

# Cellular Fundamentals 5: Handoff and Cellular Hierarchy

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- Handoff in APMS
- Generic Handoff Management
- Cellular Hierarchy



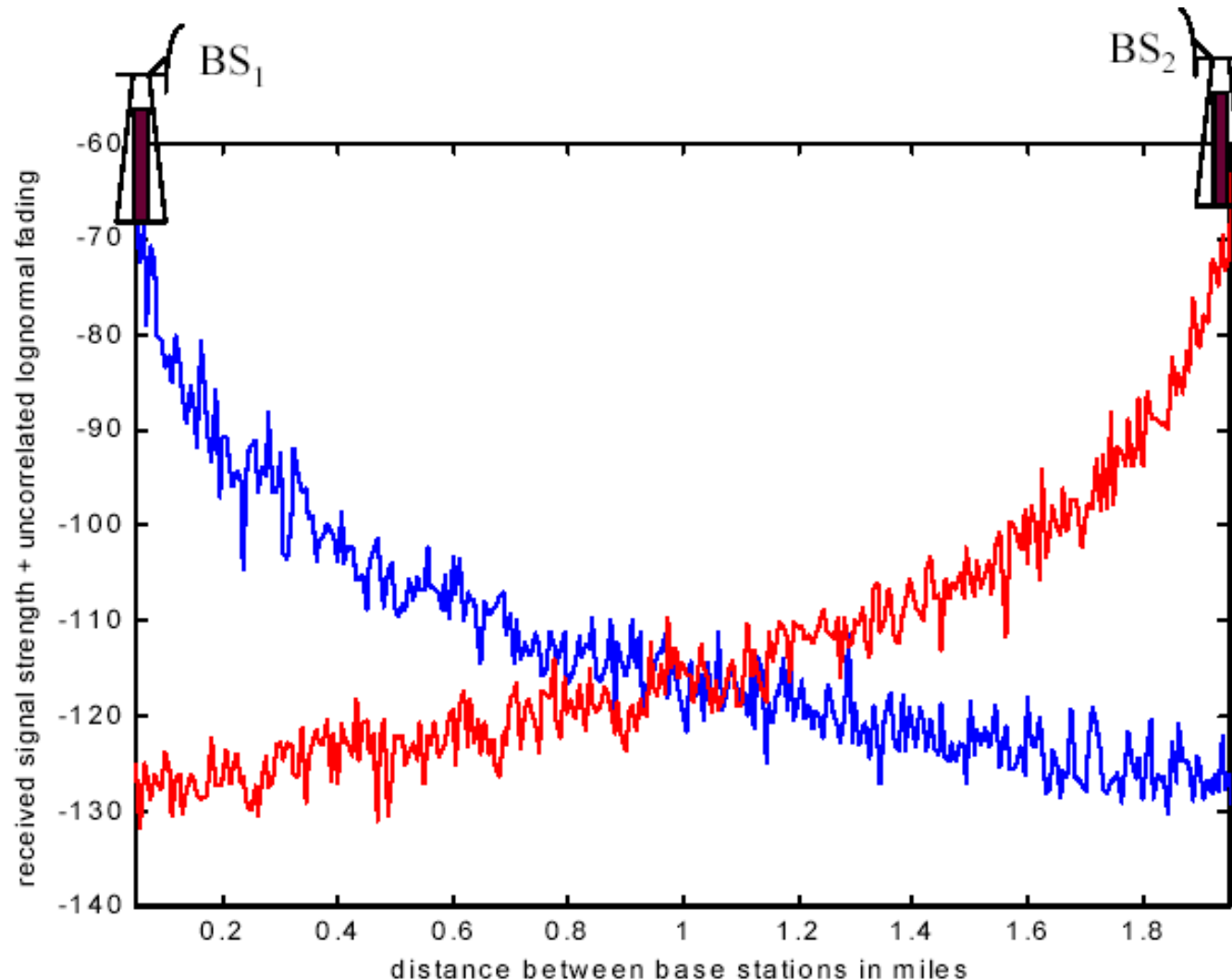
# Handoff Stages

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[Far96]

1. *Measurement and trigger stage*
  - RSS measured by the BS or MS (report)
  - RSS below threshold – handoff request
2. *Search stage*
3. *Selection stage*
  - Select target cell
4. **Execution Stage**

