Problems and Solutions (Chapter 8)

1. What are the specific advantages of static channel allocation over dynamic channel allocation strategies? Explain clearly.

   [Solution]

   FCA is simple. It needs low computational effort and is easy to implement. Therefore, it has a lower call setup delay.

   From the view of performance, it has better performance under heavy traffic and maximum channel reusability. And it's suitable for large cell environment.

2. Are there collisions present in traffic or information channels in a cellular system?

   [Solution]

   No collisions are possible in traffic or information channels because the BS controls all the mobile stations and the channel assignment is collision free.

3. What are the differences in channel allocation problem in FDMA/TDMA-based system versus CDMA-based system? Explain clearly.

   [Solution]

   In FDMA/TDMA system, the number of frequencies and time slot is limited. Channel allocation problem in FDMA/TDMA is how to efficiently allocate the frequency or time slot to support more users. While in CDMA system, the number of possible codes indicate the number of users that can be supported. Hence, the allocation problem in CDMA is converted to how to control the transmission power so as to minimize the interference.

4. If you do not sector the cells, can you still borrow channels from adjacent cells? Explain clearly.

   [Solution]

   You can still borrow channel from adjacent cells. However, you must carefully choose the channel to make sure that the same channels cannot be used in adjacent cells at the same time and there is no interference with the cells of other clusters, which are within reuse distance of it.

5. In a cellular system , with omni-directional antennas, employs a cluster of size 7. The cell at the center of the cluster has a lot more traffic than others and need to borrow some channels from adjacent cells. Explain the strategy you would employ to determine a donor cell

   (a) Within the cluster.

   (b) Outside the cluster.

   [Solution]

(a) Choose a free channel, which is not being used by the other cells of this cluster.

(b) Choose a free channel, which could minimize the possible interference with the cells of the other clusters, which are within reuse distance of the center cell.

6. Which cell(s) may borrow channels and which could be an appropriate donor(s) in Problem 5.11?

[Solution]

The cell with 4000 calls per hour may borrow channels. The cells with 900 and 1000 calls per hour could be appropriate donors.

7. What are the advantages of cell sectoring? How do you compare this with SDMA?

[Solution]

Cell sectoring minimizes the interference by reducing possible number of co-channels that could cause interference within each cell, SDMA facilitates simultaneous multiple connections using the same frequency. Both these techniques are useful in optimizing the reuse of RF resources.

8. In a cellular system, with 7-cell clusters, has the following average number of calls at a given time:

Cell number	Average number of calls/unit time
1	900
2	2000
3	2500
4	1100
5	1200
6	1800
7	1000

If the system is assigned 49 traffic channels, how would you distribute the channel if

(a) Static allocation is used.

(b) Simple borrowing scheme is used.

(c) Dynamic channel allocation scheme is used.

[Solution]

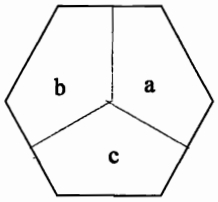
(a) Distribute the channels according the traffic load of each cells.

Cell number	1	2	3	4	5	6	7
Channel number	4	9	12	5	6	8	5

(b) Allocate seven channels to each cell and borrow channels from adjacent cells with low traffic

(c) Channels are allocated dynamically as new call arrival in the system and is achieved by keep all free channels in a central pool.

9. Each cell is sectored in a slightly different way as follows:

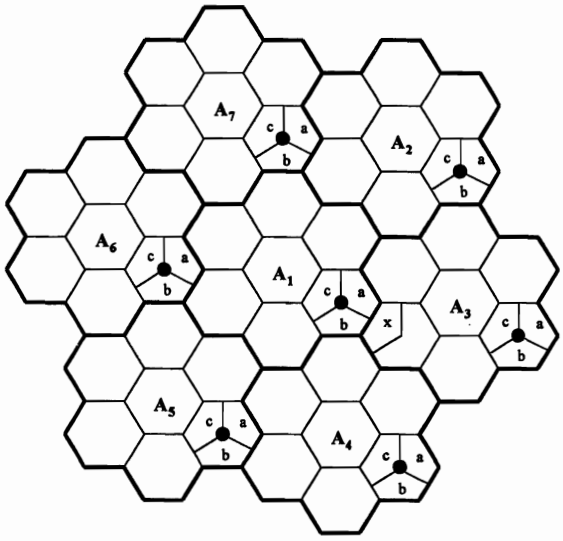


3-sector of a cell: an alternative approach (Figure for problem 8.9).

