IoT, Course introduction

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3.3 – Radio Interface

Wireless systems

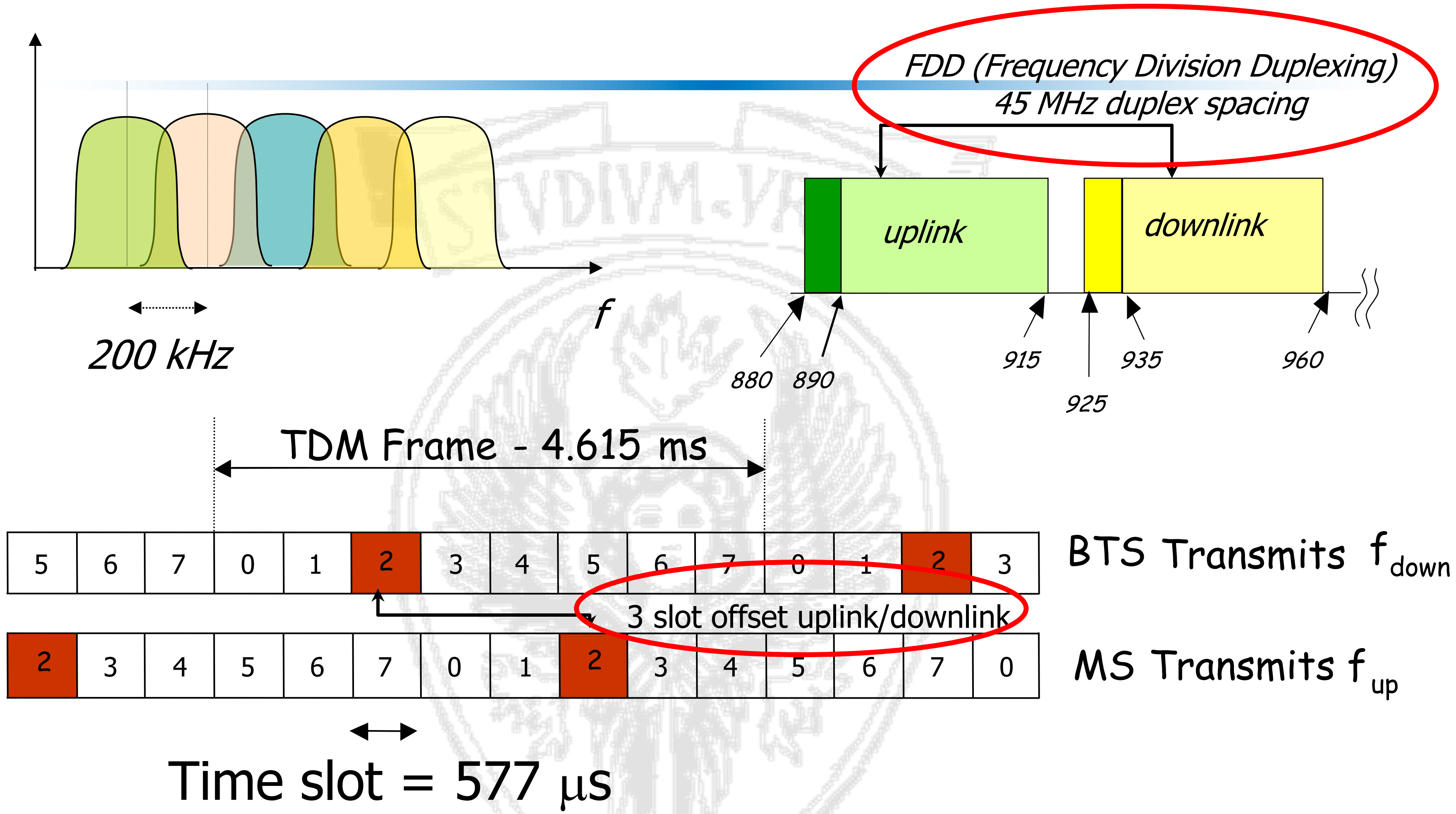
Radio Interface

si veda

- O. Bertazioli, L. Favalli, *GSM-GPRS*, Hoepli Informatica 2002

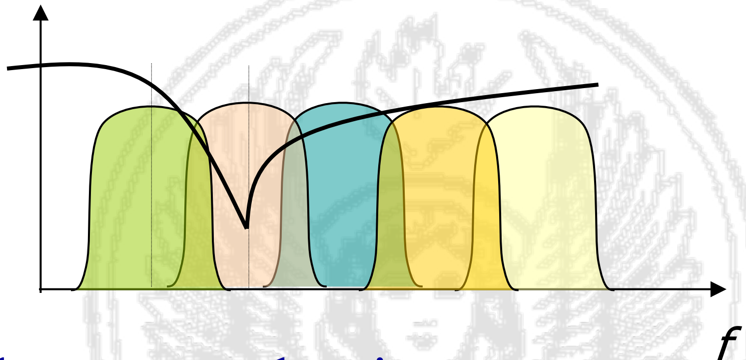
Capitolo 6

Radio Interface



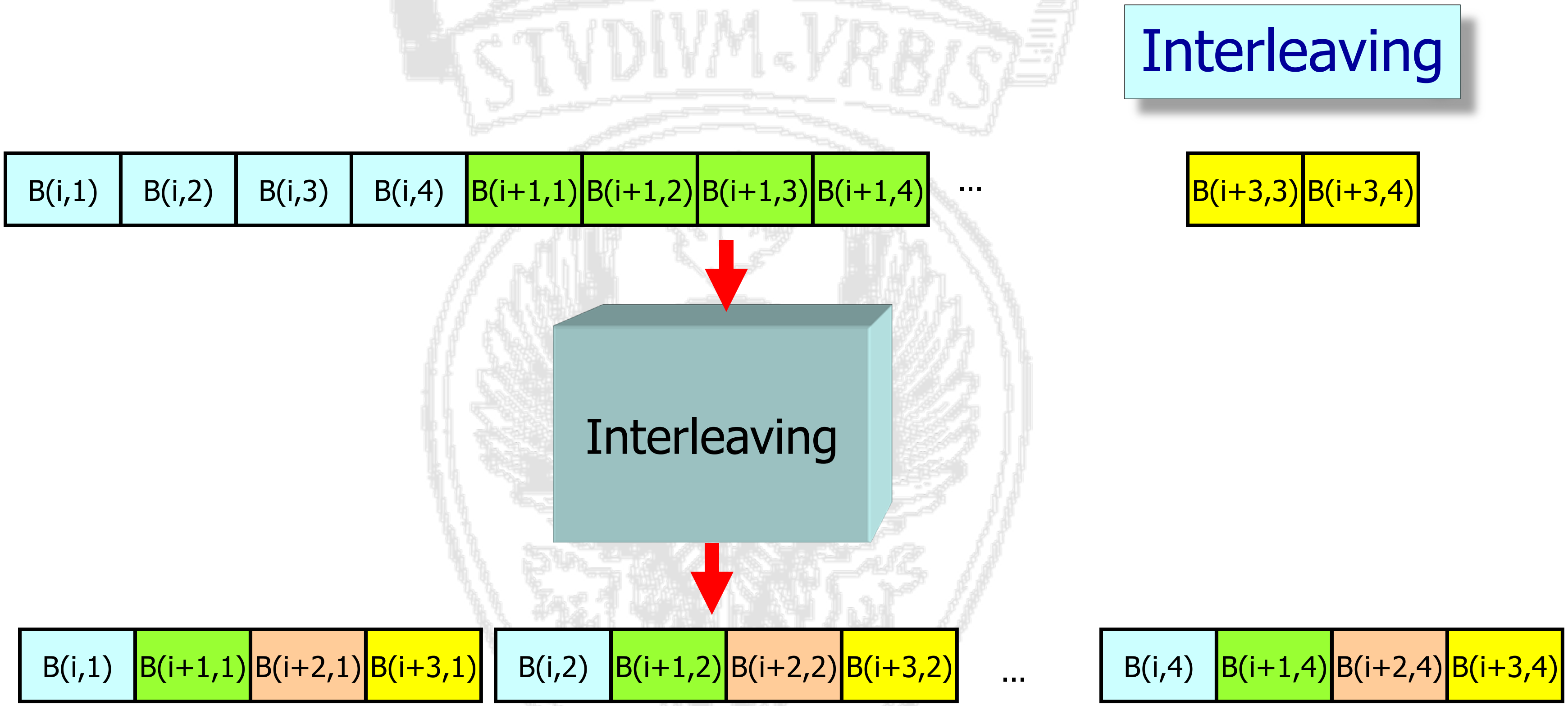
Frequency Hopping

- Multipath fading depends on the carrier used for transmission
- At a given time, when transmitting to a user some carriers may suffer high attenuation while others low attenuation



- Since FEC codes are used to increase transmission robustness, it is better if the errors due to the high attenuation suffered by a carrier are spread over multiple information flows (similarly to what we have seen when we discussed interleaving techniques)
- Frequency hopping changes the carrier used for transmission on a per slot basis, according to a predefined pseudorandom sequence

Interleaving



Power Control

- The output power of the MS is controlled by the BTS
- The BTS sends power control commands that require the MS to raise or lower the transmit power
- The step increment / decrement is 2 dB
- The objective of the control is to bring the power received from the BTS to a predetermined level (just above what needed for reception)
- The power control reduces the interference in the system by reducing the average power of the MS with little attenuation of the channel (close to BTS)
- The power control also reduces the energy consumption of the MS

GSM Synchronization

