The Cellular Concept：

System Design Fundamentals

Mobile Communications

Mobile communications are around us !

Voice

Message

Mobile APP

Video Chat

Contents of Chapter 2

1. Cellular Geometry
2. Channel Assignment and Handoff
3. Interference and System Capacity
4. Trunking and Grade of Service
5. Improving Capacity in Cellular System

Chapter 2

1. Cellular Geometry
2. Channel Assignment and Handoff
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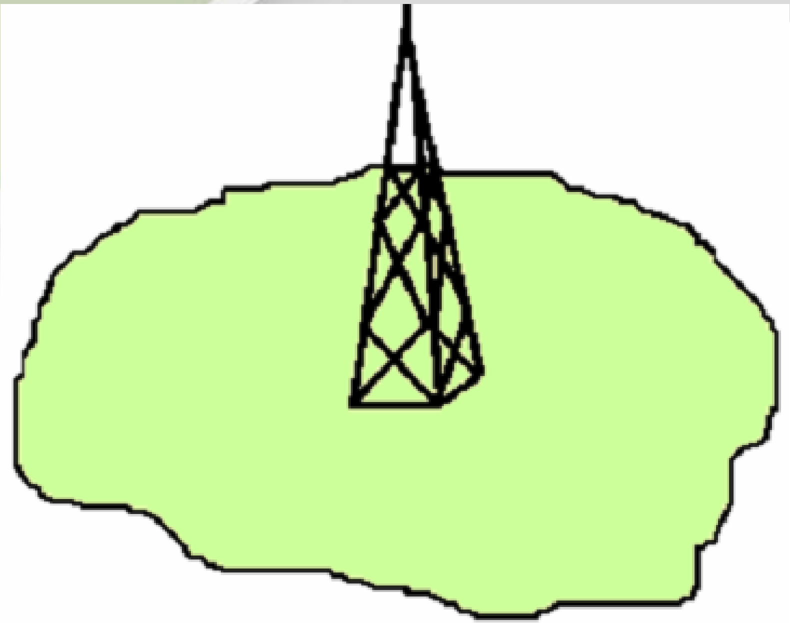
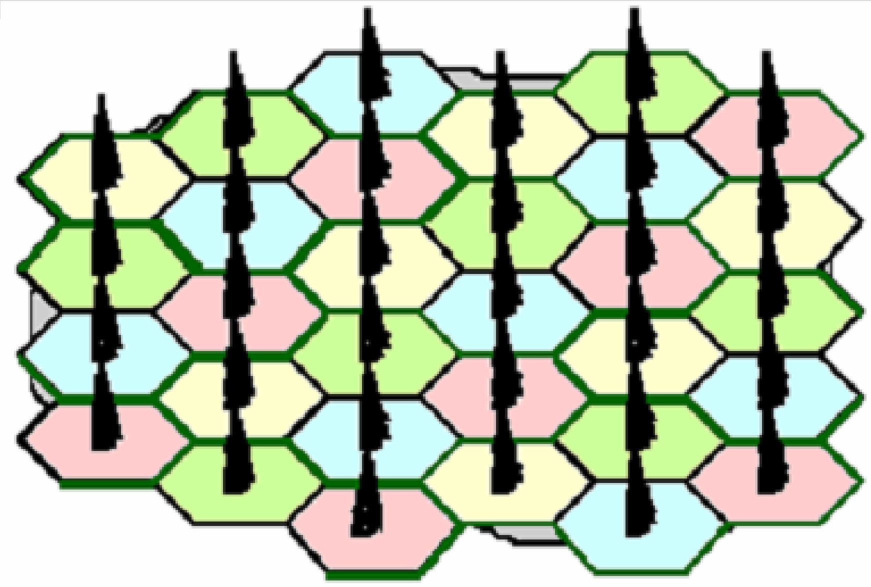
The proposal of cellular concept



- high-power transmitter
- large coverage area

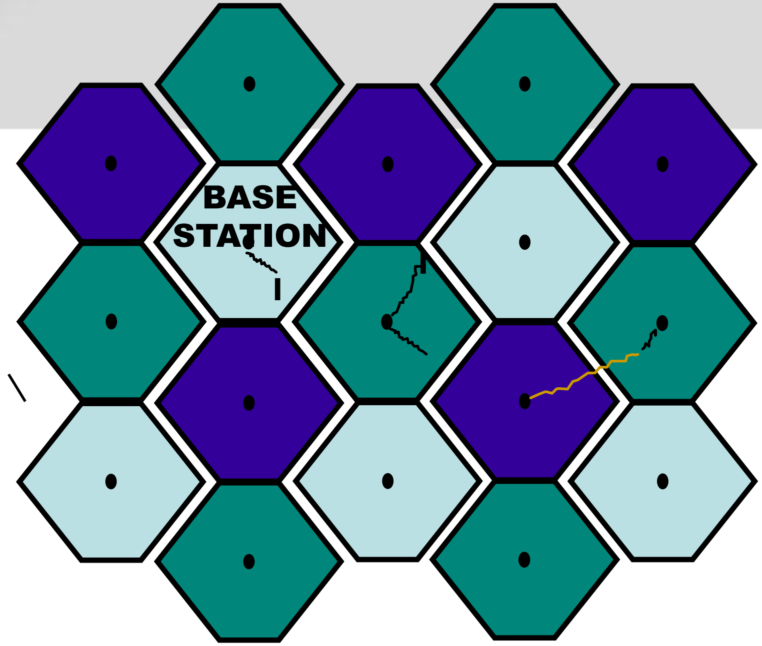
small capacity



- low-power transmitter
- small coverage area (cells)

large capacity

Cellular Concept

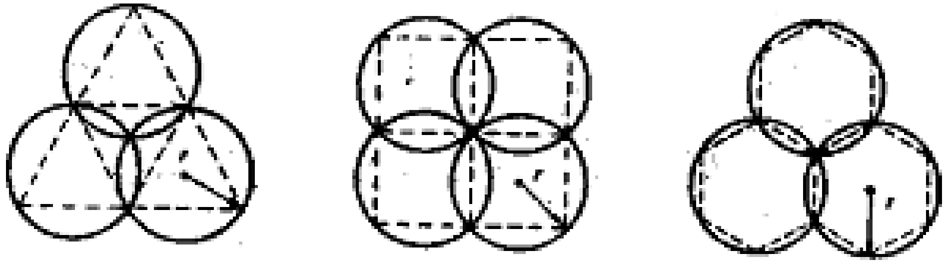


✓Feature: High capacity with limited radio spectrum

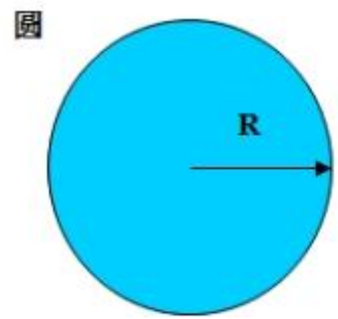
Key idea: **Frequency Reuse** (use lower power transmitters per cell and shrink cell size, so that frequencies can be reused more often)

Cell shape

Why the Hexagon is chosen?

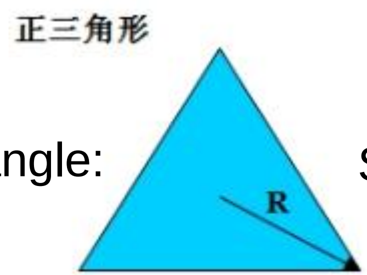


Circle:



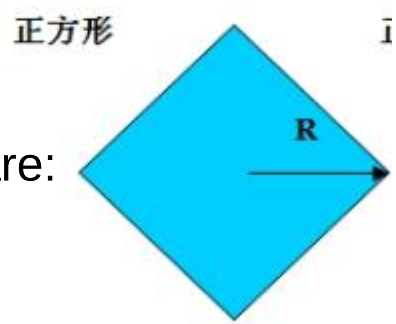
πR^2

Equilateral triangle:



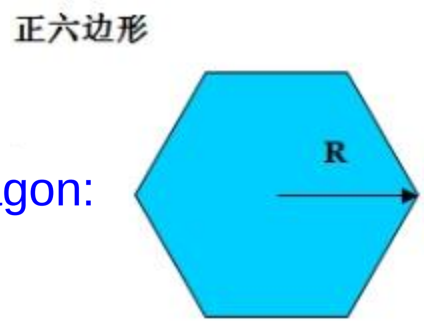
$1.299R^2$

Square:



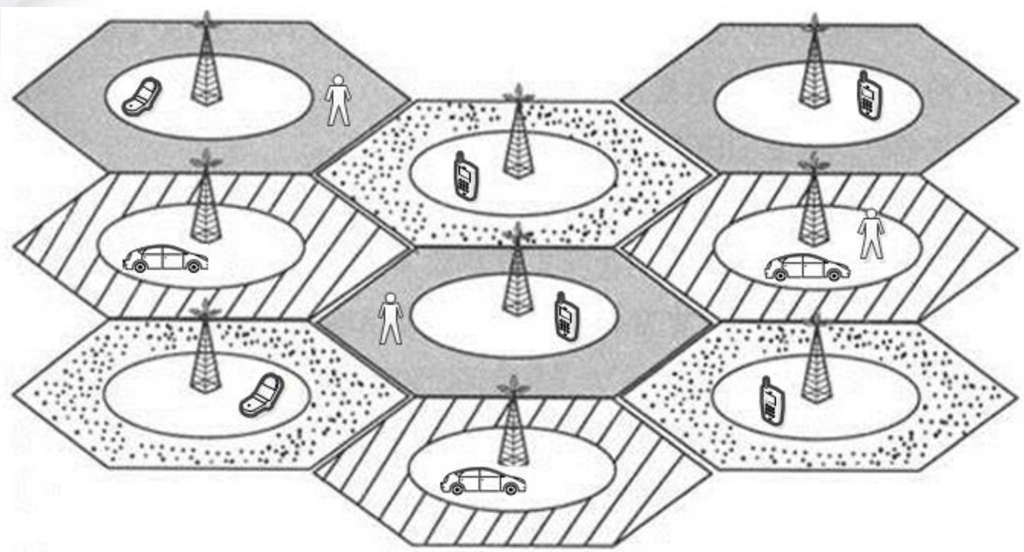
$2R^2$

Hexagon:

