TELECOMMUNICATIONS

FACT SHEET + EXTENSION QUESTIONS

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# INTRODUCTION

Telephones are a point-to-point communication system whose most basic function is to allow two people separated by large distances to talk to each other. All modern telephones have a microphone to speak into, an earphone (or 'speaker') which reproduces the voice of the other person, a *ringer* which makes a sound to alert the owner when a call is coming in, and a keypad (or on older phones a telephone dial) to enter the telephone number of the telephone to be called. The microphone and earphone are usually built into a handset which is held up to the face to talk. The keypad may be part of the handset or of a base unit to which the handset would be connected. A landline telephone is connected by a pair of wires to the telephone network, while a mobile phone (also called a cell phone) is portable and communicates with the telephone network by radio. A cordless telephone has a portable handset which communicates by radio transmission with the handset owner’s base station which is connected by wire to the telephone network, and can only be used within about 50 feet from the base station.

The microphone converts the sound waves to electrical signals and then these are sent through the telephone network to the other phone and there converted by an earphone, or speaker, back into sound waves. Telephones are a duplex communications medium, meaning they allow the people on both ends to talk simultaneously. The telephone network, consisting of a worldwide net of telephone lines, fiberoptic cables, microwave transmission, cellular networks, communications satellites, and undersea telephone cables connected by switching centers, allows any telephone in the world to communicate with any other. Each telephone line has an identifying number called its telephone number. To initiate a telephone call the user enters the other telephone's number into a numeric keypad on the phone.

Although originally designed for simple voice communications, most modern telephones have many additional capabilities. They may be able to record spoken messages, send and receive text messages, take and display photographs or video, play music, and surf the Internet. A current trend is phones that integrate all mobile communication and computing needs; these are called smartphones.

By the end of 2009, there were a total of nearly 6 billion mobile and fixed-line subscribers worldwide. This included 1.26 billion fixed-line subscribers and 4.6 billion mobile subscribers.

# LANDLINE PHONES

## HISTORY

Credit for the invention of the electric telephone is frequently disputed, and new controversies over the issue have arisen from time to time. As with other influential inventions such as radio, television, the light bulb, and the computer, there were several inventors who did pioneering experimental work on *voice transmission over a wire* and improved on each other's ideas. Innocenzo Manzetti, Antonio Meucci, Johann Philipp Reis, Elisha Gray, Alexander Graham Bell, and Thomas Edison, among others, have all been credited with pioneering work on the telephone. An undisputed fact is that Alexander Graham Bell was the first to be awarded a patent for the electric telephone by the United States Patent and Trademark Office (USPTO) in March 1876. That first patent by Bell was the *master patent* of the telephone, from which other patents for electric telephone devices and features flowed.

A Hungarian engineer, Tivadar Puskás, quickly invented the telephone switchboard in 1876, which allowed for the formation of telephone exchanges, and eventually networks.

The word *telephone* comes from the Greek: τῆλε, *tēle*, "far" and φωνή, *phōnē*, "voice".

A traditional landline telephone system, also known as "plain old telephone service" (POTS), commonly carries both control and audio signals on the same twisted pair of insulated wires: the telephone line. The signaling equipment, or ringer, (see figure 1) consists of a bell, beeper, light or other device to alert the user to incoming calls, and number buttons or a rotary dial to enter a telephone number for outgoing calls. Most of the expense of wire-line telephone service is the wires, so telephones transmit both the incoming and outgoing voice channels on a single pair of wires. A twisted pair line rejects electromagnetic interference (EMI) and crosstalk better than a single wire or an untwisted pair.

## TECHNOLOGY

When you pick up a landline phone, it connects you to the local phone company’s switching center which sends back a dial tone to let you know the line is open. When you dial a number, the LSC compares the town exchange (area code) with its own three-digit code. If the area codes are the same, the LSC opens a direct connection with the number being called and the phone receiving he call. If the local exchange (area code) is different, the LSC opens a connection with another LSC in another town. The 1 on a long-distance phone call routes the call to a long-distance switching center.

# CELL PHONES

Because "Radio-phone" just didn't stick

A cell phone is nothing more than a radio. It is a complex radio, but still operates using radio waves through the air. Cell phones communicate with a local cell tower, and a group of cell towers all connect/communicate with a central Mobile Telephone Switching Office. Different frequencies allow thousands of people to use their phones at the same time.

## HISTORY

Back around the early 1950s', cell phones were really only used in automobiles. But these mobile-radio-phones were about as common as cruise control in post World War II cars. They were literally like driving around with an entire telephone company in one's car. And to make things worse, they only worked in cities.

