Addressing the gender gap: Teaching preadolescent girls computer networking concepts

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ADDRESSING THE GENDER GAP:  
TEACHING PREADOLESCENT GIRLS  
COMPUTER NETWORKING CONCEPTS  

BY  
CYNTHIA D. STRONG  

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR  
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Rochester Institute of Technology  
B. Thomas Golisano College of  
Computing and Information Sciences
ROCHESTER INSTITUTE OF TECHNOLOGY
B. THOMAS GOLISANO COLLEGE OF COMPUTING AND INFORMATION SCIENCES

MASTER OF SCIENCE IN NETWORKING AND SYSTEMS ADMINISTRATION
THESIS APPROVAL FORM

Student Name: Cynthia D. Strong

Thesis Title: Addressing the Gender Gap: Teaching Preadolescent Girls Computer Networking Concepts

Thesis Committee

Name                      Signature             Date

Professor Sharon Mason
Chair
Dr. Charlie Border
Committee Member
Dr. Luther Troell
Committee Member
Addressing the Gender gap: Teaching Preadolescent Girls Computer Networking Concepts

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Date: March 8, 2010
Signature of Author: Cynthia D. Strong
Dedication

To my parents whom I love very much.

Thank you for encouraging me, inspiring me, and believing in me.
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I would like to thank the following people for their support . . .

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The Networking, Security and Systems Administration Faculty and Staff
My Rochester Friends and Family
ABSTRACT

Due to the decline in the number of professional women entering labor markets in the area of computing and technology, there is a need for intervention. Focus should be given to improving these numbers by creating an early interest in women in computing and technology. This thesis focuses on developing educational modules that will create interest in networking concepts in preadolescent girls. Educational best practices, fundamentals of how people learn, assessments of pedagogy effectiveness, observations, and personal experiences frame the modules. Research such as this in the area of creating early interest will help address the issue of equal opportunity and representation for the underrepresented population of women in the computing and technology areas.
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INTRODUCTION

In this current Information Age, technology is the underlying driving force of most day-to-day activities. Technology influences every industry, organization, and field. The impact and usefulness of technology will continue to grow. As important as the technology, are the skilled workers developing and using the technology. The process of training a skilled worker does not begin with a high school or college degree. All the formal years of education contribute to the knowledge of a skilled worker. In the United States, all children are entitled to equal access to education. This allows all children to have equal opportunities for socio-economic development once becoming adults. The Stanford Encyclopedia of Philosophy states education “... equips individuals with the skills and substantive knowledge that allows them to define and to pursue their own goals, and also allows them to participate in the life of their community as full-fledged, autonomous citizens” (Phillips 2008).

There are different ways that an individual can live his or her life and contribute to society. An individual can choose many different occupations, professions, hobbies, vocations, and careers. Some individuals choose more than one such life work. Although children have equal access to education and the same education, women are less likely to choose occupations and career paths that involve Science, Technology, Engineering, and Mathematics (STEM). Evidence supports the phenomenon of a gender gap when students choose areas of concentration for post secondary education. Some authors attribute the gender gap to the structure of educational institutions. Whatever the cause for this
difference in educational and career paths between men and women; it has an effect on the
technology field. Women are underrepresented in the area of technology.

According to statistics given by the U.S. Department of Labor: Women Bureau (2009); in
2008, there were 1,034,000 computer software engineers, only 20.9% were women. In
2008, there were 227,000 network and computer systems administrators, only 21.4%
were women. According to the U.S. Department of Labor, several technical occupations are
projected to grow much faster than the average for all occupations over the period of 2006
to 2016. Computer systems analyst occupations are expected to grow by 29 percent (U.S.
to increase by 38 percent (U.S. Bureau of Labor Statistics, 2007a). Computer support
specialists and systems administrator occupations are expected to increase by 18 percent
(U.S. Bureau of Labor Statistics, 2007b). The number of technical occupations is projected
to grow; however, the number of women studying, and starting careers in this area is
decreasing. If these conditions hold true, there will be a deficiency of skilled women
available in the area of technology. As a result, women’s overall usage and understanding of
technology will be limited.

This thesis addresses the underrepresentation of women in the area of technology by
creating modules to garner early interest in technology. Without an equal representation
of women in the area of technology, technology and its applications will not reach its full
potential. These areas of technology will be underdeveloped because it will lack the
developmental and design perception that diverse analytical thought processes provide.
By getting women interested in technology earlier, there is a greater chance that they will enter technology fields and create positive change and advancements in the area.

PURPOSE STATEMENT

The purpose of this thesis is to provide a learning intervention to preadolescent girls in the area of technology by creating modules to teach them networking concepts that will help create an early interest in technology.

LITERATURE REVIEW

Research in the area of teaching preadolescent girls computing concepts is two-fold. First, understanding the technology gender gap is essential. The technology gender gap is the catalyst that draws attention to the need for preadolescent girls to be educated in the area of technology. Second, when seeking to teach someone a new concept it is necessary to understand how people learn and how to assess learning. Factors that influence the technology gender gap and effective pedagogy were explored because both were essential to the success of this research.

There has been a great deal of research in the area of women in computing and the prevailing gender gap. Part I of the literature review highlights specific research and studies conducted in the area of the gender gap, as well as factors many authors agree have significant importance to this field. Part II of this literature review highlights elements of how the brain works, effective pedagogy, and assessment of learning.
PART I

PUBLICATIONS ADDRESSING THE GENDER GAP

The American Association of University Women (AAUW), founded in 1881, is an organization that seeks to encourage equity for women and girls through advocacy, education, and research. The AAUW has commissioned several researchers to examine a number of women’s issues. These issues range from sex discrimination in academia and work, to examining gender differences in education. Thought of as one of the leading voices and influences in gender equity today; several publications by this organization were reviewed to gain a better understanding of the gender gap.

Jane Margolis, a social scientist, and Allan Fisher, a computer scientist and educator, conducted extensive research at Carnegie Mellon University to identify influencing variables at the university level. Margolis and Fisher interviewed more than 100 computer science students at Carnegie Mellon University over a four-year period. Their findings, published in Unlocking the Clubhouse: Women in Computing has been hailed as a great success. Anita Borg, President and Founding Director of the Institute for Women and Technology gave this affirmative review of the work:

Drs. Margolis and Fisher have done a great service to education, computer science, and the culture at large. Unlocking the Clubhouse should be required reading for anyone and everyone who is concerned about the drop in women’s participation in computing. (Borg)
Wm. A. Wulf, President of the National Academy of Engineering, had this to say about the book:

> On the surface, it seems that computing should be an attractive career for women, but for many it hasn’t been. Margolis and Fisher give us a deep and nuanced insight into this troubling problem. No simplistic answers are offered, but rather the far richer perspectives of real human experience. (Wulf)

In 2002, Margolis won the Frandson Award for Literature in the Field of Continuing Higher Education (MIT Press) and in 2003; she won the University Continuing Education Award for Literature (Schnabel). As a result of the high reviews for this work, Unlocking the Clubhouse was selected as one of the publications for review to understand the gender gap.

The literature review also includes Ghosts in the Machine: Women’s Voices in Research with Technology. Nicola Yelland and Andee Rubin edited this work. They sought to combine research completed by women in the area of technology into a cohesive book providing the women’s findings and recommendations. The researchers examined a wide range of topics such as how curriculum can be modified to encourage more participation from women, how video games affect women, and the differences between girls and boys in the way they relate to technology and learning.

**UNDERSTANDING THE GENDER GAP**

Based upon the resources reviewed, five areas of concentration were identified. These five areas are points of concern, as well as recommendations to help improve the current state of the gender gap. The five areas of concentration were as follows. One, the introduction to computing and identifying computing interest; two, the importance of preserving human
interactions; three, the desire to solve real-life problems; four, having a support system, and five, the importance of seeing more women in non-traditional roles.

**INTRODUCTION TO COMPUTING & IDENTIFYING COMPUTING INTEREST**

When and how girls are introduced to computing effects their view of computing and the roles men and women play as it pertains to computing. Margolis and Fisher’s research explicated that most men were introduced to computers early – before high school. Their fathers in a relationship similar to a “father-son internship” often introduce the boys to computers (Margolis & Fisher, 2002, p. 24). In this relationship, the boys are encouraged to use computers and learn about them. Oftentimes boys are bought computers or have the household computer located in their room (p. 23).

Of a sample of ninety-seven computer science students in the Margolis and Fisher (p. 22) study; 43 percent categorized a male family member as technology savvy; however, only 8 percent categorized a female family member by the same title. These views play a part in how children view computing and technology. Roles are defined in a child’s mind very early. Early in life, children identify objects and activities as “for boys” or “for girls.” The “father-son internship,” boys having ample access to computers, and children seeing more men as tech-savvy influences future choices in and attitudes toward computing. This is why it is important for young girls to be introduced to and have access to computers at an early age.

The type of introduction to computing is equally important. The AAUW commission highlights the difference in the way girls are becoming involved with computing. Instead of taking computer science courses, girls are taking courses on computer tools. This includes
courses on graphs, databases, and productivity software. (AAUW, 2000) These types of courses focus on girls being end-users of computers, but not innovators and developers of technology.

After girls are introduced to computers, it is important to recognize their interest and passion for computers. The AAUW, Margolis, and Fisher all highlight a distinction in the way girls and boys express their interest in computing. The female students in Margolis and Fisher’s research expressed their love and interest in computers; however, they did not dedicate long hours to using a computer. This is in contrast to male students interviewed who spent significant time using computers (Margolis & Fisher, 2002, p. 18). Girls interviewed in both case studies were careful to draw a distinction between their passion and interest in computing and the passion and interest in computing by boys. Based on this, it is important to note that girls may express an interest in technology, but the expression tends to be uniquely different from boys’ expression of interest.

PRESERVING HUMAN INTERACTIONS & SOLVING REAL-LIFE ISSUES

The field of computing has very strong stereotypes associated with it. Many people think of computer professionals as men sitting in front of a computer in a dark room with very little interaction with other people. Girls in the case studies emphasized the need to preserve human interactions. This view of minimal human interaction discourages young girls from studying technical fields. Additionally, girls want to solve problems and create solutions. Girls should be taught their ability to use computers to “engage in imaginative, creative, and improvised solutions to problems” (AAUW, 2000 p. 20). One recommendation by the AAUW is that educators give a more realistic view of various occupation’s dependence on
computer technology. Many of these jobs emphasize communication, collaboration, and creativity. Attention should be given to how computer technology is going to influence nontechnical occupations (AAUW, 2000, p. 61).

Findings from one AAUW commission that examined technology, gender, and teacher education support the view that maintaining human interactions is a priority for girls. The commission’s findings published in *Tech-Savvy: Educating Girls in the New Computer Age*, found that girls have a “we can, but I don’t want to” (AAUW, 2000) attitude toward computing. Based on case studies, girls do not feel as though they are less competent when it comes to computing, but they are just simply not interested in computing. The girls viewed computing as disengaging with the world. The girls would rather create and maintain human interactions.

The girls viewed boys’ usage of computers as anti-social and lacking in social skills. Additionally, the girls in the study held strong to stereotypes of computing professionals – male and anti-social. Girls viewed technology as a tool and felt strongly that boys viewed technology as a toy. The finding of the AAUW is that girls are not phobic of technology, only disenchanted (2000).

Girls should not feel as though computer technology is contradictory to their passions. Technology influences all industries and it can manifest itself in many forms. Girls have an opportunity to realize their interest in technology while participating in many industries. Computer science and other related courses are not the only entry point to computer technology. A professional does not have to be a “computer engineer” or “systems analyst” to solve real-life issues with computer technology. This is an important enticement for girls
that do not want to be labeled as techie or geeks, but want to be involved with computer technology.

The Margolis and Fisher study supports this view. The women in the study were mostly drawn to computer science because of its possible influence in other fields. Forty-five percent of the women connected their interest in computer science and technology with interest in other fields (Margolis & Fisher, 2002, p. 53). The students wanted to use computer science in the context of human and social interactions. Computers were an attraction; however, the impact that computers could have in solving problems was an even greater attraction.

SUPPORT SYSTEMS AND WOMEN IN NON-TRADITIONAL ROLES

One way to help girls become enchanted with computing is to have support systems. Research by Corina Koch (1995) finds that girls must be actively encouraged and supported to choose computing activities. Koch found through observation that if specific time was not assigned to girls for computer use; girls would miss precious opportunities to learn about computers. Koch observed seventh and eighth grade girls not using the computers in her classroom during free time. After inquiring why the girls were not using the computers, she discovered that the girls felt that the boys dominated the computers. Therefore, Koch feels it is necessary to assign time for girls to use the computers. This assigned time would allow girls to create friendship communities over the shared knowledge of the computers. This was something the boys were able to do regularly, but the young girls often missed this opportunity (Koch, 1995).
Karen Littleton and Celia Hoyles reaffirm what Koch observed. Boys are more dominant when it comes to computers and teacher resources. Boys display a strong confidence and often dominate machines, newest software, computer discussions, and computer activities (Yelland & Rubin, 2002, p. 6). Girls in these situations can become easily intimidated. As time goes on, girls tend to become less and less aggressive in the area of computing. As a result, their confidence can wane. Littleton and Hoyles were not necessarily advocating single-sex classrooms as an answer to the gender gap. Single-sex classrooms have their own challenges and may be used by some as a superficial fix (Yelland & Rubin, 2002, p. 11). However, Littleton and Hoyles were highlighting the need for special dedication to girls in the area of computing. It is necessary to give girls the opportunity to interact with computers in a supportive environment.

The AAUW supports the belief that support systems should be created to encourage girls and women in the area of computing and technology. According to the AAUW, these support systems can be in the form of computing clubs, mentoring programs, science fairs, and summer camps (2000).

Girls should be given the opportunity to see more women in the fields of computing and technology. Visibility of women in these fields helps to dispel the notion of “for boys” and “for girls” often formed at an early age based on adult interactions with computer technology. A supportive environment together with effective pedagogy will help to build confidence in preadolescent girls in the area of computing and technology.
SUMMARY OF PART I

The prevailing gender gap is an issue. There are several factors and recommendations in published works to help mitigate and explain the gap. The AAUW summarizes the issue and gives several recommendations for changing the current trends. Fisher, Koch, Margolis, and others support the AAUW proposals. Their recommendations are as follows. First, the need of computing should be integrated through all subject areas. Second, computer literacy should be redefined so that students are expected to know more than computing applications. Computer literacy involves using technology to solve real-life problems. Third, there is a need to recognize that computer science and related courses are not the only way to begin a career in computing. Other entry points may be more appealing to girls. Fourth, girls need to see more women involved in computing as this will help to dispel the stereotypes of technology professions (AAWU, 2000, p. xii).

PART II

PUBLICATIONS ADDRESSING PEDAGOGY AND LEARNING

The second part of this thesis addresses learning and effective pedagogy strategies. There are many publications about how the brain works, how students learn, how memory works, and difference in learning styles. The resources selected were publications that address all of these topics.

How People Learn: Brain, Mind, Experience, and School by the National Research Council of the National Academics is based on two years of research completed by a committee of 16 individuals (NRC, 2000, p. v). The committee reviewed new developments in the science of
learning. The committee focused on making real connections between classroom activities and learning behavior. *How People Learn* explicated learning relevant to what is taught, how it is taught, and how to assess learning.

Patricia Wolfe applies principles from neuroscience, cognitive science, and educational research to educational practice. In *Brain Matters: Translating Research into Classroom Practice*, Wolfe takes what is known about how the brain translates and stores information and gives practical techniques for teaching based on it.

**UNDERSTANDING EFFECTIVE PEDAGOGY**

Because most girls do not choose STEM fields, it is important to present technology in an appealing way. There are many ways to teach students information. Several components factor into effective pedagogy. One factor is to understand how the brain processes and stores information. Considering how the brain functions helps an instructor effectively teach new concepts. The information-processing model is a way to explain how the brain functions. Taking this and combining it with what is known about preconceptions, conceptual frameworks, and metacognition gives a well-defined view of effective pedagogy. Lastly, assessment plays a role in learning. Assessments are a way to confirm if true learning and understanding has taken place.

