EEG473 Mobile Communications
lecture # (11)

The Cellular Concept –
System Design Fundamentals

Improving Capacity in Cellular Systems

Cellular design techniques are needed to provide more channels per unit coverage area.

1. **Cell splitting:** allows an orderly growth of the system. (increases the number of base stations in order to increase capacity)
2. **Sectoring:** uses directional antennas to further control the interference and frequency reuse of channels. (rely on base station antenna placements)
3. **Coverage zone approaches:** distributes the coverage of a cell and extends the cell boundary to hard-to-reach places.

Cell Splitting

The process of subdividing a congested cell into smaller cells. (each with its own base station and a corresponding reduction in antenna height and transmitter power)

- By defining and installing new cells which have a smaller radius than the original cells (microcells).
- Cell splitting preserves the geometry of the architecture and therefore simply scales the geometry of the architecture
- The increased number of cells would increase the number of clusters which in turn would increase the number of channels reused, and capacity

Cell Splitting (2)

- if every cell **were reduced** in such a way that the **radius of every cell was cut in half.** In order to cover the entire service area with smaller cells, approximately four times as many cells would be required.

- Cell splitting **not upsetting the channel allocation scheme** required to maintain the minimum co-channel reuse ratio Q between co-channel cells.

Cell Splitting (3)

- **In Figure 3.8,** the base stations are placed at corners of the cells, and the area served by base station **A** is assumed to be saturated with traffic

  (i.e, the blocking of base station A exceeds acceptable rates).

- Cell Splitting is applied, note that **the original base station A has been surrounded by six new microcell base stations**.

  (the smaller cells were added in such a way as to preserve the frequency reuse plan of the system).

- Microcell **G** was placed half way between two larger stations utilizing the same channel set **G**

  (also, for other microcells in the figure).

Cells are split to add channels with no new spectrum usage

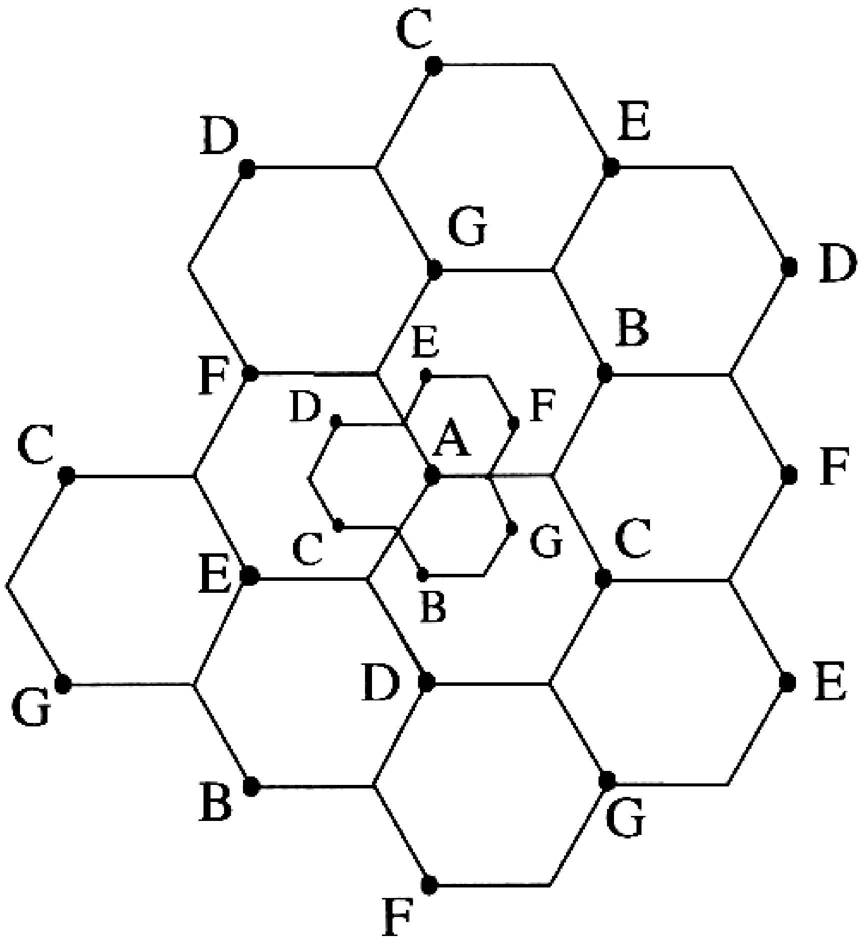

Figure 3.8 Illustration of cell splitting.