## Sample RSS from two BSs as seen by the MS travelling in a straight line [PK 02]



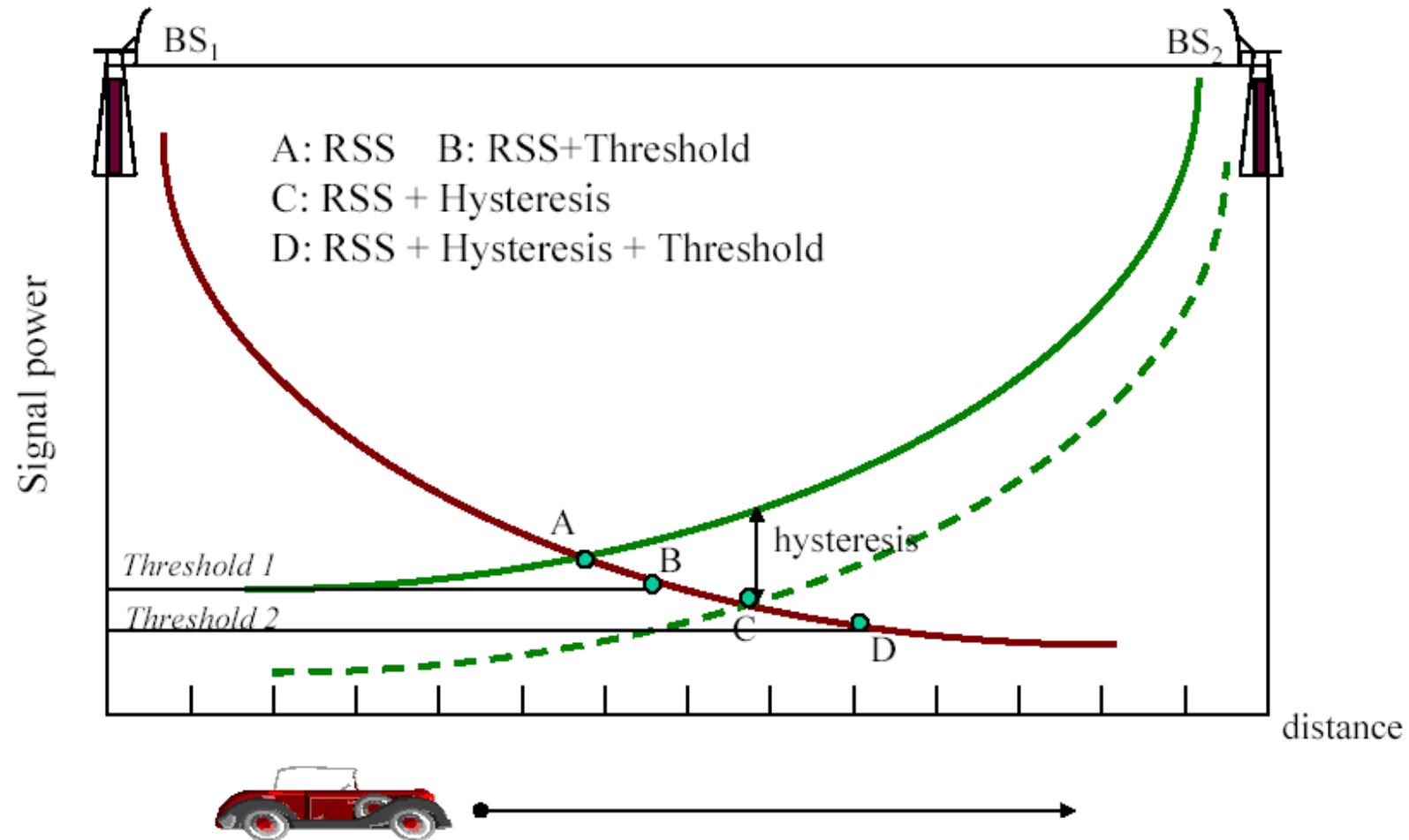


# Handoff – Search Stage

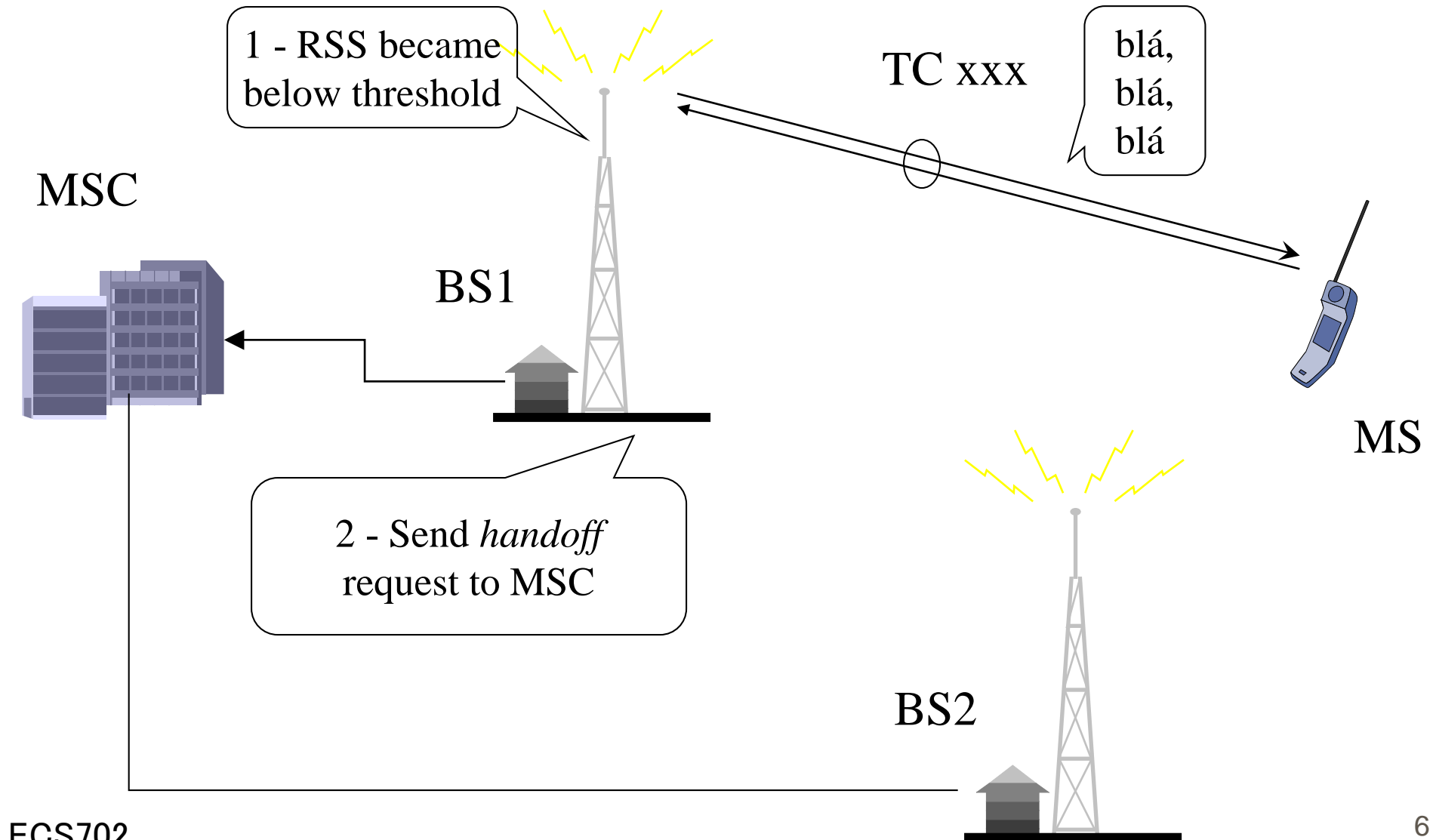
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- Search for the candidate cells based on
  - Received signal strength (RSS) (or received power  $P$ )
    - ♦ choose  $BS_{new}$  if  $P_{new} > P_{old}$
    - ♦ ping pong effect
  - Received signal strength (RSS) plus Threshold
    - ♦ choose  $BS_{new}$  if  $P_{new} > P_{old}$  and  $P_{old} < T$
  - Received signal strength (RSS) with Hysteresis
    - ♦ choose  $BS_{new}$  if  $P_{new} > P_{old} + H$
  - Received signal strength (RSS) with Hysteresis and Threshold
    - ♦  $BS_{new}$  if  $P_{new} > P_{old} + H$  and  $P_{old} < T$