- Carrier frequency synchronization
  - Each MS must retrieve precisely the frequency of the radio carrier
- Slot synchronization
  - Each MS must have information on the current slot
- Frame synchronization
  - Each MS must know the current Frame Number
- Base station synchronization (optional)
  - The base stations have synchronous clocks
  - The base stations have the same Frame Number

Carrier frequency synchronization

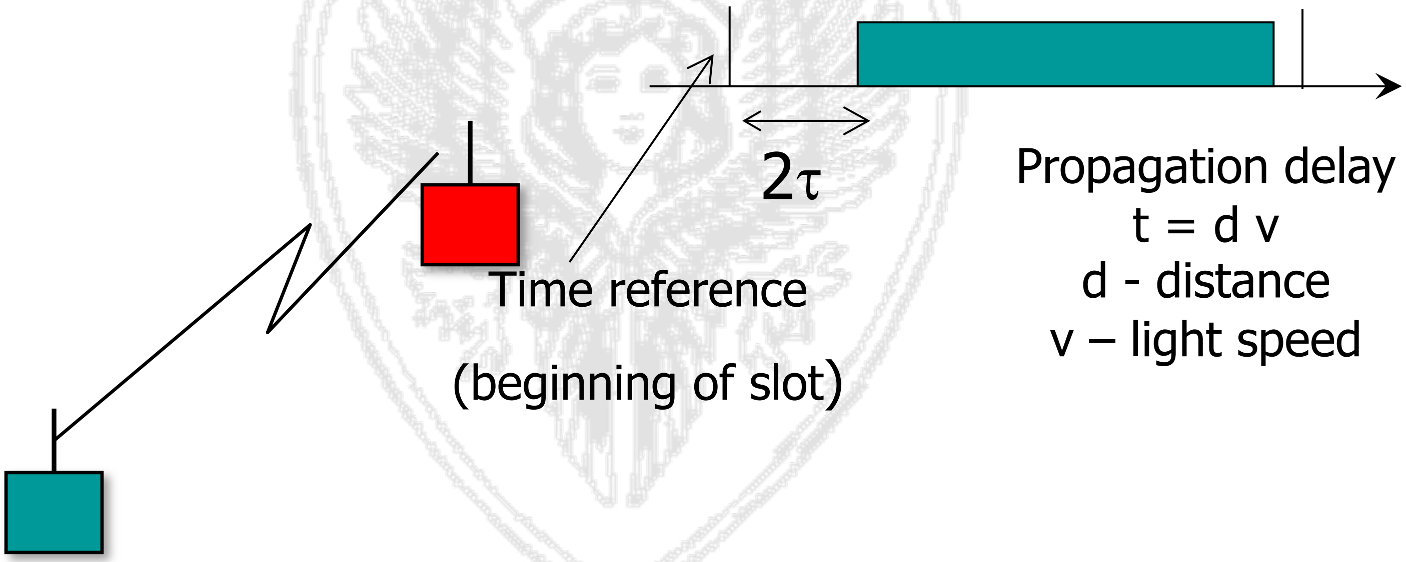
- The frequency of the radio carrier is obtained by the MS listening to the broadcast common control channel transmitted by the BTS
- On this channel, at regular intervals, a special fixed sequence of bits is transmitted at high power that is used to select the carrier frequency, and then adjust the frequency of the local oscillator

Slot and frame synchronization

- Many channels in GSM follow a multiframe structure (for example, the broadcast channel is broadcast every x frames)
- The sequence of frequency hopping depends on the multiframe structure
- Each MS must therefore know the number of the current frame to correctly interpret the information
- The BTS transmits on the broadcast channel the information needed for the MS to be able to reconstruct the current time slot and Frame Number

Slot synchronization

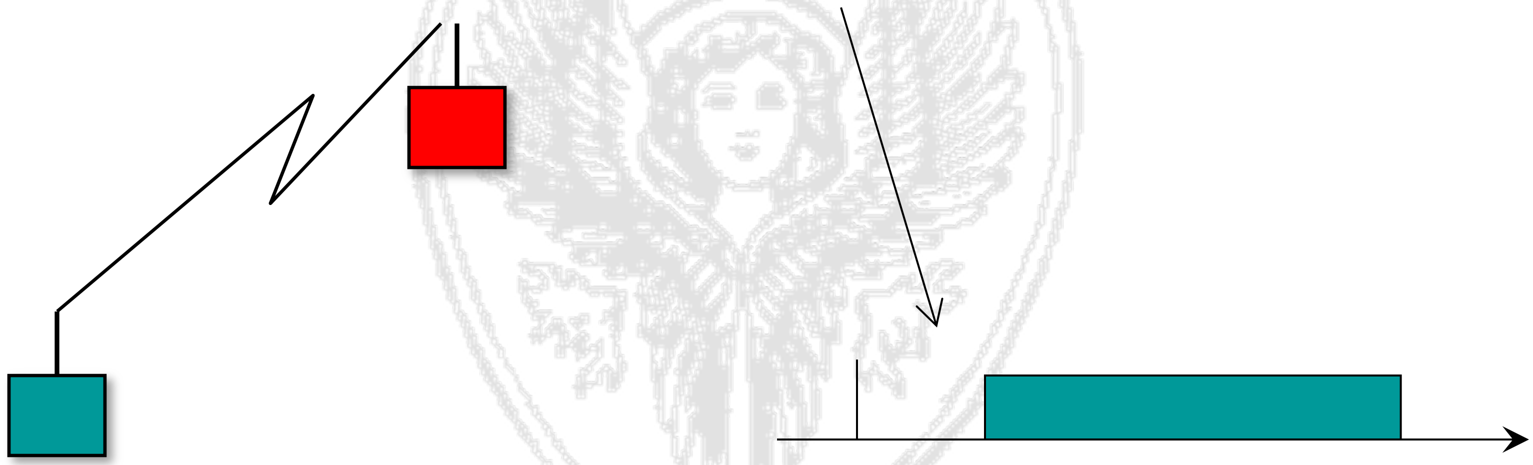
- Up/down link transmissions go through propagation delays which depend on the relative distance between the BTS and the MS
- Each slot needs to have a guard period to compensate for synchronization errors



