Παρουσιάσεις για το Μάθημα Ασύρματων και Κινητών Τηλεπικοινωνιών του ΔΜΠΣ στο ΕΚΠΑ

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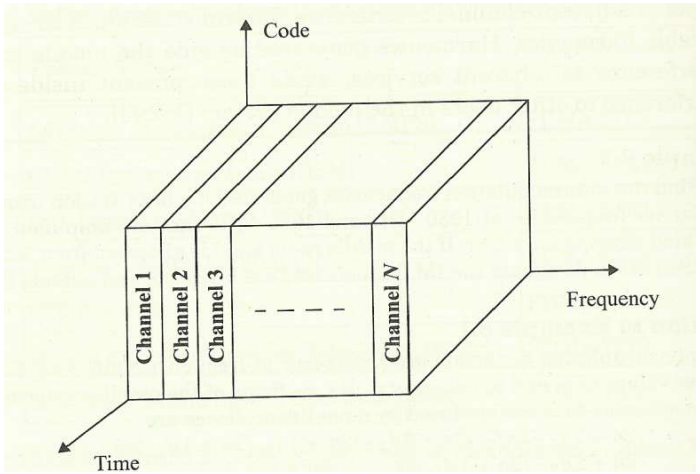
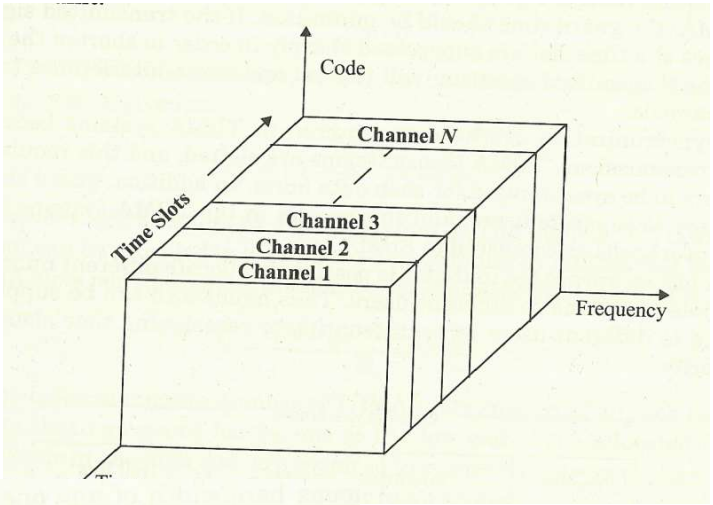
Αθήνα, 2025