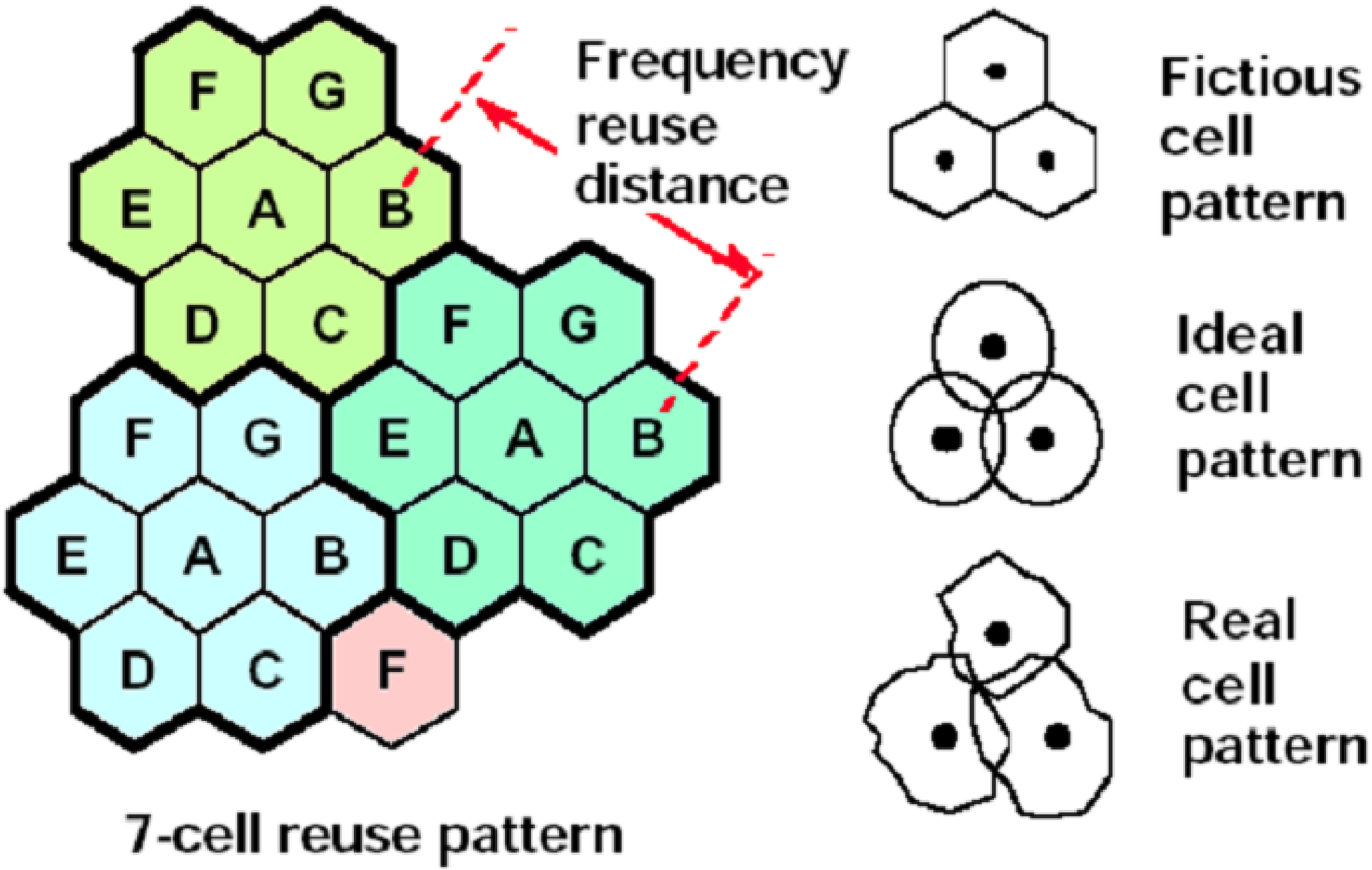


$2.598R^2$

Cellular System



Cellular shape



The size of a cell

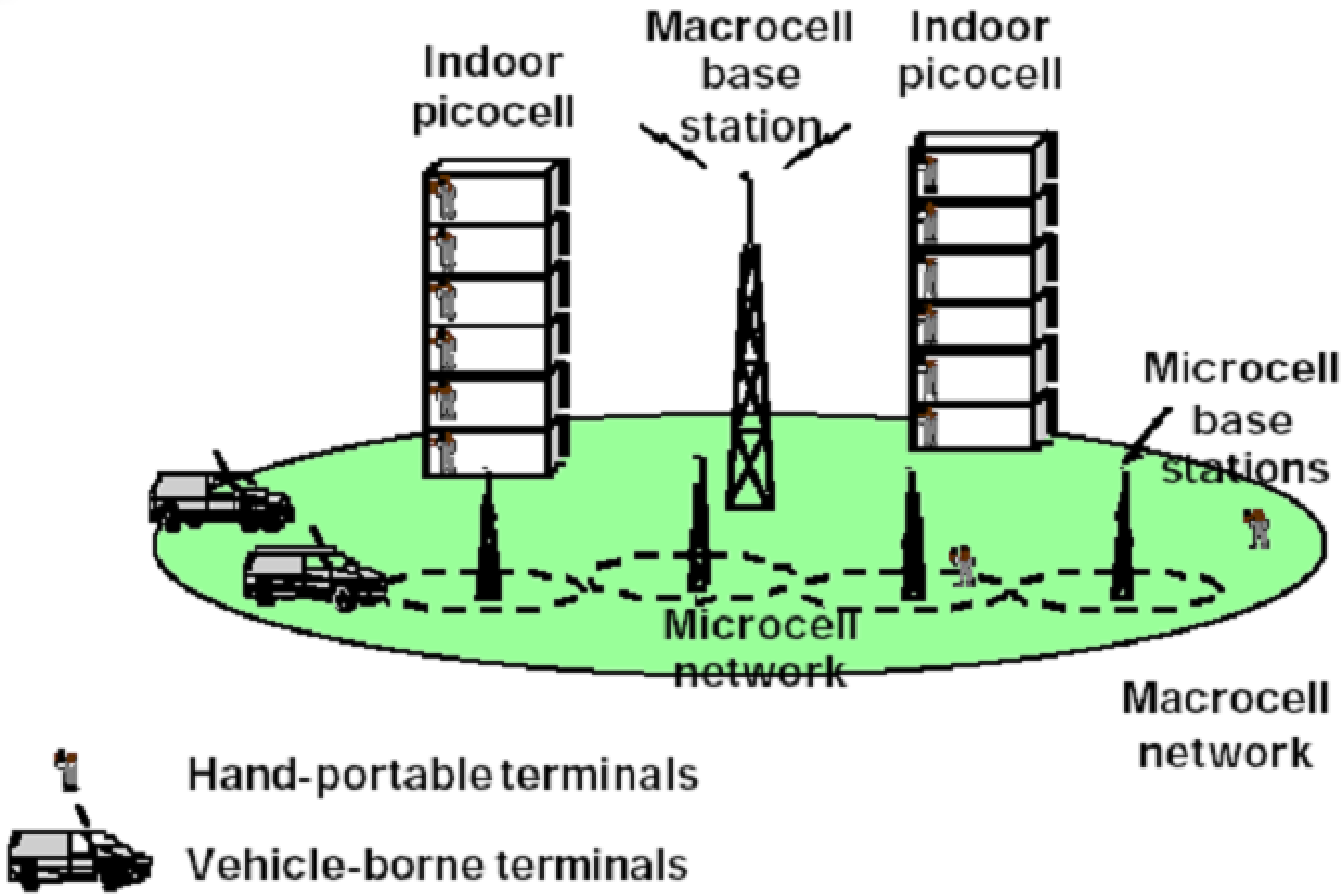
Macrocell: large, covering a wide range of several hundred km to ten km mostly deployed in rural and sparsely populated areas

Microcell: medium cell, coverage are a smaller than in macro cells

range of several hundred metres to a couple of kilometres

deployed mostly in crowded areas, stadiums, shopping malls

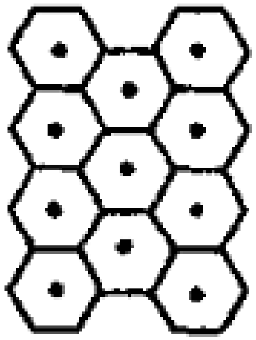
Picocell: small, covering a very small area range of several tens of metres low power antennas, indoor

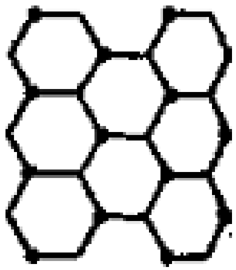

Indoor picocell
Macrocell base station
Indoor picocell
Microcell base stations
Microcell network
Macrocell network
Hand-portable terminals
Vehicle-borne terminals

Base station transmitters

In hexagonal cells, base stations transmitters are either :

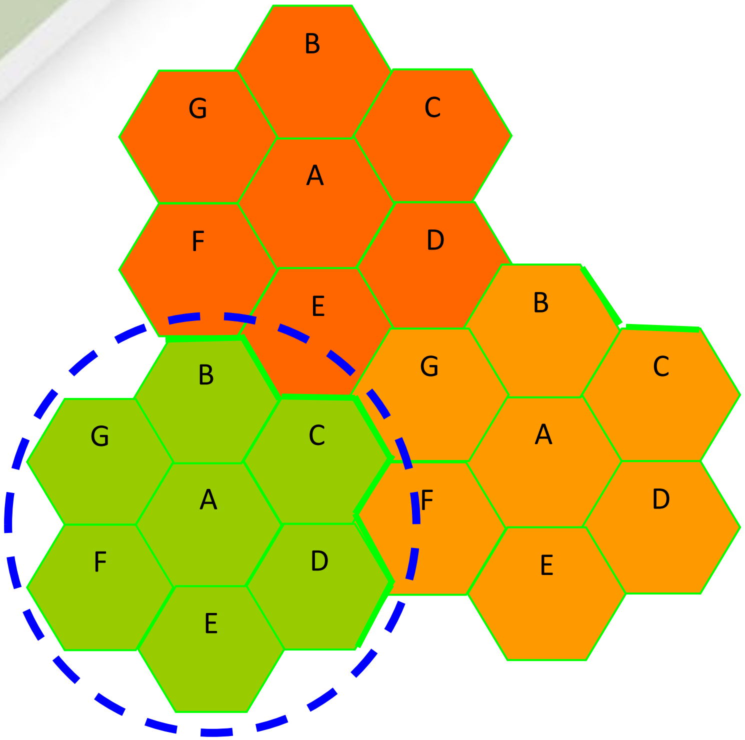
- **centre-excited, base station is at the centre of the cell**
- **edge-excited, base station at 3 of the 6 cell vertices**





centre-excited **edge-excited**

Cell cluster



- **Consist of some cells adjacent to each other.**
- **No frequency reuse in the interior of a cell cluster.**
- **Cell cluster becomes the smallest unit of cellular systems.**

Capacity of Cellular System

(PP. 51-52)

Total number of available channels:

$$S = kN$$

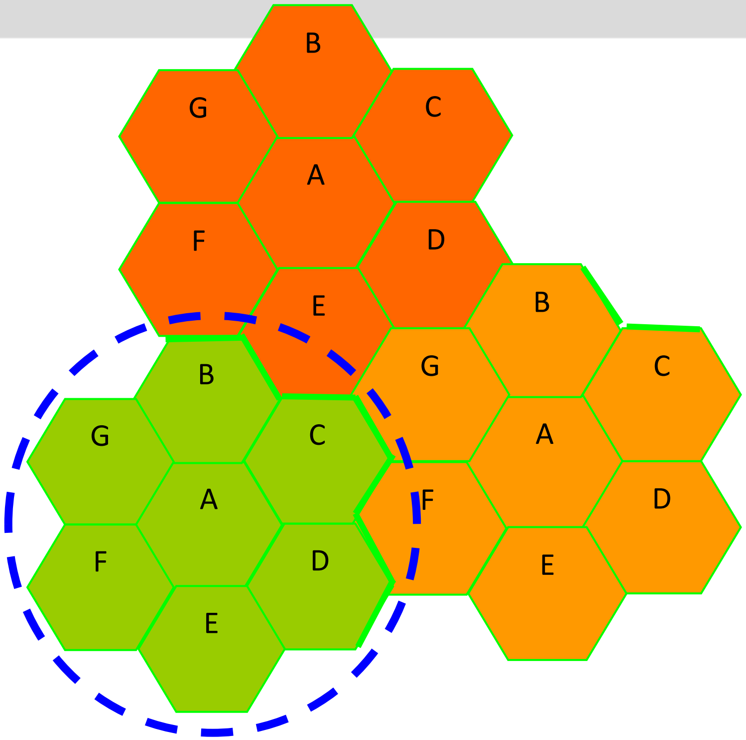
$$(28 = 4 \times 7)$$

Total number of channels of the cellular system:

$$C = MS$$

$$(84 = 3 \times 28)$$

C **can be used as a measure of capacity !**



Cluster Size : *N* = 7

Available channels: 28

"Frequency reuse factor" : 1/*N*

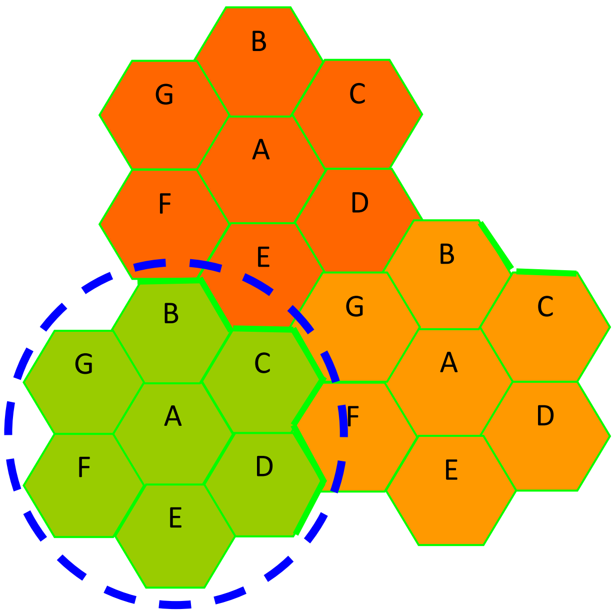
Question 1

What is the relationship between *N* and *C* ?

or Given *S*, *N*↓ ⇒ *C* ?

***Answer* :**

Given *S*, *N*↓ ⇒ *M*↑ ⇒ *C*↑



Smaller cluster size means larger capacity !

Example 1

A mobile communication system uses a frequency reuse factor of 1/7 and 420 channels available. If 21 channels are allocated as control channels, assume a traffic channel supports 8 users, compute the number of simultaneous users per cell.

Solution:

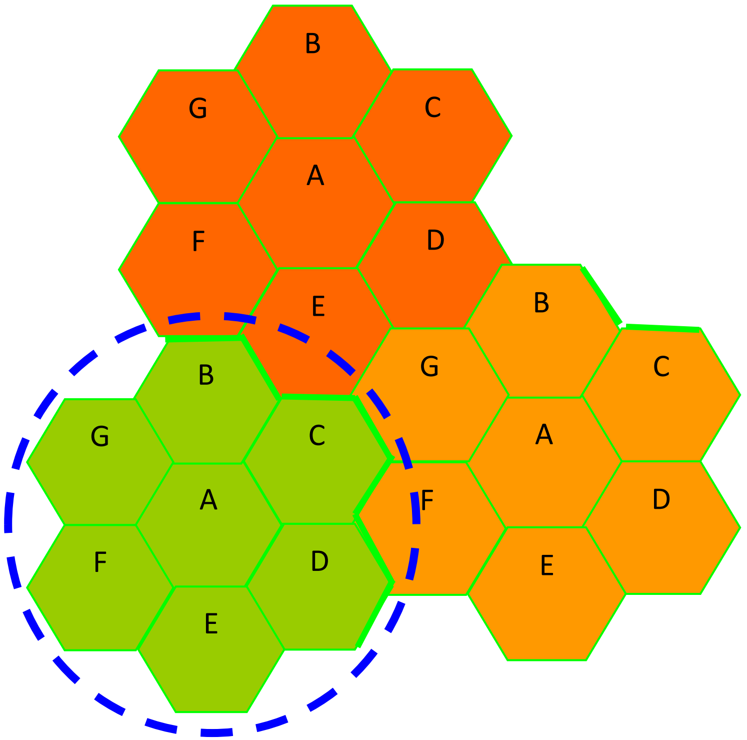
Channels available for allocation = 420 - 21 = 399

Channel Number of a cell = 399 / 7 = 57

Number of simultaneous users per cell = 8 x 57 = 456

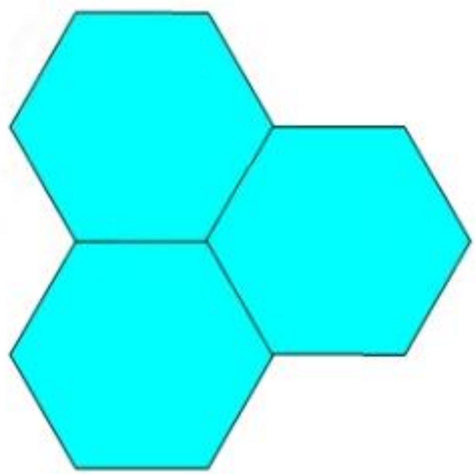
Conditions to be a Cell cluster

- **Seamless coverage of the whole area by cells adjacent to each other.**
- **The distance between two nearest co-channel cells is constant.**



What is “Adjacent to each other”?

- 什么是“相互邻接”？区群中任意正六边形小区都至少与区群中另外两个小区存在公共边。



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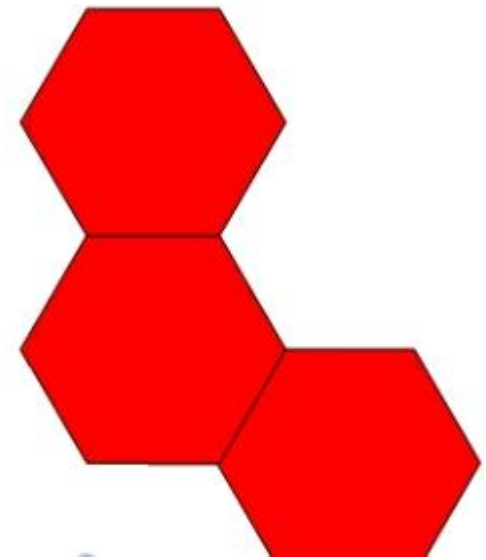

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Cluster size

(PP. 52)

The cluster size N cannot be chosen as arbitrary integer.

It should satisfy :

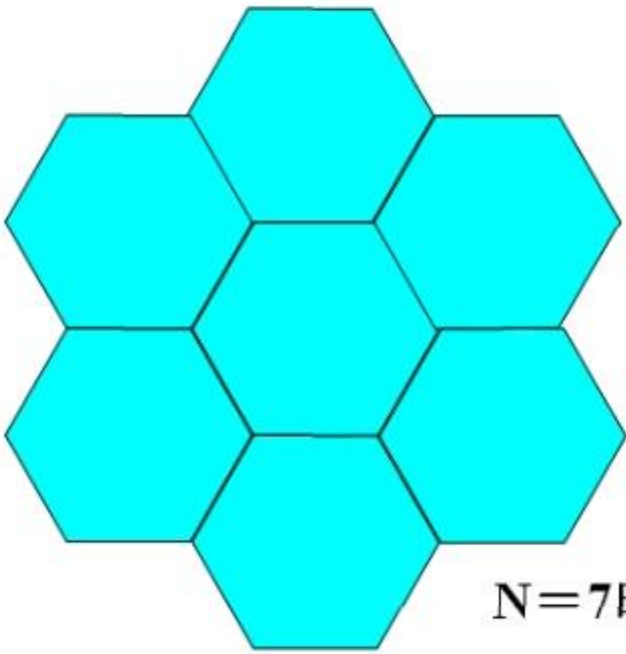
$$N = i^2 + ij + j^2$$

where i and j are both natural number.