**INFORMATION-PROCESSING MODEL**

The first step in understanding learning and pedagogy strategies was to understand how information is received and stored in the brain. Memory is the process of information being stored and recalled. The predominant model of memory is the information-processing model (Wolfe, 2001). Shown below in Figure 1 is a functional representation of how
memory works. Memory plays an essential role in learning and it is important to understand how memory works to develop effective pedagogy strategies.

Figure 1

The three categories of memory: sensory memory, working memory, and long-term memory represented in Figure 1 is not to imply that they are autonomous systems or individual stages in the process of memory. They are presented in this manner to help explain the process of how the brain encodes, stores, retrieves, and integrates new information with previously stored information (Wolfe, 2001).

SENSORY MEMORY

First, information is received from sensory receptors. Sensory receptors form the five basic senses: sight, hearing, smell, taste, and touch. According to Wolfe, the responsibility of sensory memory is to take information coming into the brain from the sensory receptors
and hold it for a fraction of a second until a decision is made about what to do with it (2001, p. 78). This is the first filtering process. There are many sensory stimuli influencing the body concurrently. Sensory memory determines what is relevant and irrelevant.

Different factors affect relevance or attention. One factor is the novelty of the stimuli. Novelty is an inherent attention-getter. Therefore, presenting information in a surprising, unusual manner promotes attention. Humans, however, by nature are habitual. Over time, the brain will become accustomed to the stimulus. This causes attention to diminish. Another factor is the intensity of the stimuli. Loudness and brightness are examples of intensity. Finally, another attention-getting influence is movement. Intensity and movement are both subject to habituation.

Now that a stimulus has a person’s attention, there are factors that cause the brain to give meaning to the stimuli. The data collected by the sensory receptors are “perceived” or changed into a percept. This perception of the information is influenced by already stored information. Therefore, without previously stored information about a concept or sensory stimuli, the new information is meaningless. “The assignment of meaning to incoming stimuli . . . depends on prior knowledge and on what we expect to see” (Wolfe, 2001, p. 80). The process of taking new information and affiliating it with stored information is pattern recognition. Pattern recognition is extremely important to giving information meaning (Wolfe, 2001). If the brain can complete this pattern recognition and reactivate already formed neural circuits relating to the information, one is more likely to pay attention. The next stage in the information-processing model is working memory.
WORKING MEMORY

In the representation of the information-processing model, as seen in Figure 1, the arrow pointing from sensory memory to working memory represents sensory stimuli that captured attention well enough that a person is consciously aware of it. Working memory allows new information to be integrated with previously stored information. Then working memory allows a person to consciously manipulate the information well enough to ensure that the information is stored in long-term memory. The arrow labeled rehearsal represents this process (see Figure 1). Manipulating the information includes thinking about it, talking about it, and rehearsing it (Wolfe, 2001).

Information is held in working memory for only about 15 – 20 seconds without rehearsal or constant attention. This is known as the 18-second holding period and it is an important time frame to note. If a teacher plans to introduce a new concept, time must be given for students to analyze what is being presented. After 20 seconds without rehearsal or constant attention, the new material is already forgotten. Additionally, in most traditional classrooms, students are expected to listen to the instructor and take notes at the same time. Wolfe noted that this task is an oxymoron. It is known as the “cocktail party effect” (Wolfe, 2001).

The cocktail party effect can be exhibited in both auditory processing and thought processing. If a student is required to take notes and starts to think about what the teacher says; the next input may be missed. On the other hand, if the student just records what they hear, little comprehension takes places because the student is not given the opportunity to process what was just said. It is important to note that doing two things at the same time
and *consciously processing* two inputs at the same time are different things. A student may be able to do two things at the same time if one of the tasks is an automatic process (Wolfe, 2001, pp. 94 – 97). An example would be driving a car. Experienced drivers do not consciously think about all of the functions that must be accomplished while driving. Therefore, an experienced driver is able to drive and entertain a conversation at the same time. New drivers may have difficulties completing the same task.

One last characteristic of working memory to note is the “magical number seven.” Coined by cognitive scientist, George Miller, from research done in the 1950s, the number seven (plus or minus two) represents how much information a person can consciously process at a given time. The magical number seven approximates the capacity of an adult (NRC, 2000, p. 84). Children at the age of 5 can recall two items. At the age of 7, children can recall an average of three items and at the age of 11, a child can recall five items. Age 11 falls within the target age of this study. The number of items a child can recall accurately increases by one every two years until a mental age of 15 (Wolfe, 2001, p. 97).

Instructors should be aware of factors influencing memory such as the 18-second holding period, the cocktail party effect, and the magical number seven. Activities developed for this study considered these influences and the effect they have on the human brain. In the modules, after presenting a new concept, there is an immediate time of rehearsing the concept. This will help students process the new material and combat the 18-second holding period. The modules are designed in such a way that students can focus on processing the material being presented. In the modules, students are not encouraged to take notes but they are encouraged to actively participate in the lesson. By taking this
approach, the cocktail party effect is mitigated. Finally, no more than five to six concepts are presented for processing at a single time.

LONG-TERM MEMORY

There are two types of processes or memories involved with long-term memory. The two types are procedural and declarative (Wolfe, 2001). Long-term memory is for the most part permanent, but it is not always accurate. Both procedural and declarative memory have subtypes. Each type of long-term memory and its subtype effects how memories, skills, and episodes are recalled. There are specific strategies that are more effective in committing thoughts to long-term memory. These strategies are based on the type and subtype of long-term memory. Understanding the type and subtype will help the instructor in a few ways. First, the instructor will be able to give effective study techniques to students based on the type. Second, testing for understanding can be based on the type of long-term memory stored. Third, instructors can manipulate the information to be committed to memory to model the type of long-term memory it should become.

“Procedural memory is knowing how versus knowing what” (Wolfe, 2001, p. 113). The first subtype of memory under procedural is known as skills. This is the ability to store automatic processes for routine actions. A person may not be able to say much about the process, but the information is stored. Often time it is difficult to recall or access skills without performing the skill. An example of this would be teaching someone to tie his or her shoe. It is much easier to demonstrate how to tie a shoelace than to explain it with words.
The second subtype of procedural memory is priming. “Priming involves being influenced by a past experience without any awareness of consciously remembering that experience” (Wolfe, 2001, p. 115). Memory can be influenced by experiences that we fail to recollect consciously. Studies with priming involved showing a list of words to participants and hours later asking them if they had seen any of the words before. The second part of the study involved showing participants the initial list, then showing them the beginning of a word from the list and asking them to complete the word. Participants do much better on the fragmentation completion. Having seen or experienced something more than once seems to prime a person’s ability to recall it later.

The modules developed create some procedural memories; particularly, skill procedural memories. Assuming the topics presented in the modules are new to the students, they will not have past experiences that will influence their memory. Therefore, priming is not a factor. An example of skill procedural memory created by this research is found in module three. In module three, which addresses routing, students learn how routing takes place in a network and practice routing. This memory will become a skill. It may be difficult to explain routing, but students will be able to demonstrate how routing takes place. At that point, they will be able to demonstrate “knowing how” versus “knowing what.”

“Declarative memory is our ability to store and recall information that we can declare (speak or write)” (Wolfe, 2001, p. 116). Declarative memory requires conscious processing. It is reflective rather than reflexive. The two subtypes of declarative memory are episodic and semantic memory. Episodic memory entails remembering where and when information was acquired. It is important to note that the brain does not store memory in a
linear fashion. When a person recalls a memory, they are reconstructing the event. The memory may be important enough to remember, however the details can be unclear. In cases like this, the brain refabricsates the memory; reconstructing the memory from bits and pieces of truth. Eventually, the refabrication becomes the memory and it is hard to tell the truth from the embellishments. This is why episodic memory is not always accurate. Although the memory of an event is very vivid, the details may be inaccurate.

The second subtype of declarative memory is semantic. “Semantic memory includes words, the symbols for them, the rules for manipulating the words, and their meanings” (Wolfe, 2001, p. 117). Formulas, the rules of mathematics, and general knowledge also fall under semantic memory. These concepts are usually independent of time and place and are fairly accurate. Two plus four will always equal six regardless of when this memory is recalled.

The modules do create declarative memories. However, these memories will be semantic rather than episodic. An example of semantic memory is found in module one, which explains IP addresses. Students will have to manipulate numbers and the format of IP address. The format and range of IP addresses are standard, independent of time and place.

One important concept of long-term memory to note is the consolidation period. Even after an event has been placed into memory, some time must pass before the memory is fully established or organized in the brain. This time is known as the consolidation period. Therefore, memories are not formed at the very moment information is acquired. However, it is dynamic and consolidation strengthens and stabilizes the connections over days, weeks, months, and years (Wolfe, 2001). There is no specific time-period for the consolidation period, but it is important to know that consolidation takes place.
Consolidation is enhanced by rehearsal, as a person rehearses or ponders information; it provides more opportunities for consolidation. Wolfe suggests that because of this consolidation period, instruction that allows students to attach new information with previous experiences increases the strength and complexity of their neural connection (2001). The strengthening of the neural connections helps the retention of information.

MATCHING INSTRUCTION WITH HOW THE BRAIN LEARNS

It is important to note that pedagogy does not stand alone. The curriculum being taught needs to be relevant. Good pedagogy complements wisely selected curriculum that is structured within meaningful contexts. Projects and activities are best served when composed and used as a tool to enhance learning. An activity should relate directly to a clearly defined objective. Activities superficially related to a subject do not promote understanding.

Additionally, there are strategies to help students learn, retain, and apply information. They can be categorized into three groups. First, there are strategies that help students recall important information. Second, there are strategies to help students recall information and understand concepts. Third, there are strategies that help students accomplish the goal of the first two categories and helps students‘ ability to apply the concepts learned (Wolfe, 2001, pp. 133-134). The activities developed for this study give meaningful context to the lesson topic and seek to incorporate the strategies discussed.

The National Research Council (NRC) gave insight into the topic of how people learn with a publication by the title, *How People Learn: Brain, Mind, Experience, and School*. The publication does not specifically explain learning through the facet of neuroscience or
cognitive science. Rather, the council looked at learning through behavioral and social sciences. The two are interrelated. *How People Learn: Brain, Mind, Experience, and School* highlighted three main concepts about the way people learn. First, children have preconceptions about how things work. This relates to children's neural networks. Even though having previous knowledge or predefined networks is helpful towards understanding, it can also be an obstacle. Secondly, factual knowledge, understanding in the context of conceptual framework, and organization to make easy retrieval and application of knowledge are important. Again, having a strong neural network promotes conceptual frameworks and easy retrieval. Thirdly, metacognitive instruction is important (NRC, 2000, p. 14).

**PRECONCEPTIONS**

Preconceptions of certain topics may make it difficult for students to understand new knowledge. Results of a study conducted by Stella Vosniadou and William Brewer shows how children hold to the preconception of a flat Earth. Even when presented with new knowledge that the Earth is round, children envision the Earth round like a pancake versus round like a sphere (Vosniadou & Brewer, 1989). Preconceptions about numbers also present a challenge for some students when learning fractions. Rochel Gelman and C. Randy Gallistel found that many children have difficulty believing that one-fourth is greater than one-eighth because four is less than eight (1978). Preconceptions influence the way students interpret new knowledge. In this case, students took what was already known about the subject matter and tried to apply it directly to the new information. This is how the brain works. It tries to expand already formed neural networks.
CONCEPTUAL FRAMEWORKS

According to the National Research Council, having “. . . knowledge of a large set of disconnected facts is not sufficient” (NRC, 2000, p. 16). This statement comes from studying experts and novices. Instructors should focus on giving students a chance to learn with understanding. An actual understanding and not recitation, memorization of facts transforms simple facts into usable knowledge. Experts have the ability to sift through information quickly. Experts are able to discern usable information and identify patterns. Novices generally filter through a whole set of knowledge before arriving to applicable information for a task. Experts however, do not need to sift through everything they know to find relevant information (NRC, 2000, p. 42). Educating students in a way that promotes learning with understanding helps students organize information into conceptual frameworks. Conceptual frameworks are important to “transfer.” Transfer is a student’s ability to apply what is learned to new situations.

METACOGNITION

Transfer is an acquired ability based on what a student has learned with true understanding. One technique to learning with understanding is to be metacognitive. Metacognition is “the ability to monitor one’s current level of understanding and decide when it is not adequate” (NRC, 2000, p. 47). This monitoring of one’s own learning leads students to be adaptive. The ability to set learning goals, verify one’s understanding, and the ability to place information in appropriate contexts and frameworks helps to reinforce new knowledge. Another way to reinforce new knowledge is through rehearsal and memory aids.
REHEARSAL TYPES

Rehearsal is important to committing information to long-term memory. A person does not learn, retain, and apply new information just by hearing it. Rehearsal of the information must take place. There are two different types of rehearsal. Each has its own strengths. The first type of rehearsal is rote rehearsal. Rote rehearsal consists of repeating the information or action repeatedly. Rote rehearsal is most effective for learning a procedure. Rote rehearsal can lead to completing a skill automatically (Wolfe, 2001, p. 101).

The second type of rehearsal is elaborative rehearsal. Elaborative rehearsal is most effective with semantic memories. According to Wolfe, elaborative rehearsal is best if a student needs to comprehend and not just repeat information (2001, p. 102). With elaborative rehearsal, the information is made more meaningful to the learner. One way of practicing elaborative rehearsal is to associate a new concept with a known concept. An example of this would be to link the concept of parallel lines to railroad tracks. This adds meaning to the concept of parallel lines because it is something already familiar (Wolfe, 2001, p. 105).

Both rehearsal techniques are provided in the modules. Elaborative rehearsal is used when presenting the information. IP addresses are linked to street addresses. Routing is linked to flying. Students experience rote rehearsal by being asked to constantly repeat the material in a variety of forms. First, students are asked to audibly rehearse the concept. This is done by the interactive questions that are asked throughout the lesson. Then when students are asked to complete the worksheet or activity, they are rehearsing once again the concept. This time the rehearsal comes in the form of writing or action.
For information that needs to be quickly recalled and recited, mnemonics are helpful memory aids. There are some well-known mnemonics such as FACE – the spaces in the treble clef, ROY G. BIV – the colors of a rainbow, and “Please Excuse My Dear Aunt Sally” – the order of operations for math. According to Wolfe, many educators view mnemonics as intellectually unrespectable because they do little to enhance meaningful understanding (2001, p. 179). However, mnemonics can be an effective learning strategy when used to acquire factual information. Additionally, Wolfe cites Mary Levin and Joel Levin’s publication, “Scientific Mnemonomies: Methods for maximizing more than memory” as reference that mnemonics can improve a student’s ability to apply the information. (2001)

There are many different types of mnemonics. One is acrostic sentences. “Please Excuse My Dear Aunt Sally” is an example of an acrostic sentence. The first letter of each word represents the concept to be recalled. Acronyms are an example of mnemonics as well. Acronyms are similar to acrostics except they are single words versus sentences. Each letter in the word represents the fact to be recalled. FAQ is an example of an acronym. It represents Frequently Asked Questions. Mnemonics can also be rhymes and phrases such as “I before E except after C.” Keyword mnemonics, Loci mnemonics, and narrative chaining all come under the category of mnemonic strategies (Wolfe, 2001).

Module two, which addressed network topologies, used mnemonics to help students recall the four types of network topologies. “Big Rings Shine Massively” is an acrostic sentence used to recall Bus, Ring, Star, and Mesh topologies. The instructor of the module has the
option of having students develop their own mnemonic to help them remember the topology types.

Mnemonics work because the brain is a pattern-seeking entity. As such, the brain tries to associate the information it is receiving with information already stored. Mnemonics strategies give the brain an opportunity to make this association because it creates a link to a framework. Primarily, instructors should be careful not to use mnemonic strategies in place of comprehensive instruction that can be measured. Assessments measure whether learning with understanding is completed.

**EFFECTIVE ASSESSMENTS OF LEARNING**

There are two types of assessments. The first is a formative assessment. This type of assessment is used as a source of feedback to improve the students’ learning and the instructor’s teaching. The second type of assessment is summative assessment. Summative assessments test what students have learned after receiving instruction (NRC, 2000, p. 140). The modules focus on effective strategies for summative assessments.

