

Wireless Communication System

Modul 1 INTRODUCTION



**Faculty of Electrical Engineering
Bandung – 2015**

Objectives Learning

- Students know the learning objectives wireless communication system
- Students know the organization of teaching wireless communication system
- Students learn teaching methodology, and how the assessment
- Students know the outlines of the development of wireless communication systems, terminology, basic terminology

1. Course Details

- WIRELESS COMMUNICATION SYSTEM
- Lecturer this semester (updated each semester) :

No	Lecturer	Teaching schedule	
1	Ali Muayyadi		
2	Rina Pudji Astuti		
3	Uke Kurniawan		
4	Saleh Dwi Mardiyanto		

Recommended Textbooks:

1. Andrea Goldsmith : "**Wireless Communication**", Cambridge University Press, 2005
2. Theodore Rappaport, "**Wireless Communications": Principles and Practice**, Second Edition, Prentice Hall, December 2001.

SILABUS SINGKAT SISKOMSEL

Penjelasan mengenai pengenalan konsep dasar sistem wireless dan selular : ***Model kanal Propagasi Wireless, Teknik mengatasi Fading, Modulasi Multicarier, Manajemen Interferensi, Konsep Dasar Multiple Antennas, Analisis Trafik Seluler, Perencanaan Luas Cakupan Layanan dan Kapasitas user pada jaringan selular, Karakteristik 4G Mobile Communication System serta perencanaan jaringan seluler LTE.***

3. Silabus and SAP

MGU KE	PERT KE	MATERI	
		TOPIK	SUB TOPIK
1	1	Pendahuluan	1. Pengenalan Silabus, Aturan penilaian: Quis, Ujian, Tugas dllnya
	2		2. Overview Wireless Communication Systems (Konsep Sel, Freq Re-Use, Handover, Multiple Akses : FDMA, TDMA, CDMA)
2	3	Large Scale Fading: Model prediksi redaman propagasi	3. Path Loss Model
	4		4. Model Okumura-Hata dan Model COST 231
	5		5. Model Walfish Ikegami dan Model LEE
			6. Responsi/Latihan dan Pembahasan Soal Large Scale Fading
3	6	Small Scale Fading: Multipath	7. Variasi kanal dalam domain frekuensi dan domain waktu
	7		8. Small scale fading dan Klasifikasi Small Scale Fading
			9. Tipe dispersion

Silabus and SAP Materi 1 – 7 : Bahan UTS

4	7	Small Scale Fading:Doppler shift	10. Frequency dispersion
	8		11. Responsi/Latihan dan Pembahasan Soal Small Scale Fading
5	9	Teknik-teknik Fading Mitigation	12. Diversity dan Equalization
	10		13. Channel coding
			14. Teknik Multicarrier
			15. Responsi/Latihan dan Pembahasan Soal Teknik Fading Mitigation
6	11	Modulasi Multicarier	16. Konsep Dasar OFDM
	12		17. Konsep Dasar OFDMA
			18. Pengenalan SC-FDMA
7	13	Konsep Dasar <i>Multiple Antennas</i>	19. Macam-macam <i>Multiple Antenna</i> dan Konsep <i>Multiple Antennas</i> (Diversitas dan MIMO)
	14		20. Model Sistem SISO, SIMO, MISO, MIMO
			21. Responsi/Latihan dan Pembahasan Soal OFDM dan MIMO

Silabus and SAP

8	15	Mobility Management	22. Radio Resource Management
	16		23. Mobility Management
9	17	Manajemen Interferensi Seluler	24. Jenis-jenis Teknik Manajemen Interferensi (Freq Re Use, FFR, SFR) pada seluler
	18		25. Responsi/Latihan dan Pembahasan Soal Mobility Management dan Interferensi
10	19	Teletraffic	26. Model dan jenis trafik komunikasi seluler
	20		27. Dimensioning dan cara menangani trafik
11	21	Coverage Planing	28. Komponen dan Konsep Link Budget
			29. Coverage dan Jumlah Sel
	22		31. Responsi/Latihan dan Pembahasan Soal Teletraffic dan Coverage Planning

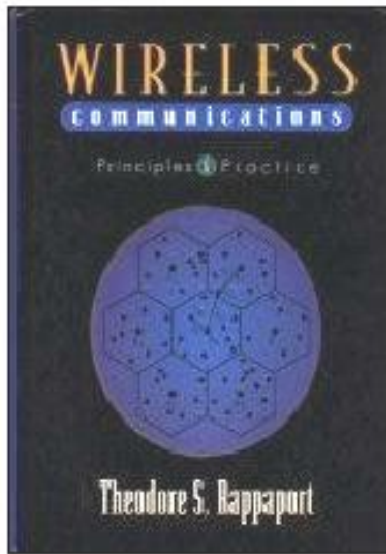
Silabus and SAP Materi 8 – 14 : Bahan UAS

12	23	Capacity Planing	32. Perhitungan kapasitas (FDMA,TDMA,CDMA) dan Jumlah sel (aspek kapasitas/trafik)
	24		33. Responsi/Latihan dan Pembahasan Soal Capacity Planning
13	25	4G LTE / LTE - Advance for Mobile Broadband	34. Karakteristik 4G for Mobile Broadband
	26		35. Karakteristik LTE - Advanced
14	27	Perencanaan Jaringan Seluler LTE	36. Karakteristik Mobile WiMAX II
	28		37. Projek desain / perencanaan luas cakupan layanan dan kapasitas user pada jaringan seluler LTE
			38. Lanjutan projek desain

2. Assessment Grading

- Component assessment
 - Mid Test : **35 - 40 %**
 - Final test : **35 - 40 %**
 - Quiz / Task / HW : **20 - 30 %**
- The presence of a minimum requirement **75 %**
- Tugas Utama (Perorangan) :
 - Tugas Perencanaan Selular
 - Makalah topik selular

C. Additional Textbooks



[RAP 96] Rappaport, Theodore S, “ **Wireless Communication : Principles and Practice**“, (1st Edition) Prentice Hall, 1996

[LEE 98] Lee, William CY, “**Mobile Communications Engineering**“, McGraw Hill, 1998

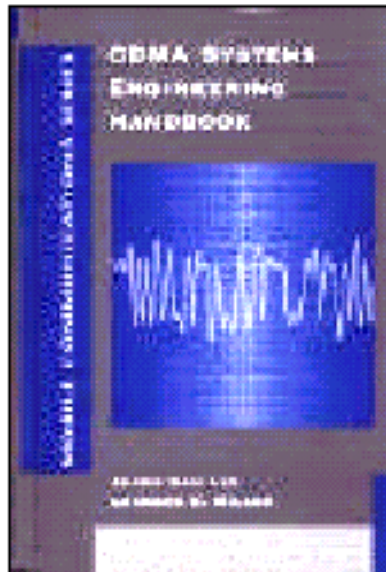
[VIJ 99] Garg, Vijay K., Wilkes, Joseph E., “ **Principles & Applications Of GSM** “, Prentice Hall, 1999

[VIJ 02] Garg, Vijay K., “ **Wireless Network Evolution : 2G to 3G** “ ,Prentice Hall, 2002

[JHO] Jhong S Lee, Miller, “**CDMA System Engineering Handbook**”,

[ERC] Erick Dahlman, Stefan Parkval, Johan Skold " **4G LTE/LTE Advanced for Mobile Broadband**", Academic Press, 2011

[UGDS] Uke Kurniawan, Galuh Prihatmoko, Denny Kusuma H, Sigit Dedi P, "**Fundamental Teknologi Seluler LTE**", Rekayasa Sains, 2012



LECTURE IDENTITY

Ir. Uke Kurniawan Usman, MT

- Office : FEK, N Building 2rd floor, Room **N.211**
- WA, Line, Telegram, SMS : **0838-2186-2917**
- email : **ukeusman@telkomuniversity.ac.id**
- Blog :
<http://ukeusman.staff.telkomuniversity.ac.id>

TIPS SUKSES BELAJAR

- **Niat yang besar dan mantap**
 - *”Jangan menganggap tugas belajarmu sebagai kewajiban, melainkan pandanglah itu sebagai sebuah kesempatan untuk menikmati betapa indahnya dunia ilmu pengetahuan, kepuasan hati yang diberikannya serta manfaat yang akan diterima oleh masyarakat apabila jerih payahmu berhasil.”* (Einstein).
 - Insanity: doing the same thing over and over again and expecting different results.
 - Jangan disetir oleh mood, tapi setirlah mood
- **Pengaruh lingkungan sekitar**
 - Cari teman yang bisa memotivasi kita untuk bersaing dalam menuntut ilmu
- **Sarana untuk belajar**
 - Baca buku di perpustakaan, e-book, browsing internet
- **Cara belajar**
 - Pelajari bahan sedikit demi sedikit, tiap mendapat materi baru, jangan ditunda untuk mempelajarinya.
 - Setelah memahami materi, coba jawab pertanyaan2 atau soal2 terkait.
- **Iringi dengan DOA**

- Berseragam (atasan kemeja putih, bawahan warna biru tua, bukan jeans)
- Bersepatu (BUKAN Sepatu Sandal)
- Tidak terlambat masuk kelas, kalau telat maka tidak dipernankan masuk kelas
- Mengikuti UTS & UAS
- Tidak ada ujian susulan, ujian khusus, ujian perbaikan (no-remedial), tugas tambahan dllnya.

ATURAN FAKULTAS

Rules:

- Every started college conducted the prayer led by one students who was appointed lecturer relevant: *"Oh God, give us strength and ability to accept and understand science and lecture today"*
- To be able to join UTS or UAS, presence of at least 75% or in accordance with institutional regulations.
- For participants who do not follow the UTS and UAS, will get the value E
- See complete info at: BPI (Buku Panduan Institusi)

- SCL (Student Centered Learning), mahasiswa sebagai subjek perkuliahan berbasis kompetensi.
- Persiapkan diri untuk jadi mahasiswa yang aktif menggali dan menguasai kompetensi setiap mata kuliah.
- Diskusi bersama.

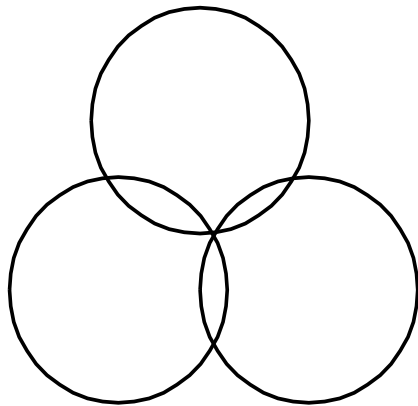
PERKULIAHAN

Subject

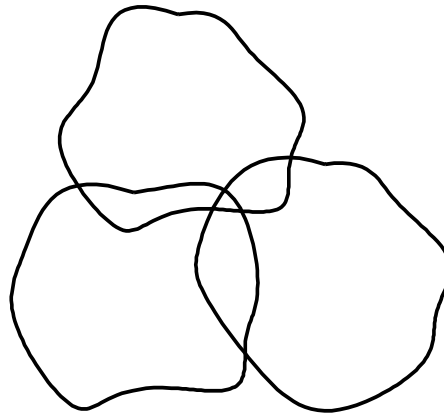
- a. **Concept of cell**
- b. **Frequency Re-Use, Handover**
- d. **Multiple Access : FDMA, TDMA, CDMA**

Representation of the cell coverage

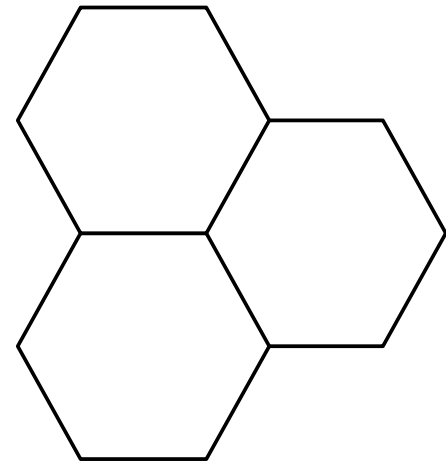
- ✓ Cell, the signal coverage
- ✓ Hexagonal cell (or other forms) is only used to simplify the depiction on the layout plan



SEL IDEAL

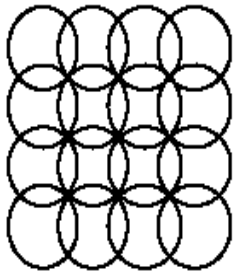


SEL REAL

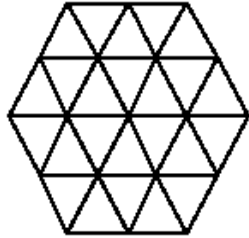


SEL MODEL

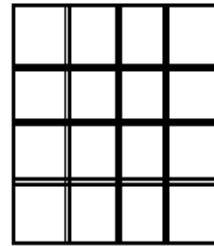
Representations coverage cellular system



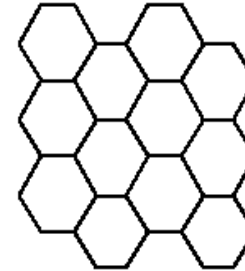
circles



equilateral triangles



squares

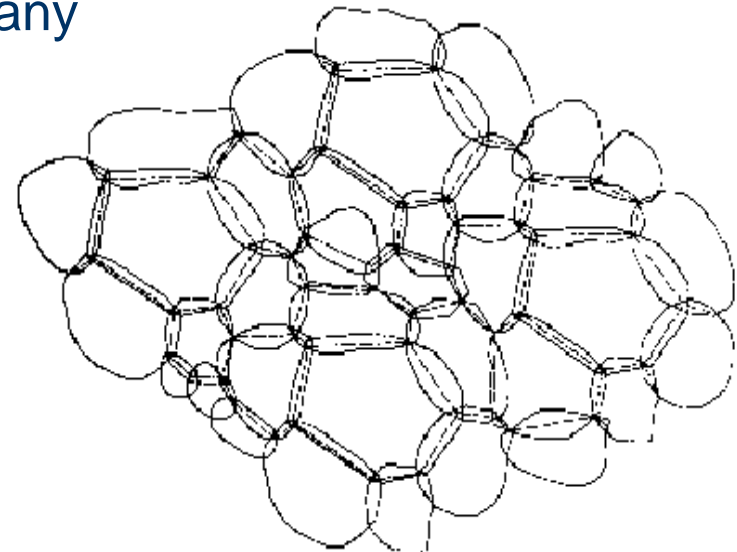


hexagons

Geometric shape which covers the entire service area without any overlap with the same area

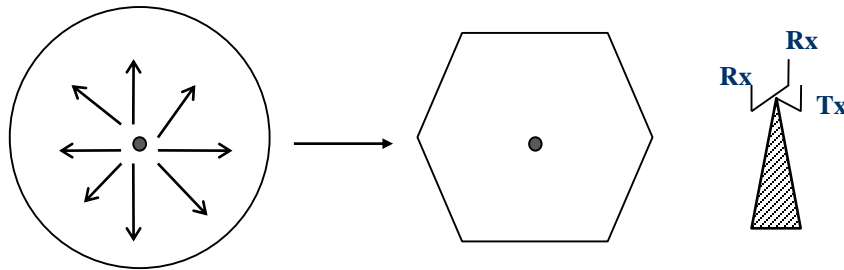
In the Reality ?

Far different! Grid cells theoretically be used to facilitate drawing / planning

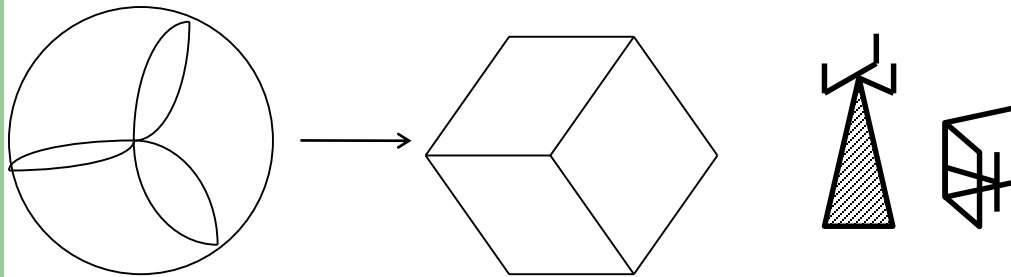


Type of antenna that is on the BTS

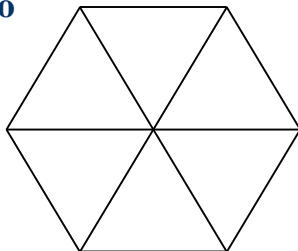
1) Omnidirectional



2) Sectoring 120°



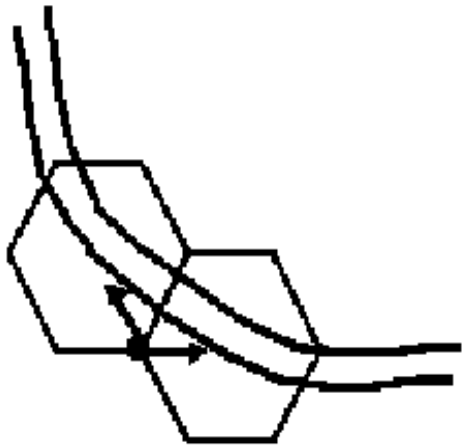
3) Sectoring 60°



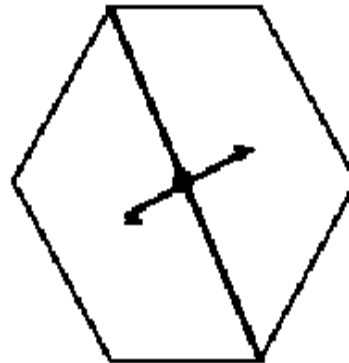
Usefulness of the pattern Sectoring

- a. Adding capacity
- b. Reduce interference

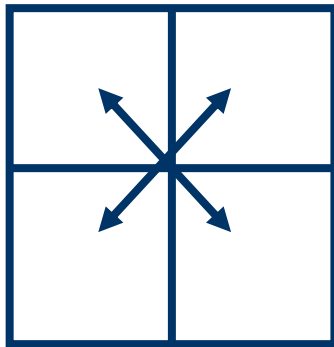
Type of Cell Configuration



2-sector

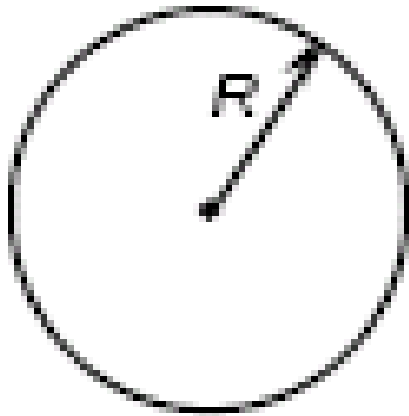


2-sector sectorized cell



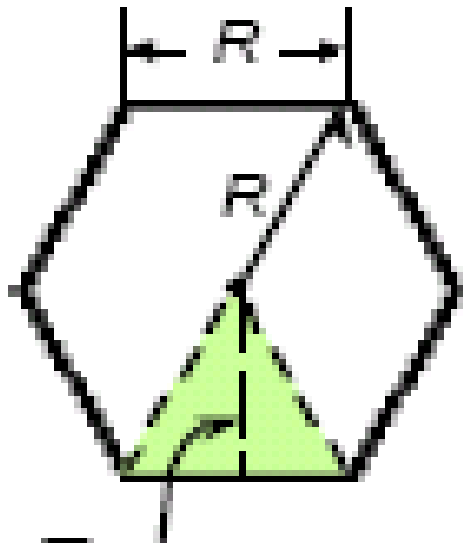
4 sector (quad sector)

Geometri Sel



$$Area_{cell} = \pi R^2 \approx 314 R^2$$

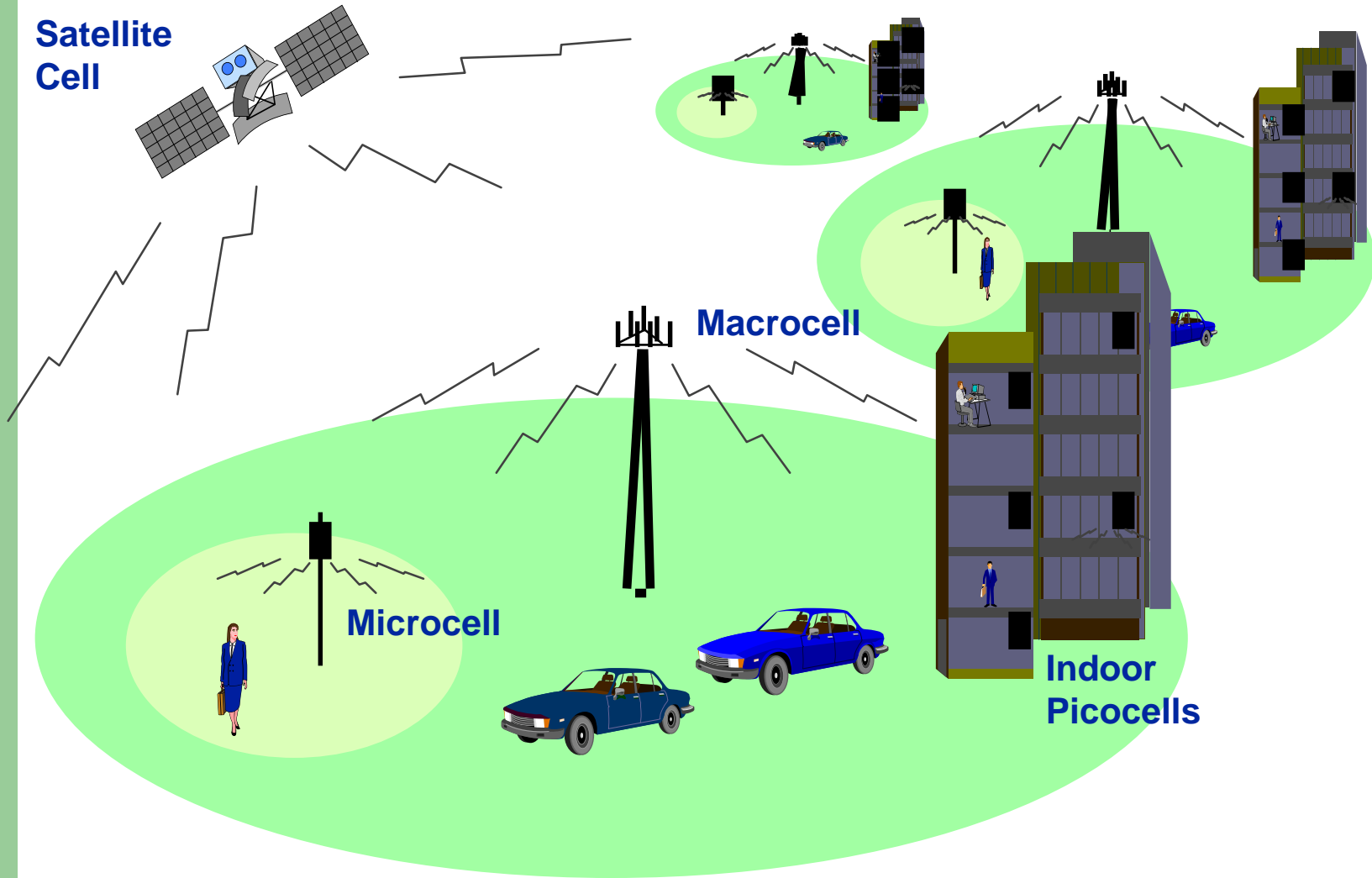
$$Perimeter_{cell} = 2\pi R \approx 628 R$$