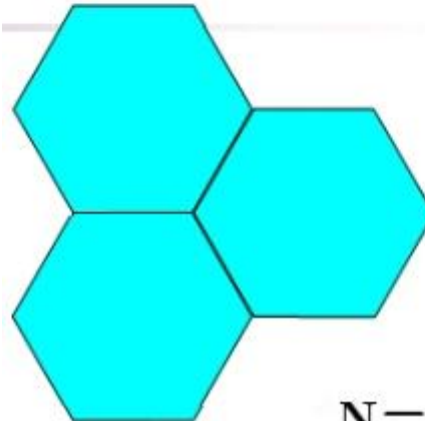
Cluster size

N \ i / j	0	1	2	3	4
1	1	3	7	13	21
2	4	7	12	19	28
3	9	13	19	27	37
4	16	21	28	37	48

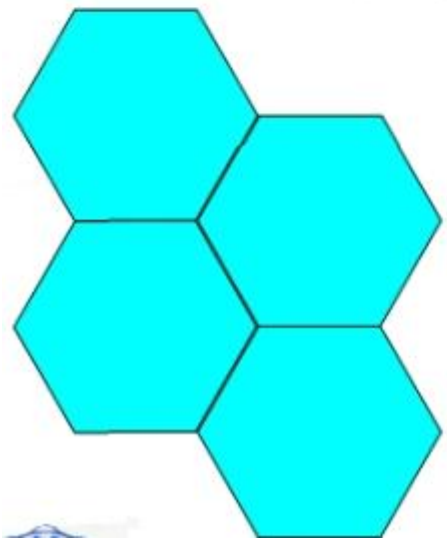
Cell cluster shapes



N＝7时

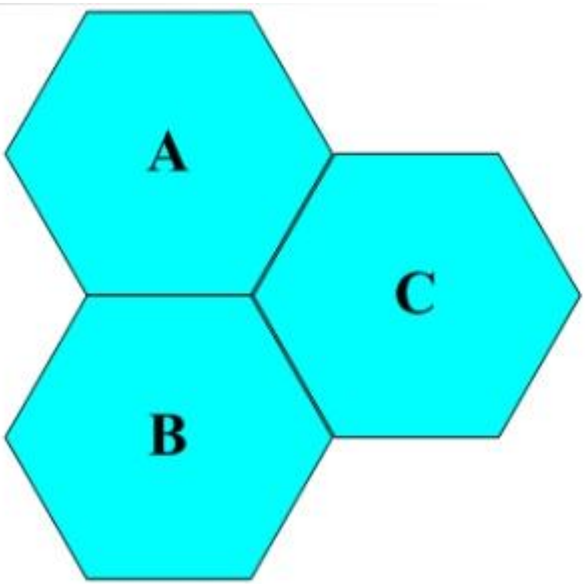


N＝3时



N＝4时

Frequency Assignment in a cell cluster



N=1.

Full frequency reuse.

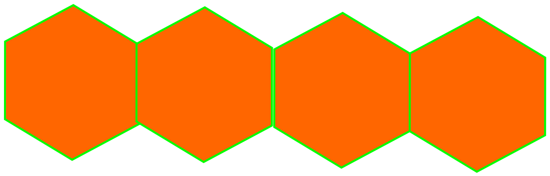
CDMA

N=3.

Frequencies are assigned to 3 cells.

Questions

Can these cells form a cluster ?



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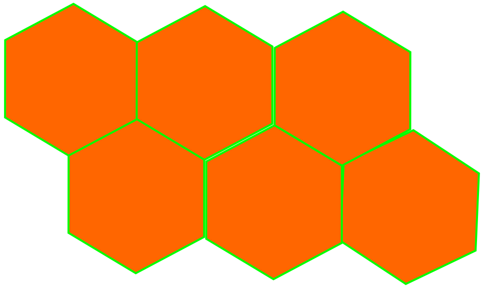


(×)

$$N = i^2 + ij + j^2$$

Co-channel cells

- **Co-channel cells : use the same frequency channels**
- **Distribution of the co-channel cells should be regular**
- **Co-channel reuse distance : the distance between two nearest co-channel cells**

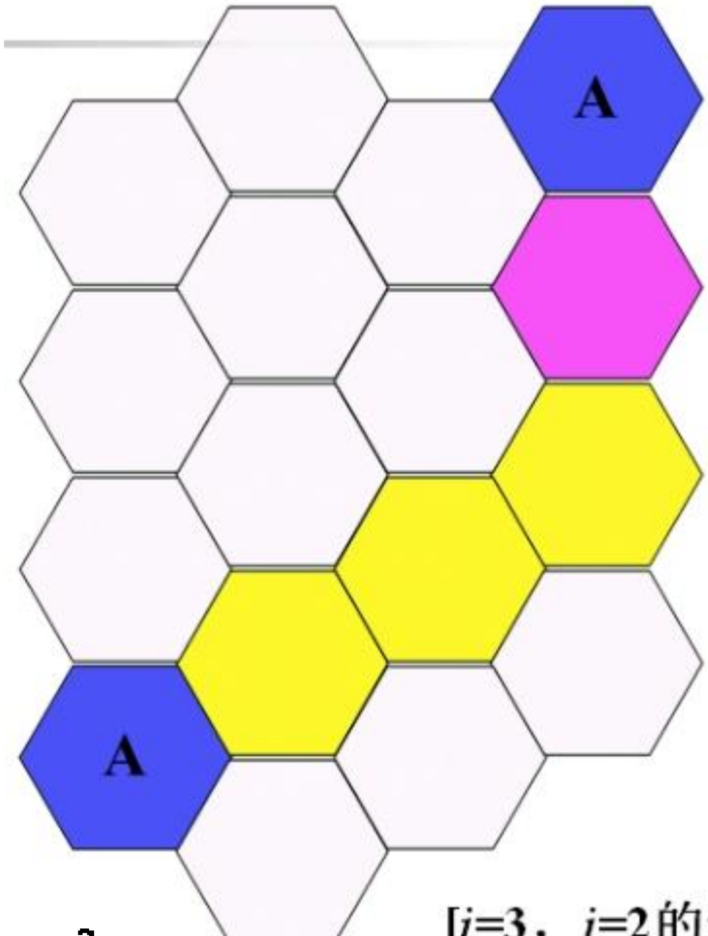
Method of locating co-channel cells

(PP. 53)

- 同频小区的确定：

1）沿某正六边形小区一条边的垂线方向行进i个小区；

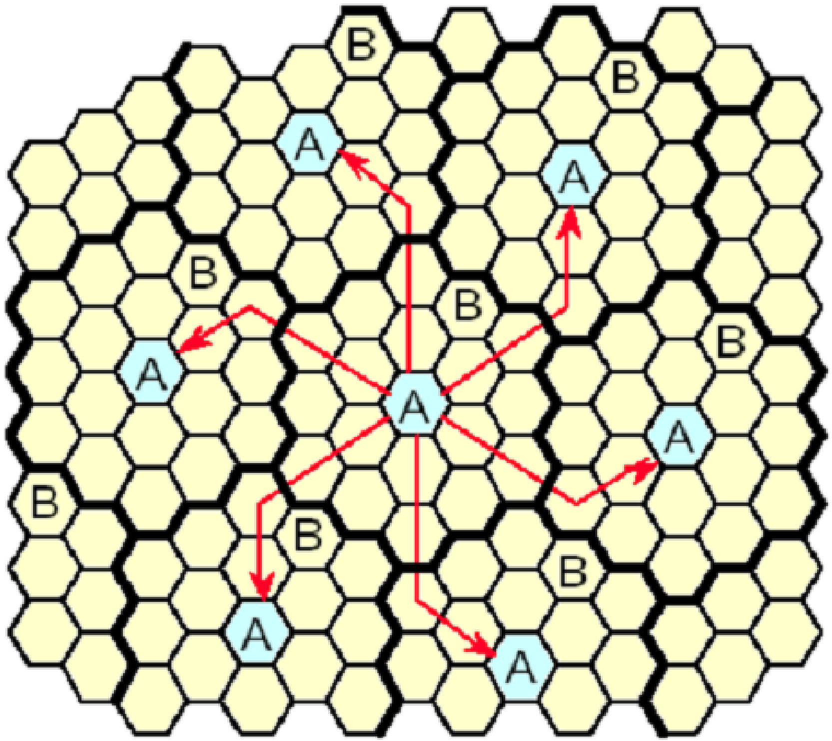
2）逆时针旋转**60**°后再向前行进j个小区。所到达的小区可以与原始小区使用相同的频道组。



[i=3，j=2的情形]

$$N = i^2 + ij + j^2$$

Method of locating co-channel cells



PP. 53

$$N = i^2 + ij + j^2 \qquad i = 3,\ j = 2$$

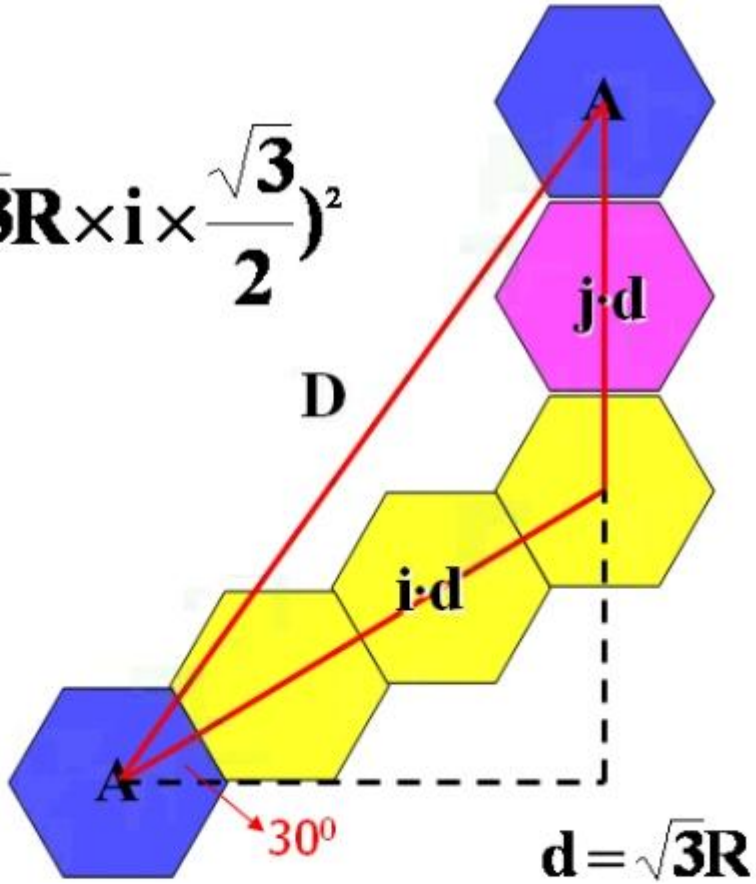
Co-channel reuse distance

$$D^2 = (\sqrt{3}R \times i \times \frac{1}{2} + \sqrt{3}R \times j)^2 + (\sqrt{3}R \times i \times \frac{\sqrt{3}}{2})^2$$

$$= 3R^2(i^2 + i \times j + j^2)$$

$$= 3NR^2$$

$$\therefore \qquad D = \sqrt{3N}R$$



N : cluster size

Distribution of the co-channel cells

N = 3 case

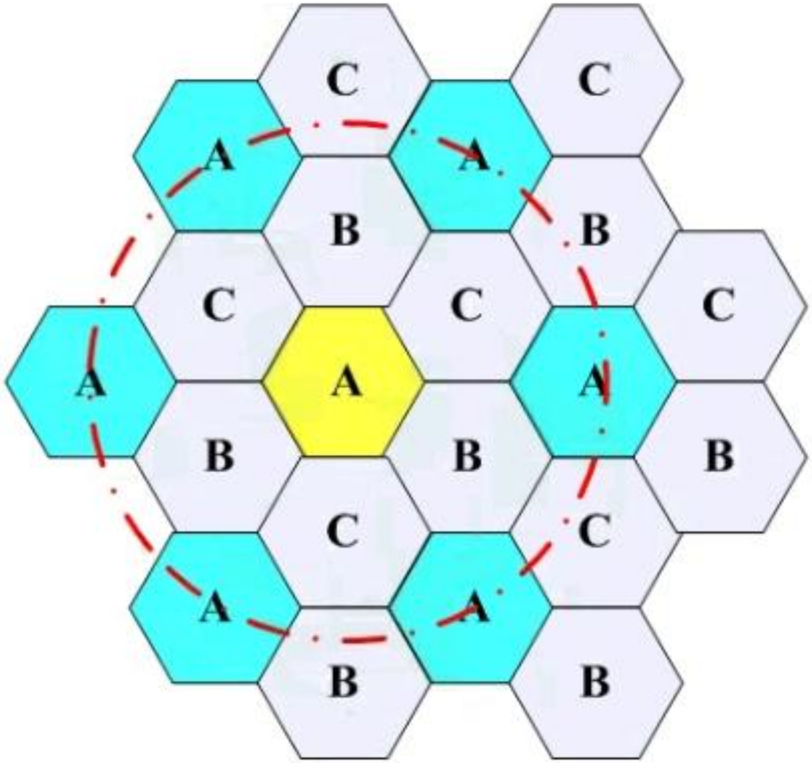
Tier 1 : 6

Tier 2 : 12

… …

Tier n : 6n

D, 2D, 3D, … … , nD



Six co-channel cells in Tier 1

Summary

1. Cellular Geometry

1.1 Cell cluster

1.2 Cluster size

1.3 Locating co-channel cells

1.4 Co-channel reuse distance

Chapter 2

1. Cellular Geometry
2. **Channel Assignment and handoff**
3. Interference and System Capacity
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Channel Assignment Strategies

(PP. 54)

Two assignment approaches

- **Fixed and static (most common)**
- **Dynamic**

Fixed Channel Assignment

Fixed channel assignment

All channels in a cell could be in use all the time

– new calls are then blocked (no channels left)

– may be solved by borrowing spare channels from nearby cells

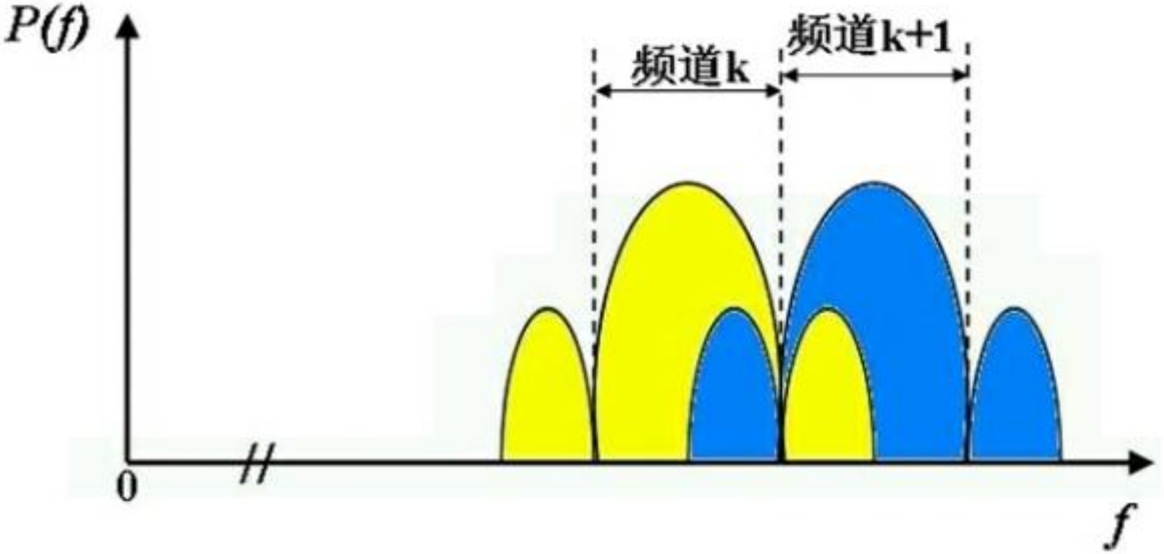
How to divide channels ?