Slot synchronization

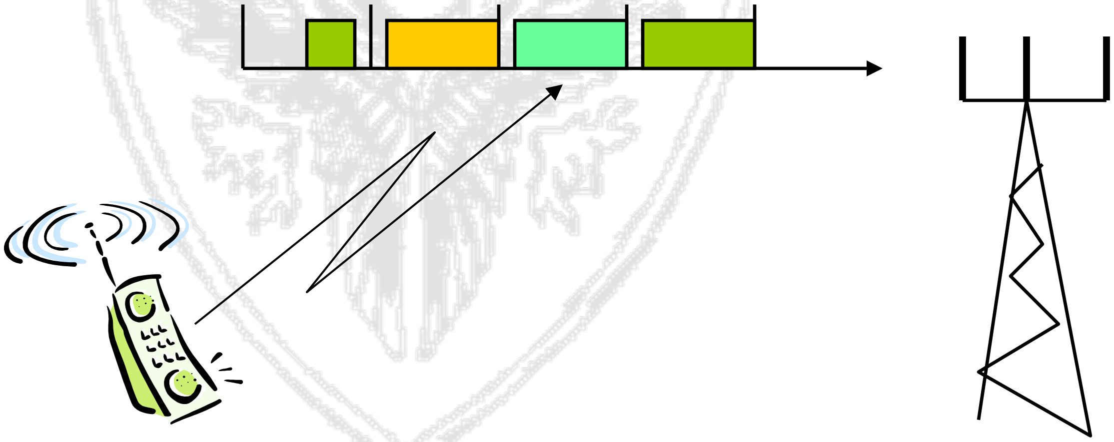
- We could make a conservative selection, setting the guard time to

$$T_g = \max_i (2\tau_i)$$



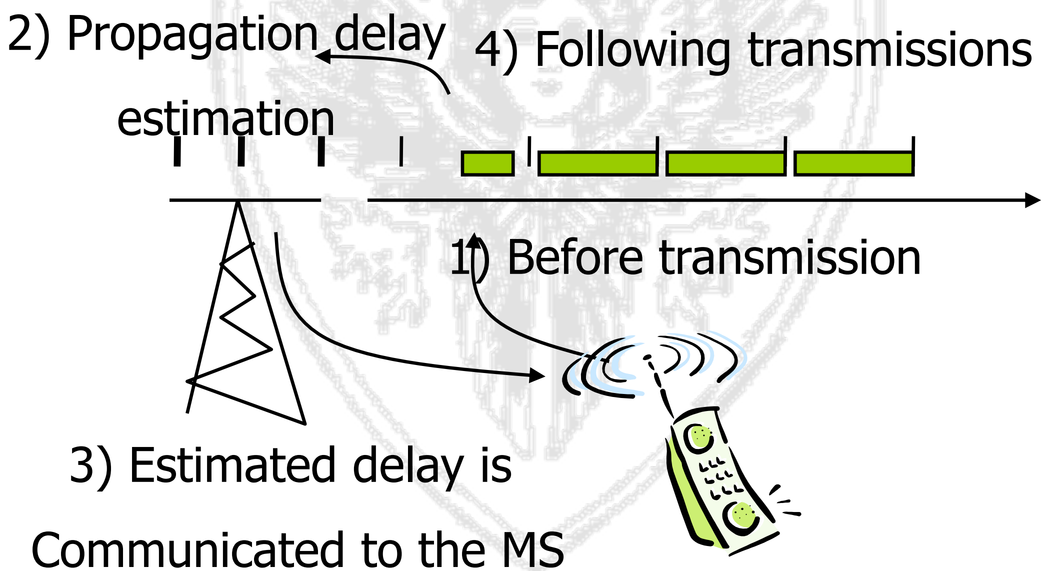
Slot synchronization

- The GSM network is designed to have cells with $R_{max} = 35$ Km
- In the worst situation (at the borders of the cell) there is a guard time of $2\tau = 2 \times 35 / 3 \times 10^8 = 233$ µs
- which corresponds to 68.25 bits at the rate of 270.8 kb / s



