Cell Splitting

Introduction

As the density of subscribers to a cellular system grows, there comes a time where the system capacity is reached. At that point you cannot continue to add new customers without degrading system performance for all your customers. You could simply refuse to add new users, but that's not a very good business plan. Another idea would be to add new channels. Assuming you can't get additional spectrum from the FCC, this would require new technology to squeeze more voice channels into the same bandwidth. For example, the transition from the analog AMPS system to digital systems such as IS-54 increased the number of voice channels available in the same spectrum by about a factor of three.

Short of a technology upgrade, a viable option is to decrease the cell size to serve the same number of users per cell at a higher user density. A not-very-smart way to do that would be to rip out all existing base stations and redesign the system from scratch using smaller cells. A better way would be to design a new system that maintains your existing base stations and channel allocations. This approach is usually referred to as *cell splitting*. The idea is to keep your existing base stations in place with the same channel allocations and add new base stations that keep your same reuse pattern intact. Consider the situation shown in Fig. 17.1.

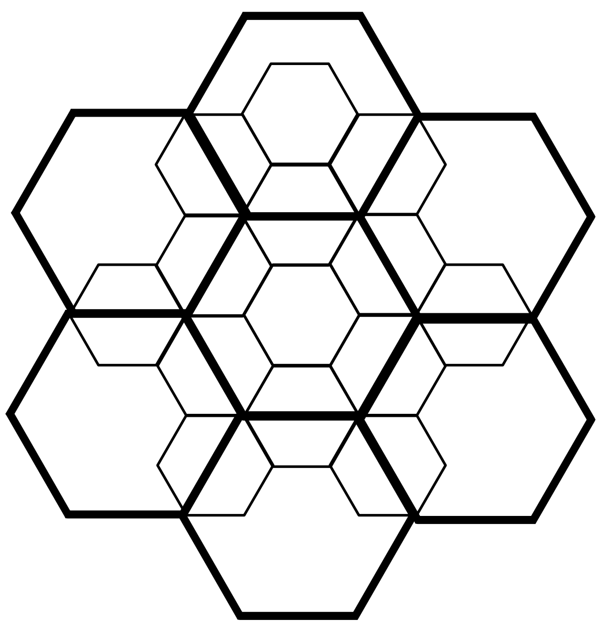

Figure 17.1: Cell splitting. The thick boundaries correspond to the original "big" cells with a base station at the center of each cell. The thin boundaries correspond to the new "small" cells, again with a base station at the center of each cell. As shown, the center of each big cell will also be the center of one of the small cells, so we can keep our original base station locations.

With reference to Fig. 17.1 we see that by keeping our original base stations and adding new ones midway between the old ones we can arrive at a hexagonal grid with cells ½ the size of the original cells. The question now is: What channel assignments do we make to the new base stations and what transmitted power is required? We will consider this for the N=3,4,7 cases.

N=3

Consider the N=3 reuse pattern as shown in Fig. 17.2. Notice that any cell falling between an A and a B cell will always be a C cell, and so on. We need to retain this pattern when doing cell splitting. We would also like to have each A, B, or C cell in the old pattern remain an A, B, or C cell in the new reuse pattern.

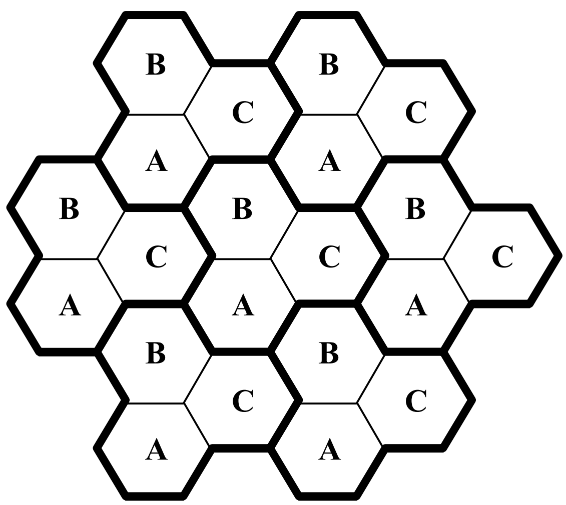

Figure 17.2: N=3 reuse pattern.

We overlay the ½-sized cell pattern on the original pattern as in Fig. 17.1. At each new cell center we look at the existing base stations this falls in between and assign the remaining channel set to the new cell. For example, if a new cell falls between a B and a C we assign channel set A, and so on. This is illustrated in Fig. 17.3. Notice that the new reuse pattern is rotated 60° clockwise from the original.