Adjacent channel interference and near-far effect

Channel Assignment strategies for reducing the Adjacent channel interference

Adjacent channel interference

- 邻频（/邻道）干扰：使用有用接收信号的相邻信道的干扰信号称为邻频干扰。



Channel Assignment strategies

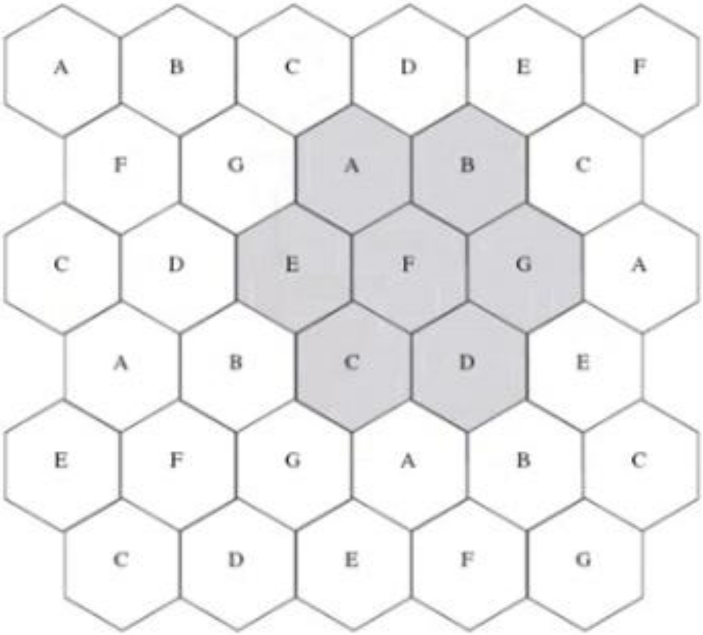
Example 1

N = 7

Available channel S = 21

信道组	信道号
A	1、8、15
B	2、9、16
C	3、10、17
D	4、11、18
E	5、12、19
F	6、13、20
G	7、14、21

Example 1



信道组	信道号
A'	1、8、15
B'	5、12、19
C'	7、14、21
D'	3、10、17
E'	6、13、20
F'	4、11、18
G'	2、9、16

Dynamic channel assignment

Dynamic channel assignment

- MSC allocates frequencies when a call is made
- Provides high channel utilization

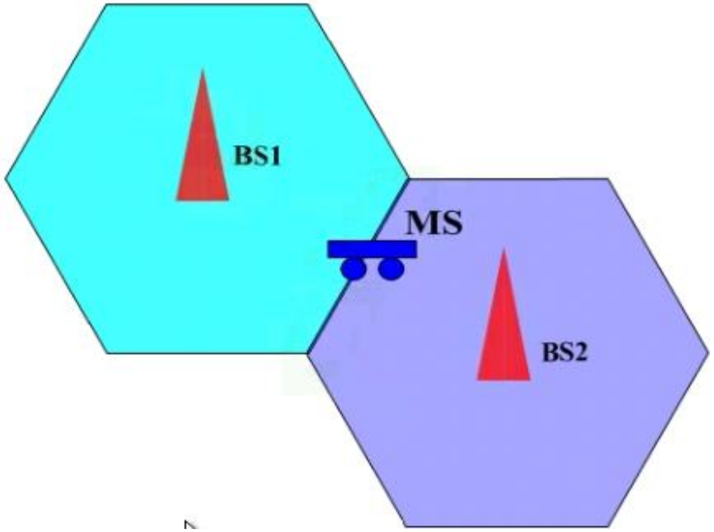
To do this it needs real-time information on

- channel occupancy
- traffic distribution
- radio signal strength indication (RSSI)

high computational load and increased storage

Handoff

- **Participant roles** : **MS、BS1、BS2、MSC**
- **Condition** : **MS moves into another cell while a conversation is in progress**
- **Operation of system** : **change the channels**



Handoff

Provides continuity of communication across cells

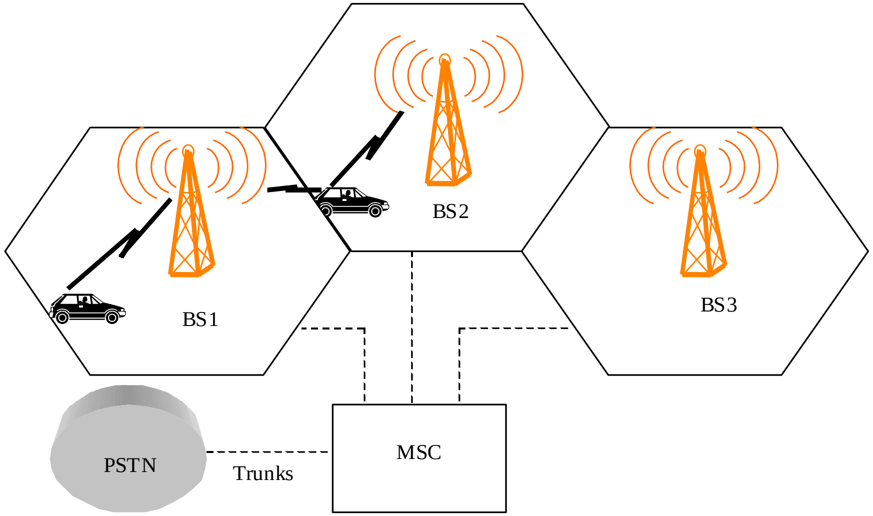
- **Difficulty**
  - **dropping a call before reconnecting is unacceptable**
  - **different cells use different frequencies**
  - **mobile phone users usually move from place to place and very quickly**

Handoff Process

Received signal weakens as mobile moves out of cell

Cell site at some point requests handoff to cell with stronger signal strength

MSC switches call to new cell after allocating channels.



When the Handoff Happens?

(PP. 55)

Handoff must not be too frequent or system is kept busy servicing handoff requests

- **handoff threshold is set slightly stronger**
- **Minimum usable signal level is normally set to be between -90 dBm and -100 dBm**

Choosing Handoff Margins

(PP. 55)

Handoff margin Δ

Δ = P r handoff - Pr minimum usable

- If Δ is too large, unnecessary handoff will occur, burdening the MSC
- If Δ is too small, there maybe insufficient time to complete the handoff before a call is lost due to weak signals
- Therefore Δ is chosen carefully

Setting Handoff Thresholds

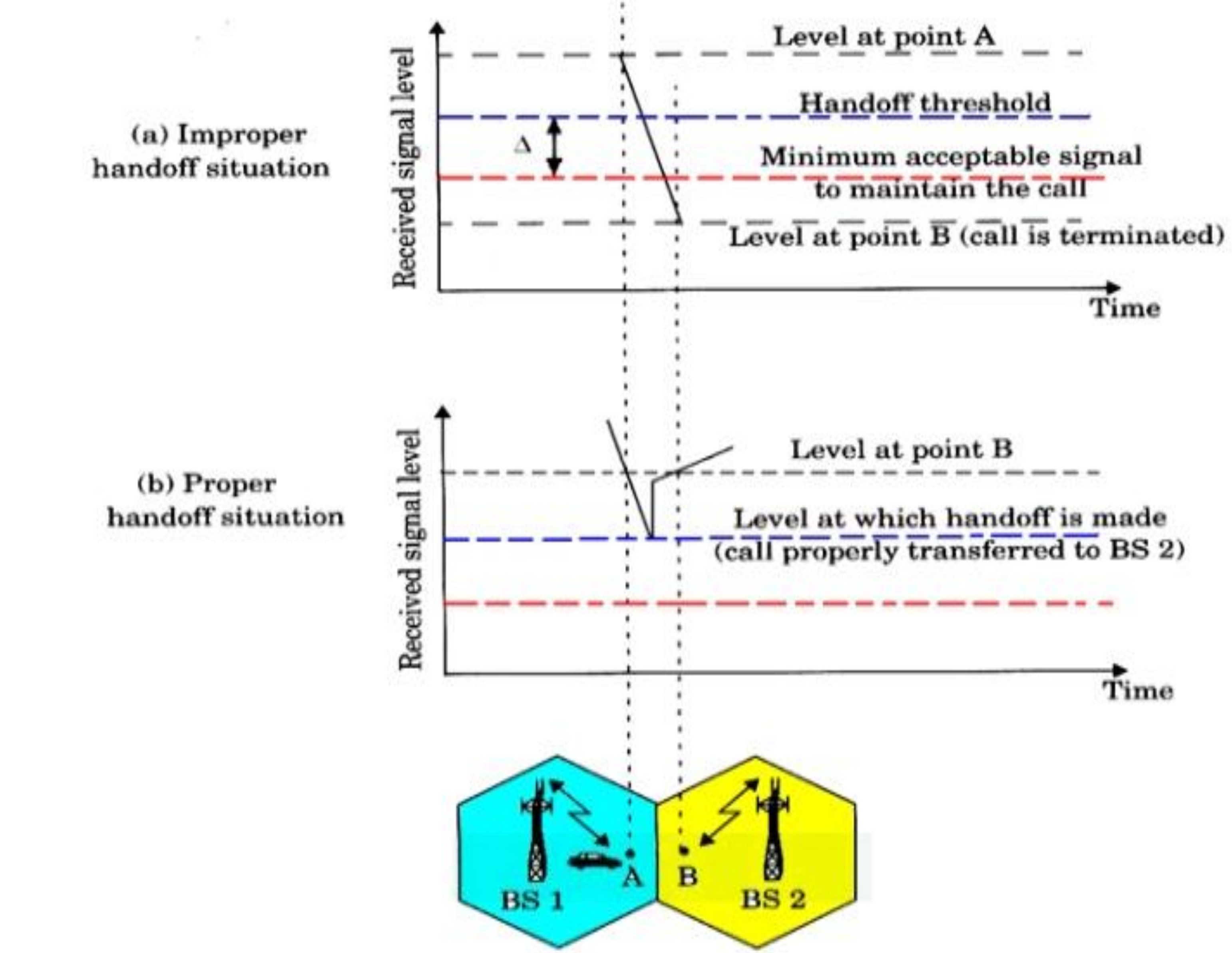


Figure 3.3 Illustration of a handoff scenario at cell boundary.

Handoff in different system

- 1G : Signal strength measurements are made by the base stations and supervised by the MSC
- GSM : MAHO, handoff decisions are mobile assisted
- CDMA : Pilot channel, Soft handoff

Practical Handoff

(PP. 57)

- **Macrocell and Microcell**
- **Cell dragging**
- **Handoff duration**
- **Handoff foundation**

Summary

2. Channel Assignment and handoff

2.1 Fixed channel assignment

2.2 Dynamic channel assignment

2.3 Handoff Process

2.4 Handoff Time

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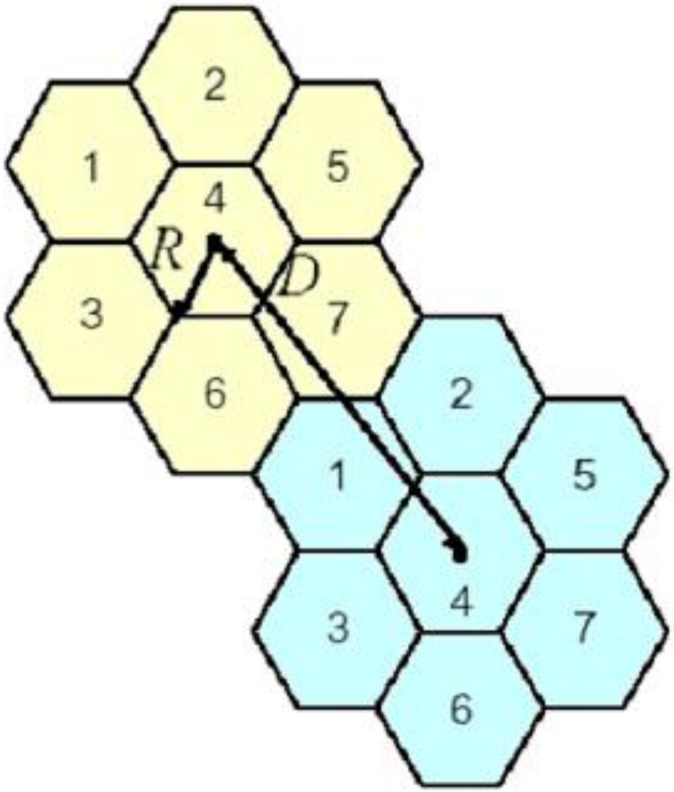
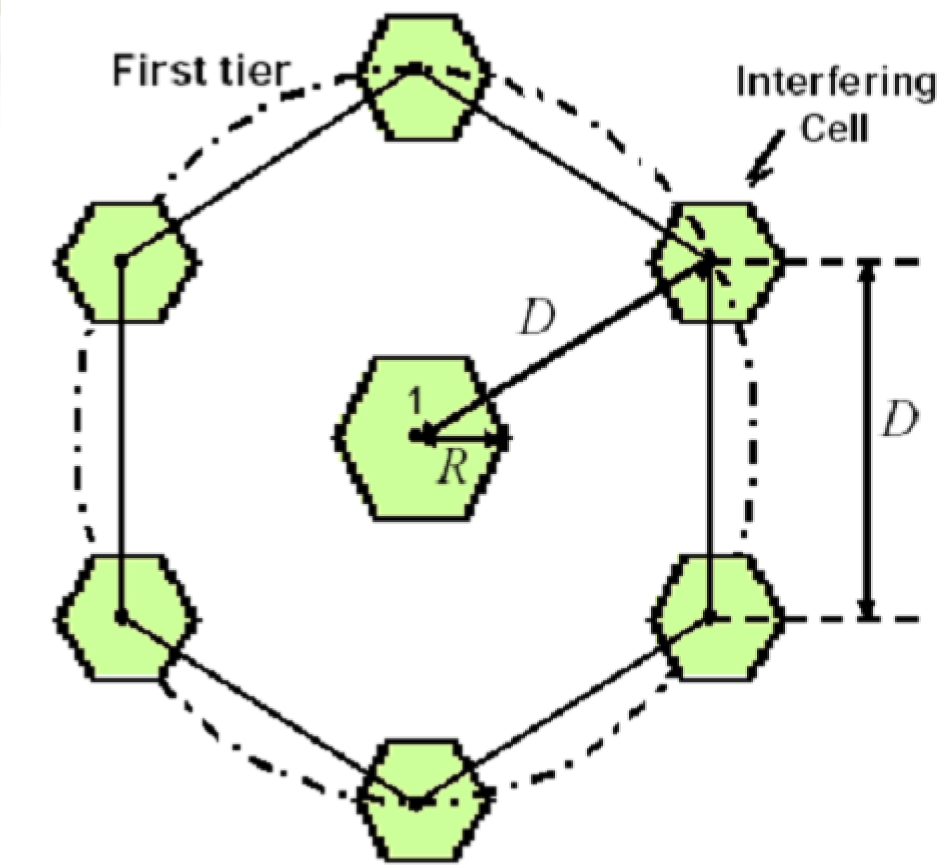
Co-channel reuse ratio

