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How the Internet Works: Routing

Unit 3. Information and the Internet

Revision Date: Jul 22, 2019
Duration: 1 50-minute session

Lesson Summary

Summary

This lesson delves deeper into the structure of the Internet and routing protocols. Students will explore the necessity of redundancy by using packets to transmit sections of data. They will then discuss standards for packets and routing. The class will simulate a network in which each student is a node through which they will send email packages from one node to another.

Outcomes

- Students will explain how the Internet moves data from one place to another using routers.
- Students will understand how data is encoded on the Internet.
- Students will explain how large amounts of data are managed on the Internet.
- Students will be able to define protocol and TCP/IP

Overview

1. Getting Started (10 min)
2. Activity Pt A: Simulation of packet transfer (10 min)
3. Activity Pt B: Simulation including lost packets (10 min)
4. Discussion (15 min)
5. Wrap Up (5 min)

Learning Objectives

CSP Objectives

- *EU CSN-1 - Computer systems and networks facilitate how data are transferred.*
  - LO CSN-1.A - Explain how computing devices work together in a network.
  - LO CSN-1.B - Explain how the Internet works.
  - LO CSN-1.C - Explain how data are sent through the Internet via packets.

- LO CSN-1.D - Describe the differences between the Internet and the World Wide Web.
- LO CSN-1.E - For fault-tolerant systems, like the Internet: a. Describe the benefits of fault tolerance. b. Explain how a given system is fault-tolerant. c. Identify vulnerabilities to failure in a system.

Math Common Core Practice:

- MP3: Construct viable arguments and critique the reasoning of others.
- MP6: Attend to precision.
- MP7: Look for and make use of structure.

NGSS Practices:

- 1. Asking questions (for science) and defining problems (for engineering)
- 2. Developing and using models
- 3. Planning and carrying out investigations
- 8. Obtaining, evaluation, and communicating information

Key Concepts

Students will be able to:

- ***Create*** a list of aspects of the Internet's design that have helped it scale and flourish, and ***articulate*** how these aspects contribute to its growth.
  Diagram the path of an email as it travels from one Internet user to another.
- ***Explain*** why it makes sense to send data in multiple packets rather than all together.

Essential Questions

- What is the Internet, how is it built, and how does it function?
- What aspects of the Internet's design and development have helped it scale and flourish?
- How is redundancy built into the Internet?
- Who is in charge of the Internet?

Teacher Resources

Student computer usage for this lesson is: **none**

1. Materials required

- Post-It Notes - each student needs 10-20 Post-Its
- Desks/Tables should be moved to form a grid such as a 6 by 6 grid.

2. Copies to make

- Teacher IP Address Locations - One for the teacher.

- Student IP worksheet - One per student. Either hand these out after students are seated, or put one at each desk prior to the start of class. Make sure that the layout of the worksheets matches the layout of the Teacher IP Address Locations.

3. Digital resources (check for access)

- (Code.org packets (https://www.youtube.com/watch?v=AYdF7b3nMto&index=4&list=PLzdnOPI1iJNfMRZm5DDxco3UdsFegvuB7)) or World of Science video (https://www.youtube.com/watch?v=Gfoc3Cxgnpk).

4. Required background knowledge

- http://web.stanford.edu/class/msande91si/www-spr04/readings/week1/InternetWhitepaper.htm (http://web.stanford.edu/class/msande91si/www-spr04/readings/week1/InternetWhitepaper.htm)
  - Particularly the IP and Routing Hierarchy sections.
- http://www.dummies.com/how-to/content/exploring-tcpip-routers.html (http://www.dummies.com/how-to/content/exploring-tcpip-routers.html)
  - Routers
- https://www.youtube.com/watch?v=RbY8Hb6abbg (https://www.youtube.com/watch?v=RbY8Hb6abbg)
  - How IP works (This can be shown to students at the discretion of the teacher.)

Lesson Plan

Getting Started (10 min)

Journal

Prompt students to respond in their journals to one or more of these questions:

- When you type the name of a website (URL) into your browser, how does the browser know how to find that website?
- How does data get from one point to another on the Internet?
- Who is in charge of the Internet.

