Channel Planning

Chapter 7

This chapter is designed to provide the student with the fundamentals of channel planning.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- Define “re-use distance”
- Identify and discuss the various channel plans
- Explain how to avoid co-channel and adjacent channel interference during channel assignment

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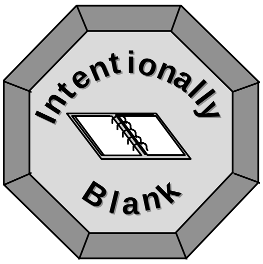
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CELL PLANNING

The simplest solution to a cell planning problem is to have one cell and use all available carriers in that cell (Figure 7-1). However, such a solution has severe limitations. It is seldom that coverage can be maintained in the entire area desired. In addition, even though the channel utilization may be very high, limited capacity soon becomes a problem due to the limited number of carriers available to any operator.

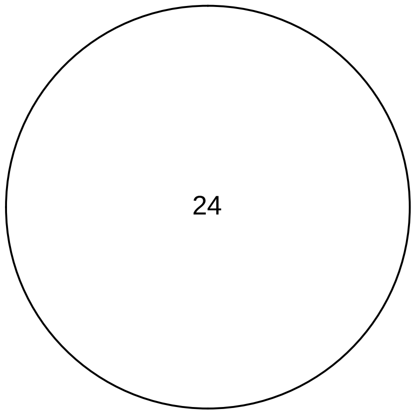

Figure 7-1 Example of an area served from one cell by 24 carriers

A cellular system is based upon re-use of the same set of carriers, which is obtained by dividing the area needing coverage into many smaller areas (cells) which together form clusters (Figure 7-2).

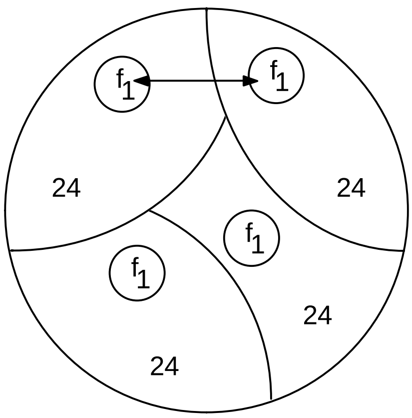

Figure 7-2 This is same area as in Figure 7-1 but now schematically divided into four clusters, each cluster using all (here 24) carriers. The small circles indicate individual cells where the frequency f_1 is used and a distance between the corresponding sites, a so-called frequency re-use distance, is indicated by the double arrow

A cluster is a group of cells in which all available carriers have been used once (and only once). Since the same carriers are used in cells in neighboring clusters, interference may become a problem. The frequency re-use distance (i.e. the distance between two sites using the same carrier) must be kept as large as possible to help prevent interference. At the same time, the distance must be kept as small as possible from a capacity point of view. Cellular systems are often interference-limited rather than signal-strength-limited.

Re-using the carrier frequencies according to well-proven re-use patterns (Figure 7-3 and Figure 7-4), neither co-channel interference nor adjacent channel interference should become a problem. This is true if the cells have homogenous propagation properties for the radio waves.

The re-use patterns recommended for GSM are the 4/12- and the 3/9-patterns. 4/12 means that there are four three-sector sites supporting twelve cells (Figure 7-3).