Most assessments in educational institutions excessively emphasize the memorization of material. The goal of education should be learning with understanding, which promotes transfer. One way to test for learning with understanding is to have open cases. Explicit instructions on how to solve the problem are not given or kept to a minimum. Cases like this allow the instructor to see how students analyze the problem and use the appropriate solution sets to solve the problem. The absence of explicit instructions on what tools and procedures to use to solve the problem, forces the students to develop a comprehensive solution based on understood knowledge, not hints and cues (NRC, 2000, p. 244).
The post assessment in each module follows the open case format. There are minimal instructions and the students are expected to apply the knowledge learned during the course of the module to answer the questions. The worksheet provided in the modules prepares students to do well on the post assessment, by giving them practice. The post assessment takes the task accomplished in the activity and asks the students to complete them again with less guidelines on how to complete it.

**SUMMARY OF PART II**

Many elements influence learning and understanding. The brain is a complex entity that allows for a person to process, retain, and recall information. Pedagogy strategies should consider how the brain functions. The brain does not process information in a serial linear fashion. However, as the information-processing model shows, there are different functions that take place as information is perceived, rehearsed, and stored. The strategies presented in the modules take advantage of the way the brain processes information and addresses the challenges. Particularly, the advantages and disadvantages of the cocktail party effect, 18-second holding pattern, consolidation, and the magical number seven have been integrated in the modules.

The appropriate types of procedural and declarative memories are developed in the modules. However, students must additionally develop the skill of metacognition to promote learning with understanding. Likewise, instructors can improve pedagogy by presenting the appropriate rehearsals techniques given in the modules. This includes rote rehearsals and memory aids such as mnemonics. Lastly, effective pedagogy is measured by
using summative assessments. Summative assessments note students understanding of material and their ability to apply it appropriately.

**SUMMARY OF LITERATURE REVIEW**

Based on the literature reviewed, there were important steps and guidelines that needed to be followed to make this research effective and successful. First, the literature reviewed shows why this study is important. Statistics show that girls and women are choosing not to participate in STEM fields. The field of technology is growing without the influence of women. As technology continues to change society and the way people live life, women should not be left behind. I have chosen to address this gap by educating preadolescent girls in the area of networking.

Boys are introduced to computing early and often have the confidence to explore technology. Studies show that girls are not given that same introduction. Additionally, if girls are not given dedicated time and resources to learn technology; there is a stronger chance their confidence will wane. Girls do not feel inferior to boys in the area of computing, however; girls exhibit strong misconceptions about the computing field. The American Association of University Women suggests creating support systems and promoting technology through education.

As it pertains to education, many driving factors influence true learning with understanding. A report completed by the National Research Council highlights three elements of the learning process that have a profound effect on how people learn. The ideas of preconceptions, learning with understanding, and metacognition have roles to play in
what people learn and how people learn. Even after instruction based on the best educational practices, there is a need for assessment of the instructional process. The literature reviewed supports the opportunity of research in the area of technology gender gaps and educational solutions.

The three principles of how people learn have an influence on what instructors need to do to be effective teachers. Instructors must take time to understand the preconceptions about the subject material students may have. After understanding a student’s preconceptions, instructors are able to address them in a manner that corrects misconception or leads to a better understanding of new material. An in-depth instruction of subject material is necessary for development of conceptual framework. Students should be presented with the subject material in several different cases. This helps the student build conceptual frameworks for the subject. Assessments of learning should test for understanding versus factual knowledge.

All of these factors were considered while developing the deliverables for this research and as a result, the deliverables contain information that is specific to the task – addressing the technology gender gap. The deliverables provide the learning intervention to preadolescent girls in the area of technology using the best pedagogy strategies and within the context of what girls want from technology – to maintain human interactions and solve problems.
DELIVERABLES

DELIVERABLES OVERVIEW

This thesis provides readers with modules to teach preadolescent girls networking concepts. The modules can be particularly useful to the Women in Computing organization on Rochester Institute of Technology’s campus. A module includes practical discussion suggestions, a bulleted-point lesson plan, a Microsoft PowerPoint presentation, pre-assessment questions, post-assessment questions, and a worksheet or activity relating to the lesson topic. The practical discussion suggestions are discussion topics for the instructor to use. The instructor should lead the participants in a discussion about how the networking topic can be used in real life. The lesson plan is a comprehensive view of what will be covered, how it will be covered, what materials are needed, and learning milestones.

The Microsoft PowerPoint presentation is available to aid the instructor in teaching the networking concept. The powerpoint presentation follows the outline of the lesson plan. It uses the pedagogy strategies found to be effective from the literature review. The powerpoint presentation should serve as a guideline and edited to best fit the students.

Pre and post-assessment questions are necessary to assess students’ preconceptions and understanding. The literature reviewed in this field discussed how preconceptions affect students’ ability to process new information. The pre-assessment questions have two purposes. First, it will highlight preconceptions that students may have. Secondly, it will call attention to the networking topic. After the pre-assessment, students will have a general knowledge of the topic that will be covered in the current module.
The post-assessment has two purposes as well. First, it helps to summarize the material covered in the lesson. It serves as a review and helps with the consolidation period. Secondly, the post-assessment highlights any misconception students have about the networking topic after the lesson. Additionally, the literature reviewed makes a distinction between memorization and learning with understanding. The pre-assessment questions help set a baseline of previous knowledge and the post-assessment questions are used to help evaluate if learning has taken place. The post-assessment questions are structured in a way that memorization is not encouraged and students will have to apply the concepts learned.

The worksheet or activity that accompanies each module is a way to engage students in practicing the networking concept learned. Some modules include a worksheet that students should complete that will help to reinforce the new concept. Other modules have activities for students to complete that are more hands-on and representative of the networking concept. This will actively reinforce the knowledge learned. Some modules may use a combination of worksheets and hands-on activities. Novelty is an attention getter and the worksheets and the hands-on activities are designed to be fun and exciting as well as educational.

There are five modules included in this thesis. Each module should take about an hour to complete. Depending upon the size of the class and the number of questions from students, it may take more or less time. Approximately ten minutes are devoted to the practical discussion and pre-assessing students’ knowledge. This sets a baseline and exposes preconceptions. About twenty minutes are devoted to instruction regarding the subject
material for the module. During this time, the instructor explains the networking concept related to the module and participants learn about the practical and technical aspects of it. Participants should take about twenty minutes to complete the hands-on activity or worksheet that gives them the opportunity to apply the information just learned. This reinforces the new knowledge and promotes learning with understanding. Finally, participants should take about ten minutes to participate in a feedback and post assessment period. During this time, participants are able to inquire about any uncertainties. The instructor should also use this time to assess learning and teaching techniques.

The format of the modules is standard. To begin, the instructor should begin with the practical discussion of the networking concept. The discussion on practical uses of the networking concept is very important. The literature reviewed makes a strong case that preadolescent girls are attracted to and stay in computing fields due to the possibility of using computing to solve real world problems. Additionally, girls like to maintain human interactions and many felt computing did not promote this (AAUW, 2000, p. 20). As such, the discussion about the practical uses should focus on how the networking concept presented in the module can solve problems and maintain human interactions. The students will be introduced to the problem, and through instruction, the instructor will show the students how computer networking can be used to address that issue.

After the practical discussion, the instructor should give the pre-assessment questions. Next, the instructor should introduce the networking concept. This is done by using the powerpoint presentation. Guided and independent practices of the networking concept
may be dispersed throughout the instruction or it may come at the end of the instruction. The worksheet or hands-on activity should be completed before the post-assessment questions are answered. These post-assessment questions will evaluate how much the students have learned with understanding. Finally, there is a time for feedback and further discussion.

It is important to note that the deliverables presented with this thesis are not gender specific. Preadolescents of either gender could learn and benefit from material presented. According to the American Association of Women (AAWU, 2000); however, there should be special support systems for girls. In order to achieve that goal and address the technology gender gap, the deliverables were designed with a focus on the Women in Computing club on the Rochester Institute of Technology campus. If needed, these deliverables are applicable for other situations involving preadolescents.

Because of the dynamic application of the deliverables presented, modules four and five will include a subset of the material included in the other modules. The modules should be used as a series and completed in a set. Each module builds upon previously learned concepts. After module three, the instructor will have an understanding of the participants in the program. At this time, the instructor should make a determination whether to continue with modules four and five or to expand and extend the first three modules.

The decision to continue with modules four and five or to extend modules one through three should be based on several factors. The goal of the modules is to introduce preadolescent girls to networking concepts and to provide a special support system, a
comfortable environment for them to learn computing. With this understanding, the
decision to continue or not should be based on the answers to the following questions.

Did students have a strong preconception about the networking topics presented? How
difficult was it to dispel these preconceptions? Are students appropriately using
metacognition? Are students able to show learning with understanding based on the
results of pre and post-assessments? If the answers to these questions are unfavorable, it
will be valuable to take more time to expound on the concepts already presented versus
introducing more concepts. The focus is not the amount of curriculum presented, but on
wisely selected curriculum that is structured within meaningful contexts.

At a minimum, the lesson plans are included for modules four and five. These lesson plans
are very detailed and provide a strong guideline for the instructor to make a powerpoint
presentation and to create any worksheets and activities needed. The lesson plans provide
suggestions of the content that should be included in the worksheets or activities. The
instructor should use these suggestions if they choose to continue with the last two
modules.

MODUL ES OVERVIEW

Each module has a different goal and had its own unique design challenges. Below, the
goals and challenges are discussed. Alternative views on how to present the networking
topic are given. Any prerequisites required in order to complete the module is outlined as
well. Additionally, factors from the literature review about the pedagogy, and learning are
highlighted.
MODULE 1

Regarding the practical application of the material in module one, students will begin to formulate that computers communicate with each other and can be used to help humans communicate with each other. Once students have completed module one, they should have a general knowledge of what a computer network is and how IP addresses play a part in networking.

This is achieved by introducing IP addresses. IP addressing is one of the fundamental concepts of networking. Every device on a network must have a unique address. Since IP addresses are required for networking, it is a good introduction point for those who are not familiar with networking. One prerequisite to this module is that students should be able to recognize number patterns.

Specific challenges to this module included explaining that the computers are grouped together in networks. Most students only have a view of their singular household computer or of a school computer lab. However, even in this case, the computers may not seem to interact with each other. Another challenge was explaining how to determine the network address from the host address and how the two relate. This is why pattern recognition is important.

MODULE 2

The practical application of the material in module two comes with understanding the benefits and challenges of the physical topologies. Students will be able to determine topologies that are best for sensitive material and topologies that are best for smaller
capital budgets. Once students have completed module two, they should have a general knowledge of how computers communicate within a network based on its topology.

This is achieved by introducing network topologies. There are two types of topologies, logical and physical. Logical topologies were not covered in this module. The basic flow of data within a network is important to understand. This flow has order and follows guidelines. Even in everyday tasks such as shopping and driving, there is order to the experience and people follow guidelines. Networks are not much different.

Specific challenges to this module included determining what everyday shape best relates to the physical network topology for illustrative purposes and finding a framework the students already possessed about cables. There are many wireless products on the market today and choosing a common item to represent a network cable was challenging.

MODULE 3

Once students have completed module three, they will have a general knowledge about routing and will be able to route traffic from source to destination given a topology. The practical application of the material in module three is an overall view of how networking devices work to get a message from source to destination.

This is achieved by introducing students to routing. Routers play an important role in networking. Routing allows multiple networks to be connected together and allows computers to communicate with computers outside its network. One of the major advantages of networking is the ability to communicate with another computer located anywhere in the world. This is why this topic was chosen. The only prerequisite for this
module was that students understand IP addresses and network addresses. This concept was covered in module one.

Specific challenges of module three were the development of the activities. It was a challenge to illustrate how a router separates networks, without subnetting. The goal of the module does not include subnetting, as subnetting is a more advance topic of networking. Some of the illustrations of networks in the module do not use network design best practices. The overall goal of the module is still achieved within this context. At the end of the lesson, students will be familiar with routing and comfortable with routing terms. As students mature in networking, they will understand more of the details of routing. The illustrations in this module are strictly for explanatory purposes and should be viewed as such.

MODULE 4

The practical application of module four is students’ ability to start building an understanding of remote access. A server can be located anywhere in the world, and the client making a request to the server does not have to be in the same network. Once students have completed module four, they will have a general knowledge of servers. In addition, students will be able to identify different application architectures.

The goal of module four was achieved by introducing application architectures. Application architectures are important to discuss when considering how resources are shared and allocated. Most times students participate in an application architecture when they use the computer. This is especially true if they access the Internet. It is beneficial for students to understand that not all of their resources are found locally, but may be located on a server.
Additionally, client-server architectures are a simple concept to explain and were feasible for this work.

One specific challenge of module four was to find a common illustrative point to help students build their framework. Most students attend a school with a school cafeteria. A school cafeteria is an example of a place where someone makes a request and gets something in return. Any common experiences with food service are good examples because of the terminology used. Each experience has a “Client” and a “Server.” A student can inherently draw the definition and function of a server based on the definition of server.

MODULE 5

The practical application of module five is best displayed in students’ general understanding of wireless networks. They will be able to identify the factors that influence wireless networks such as interference. Students will know the advantages and challenges of using a wireless network. Finally, students will know simple ways to secure a wireless network. Hotspots, wifi, and even home wireless networks are all applications of wireless technology that students see in everyday life.

The goal of module five was achieved by introducing students to wireless networks. As technology continues to advance, wireless technology will be used more. Wireless networks are different from wired networks but they accomplish the same goal. Since wireless is becoming more accessible in many different ways, it is important that students have some understanding of what it is.
One specific challenge of module five was discussing a networking medium that students could not see. In module two, students were introduced to Ethernet cables. With Ethernet cables, students have a visual representation of a medium. This challenge is overcome by associating the medium with a cell phone signal. Cell phones and cordless phones are used on a daily bases. Students will be able to draw a connection by viewing the wireless medium in this respect.

CONCLUSION

The five modules presented in this thesis should be used to engage the interest of students in computer networking. The focus of this thesis was preadolescent girls. However, the modules are not gender-specific. The application of these modules determine effectiveness. Preadolescent girls will stay interested in computer networking after seeing the value of networking in solving real world problems and maintaining human interactions. This is why the practical discussions at the beginning and end of the modules are so vital.

The target age and school level for the modules was preadolescent or middle school. These modules can be easily used for ages older than the target age. Participants at ages and grade levels lower than middle school are not recommended because of the fundamental knowledge needed to complete the modules. Students participating in the modules should be able to plan ahead, reason, concentrate, work in groups, memorize, recite, and understand cause and effect. These are all skills that are learned and taught in 1st through 4th grades. 5th grade and about age 10 up to 8th grade and age 14 was the target age of the modules.
The activities and hands-on labs included in the modules are fun and exciting. They are designed to hold the attention of the students and still be educational. They are based on how the brain processes information. Although the effectiveness of these modules would require implementation and further research, they are structured based on best practices in pedagogy, literature reviewed on the subject of the technology gender gap, and real-life experiences. Although there are many factors that influence the technology gender gap, the modules presented can play a role in addressing that gender gap and providing girls the confidence and knowledge they need to be successful in technical fields.
REFERENCES


LESSON PLANS

LESSON 1 LESSON PLAN

Lesson Plan

Grade Level: Middle School
Subject: IP Addresses

Topic and Content

Topic: IP addresses
Content: Communication, Naming, Addresses, Dotted-notation, Dynamic Host Configuration Protocol

Goals, Objectives, Materials

Goals: (Aims / Outcomes)

1. Inform students computers communicate with each other
2. Inform students that computers have unique addresses
3. Inform students how computers use IP addresses
4. Inform students that computers form networks
5. Introduce the concept of DHCP server and DHCP addresses

Objectives: (Performance / Behavioral Indicators)

After this lesson, students will be able to:

1. Identify a correctly formatted IP address
2. Know the difference between static IP addresses and DHCP addresses

3. Articulate how computers use IP addresses

4. Articulate the concept of a network

**Materials: (Aids / AV / Technology)**

1. IP Address Worksheet – Total of 4 activities
2. Post Assessment Quiz

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**Procedure / Methods**

**Pre-Assessment Questions**

1. Do you think computers talk to each other?
2. How do computers talk to each other?
3. Do computer have names?
4. Do computer have addresses?

