet mask (VLSM) and classless interdomain routing (CIDR) and their uses.

Knowledge and Skill Builders (KSB 6)

VLSM and CIDR

As you have learned so far in classful interpretation of Internet routing, the network mask is not provided. This leads to some degree of guesswork to determine a mask when matching a destination in a routing table. Providing the network mask information is the essence of CIDR (classless interdomain routing). In this KSB you are introduced to VLSM (variable length subnet mask) and CIDR. These routing protocols provide a more efficient use of an organization's assigned IP address space by allowing the use of several subnet masks within a scheme. While VLSM is used to design the internal network of an organization, CIDR offers similar benefits to the ISPs by hiding its internal structure to the outside while keeping the size of the routing table to a minimum. The only difference between VLSM and CIDR is the scale of the network.

You are to study hierarchical addressing schemes and use VLSM in a network design. Several examples of addressing schemes are used. Also, you study methods in which several large prefix routes can be combined into a shorter one. You are introduced to CIDR and work on several CIDR address space allocation examples. Your designed implementations will use some newer routing protocols such as RIPv2, OSPF, EIGRP.

Seeking additional factors and affecting the design of the network

SOURCES

- Cisco Systems: OSI Model, ConfigMaker, ***http://www.cisco.com***
- Everything You Ever Wanted to Know, by Chuck Semeria, ***http://www.3com.com/solutions/enUS/ncs/501302.html***
- Network Magazine ***http://www.networkmagazine.com/article/NMG20010226S0002***
- Network ICE, ***http://advice.networkice.com/Advice/default.htm***

Sharing. Convene the large group one or more times to share results of individual and group investigations. Invite students to listen critically to one another and facilitate a discussion of how this knowledge can be used to inform their efforts in the design of a network. Continue to work as a facilitator as students work in their groups to create alternative designs. Check to see that each group understands that its solution must address the specifications and constraints and the conditions needed to design the network. Remind each group to make decisions and select design components on the basis of their investigations. You may want to develop a rating system to determine which alternative design is preferred.

Planning and constructing. Continue to work as a facilitator as groups select their preferred alternative and develop plans for design. Facilitate a discussion of trade-offs that are made in the search for optimal design solutions. Encourage groups to identify and model functional design elements and construct their working prototype.

Testing. Bring students together as a large group and discuss ways in which groups might test their design solutions. Facilitate small group development of testing and evaluation procedures.

Have the entire group compare results. Encourage student groups to carefully review the work of other groups to glean ideas that might inform a redesign. When redesign is discussed, continue to direct students' attention to how such informed understanding can guide improvement.

Session 8: *Summing up progress on the learning goals*

Design Report. The reports provide one of the major opportunities for you to determine whether individuals have attained the goals for this module. Continue to work as a facilitator as groups document their progress and share results. Explain that each student is to submit a Design Report. Assist individuals in structuring and writing their Design Reports. The Design Report should include a discussion of redesign with justifications for the redesign decisions. Provide students with the Design Report guidelines from the NYSCATE *Pedagogical Framework*. As you introduced this module, you told students that careful documentation in the Design Journal leads to a well-written final report later on. For individuals who have trouble writing, frequently check their documentation along the way to ensure that they will have a source of information adequate to generate a report. It is advisable to set aside some class time for students to work on their reports. This provides you with clues as to how the students are progressing with their reports and enables you to assist students during regular class time.

Group presentations. Discuss with the class what is considered proper and expected behavior during group presentations. Address the need to use a variety of media to support the presentation. Review and distribute the presentation guidelines from the NYSCATE *Pedagogical Framework*, p. 27. Help students understand what is expected for their individual reports and the relationship of the report to the journal they keep.

During the group presentations to the class, encourage students (through example) to ask appropriate questions and provide constructive feedback to the presenters.

VII. ADDITIONAL SUPPORT FOR TEACHERS

Additional Information:

IP addresses are layer-3 addresses (logical). Be sure that you are familiar with the commands available from the operating system that allow the user to make changes in the IP configuration.

Become comfortable with operating systems in order to set a software-based router. The good news is that it can be done fairly easily using what is available today and it can be done through either Windows products or any Linux (or Unix) distributions.

Microsoft Windows uses the :IPCONFIG command to allow viewing of the current configuration and the control panel network icon to change the IP protocol configuration. In most network environments, the client obtains the IP address automatically through the use of DHCP (Dynamic Host Configuration Protocol). For the proposed environment in this course, static IP addresses will be used; the IP address is to be set manually by the student. In order to implement these changes, the student will have to be given full administrative rights.

To configure a software router using Microsoft Windows Server operating systems (excluding Windows NT), it is necessary to install the routing and remote access services (RRAS). Static routes can be included in the router configuration. When connecting routers to other routers, a routing protocol is to be used and the simplest such protocol RIP can be used. If time permits, this would be a good hands-on activity but it can be lengthy. Students must be tutored on how to set and change IP addresses and verify the settings. An additional useful activity is to practice the use of the IP troubleshooting tools (ping, traceroute and pathping). Many resources, reference books and textbooks concerning RRAS are available.

Linux (or Unix) also allows setting a software router. The line command to verify IP address setting is "ifconfig *a". Due to the popularity of Linux, there are many reference materials available.

