JARINGAN SELULAR

PENGANTAR TELEKOMUNIKASI

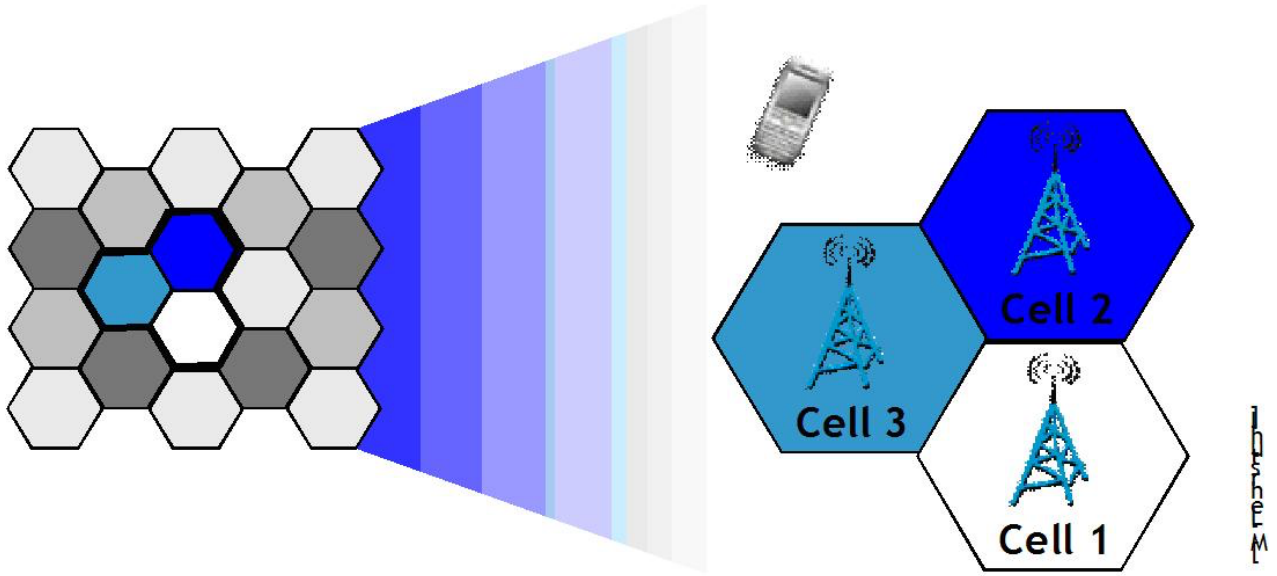
SUSMINI INDRIANI LESTARININGATI, M.T

BEBERAPA PENGERTIAN PADA SISTEM SELULAR

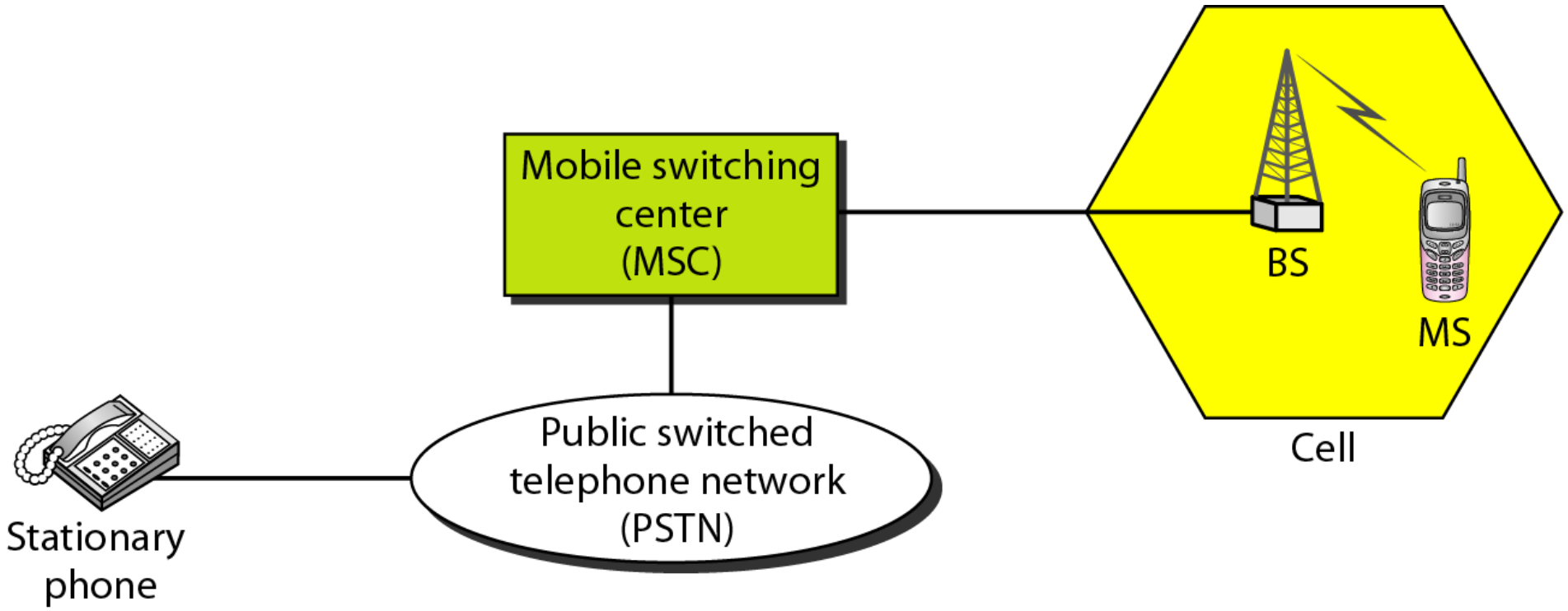
- Wireless vs Mobile
  - Wireless systems can be fixed (LMDS, microwave, optical) or mobile
- Cellular
  - Geography is divided into adjacent cells
  - Radio Frequencies can be reused in non-adjacent cells
  - Commonly in 800-900 MHz
- Base Station
  - Fixed transceiver that sends and receives signal from the mobile device
  - Connects to the wireline network

DEFINISI SELULAR

- Sistem Selular adalah sistem komunikasi yang digunakan untuk memberikan layanan jasa telekomunikasi bagi pelanggan bergerak.
- Disebut sistem selular karena daerah layanannya dibagi-bagi menjadi daerah yang kecil-kecil yang disebut sel (cell)
- SIFAT : Pelanggan mampu bergerak secara bebas di dalam area layanan sambil berkomunikasi tanpa terjadi pemutusan hubungan.

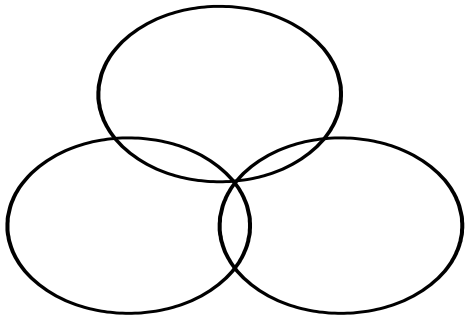


CELLULAR SYSTEM

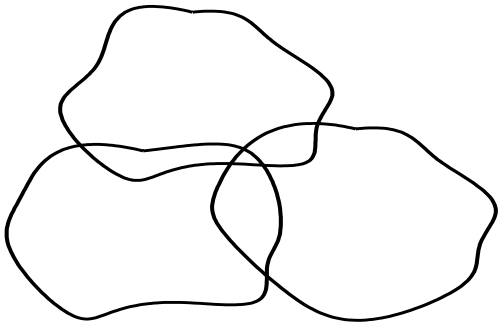


CELL (SEL)

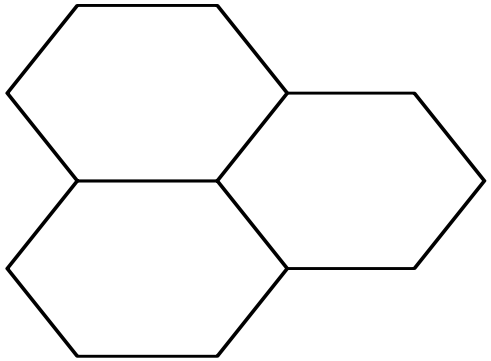
- **Definisi**: Area cakupan (coverage area) dari Radio Base Station
- **Jenis Sel**: Omni Cell, Sectored Cell
- **Ukuran Sel**:
  - Macrocell (<5km), Microcell (1-2km), Picocell(<500m)
- Sel menunjukkan cakupan sinyal
- Sel berbentuk heksagonal (atau bentuk yang lain) hanya digunakan untuk mempermudah penggambaran pada layout perencanaan



SEL IDEAL

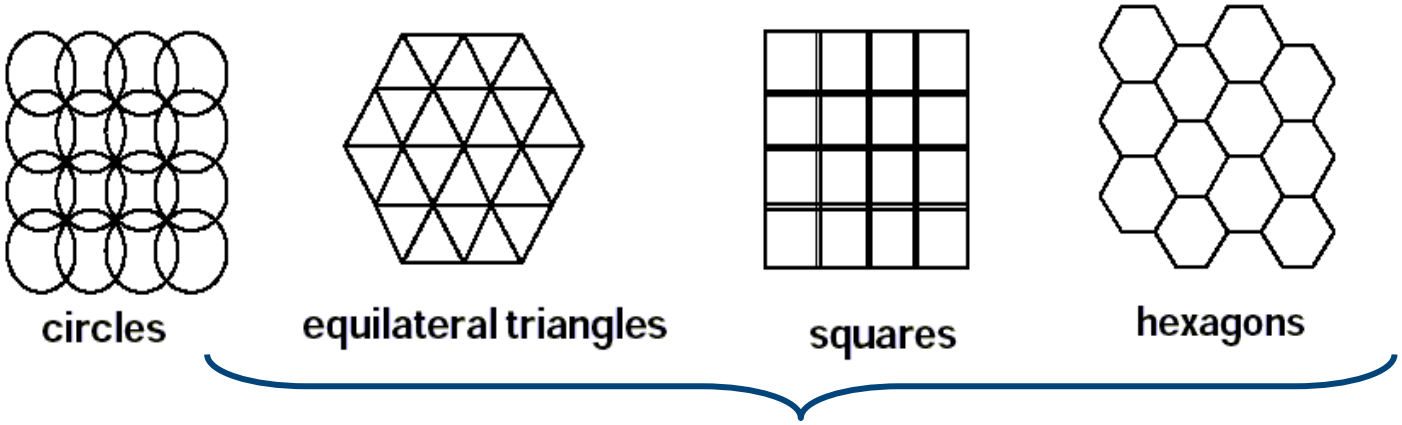


SEL REAL

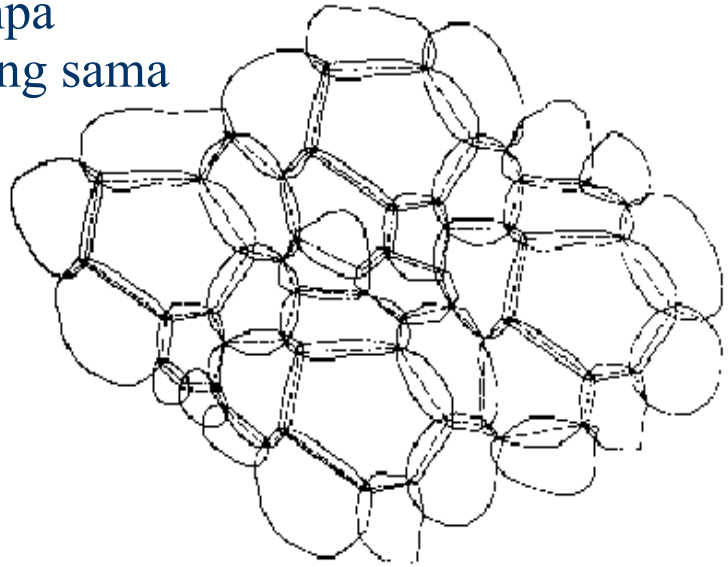


SEL MODEL

REPRESENTASI COVERAGE SISTEM SELULER



Bentuk geometris yang meliputi keseluruhan daerah service tanpa overlap dengan luas daerah yang sama

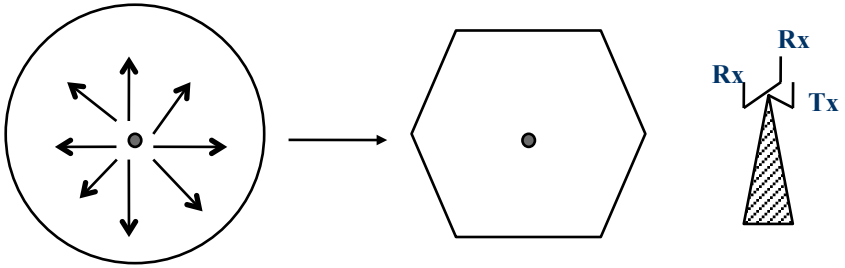


Realitas ?

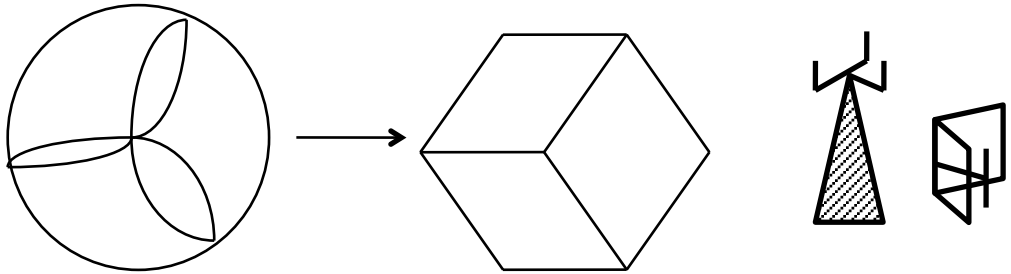
Jauh berbeda ! Grid sel teoritik digunakan untuk mempermudah penggambaran / perencanaan

TIPE ANTENA PADA BTS

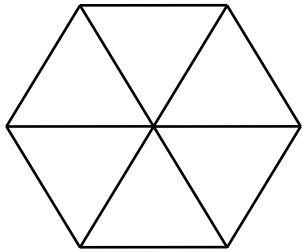
1. Omnidirectional



2. Sectoring 120



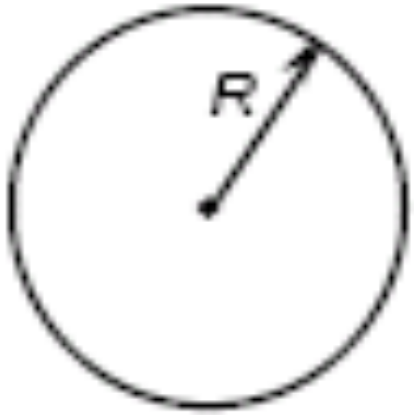
3. Sectoring 60°



Manfaat dari penggunaan Antena Sektoral:

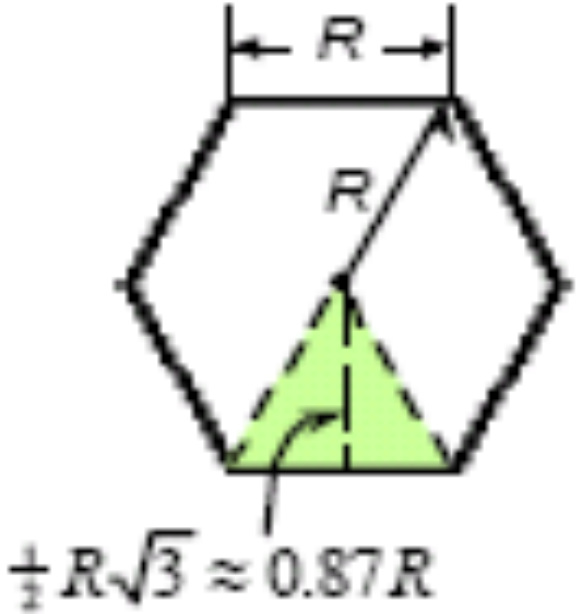
a. Menambah Kapasitas
b. Mengurangi Interferensi