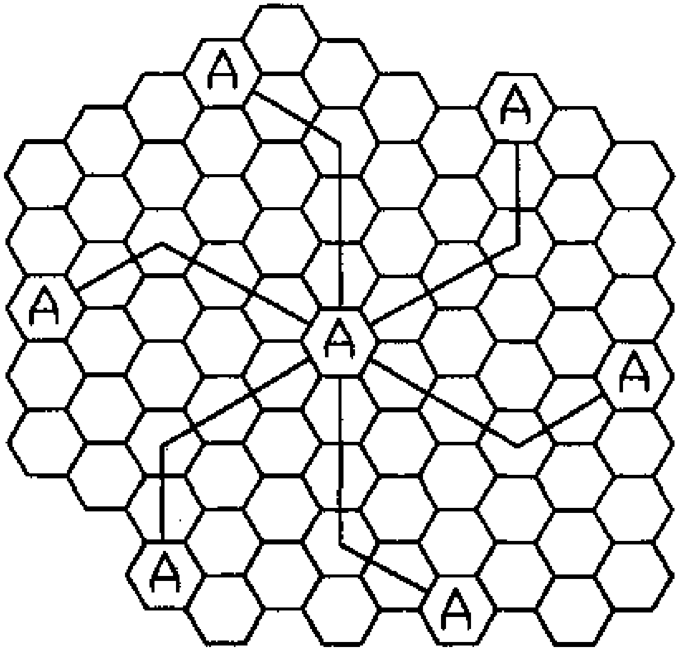


Q = co-channel reuse ratio
D = frequency reuse distance
R = cell radius
N = # cells per cluster
$1/N$ = frequency reuse factor

$$Q = \frac{D}{R}$$

Six Effective Interfering Cells of Cell 1





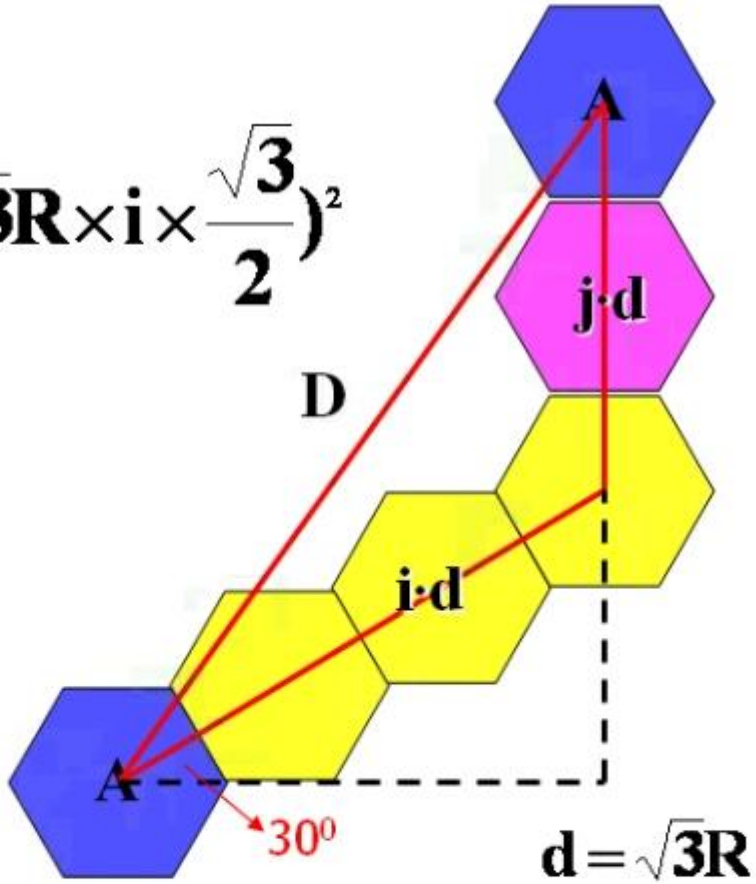
Co-channel reuse distance

$$D^2 = (\sqrt{3}R \times i \times \frac{1}{2} + \sqrt{3}R \times j)^2 + (\sqrt{3}R \times i \times \frac{\sqrt{3}}{2})^2$$

$$= 3R^2(i^2 + i \times j + j^2)$$

$$= 3NR^2$$

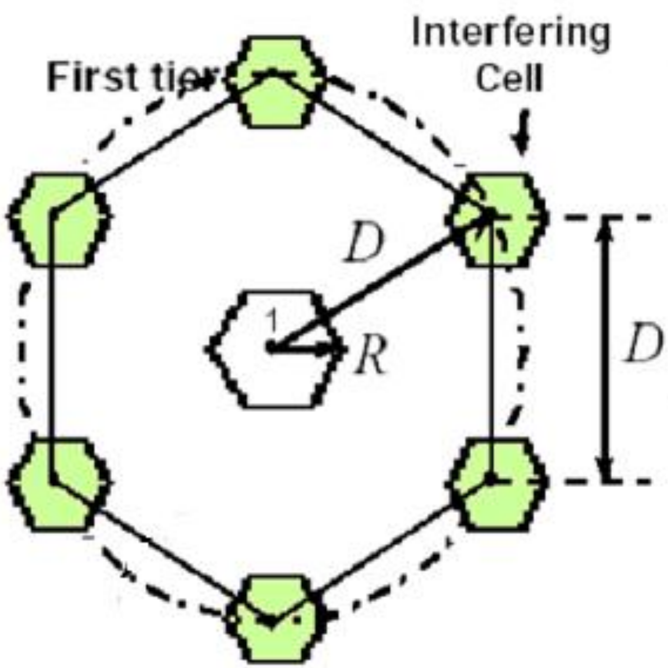
$$\therefore \qquad D = \sqrt{3N}R$$



N : cluster size

Co-channel reuse ratio Q

(PP. 60)

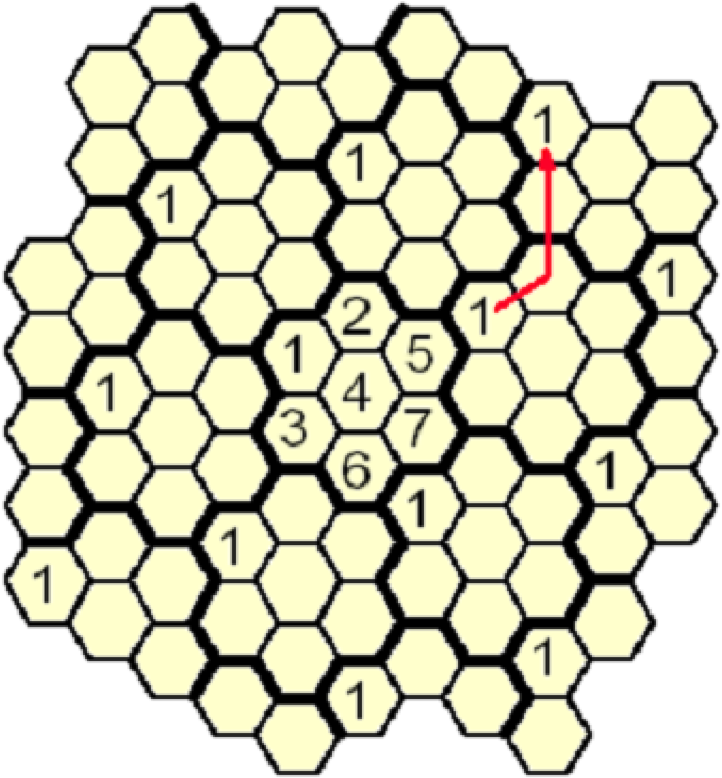


$$D^2 = 3R^2\left(i^2 + ij + j^2\right)$$

$$\frac{A_{large}}{A_{small}} = 3\left(i^2 + ij + j^2\right) = \frac{D^2}{R^2} = 3N$$

$$\boxed{\frac{D}{R} = Q = \sqrt{3N}}$$

7-cell reuse pattern

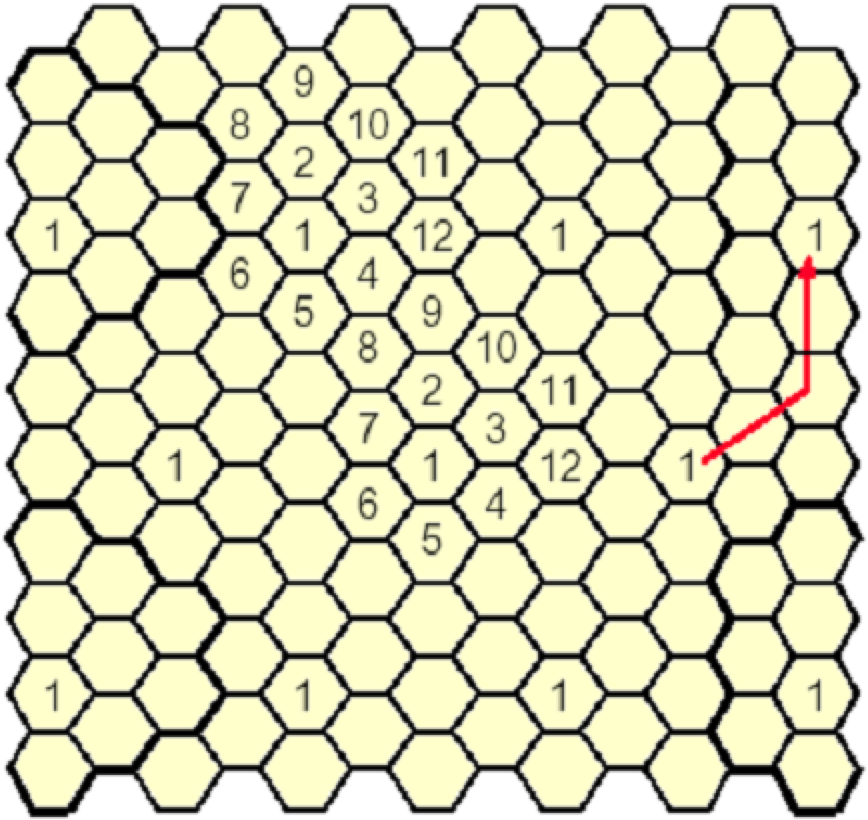


$i = 1, j = 2$

$N = i^2 + ij + j^2 = 7$

$Q = \sqrt{3N} = 4.58$

12-cell reuse pattern

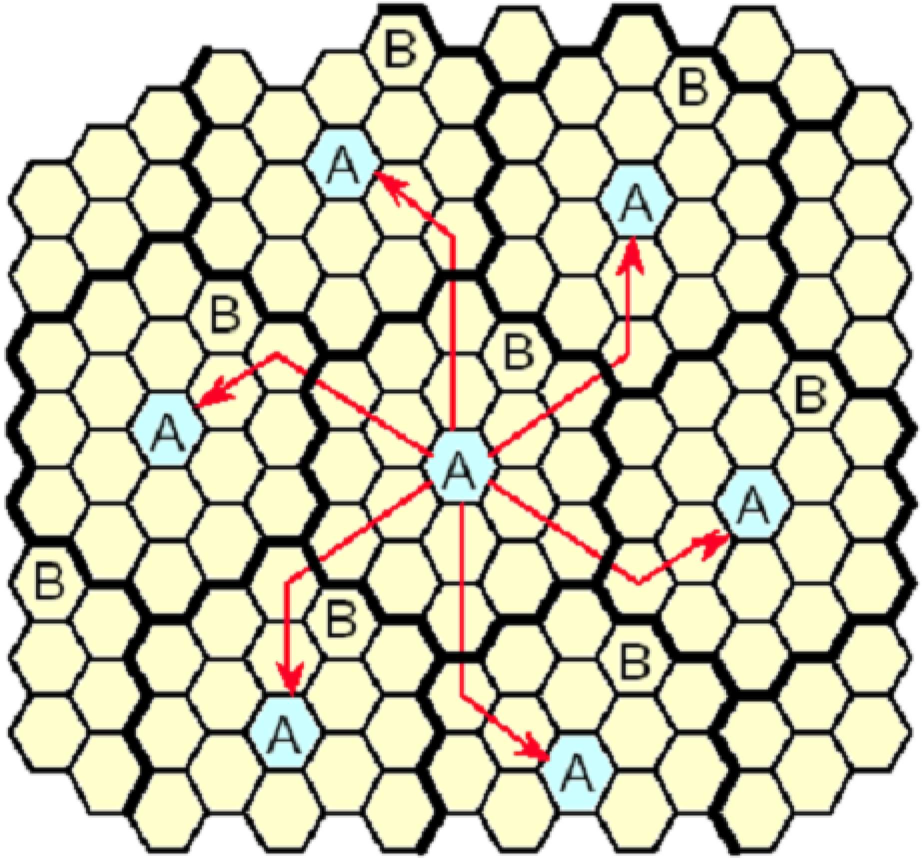


$i = 2, j = 2$

$N = i^2 + ij + j^2 = 12$

$Q = \sqrt{3N} = 6$

19-cell reuse pattern



$i=3, j=2$

$N=i^2+ij+j^2=19$

$Q=\sqrt{3N}=7.55$

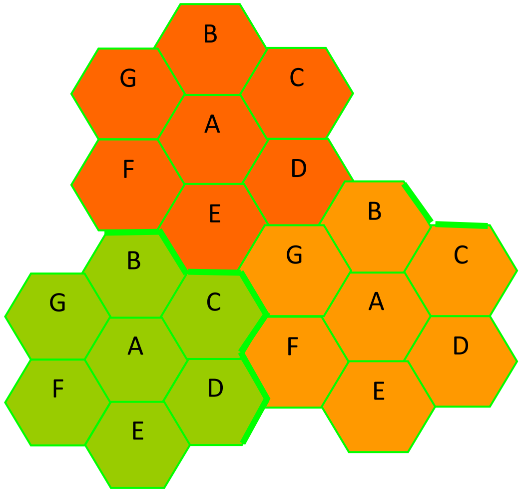
Co-channel reuse ratio vs. frequency reuse pattern

i	j	$N = \left(i^2 + i\,j + j^2\right)$	$Q = D/R = \sqrt{3N}$
1	0	1	1,73
1	1	3	3,00
2	0	4	3,46
2	1	7	4,58
3	0	9	5,20
2	2	12	6,00
3	1	13	6,24
4	0	16	6,93
3	2	19	7,55
4	1	21	7,94
3	3	27	9,00