References:

a) On how to configure a software router using Linux:
- http://www.geocrawler.com/archives/3/47/2003/5/0/10502321
- http://www.linuxquestions.org/questions/archive/3/2001/07/1/3938
- Ipmasq: http://www.linux.org
- http://www.freesco.org

b) On how to configure a software router using Microsoft Windows Server:
- Exploring Windows 2003 Security: RRAS and IAS: http://www.serverwatch.com/tutorials/article.php/3115701
- Routing and Remote Access (RRAS): http://computerperformance.co.uk/Litmus/rras.htm
- http://www.microsoft.com

Suggested optional activities:

1) Using figure 1,

KSB 1:

- Assign the students IP addresses that belong to different IP networks.
- Assign the students IP addresses that belong to the same IP network.
- Use different network prefix (or subnet mask) to force different IP networks.

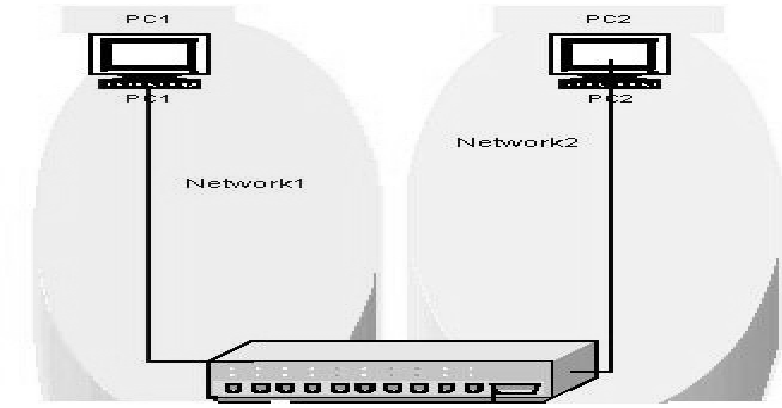


Fig1

2) Using figures 1a and 2

KSB 3:

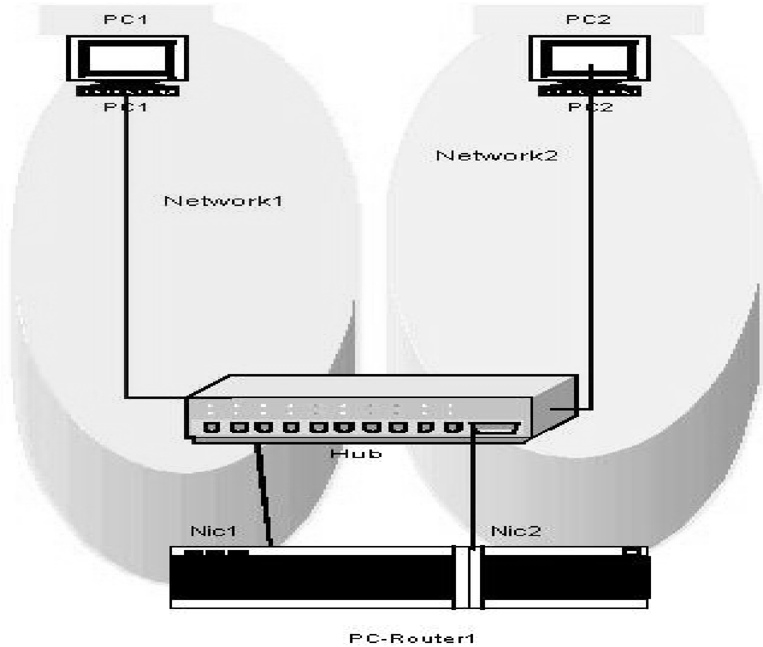


Fig1a

To illustrate the concepts and issues concerning IP addressing schemes and IP connectivity, the instructor can have PC1 and PC2 managed by the student (or group of students), with each PC belonging to a different network (respectively N1 and N2). The student (or the group) will either select or be given a network address. With only the TCP/IP protocol stack installed on the client, the following three situations can be tested:

a) If two nodes belong to two different IP network, they cannot connect to each other unless a router is used.

b) If two nodes belong to two different subnetworks, they cannot connect to each other unless a router is used.

c) If two nodes belong to the same IP network or subnetwork, they cannot connect to each without the use of a router.

The PC-Router will have to be prepared by the instructor unless students are familiar with the operating systems.

This lab can be used to illustrate several concepts:

· Without the PC-Router: No connectivity.

· With the PC-Router: Full connectivity.

· Have the class rewire using figure 2 including router-router connections (the router-to-router connections must not belong to the same IP network address as the client nodes PC1 and PC2).

· A network connection depends on the network protocol stack. Several network protocol stacks are available and can be installed on the same node. A network application on a node can then have multiple ways of establishing a connection, based on the protocol. In a local area network environment, IP connectivity is only one possible network connectivity. If one removes the IP stack on the client PC1 and PC2, but enables some other network protocol stack, then it can be verified that nodes PC1 and PC2 can connect to each other but not through the IP stack (no IP connectivity). If a network is designed around the TCP/IP protocol suite, then the clients should only have that one protocol available.

· The use of troubleshooting tools and commands.

· The importance of the selection of the IP network addresses and client addresses as well as the network prefix (or network and subnetwork mask).

This activity can be extended by connecting a third PC representing another network to the HUB.

