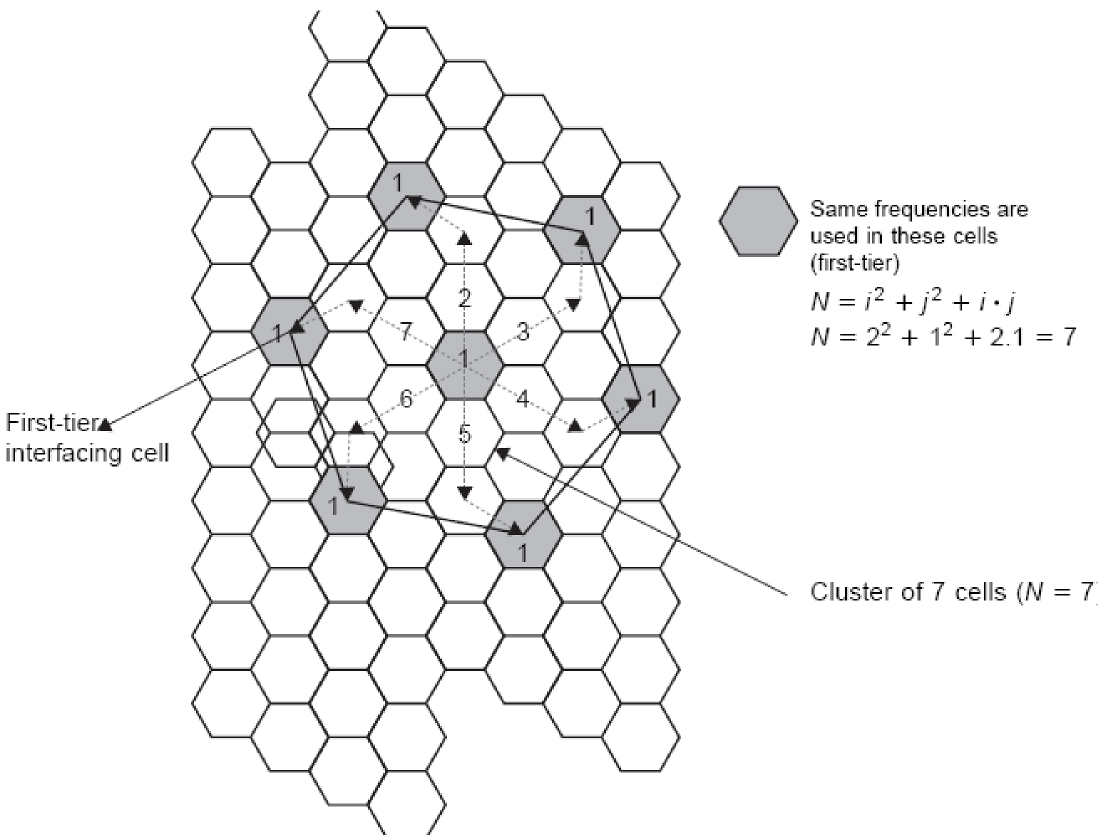
# Cellular Systems

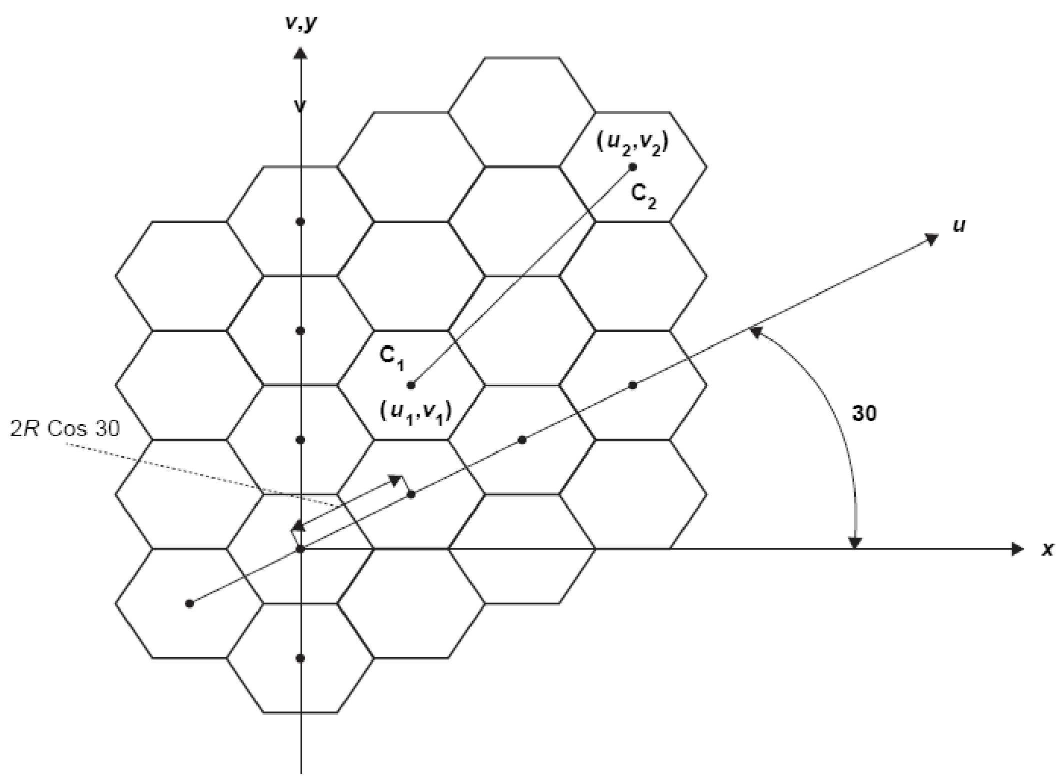
Most commercial radio and television systems are designed to cover as much area as possible. These systems typically operate at maximum power and with the tallest antennas allowed by the Federal Communications Commission (FCC). The frequency used by the transmitter cannot be reused again until there is enough geographical separation so that one station does not interfere significantly with another station assigned to that frequency. There may even be a large region between two transmitters using the same frequency where neither signal is received. The cellular system takes the opposite approach [1,3,4,5,9,11–14]. It seeks to make an efficient use of available channels by employing low-power transmitters to allow frequency reuse at much smaller distances (see Figure 5.1). Maximizing the number of times each channel may be reused in a given geographic area is the key to an efficient cellular system design. Cellular systems are designed to operate with groups of low-power radios spread out over the geographical service area. Each group of radios serve mobile stations located near them. The area served by each group of radios is called a *cell*. Each cell has an appropriate number of low-power radios to communicate within the cell itself. The power transmitted by the cell is chosen to be large enough to communicate with mobile stations located near the edge of the cell. The radius of each cell may be chosen to be perhaps 28 km (about 16 miles) in a start-up system with relatively few subscribers, down to less than 2 km (about 1 mile) for a mature
system requiring considerable frequency reuse.