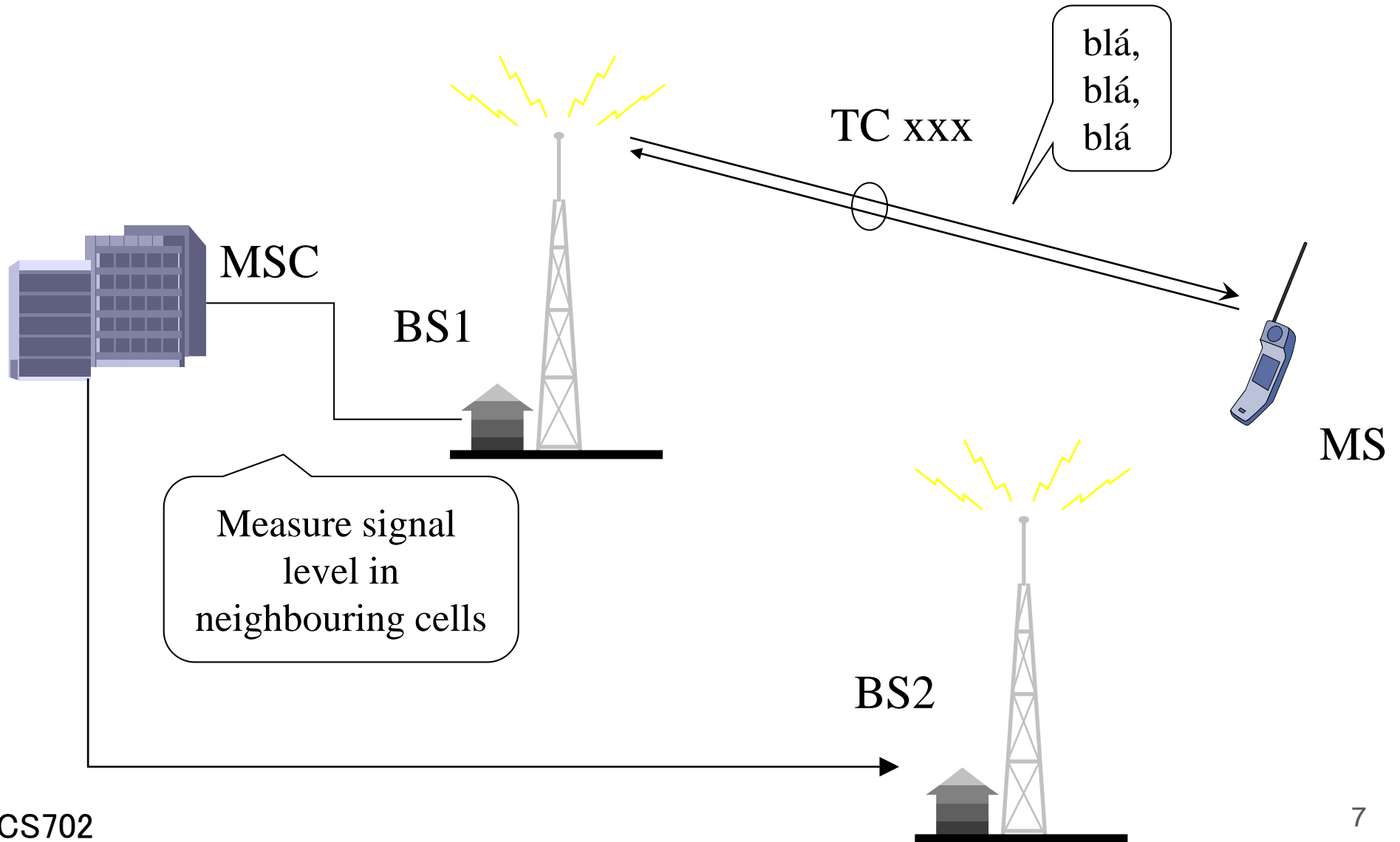
# Handoff using RSS thresholds and Hysteresis [PK 02]



