

Hello, are you listening?

1. This unit has two activities that investigate how conventional and cellular telephone calls are routed from caller to receiver. It connects how engineers approach large, system based problems.
2. The activities can be done individually or together.
3. Each activity has a resource page that provides background information.

Communication

Grades 7 & 8 (suggested)

Objective

The goal is for students to have a basic understanding of the engineering components behind telecommunications. In particular, it focuses on creating an understanding of the way telephone communication works to link one phone to another for both conventional and cellular telephones. After doing these activities the students should have a good understanding of how a phone call is transmitted from the caller to the recipient.

The solution for call routing has existed for decades. By developing their own strategy and understanding what type of information is required to get a call from one location to another the students will develop a more thorough understanding of how this type of communication operates.

Skills & Standards

- Develops an understanding of technology as a system with inputs and outputs.
- Involves decisions related to advantages and disadvantages of products and processes.
- Uses resources (people, references, Internet) to gain knowledge.
- Uses mathematical scaling
- Includes consideration of environmental impact

Activity Outline

Materials required

Part 1:

- 4 sheets of paper that are 2 different colors

Materials required

Part 2:

- One ball of yarn/string

Time frame:

Part 1: 30 minutes

Part 2: 40 minutes

Overview of Presentation

Briefly explain engineering (See Presenter's Guide for more detail).

Engineers use scientific information to design and create useful things. In designing and creating, the engineer goes through a problem solving process in which both math and science are important components.

Introduce the activity to the students.

Have a general discussion about telephones. Encourage students to share what they know or think about how to place a phone call for local and long distance calls.

Begin the activity.

Before passing out the materials, present the '*problem*' and '*who wants to know*' which are listed at the end of the activity sheet. You can change the description to match your location.

Do the activity.

Pass out the materials and do the activity. As the students work on it present '*how can you help solve the problem*' and '*let's try it*' to help them with the brainstorming and testing.

Reflect on the activity.

After the activity is completed spend time discussing what was discovered and learned. Was there additional information that would have been helpful? Are there other ideas that could be tried? Present '*will your suggestion work*' to think about potential re-tests.

Career Connection:

Discuss what types of jobs are involved with telecommunications. Asking '*Who can help you solve the problem*' may help students think about the type of people who would know.

Activity 1: Conventional Telephone Communications – Call Routing

This activity has the students simulate how phone calls are connected by acting out a variety of searches for both local and long distance calls. It shows the way engineers can approach solutions to systems that require the transfer of large amounts of information. The activity has been developed based on a traditional engineering design process which pose key questions – all identified in boldface type, that help the students approach the problem as engineers.

ROUTING LOCAL CALLS

- In advance, make a double-sided photocopy of Worksheet A and Worksheet C. On a **different color piece of paper**, make a double-sided photocopy of Worksheet A and Worksheet D.
- Cut each page up along the dotted marked sections. Use as many phone numbers as there are students.

What's the problem? There are hundreds of homes in your town and you need to determine an effective way for people to place calls not only to each other but also to homes in other communities and states. How do you determine what is effective? Is it fast connections? Is it as many connections as possible? Is it a combination of both?

Who wants to know? The people of the town want to make sure that when they place a call it goes through to the destination without any problems.

- Have the students spread themselves out in the room and give each one a Home # and a Call #, making sure that the phone numbers are different.

How can you help solve the problem? Think about what might happen when you make a phone call. What path does the phone call follow? Propose an efficient solution(s) and explain how it will work.

Let's try it! Put your idea to work. How can you demonstrate your idea and/or test to see if it works?

- To start, select one student who will 'make a call.' Have the remaining students place their phone number face down so that the word Home # is face-up. The calling student takes her Call # phone number and goes around trying to find the matching Home #. To do this, she approaches students and asks them to show her their Home #. When she finds the matching one, the call is connected. Try to make the connection as quickly as possible.
- Increase the number of students trying to 'make a call' at the same time. Again, try to make the connections as quickly as possible.
- Stop and have the students think about and discuss ways that might be more efficient for finding the correct number.

Will your suggestion(s) work? Are your ideas realistic? How many phone calls can be placed through one telephone line at a time? How does each call know where to go? Is there other information you need to know?

- Assign one student to direct the calls for each local exchange. The students with home numbers for that local exchange should move close to their local exchange manager. Now select a new set of students to make calls. Did the connections get made more quickly?

Who can help you solve the problem? What type of information or knowledge is needed to work on this problem?

ROUTING LONG DISTANCE CALLS

1. In advance, make a double-sided photocopy of Worksheet B and Worksheet C. On a **different color piece of paper**, make a double-sided photocopy of Worksheet B and Worksheet D.
2. Cut each page up along the dotted marked sections. Use as many long distance phone numbers as there are students.
3. Distribute one Home # and one Call # to each student.
4. Discuss how the students want to set up their calling network given their experience with the local calling activity. Do they want to just try to find the numbers? Do they want to use exchange managers? Should the exchange managers be local, state, or both?
5. Have the students create and test their system for how quickly the calls are placed.
6. Discuss the solution tested. Is there another approach they would like to try?