GEOMETRI SEL



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

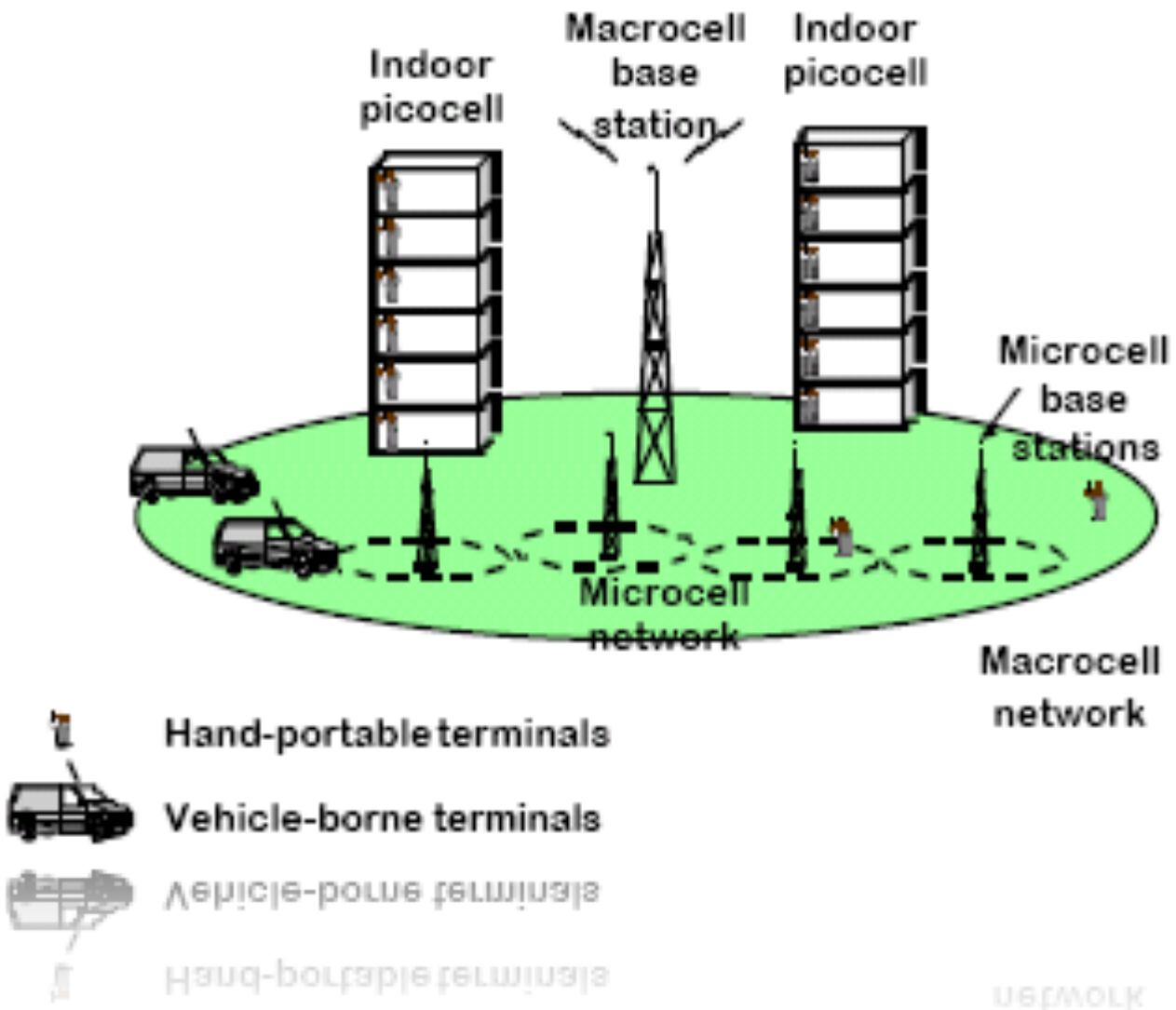
$$Perimeter_{cell} = 2\pi R \approx 6.28\,R$$



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

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

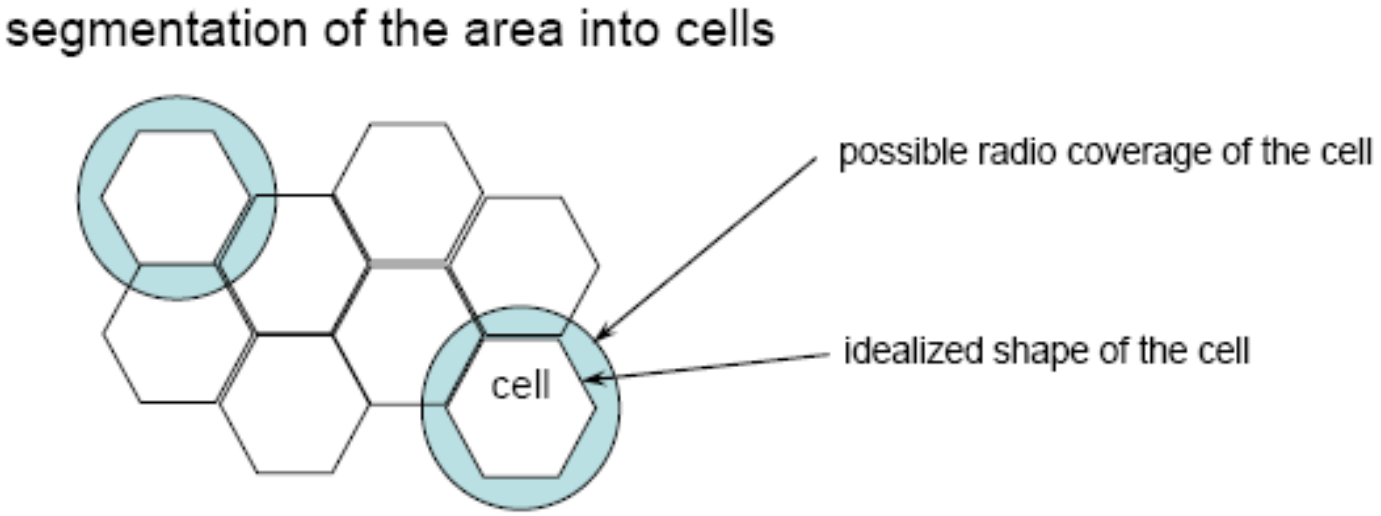
JENIS SEL


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

KARAKTERISITIK DARI SISTEM SELULER

- Frequency reuse
- Channel Sharing
- 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

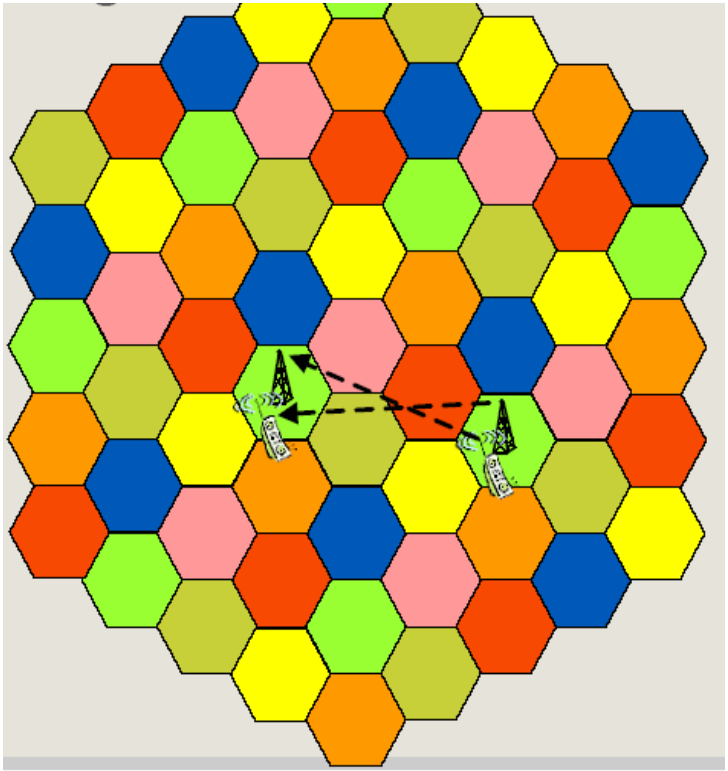
MEMBAGI DAERAH KEDALAM SEL



- Menggunakan beberapa frekuensi carrier
- Tidak menggunakan frekuensi yang sama pada sel yang saling berdekatan
- Besarnya sel bervariasi dari 100m hingga 35 km bergantung dari kepadatan pengguna, letak geografis, daya pengirim dan lain sebagainya
- Bentuk sel hexagonal dianggap ideal
- Jika pengguna (mobile user) berpindah sel: maka terjadi handover ke sel tetangga

