6. How cellphones work

Cellphones (also known as cellular phones and, chiefly in Europe, as mobile phones or mobiles) are radio telephones that route their calls through a network of masts linked to the main public telephone network. Here's how they work.

Although they do the same job, land lines and cellphones work in a completely different way. Land lines carry calls along electrical cables. Cut out all the satellites, fiber-optic cables, switching offices, and other razzmatazz, and land lines are not that much different to the toy phones you might have made out of a piece of string and a couple of baked bean cans. The words you speak ultimately travel down a direct, wired connection between two handsets. What's different about a cellphone is that it can send and receive calls without wire connections of any kind. How does it do this? By using electromagnetic radio waves to send and receive the sounds that would normally travel down wires.

How cellphone calls travel

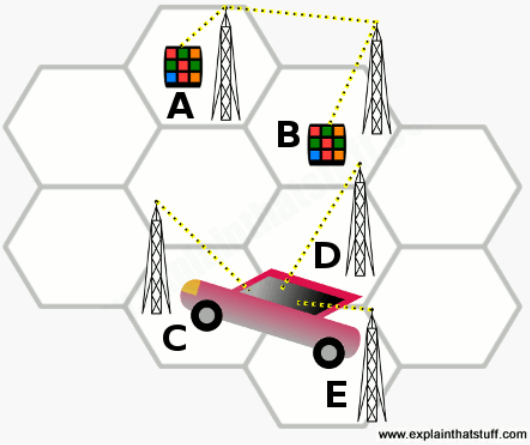
When you speak into a cellphone, a tiny microphone in the handset converts the up-and-down sounds of your voice into a corresponding up-and-down pattern of electrical signals. A microchip inside the phone turns these signals into strings of numbers. The numbers are packed up into a radio wave and beamed out from the phone's antenna (in some countries, the antenna is called an aerial). The radio wave races through the air at the speed of light until it reaches the nearest cellphone mast.

The mast receives the signals and passes them on to its **base station**, which effectively coordinates what happens inside each local part of the cellphone network, which is called a **cell**. From the base station, the calls are routed onward to their destination. Calls made from a cellphone to another cellphone on the same network travel to their destination by being routed to the base station nearest to the destination phone, and finally to that phone itself. Calls made to a cellphone on a different network or a land line follow a more lengthy path. They may have to be routed into the main telephone network before they can reach their ultimate destination.

What cells do

So why bother with cells? Why don't cellphones simply talk to one another directly? Suppose several people in your area all want to use their cellphones at the same time. If their phones all send and receive calls in the same way, using the same kind of radio waves, the signals would interfere and scramble together and it would be impossible to tell one call from another. One way to get around this is to use different radio waves for different calls. If each phone call uses a slightly different **frequency** (the number of up-and-down undulations in a radio wave in one second), the calls are easy to keep separate. They can travel through the air like different radio stations that use different wavebands.

That's fine if there are only a few people calling at once. But suppose you're in the middle of a big city and millions of people are all calling at once. Then you'd need just as many millions of separate frequencies—more than are usually available. The solution is to divide the city up into smaller areas, with each one served by its own masts and base station. These areas are what we call **cells** and they look like a patchwork of invisible hexagons. Each cell has its base station and masts and all the calls made or received inside that cell are routed through them. Cells enable the system to handle many more calls at once, because each cell uses the same set of frequencies as its neighboring cells. The more cells, the greater the number of calls that can be made at once. This is why urban areas have many more cells than rural areas and why the cells in urban areas are much smaller.



This picture shows two ways in which cells work.

Simple call

If a phone in cell A calls a phone in cell B, the call doesn't pass directly between the phones, but from the first phone to mast A and its base station, then to mast B and its base station, and then to the second phone.

Roaming call

Cellphones that are moving between cells (when people are walking along or driving) are regularly sending signals to and from nearby masts so that, at any given time, the cellphone network always knows which mast is closest to which phone.

If a car passenger is making a call and the car drives between cells C, D, and E, the phone call is automatically "handed off" (passed from cell to cell) so the call is not interrupted.

The key to understanding cells is to realize that cellphones and the masts they communicate with are *designed* to send radio waves only over a limited range; that effectively defines the size of the cells. It's also worth pointing out that this picture is a simplification; it's more accurate to say that the masts sit at the intersections of the cells, but it's a little easier to understand things as I've shown them.

Types of cellphones

The first mobile phones used analog technology. This is pretty much how baked-bean can telephones work too. When you talk on a baked-bean can phone, your voice makes the string vibrate up and down (so fast that you can't see it). The vibrations go up and down like your voice. In other words, they are an *analogy* of your voice—and that's why we call this analog technology. Some land lines still work in this way today.

Most cellphones work using **digital technology**: they turn the sounds of your voice into a pattern of numbers (digits) and then beam them through the air. Using digital technology has many advantages. It means cellphones can be used to send and receive computerized data. That's why most cellphones can now send and receive text (SMS) messages, Web pages, MP3 music files, and digital photos. Digital technology means cellphone calls can be encrypted (scrambled using a mathematical code) before they leave the sender's phone, so eavesdroppers cannot intercept them. (This was a big problem with earlier analog phones, which anyone could intercept with a miniature radio receiver called a scanner.) That makes digital cellphones much more secure.