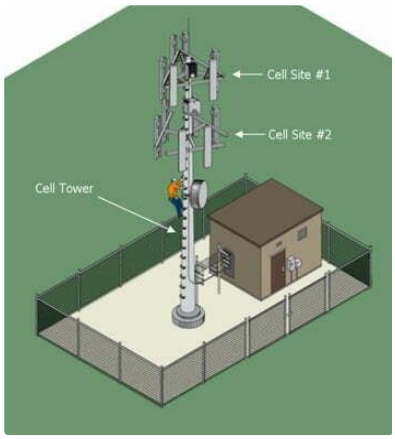
Antennas

Owned by David Cherney DISH •••
Last updated: Jul 01, 2023 • Initializing...

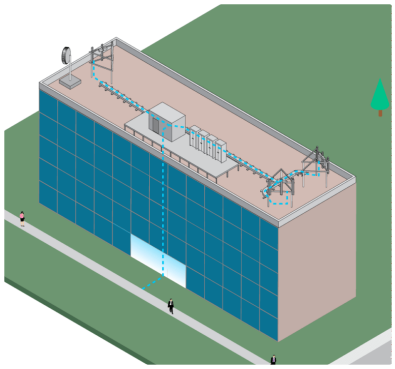
Antennas are used to both transmit a receive electromagnetic waves. So that you can recognize them when you are out and about, here is a picture I took of a tower at the intersection of Santa Fe and 470 in Littleton. The antennas are the white rectangles, and the tower is the vertical tan colored structure the four platforms attach to.

The 4 different platforms (vertical layers of antenna arrays) are for the 4 major network operators: DISH, T-Mobile, Verizon, and AT&T. That covers the difference between a cell tower and an antenna. There is also a notion of a cell site, which is a bit more tricky. A cell site consists of a network operator's antennas together with any ground equipment locate with those antennas. So, each network operator has a cell site at a tower. For this reason, the installation of a cell site on an existing tower is called a collocation.



The tower might belong to one of the major network operators, or to one of the many companies that rent to the network operators. The largest two companies of the latter variety are Crown Castle and American Tower. The range of an antenna on a tower can be anywhere from a half mile to 25 miles.

Increasingly, cell sites are on buildings too. To maintain the three-sector structure antennas are placed on 3 sides, as in the figure below. If the building is tall, the range is about the same as for a tower.

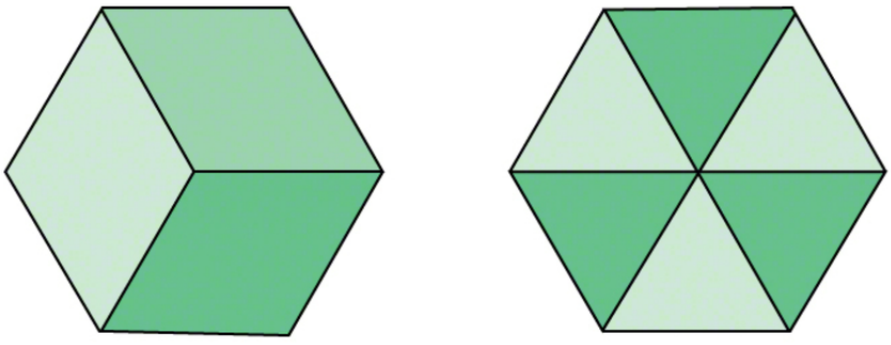


Small cell antennas are also becoming common. These are places on structures like light poles, as in the image below. The ground equipment for these cell sites is about the size of a high school locker.

Water towers, utility poles or towers, billboards, outdoor stadium light poles, and other creative installations are also becoming common hosts to cell sites.

Sectors

A cell is comprised of sectors. There are two options; three sectors or six sectors.