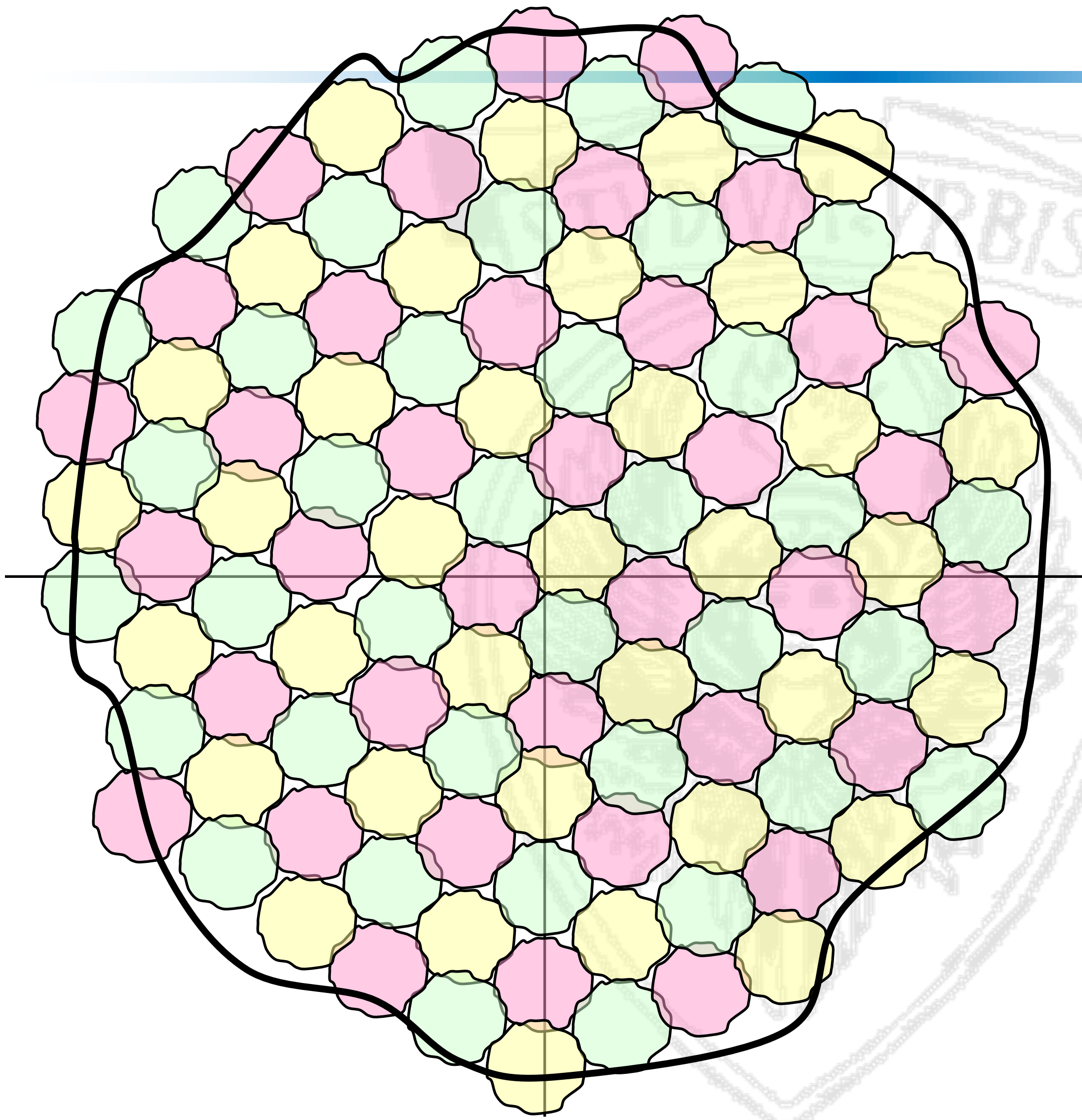
Slot synchronization: Timing Advance

- To limit guard time:
- the BTS estimates the delay and sends the information to the MS which can then compensate by anticipating the transmission
- used in GSM : transmission is anticipated as the MS moves away from the BTS (timing advance, reduces the guard time to about 9 bits, equal to 33,3 msec)



Mobility management

Cellular coverage (microcells)



many BS

Very low power!!

Unlimited capacity!!

Usage of same spectrum

(12 frequencies)

(4 freq/cell)

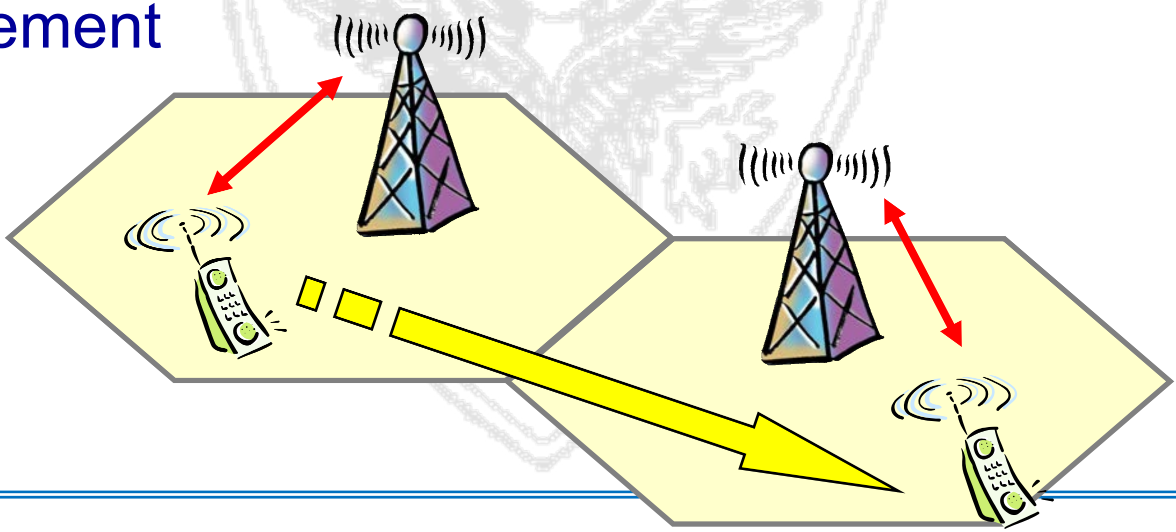
Disadvantage:

mobility management

additional infrastructure costs

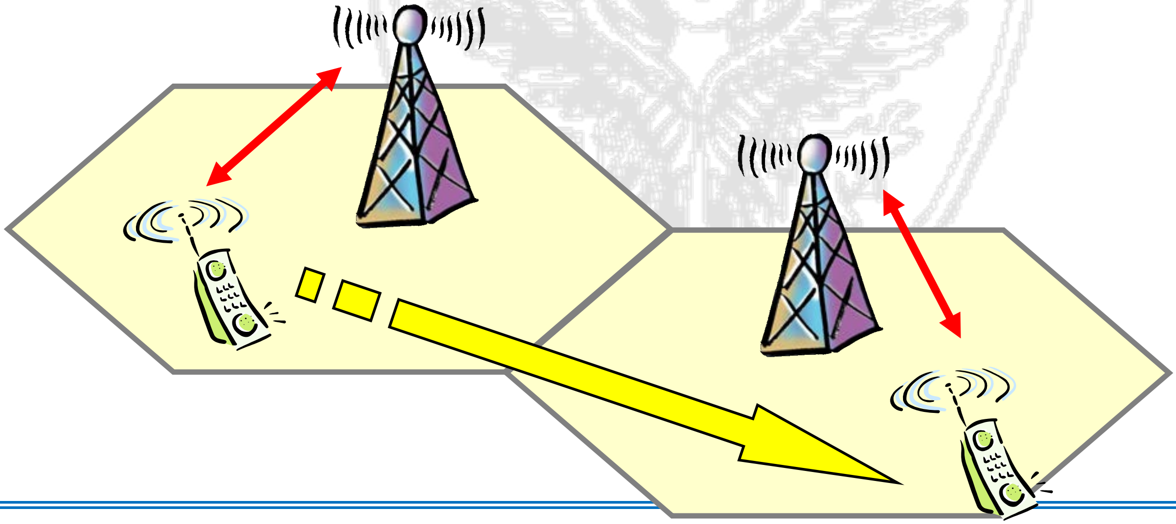
Mobility management

- cellular networks, users can move around in the system and then move from one cell to another
- This obviously poses problems of routing information (or more simply of the calls in the case of voice service)
- All procedures that the network puts in place to enable mobile users to be reached by a communication and maintain active communication even in the presence of a change of the cell go under the name of mobility management



Mobility management

- Users of cellular systems WHILE MOVING can:
  - call out
  - be called
  - converse
- And there should be some "intelligence" that supports this.