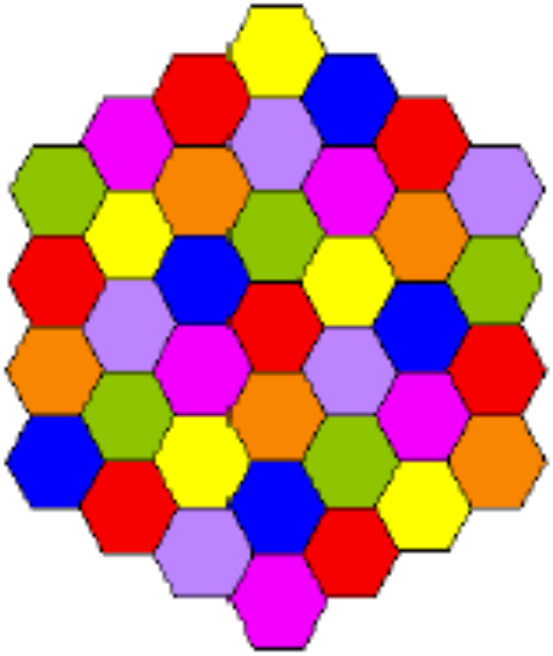
PERENCANAAN FREKUENSI PADA GSM

- Reuse Factor
- Tighter reuse
  - higher capacity
  - interference between cell

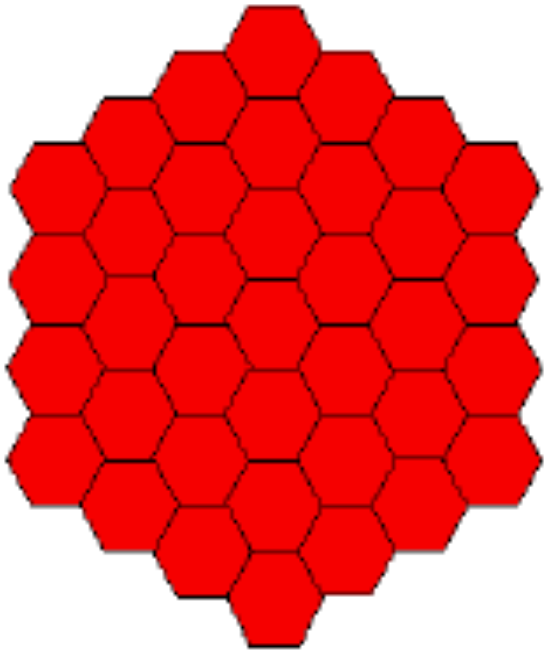


PERENCANAAN FREKUENSI

GSM

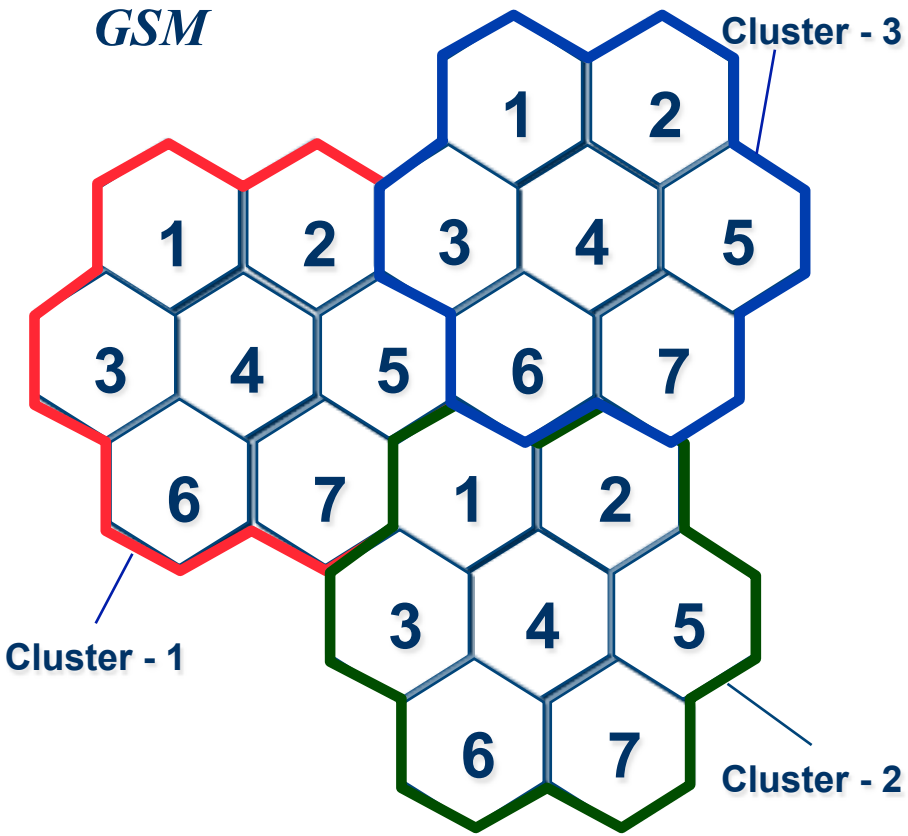


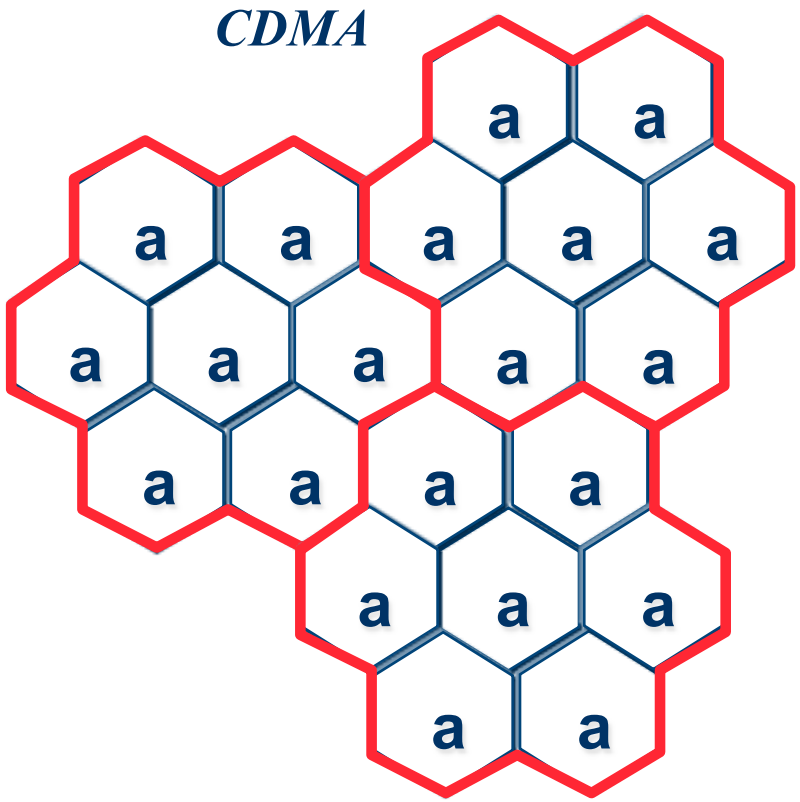
UMTS



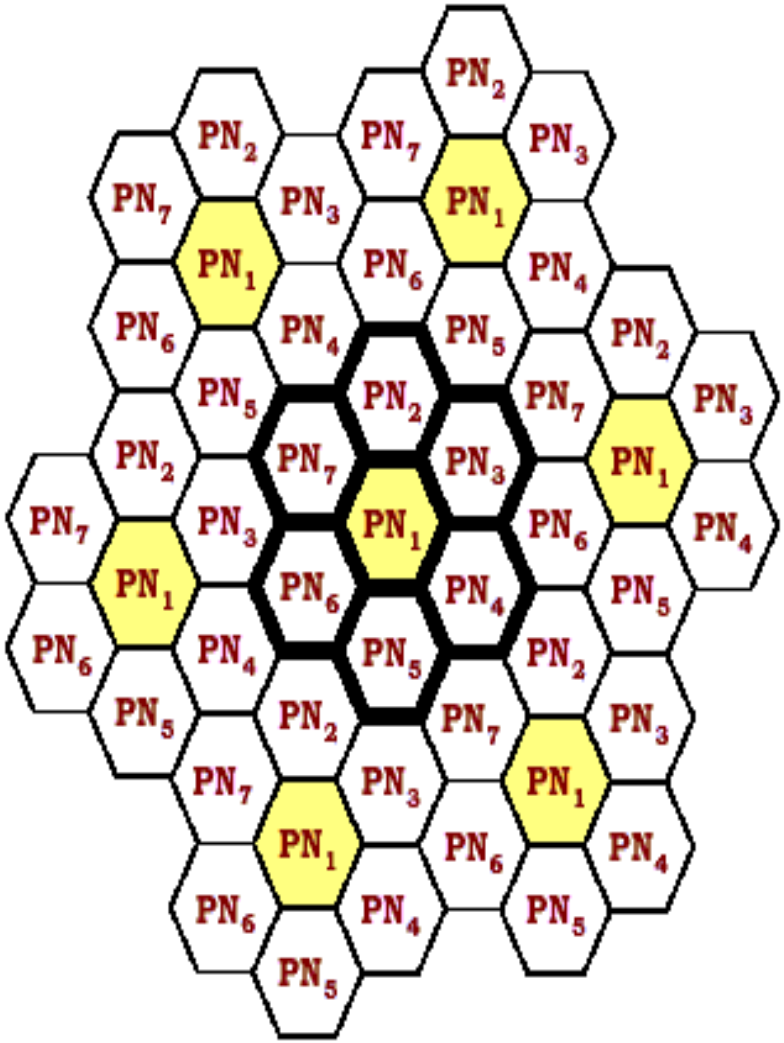
No planning of frequency on the overlay

DESAIN FREKUENSI SEDERHANA





KONSEP KLUSTER PADA CDMA



- Pada jaringan selular CDMA, Kcdma = 1, artinya frekuensi operasi yang sama diterapkan untuk semua sel
- CDMA menggunakan konsep clustering untuk perencanaan kode PN, hal ini untuk mencegah kemungkinan terjadinya aliasing antar kode didalam satu sel
- Pada jaringan CDMA, dikenal dengan PN reuse factor

SISTEM KOMUNIKASI BERGERAK SELULER

Alasan

- Keterbatasan spektrum frekuensi
- Efisiensi penggunaan spektrum frekuensi

Parameter Dasar

- Frequency reuse
- Konsep Handoff

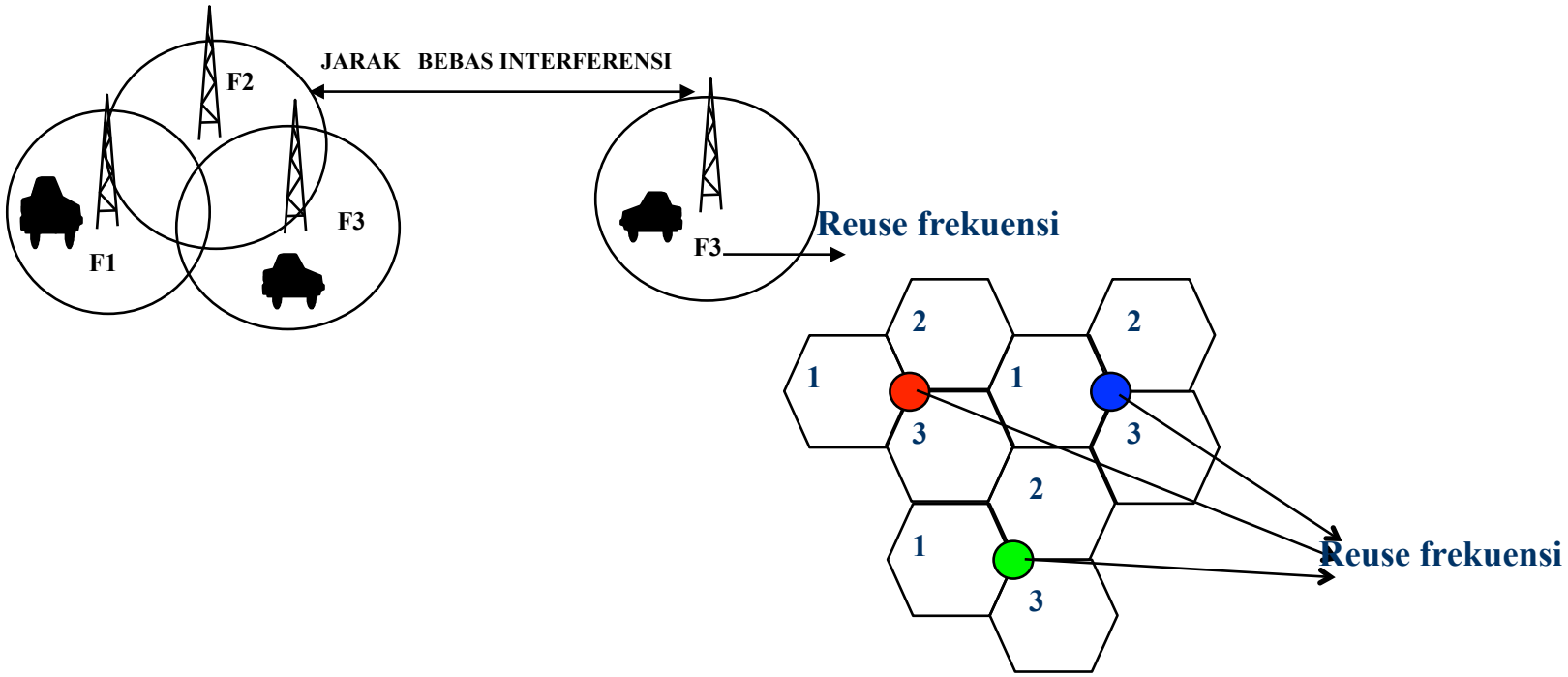
PARAMETER DASAR

- **Konsep Frequency Re-use** memungkinkan penggunaan frekuensi yang sama pada sel yang berbeda , diluar jangkauan interferensinya. Parameter yang menjadi ukuran adalah perbandingan daya sinyal / carrier terhadap total daya interferensinya

- Sedangkan **Handoff** memungkinkan seorang pengguna pindah dari suatu sel ke sel yang lain tanpa adanya pemutusan hubungan. Terjadi pemindahan frekuensi / kanal secara otomatis yang dilakukan oleh sistem

FREQUENCY REUSE

Pengulangan frekuensi yang sama pada area yang berbeda diluar jangkauan interferensinya

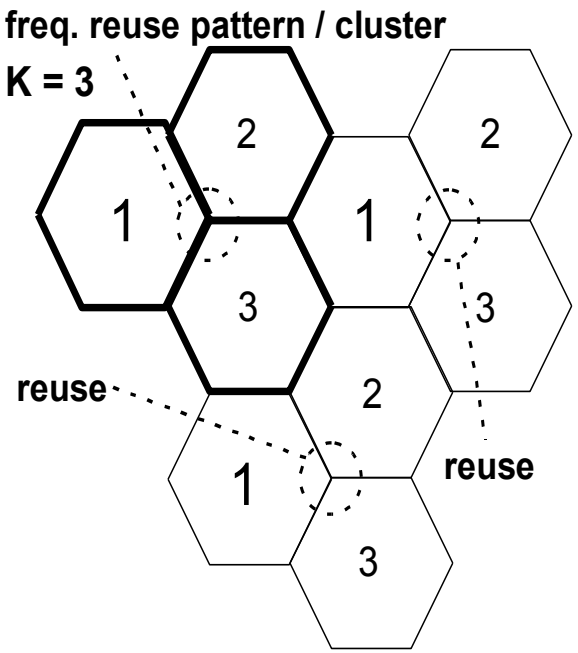


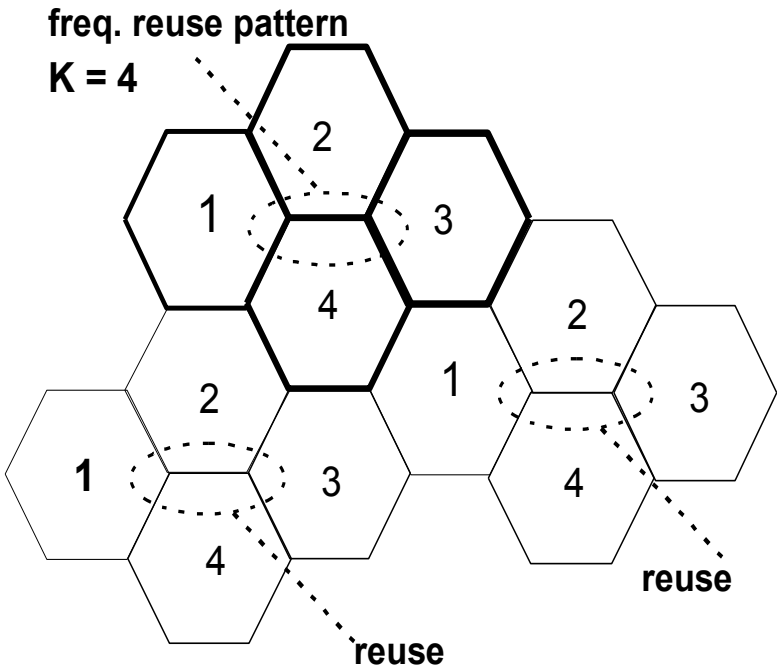
LATAR BELAKANG PENGGUNAAN FREQUENCY REUSE

1. Keterbatasan alokasi frekuensi
2. Keterbatasan area cakupan cell (coverage area).
3. Menaikkan jumlah kanal.
4. Membentuk cluster yang berisi beberapa cell.
5. Co-channel interference.

FREQUENCY REUSE PATTERN/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



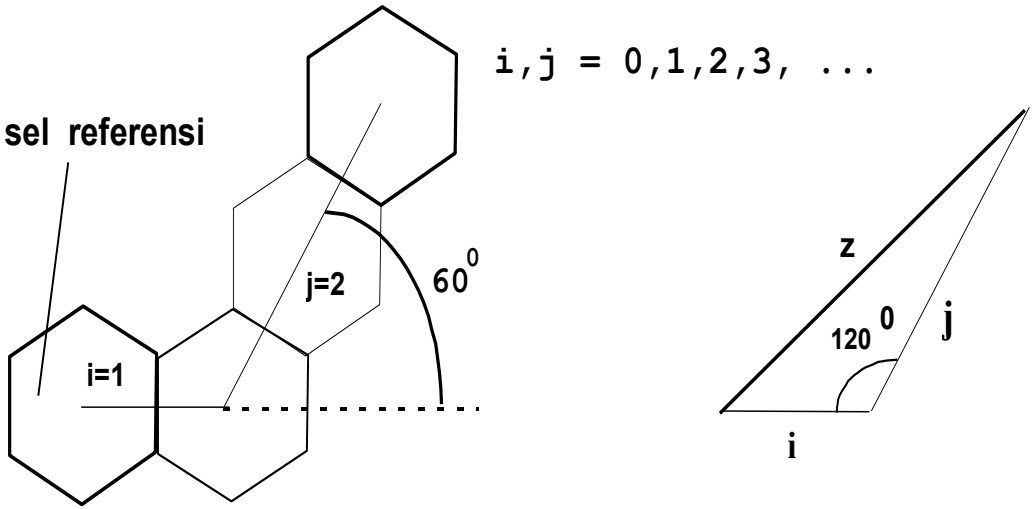


K=3 means there are 3 cells in one cluster

K=4 means there are 4 cells in one cluster

KAIDAH PENENTUAN NOMOR SEL

- Lalui sejauh i sel dari sel referensi sepanjang rantai heksagonalnya (garis lurus yang menghubungkan dua pusat sel), lalu berputar 60° berlawanan dengan arah jarum jam, kemudian lalui sepanjang j sel pada arah tersebut. Pada posisi akhir disitulah letak frequency reuse nya.



$Z^2 = i^2 + j^2 - 2ij.\cos 120^o$
$Z^2 = i^2 + j^2 + 2.i.j\ (0,5)$
$Z^2 = i^2 + j^2 + i.j$
Z^2 K ---- K = ukuran cluster
$K = i^2 + j^2 + i.j$

Untuk

i = 1 dan j = 1 K = 3
i = 1 dan j = 2 K = 7
i = 0 dan j = 2 K = 4
i = 2 dan j = 0 K = 4

SIGNAL TO INTERFERENCE RATIO (SIR)

- Menghitung besarnya interferensi dari sel co-channel yang berdekatan

$$\mathrm{SIR}_{\min} = -K_1 \log_{10}\left(D_{co}/R - 1\right) - 10\log_{10}\left(7\text{-}1\right)\ \mathrm{dB}$$

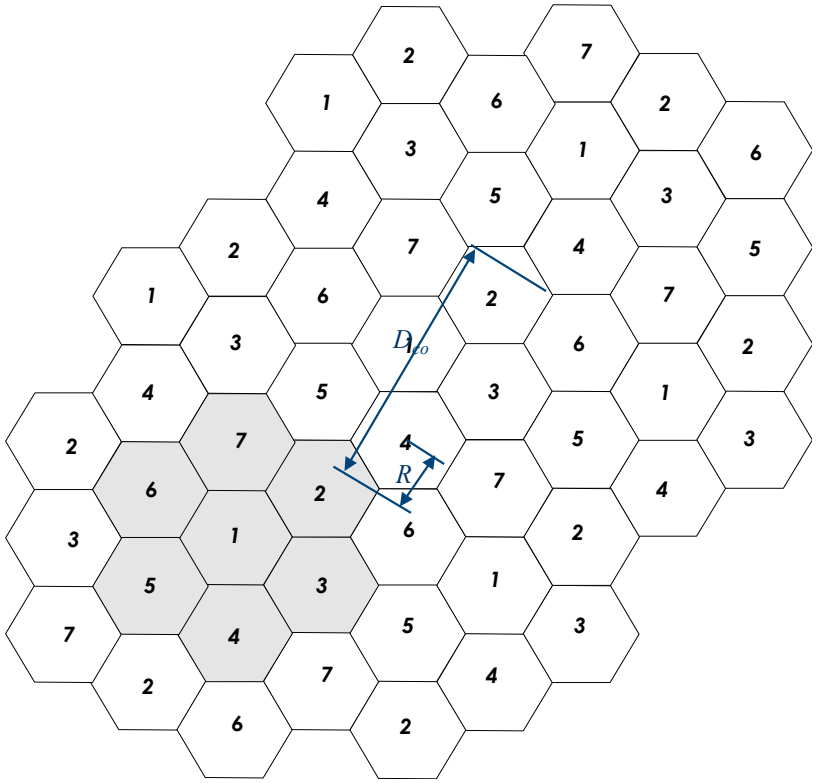
$$= = -K_1 \log_{10}\left(D_{co}/R - 1\right) - 7.78\ \mathrm{dB}$$