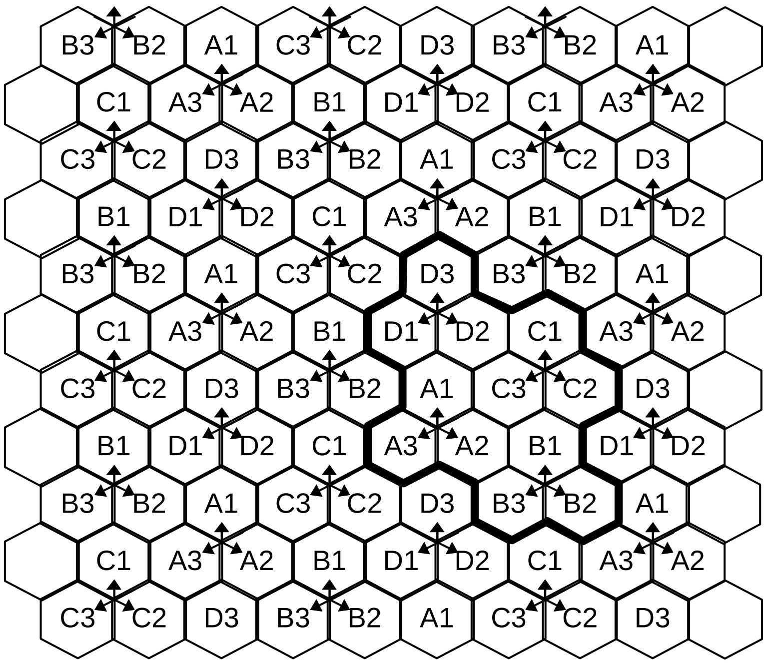

Figure 7-3 4/12 re-use pattern (Note: Observe the positions of the frequency groups D1 and D3)

The re-use pattern in Figure 7-3 is compatible with the planning criterion C/I>12 dB. A shorter re-use distance giving a smaller C/I-ratio, is used in the 3/9-pattern (Figure 7-4).

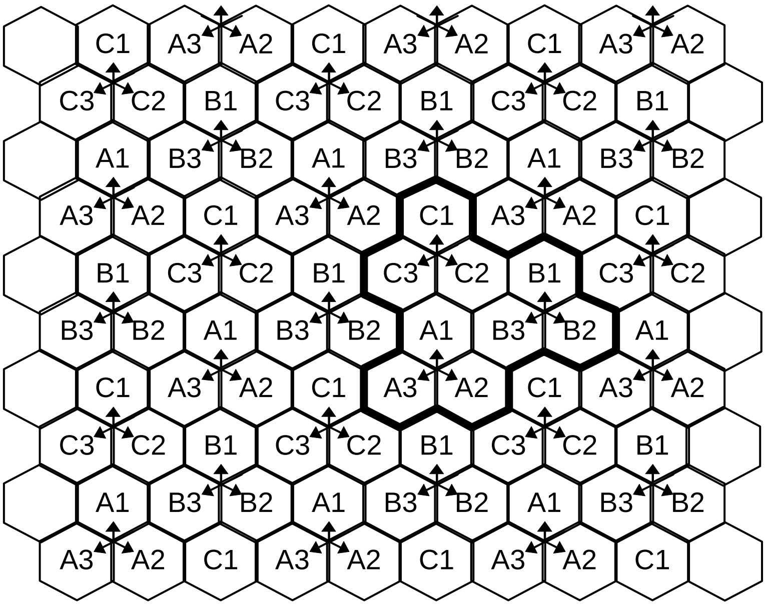

Figure 7-4 3/9 re-use pattern

This re-use pattern (Figure 7-4), which has a higher channel utilization (since the carriers are distributed among nine cells rather than twelve) is recommended only if frequency hopping is implemented. That is, it is compatible with the planning criterion C/I >9 dB. In addition, since C/A ≈ 0 close to some of the cell borders (Figure 7-5) special care must be taken. Other re-use patterns such as the 7/21, with much higher re-use distances, must be used for systems which are more sensitive to interference, e.g., analogue mobile telephone systems.

As an example, suppose that one operator has been given 5 MHz of bandwidth and distributes the carriers over nine cells, it can look like Figure 7-5.

Channel groups	A1	B1	C1	A2	B2	C2	A3	B3	C3
RF	512	513	514	515	516	517	518	519	520
Channels	521	522	523	524	525	526	527	528	529
	530	531	532	533	534	535			

Figure 7-5 24 frequencies in the 3/9 cell plan. The Absolute Radio Frequency numbers (ARF) given here correspond to the frequency interval 1710 - 1715 MHz in GSM 1800. Note that the adjacent cells A1 and C3 also have adjacent frequencies 200 kHz apart (f(ARFCN) = 1710.2 + 0.2(ARFCN - 512))

From this example, it can be seen that channels used in the same cell of a 3/9 (4/12) cell plan are always nine (twelve) RF channels apart. This is beneficial regarding the properties of the combiners. A filter combiner requires 600 kHz and a hybrid combiner 400 kHz channel separation for GSM 900.