What will be the impact of such sectoring on channel borrowing and its effect on co-channel interference? Explain carefully.

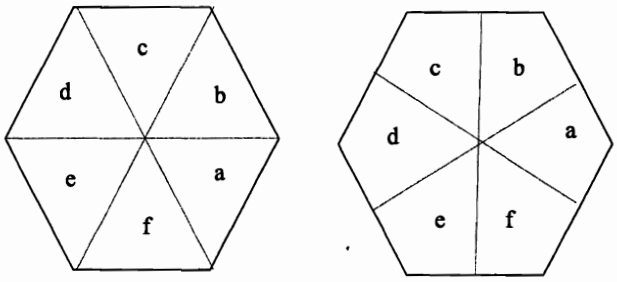
[Solution]

If sector x borrows channels from sector a of A_1, clusters A_5, A_6, and A_7 satisfy the reuse distance. The directions of a sectors of A_2, A_3, and A_4 make them not interfere with sector x.



Solution 8.9

10. Each cell of a wireless system, is partitioned in to 6-sector as shown below:



(i) 6-sectors of a cell (ii) Alternative sectoring scheme

Figure for problem 8.10

(a) What will be the impact of channel-borrowing and co-channel interference if sectoring scheme of (i) is used?

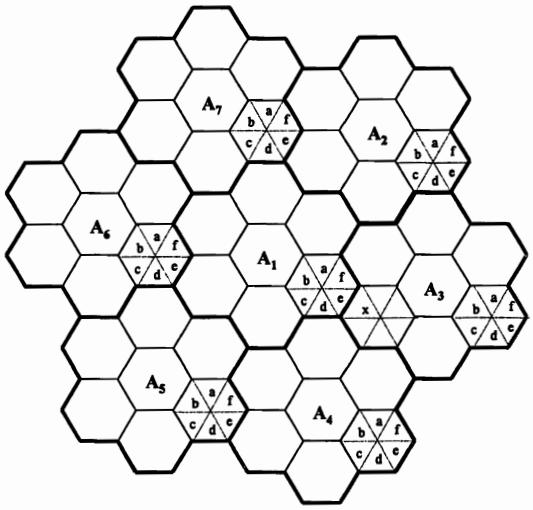
(b) Repeat (a) if the scheme of (ii) is used?

(c) How do you compare (a) with (b)?

(d) Is it possible or desirable to use a combination of sectoring schemes of (i) and (ii)? Explain carefully.

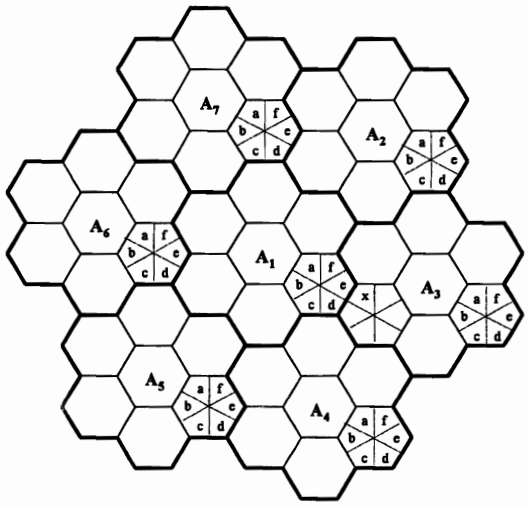
[Solution]

(a) Sector x can borrow channels from sector e because either the reuse distance is satisfied or the directions of e sectors are such that they will not interfere with sector x.



Solution 8.10 (a)

(b) Similar with (a). Co-channel interference is the same as the analysis on page 113. There are only one co-channel interference sector for each sector.



Solution 8.10 (b)

(c) See parts (a) and (b).

(d) No. It makes the borrowing scheme more complicated. Because in a simple sectoring scheme, you only need consider the effect on the co-channel interference of a single cell and the scheme could be applied on all other cells.