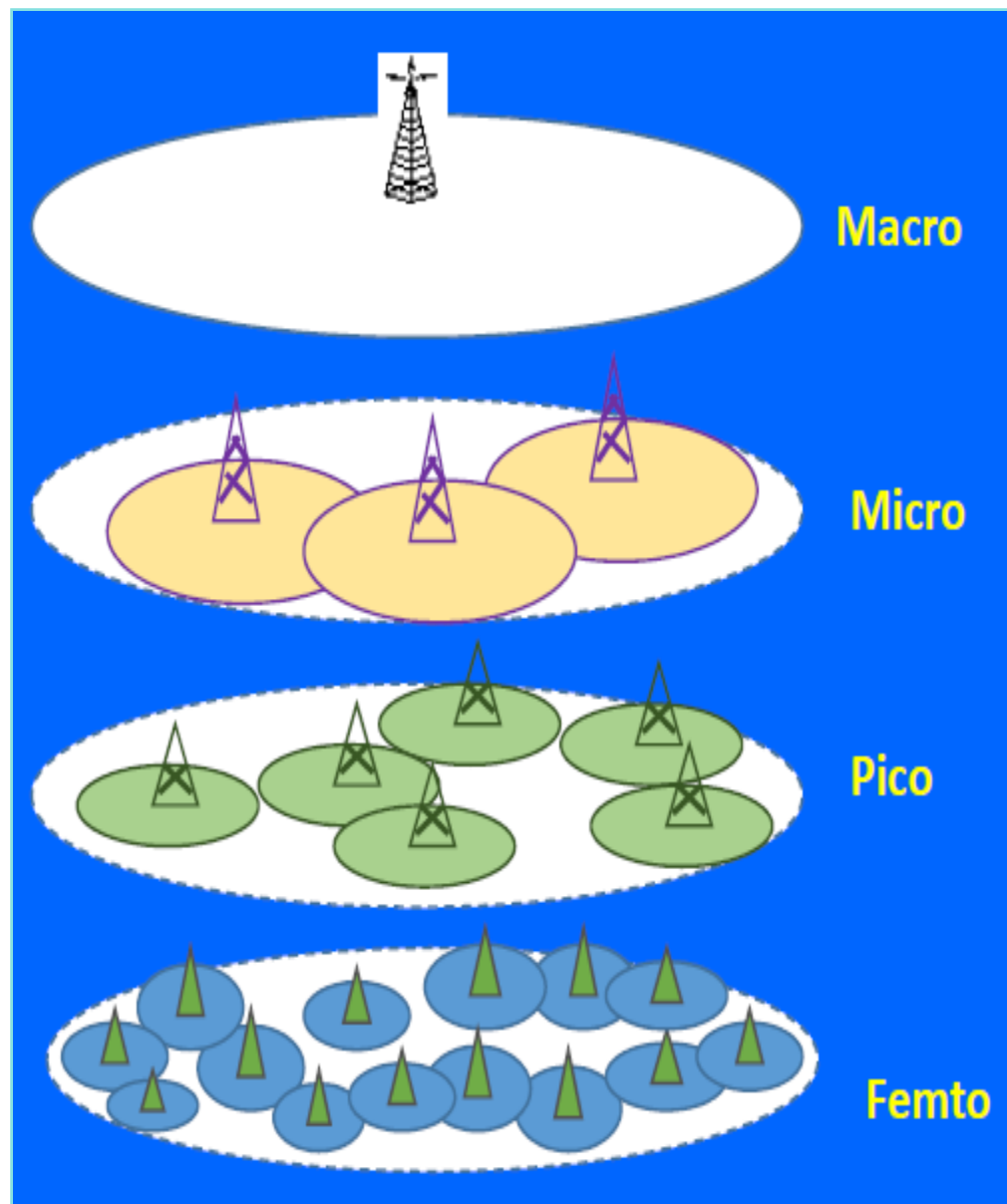
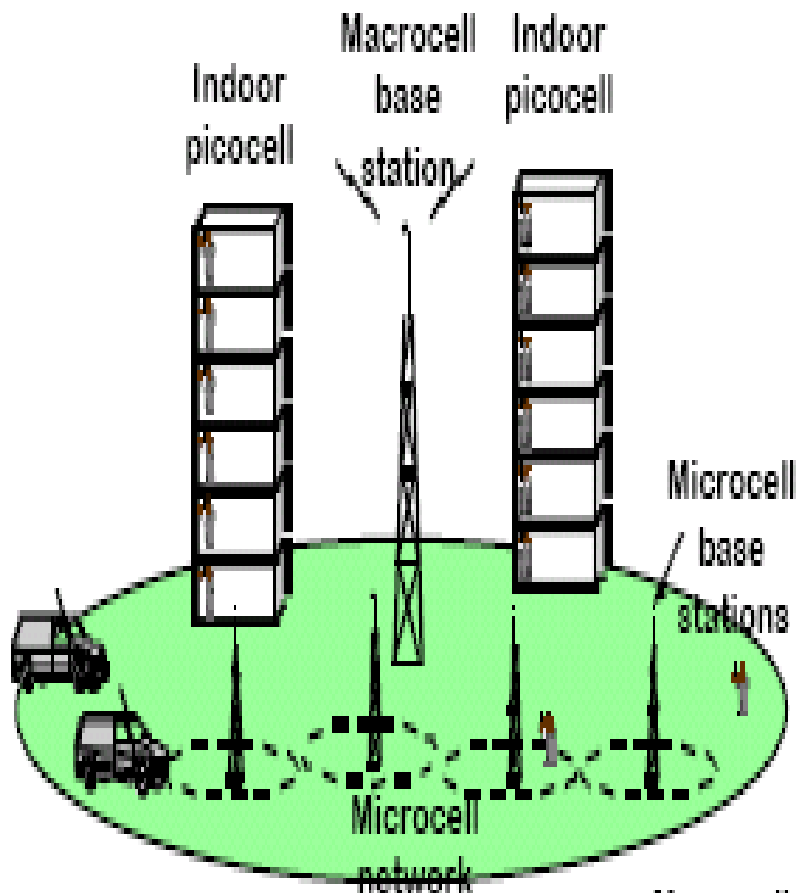
$$Area_{cell} = 6 \times \frac{1}{2} R \sqrt{3} \times \frac{1}{2} R = \frac{3}{2} R^2 \sqrt{3} \approx 2.6 R^2$$

$$Perimeter_{cell} = 6 \times R$$

Macrocell, Microcell, dan Picocell ...



Mixed Cell Architecture



Hand-portable terminals

Vehicle-borne terminals

Characteristics of Cellular Systems

What makes cellular radio work?

- Frequency Reuse
- Channel Sharing (trunk effect)
- Handover/Handoff
- High Spectral efficiency

Other related considerations

- Propagation Attenuation is like $d^{-\gamma}$, $2 < \gamma < 6$ (path loss exponent)
- Multipath fading
- Doppler spread
- Multiple access interference
- Quality of service

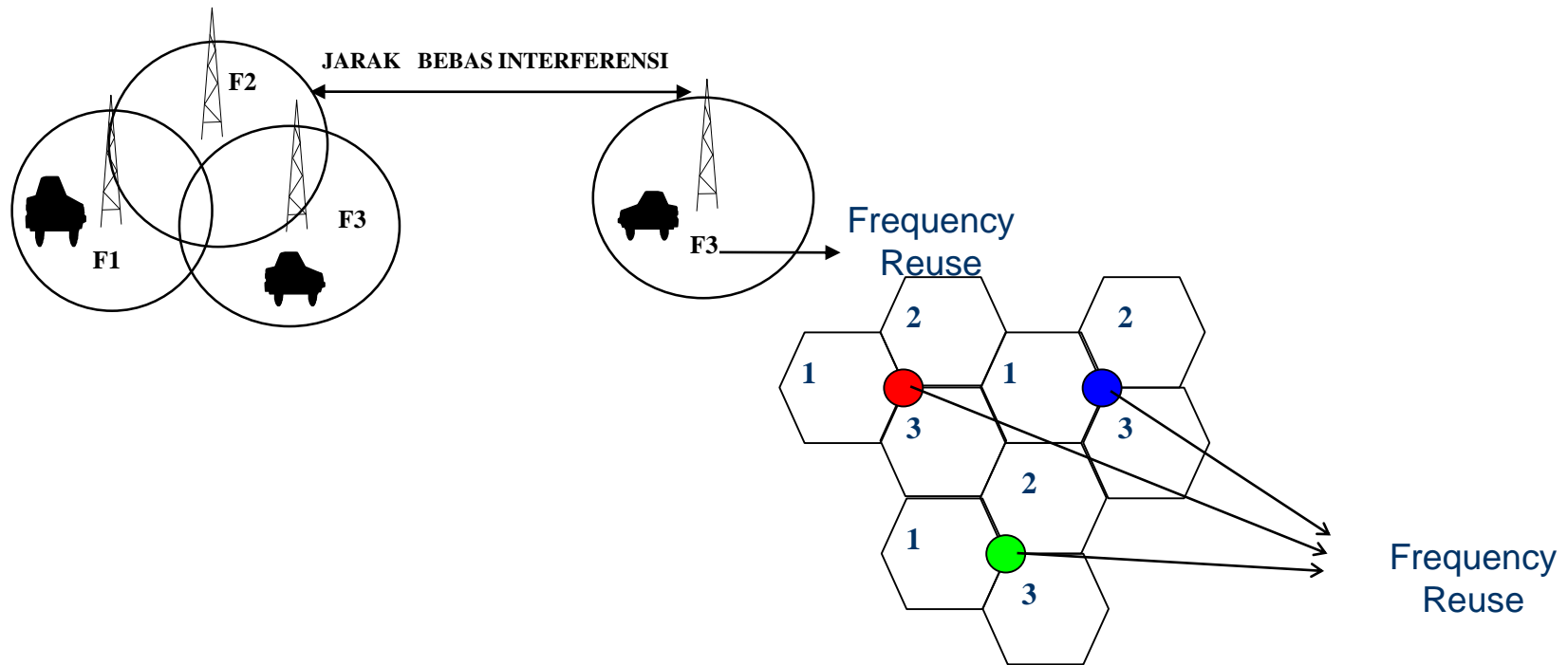
Characteristics of Cellular Systems

- 1. Frequency Reuse**
- 2. Concept of Hand Off**

- The concept of frequency reuse allows the use of the same frequency in different cells, beyond the reach of interference. The parameter is a measure of power ratio signal / carrier to total interference power
- While the handoff allows a user to move from one cell to another without any termination. Displacement occurs frequency / channel is automatically done by the system

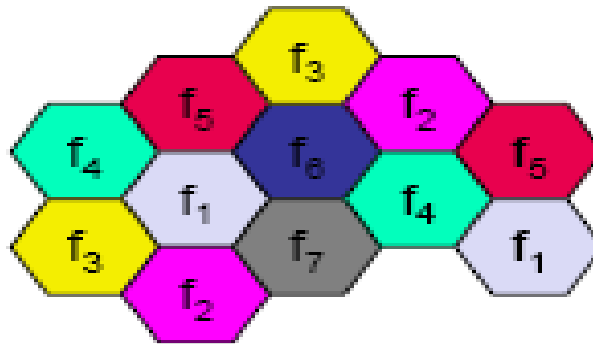
Definition of Frequency Re-use

Repetition or re-using the same frequency in different areas outside the reach of interference



Background Frequency Re-Use.

1. Limitation of frequency allocation
2. The limited cell coverage area (coverage area).
3. Raising the number of channels.
4. Form a cluster that contains several cell.
5. Co-channel interference.



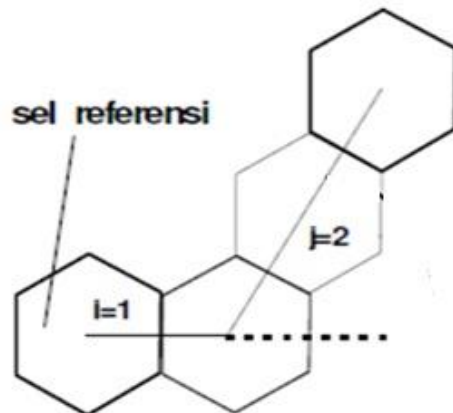
Frekuensi Reuse

$$D/R = \sqrt{3K}$$

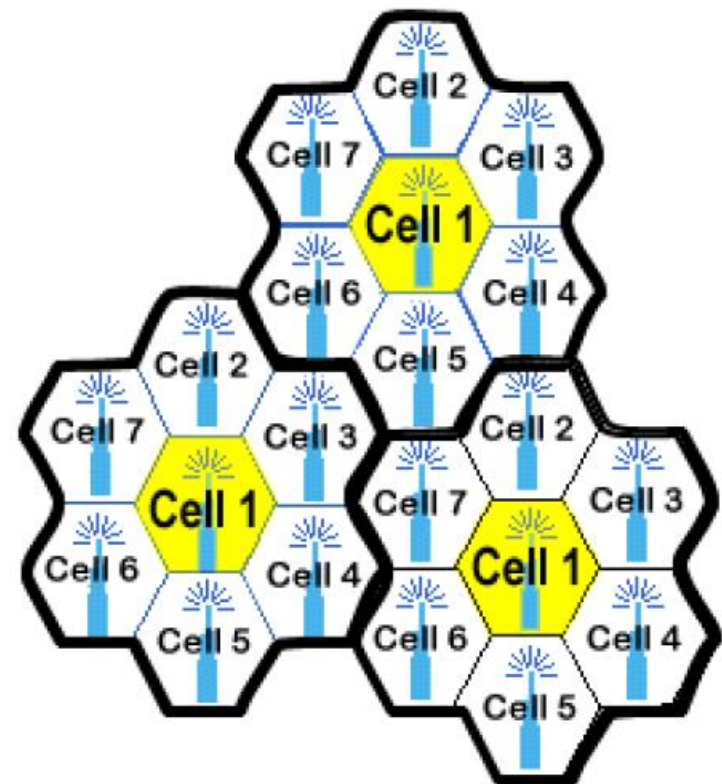
Di mana : D = jarak antara BS dengan BS yang lain

R = radius sel

K = jumlah pola frekuensi



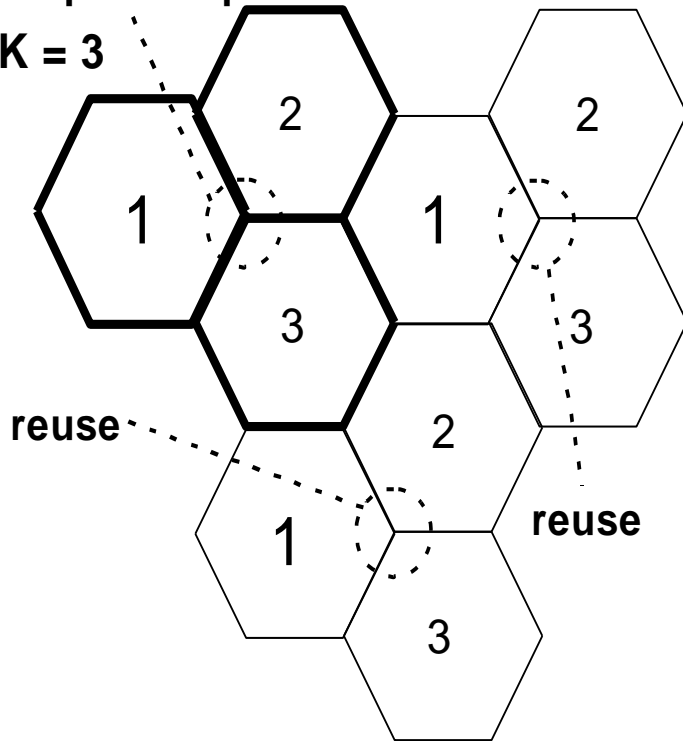
Frequency Reuse



Frequency Re-use

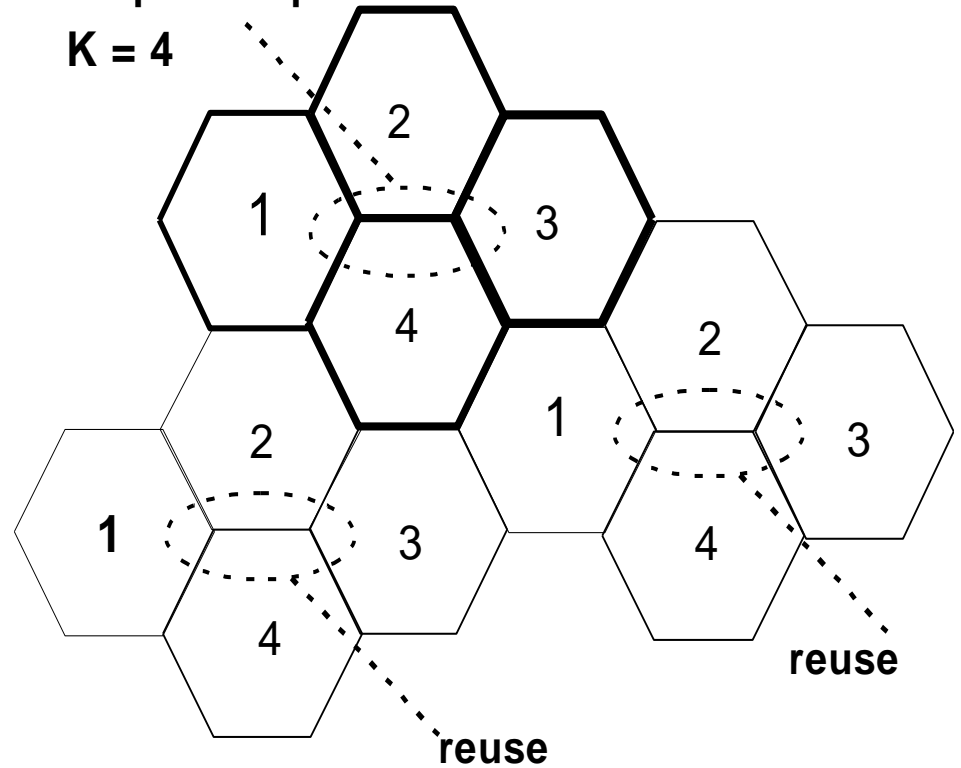
freq. reuse pattern / cluster

$K = 3$



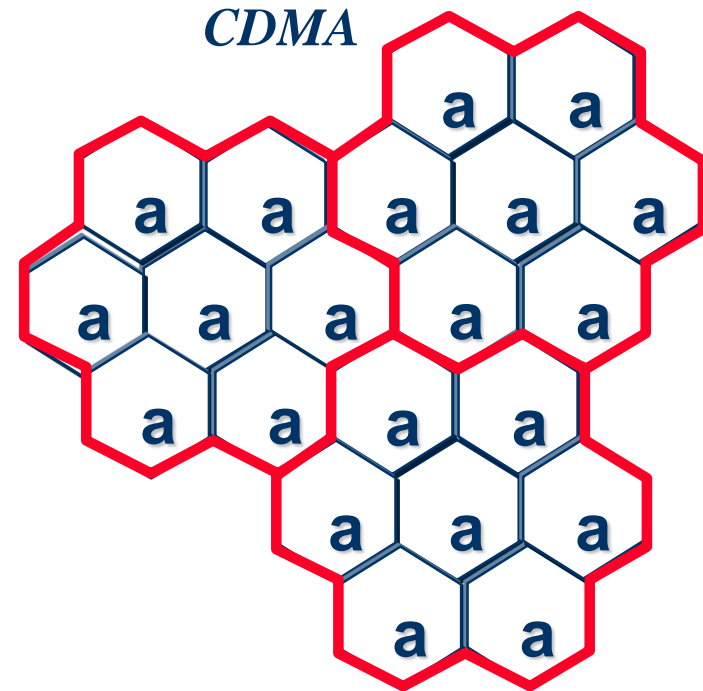
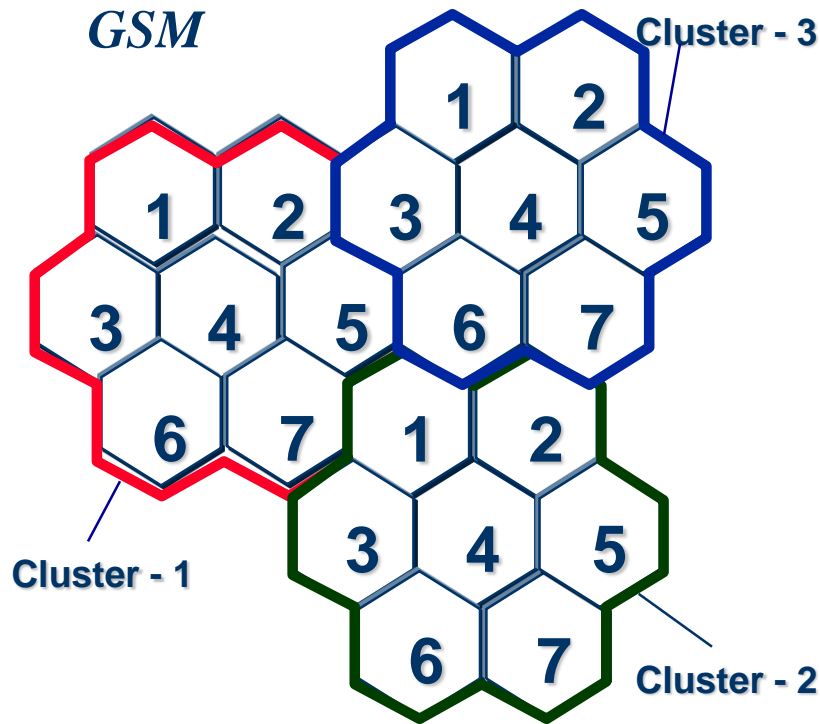
freq. reuse pattern

$K = 4$



Frequency Re-use

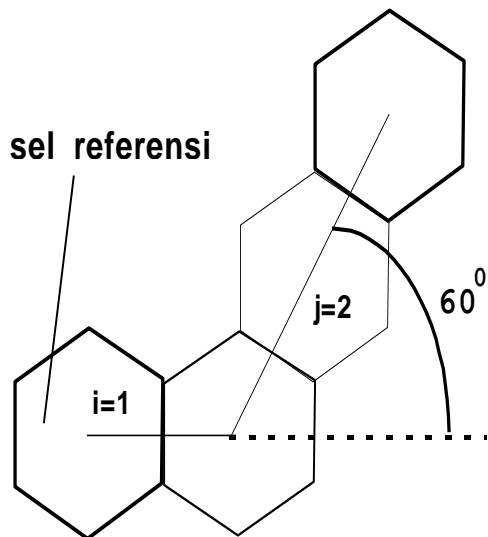
Design a simple frequency



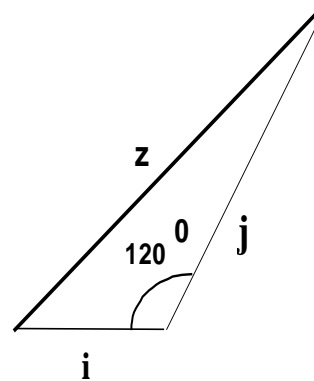
Rule Determination of cell number → Slide Rule

Parameters

Through the extent of cell i along the chain heksagonalnya reference cell (the straight line connecting the two centers of cells), then rotates 60° opposite direction clockwise, then pass along the j cell in that direction. In the final position therein lies → its freq. reuse.



$$i, j = 0, 1, 2, 3, \dots$$



$$Z^2 = i^2 + j^2 - 2ij \cdot \cos 120^\circ$$

$$Z^2 = i^2 + j^2 + 2 \cdot i \cdot j \quad (0,5)$$

$$Z^2 = i^2 + j^2 + i \cdot j$$

$$Z^2 \cong K \quad \text{----} \quad K = \text{size of cluster}$$

$$K = i^2 + j^2 + i \cdot j$$

for,

$$i = 1 \text{ dan } j = 1 \rightarrow K = 3$$

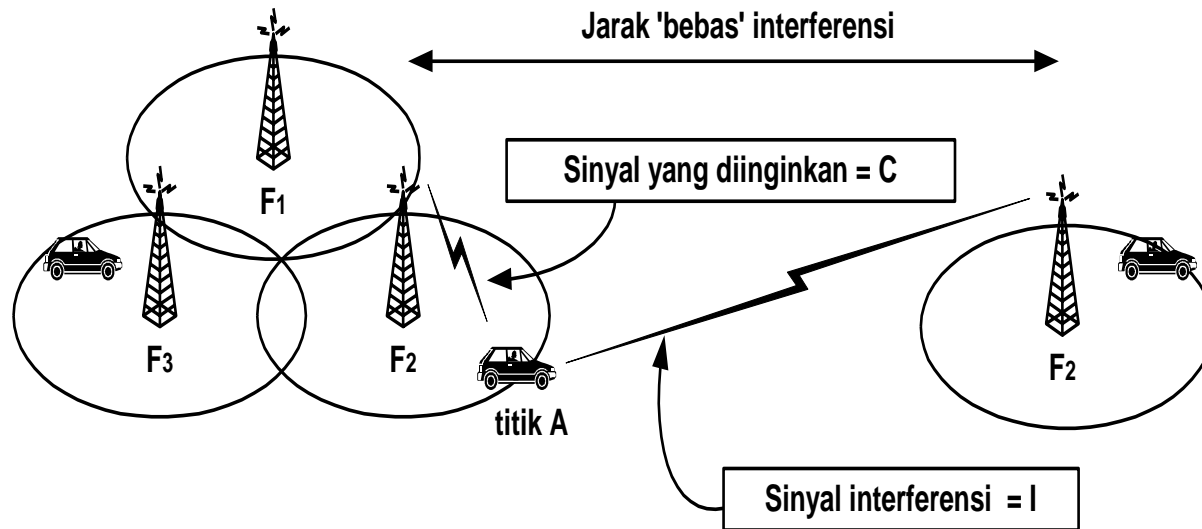
$$i = 1 \text{ dan } j = 2 \rightarrow K = 7$$

$$i = 0 \text{ dan } j = 2 \rightarrow K = 4$$

$$i = 2 \text{ dan } j = 0 \rightarrow K = 4$$

Performance Parameters

→ C/I (Carrier to Interference Ratio)



- From the picture above, the worst case conditions exist at point A
- carrier power to interference power ($C / I = \text{Carrier to Interference}$) must remain greater than or equal of the C / I the minimum required by the relevant cellular systems

Concept Cluster

- Cluster is a group of cells, each cell has 1 set of frequencies that are different from other cells.
- Size of clusters (denoted = K , often denoted = N) is the number of cells contained in 1 cluster

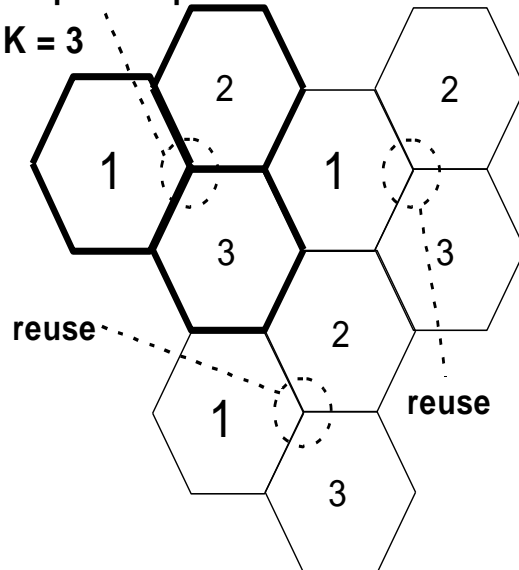
Contoh :