(How much the transmit power must be reduced for the new smaller cells?

the received power (P_r) at the new and old cell boundaries and setting them equal to each other. (to ensure that the frequency reuse and S/I is the same)

In the previous class we adopted the simple propagation model

$$P_R = P_o \left(\frac{d}{d_o} \right)^{-n}$$

$$P_r[\text{at old cell boundary}] \propto P_{t1} R^{-n}$$

$$P_r[\text{at new cell boundary}] \propto P_{t2} (R/2)^{-n}$$

where $\mathbf{P_{t1}}$ **an** $\mathbf{P_{t2}}$, are the transmit powers of the larger and smaller cell base stations, respectively, and **n** is the path loss exponent.

If we take **n = 4** and set the received powers equal to each other, then

$$P_{t2} = \frac{P_{t1}}{16}$$

the transmit power must be reduced by **12 dB** in order to fill in the original coverage area with microcells, while maintaining the S/I requirement.

Practical considerations for cell splitting

- in practice, not all cells are split at the same time therefore, different cell sizes will exist simultaneously.

- Two different transmitted power levels for small and large cells are used.

  Channels in the old cell must be broken down into two channel groups, one for smaller cell and other for larger cell.

- The larger cell is usually dedicated to high speed traffic so that handoffs occur less frequently.

- Antenna downtilting, which focuses radiated energy from the base station towards the ground (rather than towards the horizon), is often used to limit the radio coverage of newly formed microcells.

Example 3.8

- Consider Figure 3.9. Assume each base station uses **60 channels**, regardless of cell size. If each original cell has a radius of **1 km** and each microcell has a radius of **0.5 km**, **find the number of channels contained in a 3 km by 3 km square centered around A,**

(a) without the use of microcells,

(b) when the lettered microcells as shown in Fig 3.9 are used

(c) if all the original base stations are replaced by microcells.

Assume cells on the edge of the square to be contained within the square.