Discussion: Invite students to share their journal entries. The class should come to the general consensus that while their computer doesn't know where to find everything on the Internet, it is able to pass information or requests from one location to another.

- As an analogy, describe the theory behind "six degrees of separation." This theory states that if person A is told the name of one other person in the world (person B), then through no more than five individuals, one of whom is a personal acquaintance, person A will be able to contact person B. The choice of that personal acquaintance is key: If you're trying to find someone in France, it is better to ask a friend in France to find person B than to ask your neighbor (unless you already know that your neighbor has strong connections with the people in France near person B). While the theory isn't precisely true, it is true that most real-world networks tend to have "hubs" (highly connected nodes (people who know

many other people, or Internet nodes that are connected to many other nodes) and "spokes" (connections from hubs to individuals or nodes who are less well connected).
- The internet is not run by any government or business but rather is run by the IETF. https://www.ietf.org/ (https://www.ietf.org/) The IETF's mission is "to make the Internet work better," but it is the Internet *Engineering* Task Force, so this means: make the Internet work better from an engineering point of view, not politics or government.

Activity Part A: Simulation of Packet Transfer (10 min)

Transition Remark: Previously, we looked at the general structure of the Internet and how it works. Today, we will look more closely at the process of sending information between two locations using the Internet. Let's see what this looks like through a video(Code.org packets (https://www.youtube.com/watch?v=AYdF7b3nMto&index=4&list=PLzdnOPI1iJNfMRZm5DDxco3UdsFegvuB7)) or World of Science video (https://www.youtube.com/watch?v=Gfoc3Cxgnpk). (After video) We are going to simulate this same action by sending packets of information to each other without leaving our seats.

Introduction:

- Tell students that they will use rules, just like the Internet, called *protocols*. Compare the process followed by the Internet to get information from one place to another to the algorithms that they created previously (inputs of some type are given to the algorithm; it performs the same process on any information given; and then it produces a result). The protocols are applied to every packet of information that is sent. For this simulation, our protocol will have the structure “Recipient IP:____, part # of total, Sender IP:_____ “
- On the Internet, the addresses are called Internet Protocol (IP) addresses. These addresses are made up of three numbers, and often correlate to your geographical location. Today, you will each be given an IP address consisting of three letters. I have determined this address through your geographical location in the room. (As students participate in this activity, they will see the use of hierarchy. Most of their packets that begin with the same letter will go to the same general region, although there are a few that break this pattern.)
- Display the definition of TCP/IP (http://www.computerhope.com/jargon/t/tcpip.htm (http://www.computerhope.com/jargon/t/tcpip.htm)). Explain that there are many layers of protocols on the Internet from those that control hardware up to those that interact with application programs. Show the table of protocol hierarchy. (https://www.iplocation.net/tcp-ip (https://www.iplocation.net/tcp-ip))
- Your goal is to send a letter that I will hand out to the correct IP address, but here is the catch: Computers do not store the location of every IP address in the world. They are given the IP addresses of other coputers that are connected to them. Thus, you may only communicate with your neighbors to tell them your IP address. This must be done silently. (You may show them your IP address from your paper, or write it on a Post-It.)
- You can also ask your neighbors (via Post-It note) who they have access to, and your neighbors can ask the same question of their neighbors. In this way, you may find that you have access to someone else, but not know the route that the package must go to get there.
- On the back of your IP card, you have a table, which you should use to record how to get messages between yourself and different students in the class.
    - **Example:** We are going to attempt to transmit a package from B.B.A to C.B.D.
        - Student B.B.A - ask neighbors if they are C.B.D, or can get there.

        - This request should propagate through students until someone has found C.B.D.
        - C.B.D responds to their neighbor, who tells the neighbor who asked. This repetition should continue until the news has reached the original sender. B.B.A gives their message to the neighbor with the connection, and records on their paper who they went through to make the connection.
        - The message is passed on to C.B.D, who opens it, and reads it.
- Hand each student paper to serve as "packets," and allow them to send messages to one another. Make sure that they use the correct protocol on each message.
- Allow students to send packets that request information (what is your favorite ice cream, do you have siblings, etc.), and make sure that return packets are addressed and sent.