$K = 3$ means there are 3 cells in 1 cluster

$K = 4$ means there are 4 cells in 1 cluster

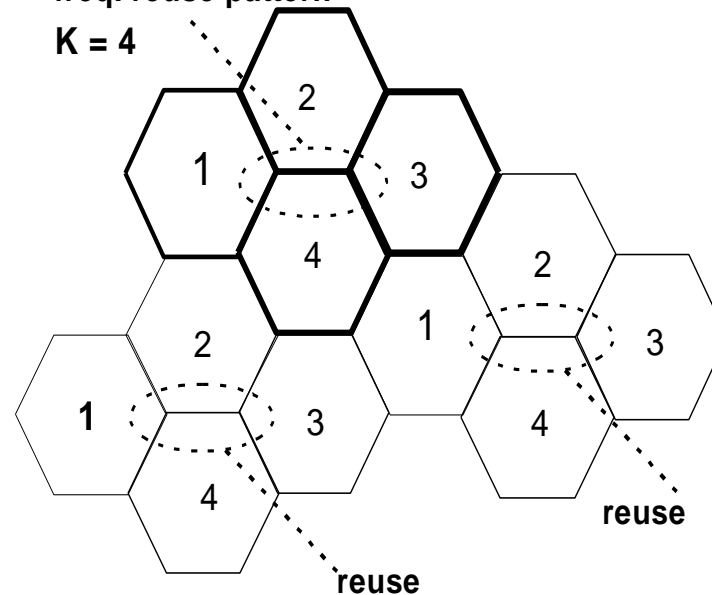
freq. reuse pattern / cluster

$K = 3$



freq. reuse pattern

$K = 4$



C/I minimum

→ **C/I minimum** depending on the cellular system which is implemented ...

$$\frac{C}{I} = \frac{1}{N} \left[\frac{D}{R} \right]^\gamma$$

$$\frac{D}{R} = \sqrt{3K}$$

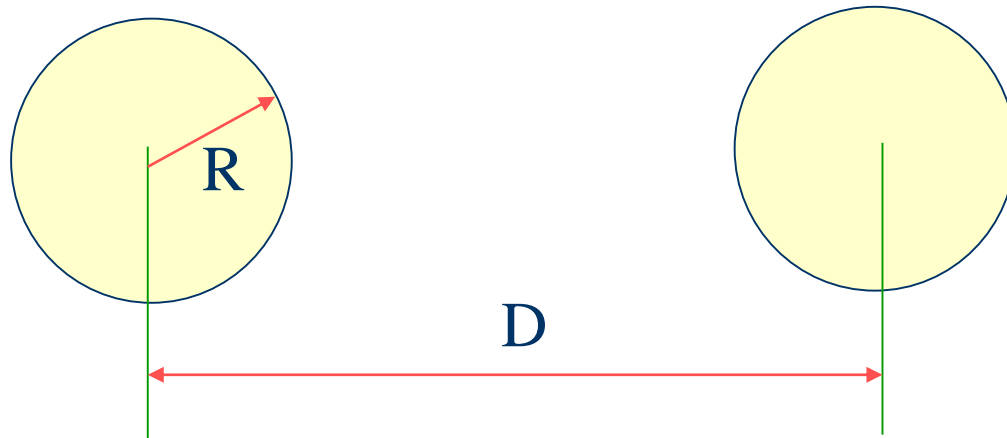
$$\frac{C}{I} = \frac{9K^2}{N}$$

AMPS, C/I = 18 dB

$$K = \sqrt{\frac{63N}{9}} = \sqrt{\frac{63.6}{9}} = 6,48 = 7$$

GSM, C/I = 12 dB

$$K = \sqrt{\frac{16N}{9}} = \sqrt{\frac{16.6}{9}} = 3,26 \approx 4$$

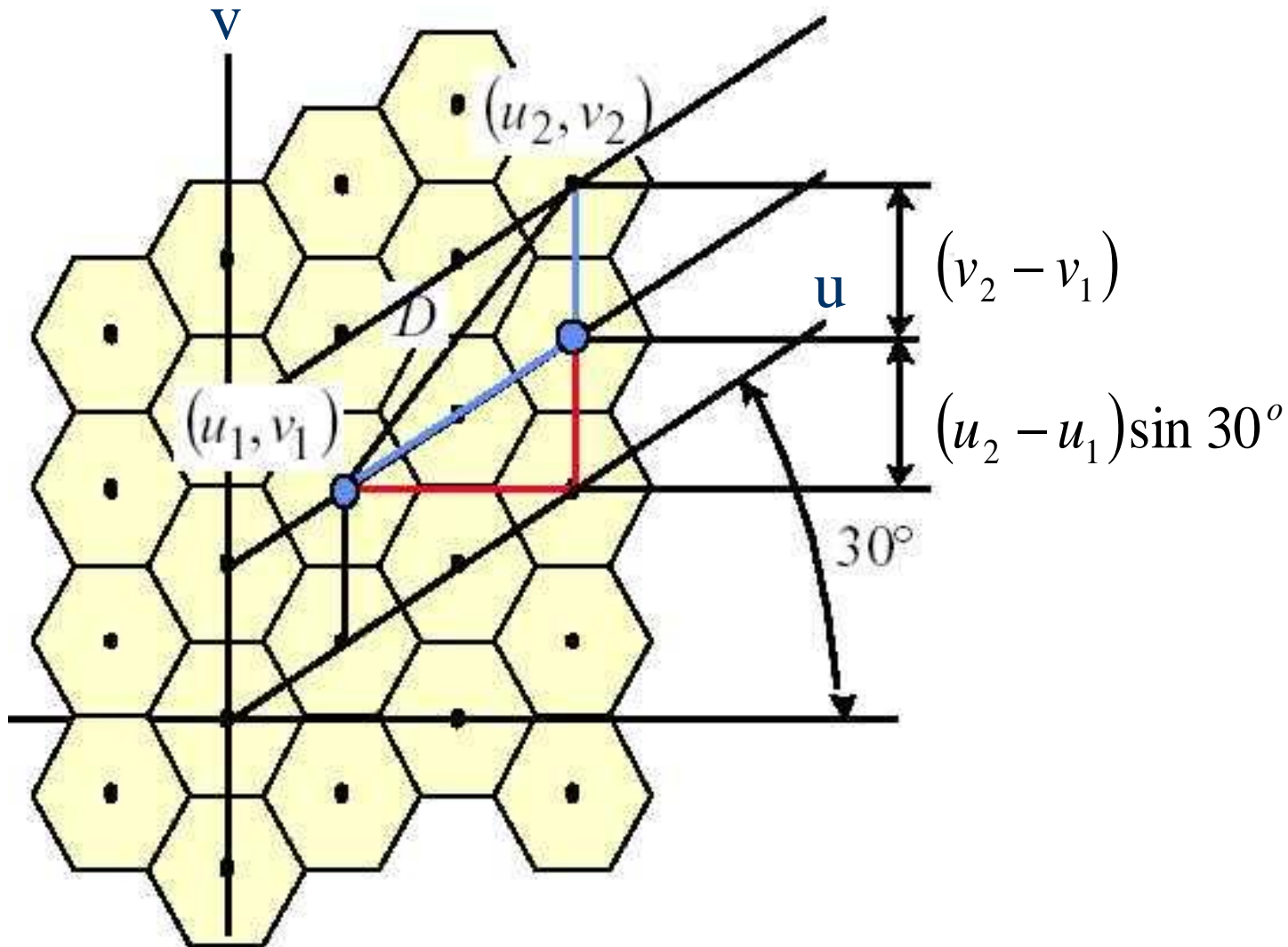


N = Number of cell interference
K = Cluster Size

Various values of K or N clusters, which may occur

i	j	$N = (i^2 + ij + j^2)$	$Q = D/R = \sqrt{3N}$
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

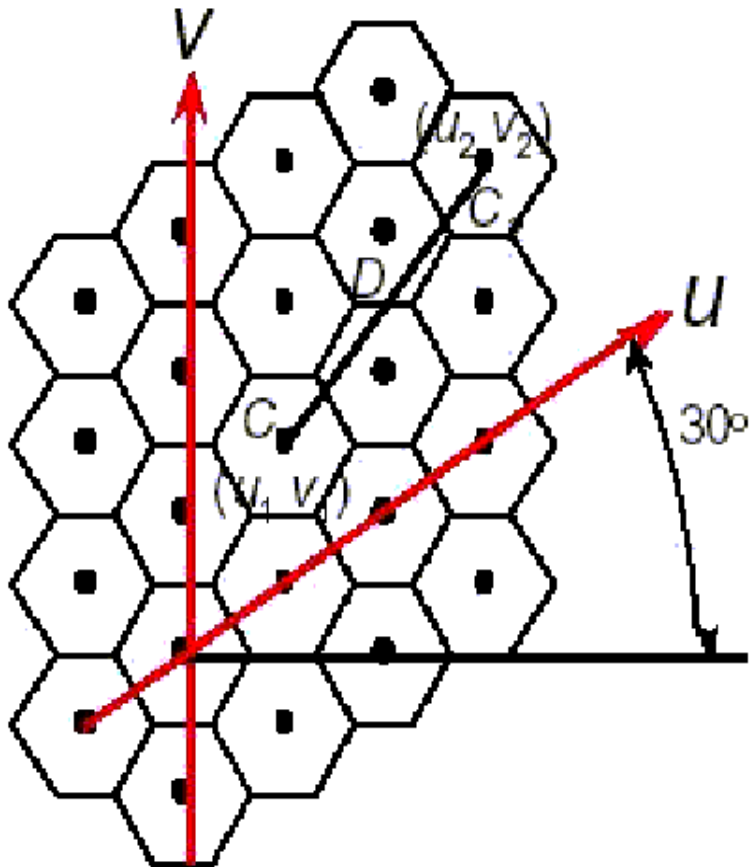
Coordinate Systems



Coordinate Systems

$$D = \left\{ (u_2 - u_1)^2 (\cos 30^\circ)^2 + \left[(v_2 - v_1) + (u_2 - u_1) \sin 30^\circ \right]^2 \right\}^{\frac{1}{2}}$$

$$D = \left\{ (u_2 - u_1)^2 + (v_2 - v_1)^2 + (u_2 - u_1)(v_2 - v_1) \right\}^{\frac{1}{2}}$$



if, $(u_1, v_1) = (0, 0)$

$(u_2, v_2) = \text{integer} = (i, j)$

then,

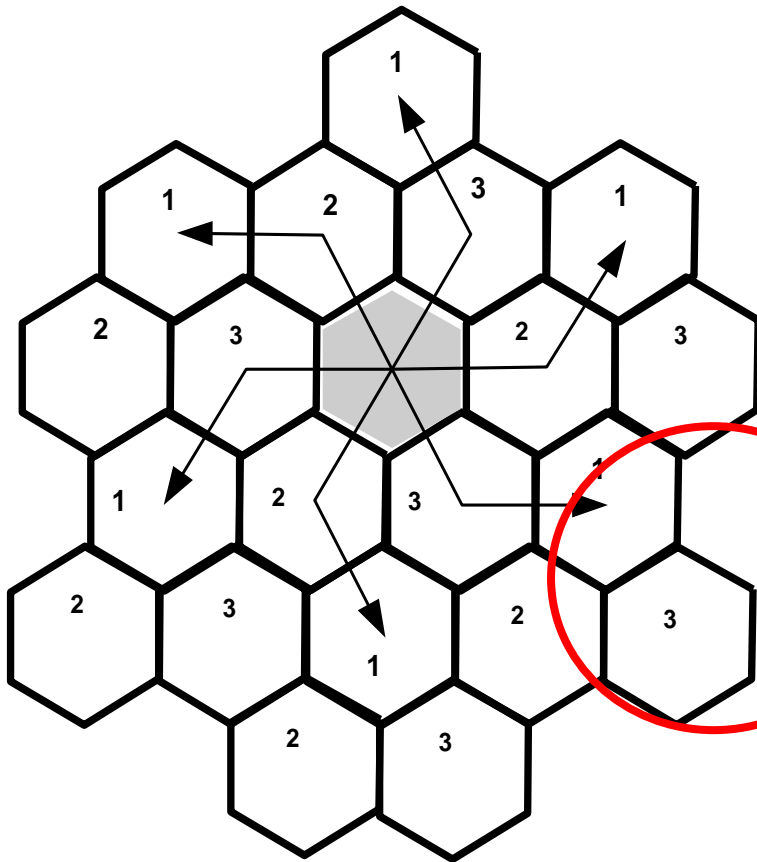
$$D = \sqrt{i^2 + ij + j^2}$$

In the next example,

$i = 2$ and $j = 1$

$$D = \sqrt{i^2 + ij + j^2} = \sqrt{2^2 + 2 \cdot 1 + 1^2} = 2,65$$

Example # 1 : $K = 3$

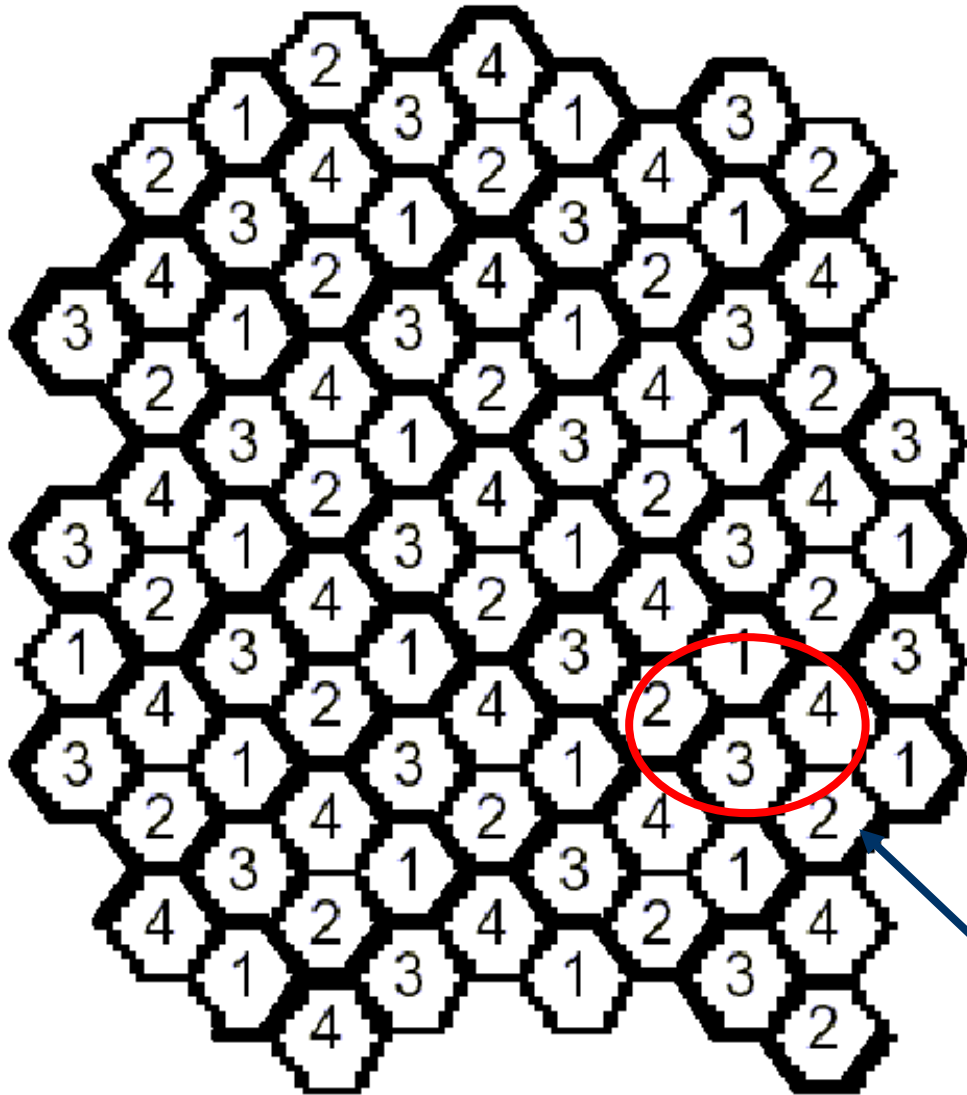


for $i = 1$ and $j = 1 \rightarrow K = 3$

- $i = 1, j = 1$
- $K = 1^2 + 1^2 + 1.1 = 3$
- Maximum interference source = 6.