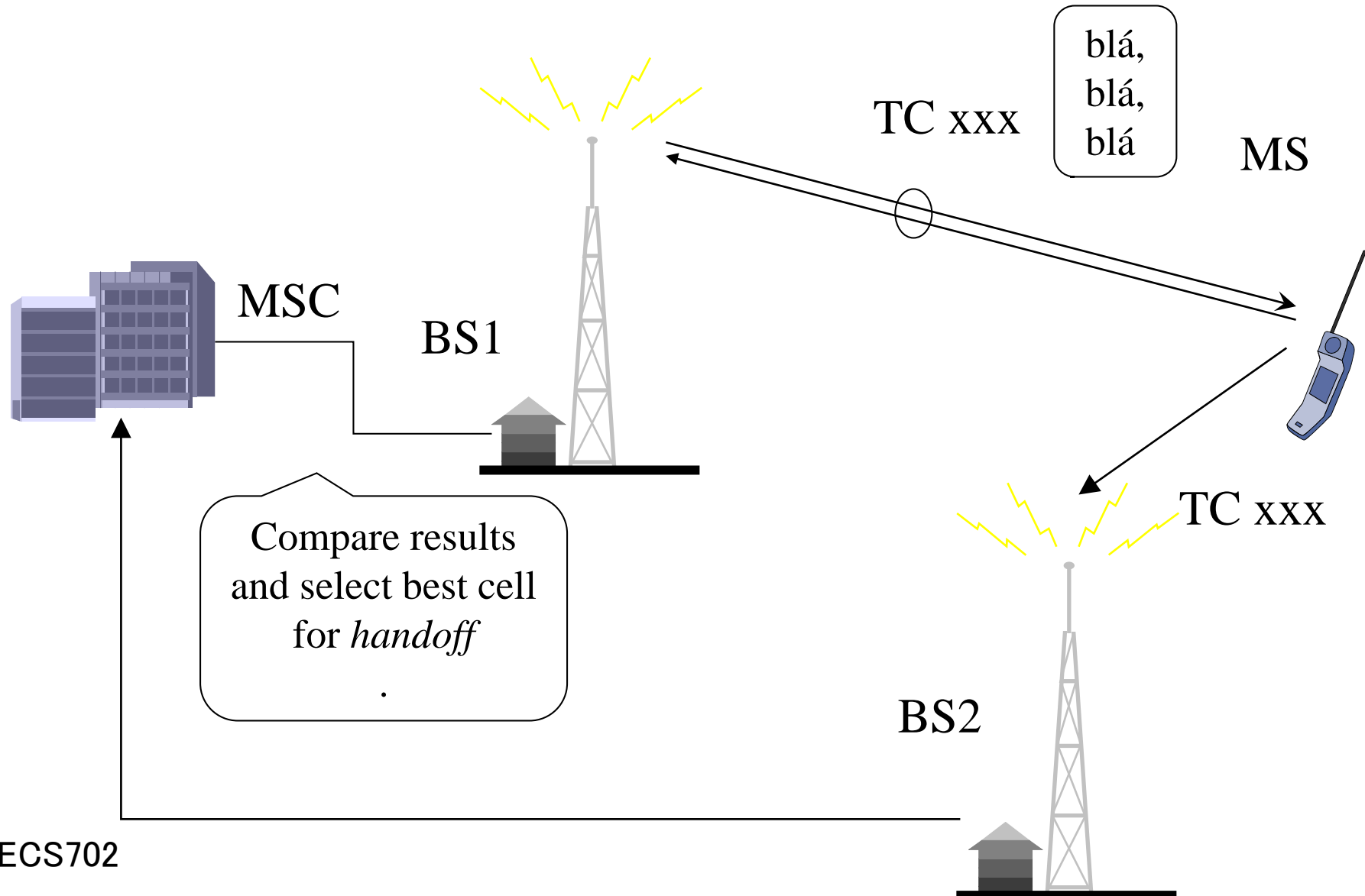
# Basic Handoff Procedure - Network Controlled (step1)