Mobility management

- In the case of circuit service mobility management procedures differ depending on whether the user is moving in the IDLE state (no active circuit) or ACTIVE (in conversation)

- ACTIVE: there is an active circuit that needs to be re-routed after every change of the cell (handover)

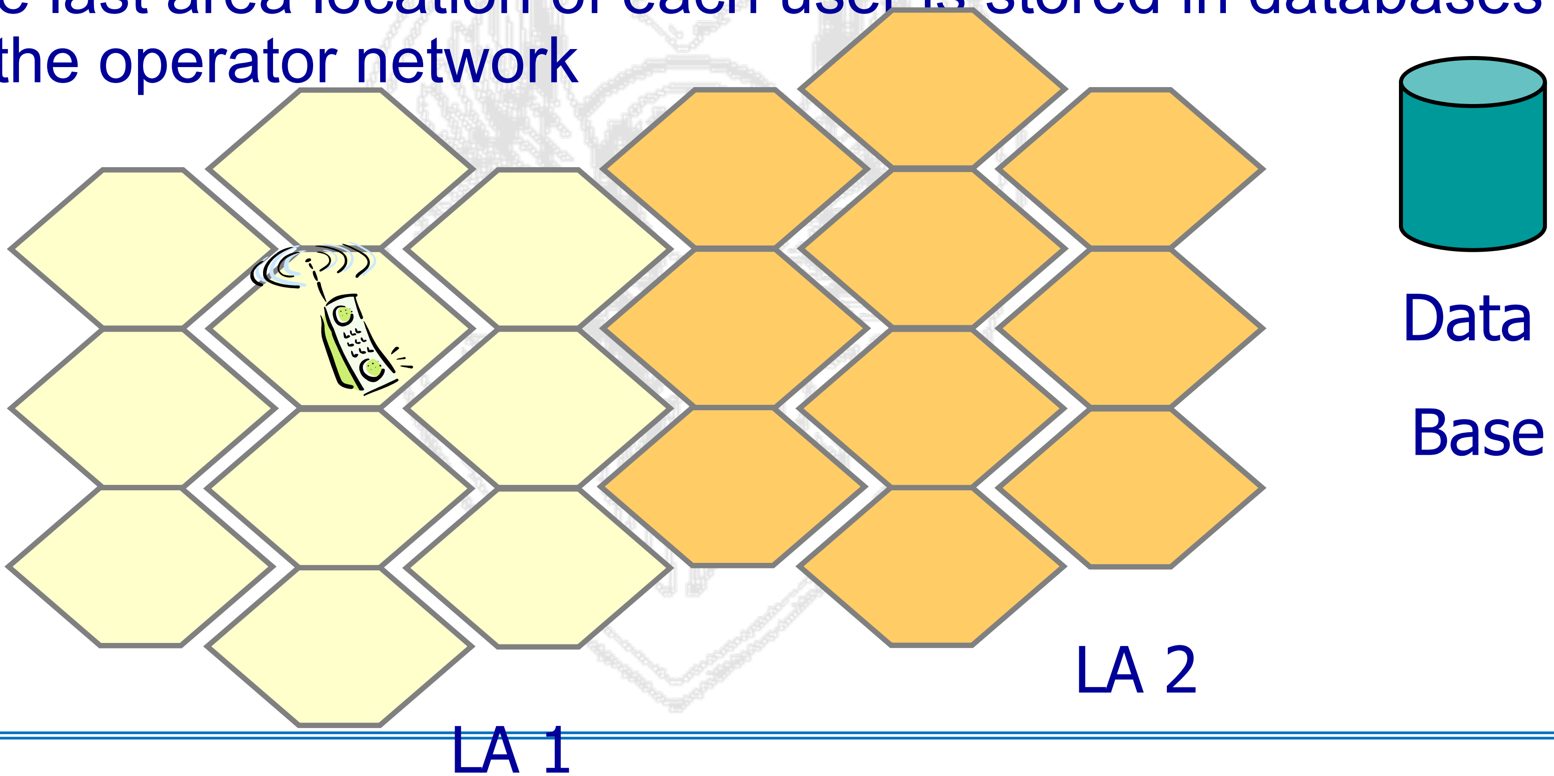
- IDLE: the user must be able to be located to be able to establish a call to/from him/her (*Location Update, Cell Selection, Cell Reselection*)

Cell selection

- A mobile terminal in idle mode "locks" to a cell on the basis of the signal received from the base station
- On a suitable common control channel the radio base station transmits the information of the system that, among other things, specifies its identifier
- The mobile terminal scans the radio frequencies to decode the control channel of the base stations in the area
- The terminal selects the base station from which it receives the strongest signal
- Periodically we continue to take steps (if the MS is in IDLE) on the signal received from the base station adjacent; if you get better from a different base station you make a cell reselection

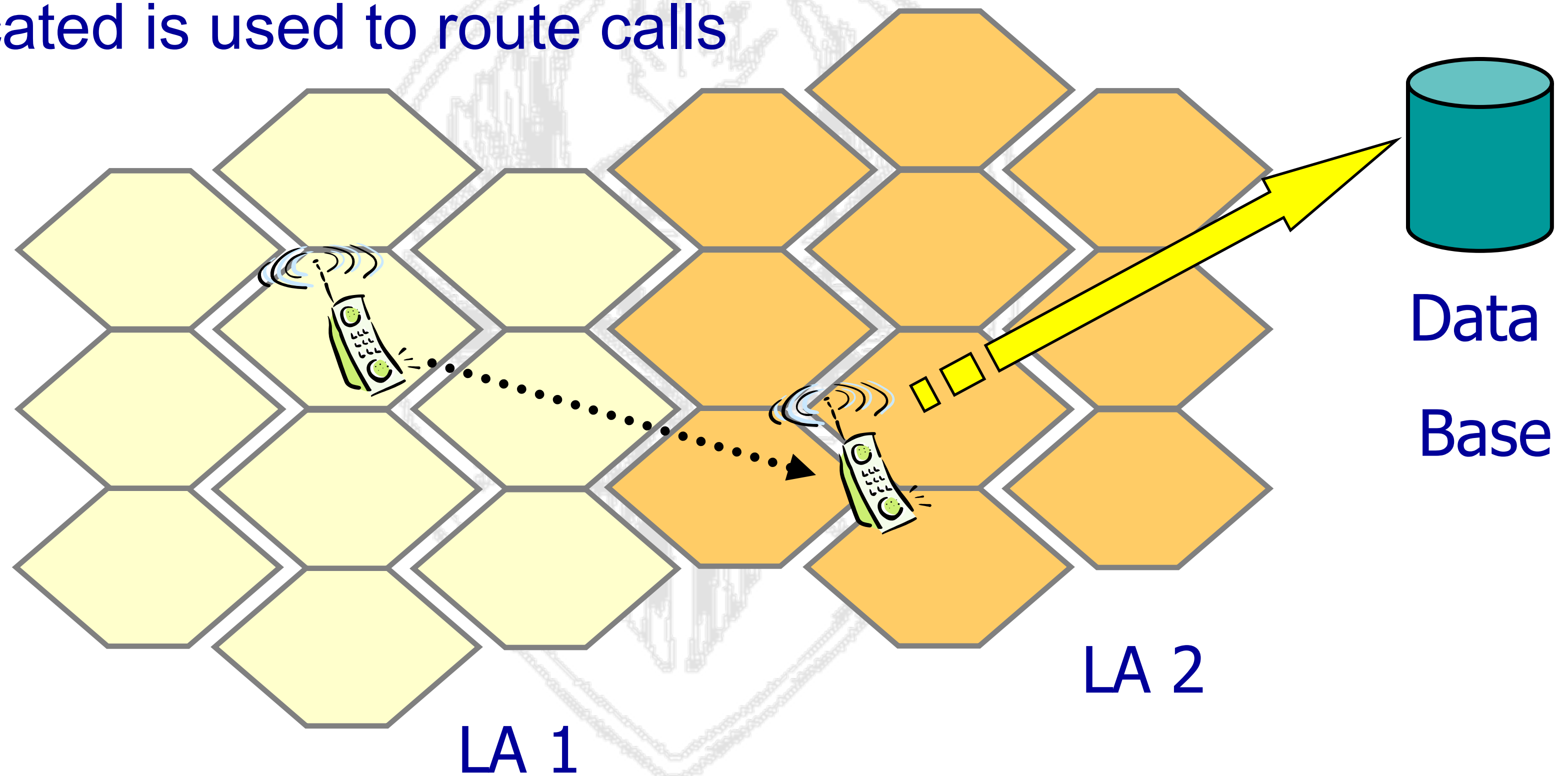
Location Update

- Location Area: topological entity that is hierarchically superior to the cell (group of several cells)
- An IDLE user is tracked by the system based on Location Area (and not on the basis of its cell)
- The last area location of each user is stored in databases of the operator network