Question 2

What is the relationship between *N* and *I* ?

or $N\downarrow \Rightarrow I$ **?**



Answer : $N\downarrow \Rightarrow D\downarrow \Rightarrow I \uparrow$

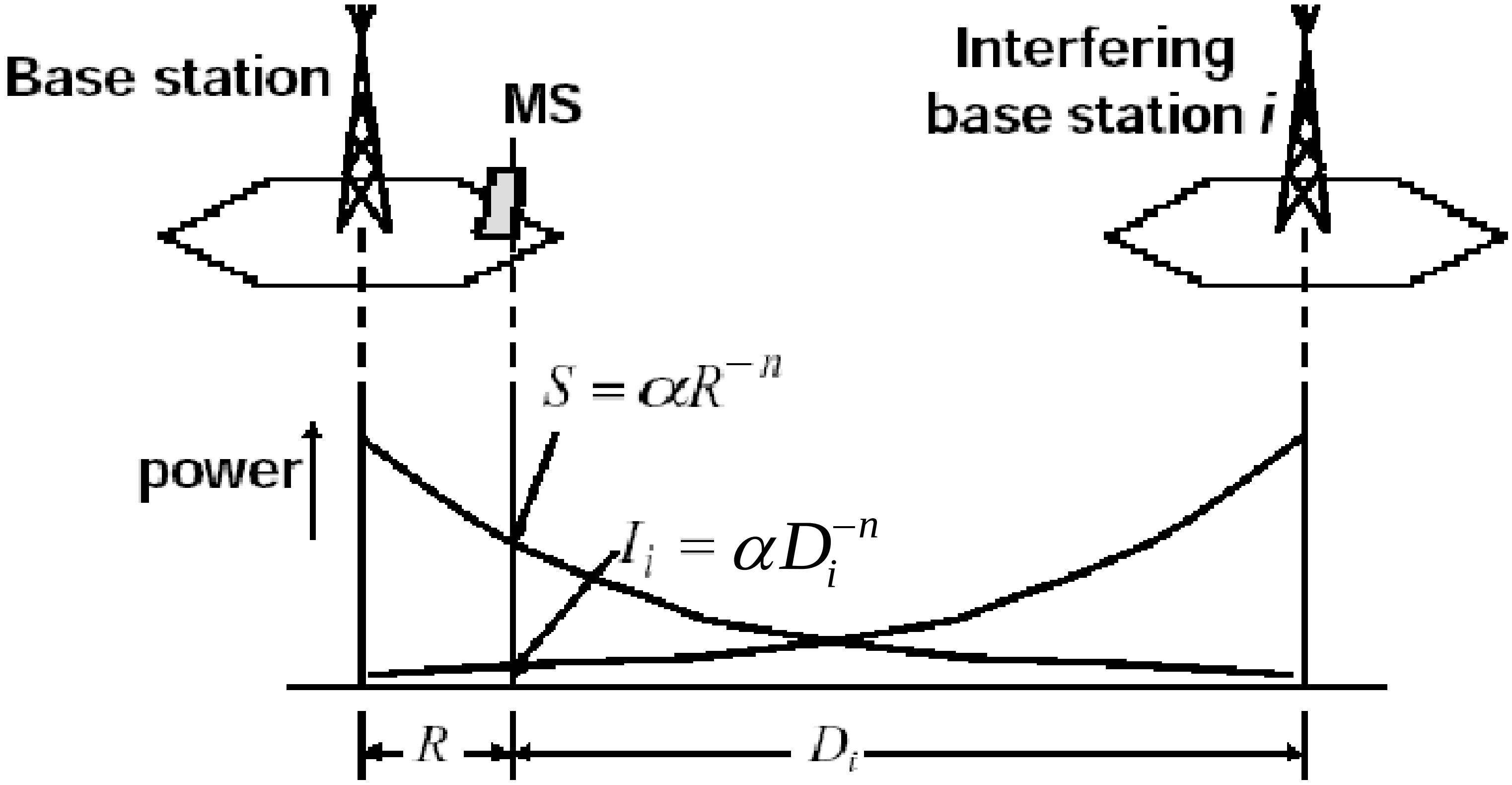
Smaller cluster size means larger interference.

$$N\downarrow \Rightarrow \begin{cases} C\uparrow \\ I\uparrow \Rightarrow S/I\downarrow \end{cases}$$

Trade-off !

Propagation model

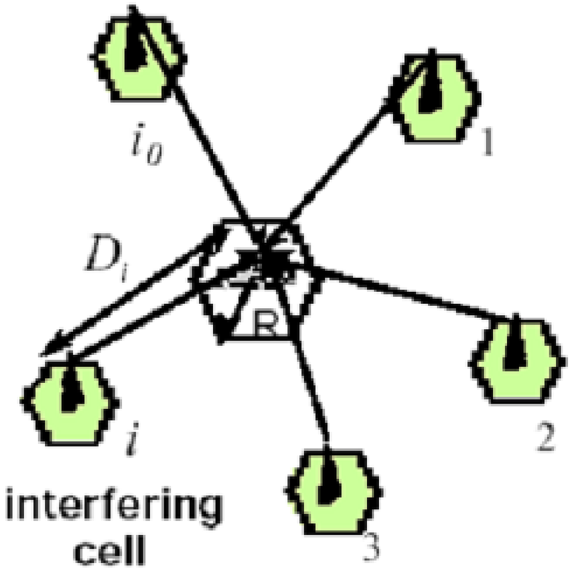
(PP. 60)



n **= path loss exponent (in urban areas: 2 < *n* < 5)**

$$\boxed{P_r(d) = \alpha d^{-n}}$$

Co-channel interference ratio



For a hexagonal-shaped cellular system:

i_0 interfering cells

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0}(I_i)}, \quad S = \alpha R^{-n}, \quad I_i = \alpha D_i^{-n}, \quad 2 \le n \le 5$$

$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{i_0} D_i^{-n}} = \frac{1}{\sum_{i=1}^{i_0}\left(\frac{D_i}{R}\right)^{-n}} = \frac{(D/R)^n}{i_0} = \frac{\left(\sqrt{3N}\right)^n}{i_0}$$

$$i_0 = 6 \Rightarrow \frac{S}{I} = \frac{Q^n}{6}$$

$$\Rightarrow \quad Q = \left(6\frac{S}{I}\right)^{\frac{1}{n}}$$

$$\frac{S}{I} = \frac{\alpha R^{-n}}{6\alpha D^{-n}} = \frac{(D/R)^n}{6} = \frac{(Q)^n}{6} = \frac{\left(\sqrt{3N}\right)^n}{6}$$

Co-channel reuse ratio vs. frequency reuse pattern

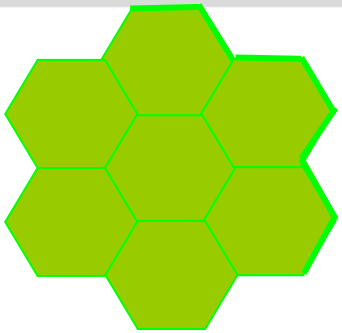
$$\boxed{\frac{D}{R} = Q = \sqrt{3N}}$$

$$Q \Downarrow \Rightarrow \begin{cases} N \Downarrow \Rightarrow \textit{channels/cell} \Uparrow \Rightarrow \textit{traffic capacity} \Uparrow \\ S/I \Downarrow \Rightarrow \textit{more co-channel interference} \end{cases}$$

Challenge: How to obtain the smallest number *N* which can still meet our system performance requirements.

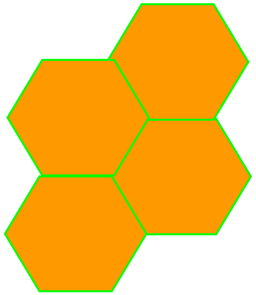
Example of Cellular System Design

1. Analogue cellular system (e.g. AMPS)



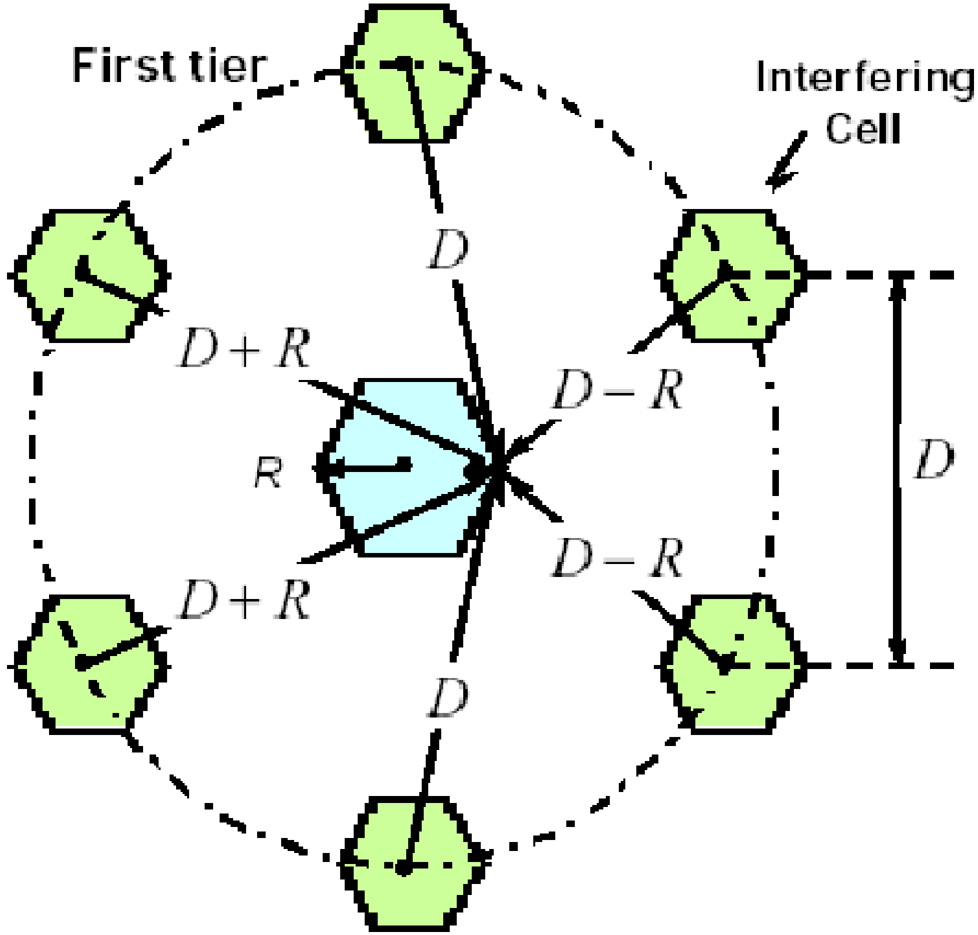
$$\frac{S}{I} = \frac{(\sqrt{3N})^n}{6} \geq 18dB, n = 4 \Rightarrow N \geq 6.49 \approx 7$$

2. Digital cellular system (e.g. GSM)



$$\frac{S}{I} = \frac{(\sqrt{3N})^n}{6} \geq 12dB, n = 4 \Rightarrow N \geq 3.24 \approx 4$$

More exact geometry layout



Closely approximately as

$$\frac{S}{I} = \frac{R^{-n}}{\sum D_i^{-n}} = \frac{R^{-n}}{2(D-R)^{-n} + 2(D+R)^{-n} + 2D^{-n}}$$

Using $n = 4$ and $D/R = Q = 4.6$,

$$\frac{S}{I} = \frac{1}{2(Q-1)^{-4} + 2(Q+1)^{-4} + 2Q^{-4}} = 54.3 = 17.3 \text{ dB}$$

Exercise

Consider a cellular system. The required minimum SIR is 15 dB, the path loss exponent *n*=4. Find the optimal *N*.

$$\cancel{\Rightarrow} N = 5$$

$$\left.\begin{array}{r} \dfrac{S}{I} = \dfrac{\left(\sqrt{3N}\right)^4}{6} \geq 15 \text{ dB} = 31.623 \;\Rightarrow\; N \geq 4.59 \\[2ex] N = i^2 + ij + j^2 \end{array}\right\} \Rightarrow N = 7$$

3. Interference and System Capacity

3.1 Co-channel reuse ratio

$$Q = D / R = \sqrt{3N}$$

3.2 Co-channel interference ratio

$$\frac{S}{I} = \frac{(Q)^n}{6} = \frac{\left(\sqrt{3N}\right)^n}{6}$$

Chapter 2

1. Cellular Geometry
2. Channel Assignment and handoff
3. Interference and System Capacity
4. **Trunking and Grade of Service**
5. Improving Capacity in Cellular System

Trunking

(PP. 67)

- Trunking: large number of users share a relatively small number of channels
- Each user is allocated a channel on a PER CALL basis
- All channels in use: new user is BLOCKED or has to WAIT in a queue
- Trunking theory: A.K. Erlang (1917)

Grade of Service (GOS)

(PP. 68)

Grade of Service (GOS)

- Measure of the ability of a user to access a trunked system during the busiest hour.
- A measure of congestion

Prob. [call is blocked] or Prob. [delay > T]

The probability of a call being blocked (for Erlang B), or the probability of a call being delayed beyond a certain amount of time (for Erlang C).

Traffic Intensity

(PP. 68)

Traffic Intensity

- Measure of channel time utilization, which is the average channel occupancy measured in Erlangs.
- This is a dimensionless quantity and may be used to measure the time utilization of single or multiple channels.