*Assess students’ preconceptions of computer communication. This will allow the instructor to determine what kind of preconceptions or base knowledge students currently have.*

**Introduction: (Focusing Event)**

1. Introduce the concept that computers talk to each other
2. Discuss basic information such as name, address, phone number
3. Introduce and discuss IP addresses format and purpose

**Development: (Modeling / Explanation Demonstration)**

1. Discuss how two friends would share information with each other by postal mail or phone
2. Relate two friends sharing information to how a computer would share information using the IP address of another computer

**Practice (Guided / Monitored Activity)**

1. Engage students in quick recognition of properly formatted IP addresses
2. Have students create their own IP addresses

**Independent Practice: (Assignments to Measure Progress)**

1. Complete the IP Addresses Worksheet
   a. Involves recognizing IP Addresses
   a. Assigning IP Address
   b. Writing Source and Destination Addresses
   c. Using a DHCP Server

**Checking For Understanding: (Assessment / Feedback)**

1. Evaluate the work completed on the IP address worksheet.
2. Administer a quick post-assessment quiz.

**Post-Assessment Questions**

1. How do computers talk to each other?
2. Please give 1 correctly formatted IP Address.
3. What does the DHCP Computer do?
4. When would you use a DHCP Computer?

*Four questions to test students’ knowledge of the networking concepts taught.*

5. Using the illustration below, Computer A wants to send a message to Computer E. What are the “From” (source) and “To” (destination) addresses?
Students must analyze the information given in the picture and determine what the appropriate source and destination addresses are.

6. Assign each computer an IP address.
   a. You may use a DHCP Computer if it’s appropriate

There are very little instructions given here. Students must determine if a DHCP server is needed. If so, students should provide the DHCP Server’s address and the scope of IPs to be given out. If a DHCP Server is not used, students should manually label each computer with an IP address.

Closure: (Wrapping it up)

1. Have students share what they learned about computers and IP addresses
2. Clarify any misconceptions about the purpose of IP addresses and their format

Evaluation and Teacher Reflection

Teacher Reflections: (To be completed after lesson)

Practical Discussion

Students need to see the value behind setting up a computer network. The practical discussion seeks to relate girls’ goals of maintaining human interaction and solving problems to using computer networks.

Maintaining Human Interactions

Some topics of discussion could be:

1. You wrote a letter to your grandparents and you did not want to wait 3 days for it to reach them via postal mail. The computer in your home could share the letter with the computer in your grandparents’ home.

2. Your best friend moves to a new state. You can use computer networks to keep in touch. You can share music, pictures, etc.

Solving Problems

Some topics of discussion could include:

1. Computers monitor the temperature in a chemical plant. If the temperature is too high or too low, a computer could send a message to alert someone.

2. Police stations across the United States could share a picture of a suspect. That way the picture of a suspect from New York could be available to police officers in California within the matter of minutes.
LESSON 2 LESSON PLAN

Lesson Plan

Grade Level: Middle School
Subject: Network Topologies

Topic and Content:

Topic: Network Topologies
Content: Bus Topology, Ring Topology, Star Topology, Mesh Topology, Ethernet Cable, Hub, Switch

Goals, Objectives, Materials

Goals: (Aims / Outcomes)

1. Introduce Ethernet cable
2. Introduce four physical network topologies
3. Introduce traffic flow based on topology
4. Introduce other network devices such as a hub and switch

Objectives: (Performance / Behavioral Indicators)

After this lesson, students will be able to:

1. Explain how an Ethernet cable is used
2. Identify a Bus topology and explain how messages travel within the topology
3. Identify a Ring topology and explain how messages travel within the topology
4. Identify a Star topology and explain how messages travel within the topology
5. Identify a Mesh topology and explain how messages travel within the topology
6. Define a hub or switch and explain its function

**Materials: (Aids / AV / Technology)**

1. Tape
2. Index Cards
3. Hula Hoop (Optional)
4. Post Assessment Quiz
5. 1 hub or switch

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**Procedure / Methods**

**Pre-Assessment Questions**

1. We know that computers form networks and talk to each other, but how do messages travel from one computer to another?

2. Does it matter how computers are arranged within a network? Should the computers be in a straight line, a circle, or scattered about?

*Assess students’ preconceptions of how computer messages actually travel. At the same time, it introduces the fact that computers can develop a shape. This will allow the instructor to determine what kind of preconceptions or base knowledge students currently have.*

**Introduction: (Focusing Event)**

1. Discuss how electricity travels by electrical lines

2. Introduce the concept that computer networks can form shapes

**Development: (Modeling / Explanation Demonstration)**

1. Use a visual representation of a school bus to explain a bus topology

2. Use a visual representation of a circle to explain a ring topology
3. Use a visual representation of an object with a common center with lines extending from the center to explain a star topology.

4. Use a visual representation of mesh shape to explain a mesh topology.

**Practice (Guided / Monitored Activity)**

1. Engage students in explaining how traffic would flow in different topologies.
2. Have students form a network topology. Then have students send and receive messages within the topology.
3. Discuss the pros and cons of one network topology over another.

**Independent Practice: (Assignments to Measure Progress)**

1. Complete the Physical Topology worksheet.
   a. Involves recognizing a physical topology.
   b. Explaining traffic flow.

**Checking For Understanding: (Assessment / Feedback)**

1. Evaluate the work completed on the Physical Topology worksheet.
2. Administer a quick post-assessment quiz.

**Post-Assessment Questions**

1. Assume that Computer C wants to send a message to Computer E in a Bus Network. List each computer in the network that will hear the message.
2. In this Ring Network, Computer D has a message it wants to send to Computer C. Can Computer D send its message now? If so, what other computers hear the message? If not, why not? What must happen first?

3. In this Star Network, Computer D sent a message to Computer A. What other computers heard the message?
4. In this Mesh Network, Computer D wants to communicate with Computer B. Given the following situation, write at least two ways Computer D can send a message to Computer B.

Situation: Line 5 and Line 4 are not available.
5. Given the following situations, which is the best network shape?

Choose from Bus, Ring, Star, or Mesh.

**Situation #1:** The computers in this network are located inside a chemical plant.

It is very important that the temperature of each room is no more than 70°.

A computer in each room monitors the temperature. It will send a message to the other computers if the temperature is more than 70°.

It is very important that the other computers receive the computer’s message.

What is the best network shape? Explain.

**Situation #2:** The computers in this network are located in your grandparents’ home. They each have a computer and you have one for when you visit.

Your grandparents didn’t have a lot of money to use to setup the network.
There are three computers in total. The messages sent by these computers are not very important. What is the best network shape? Explain.

**Situation #3:** The computers in this network are located in your school’s computer lab. There are eight computers in the network.

The school did not want to buy many cables to connect the computers and the school plans to add more computers to the network in the future.

What is the best network shape? Explain.

When administering a post assessment, it is important to formulate questions in such a way that students will have to apply knowledge, rather than recite facts.

**Closure: (Wrapping it up)**

1. Have students share what they learned about physical network topologies
2. Clarify any misconceptions about traffic flows within a specific physical topology
3. Discuss opportunities of how network topologies can help solve scientific problems
4. Discuss opportunities for improvements in network topologies

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**Evaluation and Teacher Reflection**

**Teacher Reflections:** (To be completed after lesson)
Practical Discussion

Students need to see the value behind setting up a computer network. The practical discussion seeks to relate girls’ goals of maintaining human interaction and solving problems to using computer networks.

**Maintaining Human Interactions**

Some topics of discussion could be:

1. Social networking sites like Club Penguin and Whyville.net use computer networks. What if a friend goes on vacation with their family for two weeks? You can keep in touch with them through a social networking site that uses computer networks.

2. What if you learned to play chess and needed someone to play with. You could play against someone online. In addition to playing chess with them, you can also chat with them. Online gaming sites are possible because of computer networks.

**Solving Problems**

Some topics of discussion could include:

1. Meteorologists can share information about a hurricane with one another, as the storm gets larger. This way the meteorologist can warn people if they need to leave their home.

2. A scientist has developed a cure for a dangerous disease. Instead of having to carry their computer to Africa with them, they can put the formula of the cure on one central computer and access the formula from Kenya, Africa.
Lesson Plan

Grade Level: Middle School
Subject: Routing

Topic and Content:

**Topic:** Routing

**Content:** Hops, Networks, Source Address, Destination Address, Network Address, Interface, Routers

Goals, Objectives, Materials

**Goals: (Aims / Outcomes)**

1. Introduce the concept of how packets travel to different networks
2. Introduce the terminology of source and destination address
3. Introduce the terminology of interface

**Objectives: (Performance / Behavioral Indicators)**

After this lesson, students will be able to:

1. Explain the function of a router
2. Define source address and destination address
3. Trace a packet route from source to destination

**Materials: (Aids / AV / Technology)**

1. Routing Worksheet
2. World Traveler! Game
3. Post Assessment Quiz

Procedure / Methods

Pre-Assessment Questions

1. Have you ever visited a family member in a different state or city?
2. How did you get there?
   a. Car
   b. Bus
   c. Train
   d. Airplane
   e. Boat

*Introduces the important framework on which this concept of network routing will be built.*

*The lesson assumes that students have some experience with traveling. Particularly for this lesson, students who have flown in an airplane will have a strong foundation to connect with the concept.*

Introduction: (Focusing Event)

1. Discuss that computers in different networks need to communicate with each other
2. Explain that messages to computers in different networks are passed along by a router
3. Explain that messages are sent from a router’s interface and is based on the network address
Development: (Modeling / Explanation Demonstration)

1. The basic principles of routing can be explained in the context of air travel:
   a. Discuss travel by airplane
   b. Discuss the function of an airport and its parallels to a router
   c. Terminals inside an airport are comparable to a router’s interfaces

Practice (Guided / Monitored Activity)

1. Have students identify how a traveler would get from their source to their destination by flying
2. Have students identify simple source and destination interfaces for packets using a single router
3. Have students identify routing given a topology of 4 routers

Independent Practice: (Assignments to Measure Progress)

1. Complete the Packet Travel Game
   a. Involves identifying the correct interface
   b. Requires identifying a network address based on the IP address

Checking For Understanding: (Assessment / Feedback)

1. Administer a quick post-assessment quiz
   a. Test students knowledge of the following:
      i. Routers
      ii. Source and Destination addresses
   b. Test students understanding of the following:
      i. Routing
      ii. Interfaces
2. Evaluate the answers given in the post assessment quiz

Post-Assessment Questions

Given the network layout provided, please answer the following questions:

1. From the 52.76.7.0 network, is there a direct hop to the 12.16.4.0 network?
   a. No. The only directly connected network is 40.13.5.0

2. How many hops would it take a computer with the IP address of 10.1.4.2 to send a message to 12.16.4.0 network?
   a. 2 Hops.
      i. 10.1.4.2 to 40.13.5.0
      ii. 40.13.5.0 to 12.16.4.0
3. How many hops would it take a computer with the IP address of 10.1.4.2 to send a message to 52.76.7.0 network?
   a. 3 Hops.
      i. 10.1.4.2 to 40.13.5.0
      ii. 40.13.5.0 to 12.16.4.0
      iii. 12.16.4.0 to 52.76.7.0

4. A computer with the IP address of 10.1.4.2 wants to send a message to 52.76.7.0 network. What is the route? Provide the interface.
   a. 10.1.4.2 \rightarrow E3
   b. 40.13.5.0 \rightarrow E1
   c. 12.16.4.0 \rightarrow E2

5. What is connected to E1 on router 12.16.5.0?
   a. Action Figures

Closure: (Wrapping it up)

1. Have students share what they learned about routers and routing
2. Clarify any misconceptions about the purpose of routers and routing

Evaluation and Teacher Reflection

Teacher Reflections: (To be completed after lesson)

Practical Discussion

Students need to see the value behind routing. The practical discussion seeks to introduce girls' to how computer networks are valuable in non-technical industries and occupations.
**Maintaining Human Interactions**

Computers are really a tool to bring people and ideas together. Computer networks should be thought of as a mechanism to help us accomplish our goals. No longer does distance keep people apart. Any resource or person is now accessible anytime and from anywhere in the world because of computer networks.

**Solving Problems**

How can computer networks be used in the following areas?

1. A Bank
2. A Hospital
3. A Retail Store
Lesson Plan

Grade Level: Middle School
Subject: Application Architectures

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**Topic and Content:**

**Topic:** Application Architectures
**Content:** Host-Based, Client-Based, Client-Server Based, Distributed Systems

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**Goals, Objectives, Materials**

**Goals: (Aims / Outcomes)**

1. Introduce application servers, web servers, DNS and DHCP servers
2. Introduce clients workstations
3. Introduce benefits and challenges of different application architectures

**Objectives: (Performance / Behavioral Indicators)**

After this lesson, students will be able to:

1. Explain the purpose of a server
2. Explain the role of a client workstation in a client-server application
3. Identify between host, client, and client-server architectures
4. Identify benefits and challenges of a host-based architecture
5. Identify benefits and challenges of a server architecture
6. Identify benefits and challenges of server-client architectures

**Materials: (Aids / AV / Technology)**
1. Application Architecture worksheet
2. Server Game
3. Post Assessment Quiz

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**Procedure / Methods**

**Pre-Assessment Questions**

**Introduction: (Focusing Event)**

1. The basic principles of application architectures can be explain by discussing the operation of a school cafeteria.
   a. A student can go to the cafeteria and select what they would like for a meal, without having to eat everything on the menu. In this case, they represent a “Client”. The cafeteria staff provides the meal based on the student’s selection. The staff represents a “Server”.
      i. Together this represents a client-server architecture
   b. If the student brings their own lunch from home, they do not engage the cafeteria staff at all.
      i. This represents a client-based architecture
   c. In some cases, the cafeteria staff can prepare the food and deliver it to the students without the student selecting what they would like from the menu.
      i. This represents a host-based architecture

**Development: (Modeling / Explanation Demonstration)**

Expound on the cafeteria scenario by applying the concepts to application architectures.
1. Client-server architecture can be explained by discussing accessing a webpage. Several things happen when this call is made.
   a. A DNS server translates the name www.google.com to an IP address.
      i. Quickly explain a DNS server is like a phone book
      ii. Client asks for the webpage by name, server gives the IP address so that the two computers can communicate
   b. The web browser (the client) gets the webpage from a webserver and presents it to the student.

2. Client-based architecture can be explained by discussing accessing a document saved on a computer
   a. No other computer is needed to access the document
      i. Document is stored right on hard drive
   b. The document is stored locally

3. Host-based architecture in the form of dumb terminals is rarely used anymore. However, they can be explained by discussing that all of the processing needed was completed on one central computer and then that computer returns all results to the client. For the focus of this lesson, host-based architecture will not be discussed in detail.