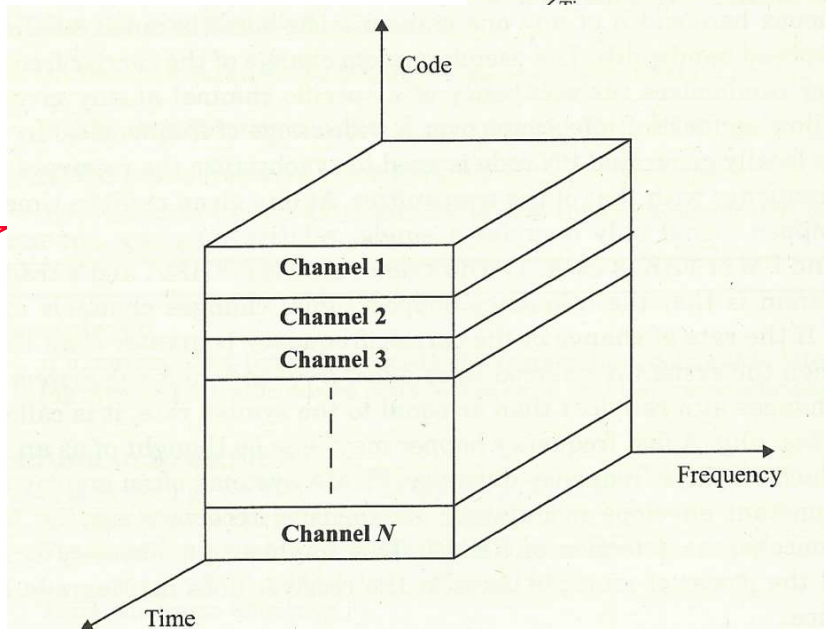
CDMA Systems

Multiple Access Techniques



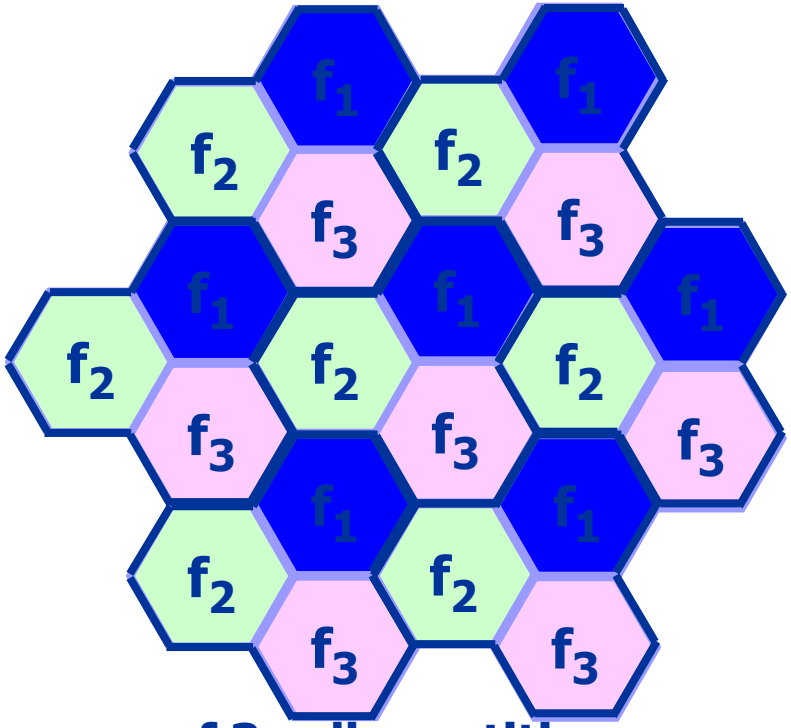


The party effect



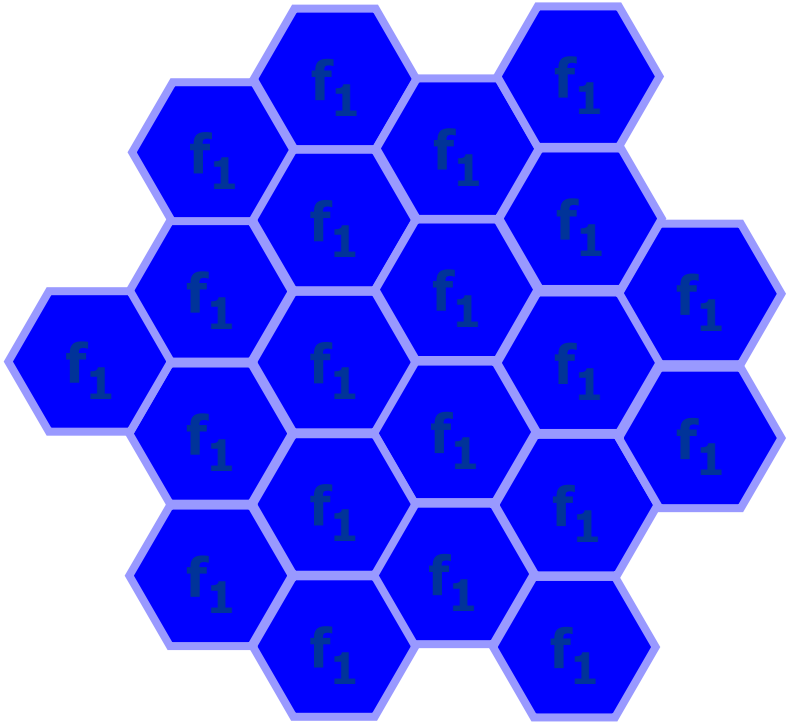
FDMA/TDMA vs CDMA

FDMA / TDMA



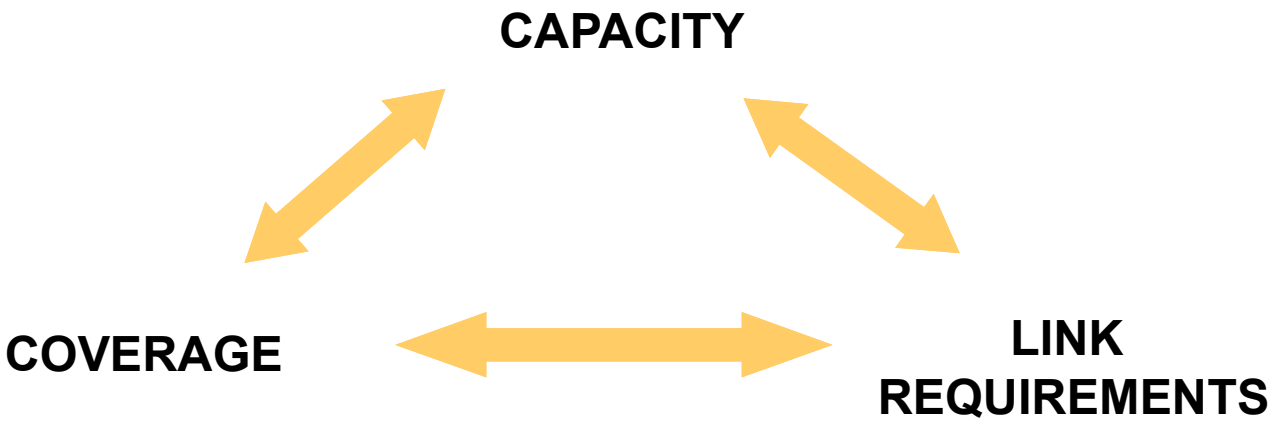
In case of 3 cell repetition Design objective is frequency allocation.

CDMA

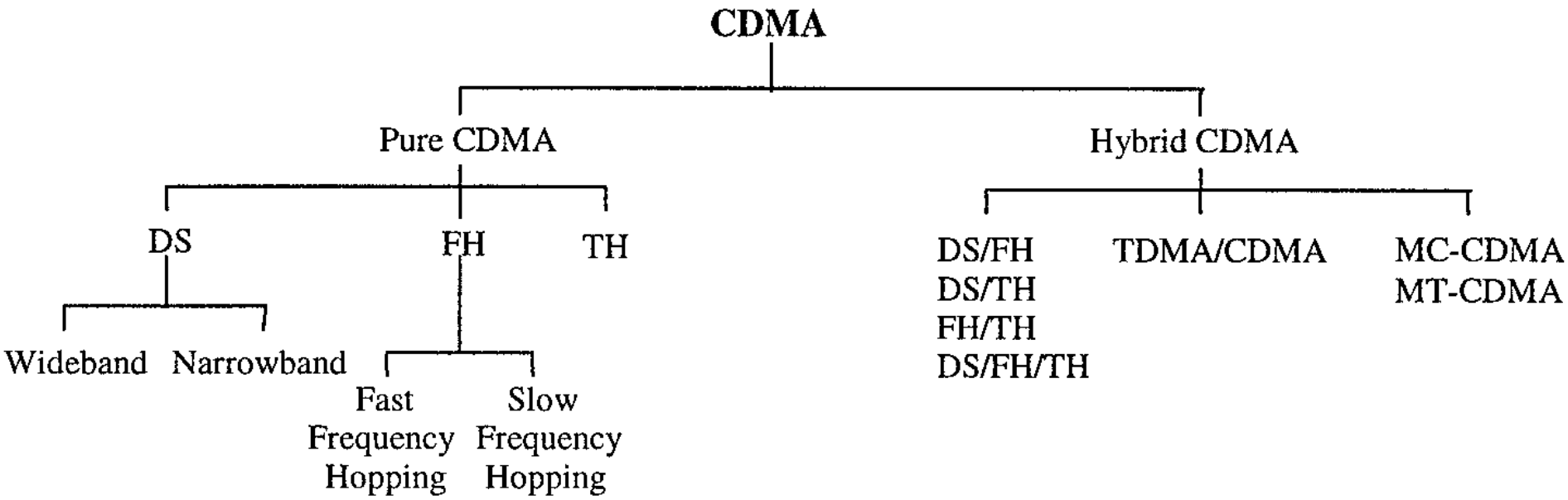


Same frequency in all area.