# Basic Handoff Procedure – Network Controlled (step 2)

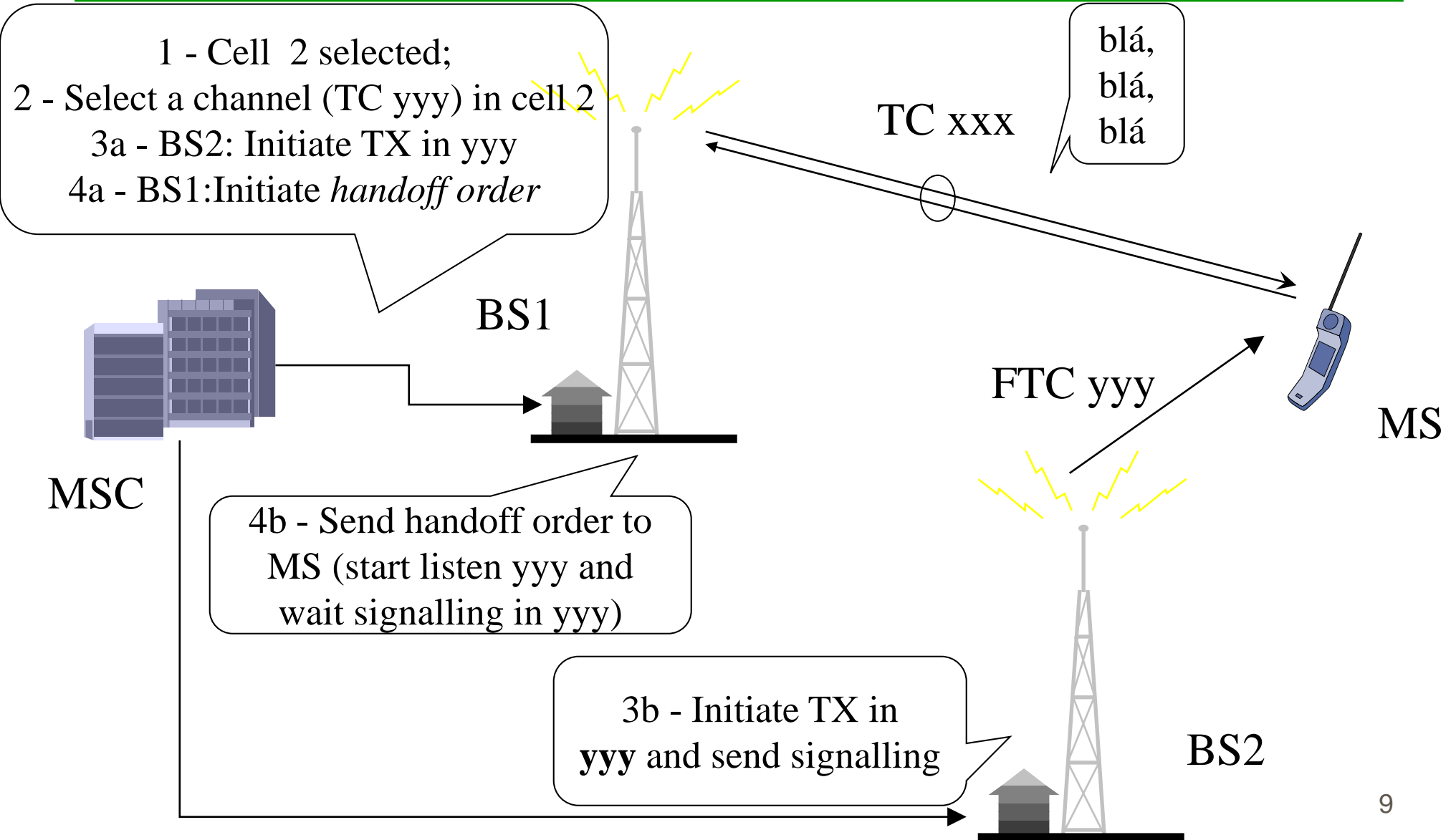


# Basic Handoff Procedure – Network Controlled (step 