As mentioned above, the 3/9 re-use pattern has adjacent channels in some pairs of adjacent cells (A1, C3) which calls for special attention when using this re-use pattern.

Hence, a nominal cellplan consists of a hexagonal pattern of cells where the sites typically are distributed equidistant and where ideally they can be placed according to a uniform pattern. However, this is seldom the case because cells often vary in size. Therefore, real nominal cellplans must be verified by means of predictions or radio measurements, in order to ensure that interference does not become a problem.

TRANSITION REGIONS

A uniform re-use pattern implies a constant traffic density over the network's coverage area. In practice, however, traffic density varies considerably over the area (and during the day). This means it is common that cells of different sizes are used in different parts of a system, small cells in high-traffic areas (normally urban) and large cells in areas with lower traffic.

Figure 7-6 shows a case where cells have assorted sizes in a coverage area. This poses special problems in channel planning, as the re-use distance will vary for different cell sizes. To avoid having a smaller cell size that has half the re-use distance of the larger cell size interfering in the larger cell, other RF channels must be used in these cells. We need a buffer zone where the same RF channels are not used in the smaller and larger cells, respectively. This is sometimes a costly but unavoidable arrangement. Another possibility that parallels this type of varied coverage is in the use of overlaid and underlaid cells. There, again, exists the need to have separate channel plans.

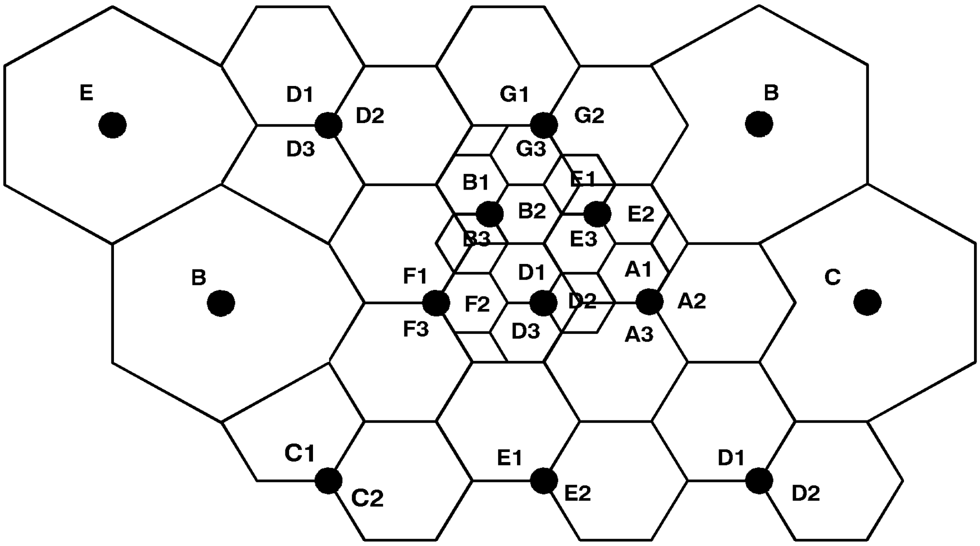

Figure 7-6 A cellular network

NETWORK COLOR CODE AND BASE STATION COLOR CODE (NCC, BCC)

The Base Station Identity Code (BSIC) is composed of two entities:

- Network Color Code (NCC)
- BTS Color Code (BCC)

NCC is used to discriminate between cells in two different PLMNs using the same frequency (Figure 7-7). These PLMNs with the same frequencies are always in different countries since the PLMNs in one country use different carrier frequencies. The operators in different countries must decide between themselves what the NCC assignment will be. The operators may use more than one NCC value as long as they only use their agreed value in the border areas.