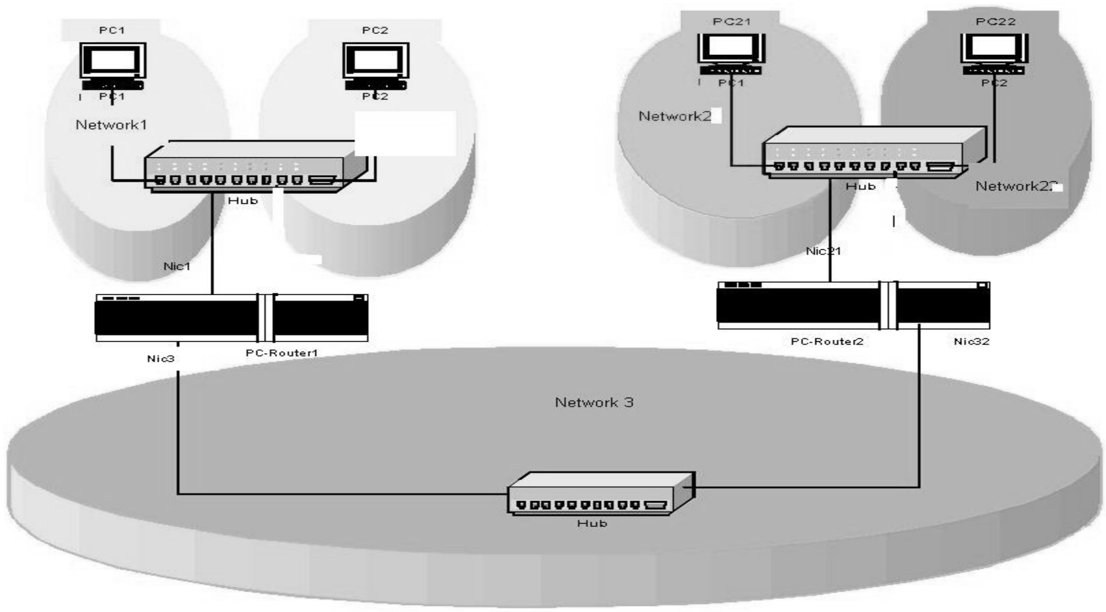


Fig2

ASSESSMENT STRATEGIES

Assessment scoring sheets that assess student performance in five categories follow:

- A. Design Solution: A network diagram illustrating the complete network configuration; summary sheets for each client that describe the addressing scheme; and routing tables that confirm connectivity for each client.
- B. Oral Presentation to Class: Preparation and presentation of material to the class. Was the design solution justified?
- C. Student Class Work and Group Work: Participation of each student including individual effort and contribution to the group effort.
- D. Design Journal: Student documentation of all investigations. Accuracy and complete records of investigations and the Design Challenge.

- E. Final Report: Does the final design solution reflect work on the KSBs? Has the design process been used correctly? Was good written English used?

Paving the Way to the Internet
Assessment Student Scoring Sheets

A. Design Challenge Solution

Network Diagram

1. Network diagram includes all subnet IDs. (0–10 pts.) ________
2. Diagram accurately describes the network configuration. (0–10 pts.) ________
3. The IP address for each connecting node is included. (0–10 pts.) ________
4. Diagram is clearly labeled and neatly presented. (0–10 pts.) ________

Summary of Services Provided

5. A summary is provided for each client/company (four clients). (0–16 pts.) ________
6. Summaries include the correct subnet ID and address. (0–20 pts.) ________
7. Summaries include the correct range of IP addresses available to the client/company. (0–20 pts.) ________
8. All fixed (reserved) IP addresses are listed for each client/company. (0–20 pts.) ________
9. All special IP addresses are listed for each client/company. (0–20 pts.) ________
10. All IP addresses are presented, using the proper CIDR notation. (0–24 pts.) ______

Routing Tables

11. Routing tables are consistent with the addresses in the network diagram and the IP addressing. (0–13 pts.) ________
12. Aggregated routing table provides a routing path to the Internet from each network within this ISP. (0–14 pts.) ________
13. Routing table summarizes full connectivity for each client. (0–13 pts.) ________

Total (200 pts.)________

B. Oral Presentation to Class

1. Presentation followed a logical sequence. (0–5 pts.) ________
2. All team members actively participated. (0–5 pts.) ________
3. Presenters were clear and audible. (0–5 pts.) ________
4. Presenters were appropriately dressed. (0–5 pts.) ________

5. Presentation held the attention of the audience. (0–5 pts.) ________
6. Audience participation was encouraged. (0–5 pts.) ________
7. Questions were answered in a professional manner. (0–5 pts.) ________
8. Presenters were well prepared (all materials were ready). (0–5 pts.) ________
9. Technical terms (where appropriate) were correctly used. (0–5 pts.) ________
10. The design solution was justified to the class. (0–5 pts.) ________

Total (50 pts.) ________

C. Student Class Work and Group Work

1. Assigned tasks were completed in a timely fashion. (0–10 pts.) ________
2. Student made good use of time management. (0–10 pts.) ________
3. Student worked collaboratively with teammates. (0–10 pts.) ________
4. Student followed teacher's instructions well. (0–10 pts.) ________
5. Student contributed her/his share of the group effort. (0–10 pts.) ________
6. Student conducted herself/himself in a businesslike manner. (0–10 pts.) ________