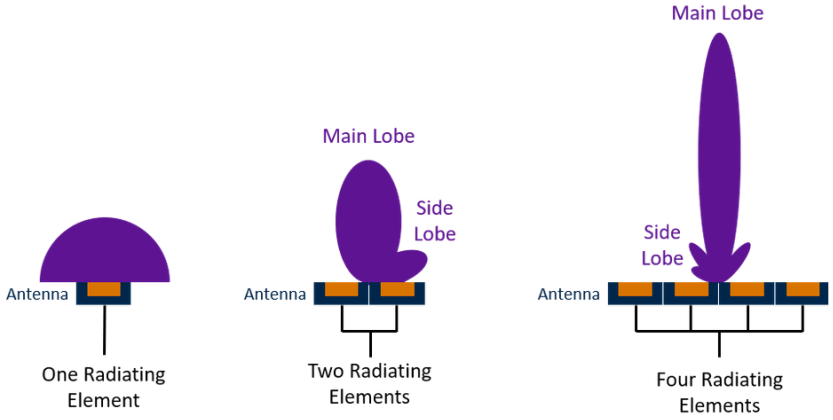


(a) Three sectors

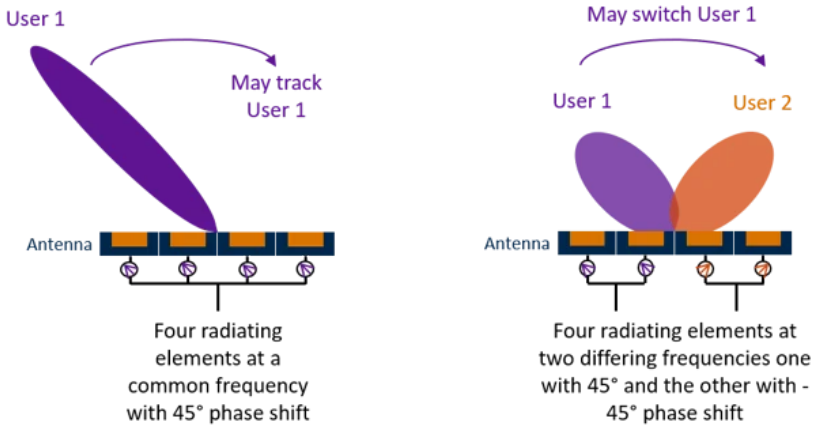
(b) Six sectors

Beamforming

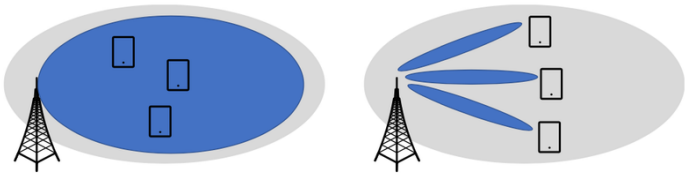
By using interference patterns between evenly spaces antennas, transmitted electromagnetic waves can take on a multi lobe shape with a main lobe. This is called beamforming.



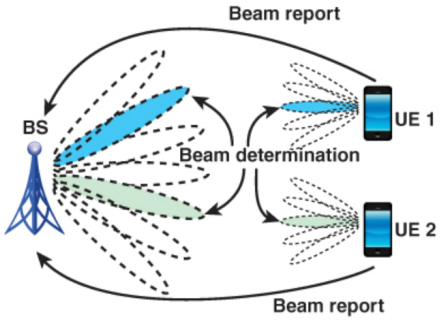
By offsetting the phase of the transmitting antennas, the main lobe can be directed. The same can be done with a different frequency; a different phase offset gives a different beam direction.



This technology allows the energy of transmission to be mostly sent directly to UE, for several UE simultaneously. The reduction is signal to noise ratio through use of this technique relative to the old isotropic wave model is remarkable.