Engineering Summary: Finish with a discussion about how the students acted as engineers.

Background Information for Activity Leader

When you lift the handset of a telephone it connects to the local phone company's switching center and plays a dial tone over the line to let you know the line is open and good.

- When you dial the number you want to call, the local switching center compares the dialed town exchange (first 3 of a 7 digit number, for example 723-xxxx) to its own 3 digit exchange. If the exchanges are the same, the local switch opens a direct connection to the number you are calling and makes the receiving phone ring. If the local exchange you are dialing is different than the exchange of your local switch, the local switch center opens a connection to the external switching center in another town that has the same local exchange you are dialing. Once that switching center has received the information it opens the connection to the number you are dialing.
- If you dial a long distance number, it always starts with a 1, followed by the area code and seven-digit number. When the local switching center 'sees' the 1 it passes the call to the nearest switching center for your long distance carrier.
- The long distance switching center then finds the best path to route the call to get to the correct area code and local switching center. Once the call gets to the correct receiving local switching center a direct connection is made to the receiving phone.

Questions to Ask

As you go through this activity with the students you should lead them through the process by asking the questions provided in the design approach of the activity. While they will not be designing and building a physical device or object, they will be developing a suggested approach for the solution and should use the outlined process. Encourage them to be creative with their solutions.

Additional questions to ask:

Q: Do you think each phone call checks every other phone until it finds the correct one?

A: No, the local switching center 'knows' to connect it to the one right number.

Q: How long do you think it takes to find the right phone?

A: It typically takes less than 1/100 of a second for the local switching center to receive the call and make the connection to the correct number.

Q: Would it make sense to have one central processing place for all phone calls?

A: No, because it would have to look at all incoming calls and make each connection one at a time. This would take a long time.

TIPS

- The number of matching home and call phone numbers should be the same as the number of students.

- Involve local experts to enhance the activity. Contact an engineering school at a local university, WEPAN at www.wepan.org or the Society of Women Engineers at www.swe.org.

Vocabulary Words

Telephone – an instrument that sends and receives voice messages and data

Local switching center – site where incoming calls are routed to the correct number

Local calls – calls within the same town or city or neighboring communities

Long distance calls – calls to places outside your local call area

Central processing – switching center for long distance calls

Expanding the Activity

1) Research how many switching centers some of the long distance carriers have and where they are located. Show them on a national map.

2) Build your own telephone network
Requires: 2 telephones, 1 9-volt battery, a 300-ohm resistor, and telephone wire. Activity described at the website www.howstuffworks.com/telephone.

Additional References

www.att.com/technology/forstudents/brainspin/routing/local.html
www.howstuffworks.com/telephone.htm
www.gtlaw.com.au/pubs/telcosysintroguide.html

Activity 2: Cellular Telephone Communications

This activity has the students figure out optimum cell tower locations for a conventional phone to cell phone call by moving around and defining areas. They use engineering strategies in determining these locations.

ROUTING CELLULAR CALLS (See Sketch A for visual of this activity.)

1. Provide a large clear working space for this activity where students can move around— either in a hallway or in a classroom. Mark a road with masking tape that winds across the floor. This can represent a major highway crossing your state or a smaller road that goes between local towns in your area.

What's the problem? As more and more people get cellular telephones they want to be able to travel and use them without any interruption to their service. Where should the cellular phone towers be located to provide the best service? What about the people who think they are ugly and want them banned from their communities?

Who wants to know? The people buying the cell phones want to make sure that when they are traveling to and from work, or about their community, that they will be able to place calls without any problems.

2. Assign roles to the students. One student remains stationary and is the person placing the call from a conventional phone. Another student travels along the road with their cellular phone. The remaining students represent cell towers, one of them is a special tower that connects conventional, or landline phones, to cellular phones.
3. Give each cell tower student a 20 meter length of yarn or string. Give the traveling student a 4 meter length of yarn or string. The stationary caller gets a piece of yarn long enough to reach the special tower.

How can you help solve the problem? Think about where it would be best to place the cellular phone towers. Are there some traffic routes that are used more than others? Propose your locations and be ready to explain why you selected them.

Will your suggestion(s) work? Are your placements possible? What is the range of each tower? What happens if you are driving a fairly long distance and pass several towers? Will your phone call continue to have a strong signal? What other information do you need to know?

4. Have the cell tower students arrange themselves along the road. They should each make a circle out of the yarn and stand at the center of it. The circle represents the area in which the cell tower can transmit and receive calls. To help the students strategize, have them sketch out their solution on a piece of paper first and then place themselves according to their sketch. **Math inclusion:** use a scale map of the area and have the students determine the scaled representation of coverage area for the cell tower.