In select urban areas, there were large, central antennas that were specifically allocated for these radio-phones. Each car that had a radio-phone required a big antenna that could transmit at least 40 or 50 miles. Since radio technology itself was only in the building phase, only about 25 channels were available for private use. So basically only 25 people could be talking on their radio-phones at the same time.

And in cities like New York and San Francisco, this was a problem, for there were more than just 25 people who had radio-phones in their cars.

## TECHNOLOGY

The solution to this problem was to divide each city up into small divisions, or "cells".

The technology behind cells have changed dramatically over the years, just as cell phones have, but now most standard cells are about 10 square miles large (about 2 mile radius from the tower). They are usually in the shape of a hexagon. Nowadays, every individual cell has its own base station, rather than only one for an entire city.

Cell phones are made to be low-power transmitters (either 0.3 watts or 6 watts), which is much lower wattage than in past decades. This means that the same frequency can be used in the same city, at the same time, but in different cells.Look at the diagram to get a visual picture of how city is divided into cells. The yellow cells are transmitting at the same frequency.

Think of it like an ice cube tray. The cell phone transmitting towers don't spill their transmissions that far out of their own cells. They may spill slightly into the most adjacent cells, but not into cells more than one cell away. Usually each separate carrier, (Verizon, AT&T, Cingular, etc) have their own control office in each major urban area called the Mobile Telephone Switching Office (MTSO). This is where they control their respective towers. This office also connects all of the cell-phone calls to the land-line phones.

But what happens when one moves from cell to cell?

Each modern cell phone (meaning it was created in the last 20 years or so) has special codes programmed into them.

The most important code is the system identification code or the (SID). It's a five digit code that the FCC gives to each different cell phone carrier. When a cell phone is turned on, whether it's making a call or not, it's picking up the SID that is being transmitted from the closest cell phone tower. The phone's personal carrier is also transmitting its SID to the phone on specific channels that the phone programmed to listen for.

But if it can't pick any of them up, the dreaded "NO SERVICE" message appears on the display. However, when the carrier can pick up the phone, you're in luck. It's connected!

Now that the phone is connected, calls can be sent and received. In addition to the SID being sent back and forth between phones and towers, there is a registration signal that is also being sent. This is so the carrier's MTSO always knows where its customers are, should someone dial their phone. When someone calls a cell phone, the MTSO finds where the phone is at and connects to it by finding a common frequency, in the cell, that the phone is in. It verifies the SID number and then, your girlfriend can finally ask you "What are you doing?"

**Roaming**

When a cell phone is not found on its carrier's MTSO, it may still be close enough to a different carrier's tower that can use the same channels (most of them can). The cell phone realizes that it is connecting to a different SID (meaning its carrier has no towers in the area or that none of them are on local network) that means the phone is roaming. But this is most important when you are moving from cell to cell, such as when you are riding in car. The tower notices that your signal is dying as you move to the boarder of its cell. In the same instance the tower in the cell you are traveling to realizes that the signal is getting stronger. With a little help from the MTSO, the two towers switch call to a different frequency in just milliseconds. And VOLIA, you can keep talking! In the cell phone business this is called a ‘hand-off’.

## ****INFRASTRUCTURE****

**Server**
The first piece of technology that makes cell phones work is the series of servers that cell phone companies setup and maintain to [store data](http://www.tech-faq.com/how-do-cell-phones-work.html). All of your cell phone records as well as the actual information that makes up phone calls, text messages, pictures, and Internet access is stored within a server much like the hard drive of the computer that you are accessing to read this article. Without this stored data, cell phone communication would be impossible.

**Tower**
The next piece of technology that is essential to cell phone communication is the tower. Cell phone companies build thousands of towers around a specific area in order to create a network in which cell phone customers can communicate within. A tower is both a transmitter that passes information from the [server](http://www.tech-faq.com/how-do-cell-phones-work.html) to your cell phone as well as a receiver that can pick up information that your cell phone broadcasts. Without the tower, cell phone users would not be able to access the server and it would therefore be impossible to communicate via cell phones.

**Cell Phone**
The final and most widely used piece of technology involved in cell phone communication is the cell phone itself. While servers and towers are key to store and transfer information, it is the cell phone itself that serves as the creation point of that information. When you dial a number, send a text message, or attempt to access the Internet, your cell phone interprets that [data](http://www.tech-faq.com/how-do-cell-phones-work.html) and broadcasts it as a radio signal that the tower can pick up, relay to the server, retrieve the information back from the server, and broadcast out to the recipient's cell phone.

## ADDITIONAL TERMS

**PCS**
PCS is a term that applies to the radio broadcasting range of 1850-1900 Mhz, which all cell phones use to communicate with each other. While PCS may not hold any personal significance to you, PCS is a rather important feature of [cell phone](http://www.tech-faq.com/how-do-cell-phones-work.html) communication as it allows for cell phones to transmit and receive information wirelessly without other devices causing interference with the broadcast. The majority of cell phone services in the United States currently use PCS as it is necessary for cell phones to communicate with other wireless networks.