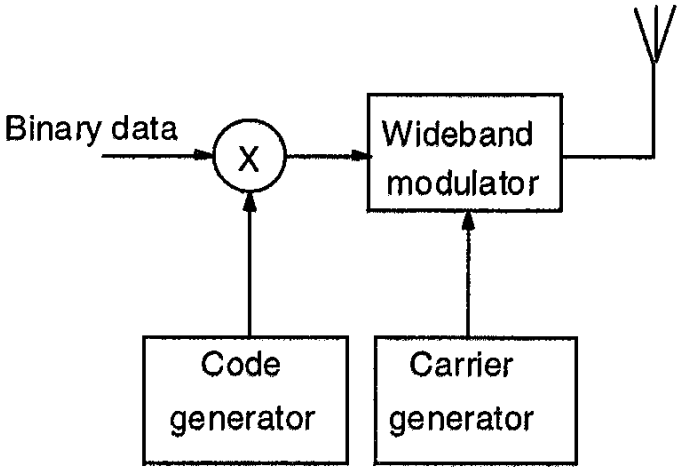
QoS Network Specifications

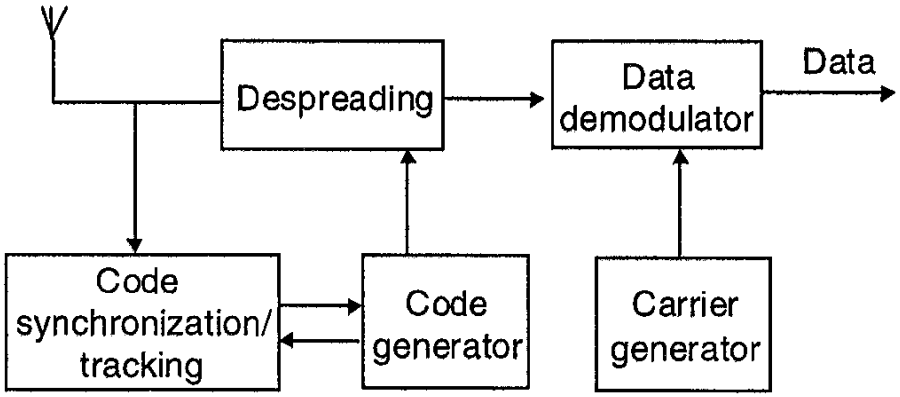


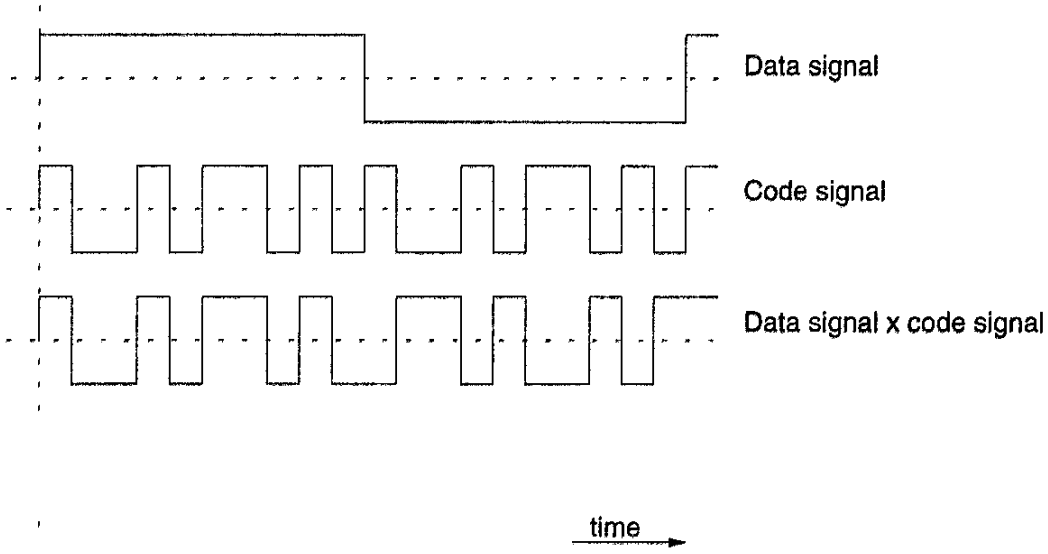
Code Divison Multiple Access Schemes



DS-CDMA System



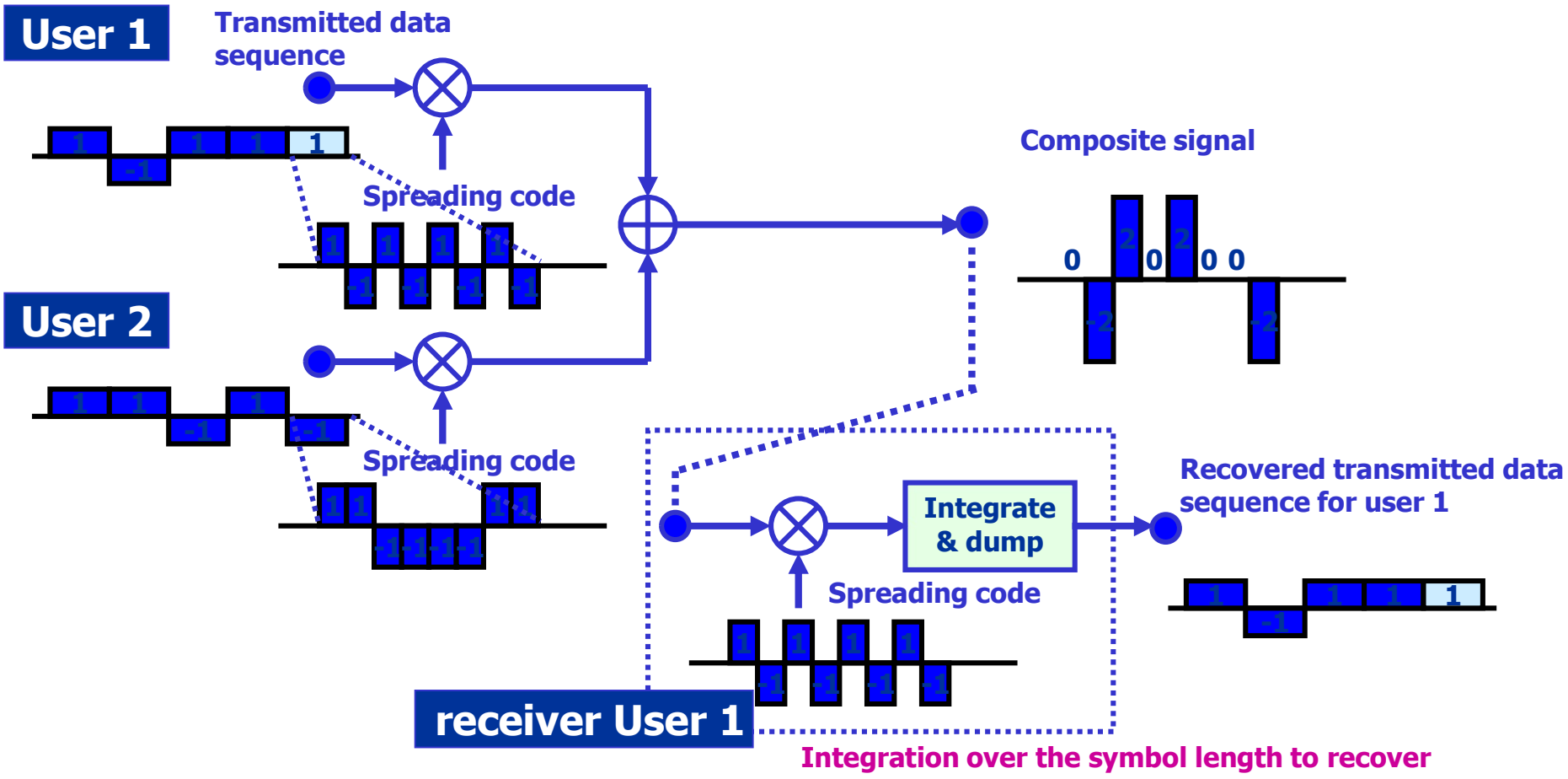




$$\left(\frac{S}{N}\right)_{user} = \frac{E_b * R}{N_0 * W} = \left(E_b / N_0\right) / G_p$$