Total (60 pts.) ________

D. Design Journal

1. Journal documents all work on both the KSBs and the Design Challenge. (0–6 pts.) ________
2. Journal contains observations and data that were collected during the KSBs and the Design Challenge. (0–8 pts.) ________
3. All entries are legible and complete with correct grammar and punctuation. (0–8 pts.) ________
4. Entries are chronologically correct. (0–6 pts.) ________
5. Entries were made on a daily basis. (0–6 pts.) ________
6. Illustrations are used to enhance the journal entries. (0–6 pts.) ________

Total (40 pts.) ________

E. Final Report

1. An introduction explains the context of the problem and notes the specifications and constraints. (0–7 pts.) ________
2. Research and investigations are documented as are existing solutions that helped solve the problem. (0–7 pts.) ________
3. Multiple solutions are generated and the selection of alternative solutions is justified. (0–7 pts.) ________
4. An optimal solution is chosen and it is based upon engineering, mathematical, and scientific data and principles. (0–8 pts.) ________
5. The construction of a working model is described and any modifications and refinements are discussed. (0–7 pts.) ________
6. Methods used to test the design solution are described; data that were collected and the evaluation of the design solution are described. (0–7 pts.) ____
7. Recommendations are made for redesign to enhance the performance of the design solution. (0–7 pts.) ________

Total (50 pts.) ________

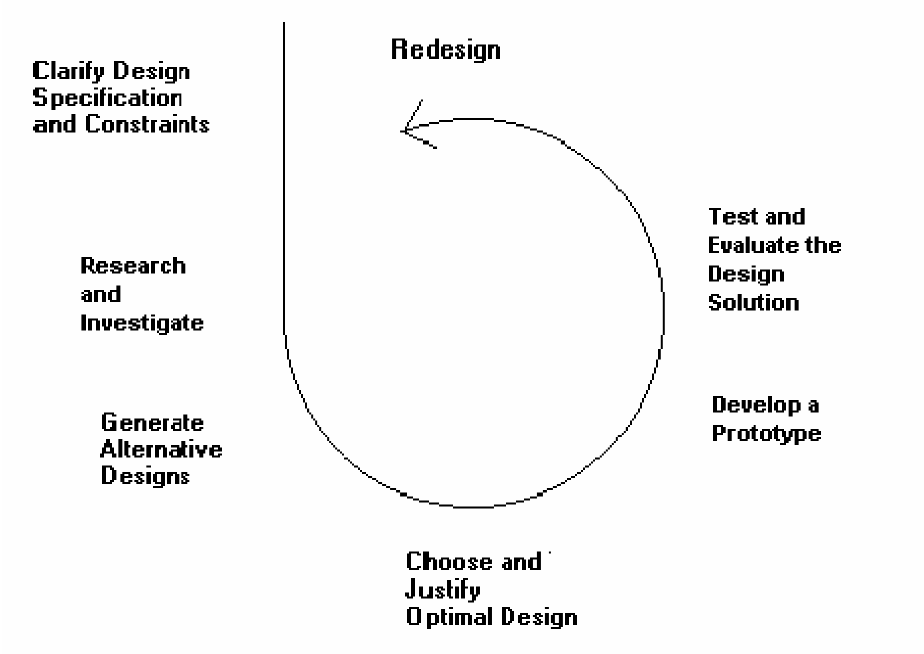
Grand Total: Sections A–E (400 pts.) ________

NYSCATE DESIGN CYCLE

- The Design Cycle

Characteristic of the design process is its iterative nature. It is iterative in that decisions are made without complete knowledge and therefore must be revisited. Each solution element can be refined in a multistep process involving monitoring performance against desired results and making appropriate modifications. Typically, trade-offs are required to address design criteria optimally.

A method is shown (see informed design loop below) to illustrate informed technological design for students.



The loop includes several phases that together are referred to as the design cycle. These repeatable phases engage the student in the design process. The student hereby works in a manner similar to adult professionals who do engineering design for a living. Engineers and other designers rarely follow these phases in order. Instead, they move back and forth from one phase to another as needed. You also should not expect students to go through these phases in the same order each time that they design something. The designer arrives at solutions while monitoring performance against desired results and making appropriate changes as needed. Almost always, following design criteria leads to trade-offs taking place. The phases of the informed design cycle are described here:

1. *Clarify design specifications and constraints.* Describe the problem clearly and fully, noting constraints and specifications. Constraints are limits imposed upon the solution. Specifications are the performance requirements the solution must meet.

2. *Research and investigate the problem*. Search for and discuss solutions that presently exist to solve this or similar problems. Identify problems, issues, and questions that relate to addressing this Design Challenge.

3. *Generate alternative designs*. Don't stop when you have one solution that might work. Continue by approaching the challenge in new ways. Describe the alternative solutions you develop.

4. *Choose and justify optimal design.* Defend your selection of an alternative solution: Why is it the optimal choice? Use engineering, mathematical, and scientific data, and employ analysis techniques to justify why the proposed solution is the best one for addressing the design specifications. This chosen alternative will guide your preliminary design.

5. *Develop a prototype.* Make a model of the solution. Identify possible modifications that would lead to refinement of the design, and make these modifications.

6. *Test and evaluate the design solution*. Develop a test to assess the performance of the design solution. Test the design solution, collect performance data, and analyze the data to show how well the design satisfies the problem constraints and specifications.