Cluster

Example # 2 : $K = 4$



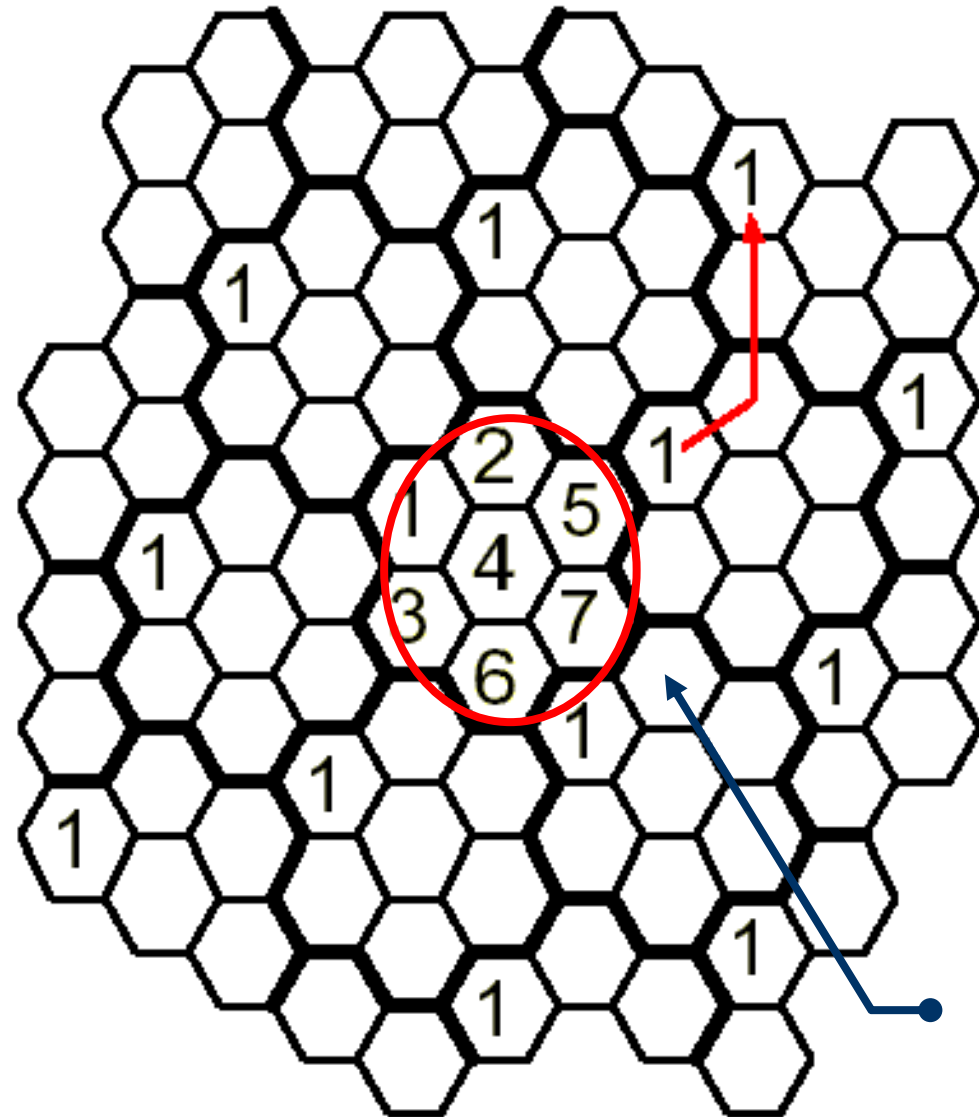
$$i = 0, j = 2$$

$$K = i^2 + ij + j^2 = 4$$

$$Q = \sqrt{3K} = 3,46$$

Cluster

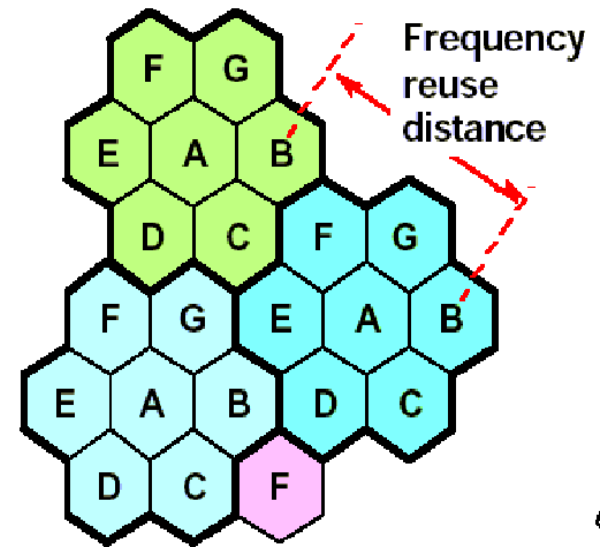
Example # 3 : $K = 7$



$$i = 1, j = 2$$

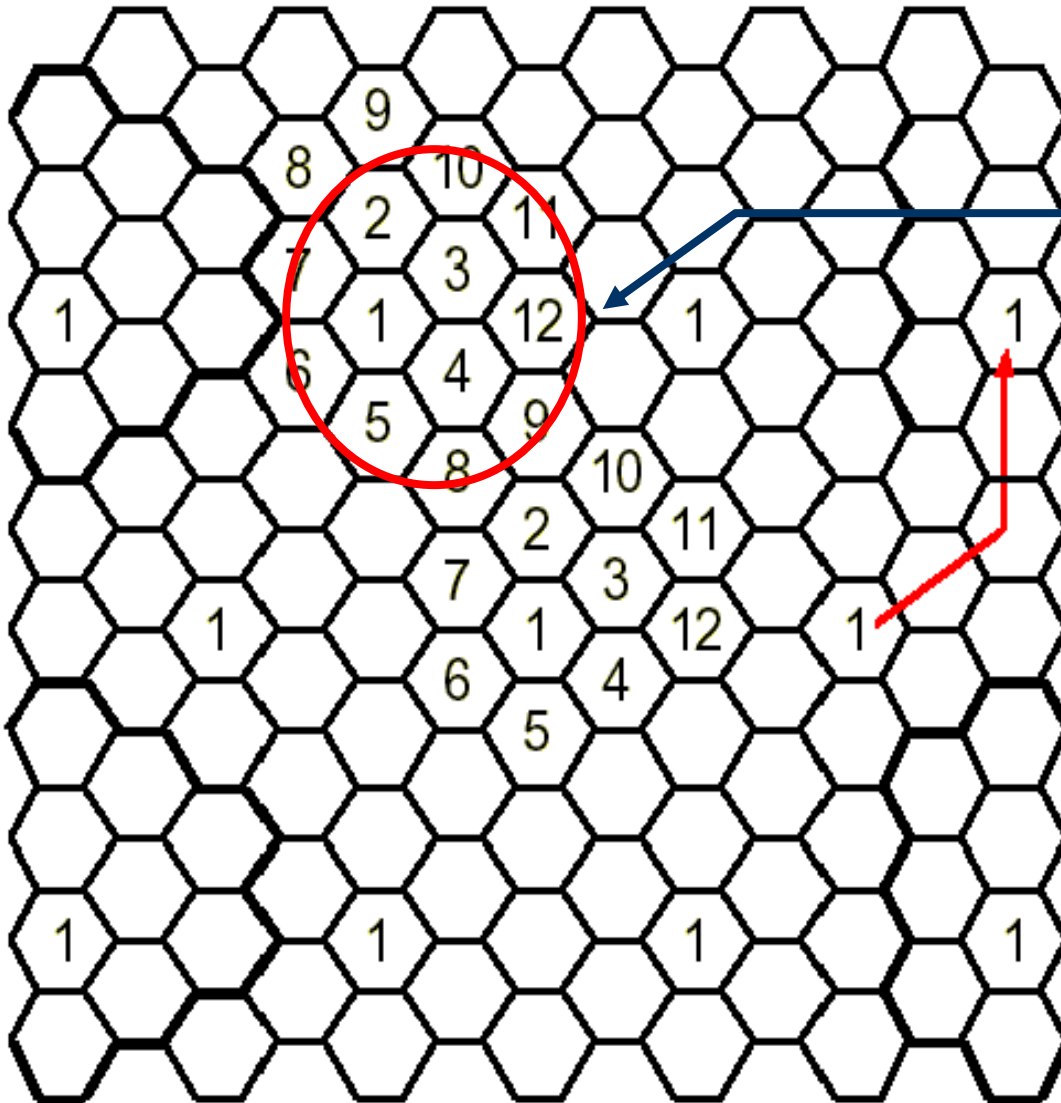
$$K = i^2 + ij + j^2 = 7$$

$$Q = \sqrt{3K} = 4,58$$



7-cell reuse pattern

Example # 4 : $K = 12$



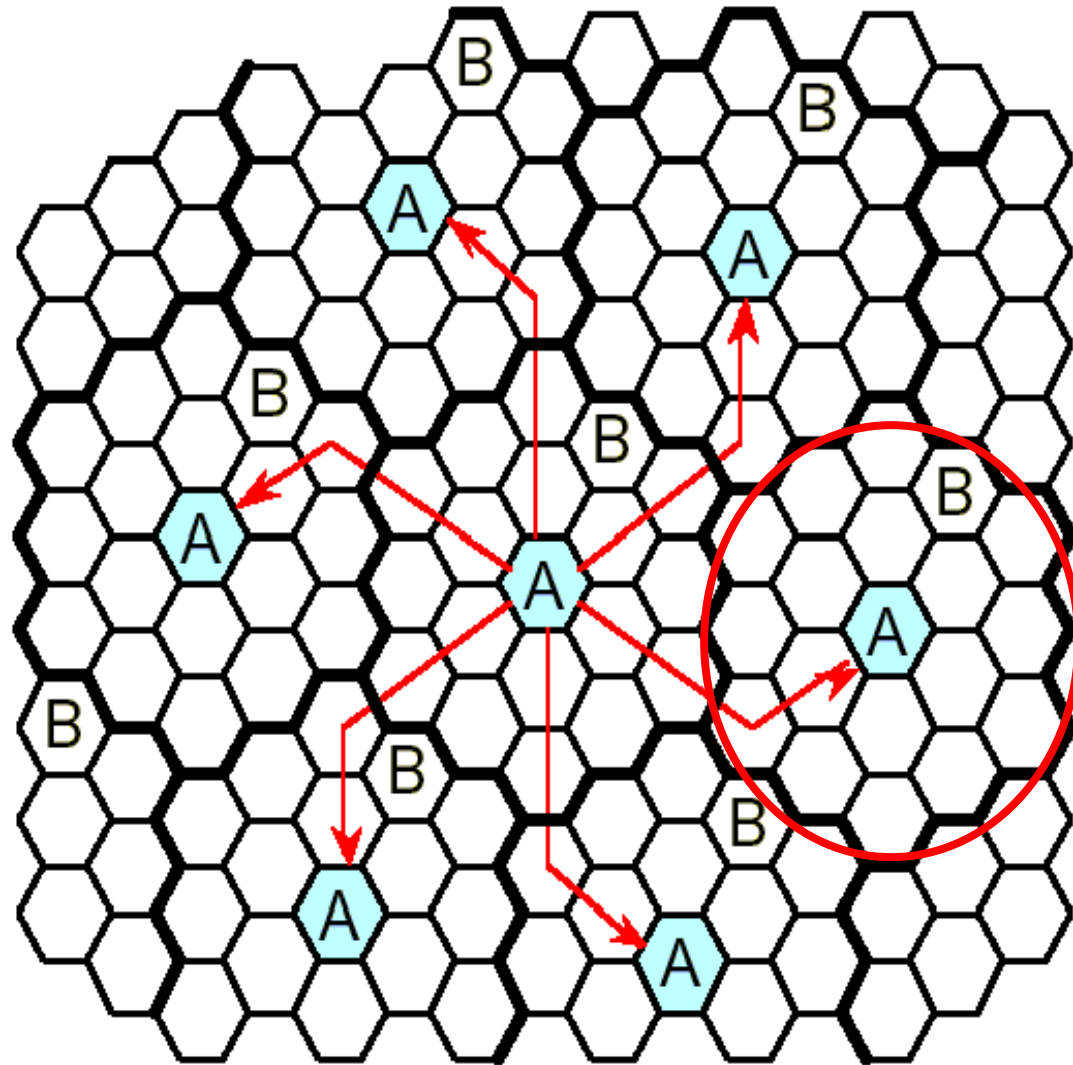
Cluster

$$i = 2, j = 2$$

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

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

Example # 5 : $K = 19$



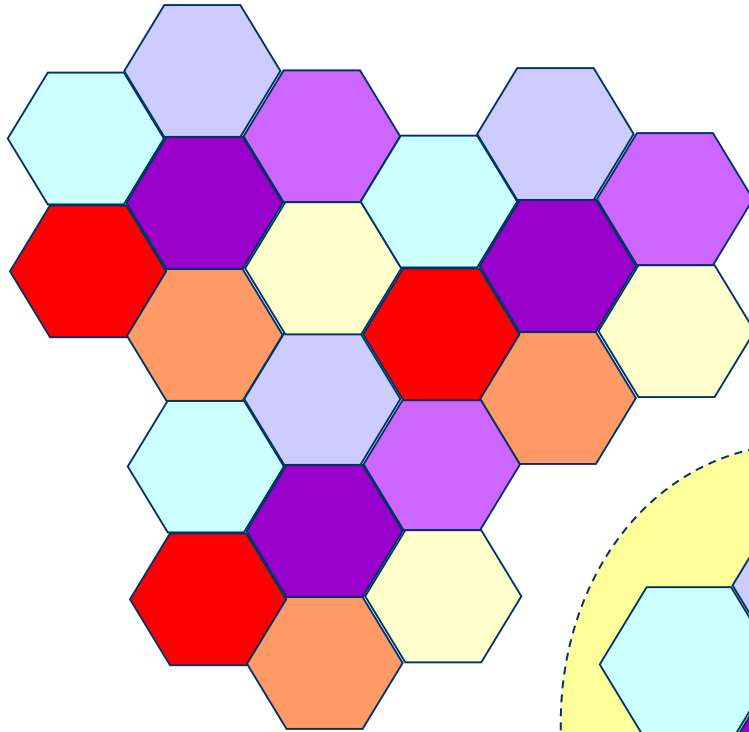
$$i = 3, j = 2$$

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

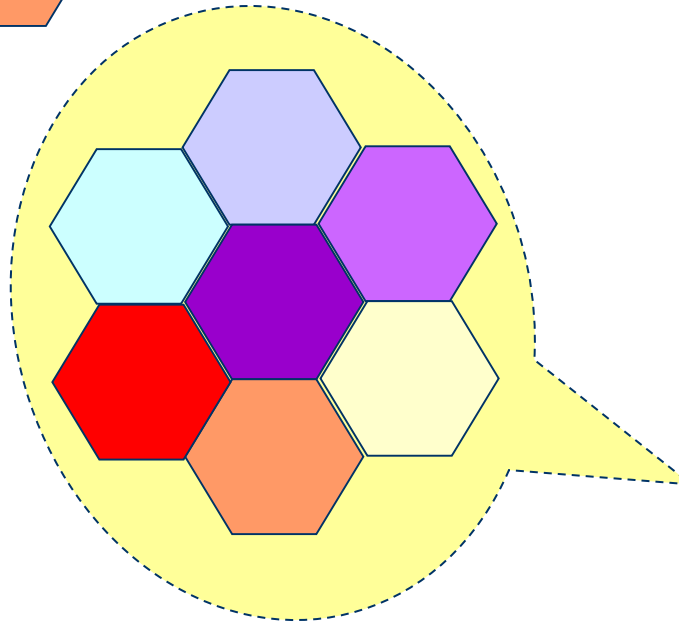
$$Q = \sqrt{3K} = 7,55$$

Cluster

Example Cluster in GSM



$K = 7$



1 kluster

Signal-to-Interference Ratio.

- Consider closest co-channel cells:

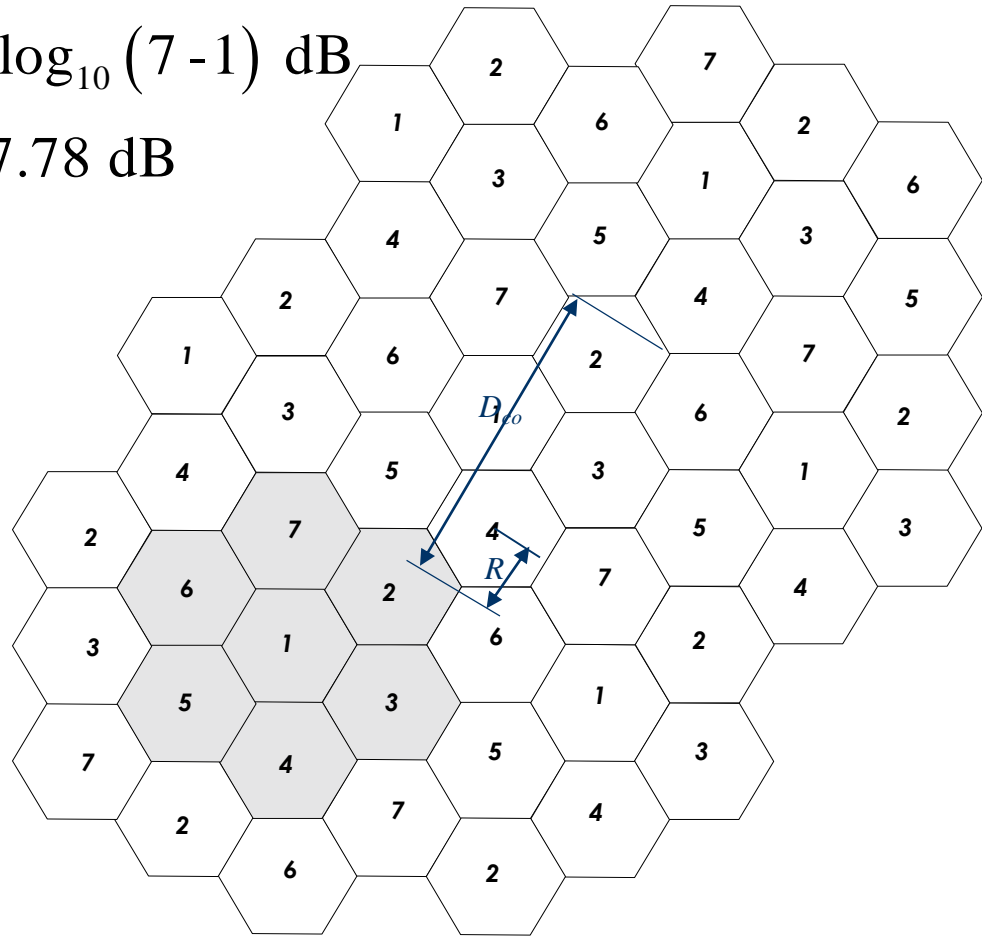
$$\begin{aligned} \text{SIR}_{\min} &= -K_1 \log_{10} (D_{co} / R - 1) - 10 \log_{10} (7 - 1) \text{ dB} \\ &= -K_1 \log_{10} (D_{co} / R - 1) - 7.78 \text{ dB} \end{aligned}$$

- Ukuran Kluster:

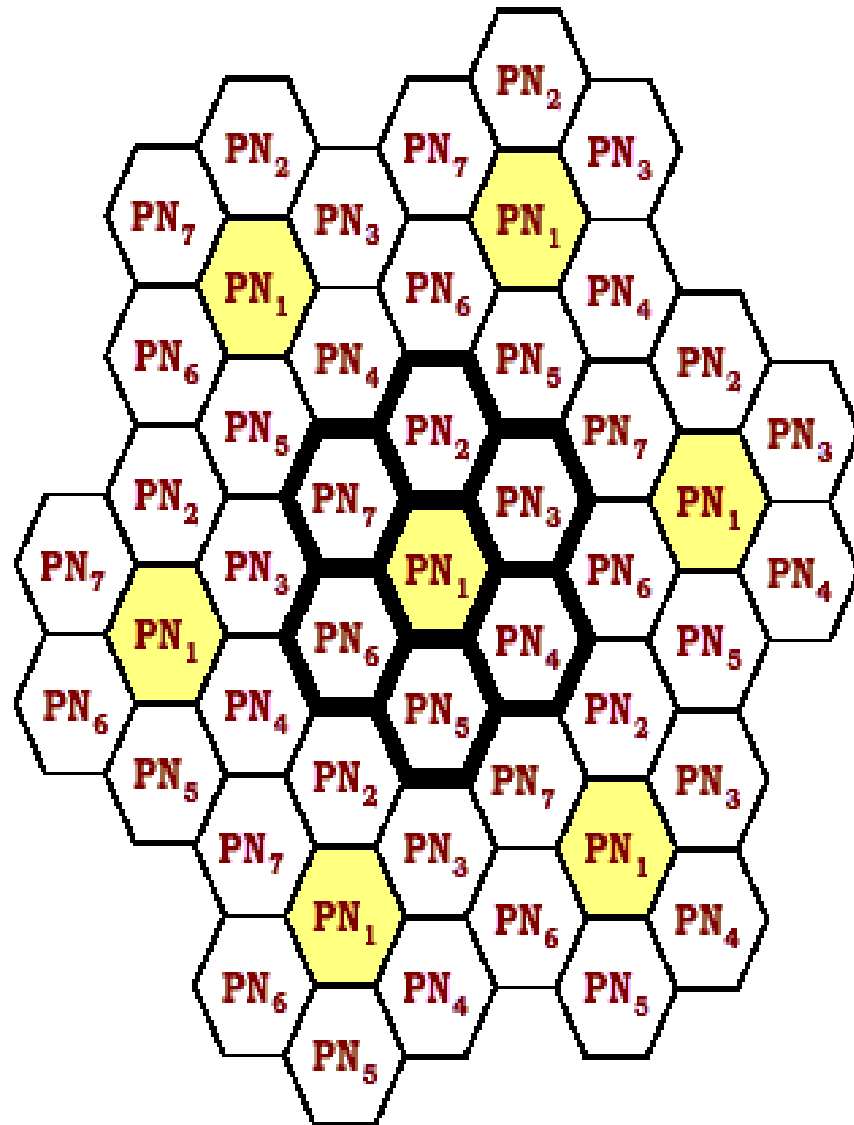
$$N = i^2 + ij + j^2$$

- Co-channel Reuse Distance Ratio:

$$D_{co} / R = \sqrt{3N}$$



Conception clusters on CDMA



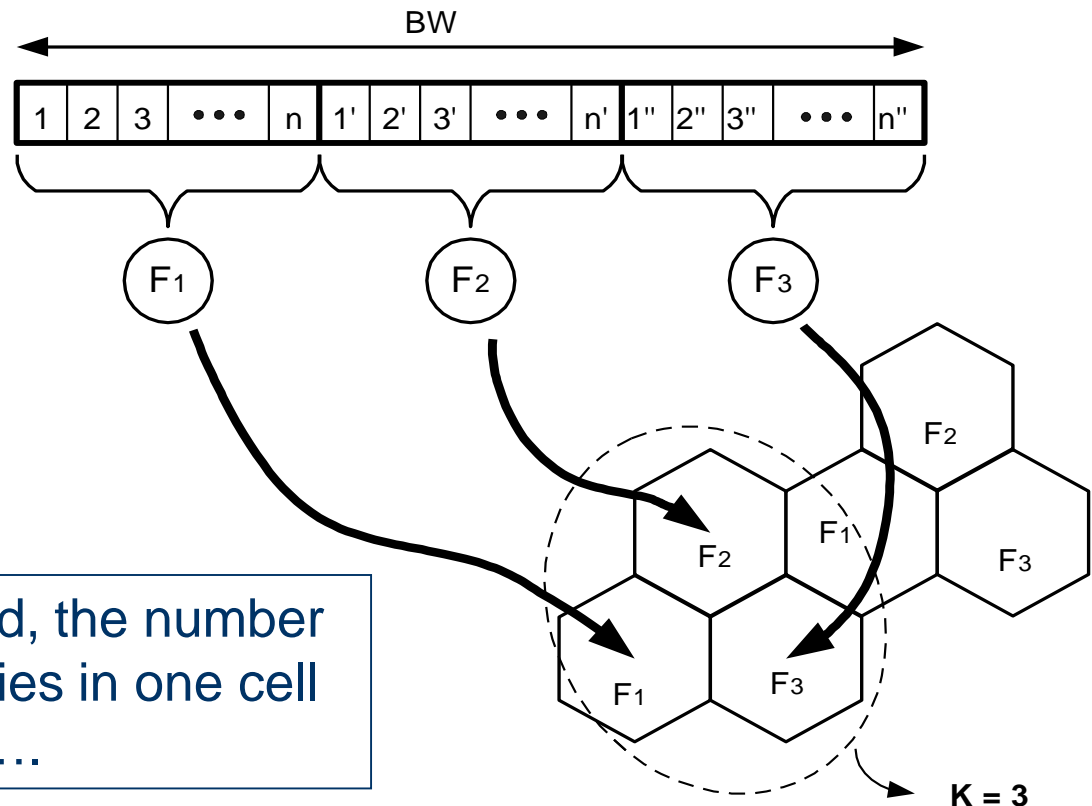
In the same sense, which we understand ... the size of clusters in CDMA cellular networks, $K_{\text{CDMA}} = 7$, meaning the same operating frequency is applied in all cells

However, CDMA uses the concept of clustering for planning the PN code, **this is to prevent the possibility of aliasing** between the code in one cell. In CDMA networks, known as **PN reuse factor**

Channel capacity of each cell

- Number of channels per cell expressed by the following formula :

$$N = \frac{BW_{Alokasi}}{BW_{ch\ RF}} \frac{\text{number of channel}}{ch\ RF} / K$$

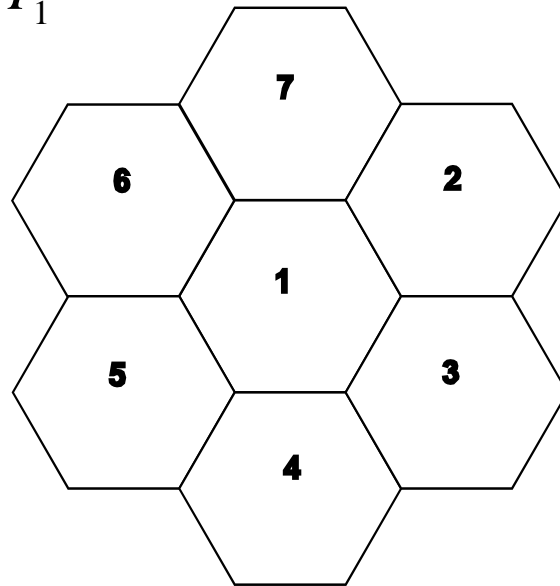


It can be concluded, the number of carrier frequencies in one cell is more than one

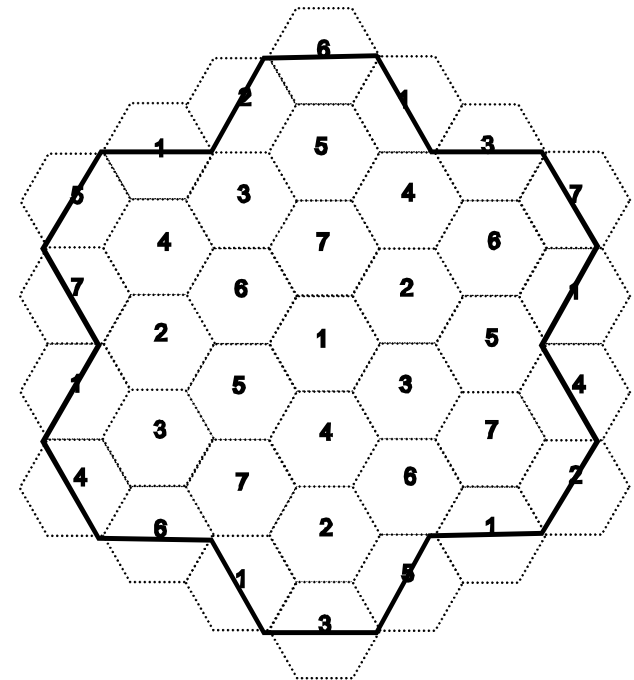
Cell Splitting

- To increase the capacity, the operator performs cell splittings

$$\frac{C_1}{C_0} = \left(\frac{R_0}{R_1} \right)^2 = \frac{P_0}{P_1}$$

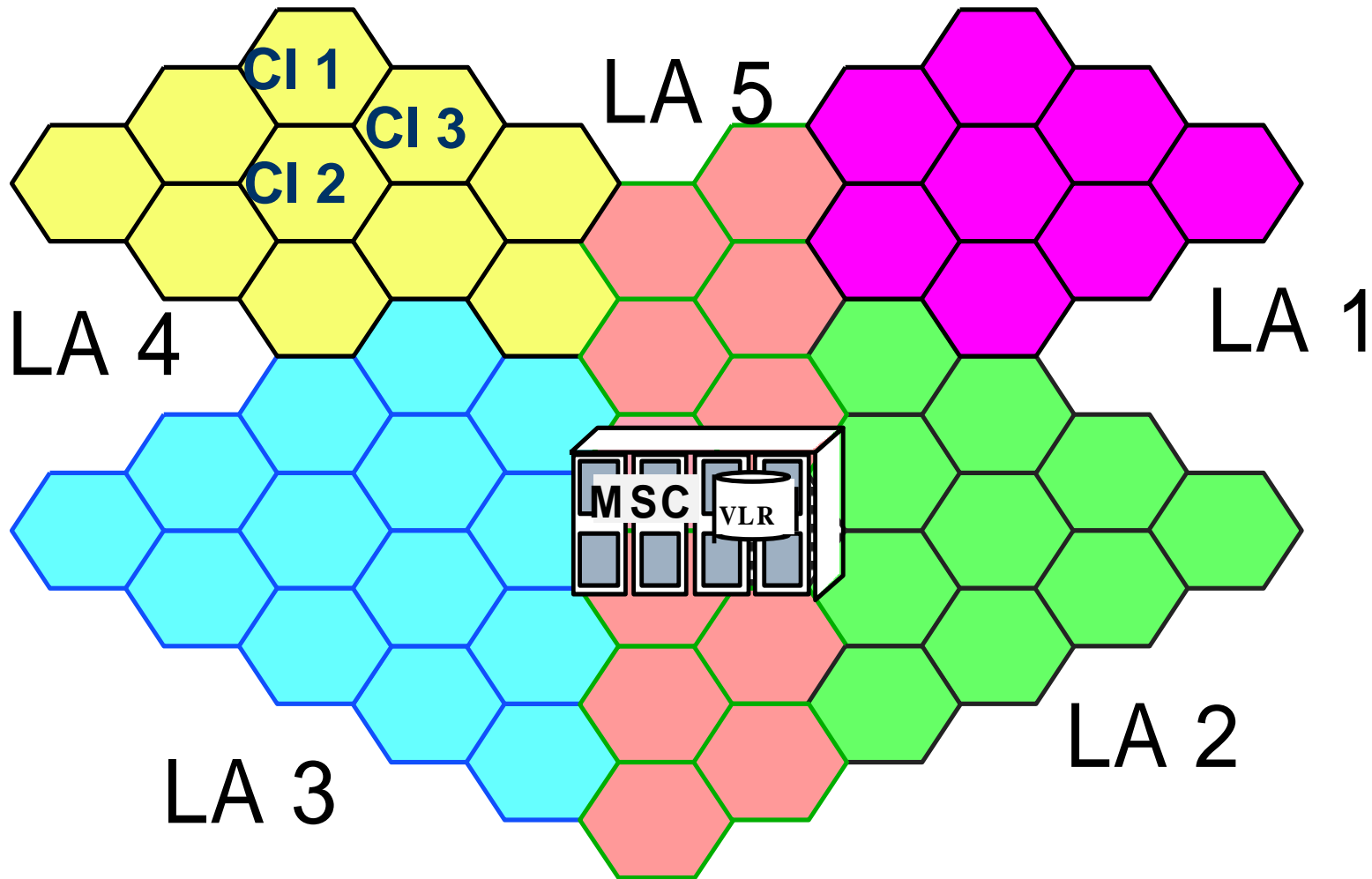


before cell splitting



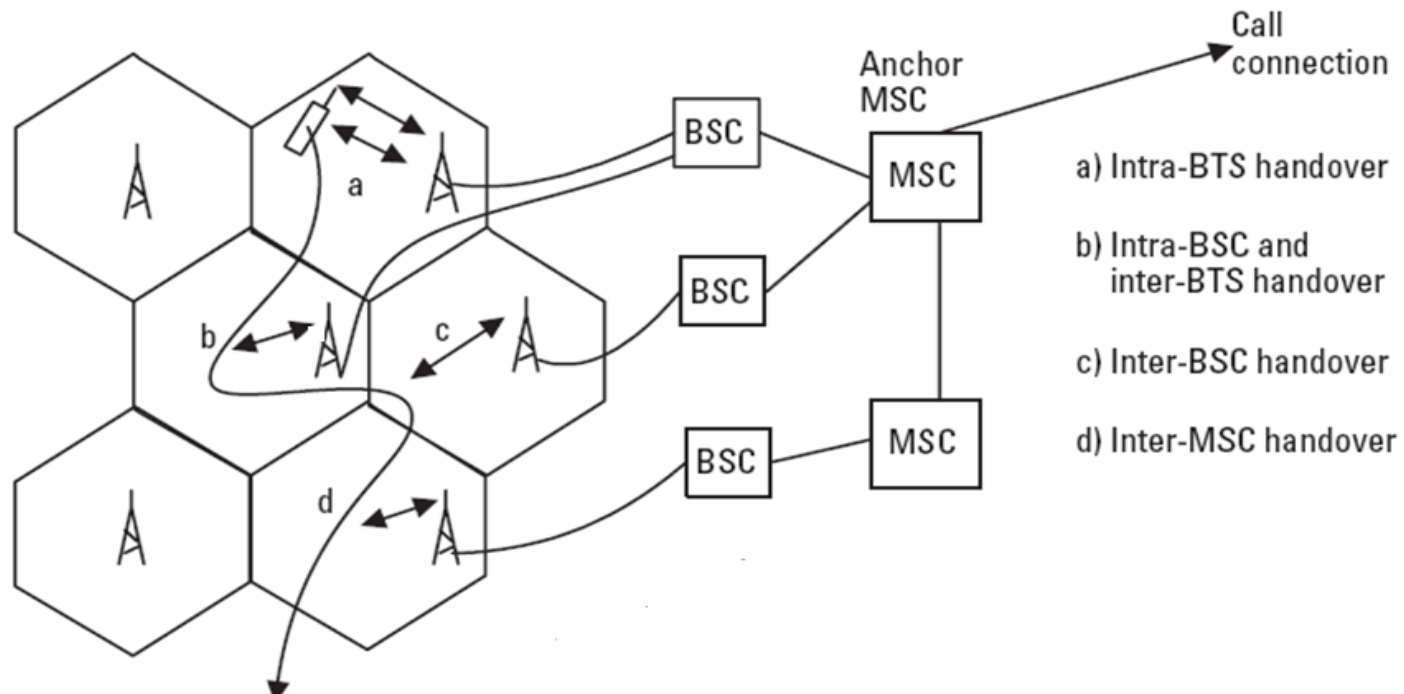
after cell splitting

Location Area and Cell Identity



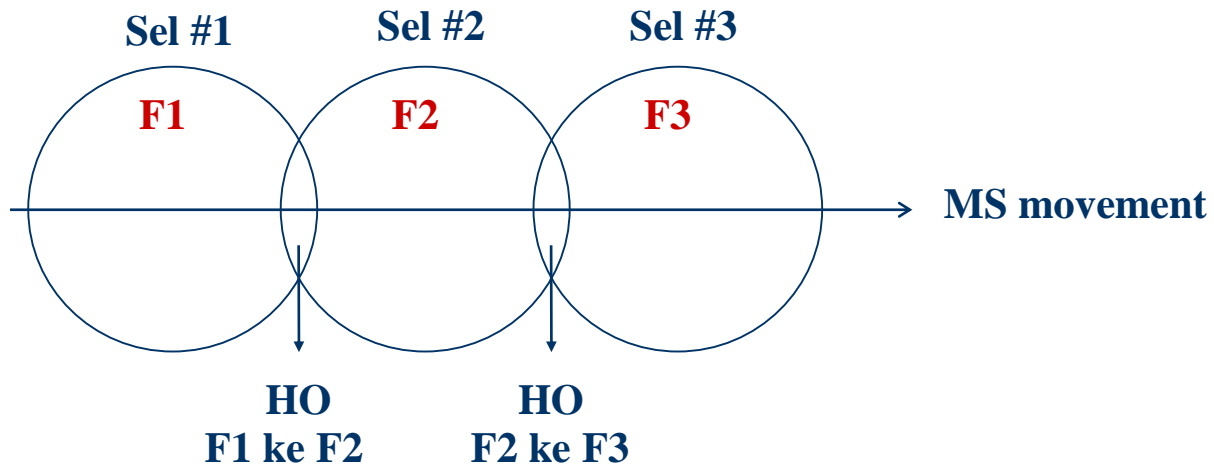
Handover

Handover adalah proses pengalihan kanal traffic pada MS yang sedang digunakan untuk berkomunikasi tanpa terjadinya pemutusan hubungan



Definition of HandOver

- Handover is the process of transfer of user traffic channels at the time of active users without termination and without intervention from the user.
- Handoff is no different except that the term handoff handover used in the U.S., while the term handover is used in Europe.
- Events hand over (HO) 'generally' occur because movement of the MS so that out of the scope of coverage of the cell of origin and entry of new cells.