**Practice (Guided / Monitored Activity)**

1. Since host-based architecture in the form of dumb terminals is rarely used, only discuss the benefits and challenges of this type of architecture.
   a. Benefits:
      i. Clients were thin and did not need a lot of processing power
b. Challenges:
   i. The central computer was very expensive and big
   ii. One single point of failure

2. Have students identify how computers process information in a client based architecture by providing various scenarios and asking questions based on the scenarios.

   a. Provide students with a visual representation of the scenario
   b. Discuss the benefits and challenges of this architecture
      i. Benefits:
         1) Resources are always accessible locally
      ii. Challenges:
         1) Resources are not accessible remotely
         2) Hard Drive space
         3) If computer becomes inoperable the resources are lost

3. Have students identify how computers process information in a client-server based architecture by providing various scenarios and asking questions based on the scenarios.

   a. Provide students with a visual representation of the scenario
   b. Discuss the benefits and challenges of this architecture
      i. Benefits:
         1) Resources are accessible remotely
      ii. Challenges:
1) Resource must travel across a network and the network must be configured properly for this to be successful

**Independent Practice: (Assignments to Measure Progress)**

1. Participate and complete the Server Game
   a. Involves recognizing various types of servers
   b. Identifying appropriate application architecture based on scenario
   c. Developing various networks based on application architecture given

**Checking For Understanding: (Assessment / Feedback)**

1. Administer a quick post-assessment quiz
   a. Tests students knowledge of host based, client based, and client server based architectures
   b. Tests students understanding of the benefits and challenges of one architecture versus another

2. Evaluate answers given in the post-assessment quiz

**Post-Assessment Questions**

**Closure: (Wrapping it up)**

1. Have students share what they learned about host based, client based, and client server based architectures and the benefits and challenges of such architectures

2. Clarify any misconceptions about the purpose of various application architecture and the way information is shared in it

**Evaluation and Teacher Reflection**

**Teacher Reflections: (To be completed after lesson)**
LESSON 5 LESSON PLAN

Lesson Plan

Grade Level: Middle School
Subject: Wireless Networks

Topic and Content:

Topic: Wireless Networks
Content: Access Point, Range, SSID, Wireless Router, Signals, Interference, Wireless NIC

Goals, Objectives, Materials

Goals: (Aims / Outcomes)

1. Introduce the concept of a wireless medium
2. Introduce the concept of interference
3. Explain the benefits and challenges of wireless networks
4. Explain simple techniques to make wireless networks more secure
5. Explain the similarities and differences between wireless and wired networks

Objectives: (Performance / Behavioral Indicators)

After this lesson, students will be able to:

1. Explain the benefits and challenges of wireless networks
2. Identify sources of interferences
3. Explain the function of an access point
4. Explain strategies for securing wireless networks
5. Compare and contrast wireless and wired networks

Materials: (Aids / AV / Technology)

1. Wireless Worksheet
2. Post Assessment Quiz

Procedure / Methods

Pre-Assessment Questions

Introduction: (Focusing Event)

1. Discuss sound and sound waves
2. Discuss cell phones and cell phone reception
3. Review the function of a DHCP Server and the function of servers in general

Development: (Modeling / Explanation Demonstration)

1. Discuss the function with an automatic door. These doors are very common – at grocery stores, malls, and department stores.
   a. Puts into perspective the concept wireless of range
   b. Introduces the concept of SSID
2. Compare and contrast wired and wireless networks
   a. Both use a router
   b. Both allow communication among computers
   c. Wireless uses less cabling
   d. Wired is more secure based on the inherent nature of the medium
3. Discuss simple techniques to help make wireless networks secure
   a. Change router default IP address
   b. Use strong passwords
   c. Disable SSID broadcast
   d. Reduce the range of assignable IP addresses
4. Discuss the benefits and challenges of a wireless network
   a. Engage students in identifying advantages of wireless networks
      i. Freedom of movement
ii. Less cables

iii. Easy access, a user doesn’t have to physically find a wall jack

b. Engage students in identifying challenges of a wireless networks

i. Various types of interference

ii. Privacy and security are challenged simply based on the medium

**Practice (Guided / Monitored Activity)**

1. Engage students in identifying various types of interference

   a. Physical objects

      i. Walls

      ii. Trees

      iii. Concrete

   b. Frequencies

      i. Microwave

      ii. Cell phone

      iii. Radio

2. Engage students in answering wireless questions based on a given wireless topology

   a. Identify various types of interference

   b. Distinguish between one wireless network and another

**Independent Practice: (Assignments to Measure Progress)**

1. Completed the Wireless worksheet

   a. Involves recognizing and defining various wireless components

      i. Access points

      ii. Routers

      iii. Ranges

      iv. Signal
v. Interference

vi. Wireless NIC

b. Involves identifying advantages and challenges of wireless networks
c. Involves identifying simple security steps

Checking For Understanding: (Assessment / Feedback)

1. Evaluate the work completed on the Wireless worksheet.
2. Administer a quick post assessment quiz.

Post-Assessment Questions

Closure: (Wrapping it up)

1. Have students share what they learned about wireless network
   a. Discuss the benefits and challenges of wireless networks
   b. Discuss simple ways to secure wireless networks
2. Clarify any misconceptions about wireless networks

________________________________________________________________________

Evaluation and Teacher Reflection

Teacher Reflections: (To be completed after lesson)
Fun activity where students simply follow the lines to identify who Computer A sent its message to. Very quick activity, but should start giving students the idea that computers communicate with each other.
This is the next level in learning curve. Students now know that computers have names and addresses. Students should be able to recognize a correctly formatted address. This activity asks students to identify a computer with its address. Next, students have to use addresses to say the source and destination of a message. Finally, in the previous set of instructions, students were introduced to networks. This activity asks students to identify the network address, the number of computers in a network and differentiate between dissimilar network addresses.
This activity seeks to give more reinforcement of computer communication. It is based on what students should know about postal mail. The use of the terms “from” and “to” should be familiar. Adding the terms “source” and “destination” should alert students of synonyms. Students are still being exposed to correctly formatted IP addresses. This is one of the first concepts taught in this lesson.

Between this activity and the previous one, students are still accomplishing the same goals; however, the information is presented in a slightly different manner. Students are associating an IP address with a computer and identifying the source and destination of messages.

<table>
<thead>
<tr>
<th>From: (Source)</th>
<th>To: (Destination)</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.1.7</td>
<td>192.168.1.4</td>
</tr>
<tr>
<td>192.168.1.2</td>
<td>192.168.1.5</td>
</tr>
<tr>
<td>192.168.1.4</td>
<td>192.168.1.1</td>
</tr>
<tr>
<td>192.168.1.6</td>
<td>192.168.1.0</td>
</tr>
</tbody>
</table>
The next level of instruction was to introduce DHCP. Students do not know it, but later they will come to understand that the "DHCP Computer" is actually a server. For now, students are asked to exercise their knowledge of correctly formatted IP addresses. Students have experienced using IP addresses in previous activities and during instruction. This activity also asks students to apply what they know about network addresses.
LESSON 2 WORKSHEET/HANDS-ON ACTIVITY

Activity #1 - Simulates communication in a Ring Network.

Place tape on the floor in a circle. Have students stand on the line in a circle. Each student represents a computer. Give each student an IP address. Have one student write a message on a folded index card. The index card is the “packet”. On the outside on the index card have the student write the source (the sending student) and destination (the receiving student) IP addresses. Inside the folded index card have the sender write a message.

The packet will travel through the Ring network. Each student will pass the packet along until it reaches its destination. Each student will have to examine the destination address to see if it is addressed to him or her. Then the destination student will open the packet and read the message. Stress that the packet has the ability to travel through the network because of the “cable”, the line that connects the students. The packet travels through the cable to its destination.

Have students send a couple of messages to each other in this fashion, relating the action they are completing to how computers would communicate in a physical ring topology.

*At some point, the instructor should remove a piece of tape from the floor. This will represent a break in the line. In a situation like this, communication would cease.

*Alternatively, have one student “down”. This would represent a computer being down and unable to pass the message. In a situation like this, communication would cease as well.

If the instructor likes, they can also simulate a Token Ring Network.

In this case, the teacher should have a “token” (any object can be used). Have the students pass the token to each other. Only the “computer” (student) with the token should be allowed to send a packet.
There is an important point that students need to understand. The computers in a Ring network take turns sending messages, unlike a Bus Network, when a computer can speak at anytime. However, computers in a Bus Network have the chance of experiencing a collision.

This interactive activity will allow students to engage in sending messages in a Ring Network. An interactive activity such as this will be a change from simply drawing lines and listing computers on paper. The intent is that the novelty of physically participating in the activity will hold the students' attention.

Activity #2 – A worksheet that explores communication in a Star Network

1. Computer A wants to send a message to Computer B. Draw an arrow showing how the message gets to Computer B.

2. Computer E sent a message to Computer C. What other computers heard the message?
3. The hub is broken and Computer D needs to send a message to Computer B, draw an arrow showing how the message gets to Computer B.

**Activity #3** – A worksheet that explores communication in a Mesh Network under different situations.

Computer A wants to communicate with Computer C. Given the following situations, write at least two ways Computer A can send a message to Computer C.

**Situation #1: Every cable is working.**

Possible Answers:  
- Use Line 6  
- Use Line 1 and Line 2  
- Use Line 4, Line 5, and Line 2

**Situation #2: Line 6 is not available.**

Possible Answers:  
- Use Line 4 and Line 3  
- Use Line 1 and Line 2
Use Line 4, Line 5, and Line 2

Situation #3: Line 1 and Line 6 are not available.

Possible Answers: Use Line 4 and Line 3

Use Line 4, Line 5, and Line 2
Activity # 1

Ask students multiple questions about travel based on this diagram.

1. If you were leaving Georgia and going to California which terminal would you leave from?
   a. Terminal C

2. What is the destination terminal of someone traveling to Minnesota?
   a. Terminal A

3. What is the source terminal of someone at California?
   a. Terminal D

4. What is the destination state at terminal B?
   a. Pennsylvania
5. I am traveling. When I reach the airport, I start at terminal D. I must go to
terminal A to catch my plane. What is my starting (source) state and what is my
destination state?
   a. Source is California
   b. Destination is Minnesota

**Activity #2**

![Diagram of networks connected by a router with IP addresses 192.168.1.0, 192.168.2.0, 192.168.3.0, and 192.168.4.0.]

In networking terms, a cloud usually represents a network. In this case, we have four
networks connected by a router. The networks are 192.168.1.0, 192.168.2.0, 192.168.3.0,
and 192.168.4.0.

Ask students multiple questions about routing based on this diagram.

1. If a computer in the 192.168.3.0 network needed to send a message to a
   computer in the 192.168.4.0 network, which interface would the packet have to
   be sent to?
   a. E4
2. What is the destination interface of a packet going to the 192.168.1.0 network?
   a. E0

3. What is the source interface of a packet in the 192.168.0.4 network?
   a. E4

4. What is the network connected at interface E1?
   a. 192.168.2.0

5. A packet starts at the E4 interface on the router. From there, the packet goes to the E3 interface. What is the source and destination network addresses of the packet?
   a. 192.168.4.0
   b. 192.168.3.0

Activity #3

Have students answer the following questions. For each scenario, the student will need to give the departments, network addresses, the source and destination interfaces.
1. Computer A with the IP address of 192.168.4.23 needs to send information to 192.168.2.13
   a. Department: Business, Music
   b. Network Address: 192.168.4.0, 192.168.2.0
   c. Source Interface: E4
   d. Destination Interface: E1

2. Computer F with the IP address of 192.168.2.3 needs to send information to 192.168.3.8
   a. Department: Music, Technology
   b. Network Address: 192.168.2.0, 192.168.3.0
   c. Source Interface: E1
   d. Destination Interface: E3

3. Computer C with the IP address of 192.168.1.6 needs to send information to 192.168.4.21
   a. Department: Science, Business
   b. Network Address: 192.168.1.0, 192.168.4.0
   c. Source Interface: E0
   d. Destination Interface: E4

4. Computer E with the IP address of 192.168.3.15 needs to send information to 192.168.1.11
   a. Department: Technology, Science
   b. Network Address: 192.168.3.0, 192.168.1.0
   c. Source Interface: E3
d. Destination Interface: E0

5. Computer A with the IP address of 192.168.4.23 needs to send information to 192.168.4.9

a. Department: Business, Business

b. Network Address: 192.168.4.0

c. Source Interface: E4

d. Destination Interface: E4

In scenario 5, Computer A will not use the router at all. The message will be sent within its own network. Students need to understand that routers are only used if messages are sent outside of its current network.

***********************

Another way to explain the function of a router is to use a room. Rooms usually have one door that is used to enter and exit the room. (Illustrate by using the room you are currently in) If you wanted to do something inside this room, like use the whiteboard; you would stay in this room. However, if you needed to do something in the room next door, you would have to exit the room through the door.

Routers are like doors in networks. If a computer needs to communicate to another computer in a different network, it will have to use the “door” (router) to “exit” the network. However, if a computer wants to communicate with another computer within the same network, there is no need to leave the network or use a router.
Activity # 4

Discuss with students that each router used is considered as a “hop”. When a packet moves from router 1 to router 2 it is recorded as 1 hop. If the packet then moves to router 3 that would be considered another hop.

Walk students through the following routes. Encourage students to provide suggestions of the next hop. However, at this time students are not ready to complete routing independently. This activity is staged to give students practice in preparation for the Packet Travel game.

1. A computer in the 40.13.5.0 network wants to communicate with Action Figures (12.16.4.2) What is the route?
   a. 40.13.5.0 \( \rightarrow \) E1
   b. 12.16.4.0 \( \rightarrow \) E0

2. A computer in the 12.16.4.1 network wants to communicate with Medicine (52.76.7.4) What is the route?
a. 12.16.4.0 \rightarrow E2
b. 52.76.7.0 \rightarrow E2

3. Action Figures (12.16.4.2) wants to communicate with Meteorologist (10.1.4.2.)

What is the route?

a. 12.16.4.0 \rightarrow E2
b. 52.76.7.0 \rightarrow E3
c. 40.13.5.0 \rightarrow E0
d. 10.1.4.0 \rightarrow E2

4. A computer in the Finance network wants to communicate with a computer in the Sports network. What is the route?

a. 52.76.7.0 \rightarrow E3
b. 40.13.5.0 \rightarrow E1
c. 12.16.4.0 \rightarrow E1

5. A computer in the 10.1.4.0 network wants to communicate with Musician (52.76.7.1) What is the route?

a. 40.13.5.0 \rightarrow E1
b. 12.16.4.0 \rightarrow E2
c. 52.76.7.0 \rightarrow E1

*It is important to slowly step students through this routing exercise. Have students trace out the route by hand if needed. This activity is a replica of the Packet Travel game which is the activity for this module.*
Activity # 5

**World Traveler! Game**

**Materials Needed**

World Traveler! Game Board

World Traveler! Scenario Cards

Paper and Pencil

**How to Play**

*Setup:*

Divide the participants into equal teams. Print enough copies of the World Traveler! game board so that each team can have a copy. Take the World Traveler! Scenario Cards and cut them on the lines. Shuffle the cards and distribute them evenly so that each team has the same number of cards.

*Instructions:*

Each team is competing against the others to route the information contained on the scenario cards from source to destination. Each team should read the scenario card given and determine the route the packet will take based on the topology given on the game board. Some scenarios may have more than one route. Students should try to identify the shortest route.

Students should write down the scenario number on their answer sheet. In order to complete the route, students should write the IP address of each hop and the destination interface associated with it. The first team to correctly route the packet in their scenario cards from source to destination wins.
Conclusion

This game can be played without teams. If there are not enough participants to divide into teams, each participant gets a deck of scenario cards to route.
World Traveler!

Kenya 12.16.4.0
South America 80.2.32.0

Michigan 76.90.14.53
Ohio 76.90.14.4

United States 76.90.14.0

Medicine 103.50.65.7

Spain 35.40.20.0
Cape Cod 52.76.7.0

Europe 10.15.3.0
Brazil 80.2.32.3
Art 80.2.32.7

Paris 10.15.3.37
History 10.15.3.75

Government 10.15.3.16
South America 80.2.32.0

Madrid 35.40.20.6
Musician 35.40.20.11

South America 80.2.32.0
<table>
<thead>
<tr>
<th>#1</th>
<th>#2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susie lives in the United States. Her computer has an IP address of 76.90.14.53. She wants to talk with her Grandmother in Brazil using a computer. Her Grandmother’s computer IP address is 80.2.32.7.</td>
<td>Mark lives in Ohio (76.90.14.4). He wants to talk with his best friend in Brazil using a computer. His friend’s computer IP address is 80.2.32.3.</td>
</tr>
<tr>
<td>What route will the packet take?</td>
<td>What route will the packet take?</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop: Destination Interface:</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop: Destination Interface:</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop: Destination Interface:</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy lives in Brazil (80.2.32.3) and wants to learn more about natural African herbs. So, she needs to communicate with a computer in Africa. The computer’s IP address is 103.50.65.7.</td>
<td>Jamie lives in Brazil. She wants to learn more about Madrid, Spain art. So, she needs to communicate with a computer in Spain. The computer’s IP address is 35.40.20.6.</td>
</tr>
<tr>
<td>What route will the packet take?</td>
<td>What route will the packet take?</td>
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<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop: Destination Interface:</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop: Destination Interface:</td>
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<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop: Destination Interface:</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop: Destination Interface:</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop: Destination Interface:</td>
</tr>
<tr>
<td>#5</td>
<td>Tim owns an art store in Brazil. He wants to open a new store in Europe. However, he does not know what Europe’s rules are for stores. How will his communication from his art store computer (80.2.32.7) travel to Europe’s government (10.5.3.16)? What route will the packet take?</td>
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</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop:</td>
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<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop:</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>#6</th>
<th>Laura wants to discover if art can be used to heal a sick person. She is currently in South America and is researching about African art. Her computer’s IP address is 80.2.32.7. The African computer’s IP address is 103.50.65.7. What route will the packet take?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>#7</th>
<th>Judy wants to discover if South American art came from Europe. Her computer’s IP address is 80.2.32.7 and the European History computer’s IP address is 10.15.3.75. What route will the packet take?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop:</td>
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<td>4&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>#8</th>
<th>Daniel is a doctor in Africa. He has some exciting news to share about the effects of art on healing the sick. Daniel wants to share this information with the South American Art Council. (80.2.32.7) Daniel’s IP address is 103.50.65.7. What route will the packet take?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; Hop:</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>
| #9 | Cynthia is a doctor in Africa (103.50.65.7). Her research team has discovered a new drug to help the common cold. Cynthia wants to share this information with Ohio State University (76.90.14.4).