7. *Redesign the solution with modifications*. In the redesign phase, critically examine your design and note how other students' designs perform to see where improvements can be made. Identify the variables that affect performance and determine which science concepts underlie these variables. Indicate how you will use science concepts and mathematical modeling to further enhance the performance of your design.

Note: Phase 4 involves: (a) hypothesizing that the design solution will meet specifications and constraints; and (b) showing that the design should work by conducting M/S/E/T analyses. When choosing the optimal design from among alternatives, two things are in play: The first is that the optimal design is chosen by rating it against design specifications and constraints. After doing so, the designer is not yet really sure that the design will work as intended. A hypothesis is made on the basis of the rating. It is not until mathematical or engineering analysis has been done that the designer is reasonably certain that the design will meet specifications. For example, if the design is a table, it is analyzed (a stress analysis is done) under the intended load. This is an interesting deviation from the current design models because it calls out specifically for two kinds of analyses to be done: one qualitative, one quantitative. It draws the student a step closer to informed design.

VIII. STUDENT HANDOUT SECTION

Student Handout section begins on the next page:

INTRODUCTORY PACKET: Overview of the Module and Design Challenge

HERE IS WHAT YOU WILL DO

In the NYSCATE module *Paving the Way to the Internet*, you work in a group to:

- Design a network to provide full Internet access for four clients/companies.
- Investigate the characteristics of the most current Internet protocol.
- Determine addressing schemes and calculations for multiple subnets.
- Create and test subnet addressing schemes using a variety of scenarios.
- Investigate routing fundamentals and protocols.
- Design networks using the more efficient classless addressing schemes.

PROBLEM CONTEXT

The "information superhighway" is by no means the smoothly paved road we all hoped it would be. We regularly encounter bumps and sharp curves along the way in our travels through cyberspace. It is the access to the multitudes of information available on the Internet that makes the process worthwhile.

Much of our active time on the Internet is spent searching for information that we need or for which we have only a passing interest. Time spent in the library 20 years ago can now be used more efficiently by accessing these same sources through the Internet. The same can be said for online purchasing (e-commerce), e-mail, and online banking.

Although we're very interested in the location of the information we are looking for, we never seem to be concerned about the path the information takes to reach us. If not for the ability to locate a remote information source, and initiate a data transfer from this source, we could not have an Internet as we know it today.

The Internet can only work if it has a method (or protocol) that enables it to identify users and direct information accordingly. The Internet protocol (IP) accomplishes this by assigning a unique address to each user. This process, which is similar in concept to the manner in which the U.S. Postal Service directs mail delivery, can suffer from the same kind of bottlenecks and congested resources. Although there are no ZIP codes (or ZIP + 4) on the Internet, strategies have been developed to optimize the process and to increase the efficiency of data transfer.

Design Challenge

You and the members of your team are to design a network that provides full Internet access for four clients/companies. You will determine the requirements of each company and then design an optimal addressing scheme to serve them.

Specifications

- Full Internet access will be provided for the following four clients/companies:
  - Small company (real estate office): 50 nodes
  - Medium company (department store): 200 nodes
  - Medium-large company (university): 1,500 nodes
  - Large company (local ISP): 5,000 nodes
- The designed network must increase data performance (decrease router table size) of a traditional single class B address network.

Constraints

- ISP (Internet service provider) has access to a single class B IP address.
- Solution must use VLSM (variable length subnet mask) and CIDR (classless interdomain routing) in the addressing scheme.

Materials Needed

(If routers are available, there is no need to have a PC act as a router.)

- Networked PCs:

One to act as the Internet (outside the designed network) with a network interface (NIC) card

One to act as the router server (Internet provider) with at least two NIC cards

Additional computers to act as the companies (clients) to be served by the network, each with a NIC card

- Network HUBs or switches having at least 4 ports
- Network cables.

STUDENT REQUIREMENTS

- Each team will be responsible for the following components of their design solution:
  - A **network diagram** that accurately describes the design solution; it should include the IP addresses for each connecting node, and all subnet IDs.
  - **Summary sheets** for each client (four total); each sheet should include the correct subnet IDs and addresses, range of IP addresses available, all fixed (reserved) addresses, as well as all special addresses.
  - **Routing tables** that will be used to summarize full network connectivity for each of the four clients/companies.
- You will maintain an individual **Design Journal**, which will contain all of your observations and collected data. Entries will be made on a daily basis and will document your efforts on the KSBs and the Design Challenge.
- You will submit a final **Design Report**, which will contain information gathered from your Design Journal:
  - literature searches
  - hands-on research (factor investigations)
  - completion of Knowledge and Skill Builders (KSBs)
  - work on the Design Challenge
  - methods used to generate the final design solution.
- Team oral presentations will be made to the members of the class.
  - The presentation should justify your design solution.

- It should use a variety of media.
- It should be prepared and delivered in a professional manner.
- It should demonstrate that the solution meets design criteria.

Knowledge and Skill Builders (KSB 1)

What Is an IP Address?

This KSB introduces you to the concept of Internet protocol (IP) addressing. A host (or node) that is on the Internet must be connected to a network as well. The Internet can be defined as the interconnection of many networks. An IP address has two parts: a network identifier and a host identifier within that network.

