

An electronic device, such as a television, radio, mobile phone, radar, etc., comprises many sub-systems. In the case of a mobile phone, the sub-systems include the display, keypad, central processing unit(s), RF (radio frequency) front-end, power supply (battery), and many others. This list is intended to point out many sub-systems with which most people are generally familiar, and to clarify that there is a specific sub-system (the “RF front-end”) where the wireless (or UHF, VHF, microwave, etc.) activity occurs. Every electronic device that we consider to be “wireless” – and this includes walkie-talkies, portable phones, mobile phones, wireless internet routers, Bluetooth devices, etc., - have an RF front-end. It is called the front-end because this is where the wireless energy enters (and leaves, in the case of a transmitting device). The sub-systems that are *behind* the front-end perform various functions that enable information to be retrieved from the wireless energy. While an illustration might be useful here, it could essentially be extremely simple: one box with the RF electronics and one box with everything else. The rest of this document focuses on the RF electronics box.

The entirety of things that can be placed inside the RF electronics box can be summarized in three categories: antenna, receiver and transmitter. The role of the antenna is to capture energy from the air and send it to the receiver; alternatively, the antenna can accept energy from the transmitter and send it into the air. In many ways, antennas are analogous to the lens of a microscope in their ability to focus electromagnetic energy into a preferred location (with this analogy, it is useful to remember that larger lenses have greater focusing power and the same is true for larger antennas). Sometimes there is a “receive antenna” and a separate “transmit antenna” and in some situations the same antenna is used for both receiving and transmitting. Most antennas are “passive devices” that do not require any power source to operate, and are typically made of metal and non-metal (dielectric) materials shaped into a desired geometry. The role of the receiver is to amplify the received energy from the antenna and perform steps generalized as *signal conditioning* to remove unwanted signals, etc. Receivers require a power source to operate, and the most critical requirement for a receiver is its ability to detect the presence of signals of extremely low energy. The role of the transmitter is also to perform some signal conditioning, but mostly it is important that the transmitter greatly amplifies the signal before it is sent to the antenna. This amplification can require a lot of power which means the transmitters are often extremely hot – to avoid overheating, air conditioning units are used with large transmitters such as those used in cellular base stations. Some RF front-ends contain only an antenna and a receiver – an example is a GPS system, which receives signals from satellites but does not transmit any information. Other front-ends contain only an antenna and a transmitter (applications of this type of system are most common in the military).

Mobile phones operate in what are called cellular networks. As the name implies, the coverage region of the network is divided into cells, and within each cell there is a base station that communicates with multiple hand-held devices (i.e., the mobile phones). Like the phone, the base station has an RF front-end and many other sub-systems (scheduling, cooling, processing, etc.). And just like the phone, the RF front-end consists of a receiver, a transmitter and an antenna. The base station antenna is mounted high above ground, typically on a (cell) tower or a building roof-top. The transmitter and receiver are usually located on the ground, because of their size and need for cooling and power. A cellular network like this

is considered to be asymmetric, not only because there are multiple hand-held devices communicating with one base station, but also because the hand-held devices are much less powerful than the base station. The hand-held devices have very small antennas which have essentially no ability to focus energy into a preferred direction, and have relatively low power transmitters since the only power source available is a small battery. The base station, on the other hand, has larger antennas that can focus energy into a preferred direction and uses high power transmitters. The transmitters at the base station may be 50-100 times stronger than the transmitter in a hand-set, and the base station has many transmitters because it is communicating with a multitude of hand-held devices at any given time.

Other definitions:

VRAD – This stands for “video ready access device” which provides DSL (digital subscriber line) and HD TV programming to a home. A VRAD device is roughly the size of a refrigerator (6’ by 4’ by 2’) and uses fiber optic and copper cable connections. Currently there are not wireless VRAD boxes. Because of the large amounts of data (i.e. large bandwidth) carried in this type of system, it is unlikely that there will be wireless versions in the near future.

Clearwire – This is a company that is developing what is called “4G wireless technology” coined WiMax. With WiMax there is the capability to connect to the internet directly from a fixed location (a home) or from a mobile device (e.g. a smart phone or a laptop in a car). This is a different approach from using an older mobile phone to connect to the internet, as in the past it was necessary to connect *through a cellular network*. Because the technology is new and different from cell phone communications, Clearwire needs to deploy its own network. Devices that connect to a WiMax network are called subscriber units. Like all wireless technologies, WiMax can operate at faster speeds *OR* over long distances, but not both. WiFi, often confused with WiMax, has many technical differences but the easiest distinction is that WiFi is popular inside homes, buildings, etc. while WiMax is a long range system.