What route will the packet take?

| 1st Hop: | Destination Interface: |
| 2nd Hop: | Destination Interface: |
| 3rd Hop: | Destination Interface: |
| 4th Hop: | Destination Interface: |
| 5th Hop: | Destination Interface: |

| #10 | Yolanda is a Scientist studying plant growth in Africa. (103.50.65.7). Madrid (35.40.20.6) has a similar research program. Yolanda wants to learn more about Madrid’s program.

What route will the packet take?

| 1st Hop: | Destination Interface: |
| 2nd Hop: | Destination Interface: |
| 3rd Hop: | Destination Interface: |
| 4th Hop: | Destination Interface: |
| 5th Hop: | Destination Interface: |

| #11 | Alex (103.50.65.7) is Niketa’s doctor. Niketa was in Paris (10.15.3.37) participating in a runway show when she felt ill. Alex needs to give the doctors in Paris Niketa’s medical history.

What route will the packet take?

| 1st Hop: | Destination Interface: |
| 2nd Hop: | Destination Interface: |
| 3rd Hop: | Destination Interface: |
| 4th Hop: | Destination Interface: |
| 5th Hop: | Destination Interface: |

| #12 | Madrid (35.40.20.6) and Paris (10.15.3.37) are both sponsoring a fashion show. They need to be in constant communication to work out the details of the show. April from Madrid needs to reach the contact in Paris to discuss sound.

What route will the packet take?

<p>| 1st Hop: | Destination Interface: |
| 2nd Hop: | Destination Interface: |
| 3rd Hop: | Destination Interface: |
| 4th Hop: | Destination Interface: |
| 5th Hop: | Destination Interface: |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Route Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>#13</strong></td>
<td>Melissa is a scientist studying snowfall in Madrid. She would like to compare the snow in Madrid (35.40.20.6) to the snow in Michigan (76.90.14.53). What route will the packet take?</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>2nd Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>3rd Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>4th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td><strong>#14</strong></td>
<td>Deana is on vacation in Madrid (35.40.20.6). She suddenly remembered that she was supposed to buy some South American art (80.2.32.7) for her sister’s birthday coming up in 2 days. What route will the packet take?</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
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<td>2nd Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>3rd Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>4th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td><strong>#15</strong></td>
<td>A couple of celebrities are planning to put on a world concert. Omar is the Spanish contact (35.40.20.11). He is trying to reach someone in Brazil (80.2.32.0) to see if they will participate. What route will the packet take?</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
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<td>2nd Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>3rd Hop:</td>
<td>Destination Interface:</td>
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<td>4th Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td><strong>#16</strong></td>
<td>Spanish and French history has different influences on the country’s music. Sidney is studying those differences. Sidney is at 35.40.20.11 and is gathering information from 10.15.3.75. What route will the packet take?</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>2nd Hop:</td>
<td>Destination Interface:</td>
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<td>3rd Hop:</td>
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<tr>
<td>4th Hop:</td>
<td>Destination Interface:</td>
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<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>
### #17

A new law is being passed in Michigan (76.90.14.53) that will make vehicles cleaner for the environment. A lawyer who works for Europe’s government (10.15.3.16) wants to learn more about the law.

When the lawyer sends a message to the Michigan, what route will the message take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
</tr>
</tbody>
</table>

### #18

Europe’s government (10.15.3.16) is sponsoring a world festival. Gerald is the contact in Europe planning the event. He wants to know if a Spanish musician (35.40.20.11) will participate in the festival.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<tr>
<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
</tr>
</tbody>
</table>

### #19

Joshua is a European History teacher. Judy contacted him to understand how Europe influenced South American art. His computer’s IP address is 10.15.3.75 and Judy’s IP address is 80.22.32.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
</tr>
</tbody>
</table>

### #20

Philip asked an European History teacher (10.15.3.75) to help him complete a report. The teacher is ready to send the report to Philip in Ohio (76.90.14.4).

What route will the report take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<td>3rd</td>
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<tr>
<td>4th</td>
<td>Destination Interface</td>
</tr>
<tr>
<td>5th</td>
<td>Destination Interface</td>
</tr>
</tbody>
</table>
#21
Ashley is visiting Paris (10.15.3.37). She sent her sister in Michigan (76.90.14.53) a gift from Paris. She wants to make sure her sister received the gift. So, Ashley sends an email to her sister.

What route will the email take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
</tr>
</tbody>
</table>

#22
Sheryl has not seen her friend since he moved from Madrid (35.40.20.6) to Paris (10.15.3.37) 2 years ago. They are going to meet in Madrid in 3 months.

Sheryl needs to reach her friend in Madrid to discuss the weather during that time.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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<tbody>
<tr>
<td>1st</td>
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<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
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</tbody>
</table>

#23
Jeff is a scientist living in Michigan. He is working with doctors in Africa to do medical research.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Destination Interface</td>
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<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
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</tbody>
</table>

#24
Jen is a fashion designer. She wants to know when the Paris fashion show is. So, she sends a message from her computer (76.90.14.53) to her coworker’s (10.15.3.37) in Paris.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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<tbody>
<tr>
<td>1st</td>
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<td>4th</td>
<td>Destination Interface</td>
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<tr>
<td>5th</td>
<td>Destination Interface</td>
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</tbody>
</table>
#25

The World Leaders Summit is scheduled for July 4th in London. Peter has a question about the summit, so he sends a message from his computer (76.90.14.53) to the Government (10.15.3.16).

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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</thead>
<tbody>
<tr>
<td>1st</td>
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<td>4th</td>
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<td>5th</td>
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</tbody>
</table>

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#26

John lives in Ohio. He wants to talk with his Uncle in Africa using a computer. His Uncle’s computer IP address is 103.50.65.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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<tbody>
<tr>
<td>1st</td>
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</tbody>
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#27

Jennifer is a zoologist living in Ohio (76.90.14.4). She is working with zookeepers in Europe to count the number of Giraffe’s on Earth. The zookeepers’ computer is located in Paris (10.15.3.37).

When they communicate with each other, what route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
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<tbody>
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<td>1st</td>
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</tbody>
</table>

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#28

A new law is being passed in Europe that will make vehicles cleaner for the environment. A lawyer in Ohio (76.90.14.4) wants to learn more about the law.

When the lawyer sends a message to the Government (10.15.3.16), what route will the message take?

<table>
<thead>
<tr>
<th>Hop</th>
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<tr>
<td>#29</td>
<td>#30</td>
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<td>-----</td>
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</tr>
<tr>
<td><strong>African doctors use natural treatments to help heal the sick. Sharon wants to know if the technique has been used in Europe. Sharon contacts an African doctor (103.50.65.7) to see if European history (10.15.3.75) played a role.</strong></td>
<td><strong>Charlie is a student studying history at Michigan State (76.90.14.53). A History professor in Europe (10.15.3.75) recently contacted him with the opportunity to go to Europe and study history.</strong></td>
</tr>
<tr>
<td><strong>What route will the packet take?</strong></td>
<td><strong>What route did the packet take?</strong></td>
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<td>1st Hop:</td>
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<table>
<thead>
<tr>
<th>#31</th>
<th>#32</th>
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</thead>
<tbody>
<tr>
<td><strong>Tiffany is a famous model. She was in Paris (10.15.3.37) competing in a runway show when she suddenly felt ill and needed to reach her doctor who was in Africa (103.50.65.7) at the time.</strong></td>
<td><strong>Lena is a French tourist guide (10.15.3.37). She often likes to reference how French art and South American art are alike. Myers is a South American art collector (80.2.32.7) and she would like to contact him.</strong></td>
</tr>
<tr>
<td><strong>What route will the packet take?</strong></td>
<td><strong>What route will the packet take?</strong></td>
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<td>#33</td>
<td>#34</td>
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</tr>
<tr>
<td>Lorie is the Secretary of State in the European government (10.15.3.16). She has been trying to contact the Secretary of State in Brazil (80.2.32.3) by email.</td>
<td>It is Mary’s responsible to organize the upcoming Medical Clinic Europe’s government (10.15.3.16) is sponsoring.</td>
</tr>
<tr>
<td>What route does the email take?</td>
<td>She wants to email Dr. Roberts in Africa to have her come and do a presentation at the clinic.</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2nd Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3rd Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#35</th>
<th>#36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megan is a Spanish musical artist (35.40.20.11). She wants to travel to Africa to sing at its hospital. In order to arrange the visit she needs to contact someone at the African Hospital in Africa (103.50.65.7).</td>
<td>Maria is a Spanish musical artist (35.40.20.11). She wants to travel to Michigan to sing to at its Christmas celebration. In order to arrange the visit she needs to contact someone in Michigan (76.90.14.53).</td>
</tr>
<tr>
<td>What route will the packet take?</td>
<td>What route will the packet take?</td>
</tr>
<tr>
<td>1st Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2nd Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3rd Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4th Hop:</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop:</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>
#37
Charlotte is a Scientist studying birds in Madrid. (35.40.20.6). Africa (103.50.65.7) has a similar research program. Charlotte wants to learn more about Africa’s program.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

#38
Fred misses his mother while he is away at school studying art. She lives in Michigan (76.90.14.53). He is currently in South America (80.2.32.7)

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

#39
Mark went on vacation with his family to Brazil (80.2.32.3). He wants to share some pictures from the vacation to his teammate in Ohio (76.90.14.4) through the computer.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

#40
Albert goes to school in Brazil. He has to do a report on European history.

If Albert used his computer (80.2.32.3) in Brazil to contact another computer (10.15.3.75) that has European history information, what route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>
**#1 Answer Key**

Susie lives in the United States. Her computer has an IP address of 76.90.14.53. She wants to talk with her Grandmother in Brazil using a computer. Her Grandmother’s computer IP address is 80.2.32.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
</tbody>
</table>

**#2 Answer Key**

Mark lives in Ohio (76.90.14.4). He wants to talk with his best friend in Brazil using a computer. His friend’s computer IP address is 80.2.32.3.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
</tbody>
</table>

**#3 Answer Key**

Amy lives in Brazil (80.2.32.3) and wants to learn more about natural African herbs. So, she needs to communicate with a computer in Africa. The computer’s IP address is 103.50.65.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>35.40.20.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
</tbody>
</table>

**#4 Answer Key**

Jamie lives in Brazil. She wants to learn more about Madrid, Spain art. So, she needs to communicate with a computer in Spain. The computer’s IP address is 35.40.20.6.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>35.40.20.0</td>
<td>Destination Interface:</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>35.40.20.6</td>
<td>Destination Interface:</td>
<td></td>
</tr>
</tbody>
</table>
**#5 Answer Key**

Tim owns an art store in Brazil. He wants to open a new store in Europe. However, he does not know what Europe’s rules are for stores.

How will his communication from his art store computer (80.2.32.7) travel to Europe’s government (10.5.3.16)?

What route will the packet take?

1st Hop: 80.2.32.0  Destination Interface:
2nd Hop: 10.15.3.0  Destination Interface:
3rd Hop:  Destination Interface:
4th Hop:  Destination Interface:
5th Hop:  Destination Interface:

**#6 Answer Key**

Laura wants to discover if art can be used to heal a sick person. She is currently in South America and is researching about African art.

Her computer’s IP address is 80.2.32.7. The African computer’s IP address is 103.50.65.7.

What route will the packet take?

1st Hop: 80.2.32.0  Destination Interface:
2nd Hop: 35.40.20.0  Destination Interface:
3rd Hop: 103.50.65.0  Destination Interface:
4th Hop:  Destination Interface:
5th Hop:  Destination Interface:

**#7 Answer Key**

Judy wants to discover if South American art came from Europe. Her computer’s IP address is 80.2.32.7 and the European History computer’s IP address is 10.15.3.75.

What route will the packet take?

1st Hop: 80.2.32.0  Destination Interface:
2nd Hop: 10.15.3.0  Destination Interface:
3rd Hop:  Destination Interface:
4th Hop:  Destination Interface:
5th Hop:  Destination Interface:

**#8 Answer Key**

Daniel is a doctor in Africa. He has some exciting news to share about the effects of art on healing the sick. Daniel wants to share this information with the South American Art Council. (80.2.32.7) Daniel’s IP address is 103.50.65.7.

What route will the packet take?

1st Hop: 103.50.65.0  Destination Interface:
2nd Hop: 76.90.14.0  Destination Interface:
3rd Hop: 80.2.32.0  Destination Interface: OR
1st Hop: 103.50.65.0  Destination Interface:
2nd Hop: 35.40.20.0  Destination Interface:
3rd Hop: 80.2.32.0  Destination Interface:
<table>
<thead>
<tr>
<th>#9 Answer Key</th>
<th>#10 Answer Key</th>
</tr>
</thead>
</table>
| **Cynthia is a doctor in Africa (103.50.65.7). Her research team has discovered a new drug to help the common cold. Cynthia wants to share this information with Ohio State University (76.90.14.4).**  
What route will the packet take? | **Yolanda is a Scientist studying plant growth in Africa. (103.50.65.7). Madrid (35.40.20.6) has a similar research program. Yolanda wants to learn more about Madrid’s program.**  
What route will the packet take? |
| 1st Hop: 103.50.65.0 Destination Interface:  
2nd Hop: 76.90.14.0 Destination Interface:  
3rd Hop:  
4th Hop:  
5th Hop: | 1st Hop: 103.50.65.0 Destination Interface:  
2nd Hop: 35.40.20.0 Destination Interface:  
3rd Hop:  
4th Hop:  
5th Hop: |

<table>
<thead>
<tr>
<th>#11 Answer Key</th>
<th>#12 Answer Key</th>
</tr>
</thead>
</table>
| **Alex (103.50.65.7) is Niketa’s doctor. Niketa was in Paris (10.15.3.37) participating in a runway show when she felt ill. Alex needs to give the doctors in Paris Niketa’s medical history.**  
What route will the packet take? | **Madrid (35.40.20.6) and Paris (10.15.3.37) are both sponsoring a fashion show. They need to be in constant communication to work out the details of the show. April from Madrid needs to reach the contact in Paris to discuss sound.**  
What route will the packet take? |
| 1st Hop: 103.80.65.0 Destination Interface:  
2nd Hop: 76.90.14.0 Destination Interface:  
3rd Hop: 80.2.32.0 Destination Interface:  
4th Hop: 10.15.3.0 Destination Interface:  
OR | 1st Hop: 35.40.20.0 Destination Interface:  
2nd Hop: 80.2.32.0 Destination Interface:  
3rd Hop: 10.15.3.0 Destination Interface:  
OR |

| 1st Hop: 103.80.65.0 Destination Interface:  
2nd Hop: 35.40.20.0 Destination Interface:  
3rd Hop: 80.2.32.0 Destination Interface:  
4th Hop: 10.15.3.0 Destination Interface: | 1st Hop: 35.40.20.0 Destination Interface:  
2nd Hop: 103.50.65.0 Destination Interface:  
3rd Hop: 76.90.14.0 Destination Interface:  
4th Hop: 80.2.32.0 Destination Interface:  
5th Hop: 10.15.3.0 Destination Interface: |
#13 Answer Key

Melissa is a scientist studying snowfall in Madrid. She would like to compare the snow in Madrid (35.40.20.6) to the snow in Michigan (76.90.14.53).

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>103.50.65.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
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</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#14 Answer Key

Deana is on vacation in Madrid (35.40.20.6). She suddenly remembered that she was supposed to buy some South American art (80.2.32.7) for her sister’s birthday coming up in 2 days.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#15 Answer Key

A couple of celebrities are planning to put on a world concert. Omar is the Spanish contact (35.40.20.11). He is trying to reach someone in Brazil (80.2.32.0) to see if they will participate.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#16 Answer Key

Spanish and French history has different influences on the country’s music. Sidney is studying those differences. Sidney is at 35.40.20.11 and is gathering information from 10.15.3.75.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>10.15.3.0</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>103.50.65.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>10.15.3.0</td>
<td></td>
</tr>
</tbody>
</table>
### #17 Answer Key

A new law is being passed in Michigan (76.90.14.53) that will make vehicles cleaner for the environment. A lawyer who works for Europe’s government (10.15.3.16) wants to learn more about the law.