As the traffi c grows, new cells and channels are added to the system. If an irregular cell pattern is selected, it would lead to an ineffi cient use of the spectrum due to its inability to reuse frequencies because of cochannel interference. In addition, it would also result in an uneconomical deployment of equipment, requiring relocation from one cell site to another. Therefore, a great deal of engineering effort would be required to readjust the transmission, switching, and control resources every time the system goes through its development phase. The use of a regular cell pattern in a cellular system design eliminates all these diffi culties. In reality, cell coverage is an irregularly shaped circle. The exact coverage of the cell depends on the terrain and many other factors. For design purposes and as a fi rst-order approximation, we assume that the coverage areas are regular polygons. For example, for omnidirectional antennas with constant signal power, each cell site coverage area would be circular. To achieve full coverage without dead spots, a series of regular polygons are required for cell sites. Any regular polygon such as an equilateral triangle, a square, or a hexagon can be used for cell design. The hexagon is used for two reasons: a hexagonal layout requires fewer cells and, therefore, fewer transmitter sites, and a hexagonal cell layout is less expensive compared to square and triangular cells. In practice, after the polygons are drawn on a map of the coverage area, radial lines are drawn and the signal-to-noise ratio (SNR) calculated for various directions using the propagation models (discussed in Chapter 3), or using appropriate computer programs [2,6–8]. For the remainder of this chapter, we assume regular polygons for coverage areas even though in practice that is only an approximation.

## Hexagonal Cell Geometry

We use the *u*-*v* axes to calculate the distance *D* between points $C_1$ and $C_2$ (see Figure 5.2). The *u*-*v* axes are chosen so that *u*-axis passes through the centers of the hexagons. $C_1$ and $C_2$ are the centers of the hexagonal cells with coordinates $(u_1,v_1)$ and $(u_2,v_2)$ [11,12].

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