11. In a cellular system, a cluster of 7-cell, is assigned 48 traffic channels. Show the assignment of channels to each cell if:

(a) Omni-directional antennas are used.

(b) 3-sector directional antennas are used.

(c) 6-sector directional antennas are used.

[Solution]

(a) 6 channels each cell

(b) 2 channels each sector

(c) 1 channel each sector

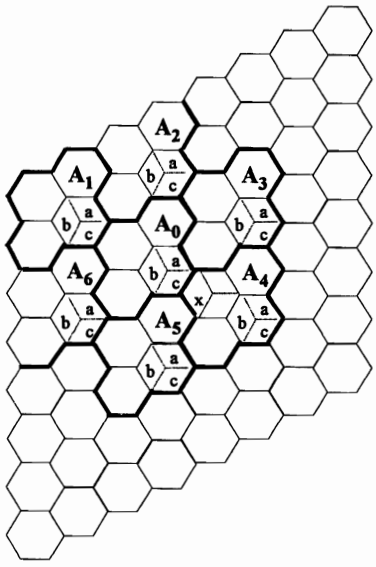
12. A service provider decided to restructure allocation of channels by selecting a cluster with 4-cell as its basic building block. What will be impact of channel borrowing if each cell employs

(a) 3-way sectoring and

(b) 6-way sectoring.

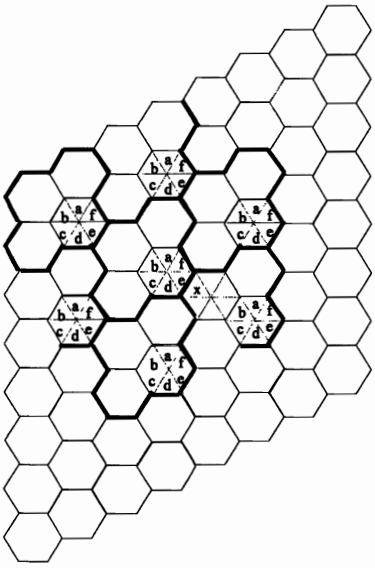
[Solution]

(a) This figure shows the 3-way cell sectoring of a system with 4–cell as its basic building block. For example, sector x of A_4 borrows channels from sector c of A_0. A_1, A_2, and A_6 satisfy the reuse distance and the directions of c sectors of A_3, A_4, and A_5 will not cause interference with sector x.



Solution 11 (a)

(b) See the figure. Similar with (a)



Solution 11 (b)

13. How do you compare hybrid versus flexible channel allocation? Which one would you prefer and why?

    [Solution]

    A hybrid channel allocation scheme is a combination of fixed and dynamic channel allocation schemes. Hybrid scheme is complicated and different and its performance analysis by an analytical model is difficult. Generally, hybrid allocation has a better service than FCA at low and moderate traffic load.

14. For a wireless network with integrated services, e.g. including both voice and data applications, there are two basic channel allocation schemes: Complete Sharing (CS) and Complete Partitioning (CP). The CS policy allows all users equal access to the channels available at all times. The CP policy, on the other hand, divides up the available bandwidth into separate sub-pools according to user type. Compare both advantages and disadvantages of these two schemes.

    [Solution]

    The advantages of CS for integrated services are: efficient bandwidth utilization and reduce the total call blocking probability. The disadvantage of CS for integrated services is that when data traffic is heavy, the blocking probability of voice calls will be increased. The advantage of CP for integrated service is that the QoS for voice can be easily supported, as data traffic does not influence the blocking probability of voice calls. But, the unused bandwidth in each category will be wasted.

15. What kind of technique(s) you could possibly use to serve a new call if all the channels in the current cell have been occupied and no channel can be borrowed from neighboring cells.

    [Solution]

    Preempt lower priorities calls or borrow some bandwidth from other lower priority calls.

16. A service provider decided to split each hexagonal cell of 20 km radius to 7 microcell of appropriate size.

    (a) What is the size of each microcell?

    (b) How is the signal strength influenced by such a redesign?

    (c) What is CCIR compared to the original design, assuming the propagation path loss slope $\zeta = 4.5$.