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

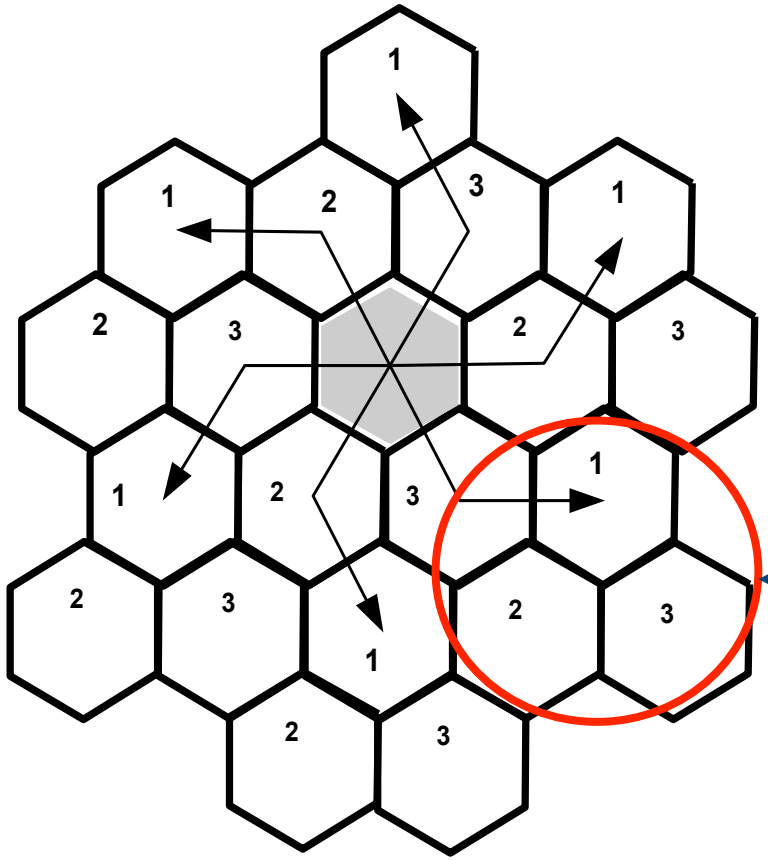
- Ukuran Cluster:

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

- Co-channel Reuse Distance Ratio



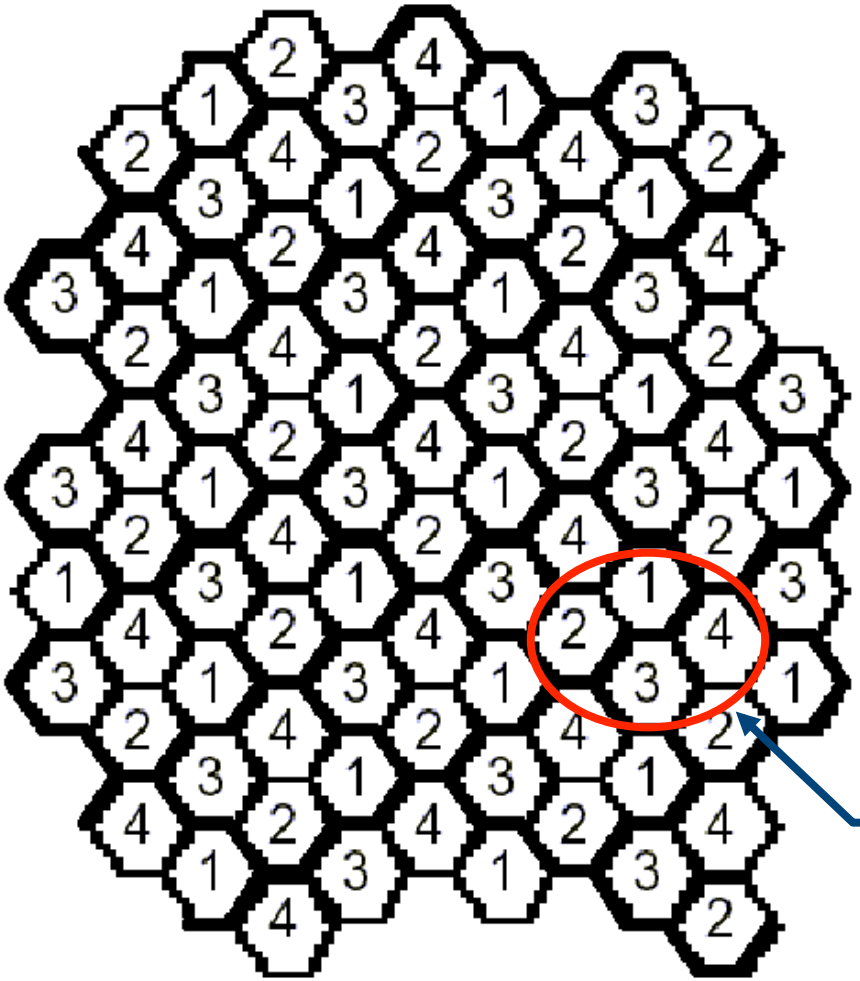
CONTOH #1



utk i = 1 dan j = 1 → K = 3

- i = 1 , j = 1
- $K = 1^2 + 1^2 + 1.1 = 3$
- Sumber interferensi maksimum = 6.