When the lawyer sends a message to the Michigan, what route will the message take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>10.15.3.0</td>
<td>2nd Hop: 80.2.32.0</td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td>3rd Hop: 35.40.20.0</td>
</tr>
<tr>
<td>3rd</td>
<td>35.40.20.0</td>
<td>4th Hop: 103.50.65.0</td>
</tr>
<tr>
<td>4th</td>
<td>103.50.65.0</td>
<td>5th Hop: 76.90.14.0</td>
</tr>
<tr>
<td>5th</td>
<td>76.90.14.0</td>
<td></td>
</tr>
</tbody>
</table>

### #18 Answer Key

Europe’s government (10.15.3.16) is sponsoring a world festival. Gerald is the contact in Europe planning the event. He wants to know if a Spanish musician (35.40.20.11) will participate in the festival.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>10.15.3.0</td>
<td>2nd Hop: 80.2.32.0</td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td>3rd Hop: 35.40.20.0</td>
</tr>
<tr>
<td>3rd</td>
<td>35.40.20.0</td>
<td>4th Hop: 103.50.65.0</td>
</tr>
<tr>
<td>4th</td>
<td>103.50.65.0</td>
<td>5th Hop: 76.90.14.0</td>
</tr>
<tr>
<td>5th</td>
<td>76.90.14.0</td>
<td></td>
</tr>
</tbody>
</table>

### #19 Answer Key

Joshua is a European History teacher. Judy contacted him to understand how Europe influenced South American art. His computer’s IP address is 10.15.3.75 and Judy’s IP address is 80.22.32.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>10.15.3.0</td>
<td>2nd Hop: 80.2.32.0</td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td>3rd Hop: 35.40.20.0</td>
</tr>
<tr>
<td>3rd</td>
<td>35.40.20.0</td>
<td>4th Hop: 103.50.65.0</td>
</tr>
<tr>
<td>4th</td>
<td>103.50.65.0</td>
<td>5th Hop: 76.90.14.0</td>
</tr>
<tr>
<td>5th</td>
<td>76.90.14.0</td>
<td></td>
</tr>
</tbody>
</table>

### #20 Answer Key

Philip asked an European History teacher (10.15.3.75) to help him complete a report. The teacher is ready to send the report to Philip in Ohio (76.90.14.4).

What route will the report take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>Source IP</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>10.15.3.0</td>
<td>2nd Hop: 80.2.32.0</td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td>3rd Hop: 35.40.20.0</td>
</tr>
<tr>
<td>3rd</td>
<td>35.40.20.0</td>
<td>4th Hop: 103.50.65.0</td>
</tr>
<tr>
<td>4th</td>
<td>103.50.65.0</td>
<td>5th Hop: 76.90.14.0</td>
</tr>
<tr>
<td>5th</td>
<td>76.90.14.0</td>
<td></td>
</tr>
</tbody>
</table>
### #21 Answer Key

Ashley is visiting Paris (10.15.3.37). She sent her sister in Michigan (76.90.14.53) a gift from Paris. She wants to make sure her sister received the gift. So, Ashley sends an email to her sister.

**What route will the email take?**

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>35.40.20.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #22 Answer Key

Sheryl has not seen her friend since he moved from Madrid (35.40.20.6) to Paris (10.15.3.37) 2 years ago. They are going to meet in Madrid in 3 months.

Sheryl needs to reach her friend in Madrid to discuss the weather during that time.

**What route will the packet take?**

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>35.40.20.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #23 Answer Key

Jeff is a scientist living in Michigan. He is working with doctors in Africa to do medical research.

**What route will the packet take?**

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
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</tr>
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<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #24 Answer Key

Jen is a fashion designer. She wants to know when the Paris fashion show is. So, she sends a message from her computer (76.90.14.53) to her coworker’s (10.15.3.37) in Paris.

**What route will the packet take?**

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
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<td>Destination Interface:</td>
</tr>
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</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
</tr>
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<td>Destination Interface:</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>
#25 Answer Key

The World Leaders Summit is scheduled for July 4th in London.
Peter has a question about the summit, so he sends a message from his computer (76.90.14.53) to the Government (10.15.3.16).

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>10.15.3.0</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#26 Answer Key

John lives in Ohio.
He wants to talk with his Uncle in Africa using a computer. His Uncle’s computer IP address is 103.50.65.7.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>103.50.65.0</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#27 Answer Key

Jennifer is a zoologist living in Ohio (76.90.14.4). She is working with zookeepers in Europe to count the number of Giraffe’s on Earth.

The zookeepers’ computer is located in Paris (10.15.3.37).
When they communicate with each other, what route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
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<td>10.15.3.0</td>
<td></td>
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<tr>
<td>4th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#28 Answer Key

A new law is being passed in Europe that will make vehicles cleaner for the environment. A lawyer in Ohio (76.90.14.4) wants to learn more about the law.

When the lawyer sends a message to the Government (10.15.3.16), what route will the message take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>80.2.32.0</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### #29 Answer Key

African doctors use natural treatments to help heal the sick. Sharon wants to know if the technique has been used in Europe. Sharon contacts an African doctor (103.50.65.7) to see if European history (10.15.3.75) played a role.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Hop</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
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</tr>
<tr>
<td>4th Hop</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop</td>
<td></td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #30 Answer Key

Charlie is a student studying history at Michigan State (76.90.14.53). A History professor in Europe (10.15.3.75) recently contacted him with the opportunity to go to Europe and study history.

What route did the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Hop</td>
<td>10.15.3.0</td>
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<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop</td>
<td>76.90.14.0</td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #31 Answer Key

Tiffany is a famous model. She was in Paris (10.15.3.37) competing in a runway show when she suddenly felt ill and needed to reach her doctor who was in Africa (103.50.65.7) at the time.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Hop</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2nd Hop</td>
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<td>Destination Interface:</td>
</tr>
<tr>
<td>3rd Hop</td>
<td>35.40.20.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4th Hop</td>
<td>103.50.65.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop</td>
<td></td>
<td>Destination Interface:</td>
</tr>
</tbody>
</table>

### #32 Answer Key

Lena is a French tourist guide (10.15.3.37). She often likes to reference how French art and South American art are alike. Myers is a South American art collector (80.2.32.7) and she would like to contact him.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Hop</td>
<td>10.15.3.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>2nd Hop</td>
<td>80.2.32.0</td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>3rd Hop</td>
<td></td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>4th Hop</td>
<td></td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>5th Hop</td>
<td></td>
<td>Destination Interface:</td>
</tr>
<tr>
<td>#33 Answer Key</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lorie is the Secretary of State in the European government (10.15.3.16). She has been trying to contact the Secretary of State in Brazil (80.2.32.3) by email. What route does the email take?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1st Hop:</strong> 10.15.3.0  <strong>Destination Interface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2nd Hop:</strong> 80.2.32.0  <strong>Destination Interface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3rd Hop:</strong>  <strong>Destination Interface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4th Hop:</strong>  <strong>Destination Interface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5th Hop:</strong>  <strong>Destination Interface:</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#34 Answer Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is Mary’s responsible to organize the upcoming Medical Clinic Europe’s government (10.15.3.16) is sponsoring. She wants to email Dr. Roberts in Africa to have her come and do a presentation at the clinic. What route will the packet take?</td>
</tr>
<tr>
<td><strong>1st Hop:</strong> 10.15.3.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>2nd Hop:</strong> 80.2.32.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>3rd Hop:</strong> 35.40.20.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>4th Hop:</strong> 103.50.65.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>5th Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#35 Answer Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megan is a Spanish musical artist (35.40.20.11). She wants to travel to Africa to sing at its hospital. In order to arrange the visit she needs to contact someone at the African Hospital in Africa (103.50.65.7). What route will the packet take?</td>
</tr>
<tr>
<td><strong>1st Hop:</strong> 35.40.20.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>2nd Hop:</strong> 103.50.65.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>3rd Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>4th Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>5th Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#36 Answer Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maria is a Spanish musical artist (35.40.20.11). She wants to travel to Michigan to sing to at its Christmas celebration. In order to arrange the visit she needs to contact someone in Michigan (76.90.14.53). What route will the packet take?</td>
</tr>
<tr>
<td><strong>1st Hop:</strong> 35.40.20.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>2nd Hop:</strong> 103.50.65.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>3rd Hop:</strong> 76.90.14.0  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>4th Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
<tr>
<td><strong>5th Hop:</strong>  <strong>Destination Interface:</strong></td>
</tr>
</tbody>
</table>
### Answer Key #37
Charlotte is a Scientist studying birds in Madrid. Africa (103.50.65.7) has a similar research program. Charlotte wants to learn more about Africa’s program.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>35.40.20.0</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
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<td></td>
</tr>
<tr>
<td>3rd</td>
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<tr>
<td>4th</td>
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<tr>
<td>5th</td>
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</tr>
</tbody>
</table>

### Answer Key #38
Fred misses his mother while he is away at school studying art. She lives in Michigan (76.90.14.53). He is currently in South America (80.2.32.7)

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>80.2.32.0</td>
<td></td>
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<tr>
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<td>103.50.65.0</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>76.90.14.0</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Answer Key #39
Mark went on vacation with his family to Brazil (80.2.32.3). He wants to share some pictures from the vacation to his teammate in Ohio (76.90.14.4) through the computer.

What route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>80.2.32.0</td>
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</tr>
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<td>103.50.65.0</td>
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</tr>
<tr>
<td>4th</td>
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<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Answer Key #40
Albert goes to school in Brazil. He has to do a report on European history.

If Albert used his computer (80.2.32.3) in Brazil to contact another computer (10.15.3.75) that has European history information, what route will the packet take?

<table>
<thead>
<tr>
<th>Hop</th>
<th>IP Address</th>
<th>Destination Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
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<tr>
<td>5th</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LESSON 4 WORKSHEET/HANDS-ON ACTIVITY

Server Game

Materials Needed:

Index Cards or 8.5 X 11 paper
String or yarn

How to Play:

Setup:

Use the index cards to assign each student a role in the architecture. Write the name of the role in big letters on the index card. Punch holes in the card and put the string in it to make a necklace with the role. The roles needed are Web servers, DNS Servers, DHCP Servers, and clients.

*Based on class size and the ability of the class, add the role of router.

*Based on class size and the ability of the class, create two networks.

Use the index cards to create web pages, A-Records and IP addresses.

A. To create web pages, write the following websites on individual index cards:

www.google.com
www.whitehouse.gov
www.games.com
www.webmd.com
www.school.com

www.clubpenguin.com
www.Whyville.net
www.music.com
www.animals.com
www.weather.com

These cards are used by the web server.

B. To create A-Records, write the following on individual index cards – IP address on one side, name on the other:
These cards are used by the DNS Server.

C. To create IP addresses, write each of the following IP addresses on individual index cards:

```
9.8.7.6       6.5.4.3
2.1.0.9       8.7.6.5
4.3.2.1       5.4.3.2
1.0.9.8       7.6.5.4
```

These IP address are used by the DHCP Server.

Strategically place the students in the room. The Web server should be located away from the other hosts as the web server would be outside of the local network. The DNS, DHCP servers and the clients will be in the same network.

*If a router is used, the router will be place between the network and the web server or between the two networks.
**Instructions:**

The instructor will read the scenario aloud. The necessary roles will act out the process needed to achieve the goal in the scenario.

**Scenarios:**

**Scenario #1:** A computer’s (client) Ethernet cable was just plugged into the wall jack. The client wants to join the network. What happens?

**Action to be taken:** The new client will make a request to a DHCP Server for an IP address. The DHCP Server will assign the client an IP address.

**Scenario #2:** A client is trying to view the web page www.google.com. What happens?

**Action to be taken:** If the client is already on the network, the client will make a request to the DNS server for the IP address of google.com. The DNS server will give the client the IP address. The client will then request that IP address from the web server. The web server will give the client the webpage.

If the client is not on the network, it will request an IP address from the DHCP server first, then complete the steps listed above.

*If the role of a router is used, add the following step. After getting the IP address from the DNS server, the client should go to the router to ask how to get that IP address. The router should point the client in the direction of the web server.*

**Scenario #3:** A client moved from one network to another. They would like to join the network. What happens?

**Action to be taken:** The client will make a request to the new DHCP Server for an IP address. The DHCP Server will assign the client an IP address.
Conclusion

Vary the scenarios based on the web pages, and IP addresses used. Rotate roles so that students will have an opportunity to play more than one role in the architecture.
Assess students' preconceptions of computer communication. This will allow the instructor to determine what kind of preconceptions or base knowledge students currently have.
According to the National Research Council in “How People Learn: Brain, Mind, Experience, and School”, preconceptions of certain topics may make it difficult for students to understand new knowledge. According to Wolfe in “Brain Matters”, the brain checks existing neural networks of information to see if the new information is something that can be matched to stored information. If there is no previously stored information, recognition will not take place and the information is meaningless.

The focus of these questions is to start the connection of IP addresses to previously stored information. In this case, preconceptions about computer communication can be examined during the lesson.

**Slide 3**

This slide starts to set the stage for students to connect everyday communication with their friends to a high-level view of how computers communicate with each other.
If someone wanted to share information with me they would need to know:

- **Name:** Cynthia Strong
- **Address:** 34 Lomb Ave.  
  Rochester, NY 14623
- **Phone #:** (585) 475-2700

Continuing to lay the foundation of how everyday knowledge – basic personal information – can be related to how computers communicate. The assumption here is that every student participating in the lesson knows his or her name, address, and phone number. The lesson also assumes that students know how each is used in everyday life. This basic information is often learned in during the preschool age (3-4).

This lesson is designed for middle school age students. Knowing the basic information listed on this slide should not be a hindrance.
Slide 5

**WHAT ABOUT YOU?**
- If someone wanted to share information with you what would they need to know?
  - Name:
  - Address:
  - Phone #:

This slide is used to turn students focus to something that is personal. This should help strengthen the idea being taught. Additionally, with this slide, the instructor will be able to identify any student that does not know this basic information.

Slide 6

**HOW DO COMPUTERS TALK?**
- Computers have the same kind of information!
- Computers share information by sending messages to each others address!

This slide starts to relate previously stored knowledge with new material. This is how the information-processing model works. Students should be able to connect computers
sending information to each other via name and address to their previous knowledge of postal mail.

**Slide 7**

First activity to be completed

**Slide 8**

**IP ADDRESS**

A computer’s address is called its “IP Address”

- Every computer on a network has a name and address.