Let's try it! Put your idea to work. How can you demonstrate your idea and/or test to see if this works?

5. After the cell towers are placed, the traveling student moves along the road, holding one end of the 4 meter yarn. When inside a tower's coverage area (inside the marked circle) that cell tower holds the other end of the 4 meter yarn, symbolizing the communication between the cell phone and the tower.
6. As the traveling phone moves, the yarn end is passed from tower to tower. If there is a place where the traveler is outside all cell tower circles, one end of the yarn is free and there is no connection for the call.
7. After the students have created a complete path for the cell phone user, stop and mark off a section right on the road that is designated as preservation land. No cell towers can be built on this area. Have the cell towers re-position themselves to try to create as much coverage for the traveler as possible.
8. Stop and discuss how the communication network would change if it were one cell phone was calling another. If there is time, have the students try to show how this system would work.

Who can help you solve the problem? What type of knowledge is needed to work on this problem?

Engineering Summary Finish with a discussion about how the students acted as engineers.

Background Information for Activity Leader

- Cell phones are very sophisticated radios, transmitting information (calls) by radio waves through the air.
- Every cell phone carrier breaks up geographic areas into ‘cells’. Each cell site has a base station with a transceiver and antenna. The range for each base station ranges from 2 – 10 miles from the antenna.
- Each carrier in an area runs a central office called the Mobile Telephone Switching Office (MTSO).
- To receive a call, the MTSO gets the call first and tries to find your phone in each cell of the region until your phone responds. When it finds your phone, you are connected to the base station of that cell and you can talk and listen.
- As you move to the edge of the cell, your cell’s base station notes that your signal strength is diminishing and another base station will detect that the signal is increasing in the new cell. The two base stations coordinate themselves through the MTSO and your phone gets a signal to change frequencies. This is called a ‘handoff’. The user of the phone is unaware that any of this is occurring.
- If the call is between a cell phone and a landline phone, the MTSO makes the connection through a local conjunction. The conjunction is a special switching site between the cell tower bases and the copper wires used for connecting calls through switching centers.

Questions to Ask

As you go through this activity with the students you should lead them through the process by asking the questions listed at the end of the activity.

Additional questions to ask:

Q: How do you think the tower keeps track of all the different phones for which it is picking up the signals?

A: The Mobile Telephone Switching Office (MSTO) tracks all the cell phones that are on, even if they are not being used. Each phone has it’s own identification number that is transmitted while on.

Q: Do you think the cell towers ‘talk’ to each other?

A: The MSTO coordinates the communication between cell phones and towers. The towers talk to each other through the MSTO.

Q: How do you think a connection is made between a cell phone and a conventional (or land line) phone?

A: The cell tower transmits the call to the MSTO which then send the call through a local conjunction to the copper wires connecting land based phones.

TIPS

- Large classrooms, with few desks are best. Gymnasiums and outdoor fields also work well.
- Involve local experts to enhance the activity. Contact an engineering school at a local university, the Society of Women Engineers at www.swe.org or WEPAN at www.wepan.org.

Vocabulary Words

Cell phone – an instrument that uses two frequencies, one for receiving, one for transmitting, to send voice messages

Land line – phones connected to a conventional wiring system. Most home phones are land lines.

Cell site – a single towers coverage area

Conjunction – special switching site between cell towers and land line phones

Expanding the Activity

- 1) Assign one or two students to represent more powerful transmission cell towers. Give them 40 foot long sections of string to define their transmission area and re-do the activity.
- 2) Research the location of cell site towers in your community and surrounding area. Make a map that shows each tower and the area it covers. If you had to expand the coverage area, where would you put the new towers?

Additional References

www.howstuffworks.com/cell-phone.htm
www.howstuffworks.com/inside-cell-phone.htm
Encyclopedia.com/printable/02470.html
www.privateline.com/Cellbasics/Cellbasics.html
www.gtlaw.com.au/pubs/telcosysintroguide.html

231-3578	231-8976	231-7765
897-7865	897-1234	897-5534
653-8976	653-6438	653-0863
231-4425	231-7830	231-9123
897-5362	897-9937	897-2745
653-7830	653-3518	653-1037
231-4778	231-9647	231-9073
897-3489	897-3822	897-1328
653-8842	653-7640	653-1754
231-5320	231-2789	231-1730

1-406-231-3578	1-406-231-8976	1-406-231-7765
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1-123-653-8976	1-123-653-6438	1-123-653-0863
1-406-231-4425	1-406-231-7830	1-406-231-9123
1-123-897-5362	1-123-897-9937	1-123-897-2745
1-123-653-7830	1-123-653-3518	1-123-653-1037
1-406-231-4778	1-406-231-9647	1-406-231-9073
1-123-897-3489	1-123-897-3822	1-123-897-1328
1-123-653-8842	1-123-653-7640	1-123-653-1754
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