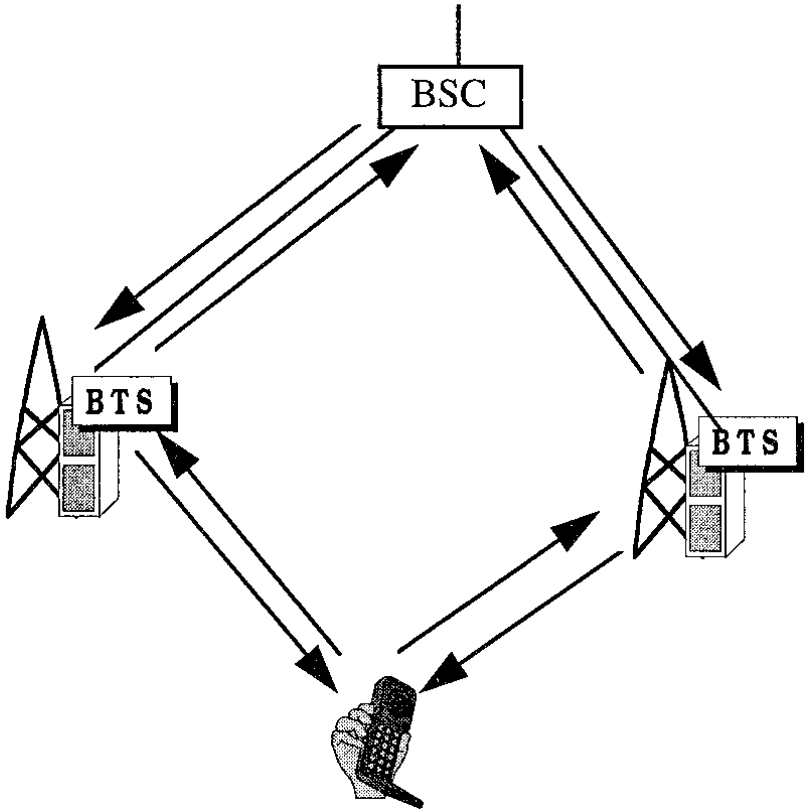
Processing Gain

Data Spreading & Recovery

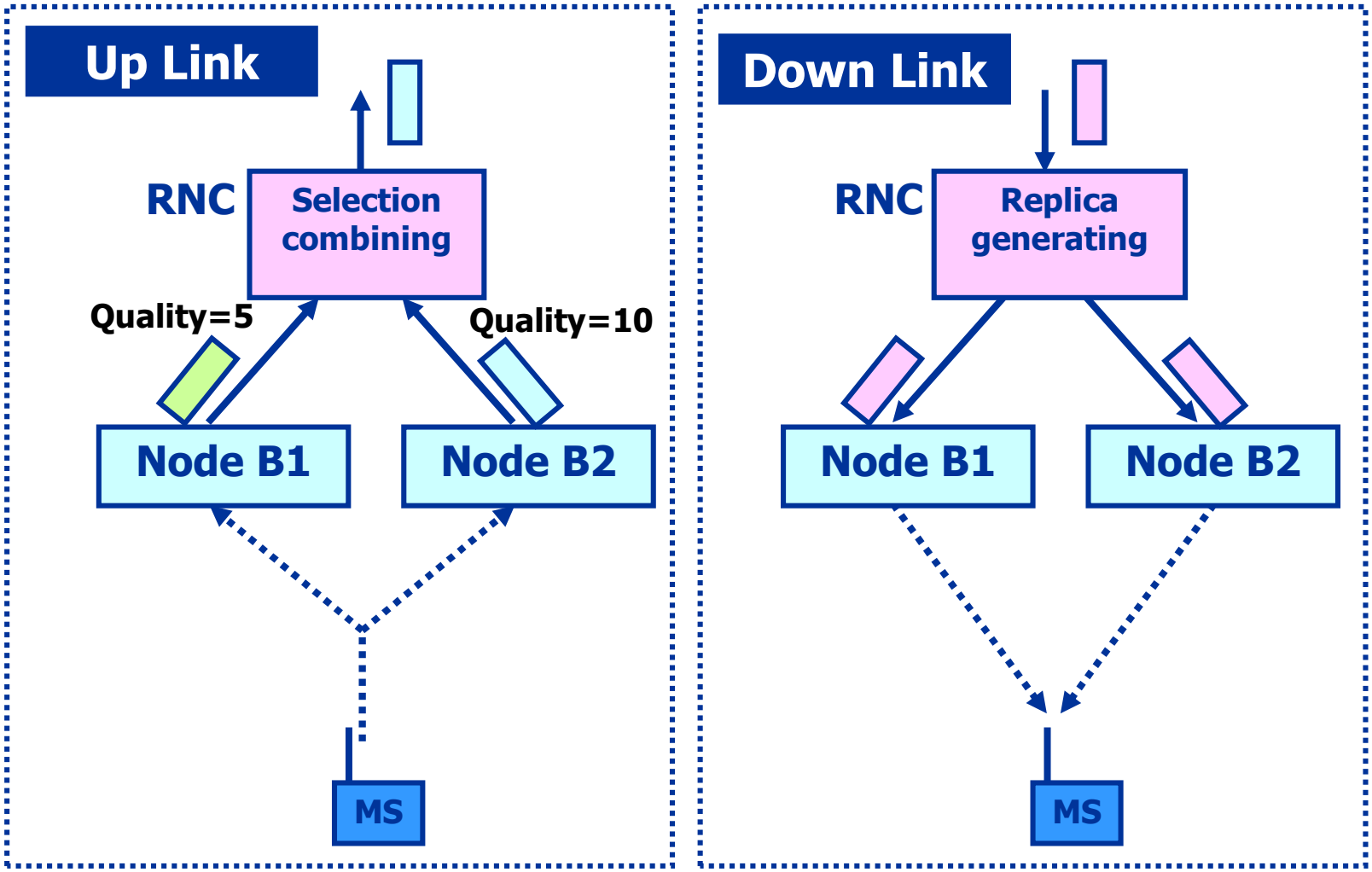


Signal Handover

- **Handover (or handoff) facilitates «make before break» calls**
  - **Soft between different BSs**
  - **Softer between same BS but different sectors**
  - **Hard between differenet frequencies**
- **It comprises an essential attribute that leads to other-user interference reduction (due to macro diversity)**
- **At the expense of system resources**



Macro Diversity



Handover Statistics

From field trials

Handoff Type	Mean, percent	Standard Deviation, percent
Softer	62.80	19.14
Two-way soft	6.52	19.05
Soft-softer	4.42	7.90
Three-way soft	0.40	0.82
Three-way softer	0.20	0.42
No handoff	25.66	10.80

$$Avg\ Channels_{user} = 1 + (2-1) * (6{,}52\% + 4{,}42\%) + (3-1) * 0{,}4\% = 1{,}12$$

12% handoff resource overhead

Channel Element "Pooling"

Example

	Speech 8 Kbps	Data 144 Kbps
Erlang/sector	30 Erl	8 Erl
Soft handover overhead	30%	30%
Total traffic (3 sectors)	117 Erl	31.2 Erl
Number of channel elements/sector from Erlang B table, pooling taken into account	44	14
Channel elements for pilot and common control channels	2	2
Total number of channel elements	46	16

- **Required CE / sector (without HO):**
  - **90 Erl (@ 2% blck) ➔ 102,9 CE ➔ 34,3 CE / sector**
- **Required CE / sector (with HO):**
  - **117 Erl (@ 2% blck) ➔ 130 CE ➔ 43,3 CE / sect**

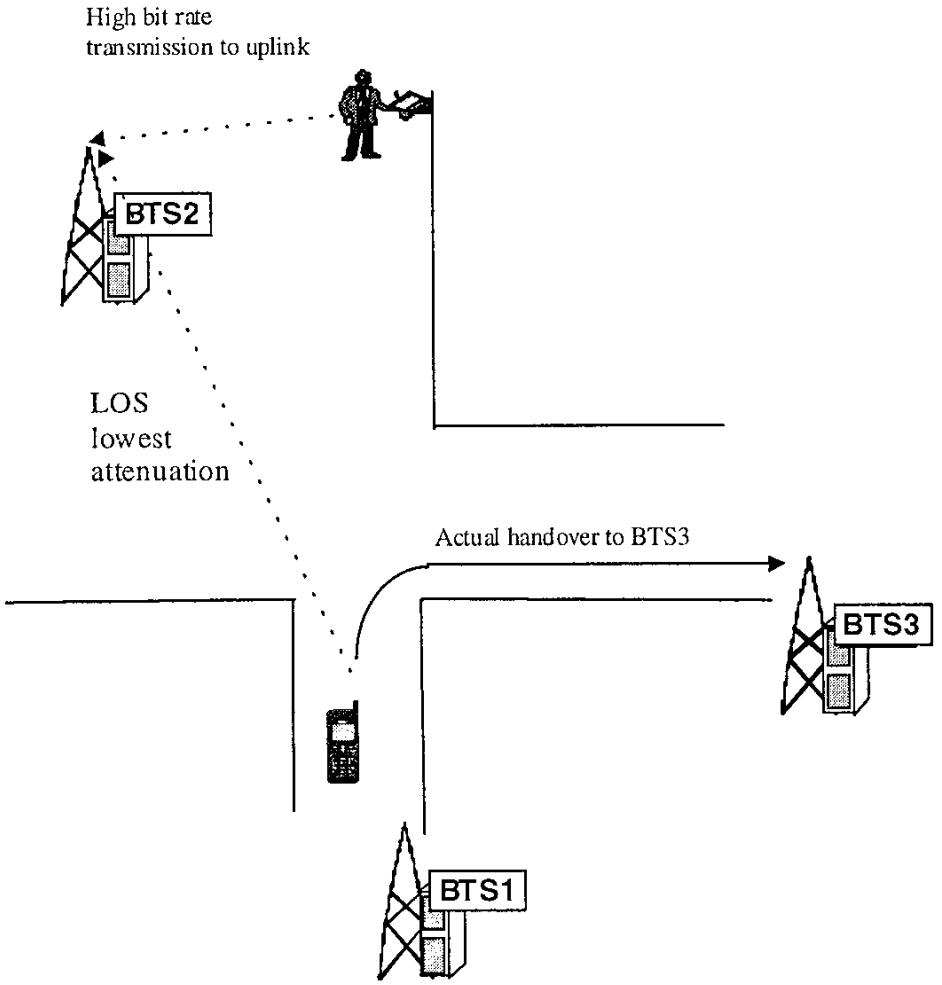
26,2% CE overhead due to HO

- **No CE pooling (with HO) :**
  - **39 Erl / sect (@ 2% blck) ➔ 49 CE / sect**

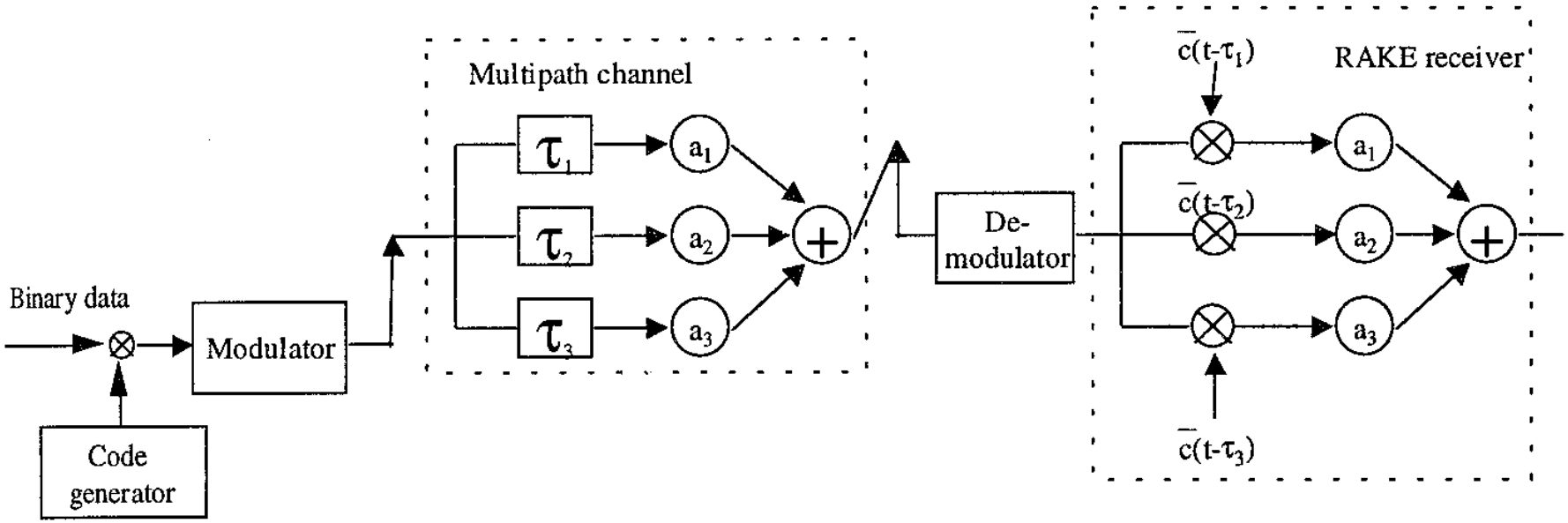
11,6% CE reduction due to Pooling

Primary Server Handover

- **Primary server (BS) is selected with respect to minimum Tx required by MS to close the link**