The basic reason for the handoff

- **MS out of the scope of the BTS (RF criteria)**
 - Received signal level is too low
 - Bit error rate (BER) is too high
- **To balance the network load (Network criteria)**
 - Traffic in one cell is too high that some MS 'handed over' to another cell

Note: Standard GSM recorded 40 reasons to handover !

2 Phase handoff ...

1. MONITORING PHASE

- Measuring the quality of the signal and 'see 'the possibility of alternative radio link
- Initiation handoff if necessary

2. HANDOVER HANDLING PHASE

- Determination of the point of attachment (PoA) new
- Initiation of the possibility of re-routing procedure

Definition ofcontinued

- Type of HandOver :

I. Internal HandOver (Controlled by oleh BSC)

- 1. *Intra-cell HandOver*:** transfer relationship to a different channel on the same single base station.
- 2. *Inter-cell HandOver*:** the transfer relationships between different base stations in a single BSC

II. External HandOver (Controlled by oleh MSC)

- 1. *Intra MSC Handover*:** the transfer of the relations between the BSC in a single MSC.
- 2. *Inter MSC Handover*:** displacement relationships that occur in 2 different MSC.

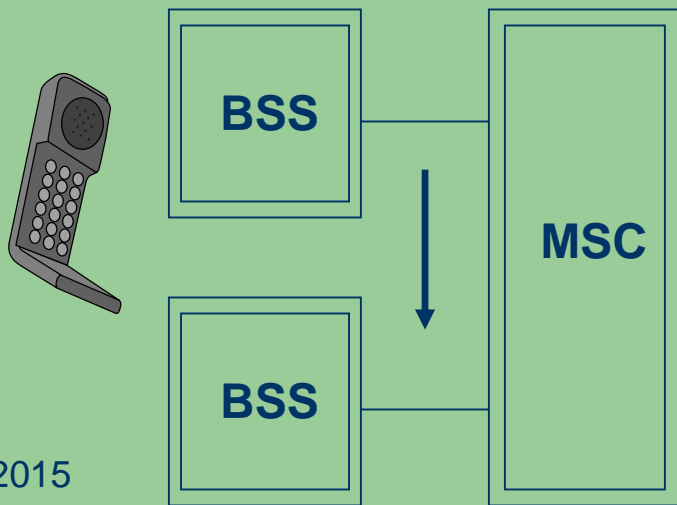
GSM handover mechanism

Handover Types

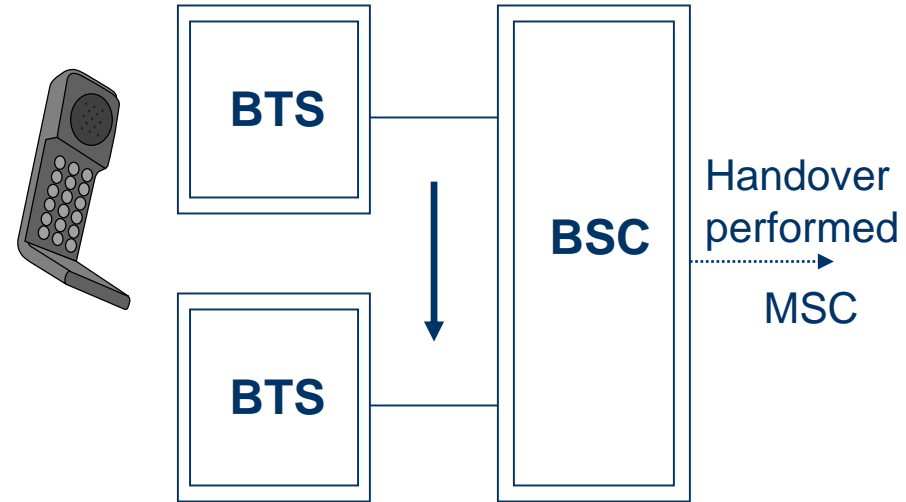
Intra-cell



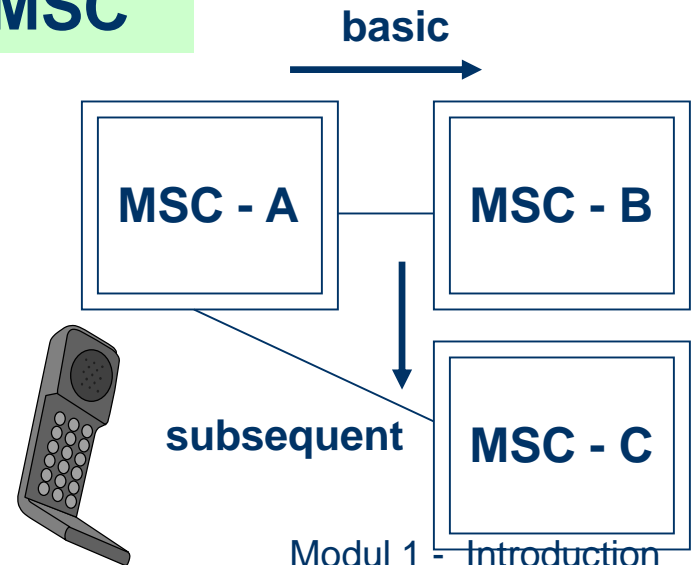
Intra-MSC



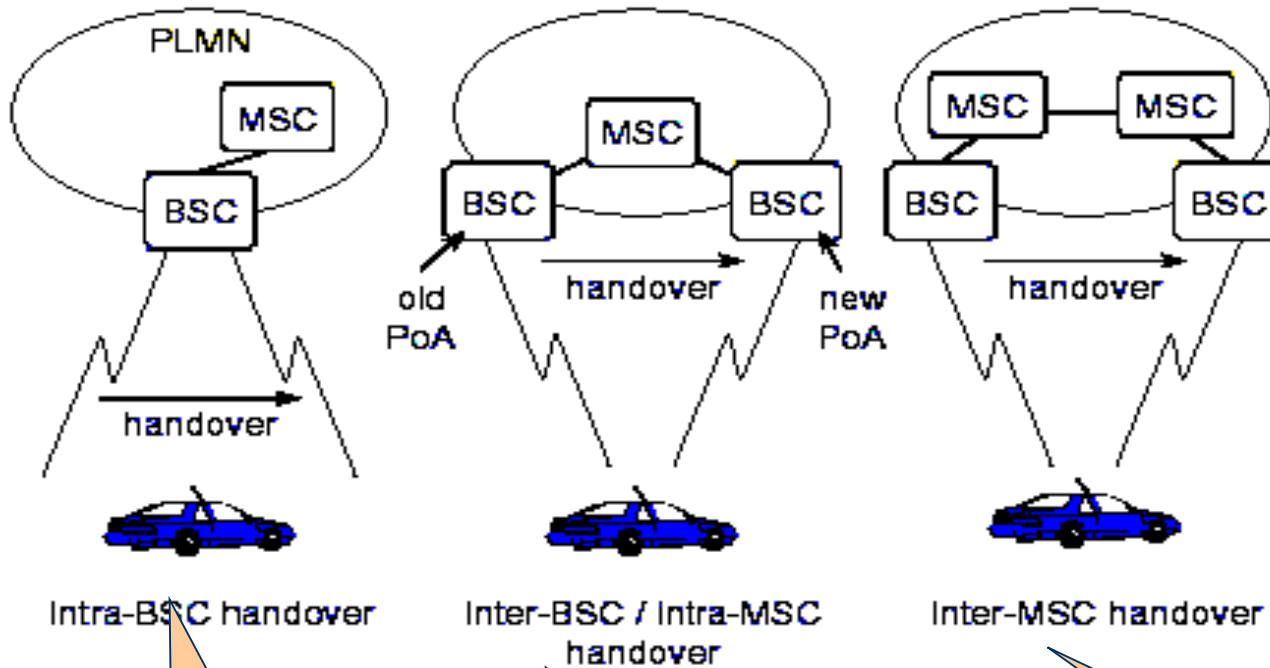
Intra-BSS



Inter-MSC



The basic reason for the handoff ...continuation

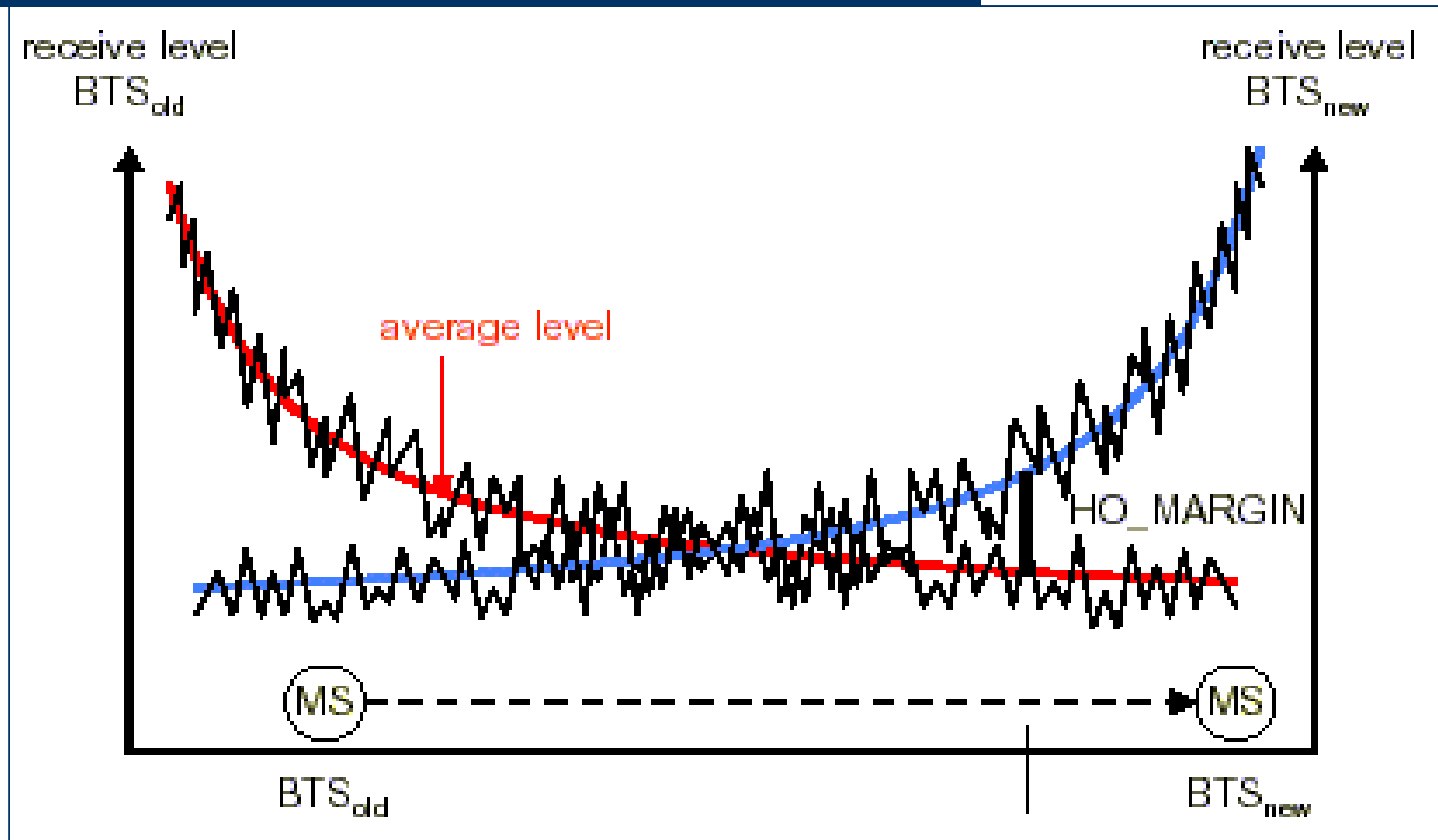


- Often due to narrowband interference

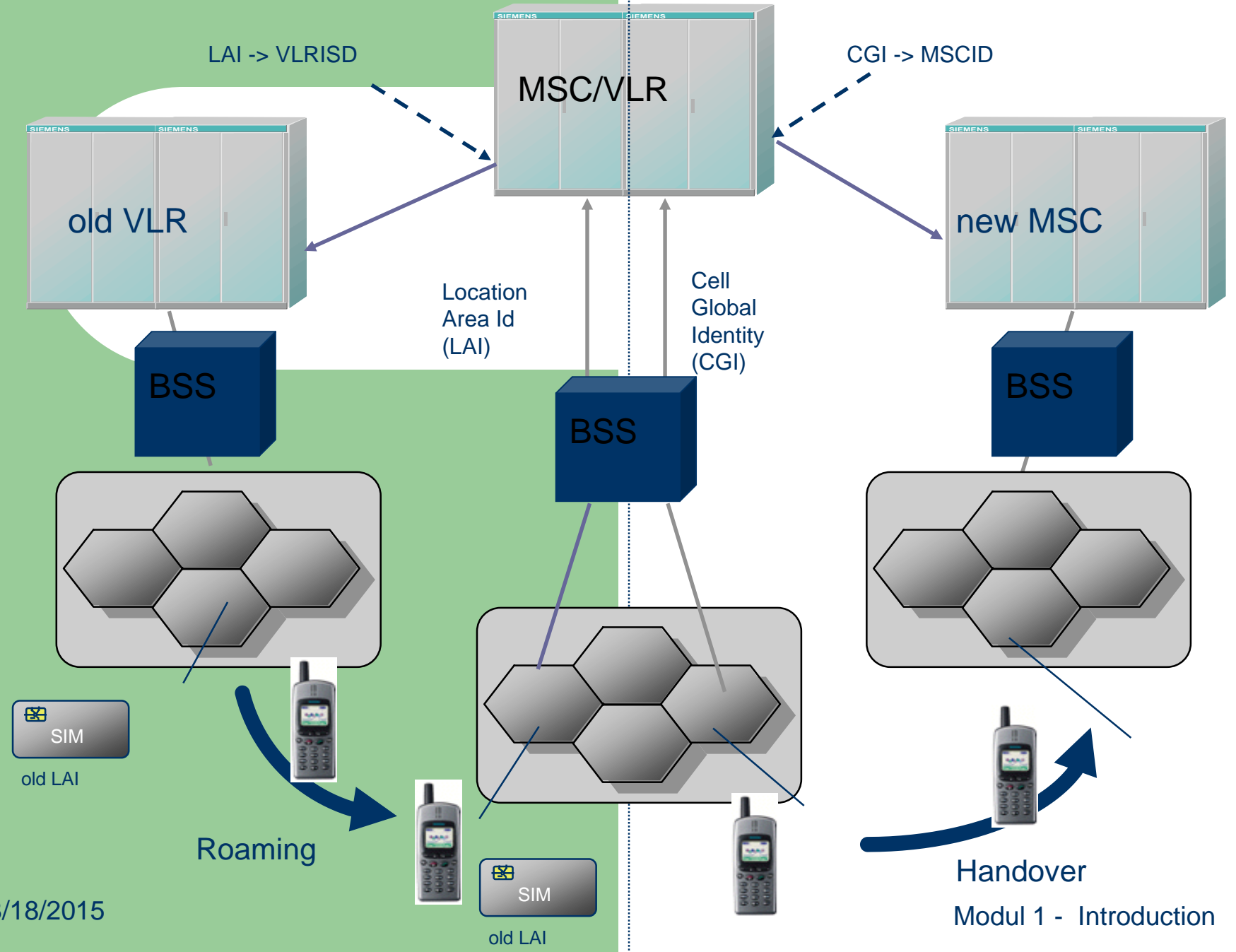
- The most common case
- 2 cases: (1)-cell inter / intra-BSC, (2) inter-BSC / Intra-MSC
- BSC HO operation, assign a new channel in the cell and remove the old channels in the previous cell

- Controlled by MSC

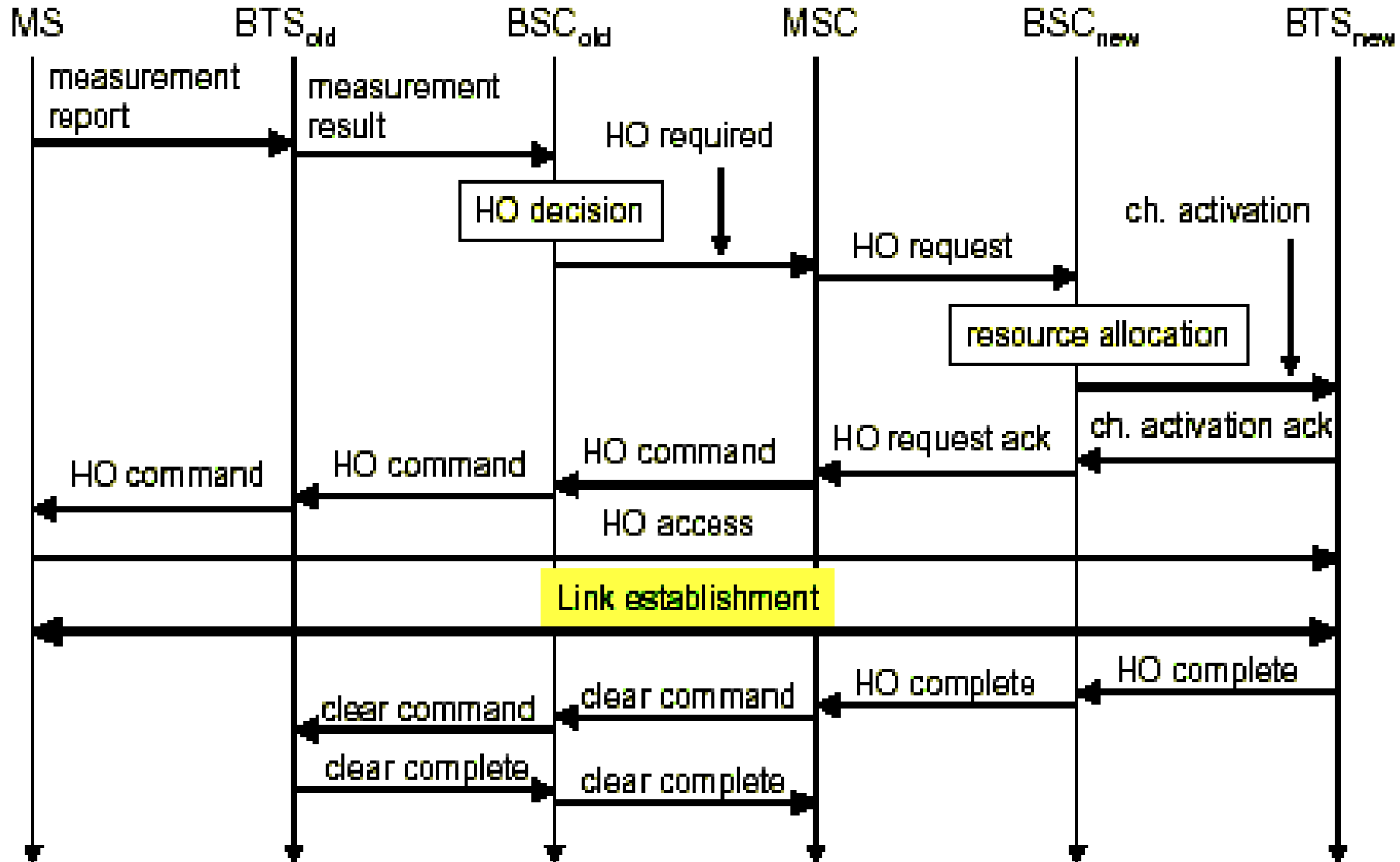
The reason for the handoff ... RF criteria



Mechanism for handover

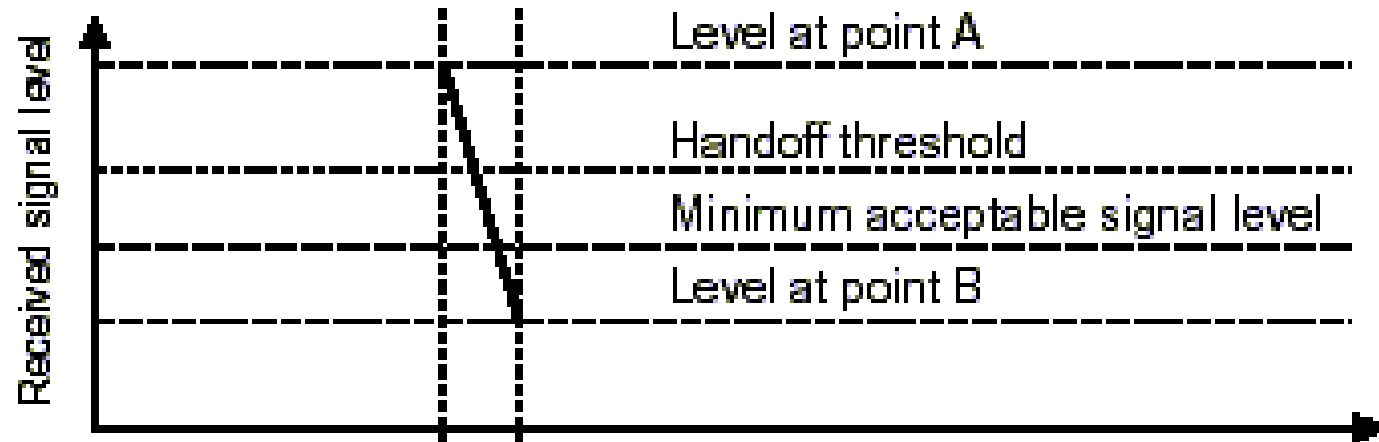


Mechanism for handover ...