**GSM**
GSM stands for Global System for Mobile Communications and is more popular in Europe and other countries than in the United States. You can recognize GSM models by the SIM card located within the phone. SIM cards allow you to store your phone's personal data such as your contact list, pictures, notes, calendar, and any other personal data that you may have and then transfer that information to a new phone by simply putting the SIM card in the new phone. Only GSM phones have this feature.

**CDMA**
CDMA stands for Code Division Multiple Access and refers to the way that the radio signal that is broadcasted and received by your cell phone is handled. In CDMA, each user is separated by a different spectrum of the radio broadcasting range and is protected by a code. This method ensures that the cell phone call does not encounter interference, which is the leading cause of dropped calls and bad signals.

**TDMA**
TDMA stands for Time Division Multiple Access which is very similar to CDMA. Like CDMA, TDMA also separates users by spectrums but instead of protecting the signal by a code, TDMA uses a time-based algorithm to process calls. Basically, TDMA takes your call or text and puts it in a line behind a few other people who are also transmitting data, and, when the other users' data has been transferred, your data will also be sent. This method allows for companies to take on a lot more customers and expand their [network](http://www.tech-faq.com/how-do-cell-phones-work.html) by processing multiple users per spectrum.

# SATELLITE PHONES

Satellites are used to help study the universe, forecast the weather, transfer phone calls, assist in navigation (GPS, ships, aircraft, etc). Communication satellites act as relay stations, receiving radio signals from one location and transmitting the to another. One communication satellite can relay several TV programs or thousands of telephone calls at once!

Most satellites are launched into orbit by rockets, some are carried up by space shuttles.

Every communication satellite involves transmission of info originating from ground station to the satellite, then retransmitted from the satellite back to the ground. Can either be retransmitted back to a select number of ground stations, or be broadcast to everyone in a large area (think TV channels). Satellite phones use LEO communication satellites (low earth orbiting – usually about 200 to 500 miles above the earth surface, travelling at about 17,000 miles per hour).

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# EXTENION QUESTIONS

* What do both the caller and receiver need in order to make a cellular phone call? (Answer: to be in range of a cellular phone tower)
* What would have happened if all of the towers were separate from all of the other ones — i.e., no sides of the hexagons were touching other hexagons? (Answer: When movement happened, the phones would go completely out of service.)
* What could the person in the house do about his/her phone service? (Answer: If the person was not in range of a tower, they should move in range of one, or have one built, or get/borrow a satellite phone.)
* What major difference did you see between the cellular phones and the satellite phone scenarios? (Answer: The person with the satellite phone could call anybody with a phone from anywhere in the world.)
* What change could you make to the cellular phone scenario so that everyone could call each other all the time? (Answer: more cellular towers in more places, mobile cellular towers) What about the satellite phone scenario? (Answer: Even though the person with the satellite phone could call everyone wherever that person was, no one else could; so you could have everyone have satellite phones.)
* Where is a location where people cannot receive very many phone calls and why not? (Answer: Places where no cellular phone towers exist would be difficult places for people to receive any cellular phone calls. Presumably on the board there are spaces without any "cells" or hexagons - these would be places where not very many cellular phone calls could be transmitted or received.)
* Where is a location where people can receive phone calls and why is it better? (Answer: Places where there are numerous clusters of hexagons or "cells" would be able to receive more phone calls. If you leave one cell, then there is one right next to it). Think about what you would change so that everybody could call everyone else all the time? (Answer: You could put in more "cells" (hexagons) so that there were no empty spaces without cellular towers. Then, everyone with a cell phone could call everyone else with a cell phone; OR, you could develop phones that did not rely on the existence of cellular phone towers.)
* Who can't the person with a satellite phone call? Why? (Answer: The satellite phone still cannot call somebody who is not in range of a cellular phone tower. While the satellite phone can send a call even when not in range of a cellular phone tower, the receiving end must be in range of a tower to receive it.)
* Is there a location where the satellite phone cannot call anybody at all? Why? (Answer: It depends, as long as someone else is within range of a tower. The satellite phone can call from anywhere, but if nobody is in range of a tower, no matter where the satellite phone is, it might not be received.)
* Is there a location from which the satellite phone cannot be called? Why? (Answer: Yes, if someone is calling from a regular landline phone. Even though the canoeist has a satellite phone, the canoeist needs to be in range of a cellular phone tower or landline to receive the caller's call, which is not going through a satellite.)
* What would you change so that everybody could call everyone else all the time? (Possible answer: If everyone had satellite phones, their chance of calling each other would increase.)