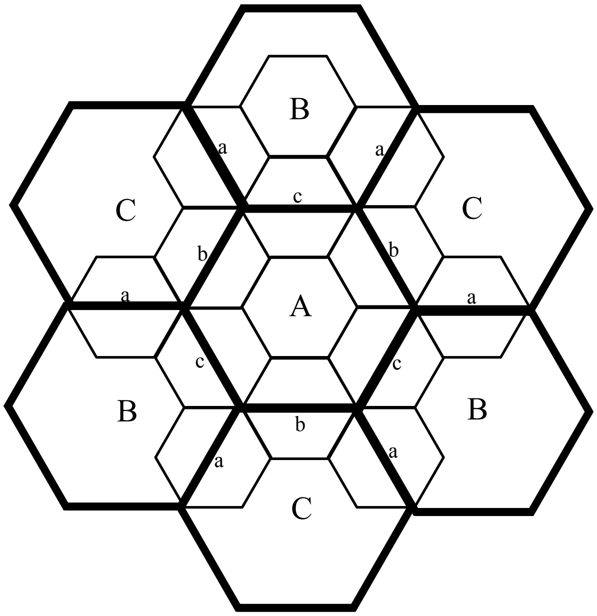

Figure 17.3: Cell splitting with N=3. (See Fig. 17.1.) The capital letters are the original base station channel assignments. We keep these in the new reuse pattern. The lower-case letters represent new base stations. The channel allocations of these new stations are chosen to maintain the N=3 reuse pattern.

N=7

For the N=7 reuse pattern (Fig. 17.4) we observe any cell falling between an A and a B is always an F cell, and so on. Our new pattern after cell splitting must maintain this arrangement. Fig. 17.5 shows the process. Notice that the resulting reuse pattern is rotated 120° clockwise from the original.

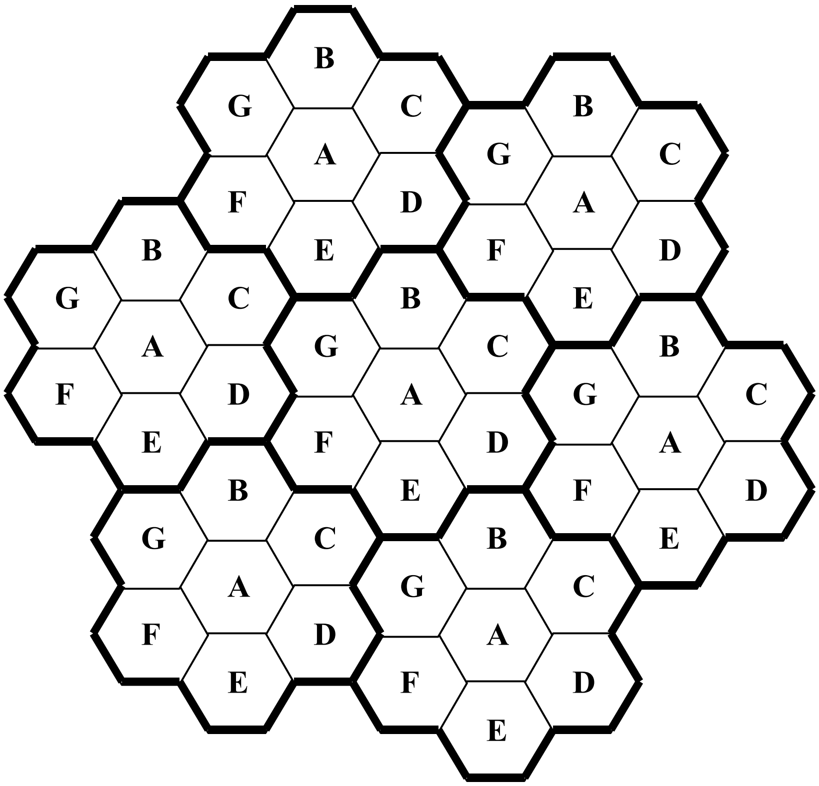

Figure 17.4: N=7 reuse pattern.