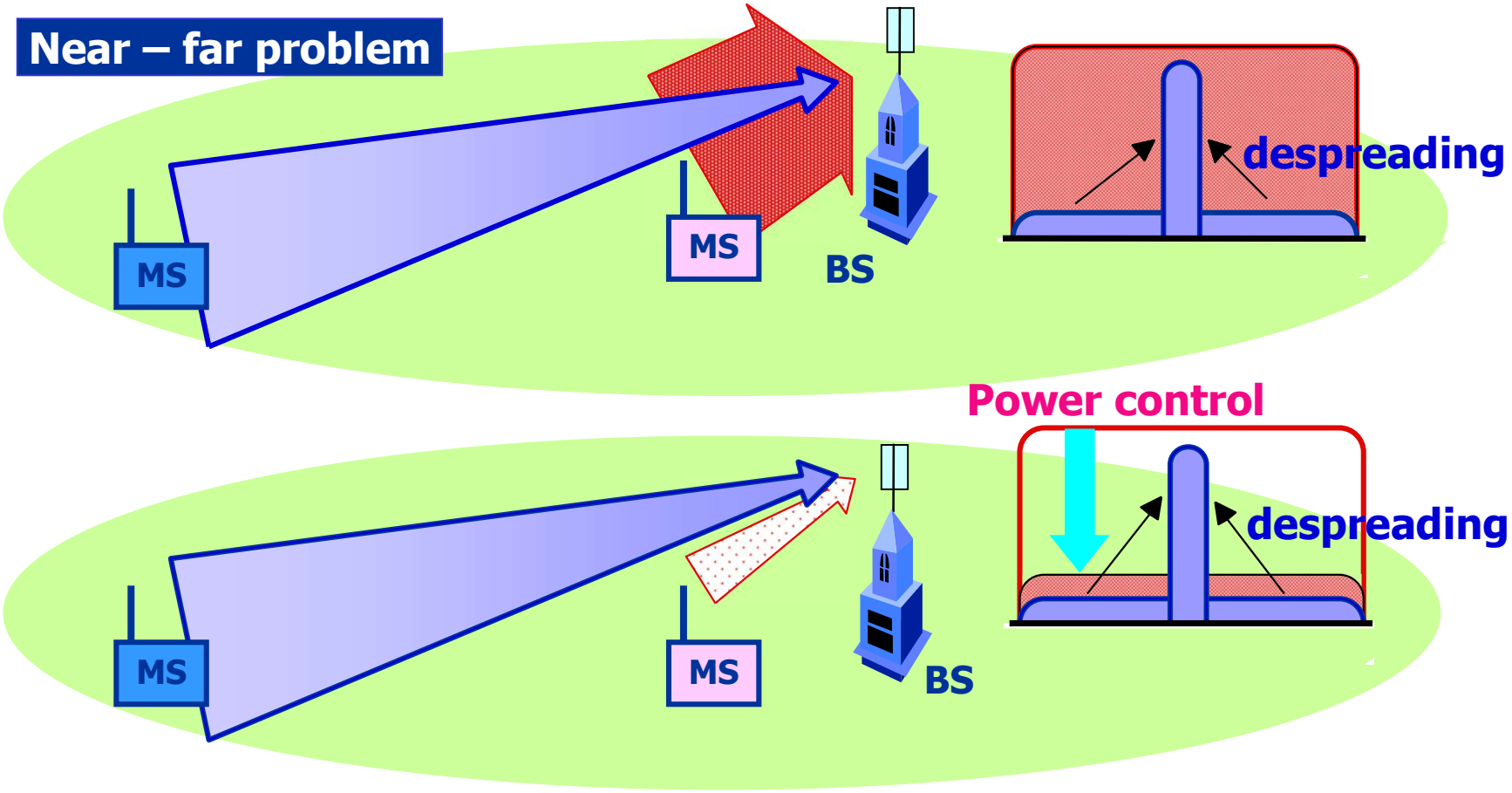
RAKE Receiver turns multipath into diversity



Power Control

- **Power control is applied to both links to reduce *other user interference***
- **At the Up-link**
  - **All signals should arrive at the BS with the same mean power to mitigate the «near-far effect»**
  - **Power control info is transmitted through the Forward (Down-) link**
  - **The MS adjusts its Tx power accordingly**
- **At the Down-link**
  - **The MS (especially those at the cell edge) suffer from other-cell interference**
  - **Quality of signal received (BER/ FER) is transmitted back to the BS to adjust the Tx power accordingly**
- ***The performance of the power control mechanisms dictates system capacity***