Measure of traffic intensity: Erlang

1 Erlang = amount of traffic intensity carried by a channel that is completely occupied.

About Erlang

- On average, during the busy hour, a company makes 120 outgoing calls of average duration 2 minutes. It receives 200 incoming calls of average duration 3 minutes. Find: (1) the outgoing traffic,(2) the incoming traffic,(3) the total traffic.

(1) The outgoing traffic is $120 \times 2 / 60 = 4 \quad \text{erlang}$

(2) The incoming traffic is $200 \times 3 / 60 = 10 \quad \text{erlang}$

(3) The total traffic is $4 + 10 = 14 \quad \text{erlang}$

During the busy hour, on average, a customer with a single telephone line makes three calls and receives three calls. The average call duration is 2 minutes. What is the probability that a call finds the line engaged?

Occupancy of line $= (3+3) \times 2 / 60 = 0.2$

Traffic Intensity

(PP. 68)

- The traffic intensity per user

$$A_u = \lambda H$$

λ: Average number of call requests per unit time per user

H: Average duration of a call

- The total offered traffic intensity

$$A = UA_u$$

U: Total number of users

- The traffic intensity per channel

$$A_c = UA_u / C$$

C: Total number of channels

Erlang B formula

(PP. 68)

For blocked calls cleared system

$$Pr[blocking] = \frac{\frac{A^C}{C!}}{\sum_{k=0}^{C} \frac{A^k}{k!}} = GOS$$

C is the number of trunked channels offered by a trunked radio system

A is the total offered traffic

$$GOS = \Pr[B] = f(A,\ C)$$

$$ErlangB \sim f(A,\ C)$$

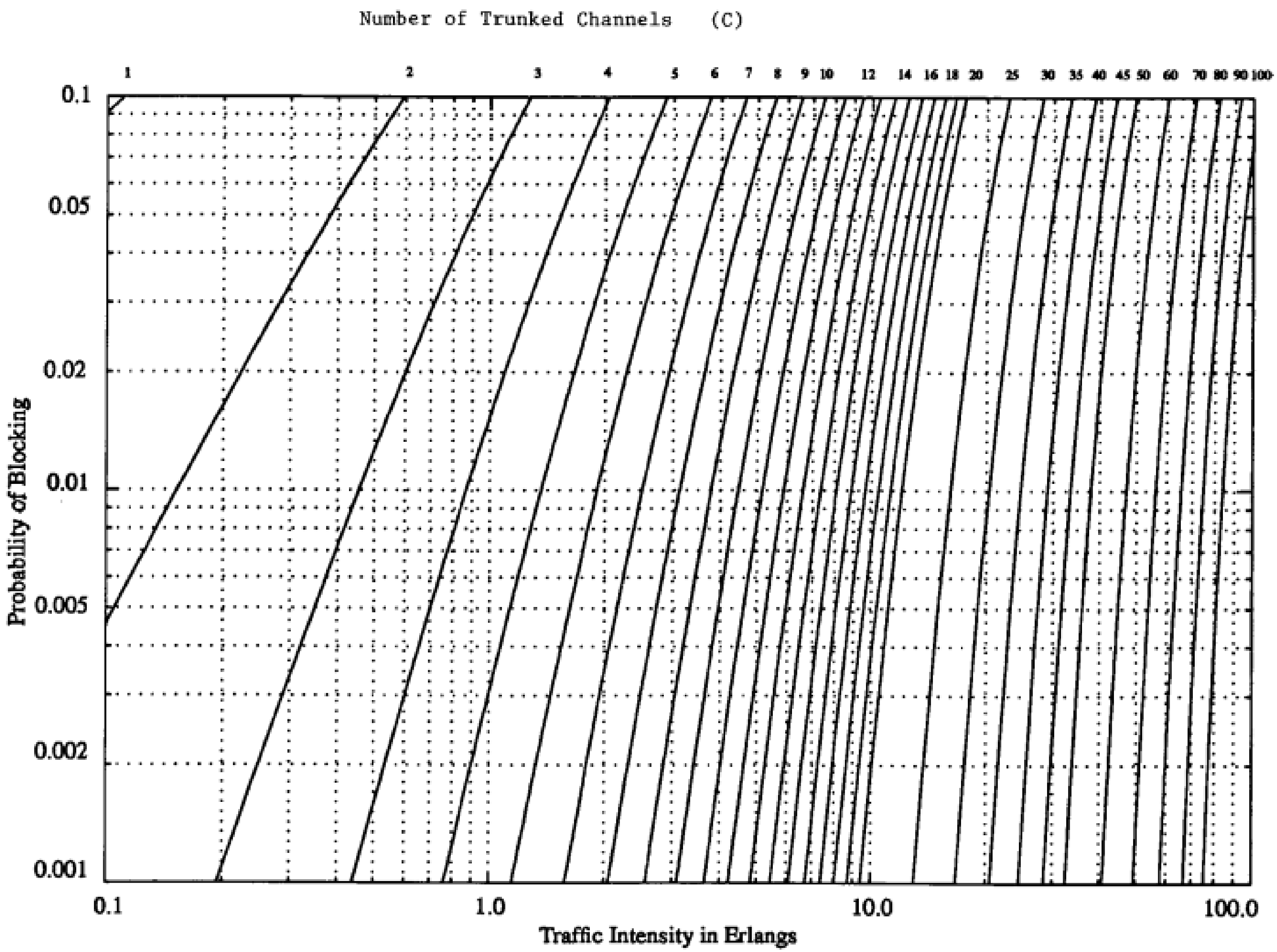
Capacity of Erlang B

(PP. 69)

Table 3.4 Capacity of an Erlang B System

Number of Channels *C*	Capacity (Erlangs) for GOS = 0.01	= 0.005	= 0.002	= 0.001
2	0.153	0.105	0.065	0.046
4	0.869	0.701	0.535	0.439
5	1.36	1.13	0.900	0.762
10	4.46	3.96	3.43	3.09
20	12.0	11.1	10.1	9.41
24	15.3	14.2	13.0	12.2
40	29.0	27.3	25.7	24.5
70	56.1	53.7	51.0	49.2
100	84.1	80.9	77.4	75.2

Erlang B Chart (PP. 71)



Example 3

Trunked mobile network provide cellular service in this area. System has 394 cells with 19 channels each. Find the number of users that can be supported at *2%* blocking if each user averages 2 calls per hour at an average call duration of 3 minutes. Compute the total number of subscribers that can be supported by this system.

Probability of blocking = *2% =0.02*

Number of channels per cell used in the system, C=19

Traffic intensity per user, $A_u = \lambda H = 2 \times (3/60) = 0.1$ Erlangs

from the Erlang B chart, the total carried traffic, *A,* is obtained as 12 Erlangs.

Therefore, the number of users that can be supported per cell is

$U = A/A_u = 12/0.1 = 120$

Since there are 394 cells, the total number of subscribers that can be supported by System A is equal to 120 x 394 = 47280

表 3-5　爱尔兰呼损表

B	1%	2%	3%	5%	7%	10%	20%
n	A	A	A	A	A	A	A
1	0. 010	0. 020	0. 031	0. 053	0. 075	0. 111	0. 250
2	0. 153	0. 223	0. 282	0. 381	0. 470	0. 595	1. 000
3	0. 455	0. 602	0. 725	0. 899	1. 057	1. 271	1. 980
4	0. 869	1. 902	1. 219	1. 525	1. 748	2. 045	2. 945
5	1. 361	1. 657	1. 875	2. 218	2. 054	2. 881	4. 010
6	1. 909	2. 276	2. 543	2. 960	3. 305	3. 758	5. 109
7	2. 051	2. 935	3. 250	3. 738	4. 139	4. 666	6. 230
8	3. 128	3. 627	3. 987	4. 543	4. 999	5. 597	7. 369
9	3. 783	4. 345	4. 748	5. 370	5. 879	6. 546	8. 552
10	4. 461	5. 048	5. 529	6. 216	6. 776	7. 551	9. 685
11	5. 160	5. 842	6. 328	7. 076	7. 687	8. 437	10. 857
12	5. 876	6. 615	7. 141	7. 950	8. 610	9. 474	12. 036
13	6. 607	7. 402	7. 967	8. 835	9. 543	10. 470	13. 222
14	7. 352	8. 200	8. 803	9. 730	10. 485	11. 473	14. 413
15	8. 108	9. 010	9. 650	10. 633	11. 434	12. 484	15. 608
16	8. 875	9. 828	10. 505	11. 544	12. 390	13. 500	16. 608

(续)

B / n	1%	2%	3%	5%	7%	10%	20%
n	A	A	A	A	A	A	A
17	9. 652	10. 656	11. 368	12. 461	13. 353	14. 522	18. 010
18	10. 437	11. 491	12. 238	13. 335	14. 321	15. 548	19. 216
19	11. 230	12. 333	13. 115	14. 315	15. 294	16. 579	20. 424
20	12. 031	13. 182	13. 997	15. 249	16. 271	17. 613	21. 635
21	12. 838	14. 036	14. 884	16. 189	17. 253	18. 651	22. 848
22	13. 651	14. 896	15. 778	17. 132	18. 238	19. 692	24. 064
23	14. 470	15. 761	16. 675	18. 080	19. 227	20. 373	25. 861

注：A—总呼叫话务量；n—信道数；B—呼损率。

4. Trunking and Grade of Service

4.1 Traffic intensity

$$A_u = \lambda H \qquad A = U A_u$$

4.2 Erlang B formula

$$GOS = \Pr[B] = f(A, C)$$

Chapter 2

1. Cellular Geometry
2. Channel Assignment and handoff
3. Interference and System Capacity
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5. **Improving Capacity in Cellular System**

Three Techniques

(PP. 76)

- **Cell splitting**
- **Sectoring**
- **Microcell zone**

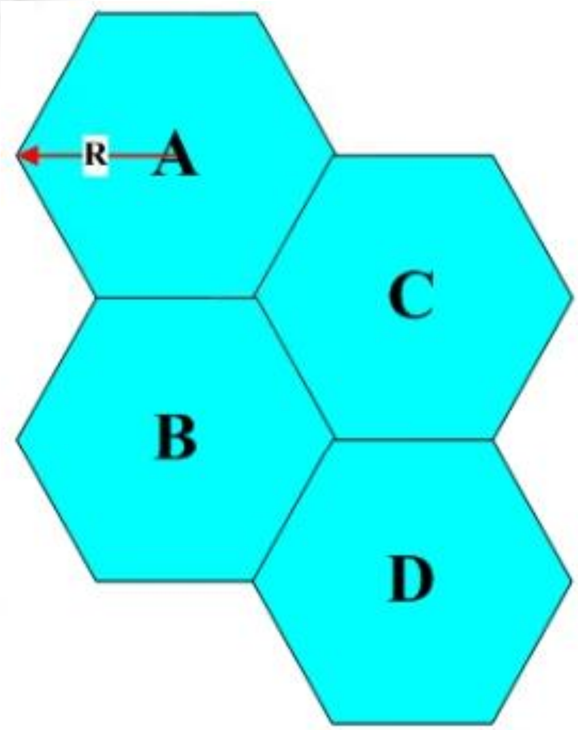
How to improve capacity ?

$$C = MS \qquad (M\uparrow \Rightarrow C\uparrow)$$

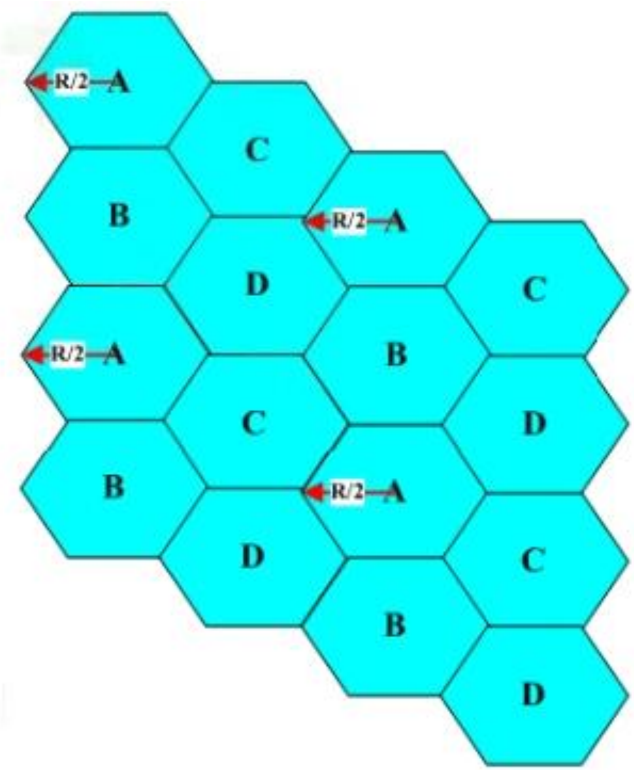
- Reduce the radius of cells *R*, while preserving the frequency reuse scheme —— **Cell splitting**

- Reduce the cluster size *N*, while ensuring the Signal Interference Ratio (SIR) —— **Sectoring**