CONTOH #2

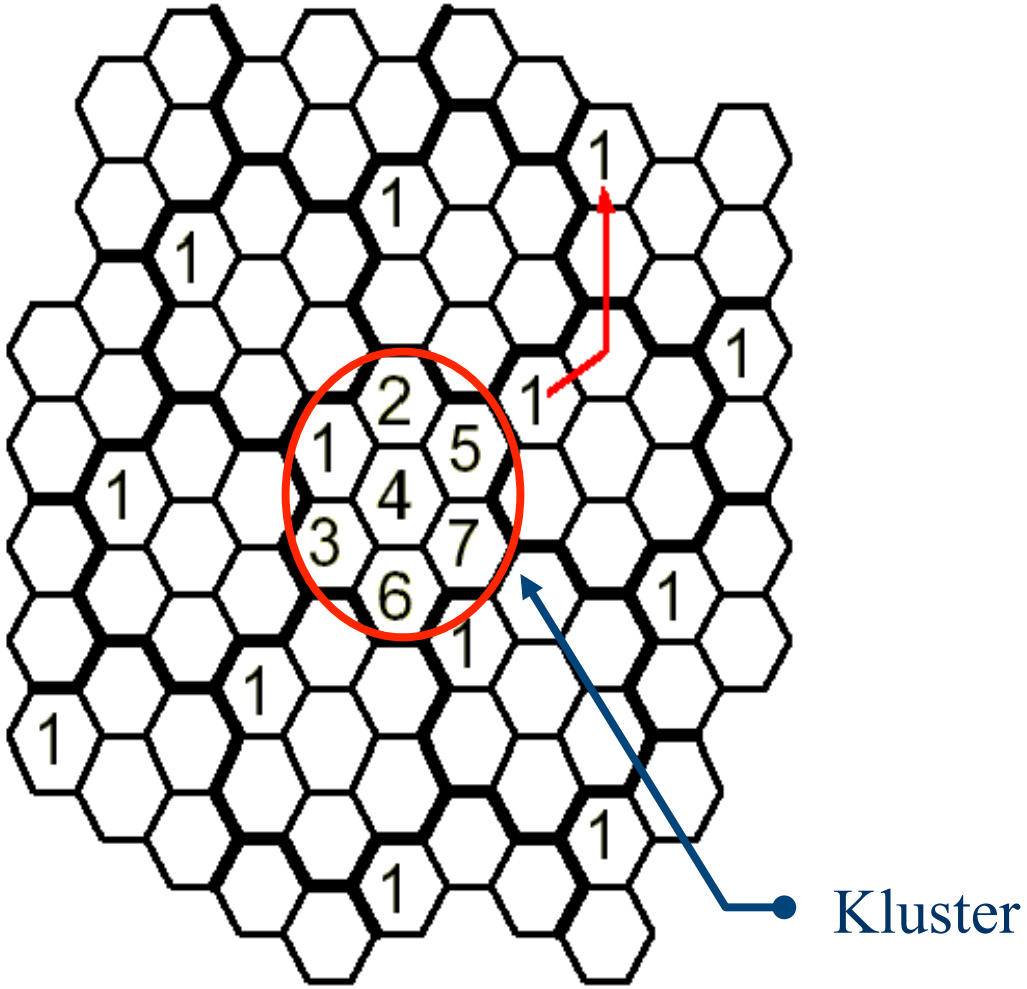


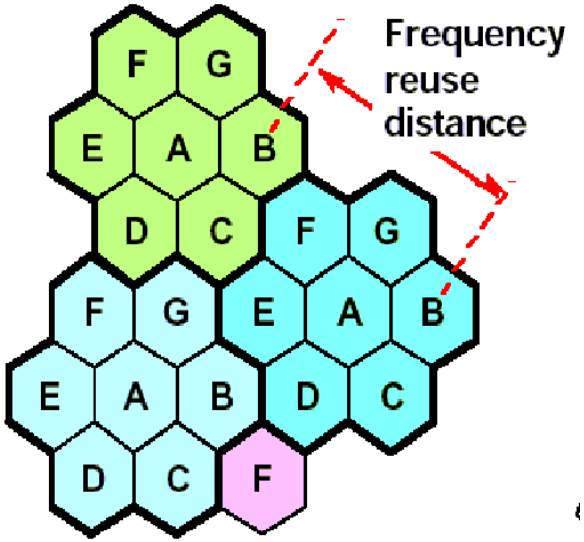
$$i = 0, j = 2$$

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

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

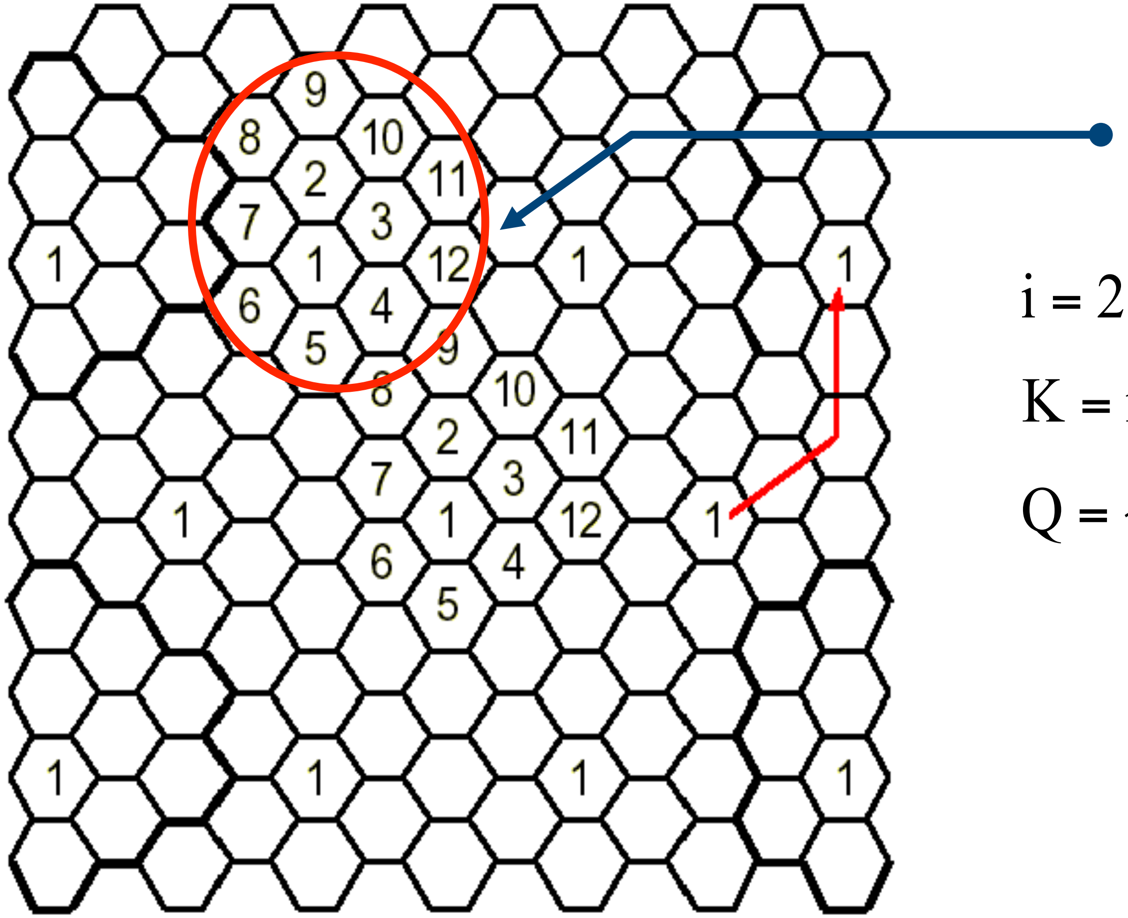
CONTOH #3





7-cell reuse pattern

CONTOH #4



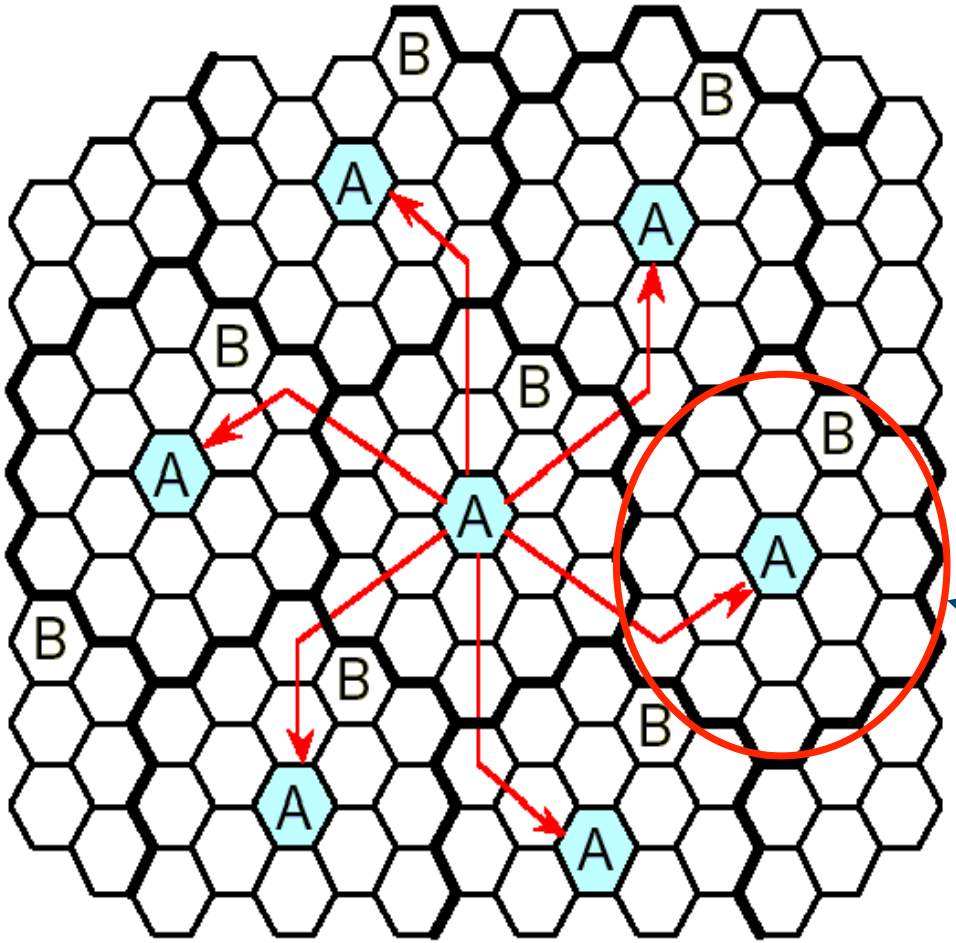
Kluster

$i = 2, j = 2$

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

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

CONTOH #5



$i = 3, j = 2$

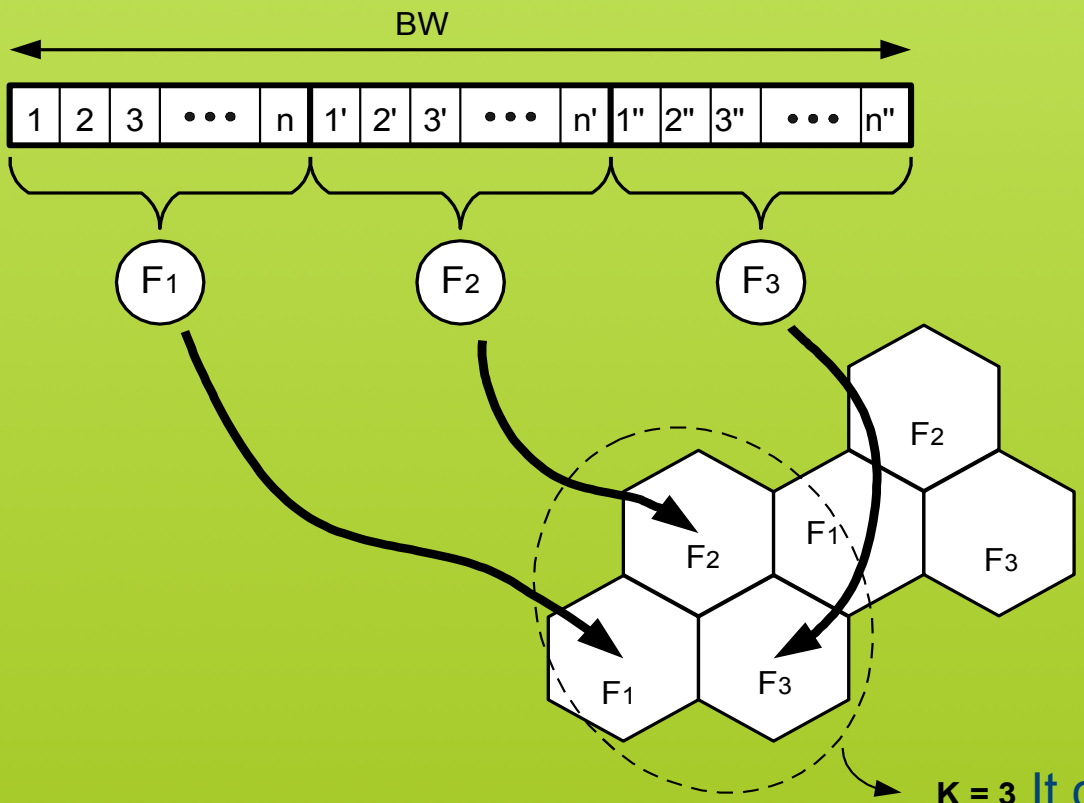
$K = i^2 + ij + j^2 = 19$

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

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

MENGHITUNG KAPASITAS KANAL TIAP SEL

Number of channel per cell expressed by the following formula:

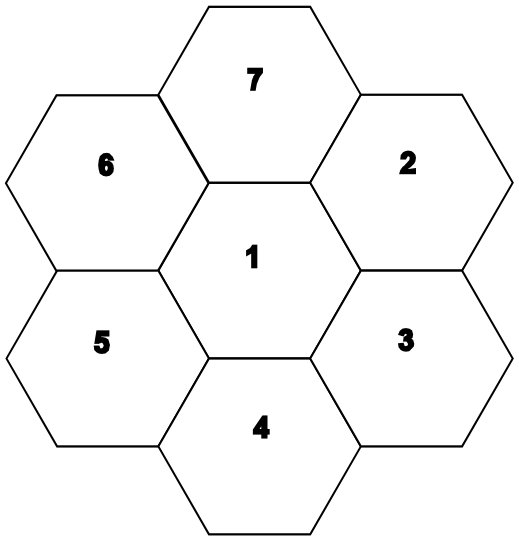


$$N = \frac{B_{alocation}}{B_{ch\ RF}} \times \frac{number\ of\ channel / ch\ RF}{freq.\ reuse}$$

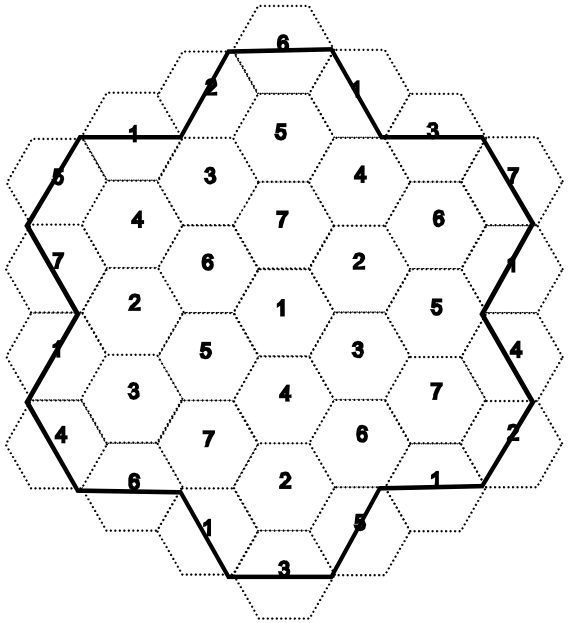
K = 3 It can be concluded, the number of carrier frequencies in one cell is more than one ….

CELL SPLITTING

- Untuk menaikkan kapasitas, operator menggunakan teknik pemecahan cel (*Cell Splitting*
- Cell Splitting diperlukan saat:
  - Kepadatan trafik dalam sel meningkat
  - Kanal yang ada tidak mampu melayani

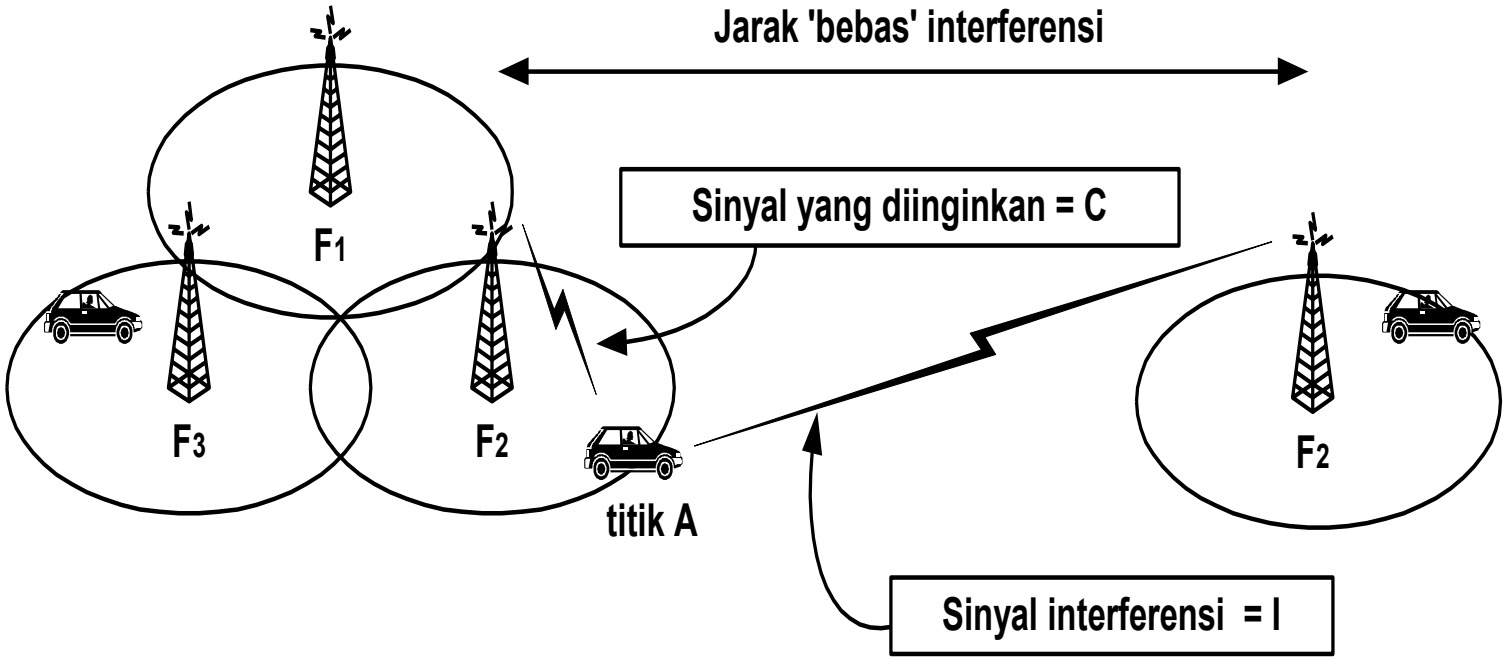


before cell splitting



after cell splitting

CARRIER TO INTERFERENCE RATIO (C/I)



- Dari gambar diatas, kondisi terburuk terjadi pada titik A.
- Daya carrier terhadap daya interferensi (C/I) harus tetap lebih besar atau sama dengan C/I minimum yang dibutuhkan oleh sistem selular yang relevan

C/I MINIMUM

- C/I minimum bergantung pada sistem selular yang diimplementasikan

$$\frac{C}{I} = \frac{1}{N}\left[\frac{D}{R}\right]^4$$

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

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

AMPS, C/I = 18 dB

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

GSM, C/I = 12 dB

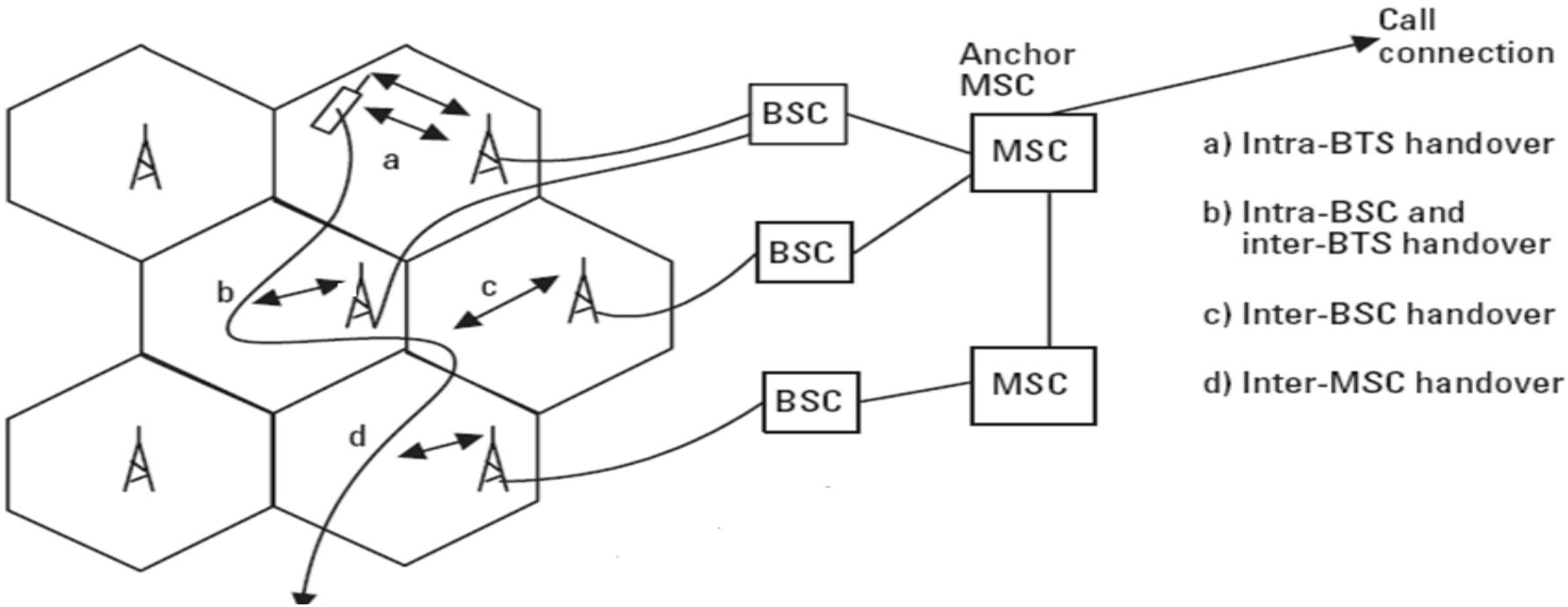
$$K = \sqrt{\frac{16N}{9}} = \sqrt{\frac{16.6}{9}} = 3{,}26 \approx 4$$