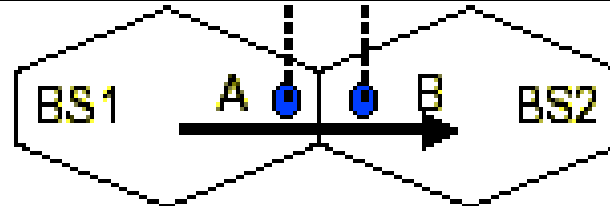
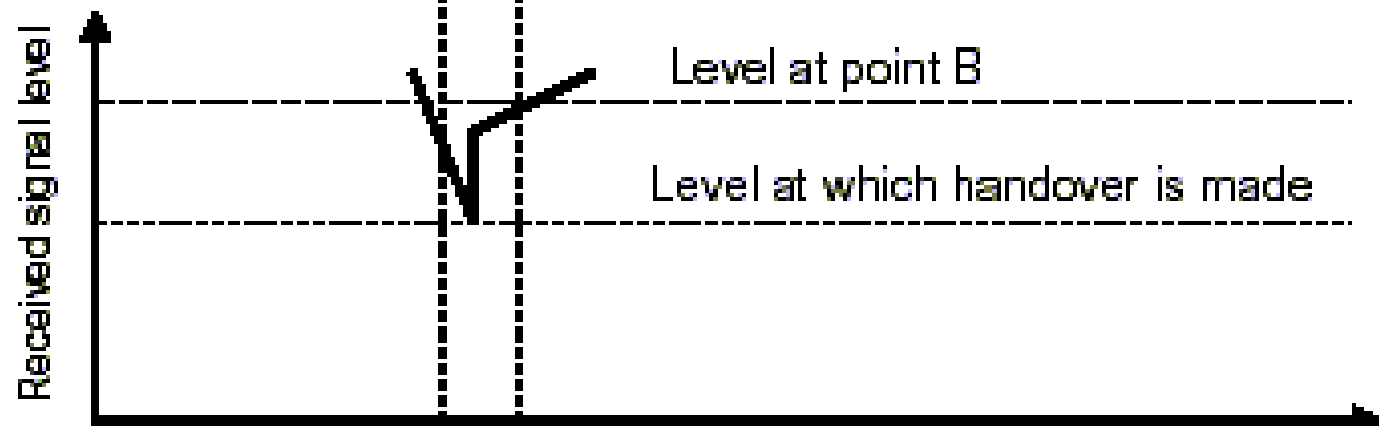


Mechanism for handover ...

Improper
handover situation

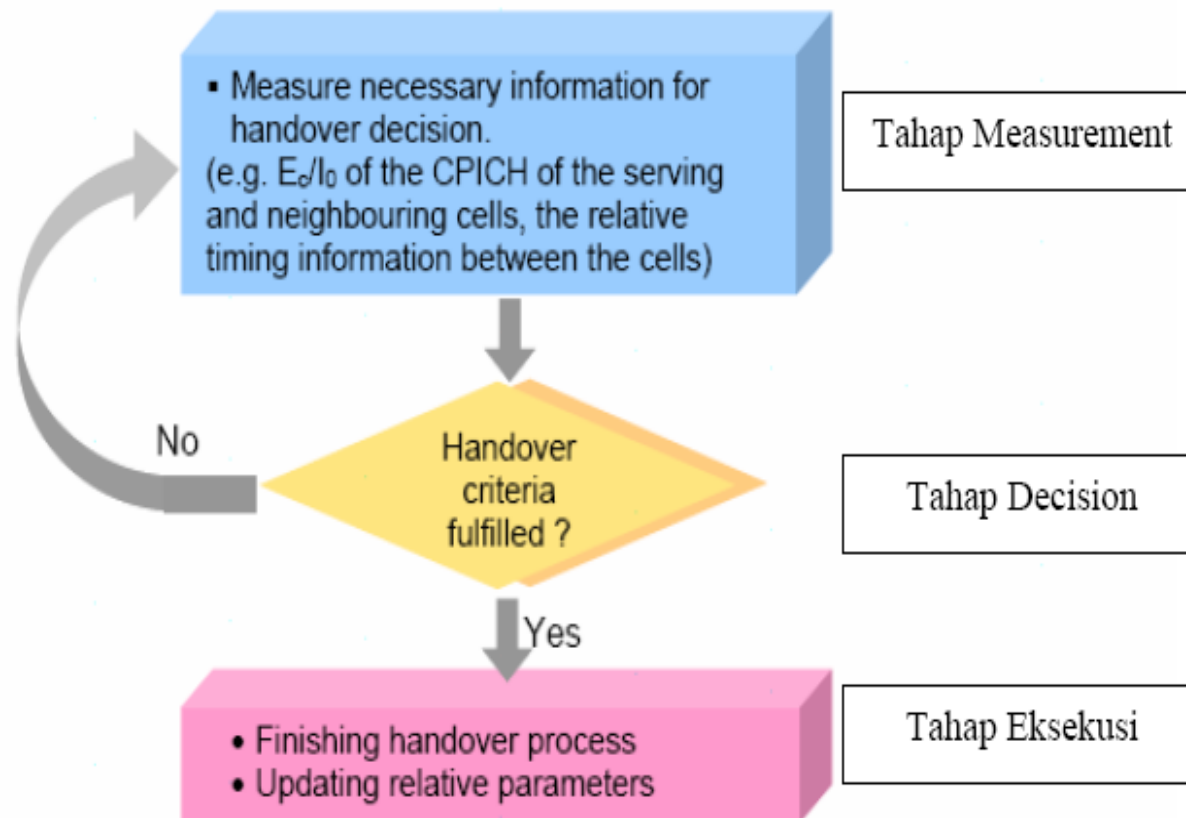


Proper
handover situation

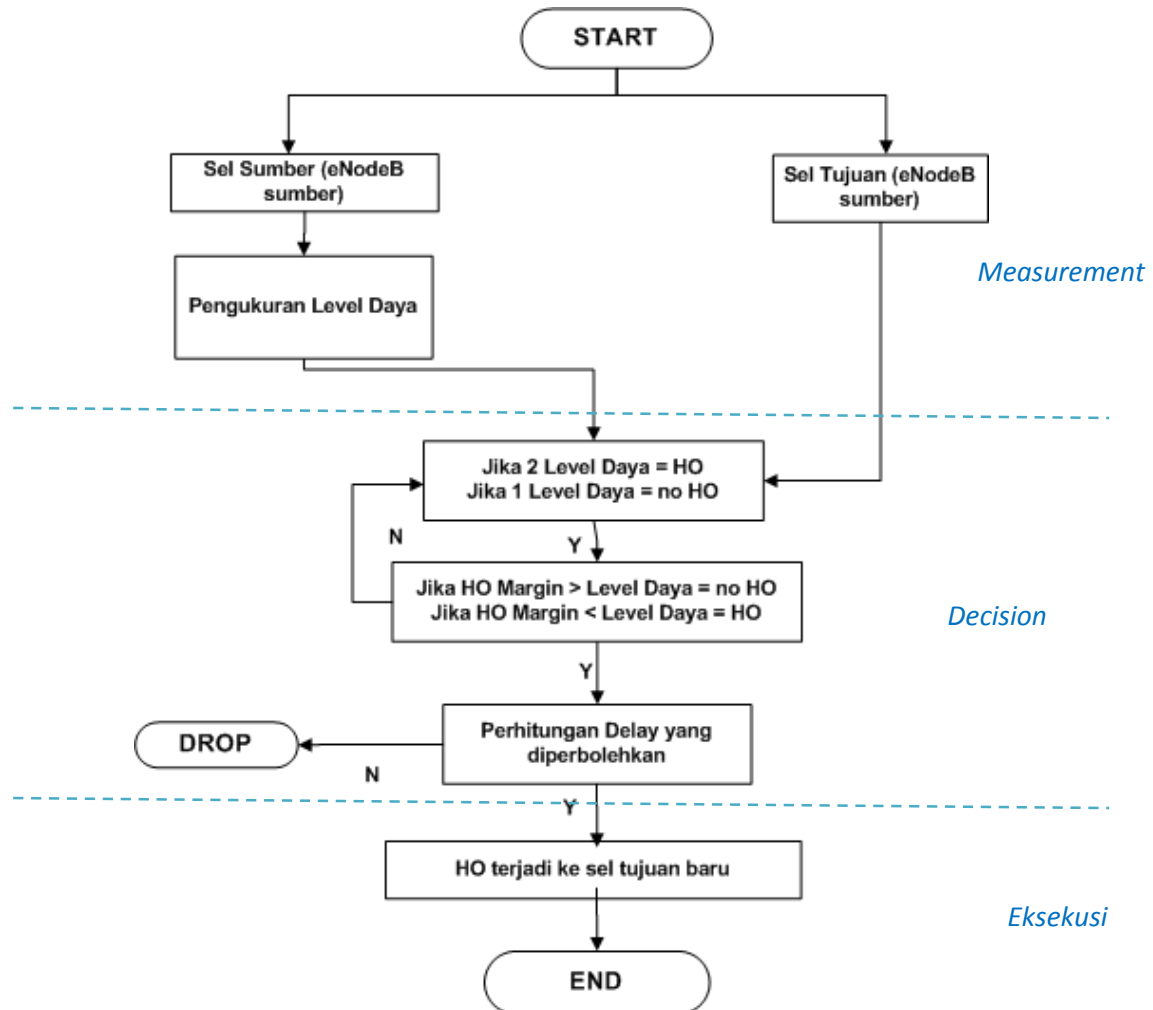


Handover

Handover is a facility in cellular system to guarantee communication continuously if customer move from one cell to other cell.



Flowchart Handover Process



GSM handover mechanism

GSM: Handover

1. mobile measures other cells



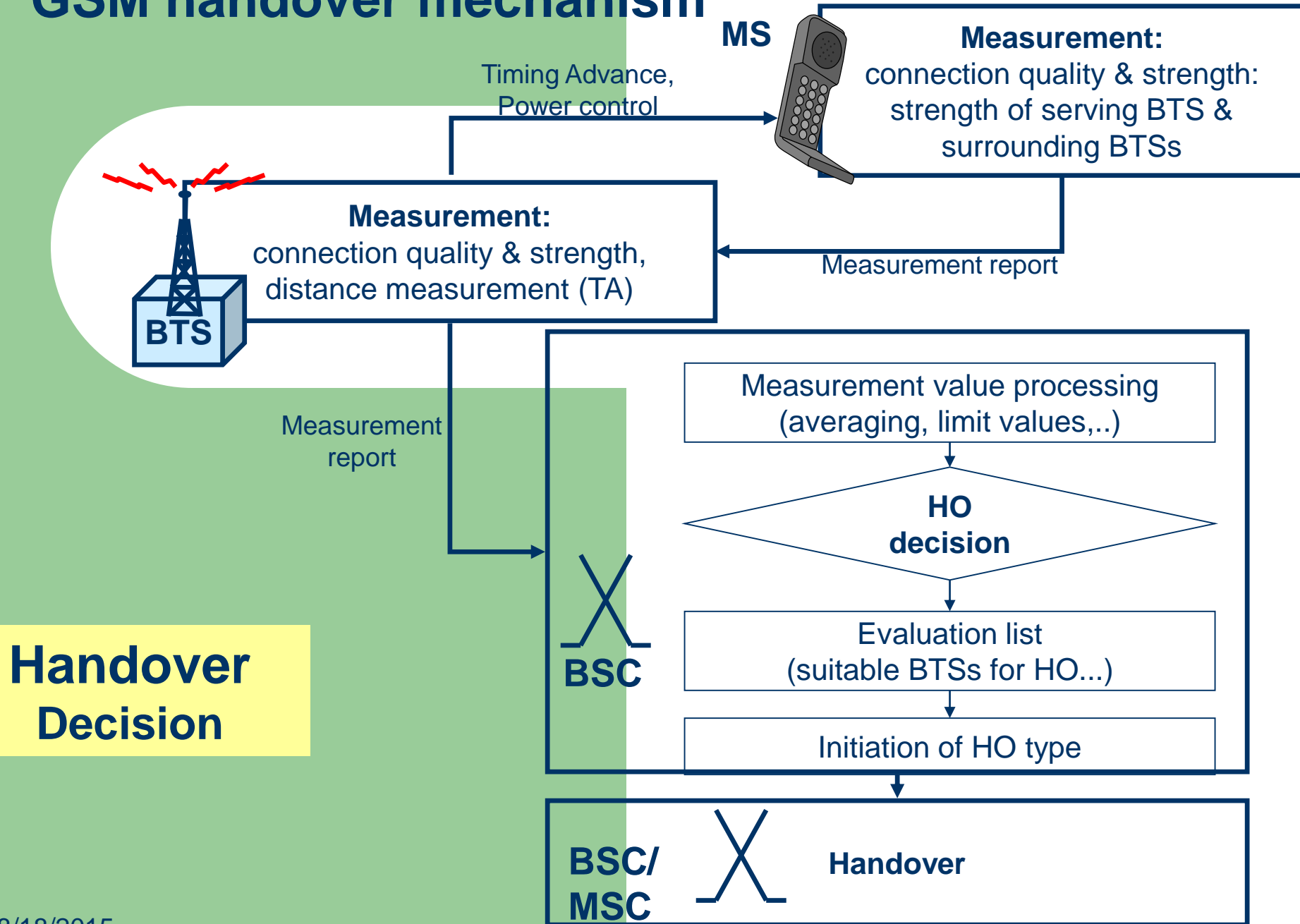
2. better cell detected, handover initiated



3. handover completed

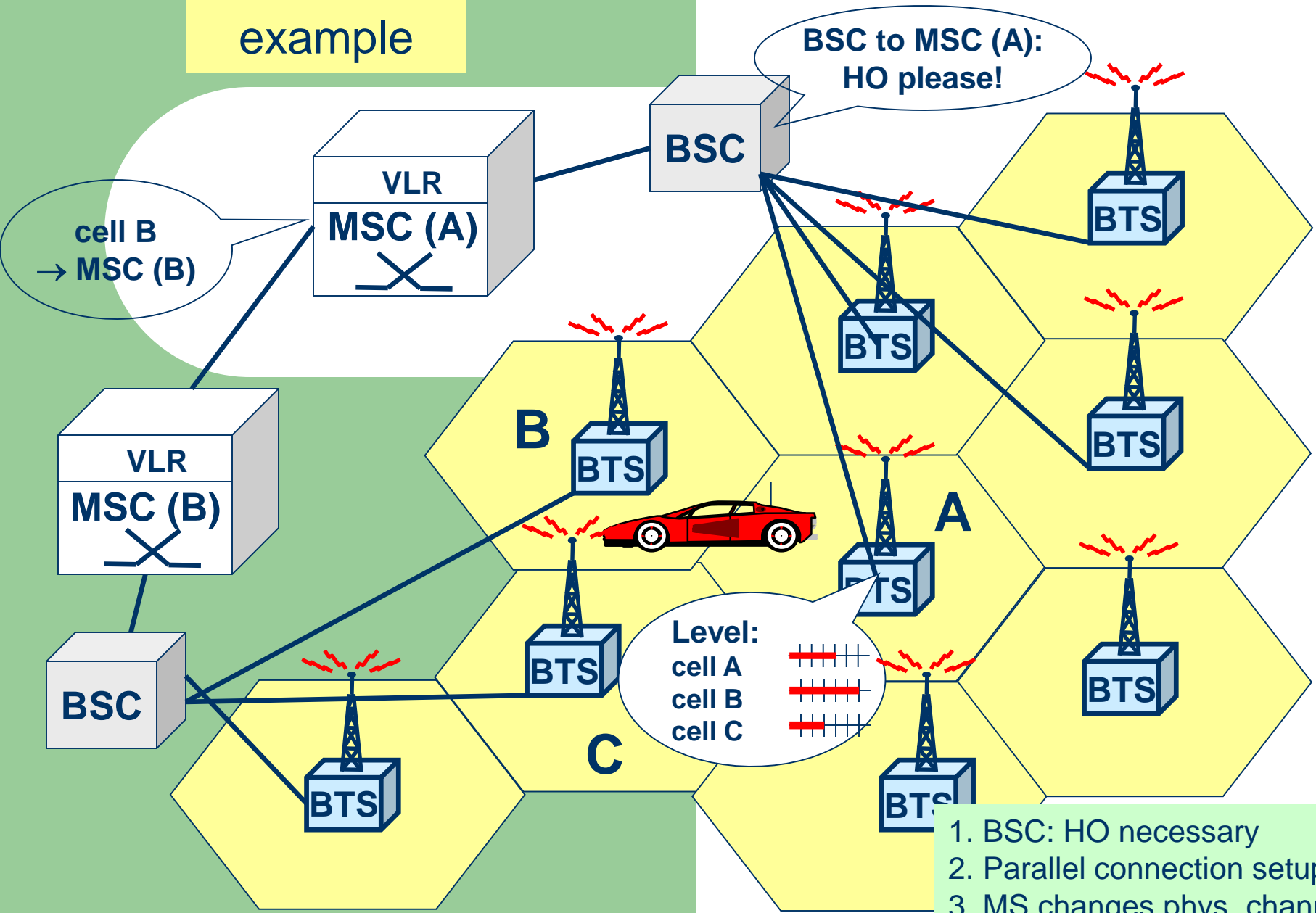


GSM handover mechanism



Handover example

GSM handover mechanism



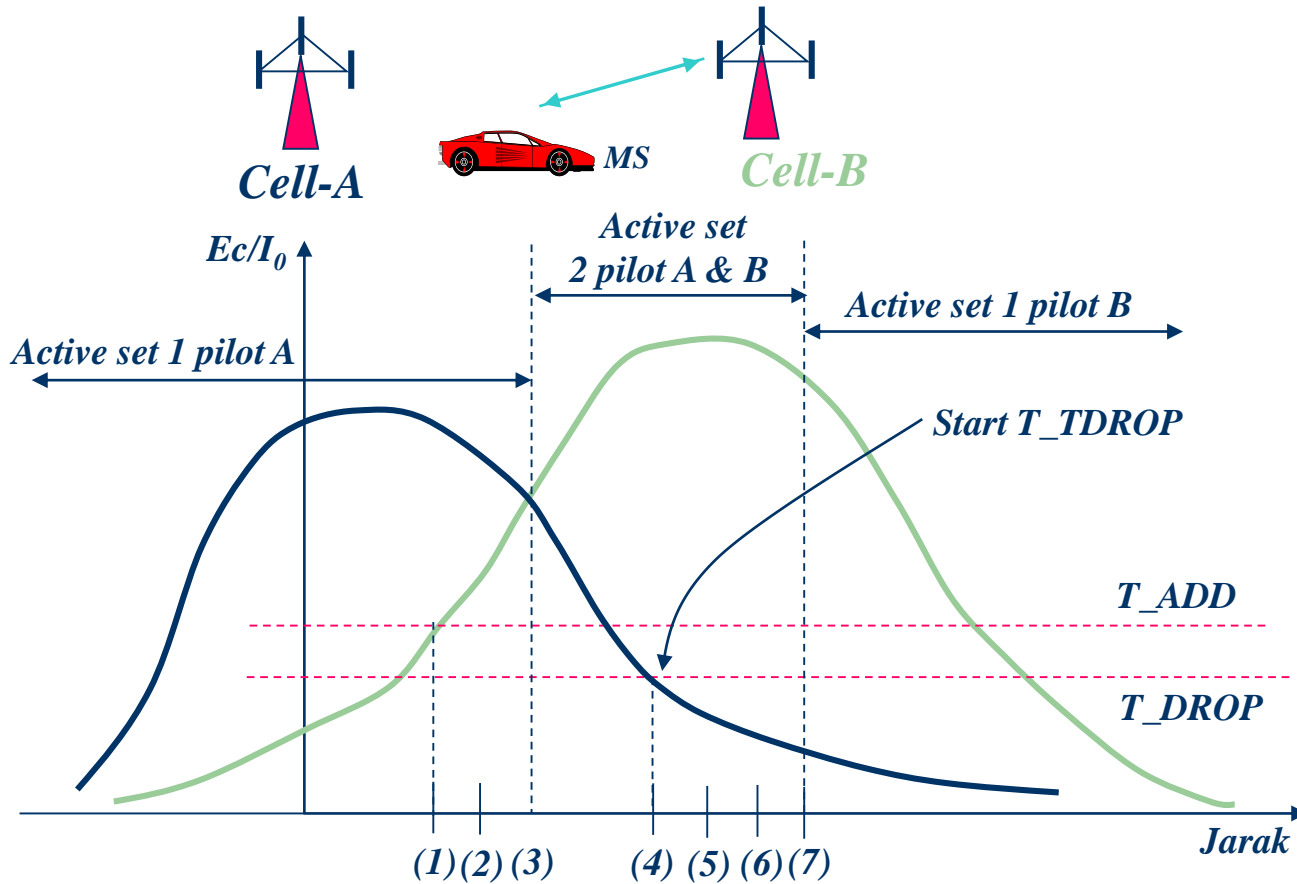
1. BSC: HO necessary
2. Parallel connection setup
3. MS changes phys. channel
4. Original connection released

The steps Handover in CDMA

- (1) MS is only serviced by cell A and active set consists only of pilots A. MS measuring the pilot B (E_c / I_o), acquired a tendency $> T_ADD$. MS sends a message the measured pilot B and B move from pilot status to the candidate neighbor set.
- (2) the MS receives a message from cell A cell B contains the PN offset and Walsh code allocation for the TCH and MS start communications using the TCH tsb.
- (3) MS B move the pilot status of the candidate set to the active set, the MS sends a handoff message completed. Now there are 2 active pilots.
- (4) MS detect the pilot A fall $< T_DROP$, MS start the timer.
- (5) Timer achieve the T_TDROP , MS send PSMM (pilot strength measurement message)
- (6) the MS receives a handoff direction message, the message contains only the PN offset of cell B (without PN offset cell A).
- (7) A pilot status of MS move from active set into the neighbor sets

The steps Handover in CDMA

□ Handoff Process



THE TYPES IN CDMA handoff

Soft and Hard Handover

Soft Handover

Cell
1

The diagram illustrates soft handover. It features two overlapping rectangular boxes. The top box is yellow and labeled 'Cell 1'. The bottom box is blue and labeled 'Cell 2'. The boxes overlap in the middle, representing the period where the mobile device is connected to both cells simultaneously.

Cell
2

Hard Handover

Cell
1

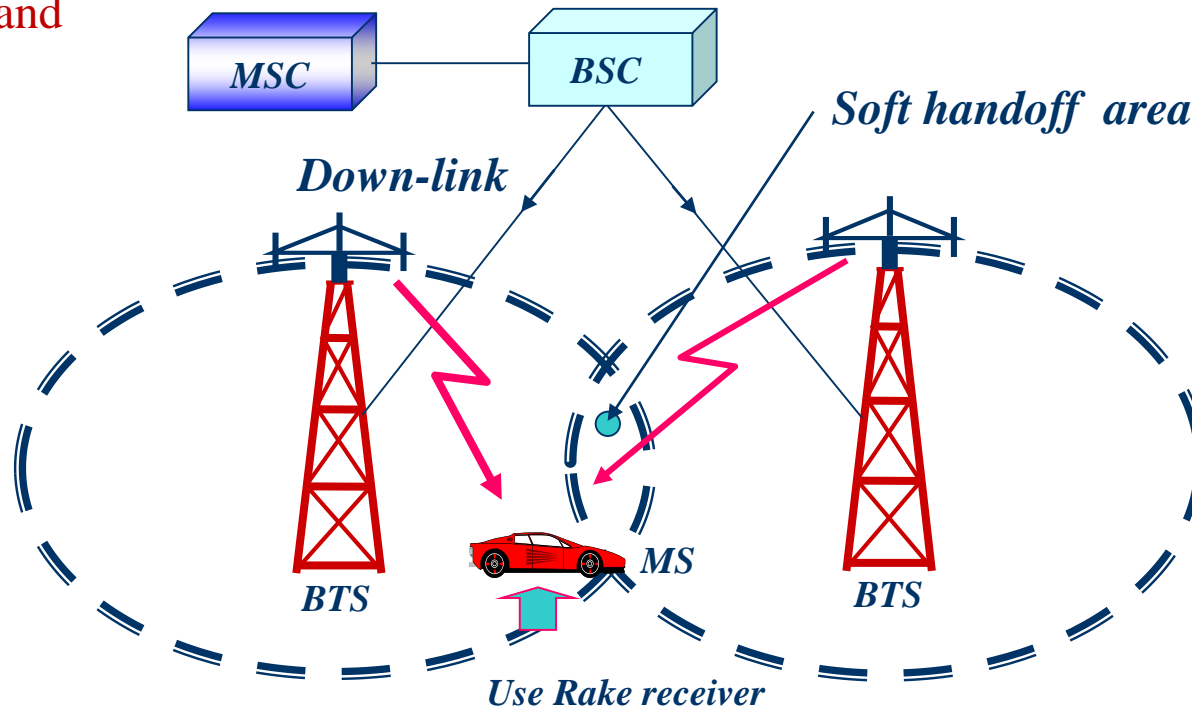
The diagram illustrates hard handover. It features two separate, non-overlapping rectangular boxes. The left box is yellow and labeled 'Cell 1'. The right box is blue and labeled 'Cell 2'. There is a clear gap between the two boxes, representing the period where the mobile device is not connected to either cell during the transition.