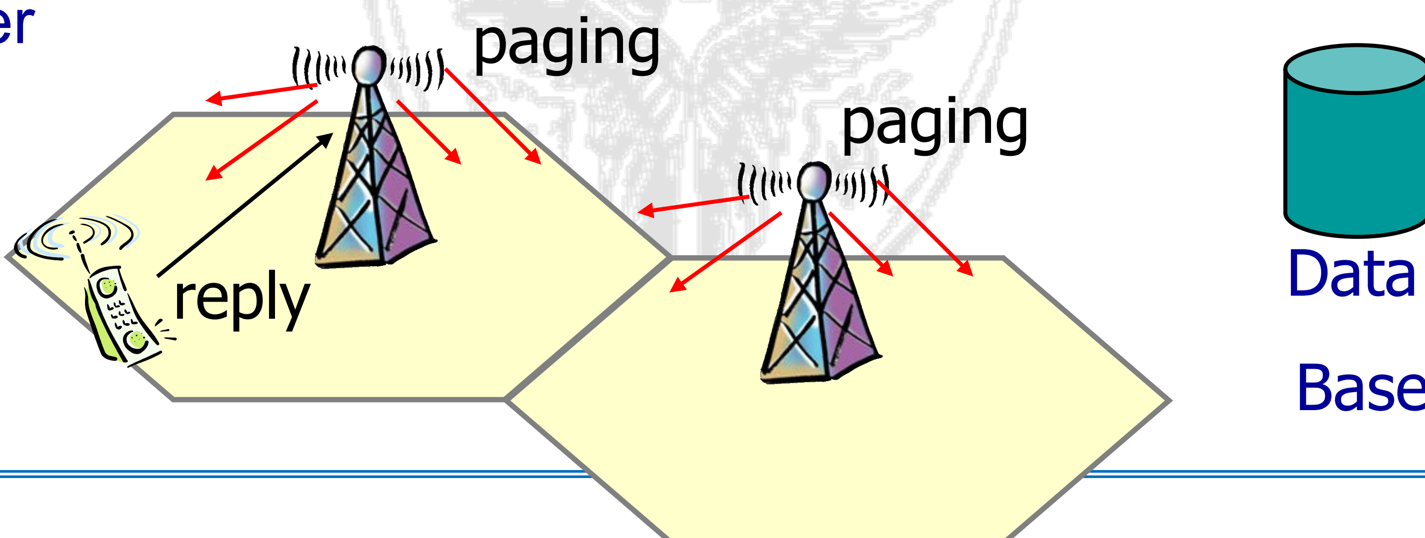
Location Update

- If a user in the IDLE state moves from one LA to another, it triggers a Location Update procedure
- The information about the LA in which a user is located is used to route calls



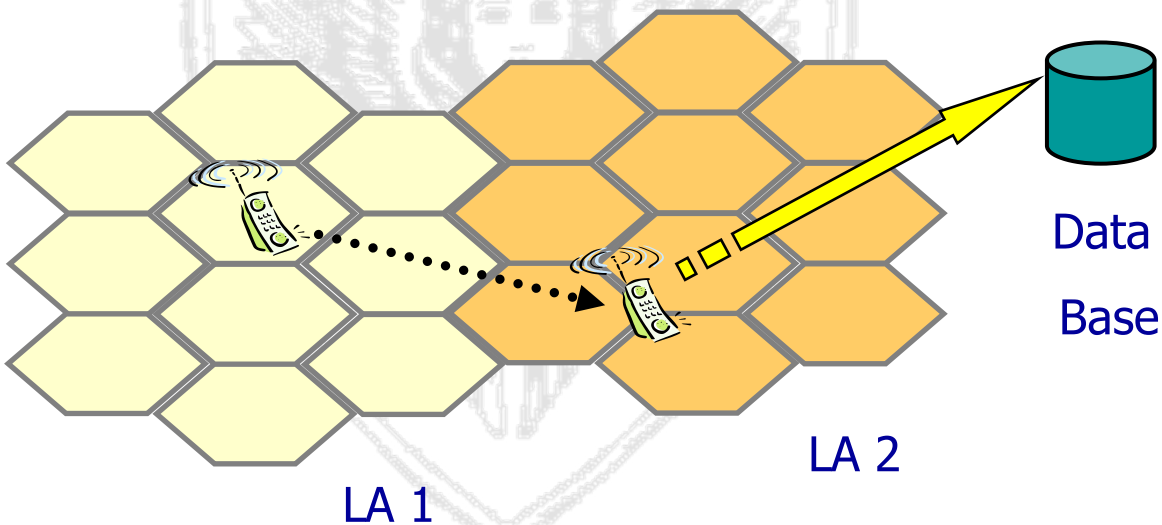
Paging

- When a call arrives for the mobile user the operatore is queried for the current user LA
- Once we know the location area where the user is located, the network initiates a paging procedure
- Each base station in the LA sends a control message broadcast with the ID of the user ID
- When the mobile terminal answers the network knows the cell and routes the call through the cell BTS till the mobile user



Paging vs. Location Update

- QUESTION:
- How big should the Location Area be?
  - small
  - large
- What drives in one direction, what in the other?

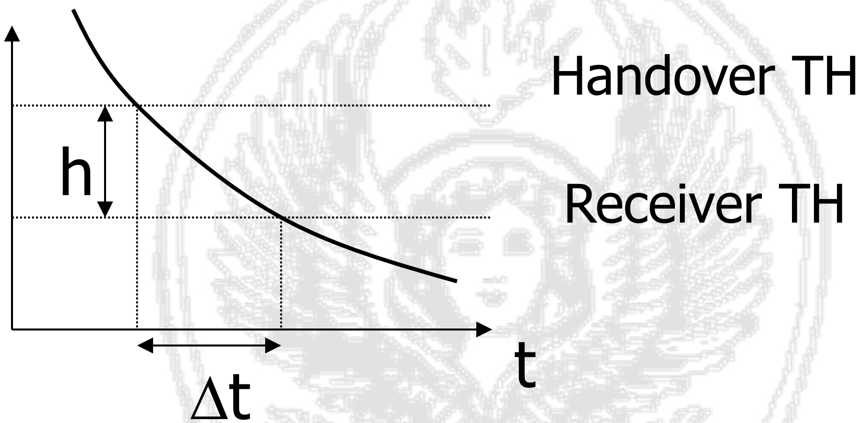


Handover

- Procedure by which a mobile terminal in conversation changes the base station it is affiliated to
- In network-controlled handoff and mobile assisted handoff (NCHO and MAHO) the procedure is always initiated by the network, on the basis of measurements (received signal strength, quality, etc.) carried out by both the network and the user side
- Handover procedures must be efficient and fast
- We will see in the case of GSM how handover procedures are managed from the point of view of network signaling and of the routing of the circuit

When to trigger an handover?