N = Number of cell interference

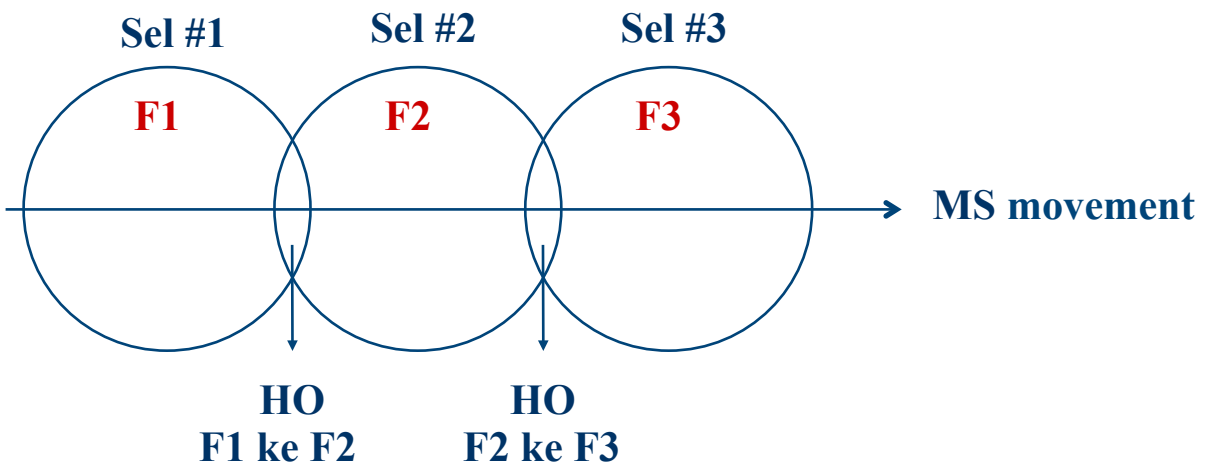
K = Cluster Size

HANDOVER

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

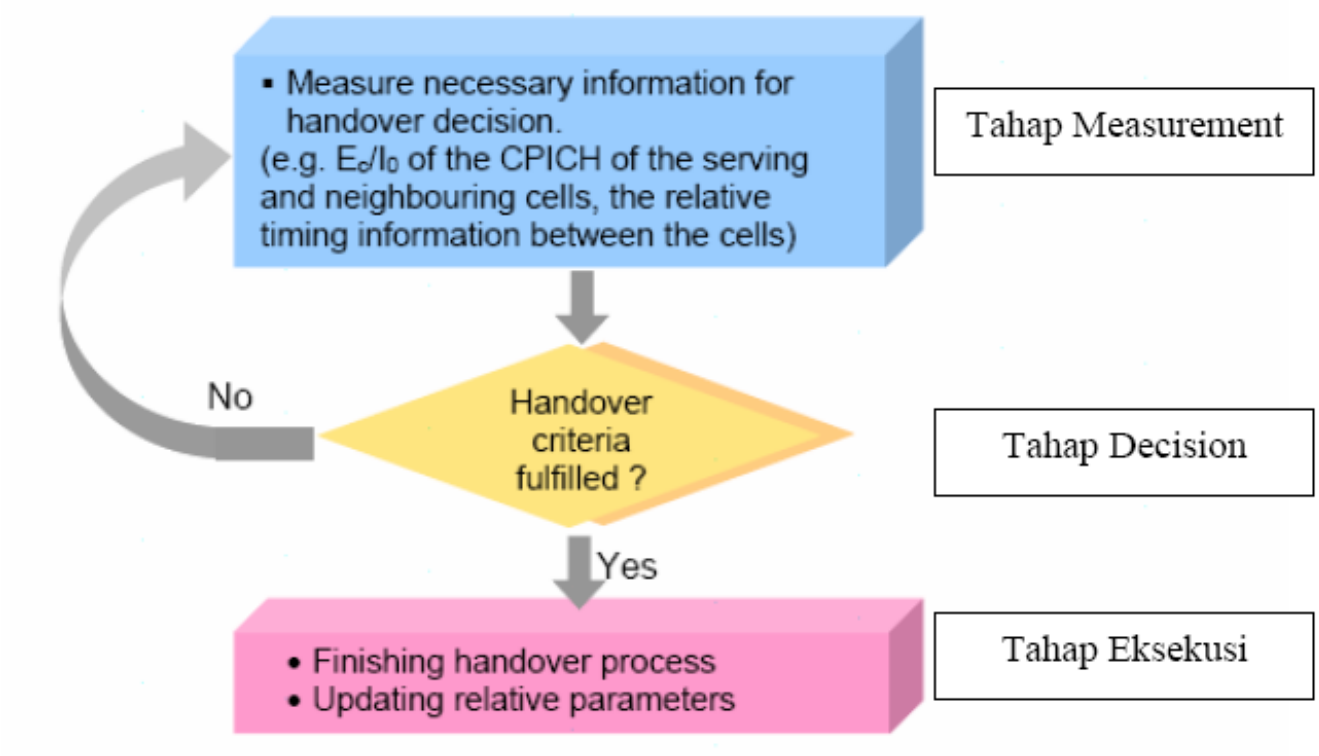


- Handover is the process of transfer of user traffic channels at the time of active users without termination and without intervention from the user.
- Handoff is no different except that the term handoff handover used in the U.S., while the term handover is used in Europe.
- Events hand over (HO) 'generally'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

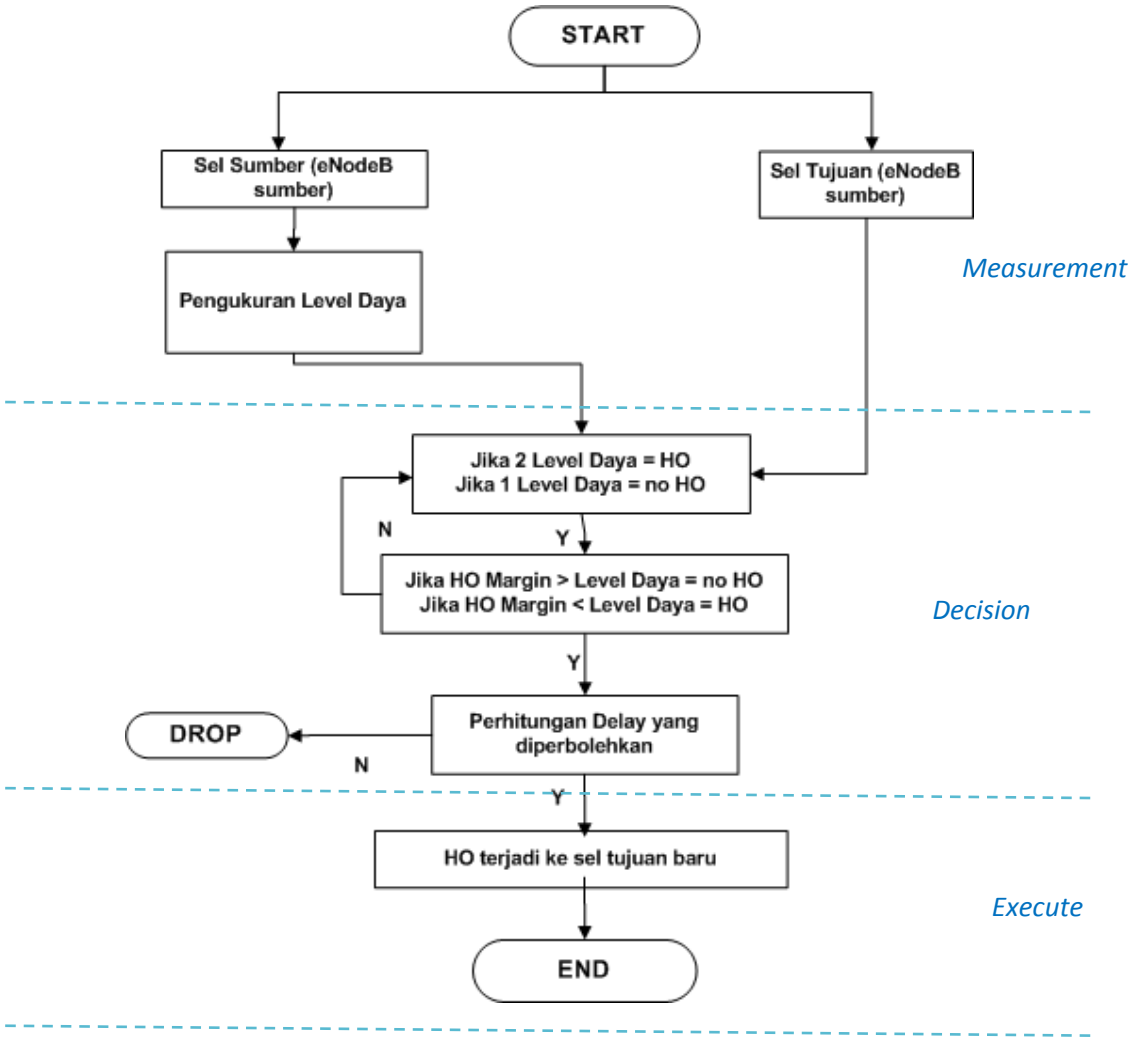


HANDOVER PROCESS

- Handover is a facility in celullar system to guarantee communication continously if customer move from one cell to other cell.



FLOWCHART HANDOVER PROCESS



ALASAN TERJADINYA HANDOFF

- MS berada diluar jangkauan BTS (RF Criteria)
  - Level penerimaan sinyal terlalu rendah
  - Bit Error Rate (BER) terlalu tinggi
- Untuk menyeimbangkan beban jaringan (Network Criteria)
  - Trafik pada sel terlalu tinggi sehingga beberapa MS dialihkan ke sel yang lain

- 2 Tahapan handoff:
  1. Tahap Monitoring
     - Mengukur kuat sinyal dan melihat adanya kemungkinan radio link alternatif
     - Menginisiasi handoff bila diperlukan
  2. Tahap Penganan Handover
     - Menentukan PoA (Point of Attachment) yang baru
     - Melakukan inisiasi kemungkinan dilakukannya prosedur re-routing

JENIS-JENIS HANDOVER

- Internal Handover (dikontrol oleh BSC)
    1. Intra-cell Handover
    2. Inter-cell Handover

- External Handover (dikontrol ole MSC)
    1. Intra MSC Handover
    2. Inter MSC Handover

JENIS HANDOVER

Intra Cell

f 1, TS 1

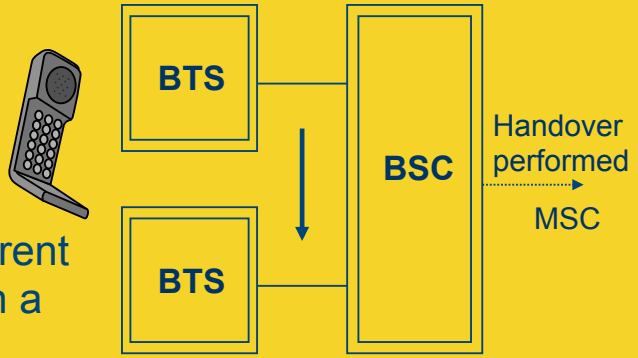
f 2, TS 2

transfer relationship to a different channel on the same single base station.

Handover performed

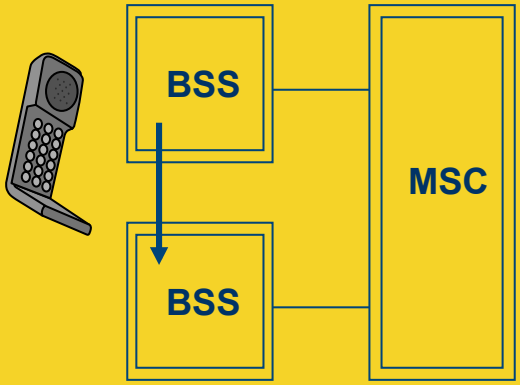
MSC

Inter Cell



the transfer relationship between different basestation in a single BSC

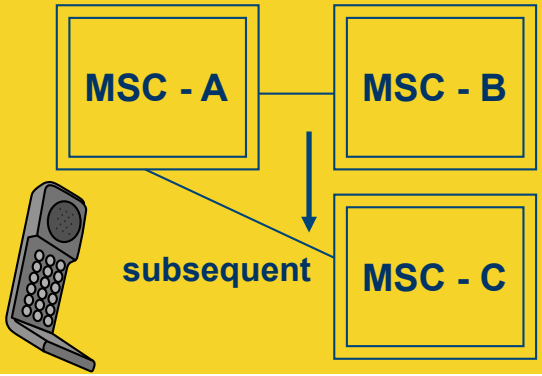
Intra MSC



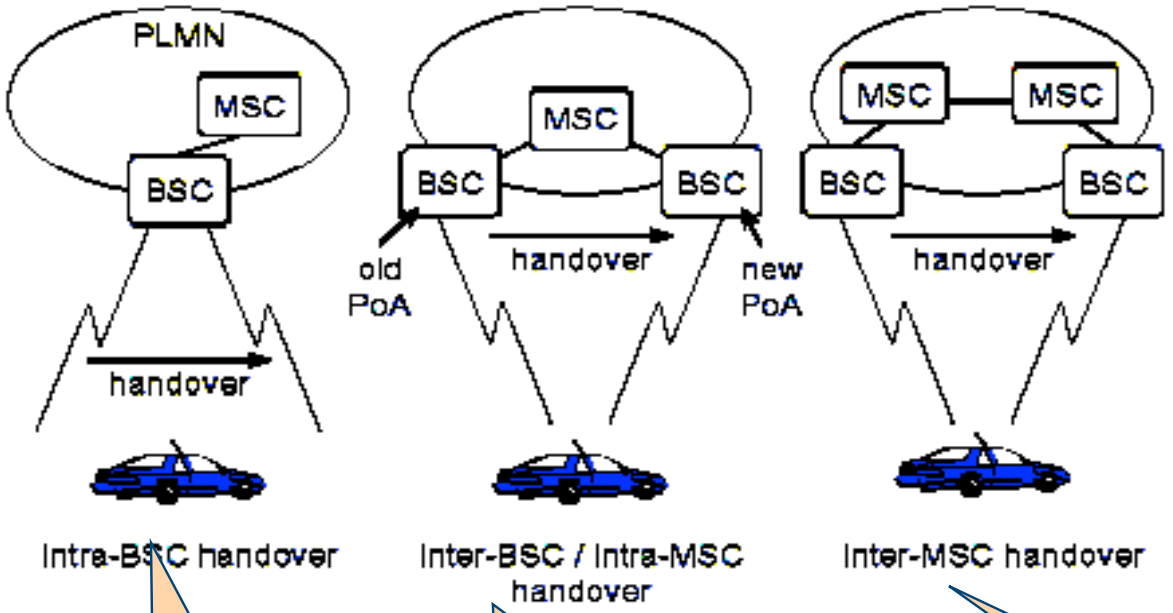
the transfer of the relations between the BSC in a single MSC.