You first check to determine whether your station is actually connected to the Internet. If it is connected, you identify your assigned IP address. You compare your IP address to that of your classmates and use the network mask to identify the net ID of your network. Since numbers can be difficult to remember, you are to explore the usage of names for nodes instead of IP numbers. Networks have different network IDs; you then compare several of them from different classes (classes A, B, and C).

Develop your understanding

1. What are the advantages of using names instead of IP numbers?

2. Check the connectivity with your classmates; are the net IDs different?

3. Connect to www.cisco.com. Identify and record the path and networks your packet crossed.

4. Run the traceroute utility. Describe the output obtained.

5. Check the network mask and use your IP to determine your network ID. Is your IP class A, B, or C?

6. Connect your PC with that of your partner using the provided network hub. Change the IP address of your PC to that given to you by your instructor.
   i) Test the IP connection with your partner.
   ii) Present and explain the results.

7. Repeat question 5 for the second set of IP addresses given to you.
   iii) Test the IP connection with your partner.
   iv) Present and explain the results.

8. Research the characteristics and uses of IP class D. What are the characteristics and uses?

Knowledge and Skill Builders (KSB 2)

Classical IP Addressing Schemes

In this KSB you are introduced to the mathematical tools and fundamental IP calculations needed to create a single network address. An IP address is used to reach a host on the Internet; an IP address is broken down into two components. The first portion of the IP address is used to access the correct network, and the second portion of the IP address is used to reach the host. A subscriber (a company or an individual) can have only one physical network; therefore, all hosts are at the same hierarchical level. See figure 1 below.

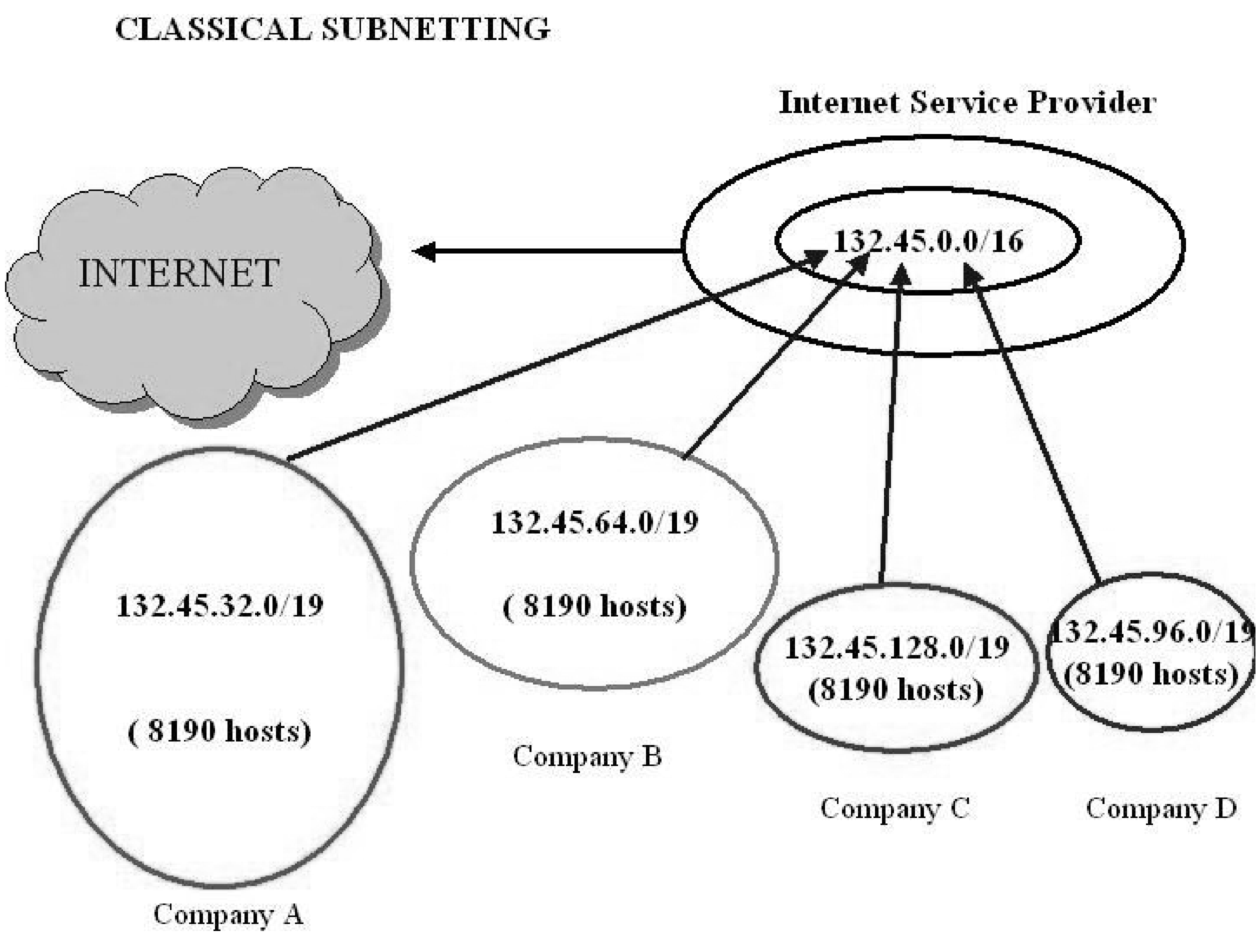


Figure 1

Different hierarchical levels are introduced by creating *logical networks*. These logical networks are produced by subdividing network addresses into subnetworks. These subnetworks (sets of smaller networks) are derived from the single IP network address given to the (subscriber) “company.” Unless it is advertised, the rest of the Internet is not aware of the existence of these subdivisions.