Cell splitting

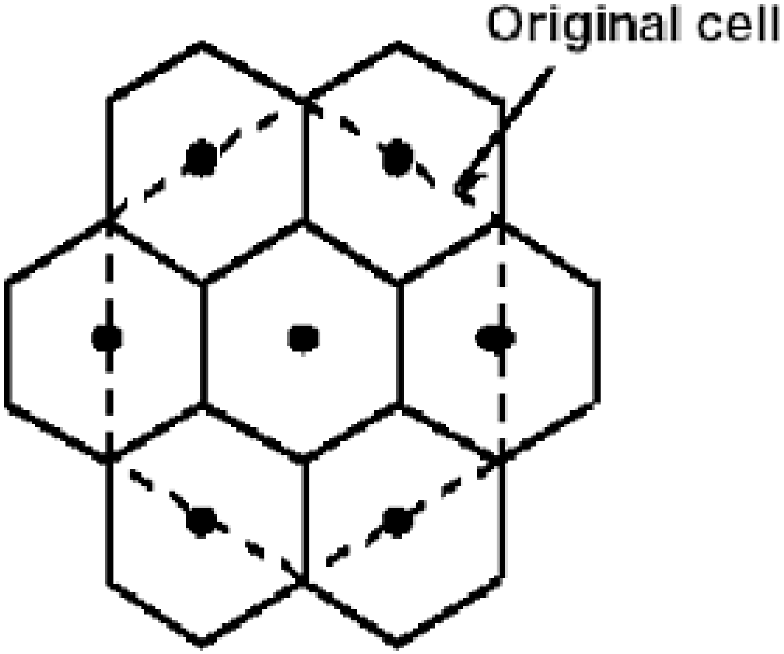


Cluster Size *N* = 4



Cluster Size *N* = 4

Cell splitting



- At old cell boundary

$$P_r \propto P_{t1} R^{-n}$$

- At new cell boundary

$$P_r \propto P_{t2} (R/2)^{-n}$$

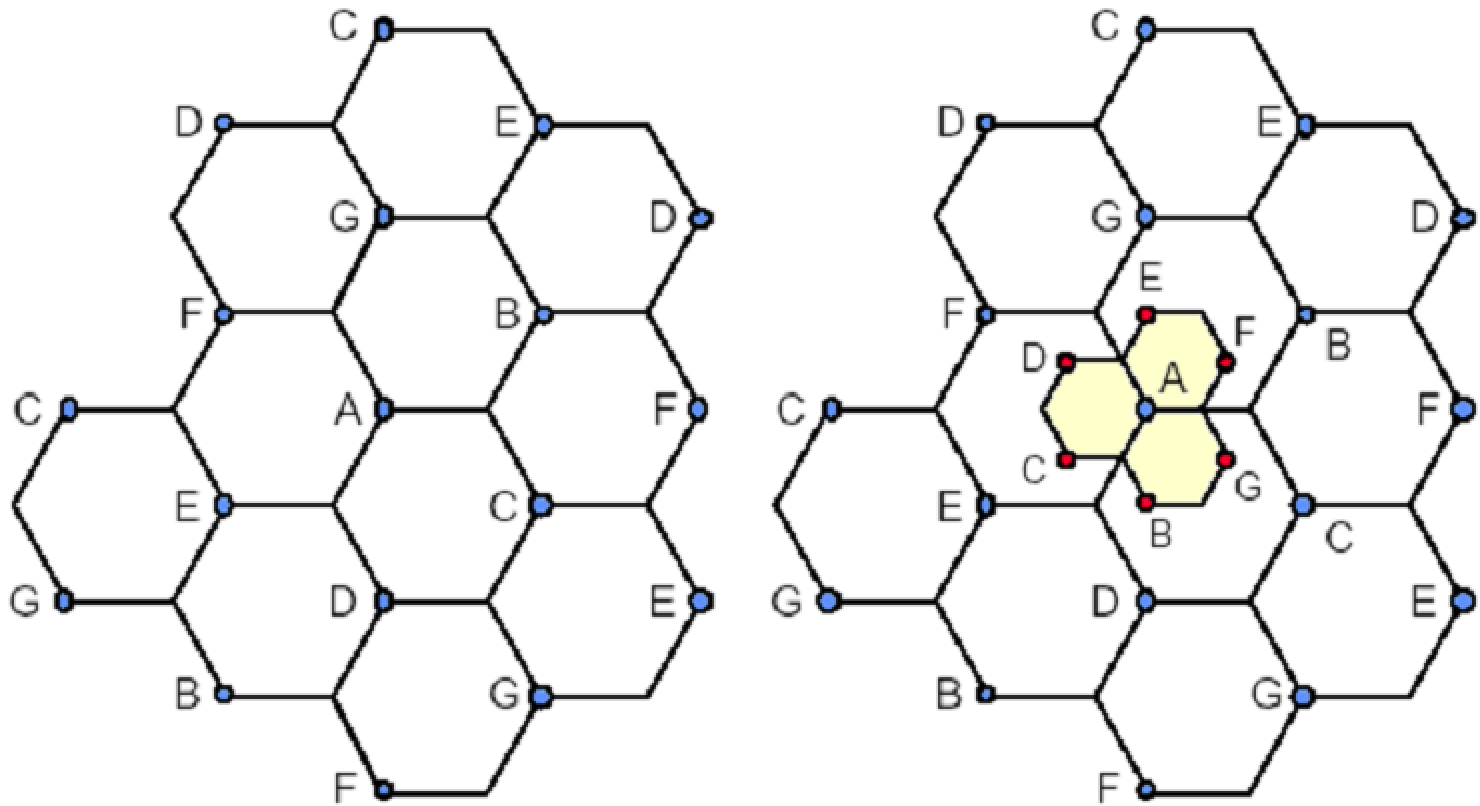
- With n=4,

$$P_{t2} = P_{t1}/16$$

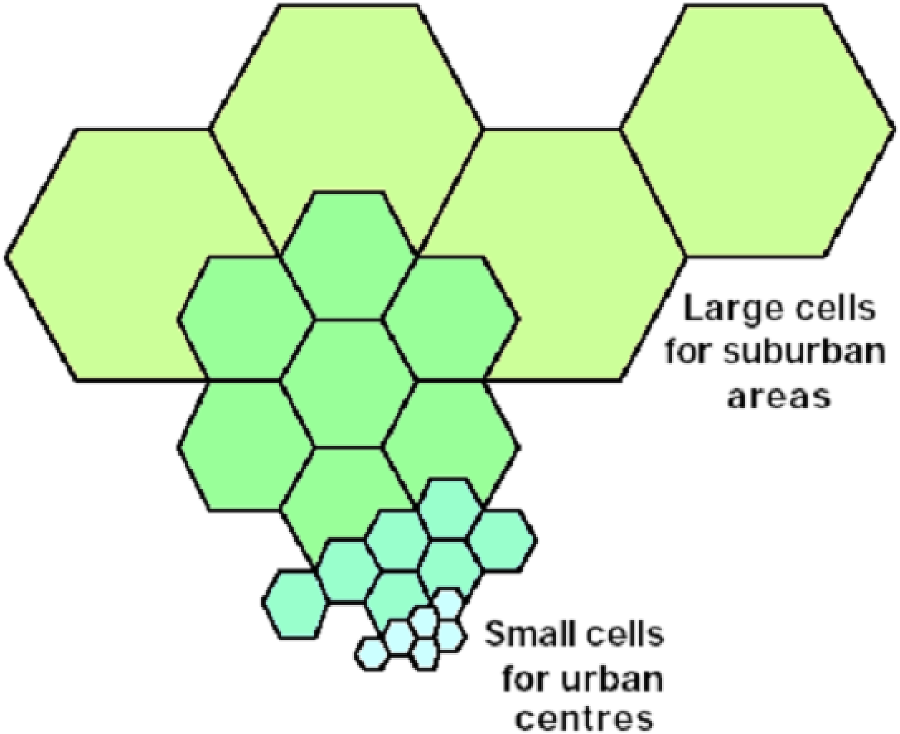
- Reduced by 12dB

Cell splitting

(PP. 77)



Cell Splitting



- The cells with different sizes exist simultaneously
- Channel assignments become more complicated

Implementation of Cell Splitting

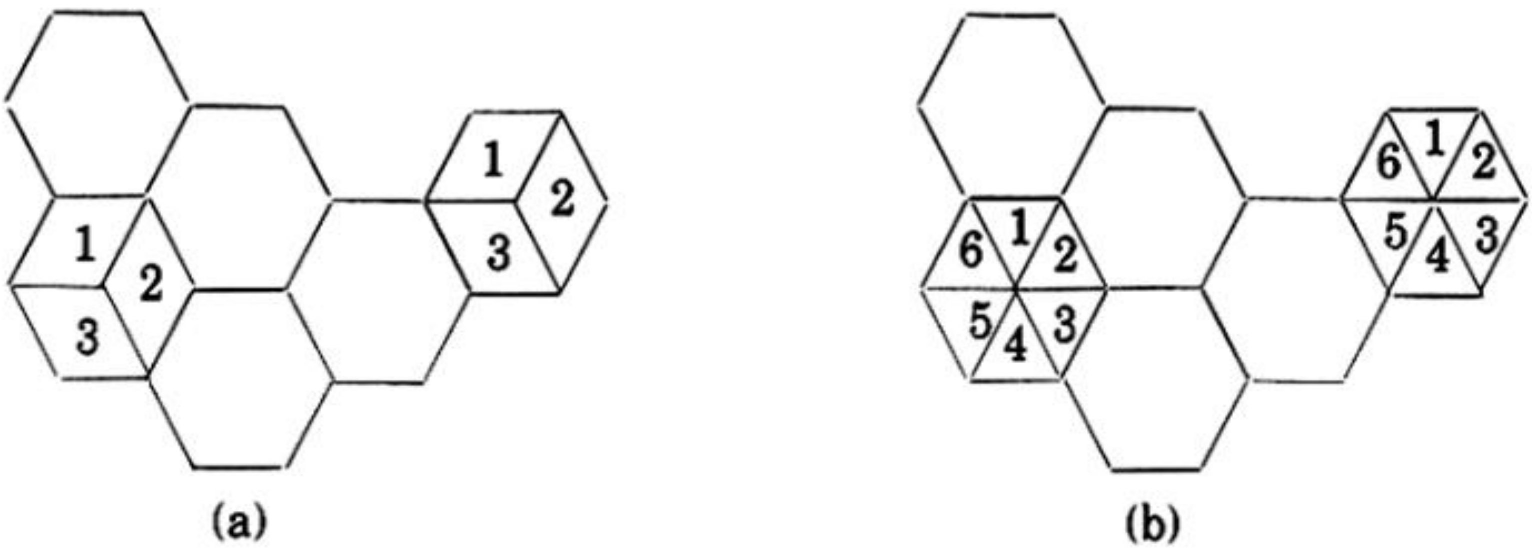
- Increase the number of base stations (BS)
- Reduce the transmitted power of the BS antennas
- Maintain the cluster size N and preserve the frequency reuse scheme

Resulted Problems of Cell Splitting

- the costs are huge for increasing the number of BS
- aggravate the handoff load due to the increased cells

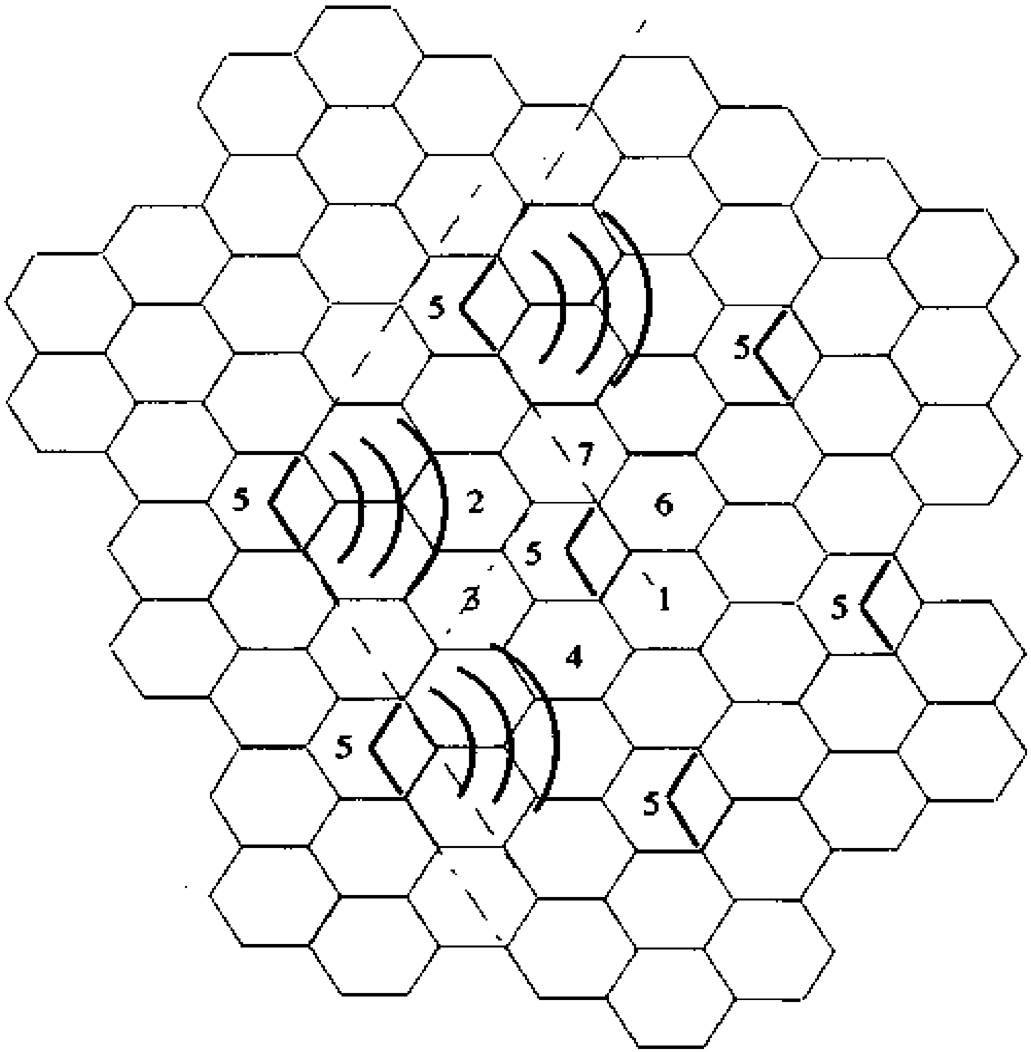
Sectoring

- By replacing a single omnidirectional antenna by several directional antennas, each radiating within a specified sector.



(a) 120° 扇区化；(b) 60° 扇区化．

Sectoring



Improve Capacity by Sectoring

multiple directional antennas in a cell

→ the number of co-channel interferences is reduced

→ the SIR is improved

→ smaller cluster size N can be used

→ the capacity can be improved

Improve Capacity by Sectoring

Requirement : SIR>18 dB

No Sectoring : N=7, SIR=18.6 dB

→ **By Sectoring : N=7, SIR=24.2 dB**

→ **By Sectoring : N=4,   SIR=18.5 dB**

Resulted Problems of Sectoring

- aggravate the handoff load among the different sectors in each cell
- decrease the trunking efficiency due to the reduced available channels in a sector

Example 4

A cellular system : an average call lasts two minutes, and the probability of blocking is to be no more than 1 %.
Every subscriber makes one call per hour, on average. If there are a total of 395 traffic channels for a seven-cell reuse system, there will be about 57 traffic channels per cell. Assume that blocked calls are cleared so the blocking is described by the Erlang B distribution. From the Erlang B distribution, it can be found that the unsectored system may handle 44.2 Erlangs or 1326 calls per hour.
If employing 120° sectoring, there are only 19 channels per antenna sector (57/3 antennas). For the same probability of blocking and average call length, it can be found from the Erlang B distribution that each sector can handle 11.2 Erlangs or 336 calls per hour. Since each cell consists of three sectors, this provides a cell capacity of 3 x 336 = 1008 calls per hour.
Thus, sectoring decreases the trunking efficiency while improving the *S/I* for each user in the system.

Summary

5. Improving Capacity in Cellular System

5.1 Cell Splitting

5.2 Sectoring

Chapter 2

1. Cellular Geometry
2. Channel Assignment and handoff
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Exercises

A cellular service provider decides to use a digital TDMA scheme which can tolerate a signal-to-interference ratio of 15 dB in the worst case.

(1) Find the optimal value of N for omnidirectional antennas (Assume a path loss exponent of $n = 4$.)

(2) Find the co-channel reuse ratio Q. Does a larger Q provide a larger capacity?

Exercises

In a trunking system:

(1) What is the maximum system capacity in Erlangs when providing a 1% blocking probability with 100 cells and 40 channels per cell?

(2) How many users can be supported in this system? Assume the average duration of a call H = 180s, the average number of call requests = 2 call / hour.