- The choice of the thresholds of activation of the handover procedure is a critical factor



- If h is too small It is too small and you risk loosing the connection
- If h is large the number of requests for handover increases, so also the signaling traffic in the network

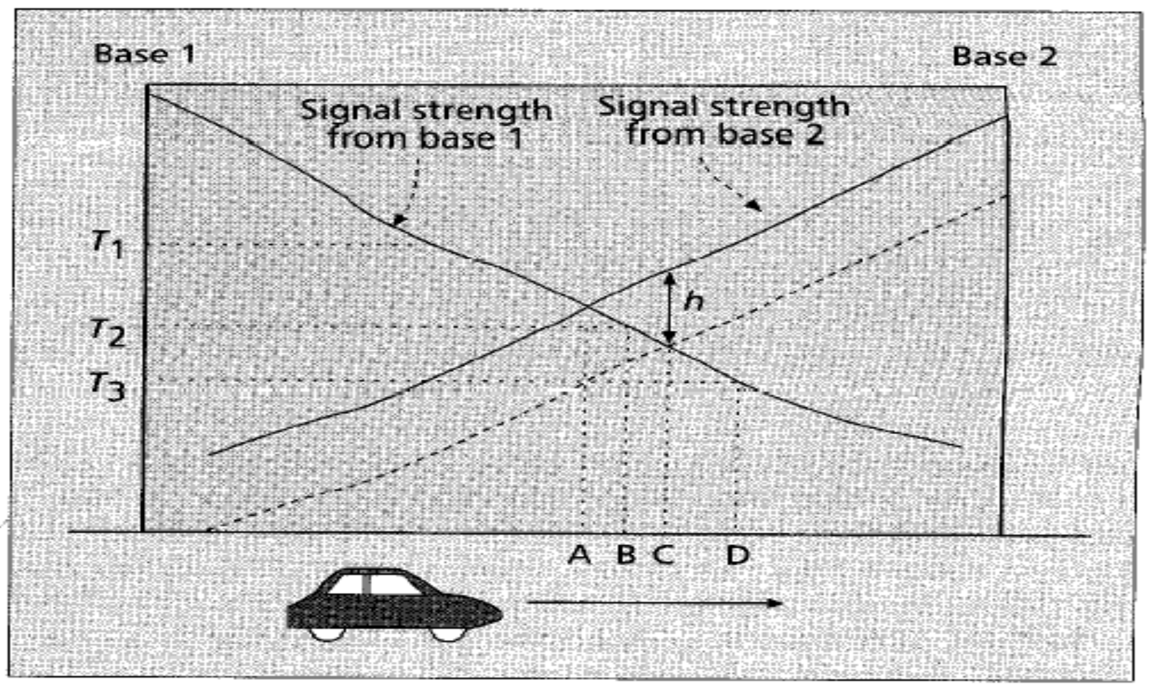
When to trigger an handover?

- There are several methods

1 - method of the strongest signal

– the handover occurs at point A

due to the fluctuations of the signal many cell changes are possible (ping-pong effect)



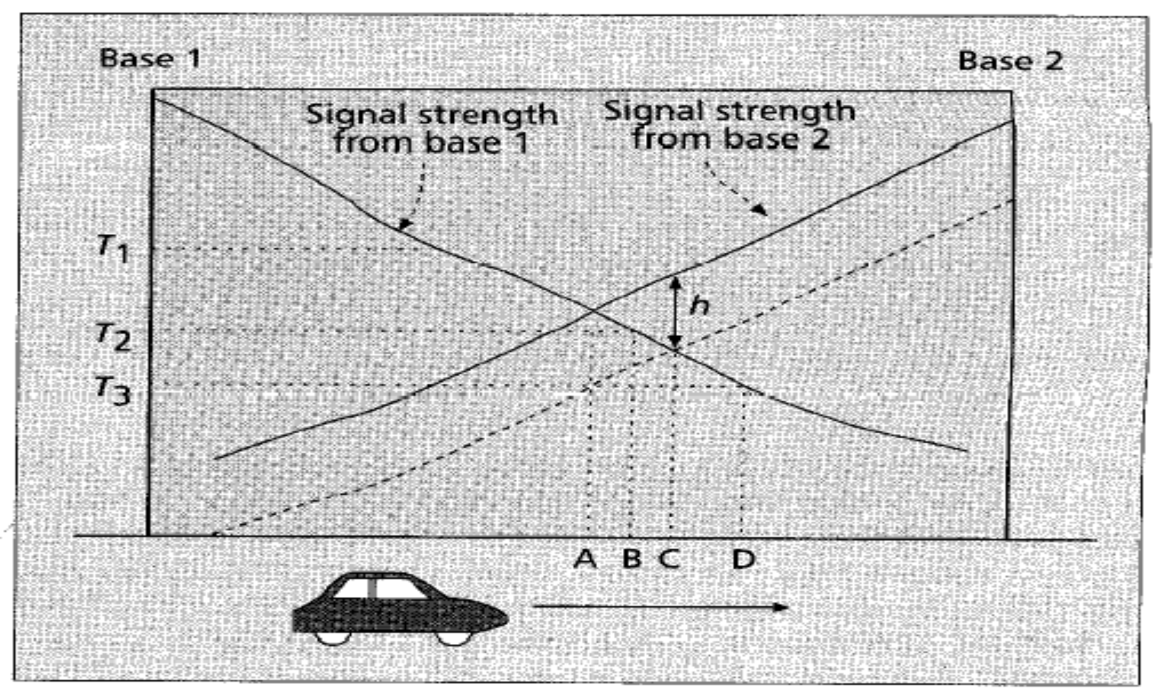
Handover

When to trigger an handover?

- There are several methods

2 - method of the strongest signal with the threshold

- if the signal received from the previous BS is less than a threshold (as. eg. T2) and the power of another BS is stronger; the handover occurs at point B