Cell
2

THE TYPES IN CDMA handoff

Soft handoff : During the handoff process of MS is connected to two or three base stations

The same signal is sent from BS1 and BS2 within one RNC, Except Power Control Command

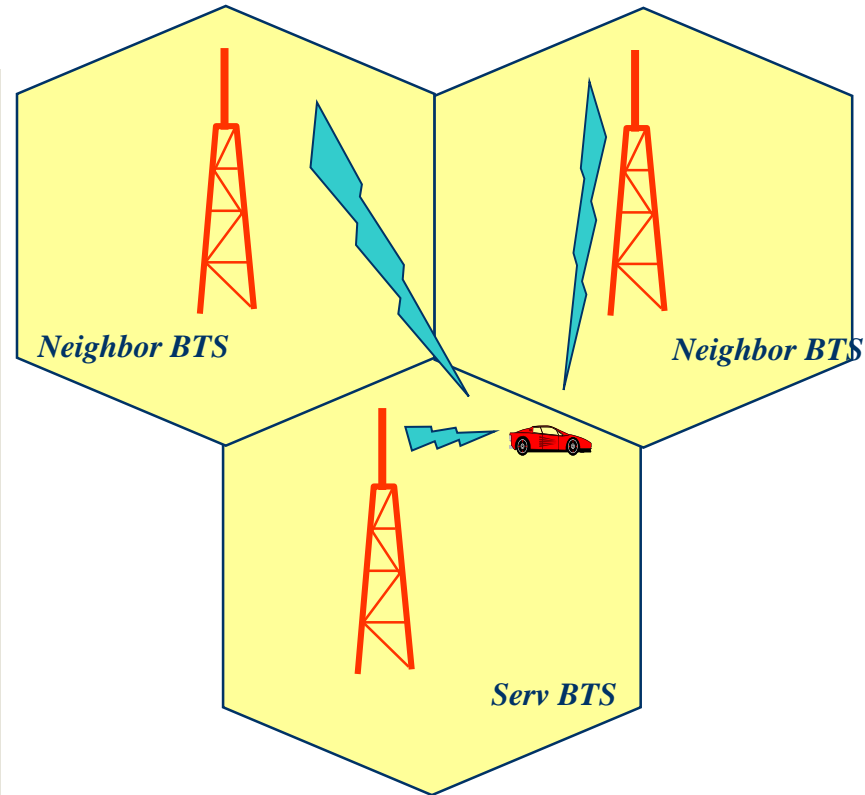
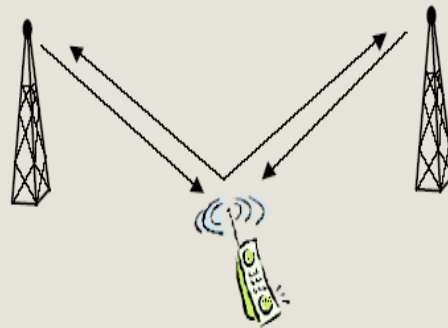


THE TYPES IN CDMA handoff

Soft-handoff Continuation

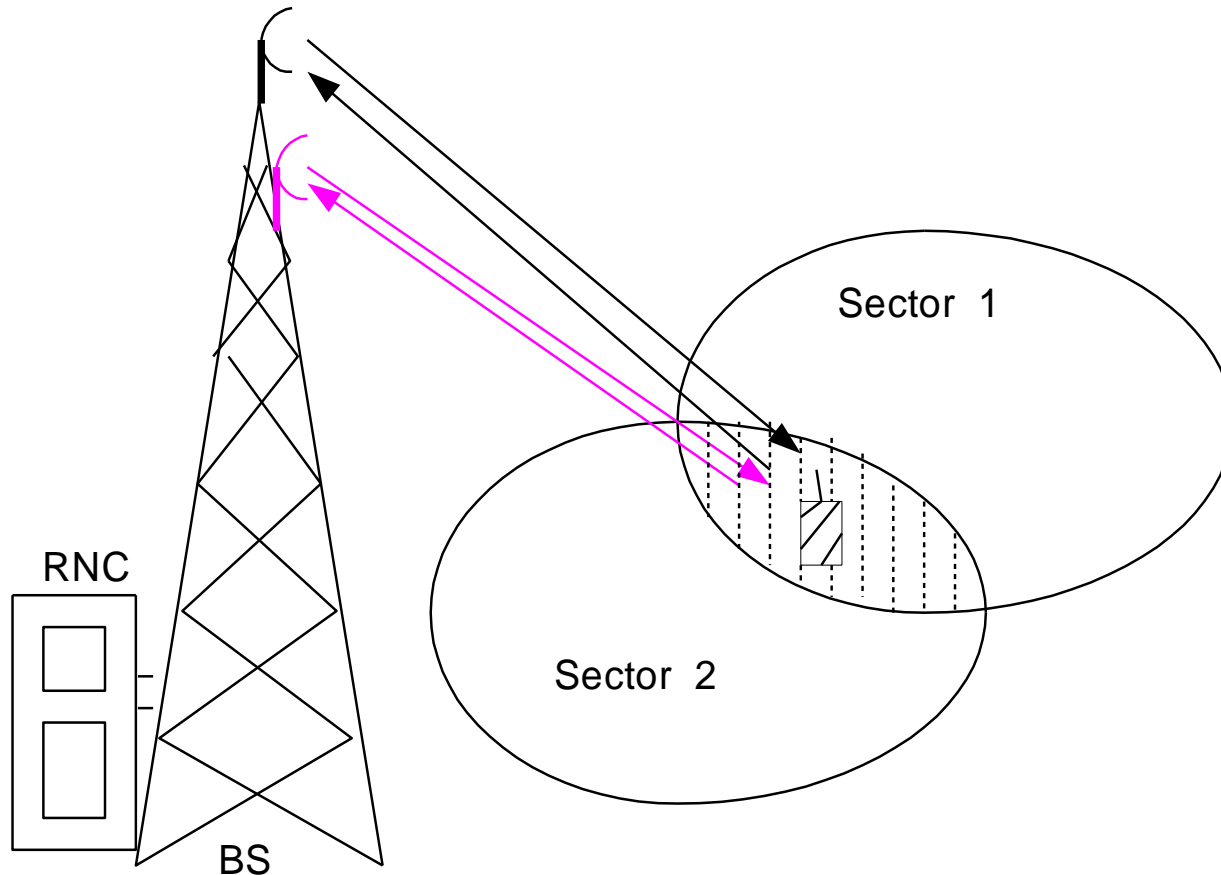
WCDMA: Soft Handover

- Enhances quality
- Reduces interference due to fast fading
- Transmit power determined by best link



THE TYPES IN CDMA handoff

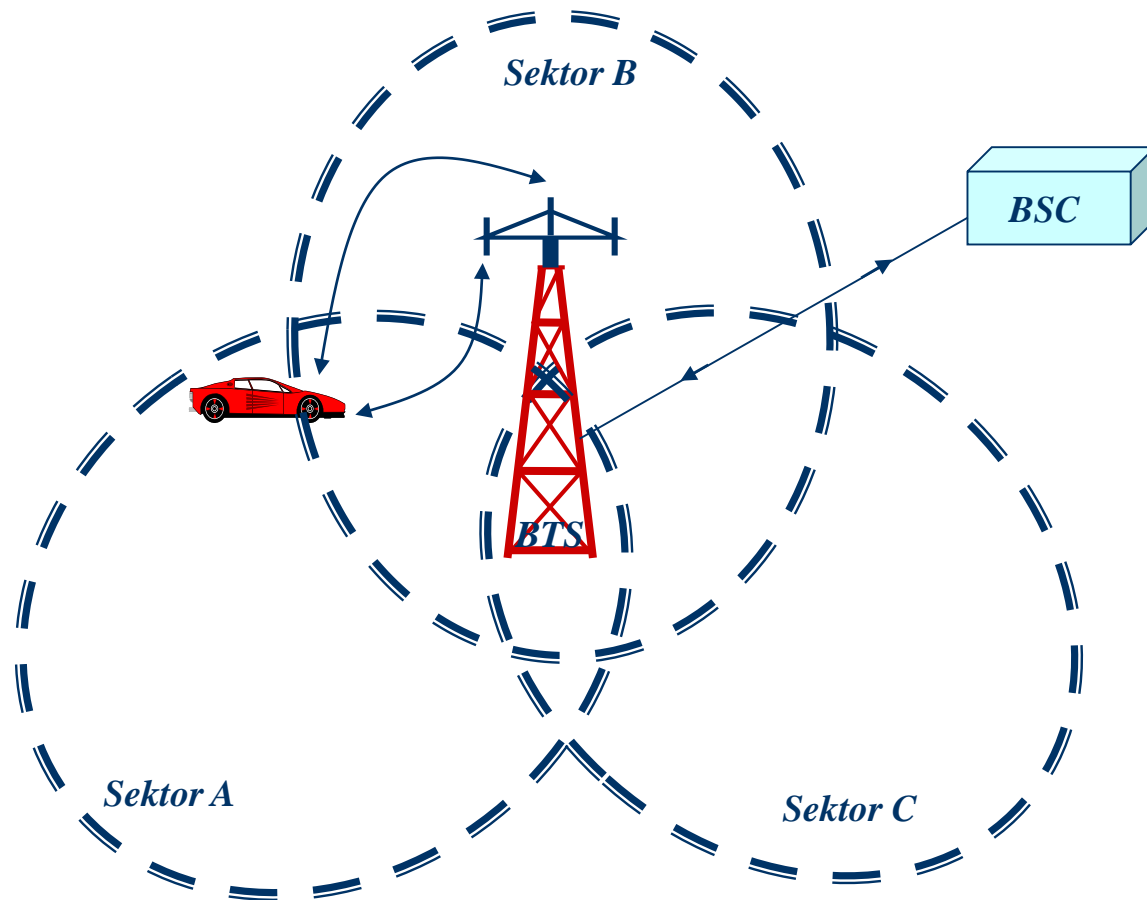
Softer HandOver



- The same signal is sent from both sectors to an MS

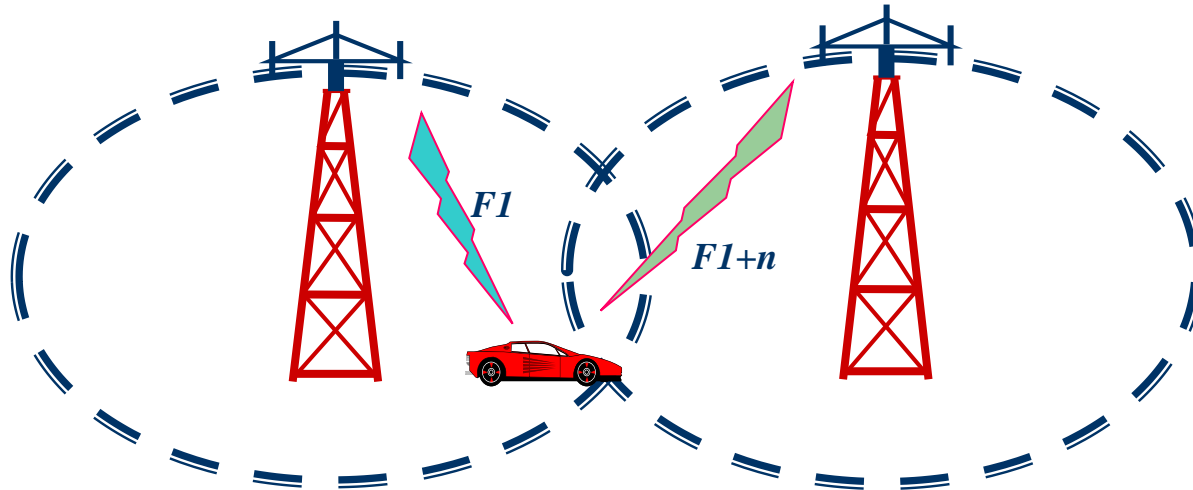
THE TYPES IN CDMA handoff

- ❑ Softer handoff: the transfer service from one sector to another within a single cell. The direction of down-link with soft handoff is the up-link selection process occurs in the BTS.



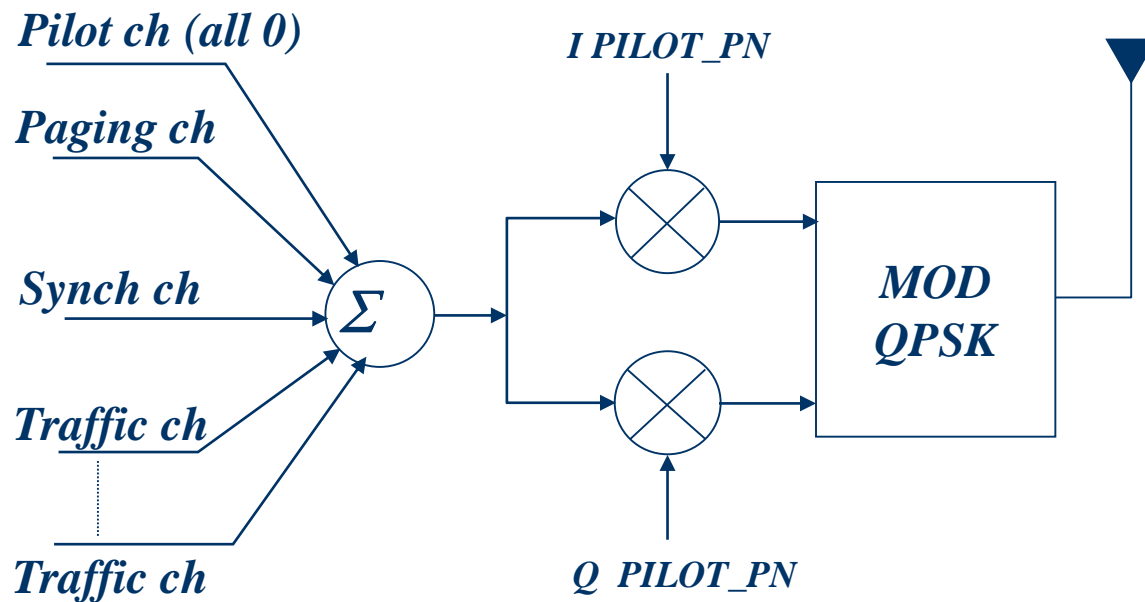
❑ *Hard handoff*

- *CDMA to CDMA handoff involves two carriers (can be different operators) is often called the D to D handoff..*
- *CDMA to Analog handoff, also called the D to A handoff.*



□ Handoff Base

- Based on the results diteksi PILOT_PN by MS is E_c/I_0
- Each cell or sector has a different PILOT_PN
- Remember there are short PN code 512 number
- The pilot will be detected value E_c/I_0

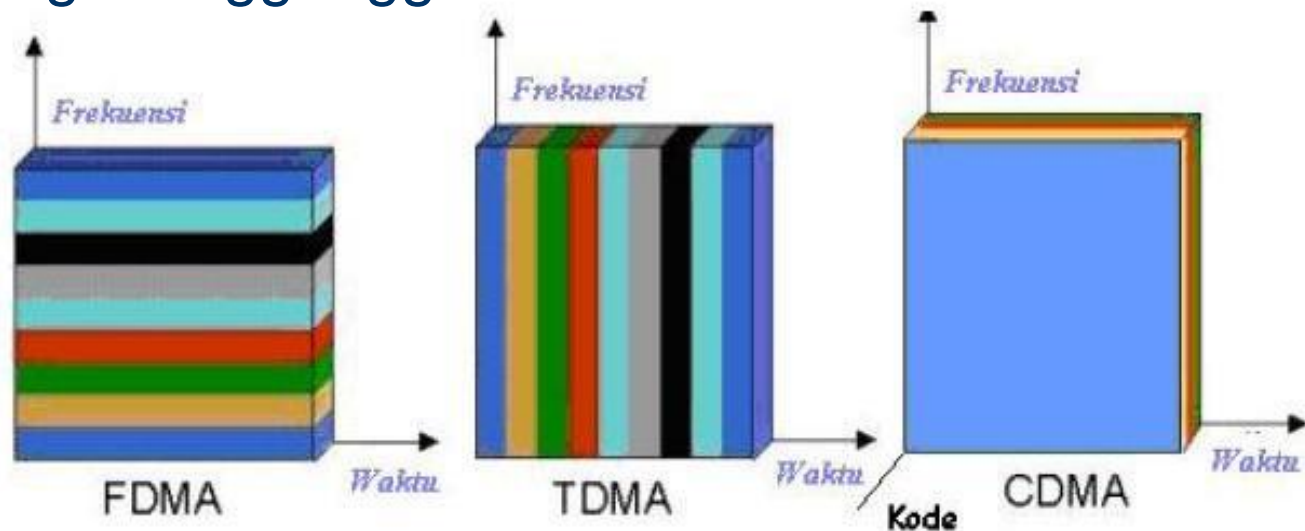


□ *Maintenance set Status*

- *Active set : contains the pilots from several cells or sectors that are actively communicating with the MS on the traffic channel. If the active set contains only one pilot only, the MS is not in soft handoff condition.*
- *Candidate set : containing pilots with adequate E_c/I_0 as a candidate for handoff, meaning a pilot who have $E_c/I_0 >$ pilot detection threshold will T_ADD included as a candidate. One pilot will be moved to neighbor set strong position if the signal falls below the pilot T_DROP drop threshold for the duration of greater than T_TDROP*
- *Neighbor set : contains the pilots was a neighbor of cell serving active MS but outside the active and candidate sets*
- *Remaining set : pilots outside of the above.*

Multiple Access

Multiple access adalah suatu teknik yang memungkinkan satu titik (Base Station) dapat diakses oleh beberapa titik tanpa saling mengganggu.



Gambar 1.1 Berbagai teknik akses jamak

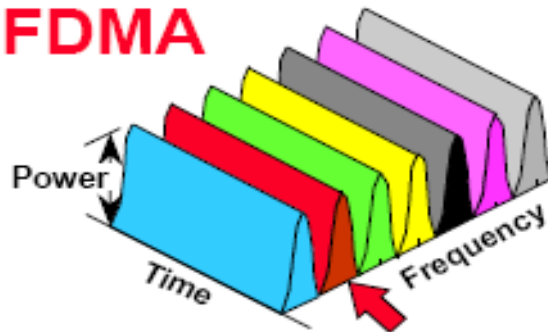
Multiple Access Methods

Base technologies	FDMA / TDMA / CDMA				
	FDD / TDD				
Access schemes	Centralized	Circuit mode	EAMPS / GSM / IS-95		Cellular telephony
		Packet mode	Polling and probing		Wired LAN
			Reservation based	FPODA / PDAMA	Satellite
	Distributed	Packet mode	Polling and probing		Wired LAN
			CSMA	CSMA/CD	
				CSMA/CA	
			ISMA / BTMA	MACA / MACAW	
			Token passing	Token Ring / FDDI	Wired LAN
			ALOHA	Pure ALOHA	Satellite
	Slotted ALOHA				
	Reservation ALOHA				

Multiple Access Methods

Wireless Multiple Access Methods

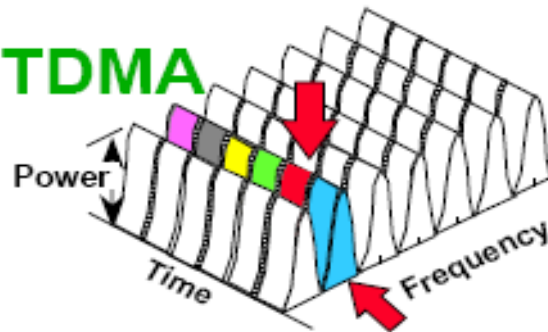
FDMA



Frequency Division Multiple Access

- A user's channel is a private frequency

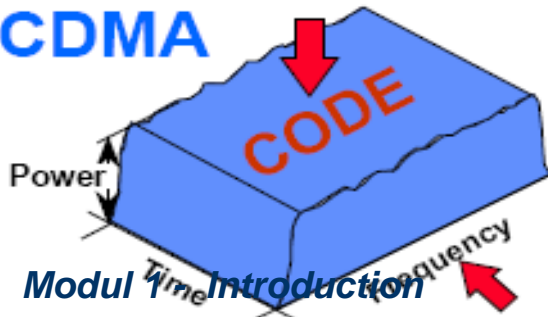
TDMA



Time Division Multiple Access

- A user's channel is a specific frequency, but it only belongs to the user during certain time slots in a repeating sequence

CDMA

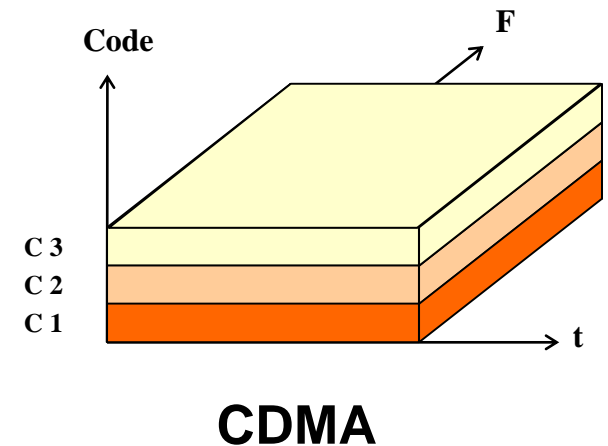
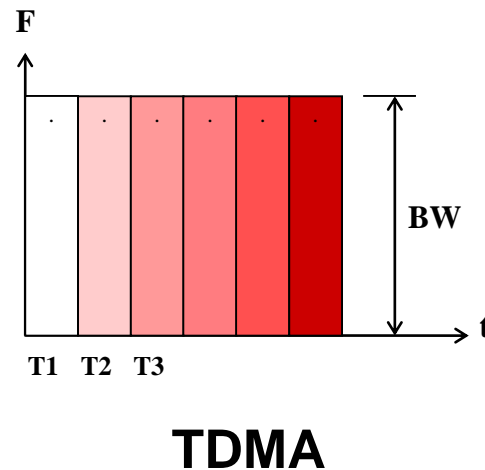
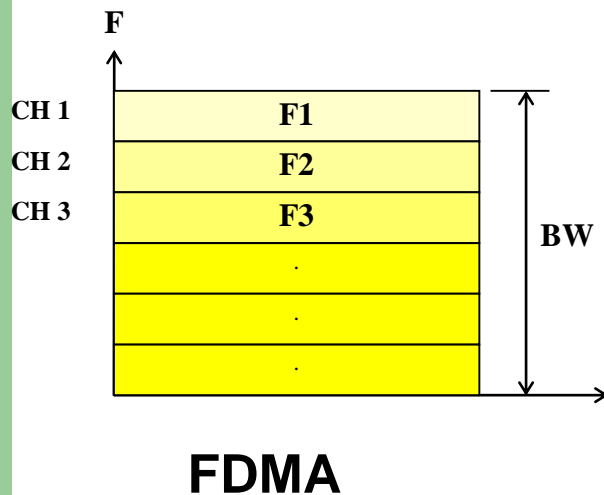


Code Division Multiple Access

- Each user's signal is a continuous unique code pattern buried within a shared signal, mingled with other users' code patterns. If a user's code pattern is known, the presence or absence of their signal can be detected, thus conveying information.