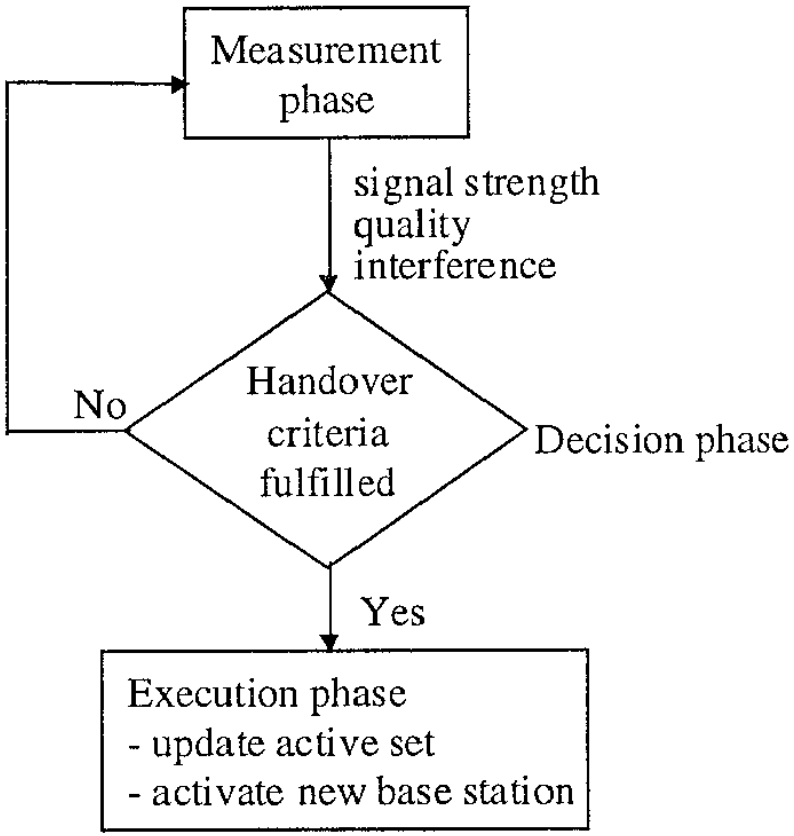
Power Control



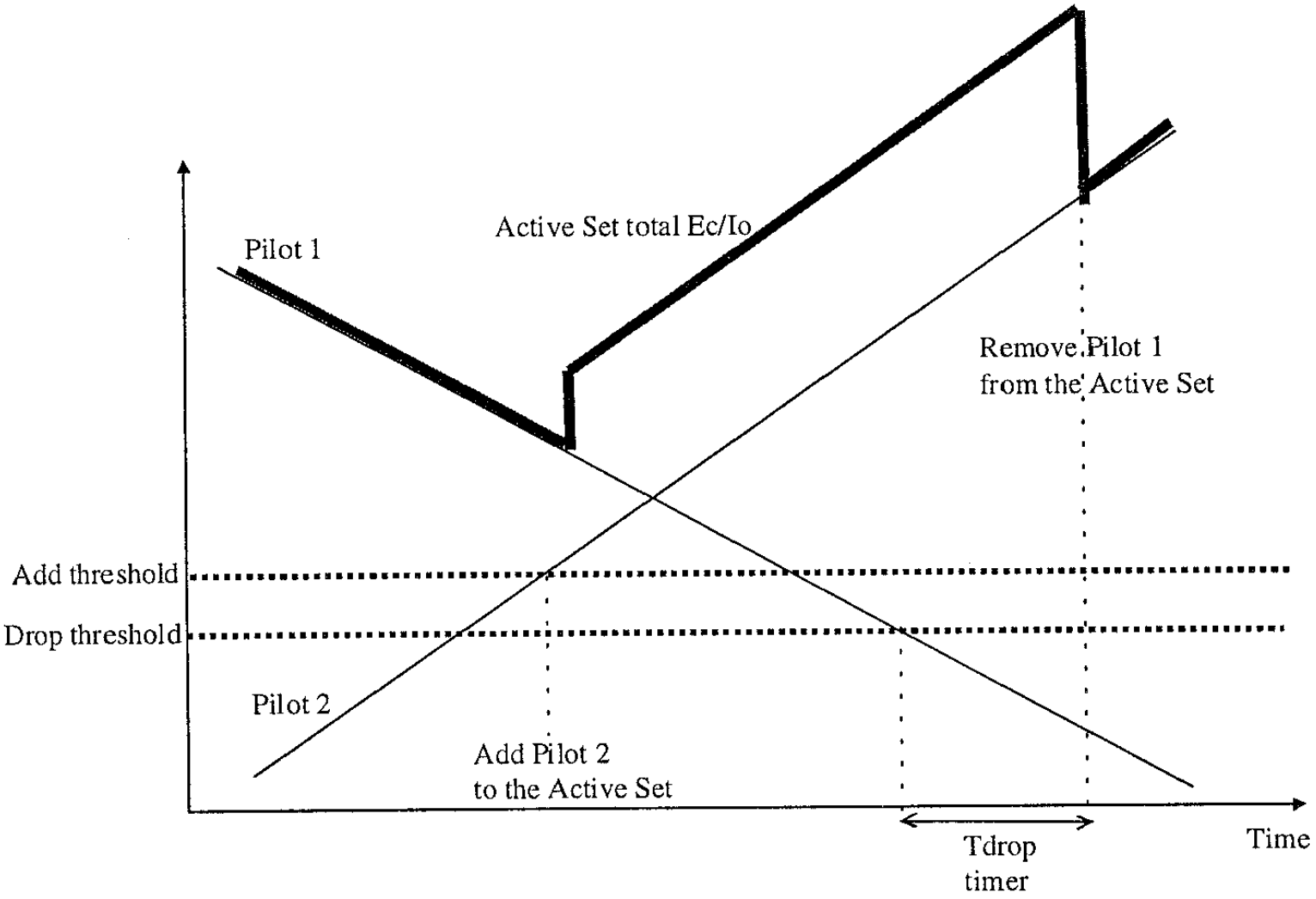
PC **is essential** ⇒ **Minimizes the Tx power** ⇒ **Increases the system capacity**

Handover Procedure

It determines the BSs that serve each mobile



Handover Decision Mechanism



Active Set: The set of BS's in HO mode

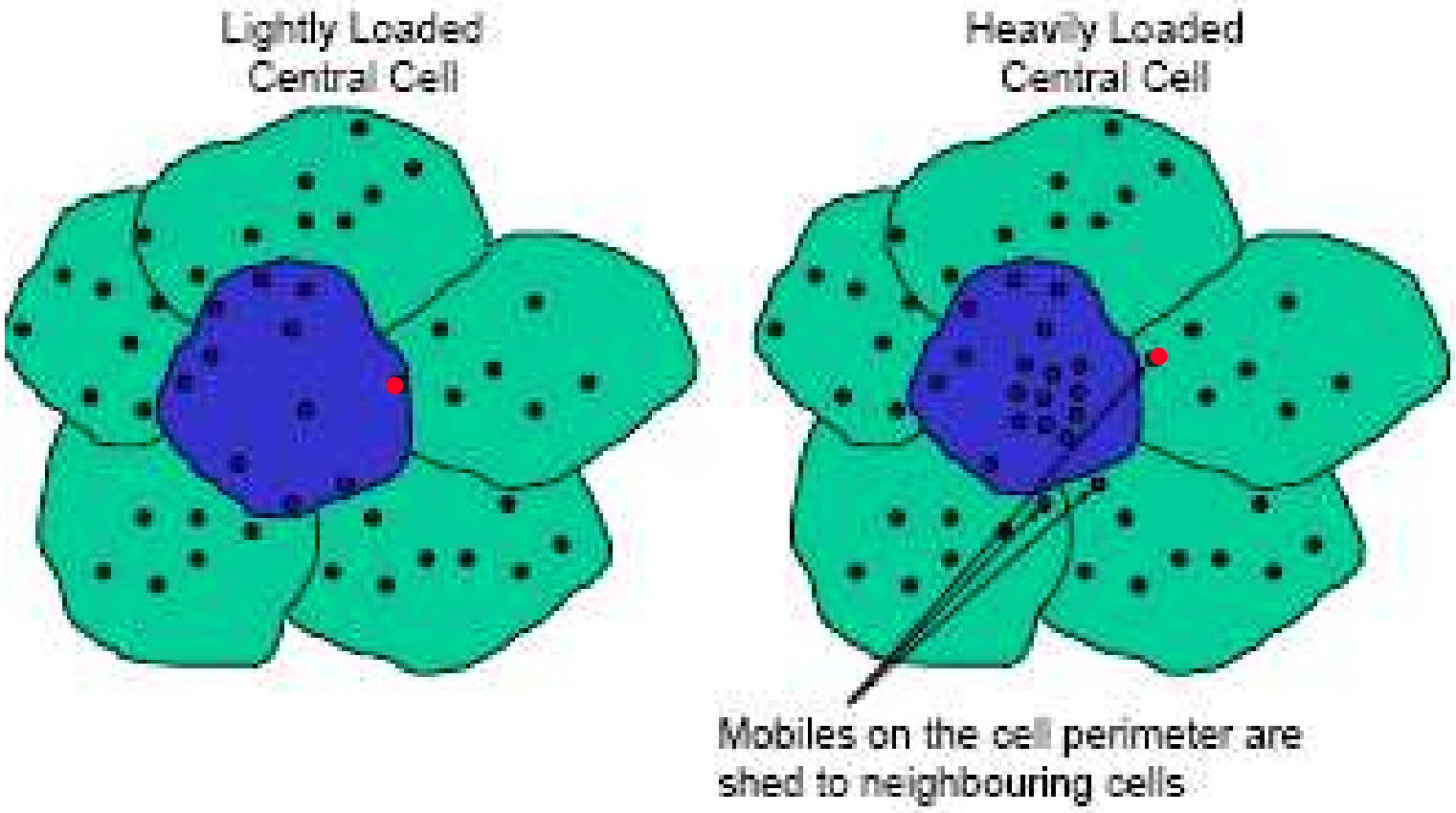
System Coverage

- **Coverage is not just a matter of max path loss between the BS and MS**
  - **It is a <u>different</u> issue at both links**
- **At the Uplink:**
  - **A MS is covered as long as its max Tx power can «close the link»**
  - **A highly loaded system results to a high Other-Cell Interference at the receiving BS ➔ Reduced Coverage**
  - **Increase of the MS Tx power increases the Other-Cell interference**
- **At the Downlink:**
  - **A MS is covered as long as it can clearly detect a BS over the interference**
  - **A highly loaded system results to a high interference at the DL ➔ Reduced Coverage**
  - **Increase of the BS Tx power increases the interference to other users**
- **Systems may be UL- or DL- limited**
- **System coverage is attained when <u>both</u> links are closed, so ...**
  - ***link balancing is very important***

Cell Breathing

- **As the loading within a cell is increased, the BS receiver Noise Floor appears to rise**
- **The MS must transmit at higher power to overcome the increased interference**
- **At some point, the MS Tx power reaches its max limit and the MS cannot reach the BS**
  - ***the cell shrinks***
- **MS at the cell boundary are connected to other neighboring cells**