3)

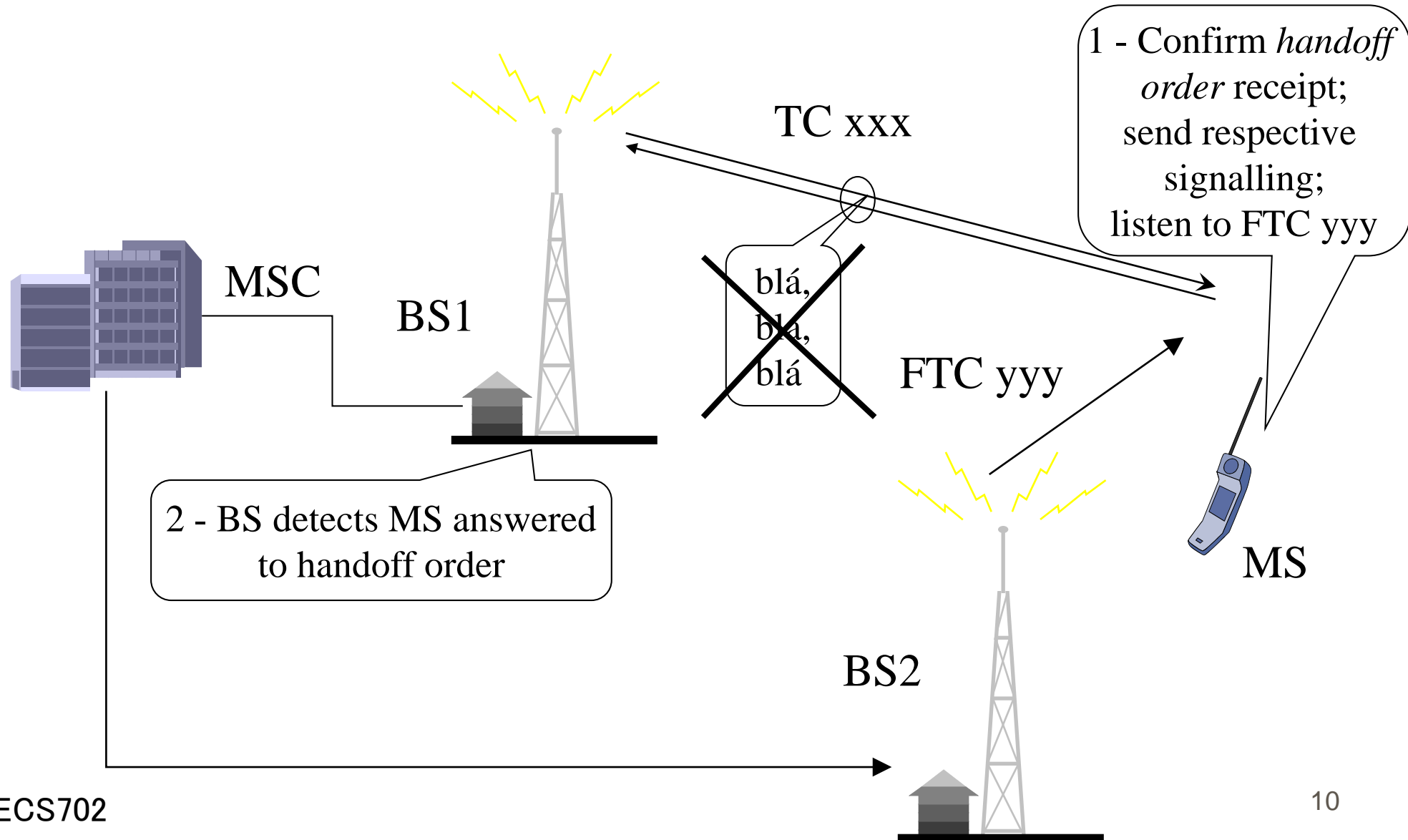




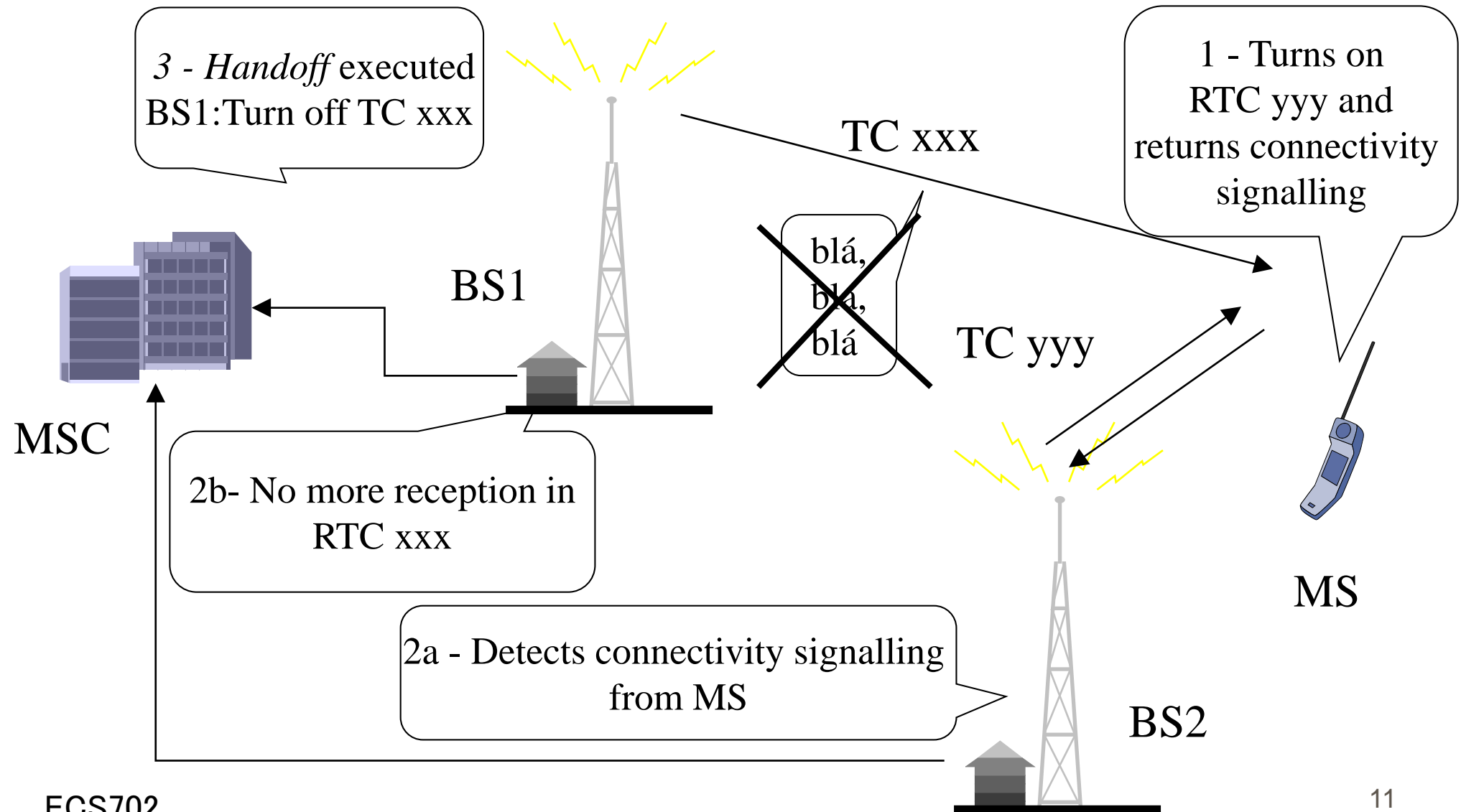
# Basic Handoff Procedure – Network Controlled (step 4)