    [Solution]

    The radius of each microcell is $\frac{R}{1.5\sqrt{3}} = 7.69$ km (see Figure 8.5). The size is 154 km^2. Because we use smaller cell, we could use low signal power to cover the whole cell.

$$
\begin{aligned}
CIR &= \frac{1}{2(q-1)^{-\gamma} + 2q^{-\gamma} + 2(q+1)^{-\gamma}}, \\
q &= \frac{D}{R} = \sqrt{3N} = \sqrt{21} = 4.58, \\
\gamma &= 4.5, \\
CIR &= 106.
\end{aligned}
$$

17. Providing cellular service along a freeway is a tough job and such a scenario is illustrated in the following. A typical road-width varies from 200 m to 400 m. If you select 1000 m as the radius of each cell, then, you require one cell for each km, while the radius of a conventional normal cell is about 20 kms. From the freeway usage point of view, very small segment of each cell is useful. Do you have any suggestions for alternative designs? What are the tradeoffs? Do you suggest the use of SDMA technique?

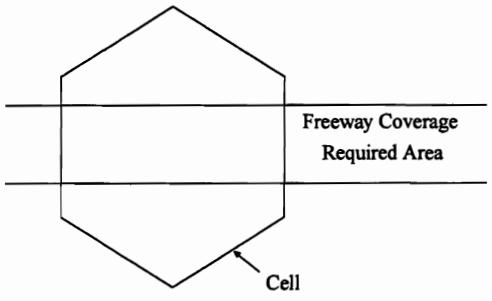


Figure for problem 8.17.

[Solution]

It is better to use smaller size cells. In this way, we could use low power BS and improve the utility of each cell. But the MS will experience more frequent handoff.

18. In a cellular system with 4 channels, one channel is reserved for handoff calls.

    (a) What is the value of $B_O$and B_H, given $\lambda_O = \lambda_H = 0.001$ and $\mu = 0.0003$?

    (b) What are the values of probabilities $P(0)$, $P(1)$, $P(2)$, $P(3)$ and $P(4)$.

    (c) What is the average number of occupied channels in this Problem?

    [Solution]

    $\mu = 0.0003$, $S = 4$, $S_c = 3$, $\lambda_0 = 0.001$, $\lambda_H = 0.001$

    Using Equations (8.11), (8.12), and (8.13), we can compute

    $P(0) = 0.01$, $P(1) = 0.06$, $P(2) = 0.18$, $P(3) = 0.41$, $P(4) = 0.34$

    $B_o = P(3) + P(4) = 0.75$

    $B_H = P(4) = 0.34$

    The average number of occupied channels

    $N = 1 * P(1) + 2 * P(2) + 3 * P(3) + 4 * P(4) = 3$

19. Repeat Problem 8.18 if the number of channels is increased to ten?

    [Solution]

    Use the same method as Problem 8.18.

20. In a cellular system, the total number of channels per cell, is given as 6 and 2 channels are reserved exclusively for handoff calls. What are the blocking probabilities for originating and if handoff request rate is 0.0001, the originating call rate is 0.001, and the service rate $\mu = 0.0003$?

    [Solution]

    Similar to Problem 13.

    $\mu = 0.0003$, $S = 6$, $S_c = 4$, $\lambda_0 = 0.001$, $\lambda_H = 0.0001$

    $P(0) = 0.04$, $P(4) = 0.3$, $P(5) = 0.02$, $P(6) = 0.0012$

    $B_o = P(4) + P(5) + P(6) = 0.32$

    $B_H = P(6) = 0.0012$

21. What is the impact on the answer for Problem 19, if the number of reserved channels is changed to

    (a) 1?

    (b) 3?

[Solution]

(a) Similar to Problem 13.
$\mu = 0.0003$, $S = 6$, $S_c = 5$, $\lambda_0 = 0.001$, $\lambda_H = 0.0001$
$P(0) = 0.04$, $P(5) = 0.17$, $P(6) = 0.01$
$B_o = P(5) + P(6) = 0.18$
$B_H = P(6) = 0.01$
B_O decreases, but B_H increases.

(b) $P(0) = 0.05$
$B_o = 0.45, B_H = 0.000012$
B_H decreases, but B_O increases