Inter MSC

basic



displacement relationships that occur in 2 different MSC

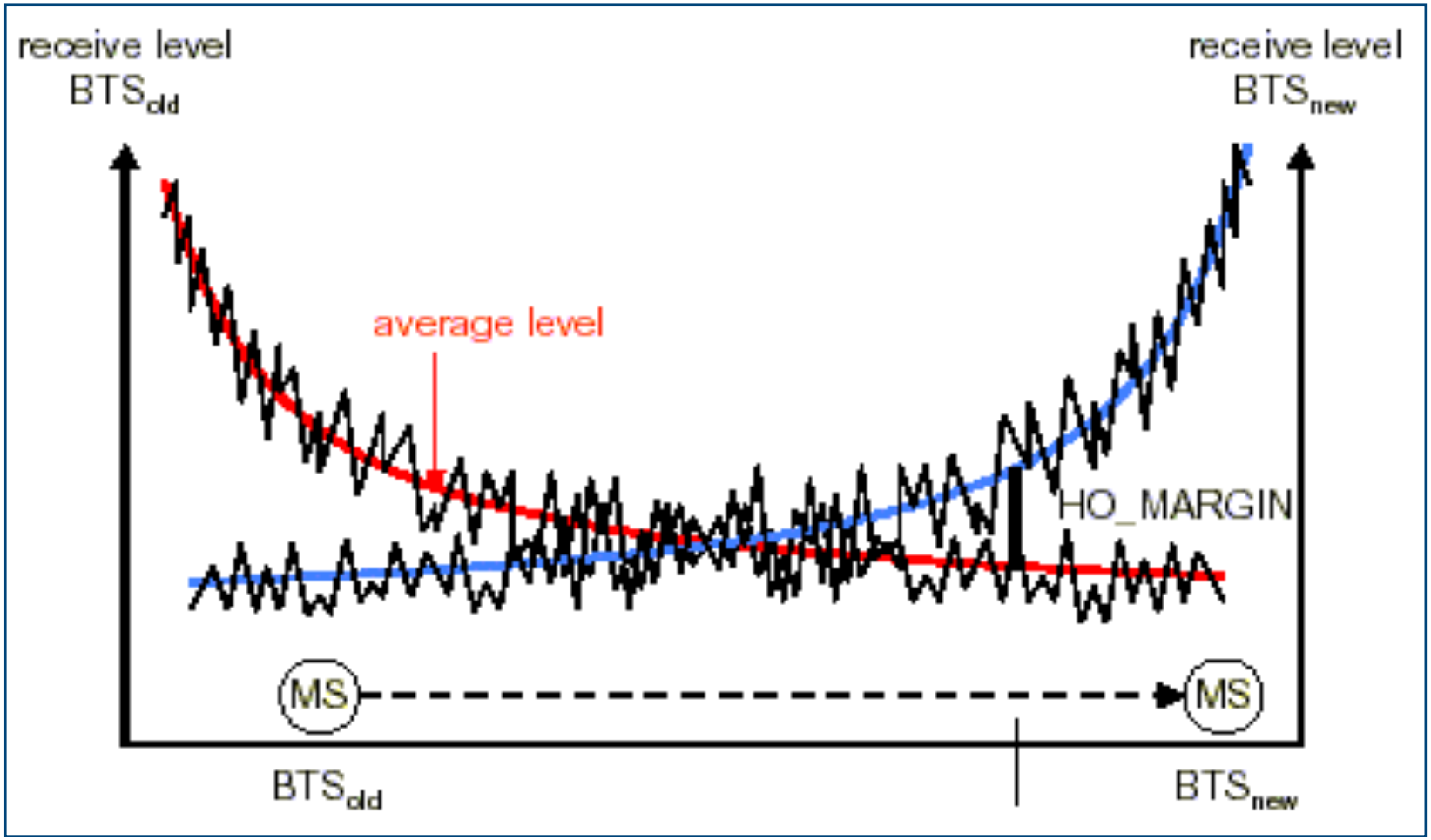


- Often due to narrowband interference

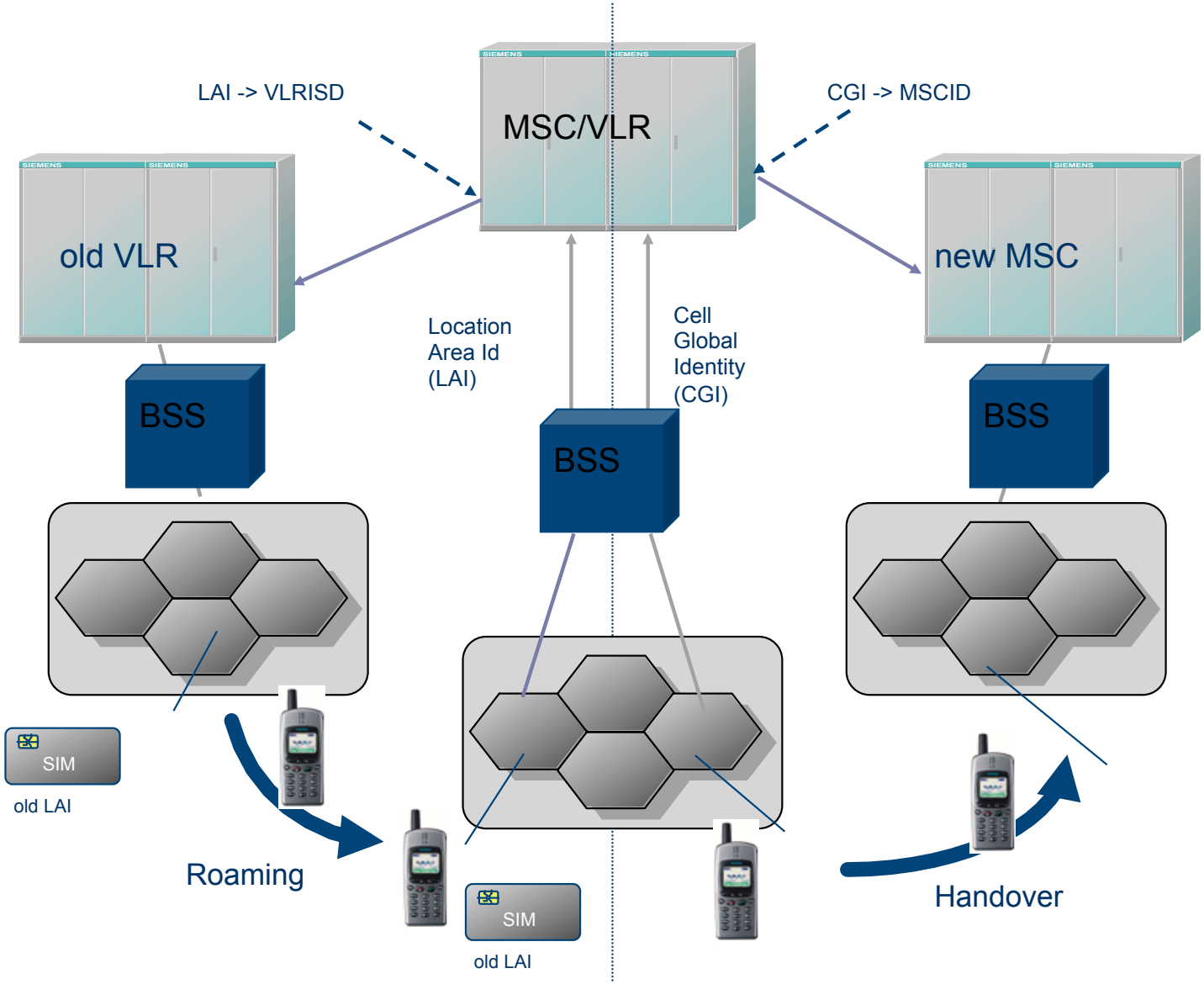
- The most common case
- 2 cases: (1)-cell inter / intra-BSC, (2) inter-BSC / Intra-MSC
- BSC HO operation, assign a new channel in the cell and remove the old channels in the previous cell

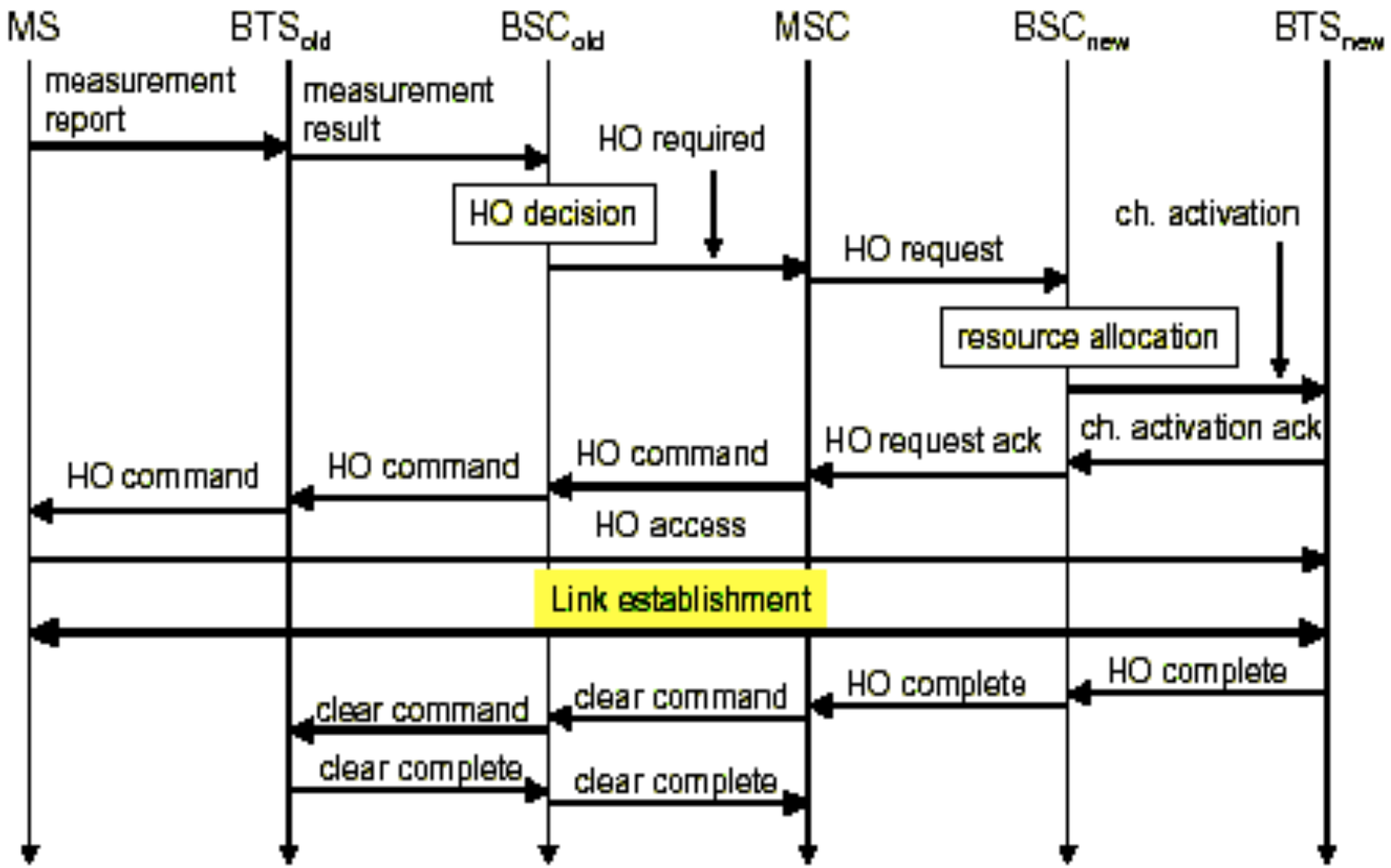
- **Controlled by MSC**

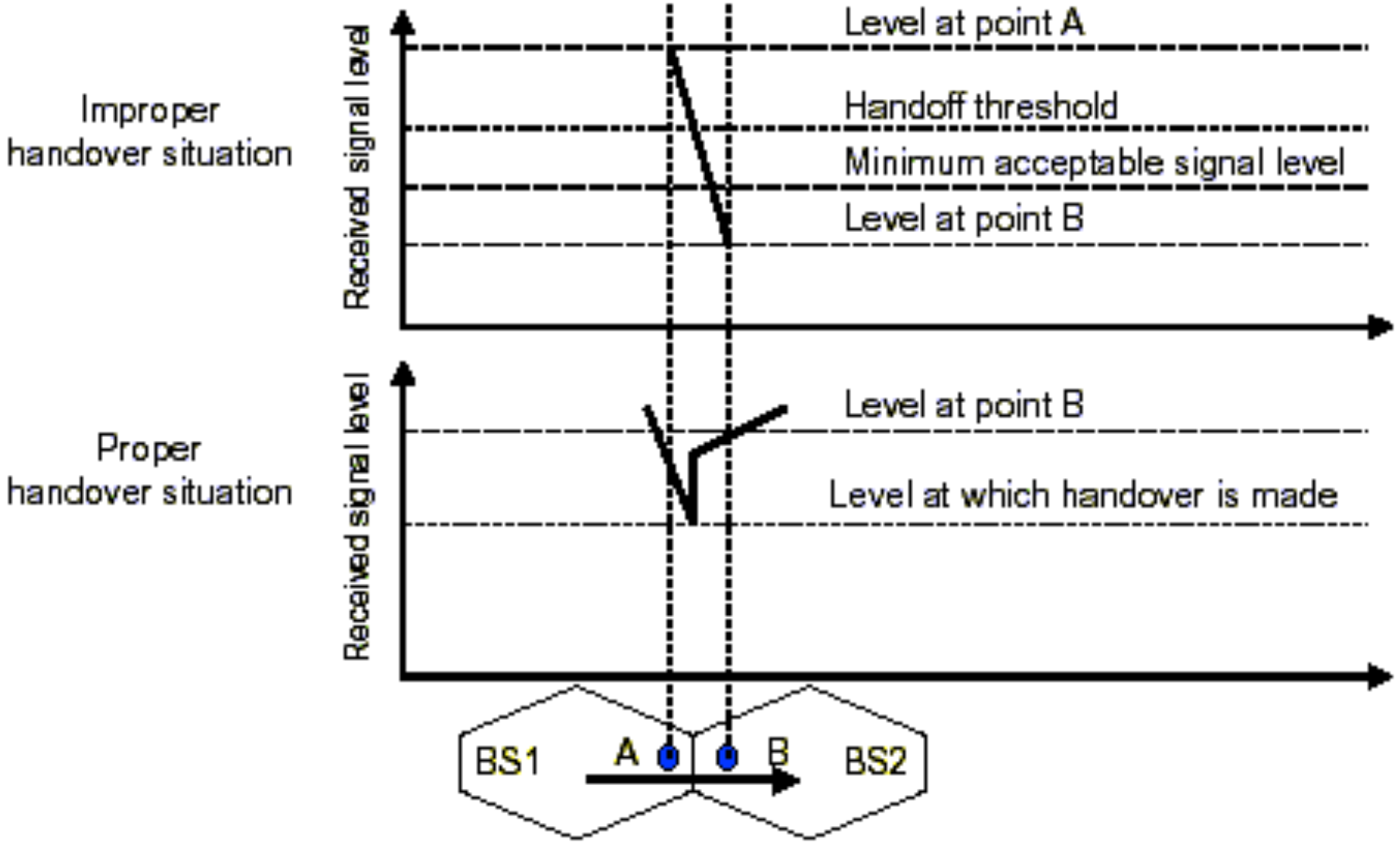
REASON FOR THE HANDOFF (RF CRITERIA)



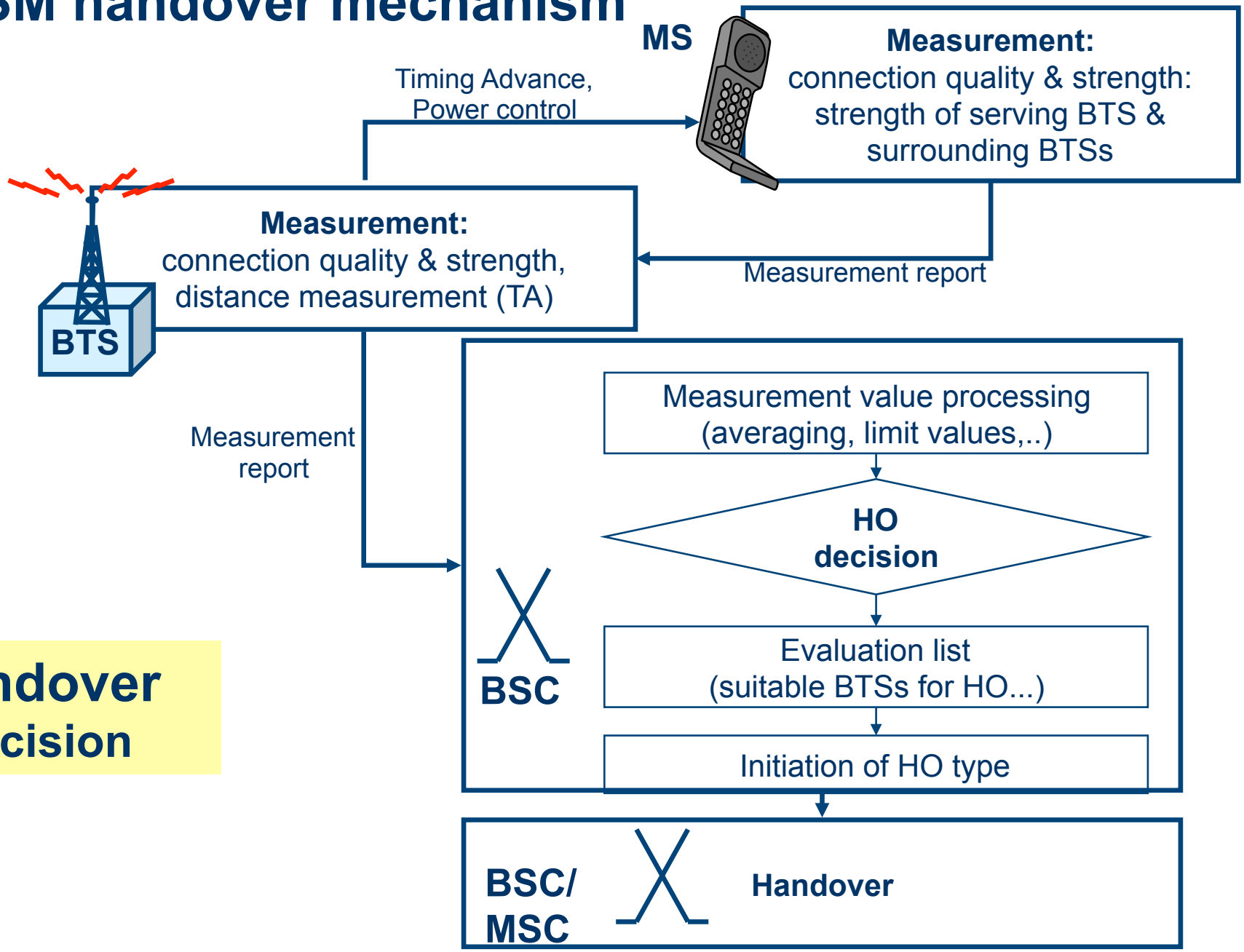
MECHANISM FOR HANDOVER




MS
BTS old
BSC old
MSC
BSC new
BTS new
measurement report
measurement result
HO required
HO decision
HO request
ch. activation
resource allocation
ch. activation ack
HO request ack
HO command
HO command
HO command
HO access
Link establishment
HO complete
HO complete
clear command
clear command
clear complete
clear complete