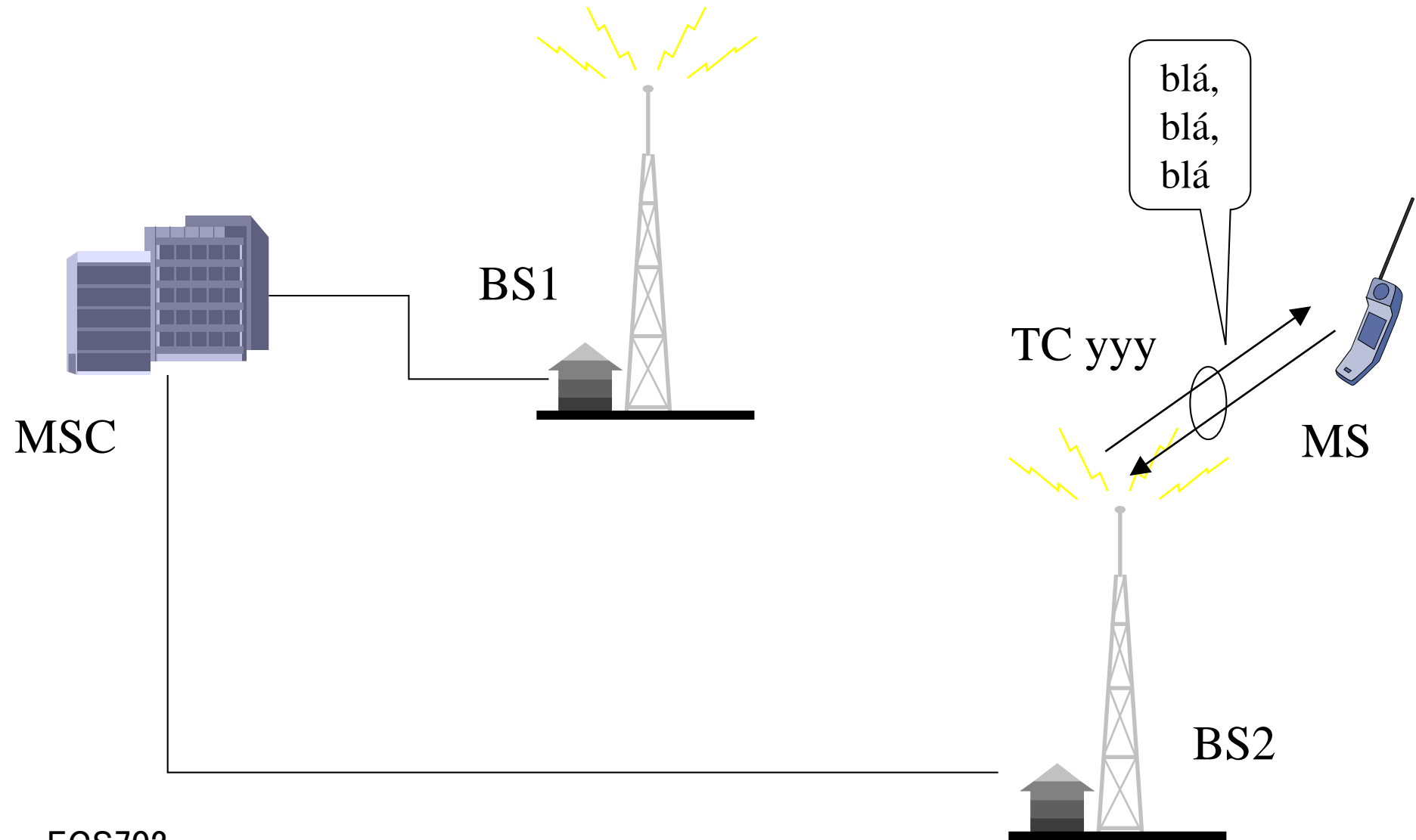
# Basic Handoff Procedure – Network Controlled (step 5)



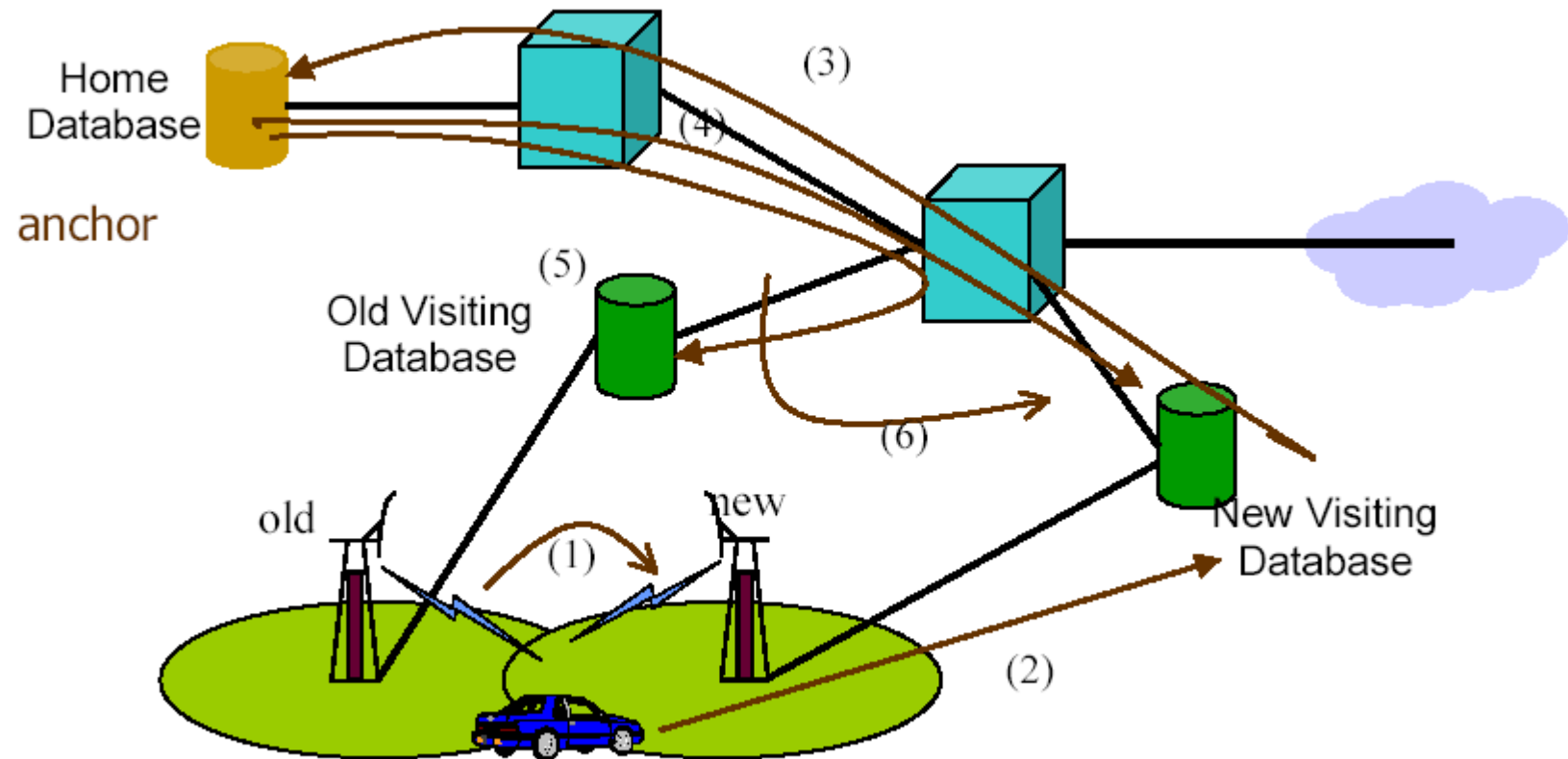
# Basic Handoff Procedure – Network Controlled (step 6)