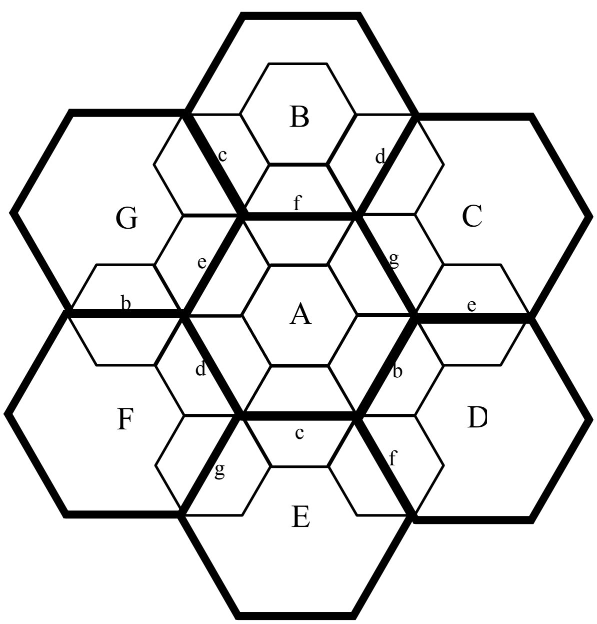

Figure 17.5: Cell splitting for N=7. The capital letters are the original base station channel assignments. The lower-case letters represent new base stations.

N=4

We can't use the same approach for the N=4 reuse pattern because each cell always falls between two cells having the same channel set (Fig. 17.6). Since adjacent cells never have the same channel set, we can't "place a new cell between each pair of old cells" and keep the same reuse pattern.

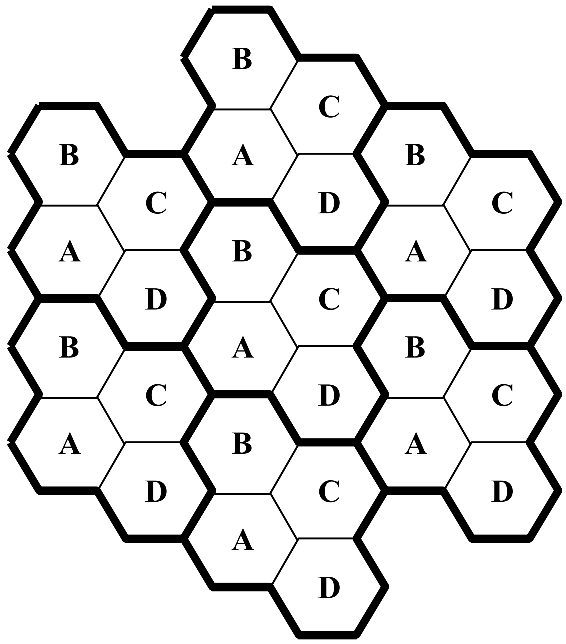

Figure 17.6: N=4 reuse pattern.

Instead, we can put new cells at the vertices of the original hexagons as shown in Fig. 17.7. The new hexagonal cells resulting from this are rotated 30° relative to the original cells. They are not $1/2 = 50\%$ the radius but $1/\sqrt{3} = 58\%$ the radius of the original cells. The resulting new N=4 reuse pattern is rotated 90° counter-clockwise from the original.

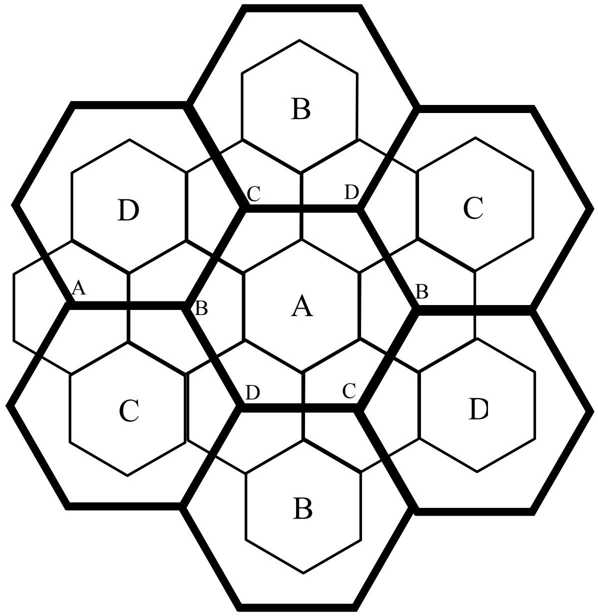

Figure 17.7: Cell splitting with N=4.

References

Garg, V. K., and J. E. Wilkes, *Wireless and Personal Communications Systems,* Prentice Hall, 1996, ISBN 0-13-234626-5.