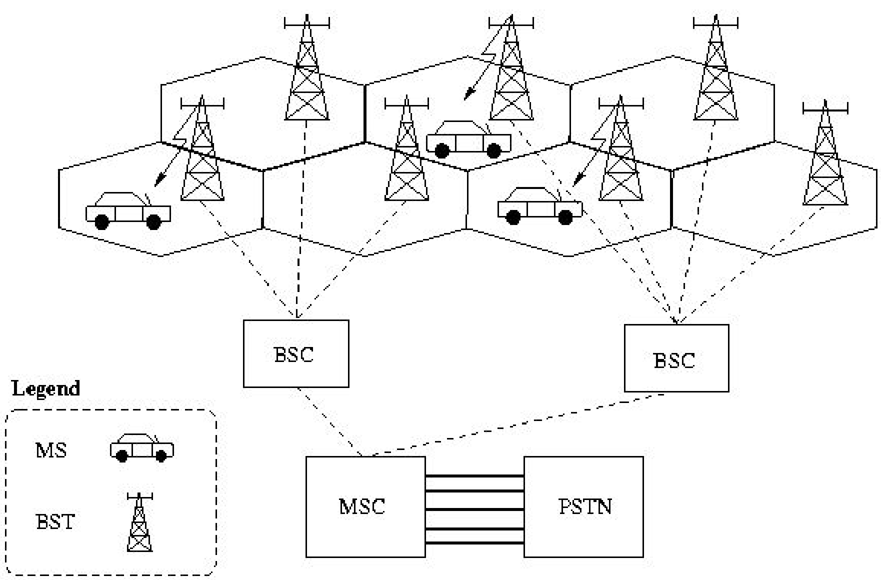
Kenzo Nakamura
Explanatory Article
Cellular Networks

A wireless cellular network is a system which affords its users wireless access to the public internet and telephone networks. Early research on wireless technologies began in 1947 at Bell Labs and culminated in commercial implementation by various companies internationally in the early 80's. Technical protocols on which these large scale technological and infrastructural enterprises rely were originally developed and implemented separately by regional organizations, but now cede authority to the neutral International Telecommunications Union in order to advance a largely uniform implementation for a global wireless cellular network. These protocols are collections of technical standards that are updated roughly every ten years to keep pace with (or perhaps push the pace of) technological advancements. Every new collection of standards are called "Generations," the first of which began in Japan as *1G* in 1979, and exists now in most parts of the developed world as *4G* or *4G LTE* [1].

Though operating largely out of sight, the wireless cellular network is grounded in a sprawling physical infrastructure. This network is a system of distributed devices, stations, and controllers that are built on top of and extend the existing infrastructure that makes up the public switched telephone and data networks. A diagram of the cellular network begins first with the concept of a cell; in modern implementations of wireless networks, the land area in which that network exists is divided into equal sized hexagons called *cells*. Within each cell are a number of

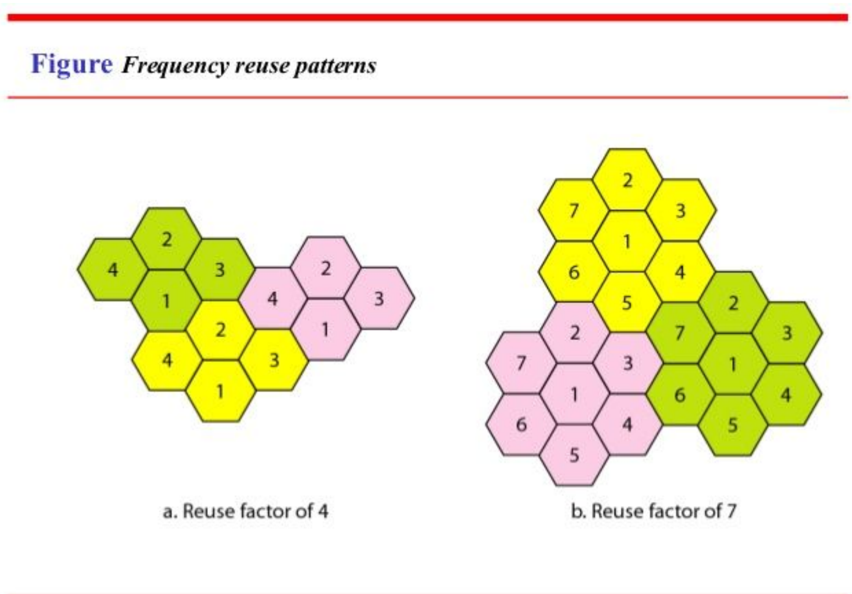


Mobile Stations (MS), usually cellular telephones, that connect to that cell's dedicated *Base Transceiver Stations* (BTS) (between one to three per cell) over digital radio frequencies. The BTS feeds that data to a Base Station Controller (BSC), which is collecting data from tens or

[1] http://www.informit.com/articles/article.aspx?p=2021961

hundreds of other BTSs from other such cells, in order to be routed. The BSC then coordinates the assignment of unique radio frequencies to mobile phones (in a strategy described later as Frequency Division Multiple Access) and controls handovers of cellular signals from a device physically moving from one cell to another. The BSC transcodes the mobile voice data into data that is compatible with the public switched (wired) telephone network to be passed along to a *Mobile Switching Center* (MSC). MSCs are the link between the wireless cellular networks and the public switched telephone and data networks. As such, MSCs handle the routing, placing, and ending of calls on cellular phones between source and destination, and authenticate that the data sent is from users with paid accounts at a mobile service provider[2].

This physical network puts into place an infrastructure that takes advantage of methods from the "cellular concept" and radio transmission techniques to achieve widespread wireless coverage and high dependability[3]. Fundamental to the efficacy of a wireless cellular network is a technique called *frequency reuse*. Frequency reuse is implemented to overcome the inevitable issue of a limited frequency range. In a given radio spectrum, (usually) governments allocate certain ranges to industries and uses where the attributes of that range are most effective for its intended purpose. And so in order to maximize the limited frequency range provided to mobile communications, dividing the cell into smaller ones becomes necessary to avoid signal overlap in a zero-sum system. If a frequency range of ten channels allows for only one call per channel, then dividing that area into two would allow for double the calls. This is the technique known as frequency reuse and these land divisions, as mentioned earlier, are the cells of a cellular network. The radius of a cell is determined by the amount of activity it is meant to support. In dense urban areas, the width of a cell will be much smaller (tens to hundreds of meters) than the width of a cell in a rural location (1-30kms). The practice of varying the size of cells to accommodate traffic is called *cell splitting*.



[2] https://www.youtube.com/watch?v=tt1-Ohe9QQU
[3] https://www.slideshare.net/asadkhan1327/cellular-concepts-in-wireless-communication

In addition to frequency reuse and cell splitting, cellular networks implement variations of “multiple access schemes” in order to take advantage of an infrastructure that can accommodate only so much of a frequency spectrum. The 3G cellular network implements *Wideband Code Division Multiple Access* (W-CDMA) which increases transmission over a network by spreading a single transmission across multiple frequencies simultaneously. 4G cellular networks often utilize a combination of multiple access schemes. The first, *Frequency Domain Multiple Access* (FDMA), assigns each transmission a unique frequency band so as to avoid interference. And the other, *Time-Division Multiple Access* (TDMA), reserves regular but separate time segments of a single frequency to multiple calls[4].

[4] https://www.slideshare.net/SammarKhan2/fdmatdmacdma