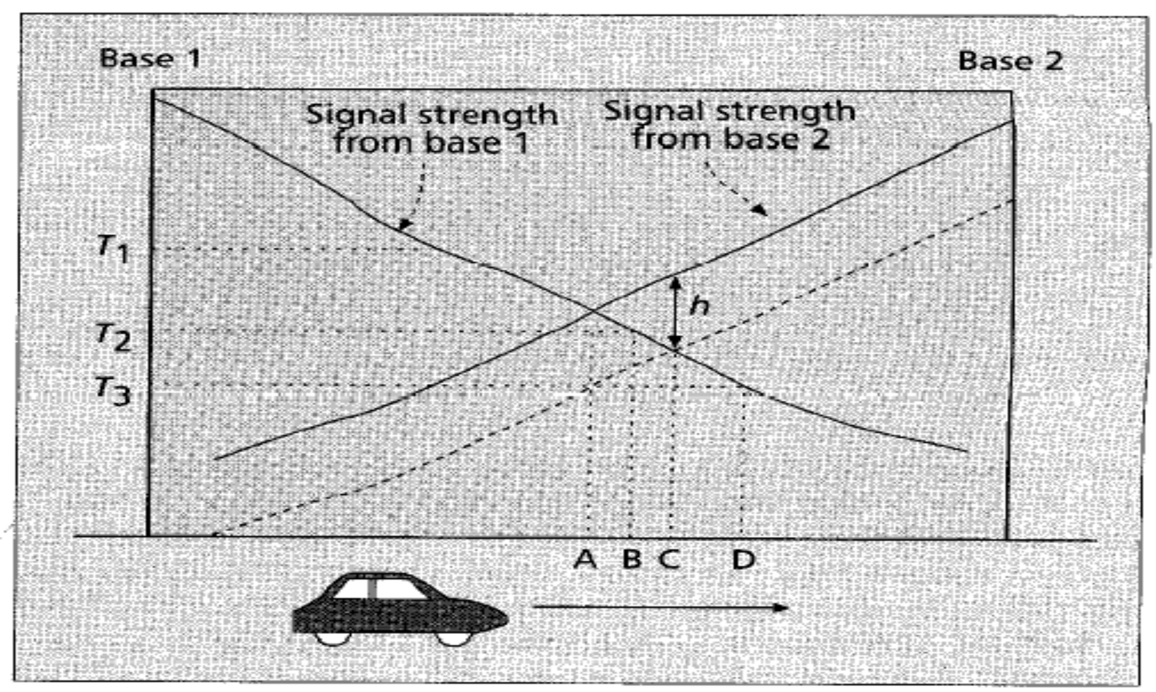
Handover

When to trigger an handover?

- There are several methods

3 - method of the strongest signal with hysteresis

- if the power of the other BS is stronger than a value of h; the handover occurs at the point C



Handover performance

- When there is a handover the channel in the old cell is released and the new channel is requested;
  - Problem: a channel in the new cell may not be available
- We define the probability of rejecting an handover (Pdrop) as the probability that a handover request can not be met and the blocking probability (Pblock) as the probability of rejecting a new call
- In systems that deal with requests for handover as the new incoming requests (call setup) Pdrop = Pblock
- In fact it is better to block an incoming call that loosing one active
- You can think of better treat requests for handover

Handover performance guard channels technique

- Guard Channels
  - A number of channels is reserved for handover requests
  - Pdrop becomes lower but the capacity of the system is lower
  - System dimensioning is critical and requires accurate estimates of the traffic dynamics (how many channels should I reserve for handover requests?)

Mobility management

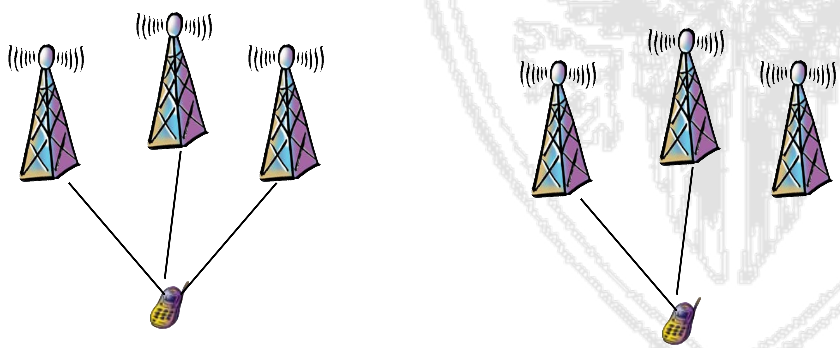
- Other Options
  - Queuing priority scheme
    - ✓ Handoff area: area within which the MS can hear both base stations. If no channels are available in the new BS the user will continue to be interconnected to the old BS; the request for handover to the new BS is buffered and served as soon as a channel is freed.
  - Subrating scheme
    - ✓ If there are no channels available at the new Base Station a channel previously allocated to a call is divided into two channels each half rate, allowing both calls to go forward.

Types of handover

- Hard Handover (GSM-2G)

Removal and establishment of a new radio link

- Soft Handover (UMTS-3G)



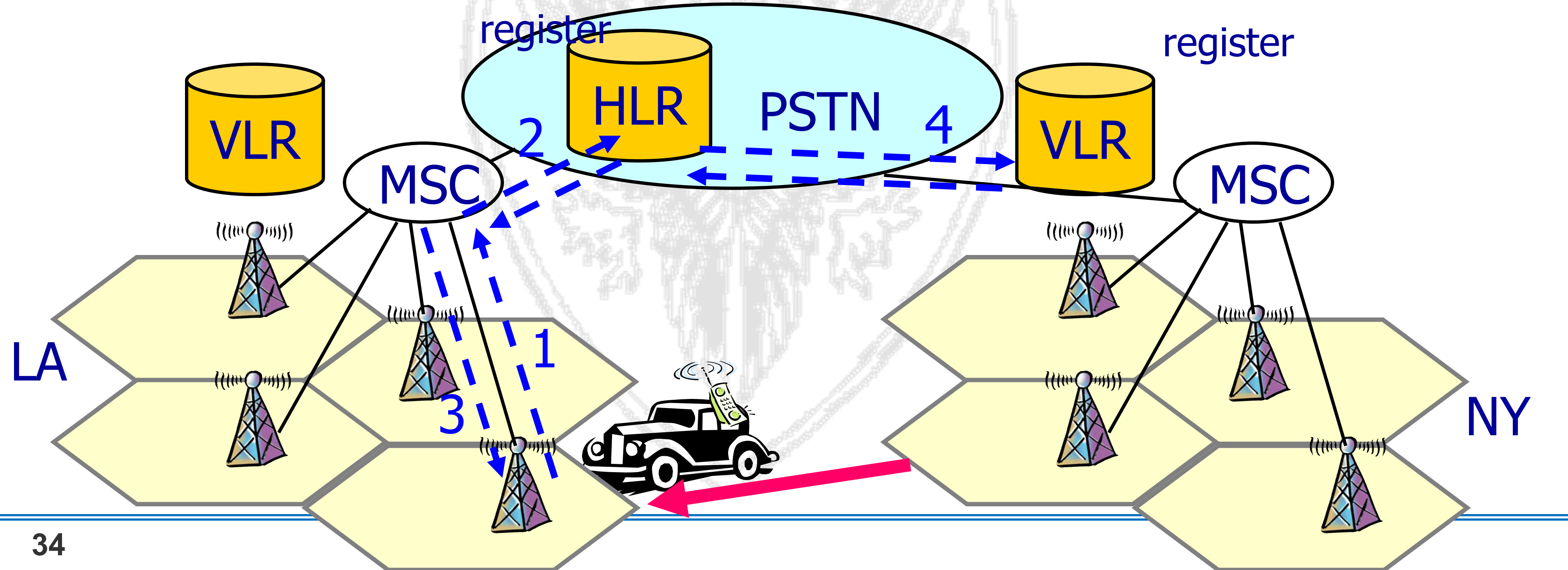
Leveraging on the user macrodiversity, the user is simultaneously connected to several base stations

Roaming

1. Upon arrival in a new LA, the user must register with the new VLR
2. The new VLR informs the HLR of the user's new location. The HLR sends back an ack with information such as the user's profile
3. The new VLR informs the user of the successful registration
4. The HLR sends a deregistration message to the old VLR

HLR: Home location register

VLR: Visiting location register



Call set up : example

1. MS→fixed phone through the VLR of the MS
2. Fixed phone→MS:through the gateway MSC of the MS the caller contacts the HLR and , throught it, the VLR currently managing the user
3. VLR provides information such as a routing number, LA of the user
4. Call set up