Activity Part B (10 min)

Transition Remark: Our simulation of the protocol system on the Internet has been relatively tame. In reality, it doesn't always work this nicely. Sometimes packets are lost; not all the information you want to transmit fits in one packet; or some routers are unable to keep working. Fortunately, the Internet is full of redundancy that allows it to keep working even if some parts fail to work, and we can send large data sets through multiple packets. We're going to run our simulation again, but this time living in the "real world."

- Allow students to send messages to one another, but this time, as students transmit packets, mix them up a bit to simulate lost packets or unreadable data.
- Require students to find information from one another, but give them a character limit (like a text or tweet) for each packet that requires them to use multiple requests to send the information.
- Give IP cards some identifiable characteristic (print them on different color paper, put a sticker in the corner, etc.), and tell students with a particular characteristic that they are unable to connect to the network. Ask the remainder of the class to try to send messages without them. This will simulate the power of redundancy.

Discussion: How does redundancy of routers contribute to Internet fault tolerance?

- Some of your packets are getting lost! Sometimes this occurs in the middle of a multi-packet message. This is very frustrating, especially when we do not know whether all of our packets were received. How could we make our protocol system better in order for our Internet to run more smoothly?
    - This discussion should end with students deciding it would be nice to have a reply message such as "I got it!" with the number the packets that went together (1 of 3). The teacher should allow students to come to this conclusion on their own, but you may need to push them in this direction.
- Return to simulation, test your new protocols. (Spend no longer than 5 minutes.)

Discussion (10 min)

Transition Remark: We just participated in a simulation that allowed us to become nodes within the Internet. By filling out the back side of your IP worksheet, each of you was essentially becoming a *router*. Each routers contains a *configuration table* with information that it can use to send packets to the correct location.

Discussion:

- What is the role of the IP address for each device on the Internet?
- How does redundancy of routers contribute to the Internet's ability to scale to more connections?
    - Students will need to extrapolate from their understanding of the simulation to answer this question.

Conclusion: This information should be written in the student's journal.

- We have simulated some protocols used to transfer information across the Internet. However, there are other protocols that are necessary for sharing information and communicating between browsers and servers on the Web. These include information exchange (HTTP protocols) and secure sockets layer/transportation layer security (SSL/TLS).

Wrap Up (5 min)

Reflection: This may be completed as an exit ticket for formative assessment or in student journals.

- In the activity, what happened when you tried to send out packets of information?
- What worked in the activity and what did not work?
- Make comparisons between what happened in the activity and what actually happens as data moves on the Internet.

Options for Differentiated Instruction

Routers

- Research how routers use IP addresses to know where to send packets of information. Write one paragraph, a poem or rap, or create a diagram to communicate what you learned on the topic.

Traceroute

- Use a Traceroute utility to trace the path that a packet takes to get to your computer. Create a flowchart/path diagram to record what you learned.

Code.org Lesson

- For an alternative lesson or to reinforce concepts, use Unit 2 Lesson 4: "Routers and Redundancy" from Code.org. https://docs.google.com/document/d/1-m0yDvgTkM10N6N9-WKdFE2wd2BrMIiHL6hmTSxy-Zs/edit (https://docs.google.com/document/d/1-m0yDvgTkM10N6N9-WKdFE2wd2BrMIiHL6hmTSxy-Zs/edit)

Evidence of Learning

Formative Assessment

Assessment will occur informally through the discussion questions:

- What is the role of the IP address for each device on the Internet?
- How does redundancy of routers contribute to the Internet's ability to scale to more connections?

Reflection questions for journal:

- In the activity, what happened when you tried to send out packets of information?
- What worked in the activity and what did not?
- Make comparisons between what happened in the activity and what actually happens as data moves on the Internet.

Summative Assessment

Assessment Questions:

Explain the role of the Internet Protocol address for each device on the Internet.

Why is the assignment of an IP address critical to connecting a device to the Internet?

How does Internet router redundancy contribute to Internet fault tolerance?

How does redundancy of routers contribute to the Internet's ability to scale to more connections?

Explain how relatively small packets are used to transmit large files on the Internet and identify what information each packet must possess.

Identify a standard protocol for Internet packet communication.

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