ECE 5325/6325: Wireless Communication Systems
Lecture Notes, Spring 2013

Lecture 4

Today: (1) Sectoring

- Reading – today: Rappaport 3.7.2; Thu and next Tue: Mol 3.2, Haykin/Moher handout (2.9-2.10) (posted on Canvas)
- HW 2 due Tue Jan 22 at 11:59 am.

1 Sectoring

In sectoring, we divide each cell into three or six "sectors" which are then served by three or six separate directional antennas, each with beamwidth of about 120 or 60 degrees.

We showed in Lecture 2 that for hexagonal cells and omnidirectional base station antennas, the S/I ratio is given by $\frac{(3N)^{n/2}}{i_0}$, where N is the reuse ratio, and i_0 is the number of first-tier co-channel base stations. When we used omnidirectional antennas at each BS, we saw that $i_0 = 6$ regardless of N. By using sector antennas at the BSes, we will show that i_0 reduces. By reducing the S/I ratio for a given N, we allow a system to be deployed for a lower N, and therefore a higher capacity system.

However, each cell's channel group must be divided into one sub-group for each sector. These new sub-groups have 1/3 or 1/6 the number of channels (N_C), and thus the trunking efficiency will be lower.

Example: Decrease in trunking efficiency for constant N
Let $N = 7$, each cell has $N_C = 100$ channels, and users who make calls with $\lambda = 0.01$ per minute with average holding time 3 minutes. For blocked-calls-cleared and a GOS (*i.e.*, Pr_{block}) of 2%, what is the number of users which can be supported in this cell? Next, using 120 degree sectoring, and otherwise identical system parameters, what is the number of users which can be supported in this cell? What percentage reduction in capacity does sectoring with constant N cause?

Example: Reducing N with sector antennas
For the same system, now assume that with 120 degree sectoring, that N can be reduced from 7 to 4. What number of users can be supported?

Why does i_0 reduce? Consider again a mobile at the edge of a cell. We need to determine which of the first tier BSes contribute significantly to the interference signal. Refer to Figures 3.10, 3.11, for $N = 7$, P3.28(b) for $N = 3$, and to Figure 1 for $N = 4$.

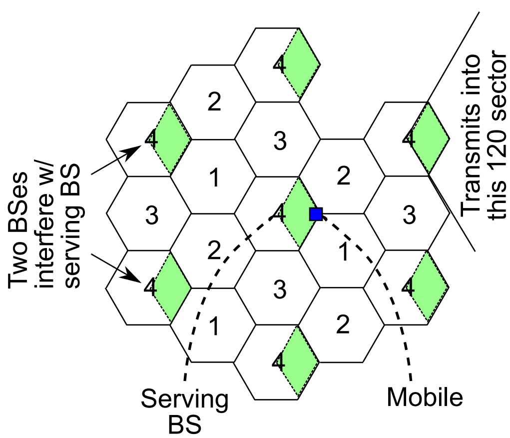

Figure 1: 120 degree sectoring for cellular system with $N = 4$. Only two first tier BSes significantly interfere with the middle BS.

Compared to when $i_0 = 6$, how much does S/I improve with sectoring?

Recall that $S/I = \frac{(3N)^{n/2}}{i_0}$ for hexagonal cells. In dB terms,

$$\frac{S}{I}(dB) = 5n \log_{10}(3N) - 10 \log_{10} i_0$$

So with $i_0 = 6$, the latter term is 7.8 dB. If $i_0 = 1, 2$, and 3, the same term is 0, 3.0, or 4.8 dB. So, the improvement is 3, 4.8, or 7.8 dB. The particular value of i_0 that can be obtained is a function of N and whether 60 or 120 degree sectoring is used.

For a particular SIR and path loss exponent, how does i_0 affect the necessary N? From lecture 3,

$$N = \frac{1}{3}(i_0 \mathrm{SIR})^{2/n}$$

So N is proportional to $i_0^{2/n}$.

1.1 Determining i_0

What is i_0 for 120 or 60 degree sector antennas? In short: it depends on N. You need to check on the hex plot to see how many sectors' base stations will "cover" the serving sector. My argument (not proven) is that when $i \neq j$, we have $i_0 = 2$ for 120^o antennas and $i_0 = 1$ for 60^o antennas. But for $i = j$, you need $i_0 = 3$ for 120^o antennas and $i_0 = 2$ for 60^o antennas. The case of $i = j$ happens at $N = 3$, and $N = 12$ (and $3i^2$ in general).

1.2 Example

Example: Assume we have $U = 533$ full-duplex channels. Assume blocked-calls cleared with a Pr_{block} of 2%, and per user offered traffic of 0.015 Erlang. Further assume we're using modulation with minimum required SIR(dB) of 19.5 dB and we've measured for our deployment area that $n = 3.3$. Find the total number of users possible per channel assuming (a) omnidirectional antennas and (b) 120^o sector antennas.

1.3 Discussion

What are some of the problems with the assumptions made in this analysis?