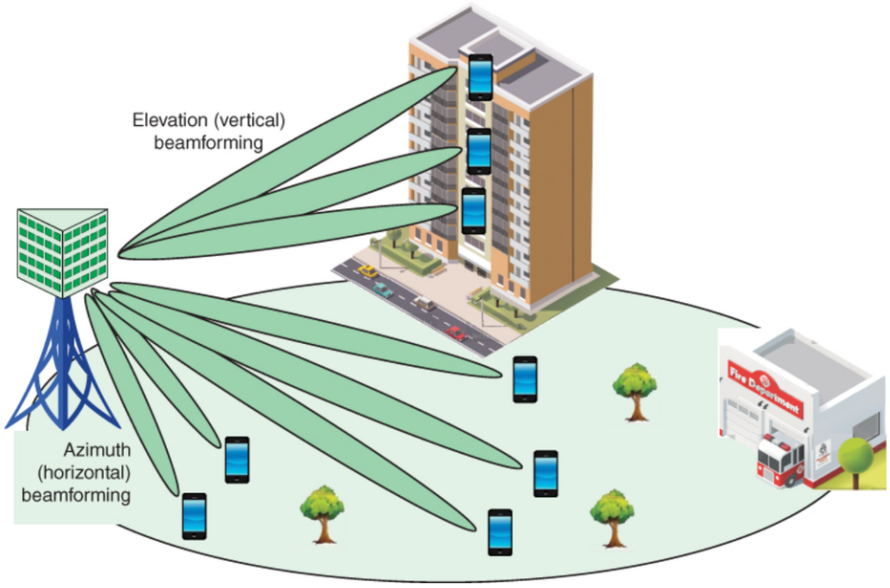


Remarkably, some modern UE are also equipped with multiple antennas and the ability to beam form.



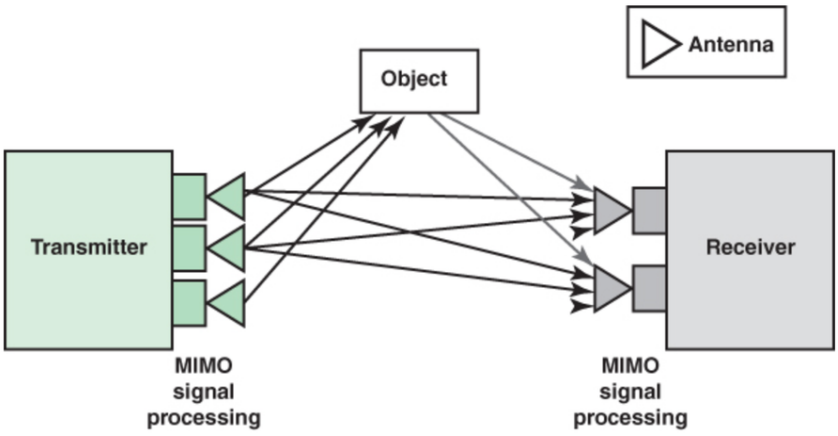
This system requires beam management; in the diagram above, the base station (BS) sends a reference signal on each of several beam paths. The UE records the strength of the reference signals on each beam path. The UE then sends a report to the BS about which beam path is best. If the UE is equipped with beamforming too, then the same process also happens in the reverse direction.

Two dimensional antenna arrays can beamform in two directions, as picture below.



MIMO

The beamforming technology above uses a multiple antenna structure. The transmitter has multiple antennas, and each UE acting as a receiver has multiple antennas too. This is called multiple input multiple output (MIMO).



In the case of multiple UE receiving signals, it is called multiple user MIMO (MU-MIMO).

The diagram above includes multipath transmission; signal bounces off an object. Beamforming and MIMO do not attempt to avoid this; multipath transmission is embraced in MIMO. As you will see, multiple antenna systems provide many solutions to the problems of mobile radio. (See the section Overcoming Difficulties.)

Massive MIMO

The benefits of MIMO systems have become so clear that the number of antennas in an array has grown to over 64 (that is 8 by 8). The diagram below shows generations of antennas, and the enumeration does not correspond to generations of mobile telecommunications. (e.g. Generation 4 is used in 5G.)