July 25, 2016

Introduction to Modern Cellular Network

Interaction of the Phone and the Cell-tower

It is a complicated progress to setup a call from the phone to the cell tower despite that the user may not feel how fast their interaction starts and completes. Once the cellular mode is turned on, the phone will try to synchronize to a nearby base station by quickly scanning the broadcast channels (different in countries). Then it will lock on to the wireless system based on the receiving information. The selected system making the radio connection could be either 2G (GSM), 3G (CDMA, UMTS, HSPA), or 4G (including various LTE technologies) and usually the one which can provide best voice and data rate (throughput rate) will be picked up. Generally when the user is close to the cell tower, the transmission power (Tx power) from the phone is low and the received power (Rx power) of the phone is high because the phone is within an good coverage area. When the user is located in a bad coverage area, the Tx power from the phone has to be high to maintain the radio link but the received power of the phone becomes low. This will consume lots of battery power to maintain the connection. As the Rx power is lower than a certain level, the phone will lost the connection to the cell power and the call will drop.

Relationships of Signal Bars and Signal Strength

People usually refer to signal bars shown on the phone to judge if they are with a good or bad network. Indeed, the signal bar is a good indicator. However, the scale of signal bars of each phone may not be the same and the numbers of signal bars of each phone are also different. A more professional way to tell the network coverage is to use the signal strength which is expressed by dBm, a unit of power in decibel.

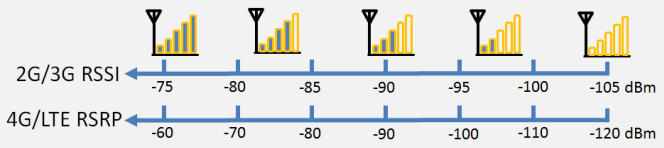

Figure 1 Relationship between signal bars and the received power level. 4G/LTE network has higher priority due to higher data rate even if the received power is lower than 2G/3G network. The data rate of the 2G network is the lowest.

As shown in Figure1, this numerical value is called RSSI (receiver signal strength indicator) for 2G/3G networks and RSRP (reference signal receive power) for 4G/LTE networks. In decibel scale, an increase of 3 dB means the signal is double stronger, 10 dB corresponds to a 10 times increase, 20 dB and 30 dB mean 100 and 1000 times. The user can see information of the signal strength or associated network from the setting of the phone or change it to Field Test Mode or using APPs. It is also possible that the user can know the phone is connected to 2G, 3G, or 4G technologies, in which frequency band, and through which channel.

2G/3G/4G Technologies and Data Rate

A cell dominated by a cell-tower (base station) can be divided into excellent, good, and poor coverage areas, as shown in Figure 2(a), where the corresponded RSRP or RSSI values are higher than -80 dBm, between -80 to -100 dBm, and lower than -100 dBm. The wireless technology among 2G/3G/4G which can provide better service will be selected by the cell tower so that the user can have the best speed (higher data rate) for downlink and uplink despite that the signal strength of the selected technology may not be the maximum, i.e., the numbers of the signal bar may be less. For example, a LTE network will have higher priority than the 3G network even if the RSRP of the LTE signal is -110 dBm while the call can still be maintained. The network service will be downgraded to have lower data rate as the received signal becomes worse (lower RSRP/RSSI).

Every wireless technology has its unique modulation schemes to provide different data rates according to the environment where the user is located at. In a good coverage area the data link can use 64-QAM modulation to give the highest data rate; in a bad coverage area the data link will switch to QPSK modulation to get lower data rate, as shown in Figure 2(b). So far, 4G network is the top one to provide the best user experience for high-speed services up to 150 Mbps. The data rate of conventional 2G network is much less than 1 Mbps.

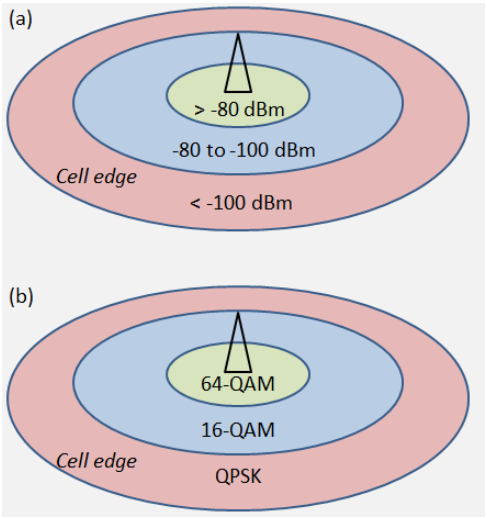

Figure 2 Overview of a cell network with the LTE technology: (a) the received power by the phone, and (b) adaptive modulation. In the LTE network, 64-QAM, 16-QAM, and QPSK modulations can support 27 Mbps, 13 Mbps, and 4 Mbps (mega bit per second) data rates, respectively.