Cell Breathing



UpLink Capacity

1/Rise above Thermal

$$Freq\ \mathrm{Re}use = \frac{I_{in}}{I_{in} + I_{oc}}$$

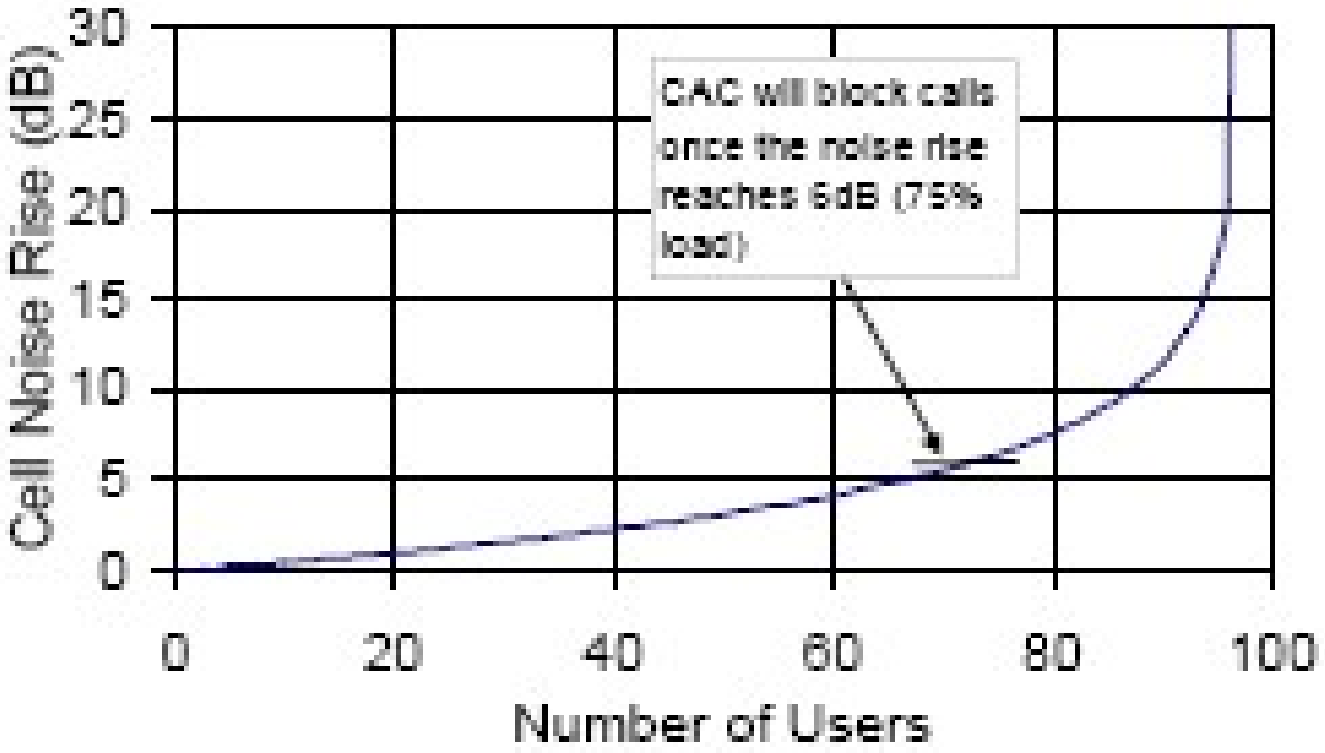
System Loading

$$C = \frac{(1-\eta)\, F_r\, (W / R_b)\, F(P_B, \sigma_p)}{\rho\, (E_b / I_0)}$$

Service Activity Factor

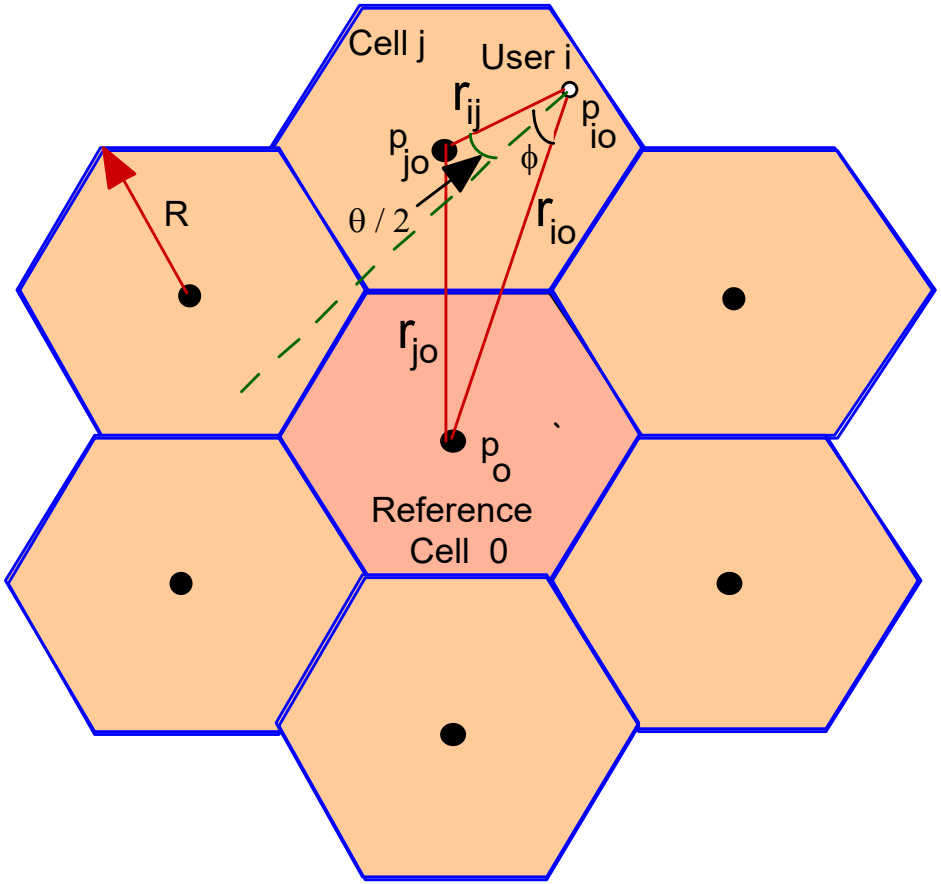
Dependency on Pb and Power Control

System Loading



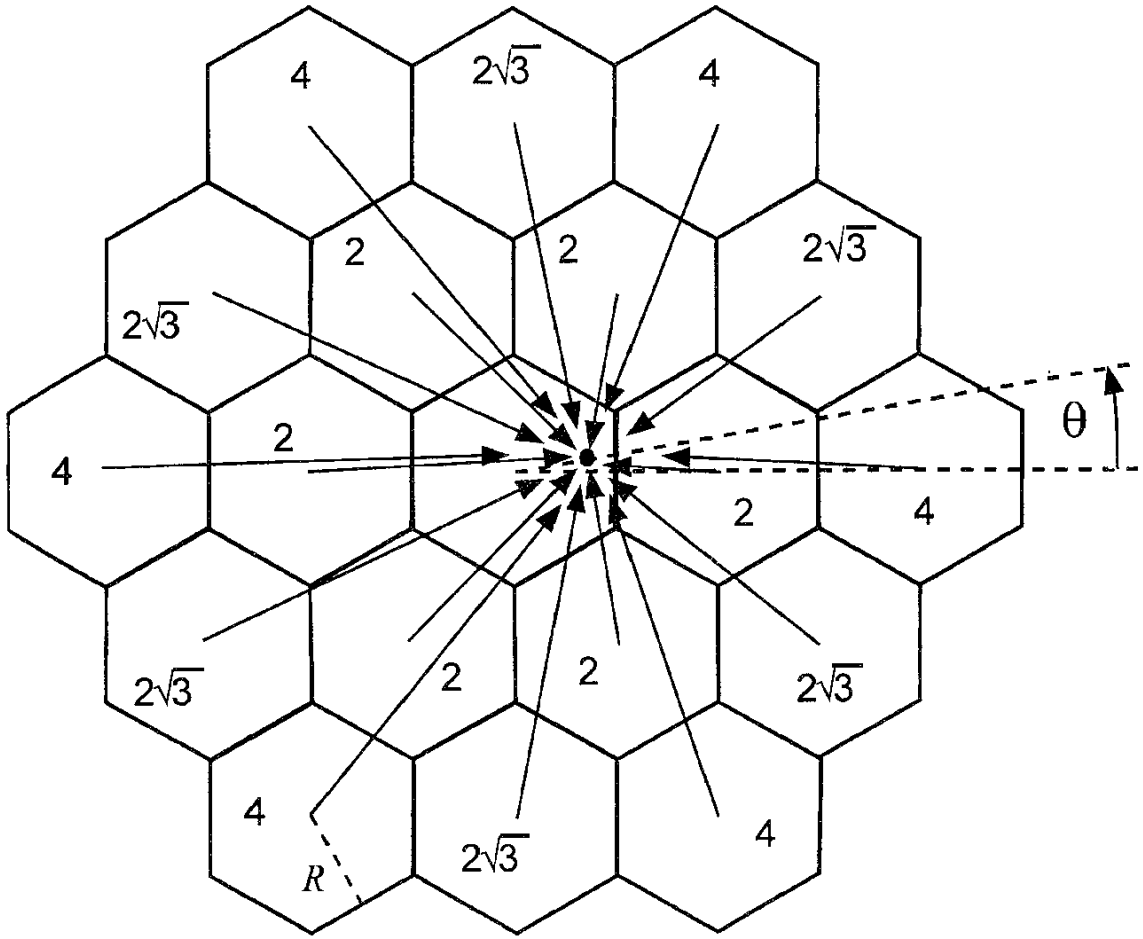
Frequency Reuse

$$F_r = \frac{\sum_{\text{all users } i} I_{i0}}{\sum_{\text{all users } i} I_{i0} + \sum_{\substack{\text{all users } k, \\ k \neq i}} \sum_{\substack{\text{all cells } j, \\ j \neq 0}} I_{kj}}$$