Improper handover situation
Received signal level
Level at point A
Handoff threshold
Minimum acceptable signal level
Level at point B
Proper handover situation
Received signal level
Level at point B
Level at which handover is made
BS1
A
B
BS2

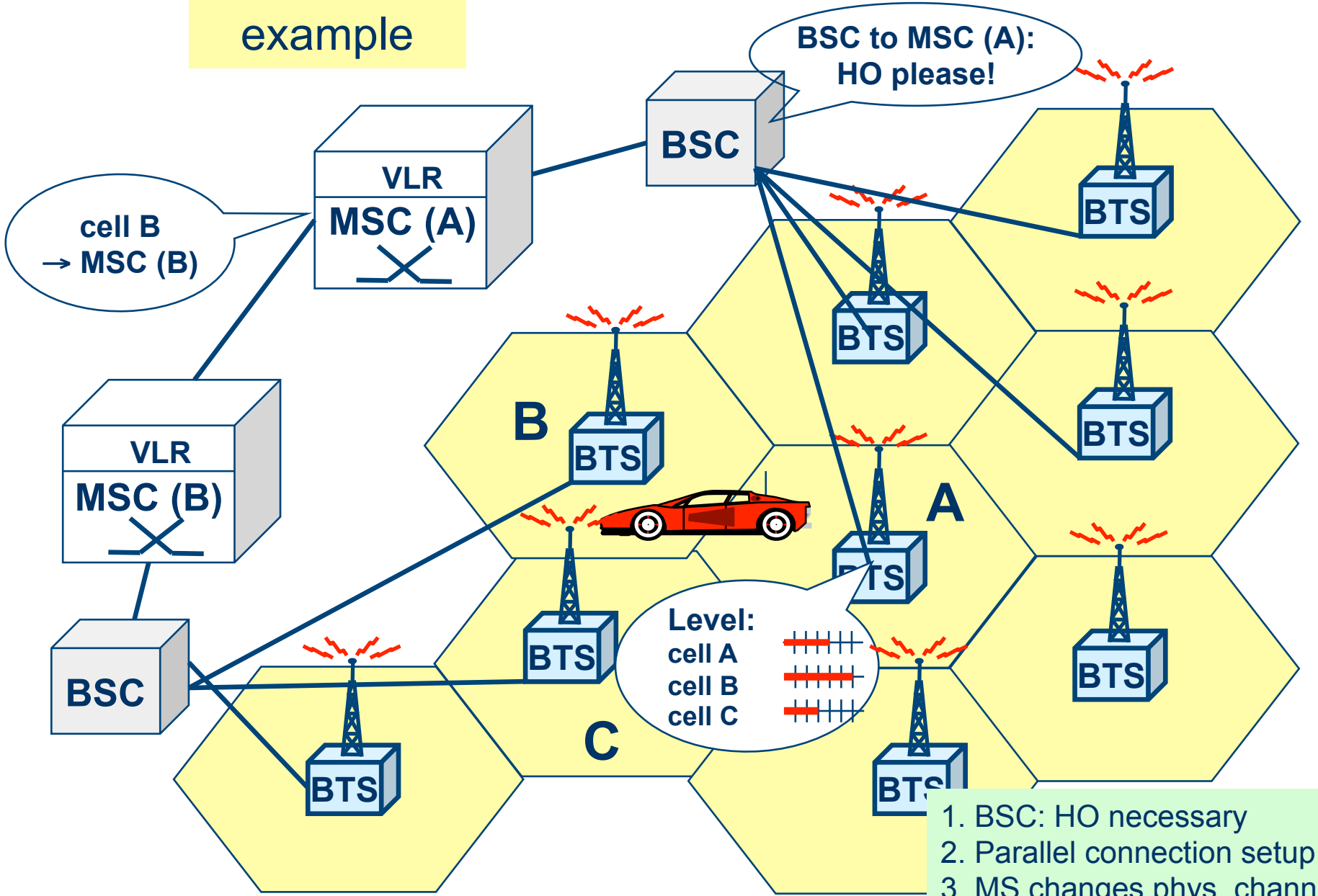
GSM handover mechanism



Handover
Decision

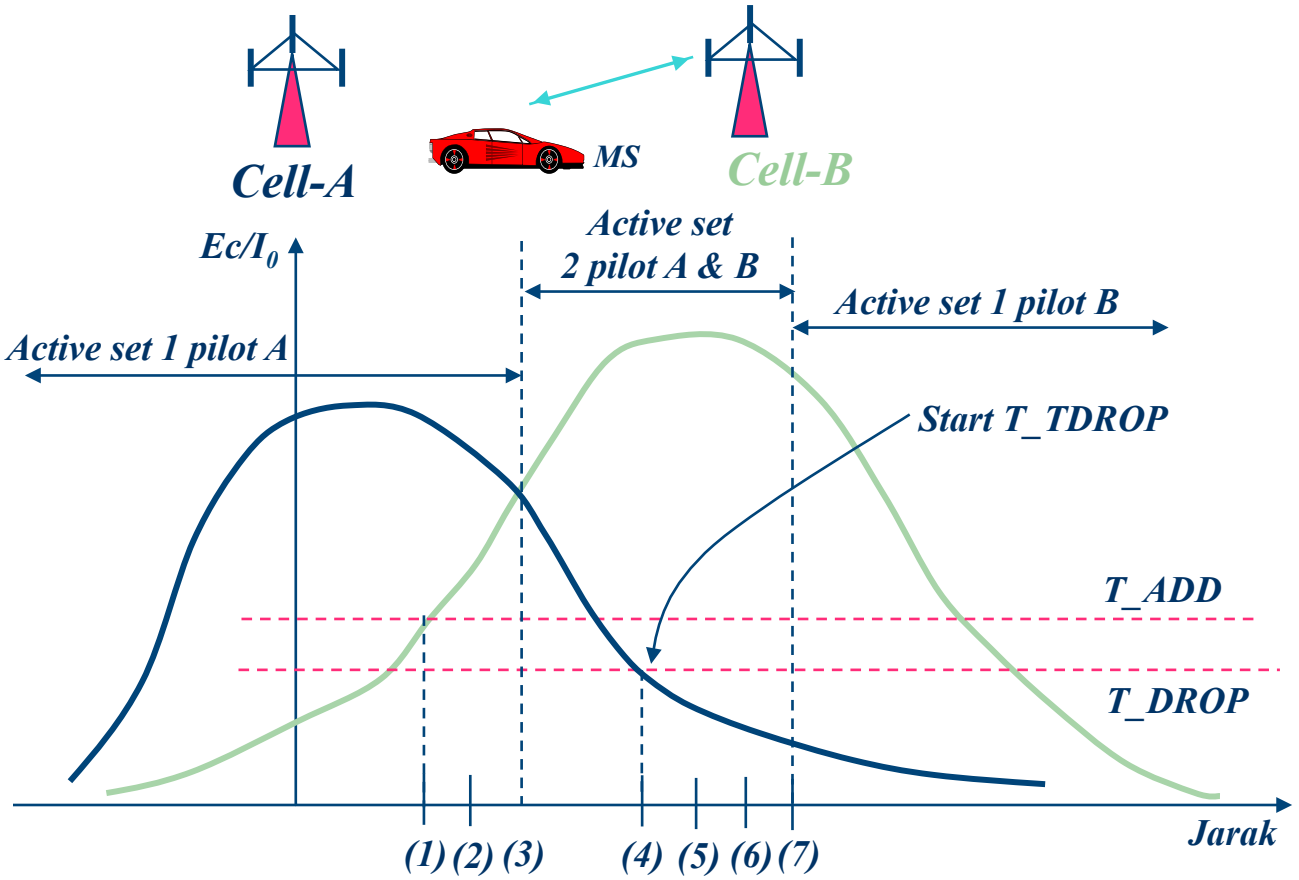
Handover example

GSM handover mechanism



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

Handover in CDMA



Steps Handover in CDMA

- MS is only serviced by cell A and active set consists only of pilots A. MS measuring the pilot B (Ec / Io), acquired a tendency> T_ADD. MS sends a message the measured pilot B and B move from pilot status to the candidate neighbor set.

- 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.

- MS B move the pilot status of the candidate set to the active set, the MS sends a handoff message complited. Now there are 2 active pilots.

- MS detect the pilot A fall <T_DROP, MS start the timer.
- Timer achieve the T_TDROP, MS send PSMM (pilot strength measurement message)

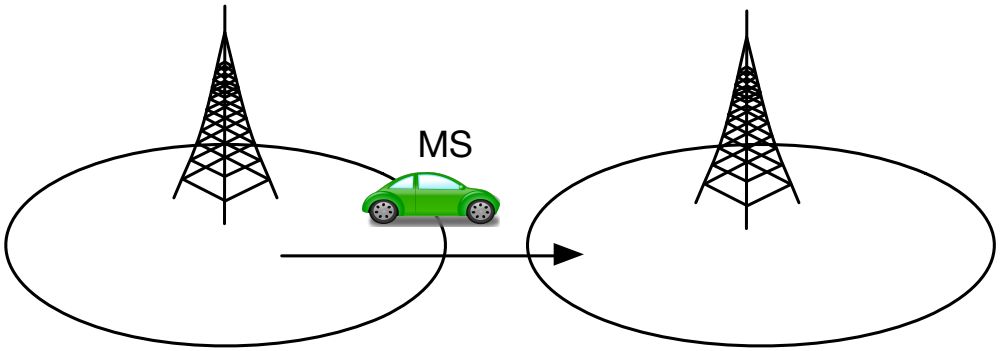
- the MS receives a handoff direction message, the message contains only the PN offset of cell B (without PN offset cell A).

- A pilot status of MS move from active set into the neighbor sets

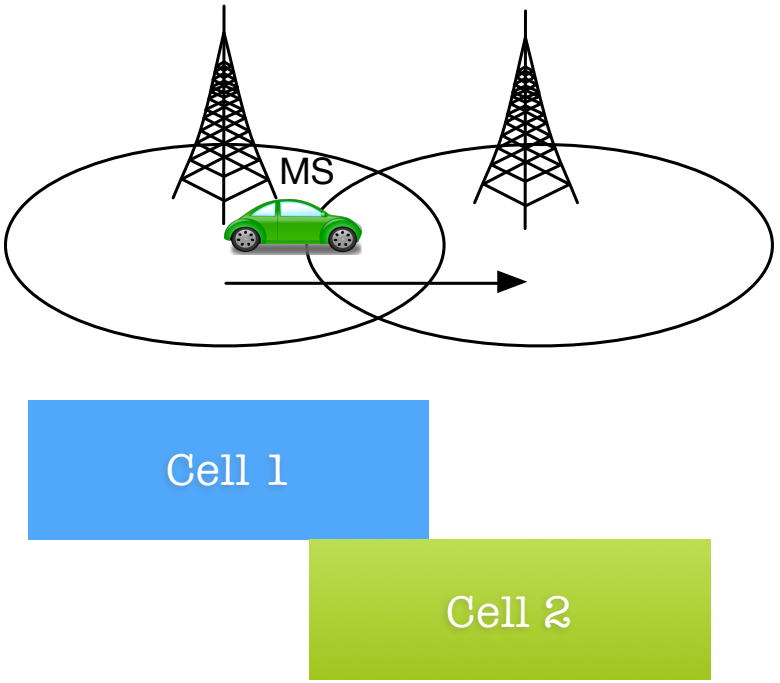
Two main Types of Handoff

- Hard handover— GSM systems
- Soft handover — CDMA systems

Hard Handoff



Soft Handoff



Hard Handover

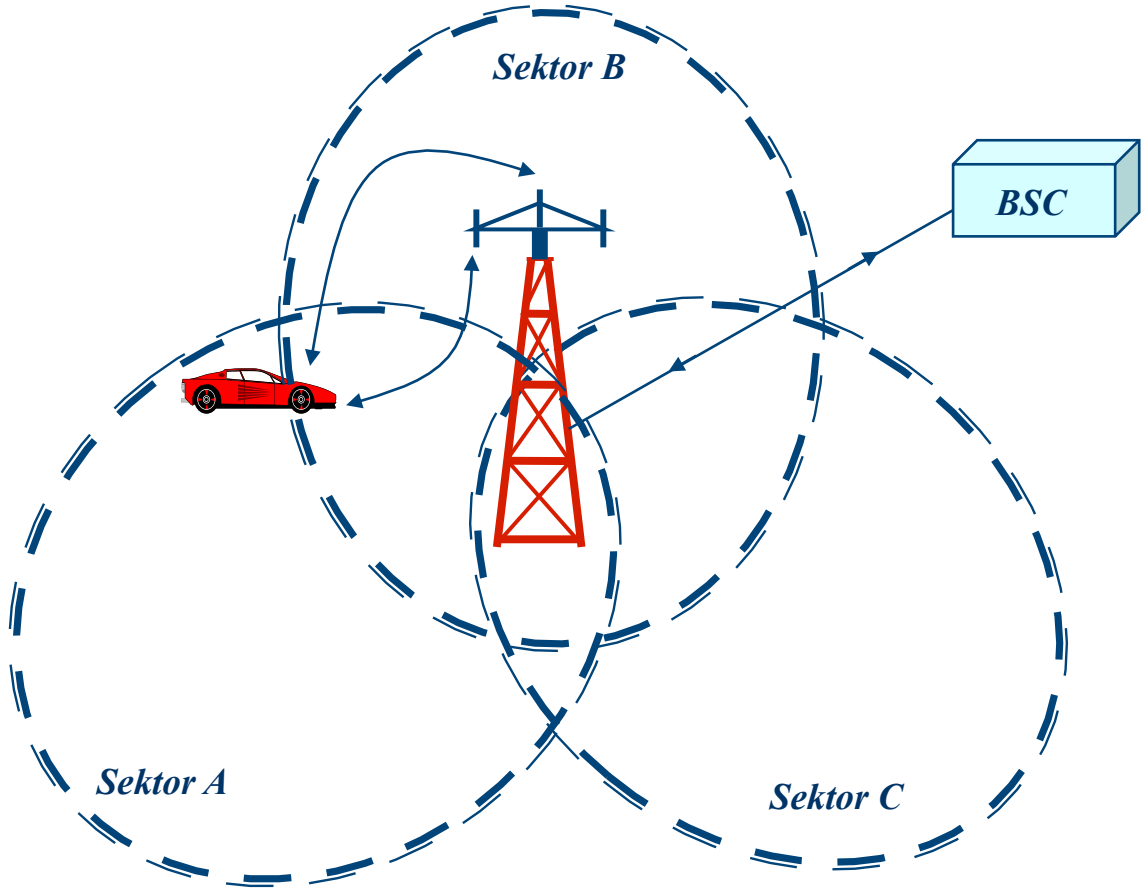
- Existing radio link must be dropped for a small period of time
- Then taken over by another base station
- A call in progress redirected not only from a base station to another base station but also from its current transmit–receive frequency pair to another frequency pair
- An ongoing call can not exchange data or voice for this duration

Soft Handoff

- Mobile station at the boundary of two adjacent cells— does not suffer call drops due to handover in the boundary region
- Gives seamless connectivity to a Mobile station
- An offset to pseudo noise code— method of soft handover
- Soft handover does not require breaking of the radio link for cell-to-cell transfer of a call. A mobile device can be simultaneously connected to several base stations

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.



Summary

- Handover when the mobile device moves out of the range of one cell (base station) and a different base station can provide it with a stronger signal or when present cell traffic high
- Hard handover in GSM
- Call drop for hard handover
- Soft handover in CDMA