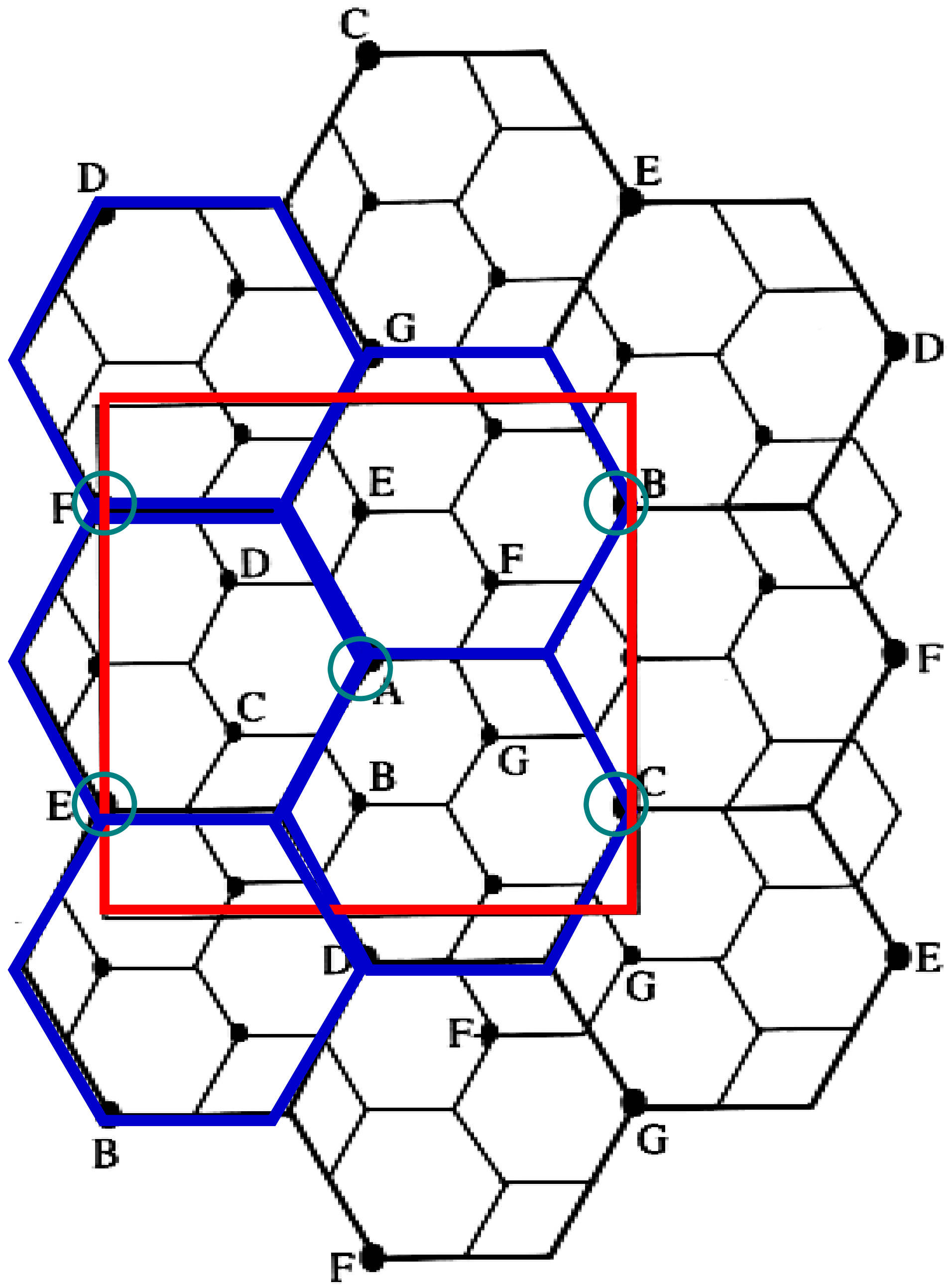

Figure 3.9 Illustration of cell splitting within a 3 km by 3 km square centered around base station A.

Solution to Example 3.8

(a) Without the use of microcells

A cell radius of 1 km implies that the sides of the larger hexagons are also 1 km in length.

To cover the 3 km by 3 km square centered around base station A, we need to cover 1.5 km (1.5 times the hexagon radius) towards the right, left, top, and bottom of base station A.

This is shown in Figure 3.9. From Figure 3.9 we see that **this area contains 5 base stations**. Since each base station has 60 channels,

The total number of channels without cell splitting is equal to $5 \times 60 = 300$ channels.

(b) With the use of the microcells as shown in Figure 3.9:

In Figure 3.9, the base station A is surrounded by 6 microcells.

Therefore, the total number of base stations in the square area under study is equal to **5 + 6 = 11**.

Since each base station has **60 channels**,

the total number of channels will be equal to 11 × 60= 660 channels. This is a 2.2 times increase in capacity when compared to case (a).

(c) if all the base stations are replaced by microcells:

From Figure 2.9, we see that there are a total of **5 + 12 = 17** base stations in the square region under study. Since each base station has **60 channels**, the

total number of channels will be equal to **17 x 60 =1020** channels. This is a 3.4 times increase in capacity when compared to case (a).

Theoretically, if all cells were microcells having **half the radius of the original cell**, the **capacity increase** would approach **4**.

Conclusion

Cell splitting achieves capacity improvement by essentially rescaling the system. By decreasing the cell radius R and keeping the co-channel reuse ratio D/R unchanged, cell splitting increases the number of channels per unit area.