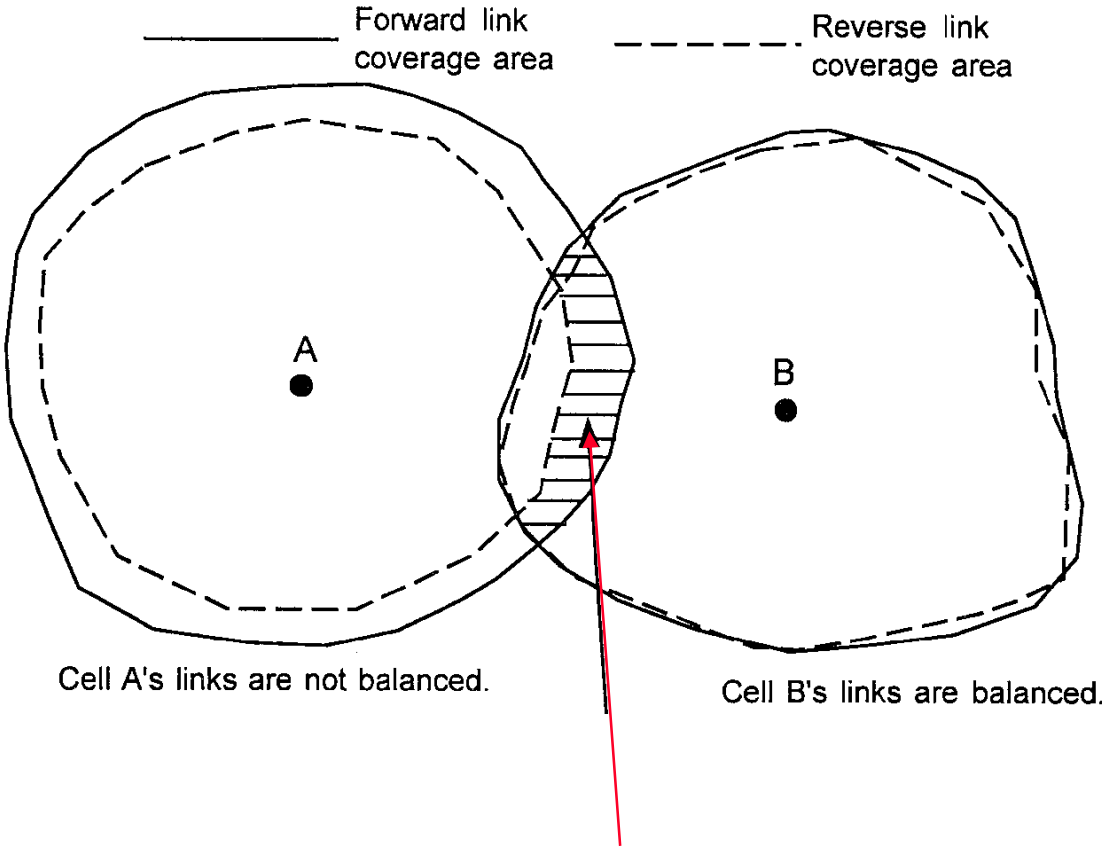


Downlink Performance

- **Capacity is determined stochastically based on**
  - **Outage Probability**
  - **Link requirement**
  - **Maximun Tx power**

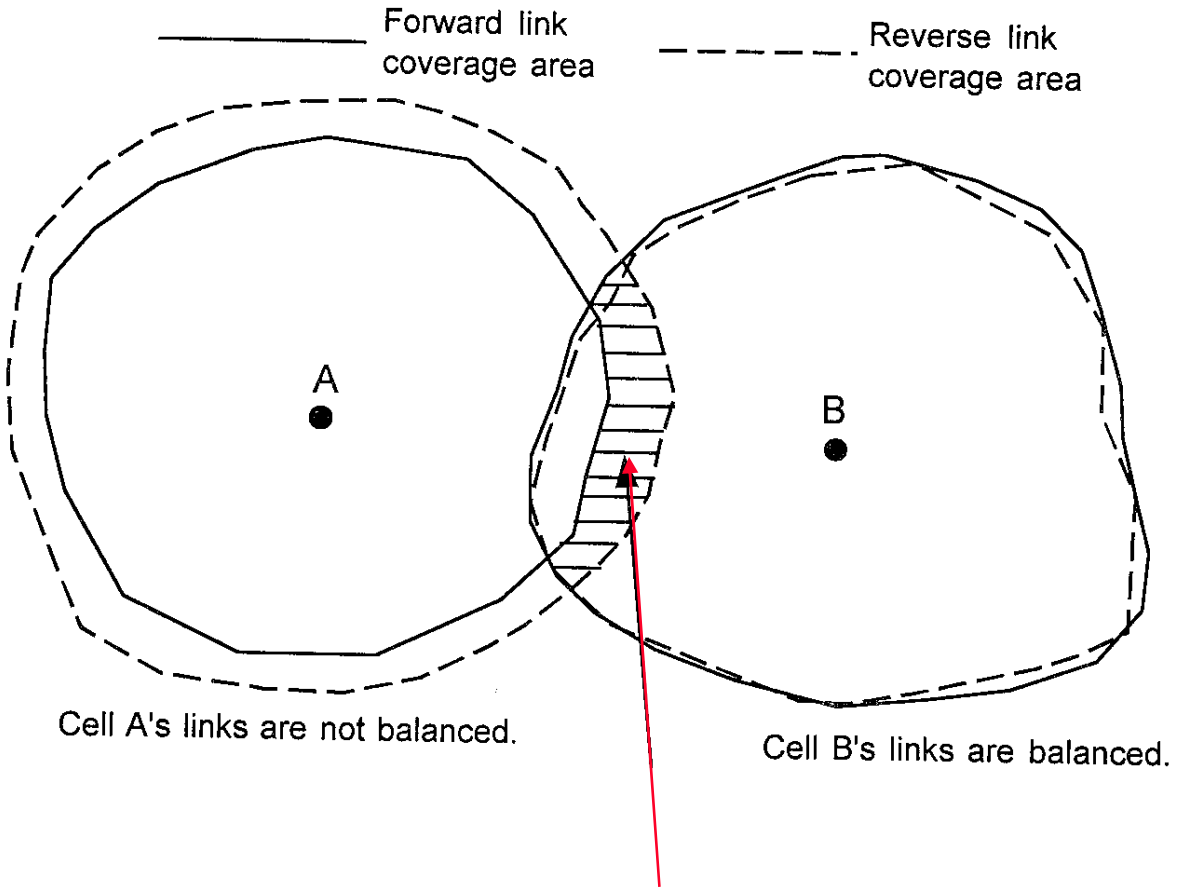


Link Balancing



- **Handovers may occur from B to A but**
- **A´s Uplink cannot support a call**

Link Balancing



- **Handovers do not occur from B to A so**
- **The MS generate interference to cell A**

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