Multiple Access Methods

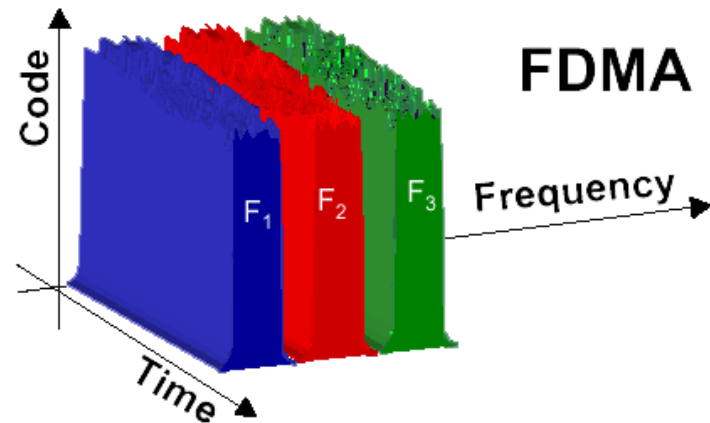
- ✓ **FDMA** (*Frequency Division Multiple Access*): Simple, intermodulation effect, low spectral efficiency
- ✓ **TDMA** (*Time Division Multiple Access*): higher spectral efficiency, needs Synchronization
- ✓ **CDMA** (*Code Division Multiple Access*): higher spectral efficiency, MAI-limited capacity, needs power control



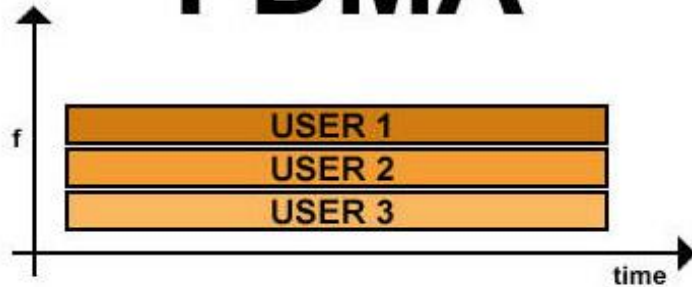
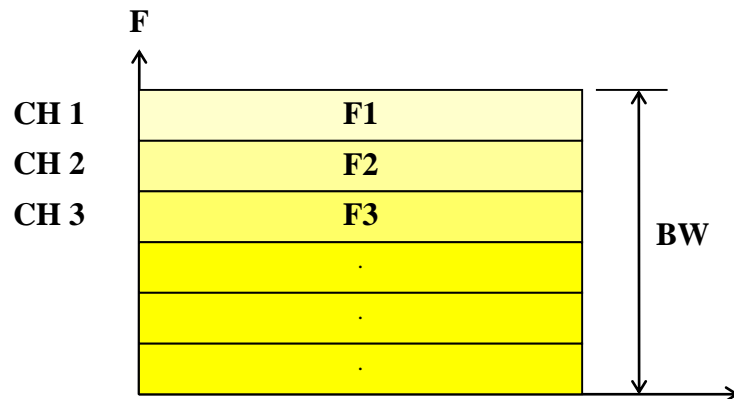
Multiple Access Methods

Frequency Division Multiple Access Principles

- A voice channel uses the same frequency band all the time
 - Other users must use other frequencies
- One frequency band is reserved for signaling



FDMA



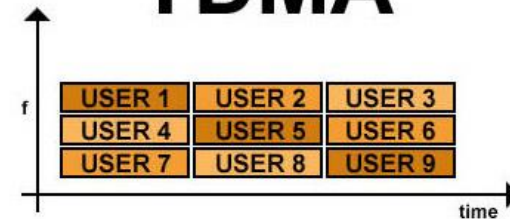
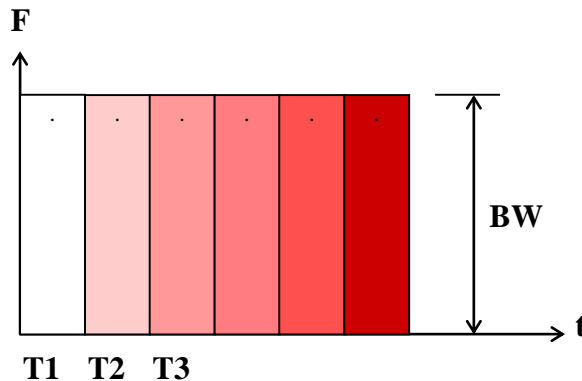
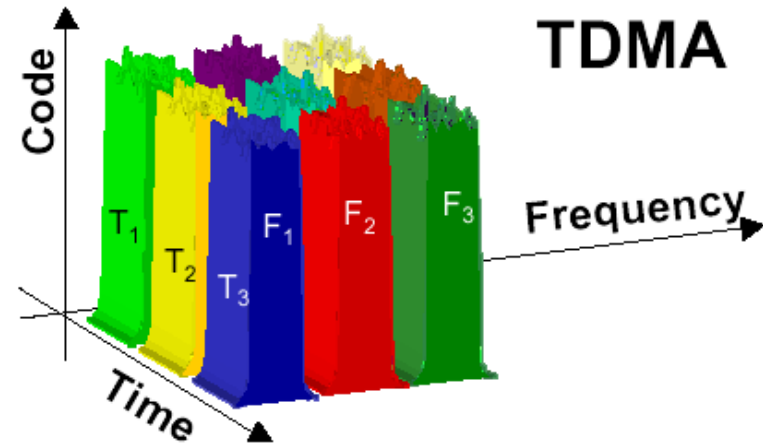
AMPS
30 kHz channels
Full Duplex
U.S.A.

TACS
25 kHz channels
Full Duplex
U.K./Asia

Multiple Access Methods

Time Division Multiple Access Principles

- A voice channel shares the same frequency band with other voice channels
 - Each channel gets assigned to a periodic *time slot*
- Signaling still use a dedicated frequency band



US TDMA (IS-136)

30 kHz channels
3 Time Slots
Full Duplex
U.S.A.

GSM (ETSI standards)

200 kHz channels
8 Time Slots
Full Duplex
"Everywhere"

Multiple Access Methods

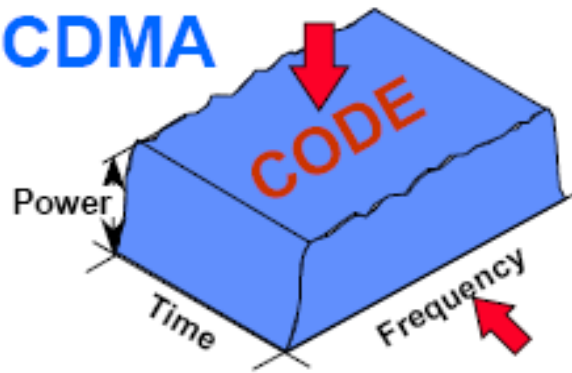
Code Division Multiple Access (CDMA)

- In CDMA, the narrowband **message signal** is *multiplied* by a very large bandwidth signal called **spreading signal (code)** before modulation and transmission over the air. This is called **spreading**.
- CDMA is also called DSSS (Direct Sequence Spread Spectrum). DSSS is a more general term.
- Message consists of symbols
 - Has symbol period and hence, symbol rate
- Spreading signal (code) consists of chips
 - Has Chip period and hence, chip rate
 - Spreading signal use a pseudo-noise (PN) sequence (a pseudo-random sequence)
 - PN sequence is called a codeword
 - Each user has its own cordword
 - Codewords are orthogonal. (low autocorrelation)
 - Chip rate is oder of magnitude larger than the symbol rate.
- The receiver correlator distinguishes the senders signal by examining the wideband signal with the same time-synchronized spreading code
- The sent signal is recovered by **despreading** process at the receiver.

Multiple Access Methods

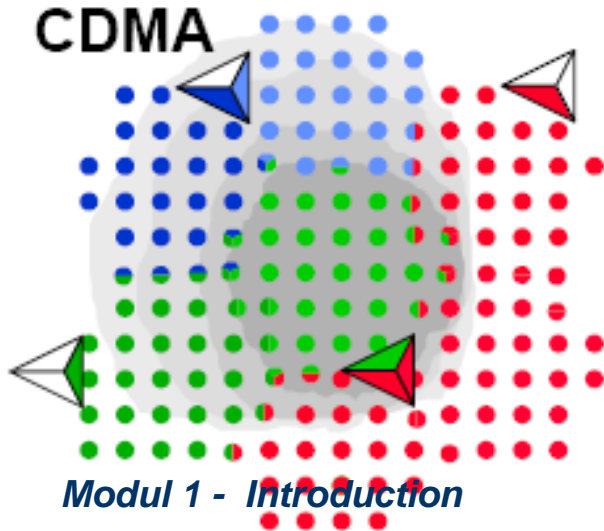
CDMA: Code Division Multiple Access

CDMA



- CDMA
- Each user's signal is a continuous unique code pattern buried within a shared signal, mingled with other users' code patterns. If a user's code pattern is known, the presence or absence of their signal can be detected, thus conveying information.
- All CDMA users occupy the same frequency at the same time! Time and frequency are not used as discriminators
- CDMA interference comes mainly from nearby users
- CDMA operates by using CODING to discriminate between users
- Each user is a small voice in a roaring crowd - - but with a uniquely recoverable code

CDMA



Multiple Access Methods

CDMA Advantages

- Low power spectral density.
 - Signal is spread over a larger frequency band
 - Other systems suffer less from the transmitter
- Interference limited operation
 - All frequency spectrum is used
- Privacy
 - The codeword is known only between the sender and receiver. Hence other users can not decode the messages that are in transit
- Reduction of multipath affects by using a larger spectrum
- Random access possible
 - Users can start their transmission at any time
- Cell capacity is not concrete fixed like in TDMA or FDMA systems. Has soft capacity
- Higher capacity than TDMA and FDMA
- No frequency management
- No equalizers needed
- No guard time needed
- Enables soft handoff

Multiple Access CDMA

- CDMA : 1 waktu, 1 frekuensi, pembeda: kode unik yang berbeda

Frequency

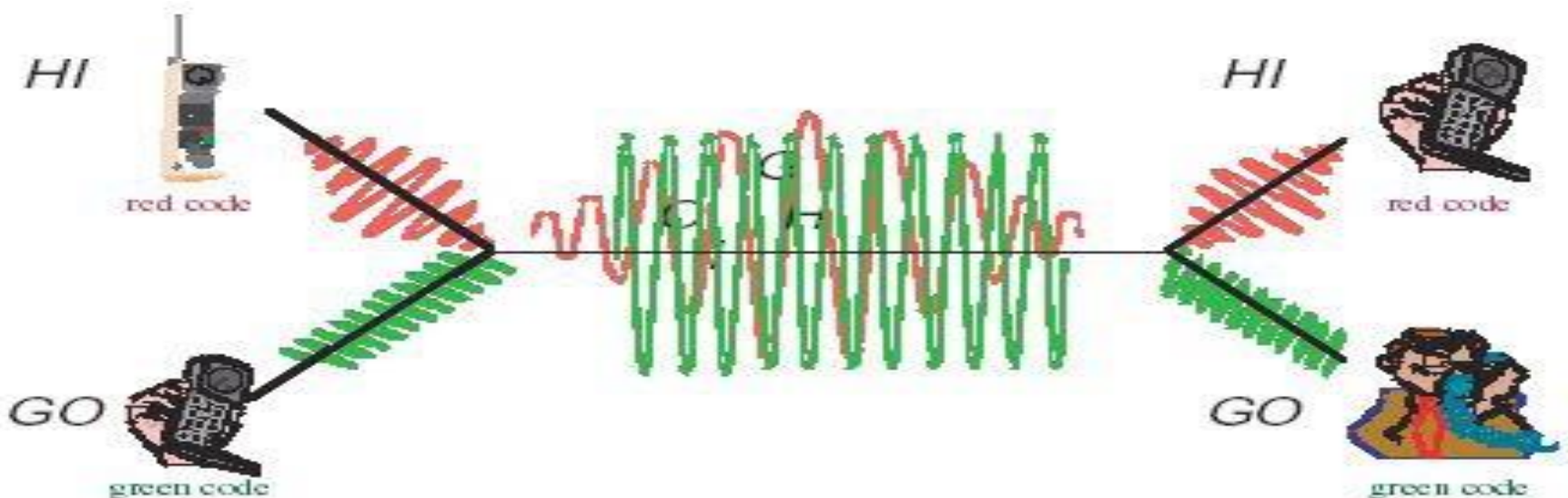
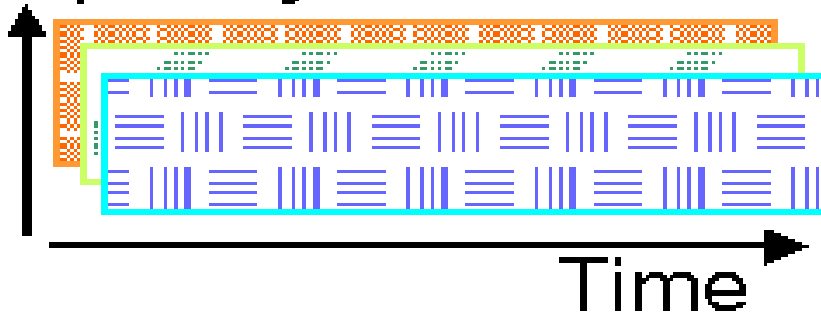
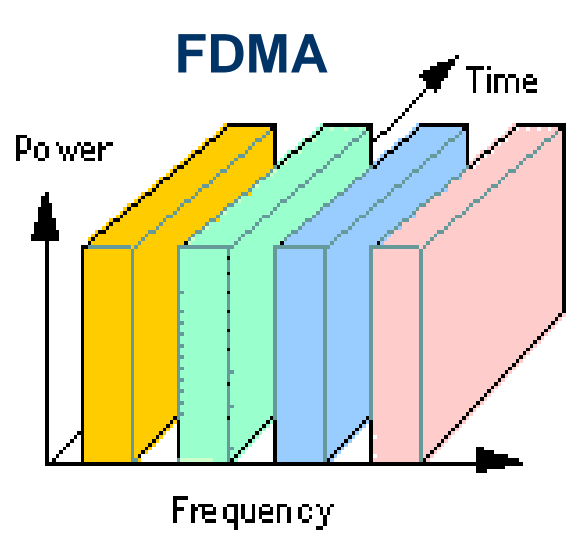
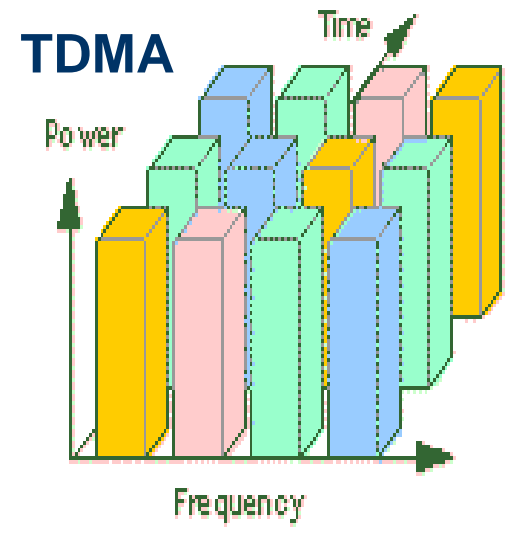


Illustration of FDMA, TDMA, and CDMA

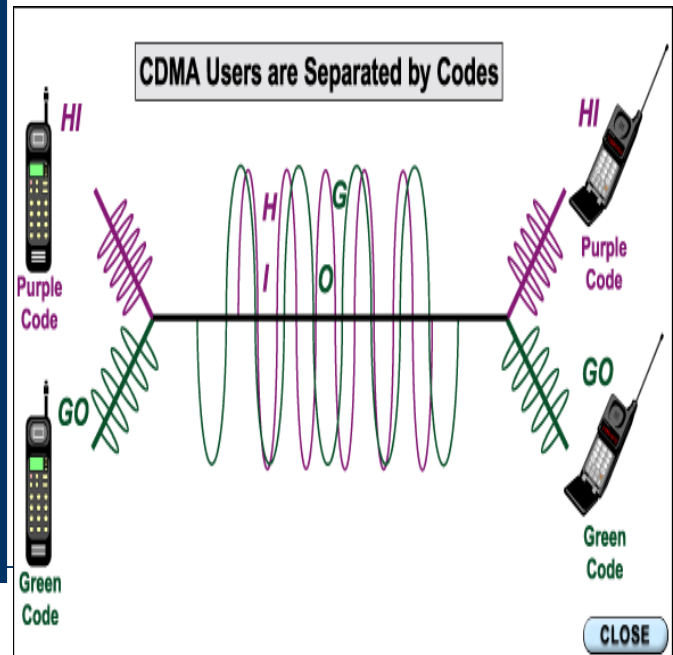
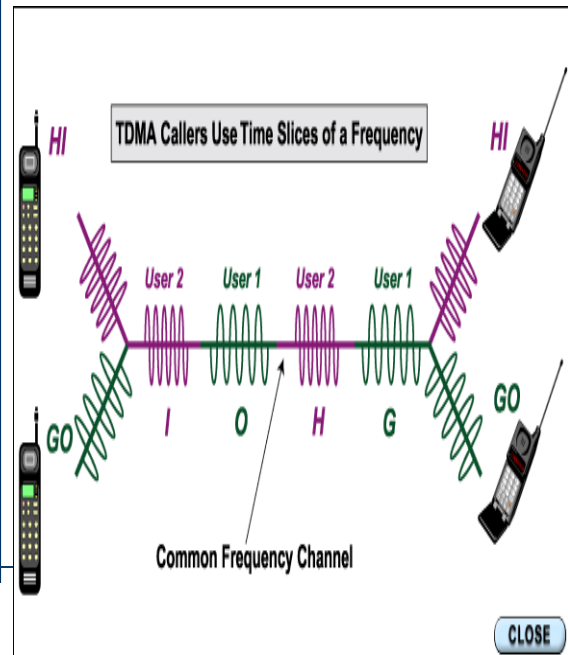
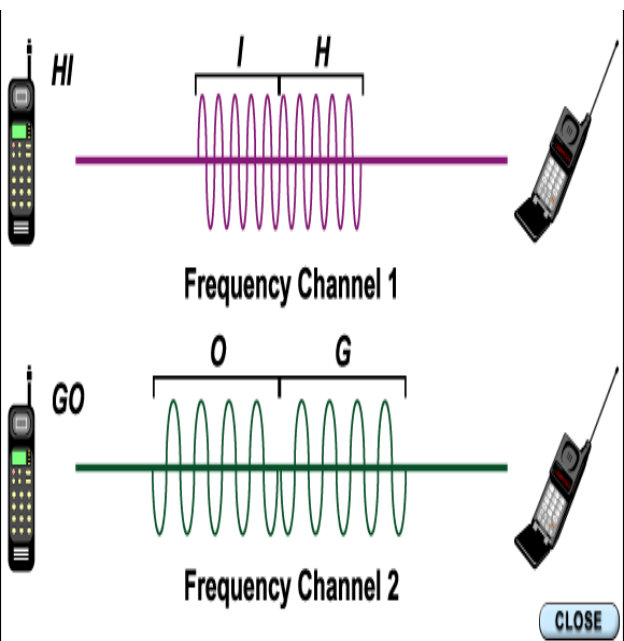
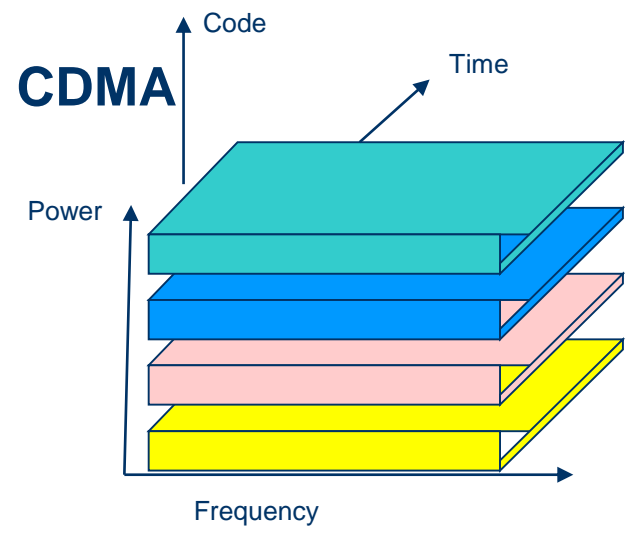
FDMA



TDMA

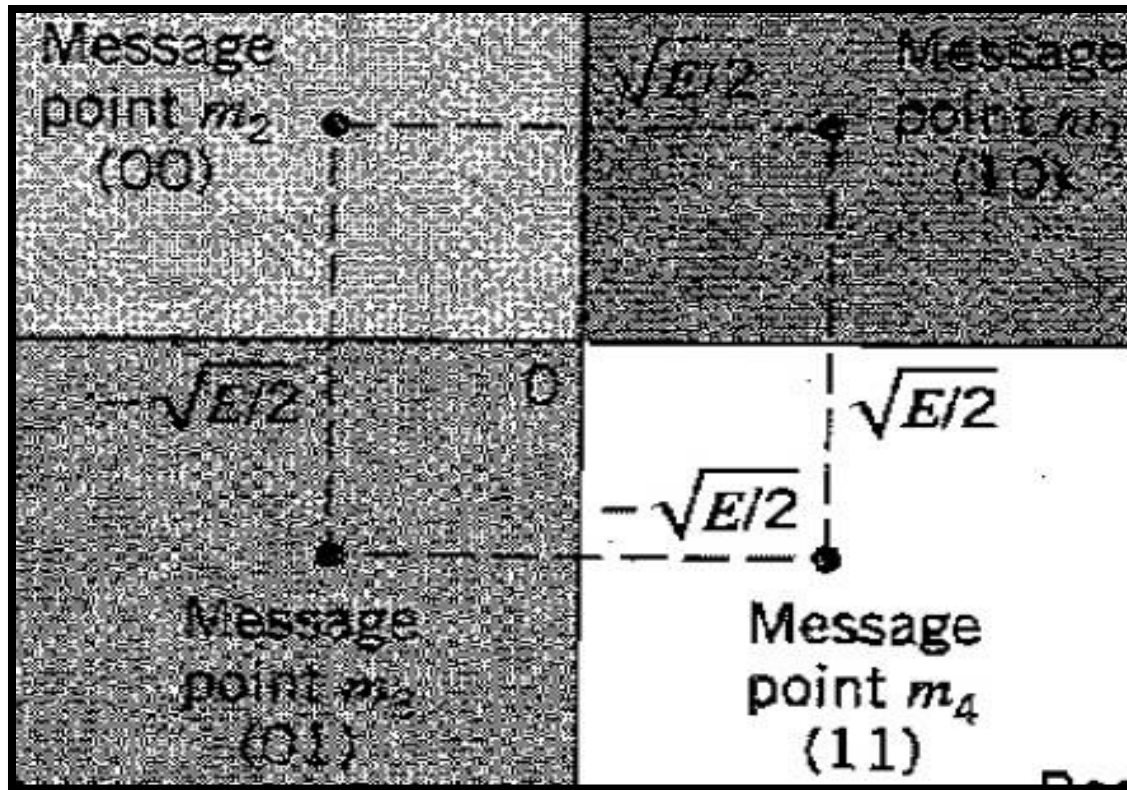


CDMA



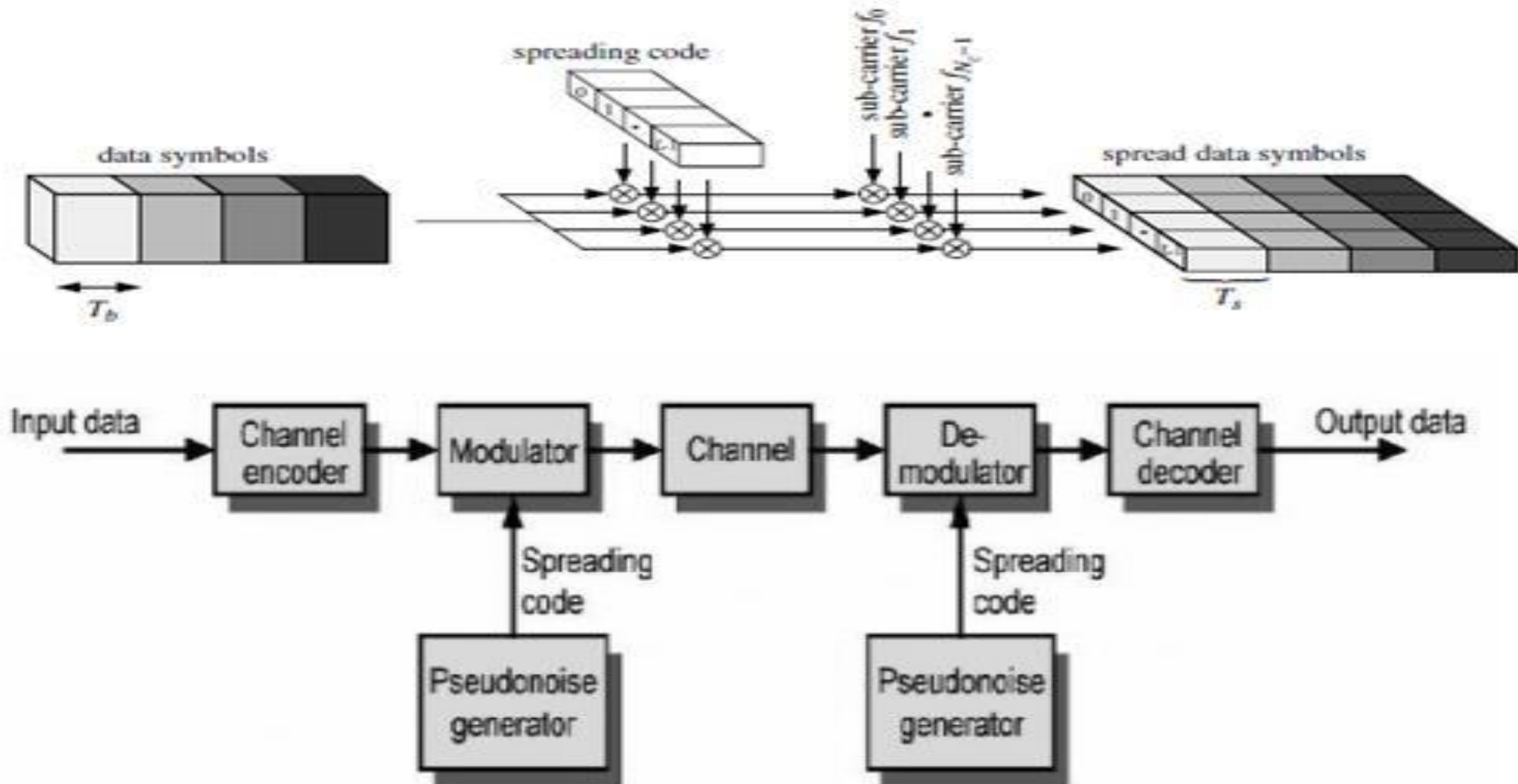
Modulasi QPSK (Quadrature Phase Shift Keying)

- Modulasi CDMA = QPSK
- QPSK = 4 simbol, 1 simbol = 2 bit, beda fasa 45°
- Konstelasi :



Spreading

- Spreading = proses menempatkan sinyal informasi pada pita yang lebih lebar dengan memanfaatkan kode khusus



Matriks Hadamard

- Berdasarkan pernyataan pada *CDMA System Engineering Hand Book*, Matriks Hadamard merupakan matriks yang berisikan +1 dan -1.
- Bentuk Matriks Hadamard :

$$\mathbf{H}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \equiv \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

Walsh Code

- Walsh Code dimanfaatkan untuk melakukan spreading ,dibentuk berdasarkan matriks hadamard
- Secara grafis, spreading dilakukan dengan penerapan operasi XOR antara urutan data informasi dengan urutan Walsh Code