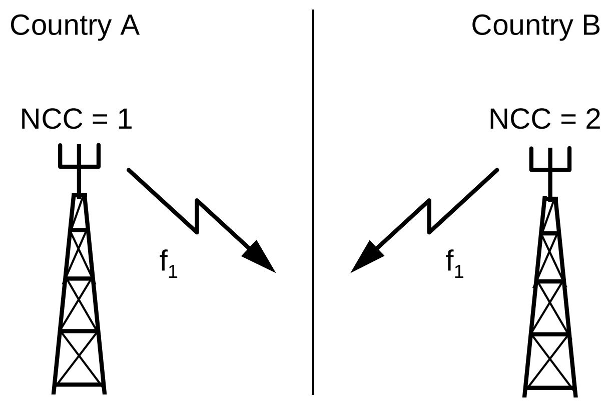

Figure 7-7 The use of NCC in two countries.

The MS reports the BCC value so that the BSC can distinguish among different cells transmitting on the same frequency. If frequency re-use clusters are used, it is recommended that all BTSs in a cluster use the same BCC, and that an adjacent cluster use another BCC (Figure 7-8). If clusters are not used, great care must be taken when planning BCC.

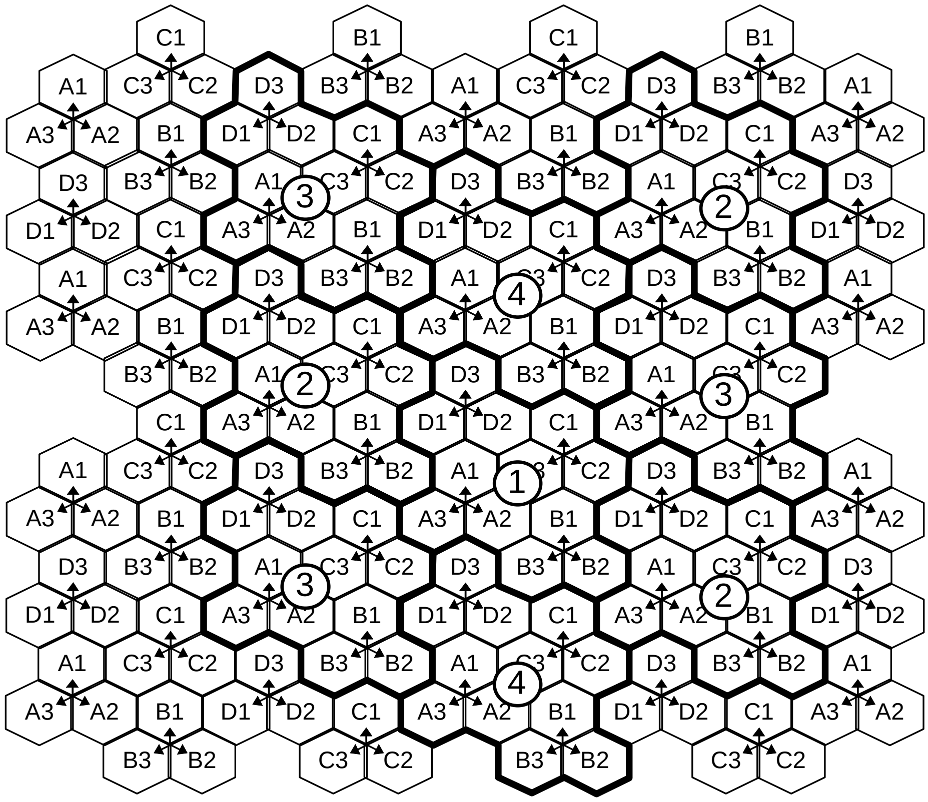

Figure 7-8 Assignment of BCC to clusters in a 4/12 re-use pattern

BSIC is defined per cell and is sent on SCH on the BCCH carrier.

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