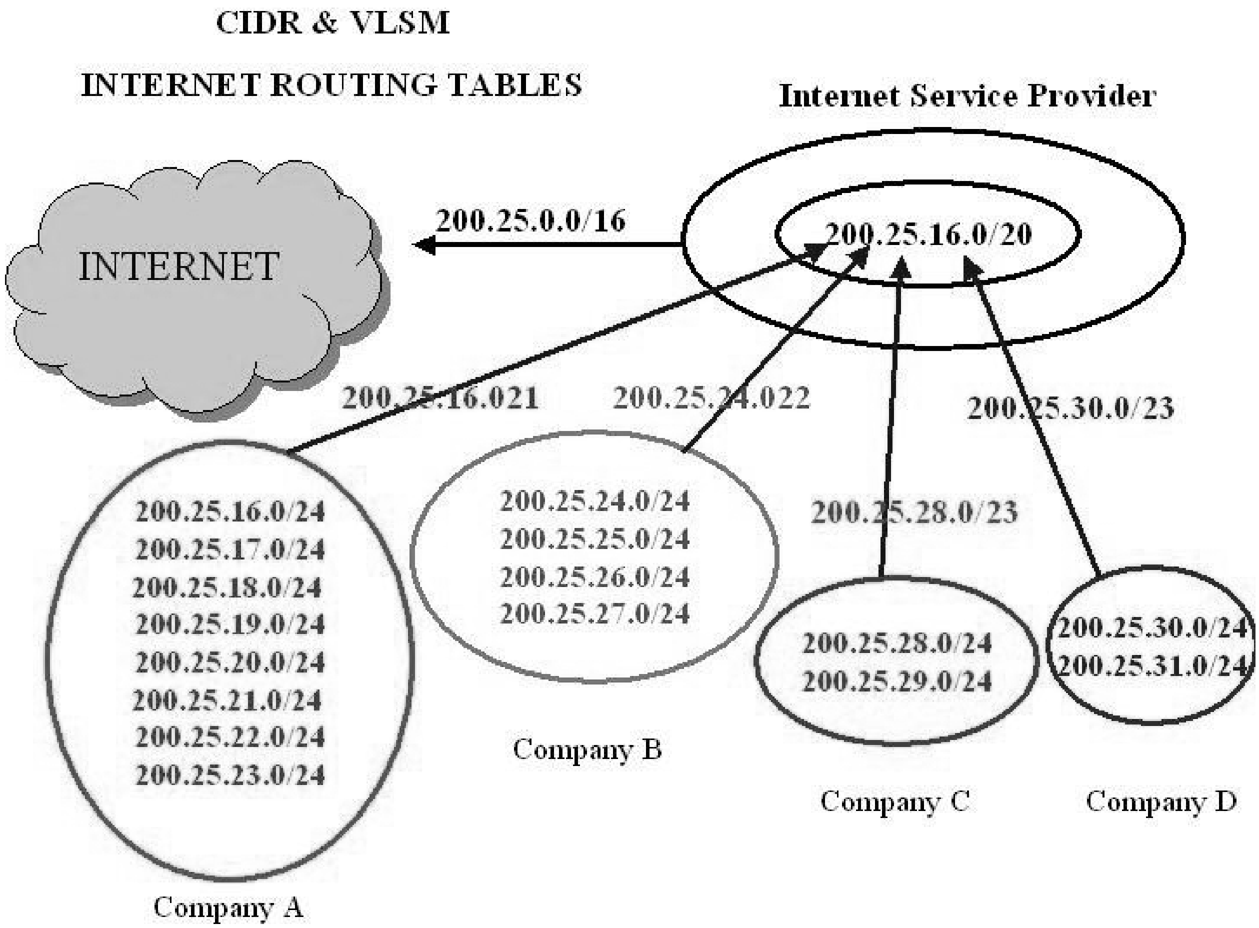


Figure 2

.
Knowing the different IP classes, do the mathematical operations needed to effectively design a subnetted network. Doing so helps you learn how to determine:

- The network ID, given a network mask.
- Whether a subnetted scheme is used.
- How to calculate the number of subnets in the schemes as well as the number of hosts and range of IP addresses for each subnet.
- How to calculate some special addresses such as subnet ID loopback and broadcast addresses.

Develop your understanding

1. Describe two situations in which subnetting can be a solution, using the printed/electronic resources provided by the instructor.

2. List and explain the advantages/disadvantages of rewiring a physical network and creating a subnetted network.

3.

   i. Describe the differences and similarities between a network and a subnetwork. If we have two subnetworks, do they belong to the same network?

   ii. Subnet the following class C 192.168.10.0 into at least 6 subnets. You and your partner are to select an IP address from the same subnet and change the IP. Connect your PC with that of your partner using the provided network hub. You and your partner then change the IP address of your PC to one from the same subnet.
      a. Test the IP connection with your partner.
      b. Present and explain the results.

   iii. Repeat the previous exercise, but now you and your partner select an IP address from different subnets.
      a. Test the IP connection with your partner.
      b. Present and explain the results.

      c. Compare these results to the previous exercise.