- A computer’s address is made up of numbers only.
  ~~~~~No words~~~~~

Introduction to IP addresses.
What is a network?
- A network is like a community.
- Your neighbors, everyone who lives on the same street as you, make up your community.
- You all have the same street address, but have different house numbers.

Since network is mentioned in the previous slide, this slide is used to explain what a network is.

Visual representation of a neighborhood of houses.
Each house on Sunny Lane shares the same street name, but have different house numbers.

Computers within a network will have the same network address, but different host addresses.

**Slide 11**

**IP ADDRESS**
- An IP address is 4 numbers separated by a "."  
  - The highest number used is 255
- Examples of IP addresses:
  
  - 0.0.0.0  
  - 192.168.1.1  
  - 64.90.101.255  
  - 87.0.100.2  
  - 2.2.2.2

- Now you write 5 correctly formatted IP addresses.

At this point, have students come to the board and write correctly formatted addresses.

This process is to just verify that students understand IP addresses are 4 octets separated by a period with no number larger than 255.
This slide reinforces that computers in a network are setup similarly to a neighborhood. Stress that all houses share the street name “Sunny Lane”, but have different house numbers.

**Slide 13**

This computer’s IP Address is 192.168.1.1

- “192.168.1.0” is the network name. (Street Address)
- “1” is the computer number. (House Number)
- Computers in the same network (community) will share the same network address (Street Address)
This slide reinforces that computers in a network are setup similarly to a neighborhood. Computers share the network address of 192.168.1.0 (street name) however, each computer has a different “computer number”.

Put the information together like a postal address, you get 192.168.1.1.

Slide 14

192.168.1.8

Network Address

Computer Number

Just as we write a postal address with house number first, then street name, this slide shows how we write an IP address. Network address first, then the host number.

The first three octets representing the network address is not true for all networks. Depending on subnetting strategies, more than the last octet can represent the host. However, for simplicity sake, the first three octets is the network and the last octet is the host.
Some networks are small, while others are very large. If there was a network of 50 computers, would you want to give each and every one an IP address?

- No!

What happens if the network is very large?

- Each computer gets an IP Address from the DHCP Computer.

192.168.1.0 Network

This slide introduces the concept of DHCP and DHCP Servers
DHCP Computer

- An IP Address from a DHCP Computer is just like other IP Addresses
  - The only difference is that a person doesn’t assign the address.
  - The “DHCP Computer”, gives each computer in the network its address.
- All you have to do is:
  - Give the DHCP Computer its address
  - Tell the DHCP Computer a range of IP addresses to use for the other computers.

This slide tries to convey there is no difference between an IP Address and a DHCP IP Address.

Slide 18

DHCP Computer

- Using a DHCP Computer is easier when there are a lot of computers in the same network.

DHCP Computer, your address is 192.168.1.254. Please give all the other computer in your network their address. Use addresses within this range: 192.168.1.1 – 192.168.1.75

192.168.1.0
Network
Explain that the DHCP Computer's address is 192.168.1.254 and that all of the computers below in the 192.168.1.0 network will get an IP address from the DHCP Computer. The DHCP Computer will use addresses from the range 192.168.1.1 through 192.168.1.75. Explain that any address outside of this range will not be given to a computer in the network.

Slide 19
Highlight that computers within this network have similar addresses – 192.168.1.x. It is important that students know that when using a range, addresses simply “count” up 192.168.1.1, 192.168.1.2, 192.168.1.3, etc.

**Slide 20**

**Slide 21**

**SUMMARY REVIEW**

- Computers use IP Addresses to talk with each other.
- An IP Address is 4 numbers separated by a “.”. The greatest number used is 255. No words!
- A Network is a community of computers. They all share the same network address (street name).
- If the network of computers is very large, assign 1 computer’s address and make it the DHCP Computer.
  - This computer will give everyone else in the network their address.

Recap of lesson. Opportunity to answer questions before post-assessment.
Complete the Post Assessment Quiz
Lesson 2 is about physical network topologies. Students will learn about Ethernet cables and how messages would travel in various topologies.

**Slide 2**

- We know that computers form networks and talk to each other, but how do messages travel from one computer to another?
- Does it matter how computers are arranged in a network? Should the computers be in a straight line, a circle, or scattered about?
Slide 3

What are these images?

This slide begins the introduction that messages are sent on a cable. Students know that electricity is carried via power lines. Similarly, computer messages travel via cables. Another example could be telephone communication. Students speak into a telephone, the sound travels via the phone line, and the person on the other end hears the message. With the invention of wireless phones and cell phones, students may have a difficult time relating to this illustration. Therefore, power lines seemed more appropriate.
Just as in this picture, power travels across the U.S.

This slide is used to show that computer messages can travel like-wise.

Cables are how messages travel. Electricity uses power lines, computer messages use Ethernet cables. Cables look a lot like telephone cords. You plug them right into the wall.
In order for computers to communicate, the computer must be connected to the network by the cable. The cable plugs right into the wall just like an electrical appliance.

**Slide 7**

- Computers make up a network.
  - We know that computers can talk to other computers by using its IP address.
- How does the message get to the other computer?
  - The message travels inside the cable.
  - The shape of the network controls what direction the message travels.

Remind students of previous lesson about networks.
Computers can talk to other computers in their network or to computers outside of their networks.

The way computers are connected in their network makes a “shape”.

We are going to explore the different shapes of computer networks and how computers talk to each other in a network.

*This lesson focuses on how computers communicate within the same network.

**Slide 8**

One way for students to recall the four network shapes would be to use the following acrostic sentence.

**Big Rings Shine Massively**

*Optional – Have students develop their own mnemonic to remember the network shapes.
Each window represents a computer.

If #1 wanted to tell #5 something, everyone on the bus would hear.

Think of riding on a bus. It can be very easy to hear what someone in the back is saying or what someone in the front is saying. The person would have to speak loudly because there is no walking on the bus while the bus is moving, so everyone hears the message.

On a bus, everyone shares the middle aisle. If someone wanted to change seats, they would use the middle aisle to walk to their new seat.

A bus has the following similarities to a Bus network shape:

• When someone talks on a bus, everyone hears it.
• When a computer sends a message to another computer, all computers in the Bus network hears it.
• Everyone riding on a bus shares the middle aisle for walking
• All computers in a Bus Network share a single cable.
Therefore, when thinking about a Bus Network, think of all of the computers in a straight line sharing one cable. Anytime a computer sends a message, all computers hear it because they are all sharing that one cable. Therefore, even though Computer 1 is sending a message to Computer 4, every computer hears the message, but the only computer that cares about the message is Computer 4 because the message was addressed to computer 4.

*****Another example of broadcast*****

In a classroom, the teacher may call Susie’s name. Then the teacher may ask Susie to walk up to the whiteboard. Everyone in the room hears what the teacher says, but Susie is the only person who responds to what was said because the message was meant for her.

Similarly, with computers in a Bus Network, everyone in the network hears the message, but only the computer it was addressed to cares about the message.

Slide 10
The message travels along this cable. Every computer connected hears the message because it is one single line.

It is best to have a few computers in this shape. Let us see why.

**Slide 11**

What happens when two computers send a message at the same time? Remember that the computers all share a single line.

**Situation:**

Computer A sends a message to Computer D. At the same time, Computer G sends a message to Computer B.

They both cannot share the cable at the same time and a collision happens.

It is best to have a few computers because there is a smaller chance that two computers will talk at the same time.
If at any point, there is a break in the line no computer will be able to send messages. This main line must be intact.

Slide 13

- Your turn!
- Draw a Bus Network.
Have students draw a bus network consisting of as many computers as they like.

**Slide 14**

A hula hoop can be used for illustrative purposes. Most hula hoops have beads inside. Explain to the students that messages, like the beads inside can only travel in one direction at a time. (Either clockwise or counterclockwise) If the ring were broken, the hula hoop would no longer be functional. It is the same with a ring network.
In a Ring Network, messages travel from one computer to the next in one direction. A Ring Network can be configured to use a token. When a computer has the token, it has permission to communicate with other computers. This allows only one computer to speak at a time. It eliminates confusion.

*** Can you imagine a classroom where everyone talked at the same time? Would you be able to clearly understand the next person? ***
At this time, students should complete Activity #1. This activity simulates computer communication in a ring network.

Networks can be in a “star” shape. Before showing students a five-point star, please have them draw their idea of a star. In general, any star will work for this illustration. It is important that students do not think that messages in a star network travel along the lines
of a five-point star. In actuality, messages leave the computer and travel to the hub and the message is broadcasted out of each port from there. Therefore, the message does not travel along the lines of a five-point star.

This fact aside, most students at this age recognize, understand, and know a five-pointed star. The next slide will illustrate how messages travel in a star network.

**Slide 18**

![Star Shape](image)

Let’s use a star that looks like this.
Now we have added the computers. How do messages travel in this network? Do they travel along the black line...... not quite.

We're still missing a part of this network.

Slide 20
Now the network is complete. The box in the center represents what is called a hub (switch). A hub acts just like a microphone.

When you speak into a microphone, you hear the same thing you said through the speakers. The microphone does not change what was said, it only repeats it.

A hub will take messages from a computer and just repeat it to other computers connected to the hub.

**** Lesson definitions should be modified if a switch is used. Switches are more intelligent that hubs and will act in a different manner ****

**Slide 21**

Computer B wants to send a message to computer D. This is how the packet travels:

1. The message leaves Computer B
2. The message goes to the hub
3. The hub repeats the message to every computer connected to it
4. Computer D receives the message

5. All of the other computers ignore the message because it’s not addresses to them

Every message travels to the hub first, then to the other computers.

What happens if the hub is broken? Then, the computers in this network will not be able to communicate with each other. Computers in a star network cannot communicate directly to each other; every message must travel through the hub.

**Slide 22**

At this time, students should complete Activity #2. This activity tests students’ knowledge of how computers communicate in a star network.
In a mesh shape network, every computer is connected to every other computer in the network.

Simple right?
Initially, students may think this architecture is great. Sure, these are point-to-point connections. Computers in this setup can communicate directly with each other. However, what happens if the network grows. This architecture is simple and easy in a small network. Let's review a larger network...

**Slide 25**

Not so simple after all.

There are benefits and challenges to a Mesh Network.

One benefit is that this type is network is very reliable.

There is a very good chance that computers will be able to communicate with each other. This is because there is more than one cable where the message can travel. Therefore, if the cable between Computer B and Computer C isn’t working, then the message can travel to Computer D first, and then the message will be passed along to Computer C. We’ll illustrate this later.

A challenge of a Mesh shaped network is the cost.
In a Mesh Network, each computer is directly connected to every other computer in the network. As you can see, there are many cables involved. As more computers join the network, more cables are required. The owner of the computer network has to pay for each cable.

**Slide 26**

Let's look at how the messages will travel in a Mesh shape network.

Computer C wants to send a message to Computer D. In this case, it could just send the message directly.
Well, what happens if the cable between Computer C and Computer D isn’t working?
Then, Computer C can send the message to Computer E and then Computer E will send the message to Computer D.
The goal is to have students understand that there is more than one way for Computer C to communicate with Computer D. That is one of the advantages of a Mesh topology – it is very redundant.

Ask students to give other possible paths of communication between Computers C and D.
Complete Activity #3

Recap of lesson. Opportunity to answer questions before post assessment.
Recap of lesson. Opportunity to answer questions before post assessment.

Slide 30

**REVIEW**

- **Computers in a Bus Network:**
  - Share one single cable
  - Every computer hears the messages

- **Computers in a Ring Network:**
  - Messages travel in one direction only
  - Only one computer has permission to talk at a time

Recap of lesson. Opportunity to answer questions before post assessment.

Slide 31

**REVIEW**

- **Computers in a Star Network:**
  - Send all of their messages to a hub first
  - The hub acts like a microphone

- **Computers in a Mesh Network:**
  - Have different ways to get message to a computer
  - Have a direct line to every other computer

Recap of lesson. Opportunity to answer questions before post assessment.
Complete the post assessment questions.
Lesson 3 is about routing between networks. Students will learn about routers and interfaces. Students will be able to know how packets go from one network to another by using the network address.

Slide 2

question

- Have you ever visited a family member in a different state or city?
- How did you get there?
  - Car
  - Bus
  - Train
  - Airplane
  - Boat
Introduces the important framework on which this concept of network routing will be built. The lesson assumes that students have some experience with traveling. Particularly for this lesson, students who have flown in an airplane will have a strong foundation to connect with the concept.

When thinking about routing, it is similar to flying. A router is much like an airport. It is the connector between one place and another. Compare each terminal at an airport to an interface on a router: An airplane at one terminal plans to travel to one destination, while an airplane at a different terminal will travel to another destination.

**Slide 3**

There are many ways to travel. If someone needs to travel a short distance, they may just drive the distance in a car. However, if a person needs to travel a longer distance, they may fly.

Similarly, if a computer needs to communicate with a computer in a different network, it will use a router to do so.
At an airport, there are many terminals. Each terminal has an airplane that will travel to a particular destination.

In networking terms, a terminal is called an interface. Each interface will send a packet to a different network.

**Airports**

- Airports have many terminals
- Each terminal has airplanes that travel in different directions
- Routers have different “terminals” as well
  - Interfaces
- Each interface will send packets to a different network

**Slide 5**

- The airport below has four different terminals:
Explain that each terminal has an airplane. If a passenger needed to travel North they would use terminal A to catch their airplane. If traveling West, use terminal D and so forth.

Slide 6

Activity #1

WORLD TRAVELER

Slide 7

Routers

- Routers are very similar to airports
  - Routers route traffic
- Computer networks are not known by names
  - Network addresses
- Remember each computer in a network has an IP address and every network has a network address
  - Routers use addresses, not names
Just as an airport flies planes to different destinations, routers send packets to different destinations.

In the previous activity, we used state names to determine source and destination of travel. However, computer networks do not use names. Computer networks use network addresses.

**Slide 8**

Network Address

- Remember network addresses from Module 1?
- Let’s review…

Have students share what they remember about network addresses. The next three slides are taken from Lesson 1 and can be used to review the definition of a network address. Network addresses are important at this time because routers route based on network address.
This slide reinforces that computers in a network are setup similarly to a neighborhood. Stress that all houses share the street name “Sunny Lane”, but have different house numbers.

Slide 10

This slide reinforces that computers in a network are setup similarly to a neighborhood.
Computers share the network address of 192.168.1.0 (street name) however, each computer has a different “computer number”.

Put the information together like a postal address, you get 192.168.1.1.

**Slide 11**

![Diagram of network address and computer number]

Just as we write a postal address with house number first, then street name; this slide shows how we write an IP address. Network address first, then the host number.

The first three octets representing the network address is not true for all networks. Depending on subnetting strategies, more than the last octet can represent the host. However, for simplicity sake, the first three octets is the network and the last octet is the host.
Let's look at the computer networks at the Owls University.

This university has four departments and each department in the university has their own computer network. The four departments are:

- Science Department
• Music Department
• Technology Department
• Business Department.

Each department wants to be able to share information within its department and to other departments as well. We have already learned how computers would share information within the same network.

Let’s quickly review.

**Slide 14**

![Computer Shapes](image)

What are the four different network shapes?

• Bus
• Ring
• Star
• Mesh
Have students tell one thing about each of the following network architectures:

- Bus
- Ring
- Star
- Mesh

**Slide 15**

Why would each Department want their own computer network?

Owls University has four departments – Science, Music, Technology, and Business.

Information about when the next opera is scheduled is of little use to someone in the Science Department. However, information about which classrooms are empty in the Science Department is important to all departments.
Let's say you want to travel to California........ well, California isn't one of the destination listed at the NY Airport.
However, we know that Colorado is in the direction of California. So, in this case, we would take an airplane from the NY airport to Colorado and from Colorado, we would take a plane to California.

Let's take a look at this

**Slide 18**

![Airports diagram]

Everyone who wants to travel from the NY airport to California will have to travel to Colorado first. The COL airport knows how to get its passengers to California.

Understand?

Let's look at some more examples.
Scenario #1 – Someone at the NY airport wants to travel to Florida. From the NY airport, they can only fly directly to Colorado or Atlanta. So how are they going to get to Florida?

First, let’s look at each of the directly connected airports to see if one of them has a flight to Florida. Let’s start with the Colorado airport.

If the person flies from the NY airport to the Colorado airport, can they then travel to Florida?

What are the destinations at the Colorado airport?

   Washington, California, Arizona, and New York

There is no flight to Florida from the Colorado airport.

Let’s take a look at the Atlanta airport. If the person flies from the NY airport to the Atlanta airport, will they be able to travel to Florida?

What are the destinations at the Atlanta airport?

   Georgia, Louisiana, Texas, and Florida


Yes! If the person travels first to the Atlanta airport, they can take a second airplane to Florida. This is the route the person needs to take.

**Slide 20**

**Airports**

- Communication between multiple computer networks work much the same way
- When traveling each airport used is called a “layover”
- In computer networks, each router a packet uses is called a “hop”

At this point, the lesson will transition into compiling all previous points together. Students will now have to use previous knowledge to identify how a packet would travel by router through multiple networks.
Recap of lesson. Opportunity to answer questions before post assessment.

Routers are like airports in that each interface is like a terminal. Just as airplane arrive and takeoff at terminals, packets arrive and leave networks at interfaces.

Routers use network addresses to send packets to their destination. The network address determines which interface to use.

Each time a router is used it is considered a hop. In the case of an airport, each time a new airport is used it’s considered layover.
Recap of lesson. Opportunity to answer questions before post assessment.

Routers are important.

Without routers, computer would only be able to communicate with computer within its own network. That means we would have to have really big networks, or each network would be isolated and alone.

Since we do have routers, we can connect multiple computers and networks together no matter where it's located.
Complete the post assessment questions.