4. If a company has two buildings, 20 departments per building, and each department has two networks, how many class C IP addresses would be needed when the company wants to separate the networks in the buildings through the use of an IP scheme? Propose a network design using a private class B IP address.

Knowledge and Skill Builders (KSB 3)

Designing a Network IP Scheme

Given a set of specifications, you are to design a network scheme. Several examples are used to illustrate the differences between the IP classes and addresses. Determining the subnet mask is one of the objectives.

You are given a network IP address from each IP class along with either the number of subnets to be created, or the number of hosts per subnet. You are to perform all the calculations for each of the networks presented to you. An interconnecting device called a *router* is needed to establish a link between different networks; the router allows hosts from one subnet to communicate with a host from another subnet. The router keeps track of the IP addressing scheme used and permits connectivity among the networks. You are to test and confirm the fact that a physical connection is not enough to provide Internet communication; a standard Internet protocol is needed as well. You are to use the TCP/IP communication protocol to explore various situations by changing IP addresses of your host and modifying protocols.

Develop your understanding

1. Define and explain the functions of a layer-2 device.

2. Select, using www.cisco.com, at least two layer-2 devices. Summarize the technical specifications for each of the layer-2 devices selected.

3. Define and explain the functions of a layer-3 device.

4. Select, using www.cisco.com, at least two layer-3 devices. Summarize the technical specifications for each of the layer-3 devices selected.

5. If we use the analogy that the Internet is equivalent to a superhighway, then what are routers equivalent to?

6. Explore and record the following issues:
    a. How many routes can you find from your current location to a specified NYSCATE site?

    b. How many routes can you find from your current location to your e-mail server?

Knowledge and Skill Builders (KSB 4)

Implementing a Classful Design

In this KSB you implement a network design using the computers that are available in your school. You become familiar with the functions and importance of routers and subnet masks. Connectivity is confirmed through the use of a variety of computer simulation tools.

You are given a set of specifications to be implemented in a network. You are to determine the network design that best meets the specifications and implements the design. Each PC represents a member of each subnet and one PC represents a node located on the Internet outside your network. In addition, you are to set up one PC as a server that acts as a router. You are to test full connectivity by creating accounts and testing access to those accounts.

Develop your understanding

1. What kinds of specific difficulties did you encounter when designing your network and how did you overcome those difficulties?

2. Describe your reactions to your design and implementation.

3. Discuss the procedure used to have the server act as a router.

4. How did you determine the connectivity for each node?

5. Diagram your solution and include all IP addresses.

Knowledge and Skill Builders (KSB 5)

Routing Fundamentals

Most processes in the network environment are designed to be transparent to the user; users usually do not need to be concerned with the network design and implementation. In this KSB you are concerned with the network design and you use a variety of tools to monitor network traffic and describe methods to route data. The data must be routed to its destination in the most efficient manner possible.

You are to view the routing table used in your network design. The routing table allows data to be routed from the source to the destination. In addition to specifying the best route, these tables provide additional information needed to establish a local map of devices that are involved in routing. You are to be introduced to a variety of tools (such as a protocol analyzer) that gather network traffic data and allow you to view and read the content of those packets as well as look at their structure.

Develop your understanding

1. What are the physical and IP addresses of your default gateway?

2. Launch the protocol analyzer and start recording. Then start your browser.
   a. Point started browser to www.cisco.com.
   b. Locate and download a document within that site.
   c. Stop the recording session of the analyzer.
   d. Locate, view, and record those packets/frames that contain the activity carried out in parts b and c.

   e. Select a packet that originated from your station. Decode the packet and locate the layer-3 header. Describe the values of the flags and items listed in the header. Specify the port used.

   f. Select a packet that was destined to your station that used the TCP transport protocol (layer 4) that contained the flag “syn” up in the transport (layer 4) header. Research the purpose of that flag and propose the likely purpose of that packet.

3. Describe the ports that are used by TCP/IP protocols.

4. Using the resource provided by your instructor, add a static route to the routing table and change your default route to another address. Describe the effects of those changes.

Knowledge and Skill Builders (KSB 6)

VLSM and CIDR

As you have learned so far in classful interpretation of Internet routing, the network mask is not provided. This leads to some degree of guesswork to determine a mask when matching a destination in a routing table. Providing the network mask information is the essence of CIDR (classless interdomain routing). In this KSB you are introduced to VLSM (variable length subnet mask) and CIDR. These routing protocols provide an efficient use of an organization’s assigned IP address space by allowing the use of several subnet masks within a scheme. While VLSM is used to design the internal network of an organization, CIDR offers similar benefits to the ISPs by hiding its internal structure to the outside while keeping the size of the routing table to a minimum. The only difference between VLSM and CIDR is the scale of the network.

You are to study hierarchical addressing schemes and use VLSM in a network design. Several examples of addressing schemes are used. Also, you study methods in which several large prefix routes can be combined into a shorter one. You are introduced to CIDR and work on several CIDR address space allocation examples. Your designed implementations will use some newer routing protocols such as RIPv2, OSPF, EIGRP.

Develop your understanding

1. Summarize the differences between /12 and /22 prefix notations.

2. Convert the entire class A address space as a single CIDR advertisement.

3. Select one Internet service provider; then investigate and report in writing the major services that that company offers.