# Basic Handoff Procedure – Network Controlled (step 7)



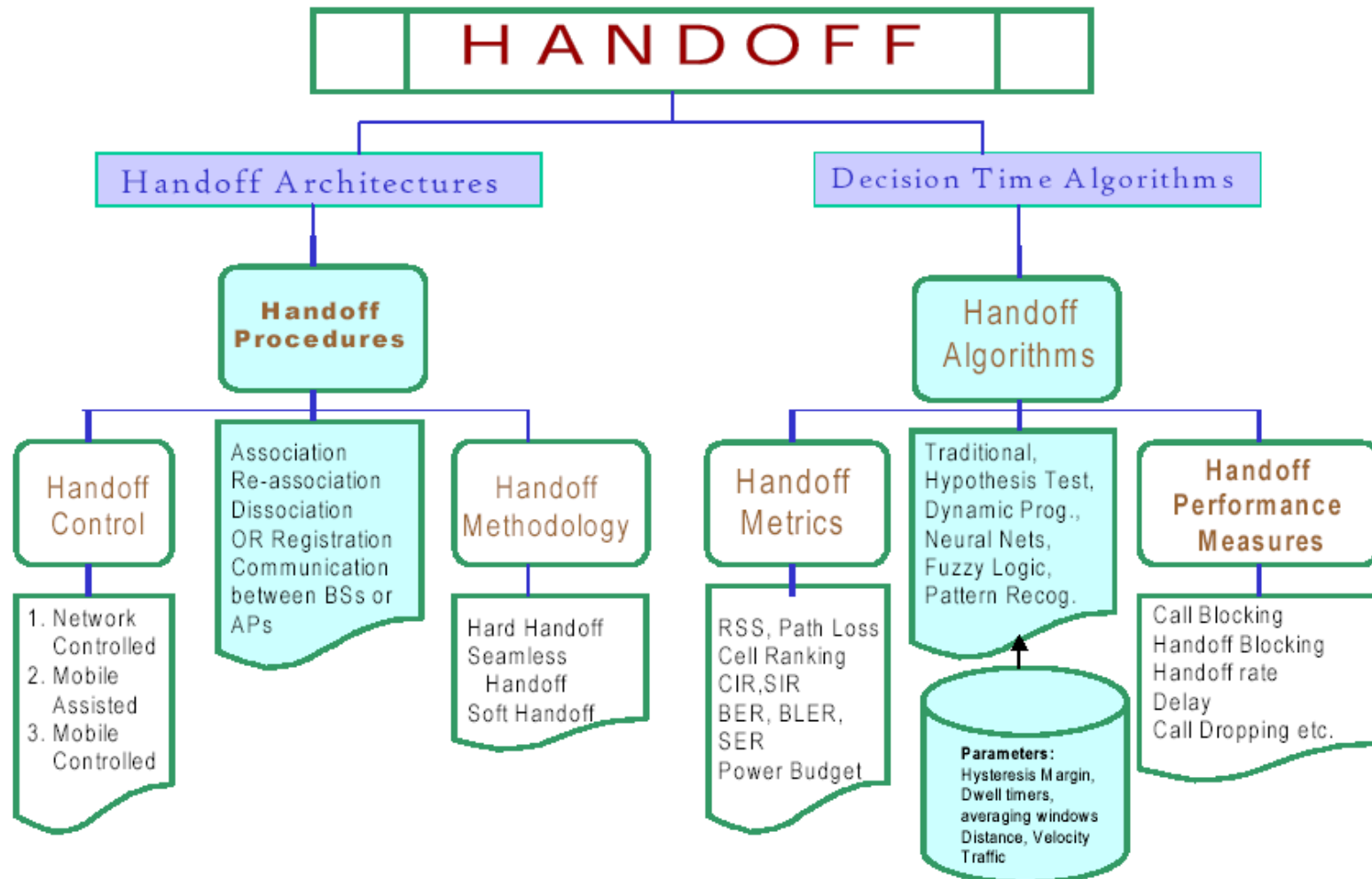
# Generic Handoff Management [PK02]



# Generic Handoff Management [PK02]

- The home data base (HLR) acts as the anchor
  - Every mobile is registered with its home data base that keeps track of the mobile's profile
- Visiting data base (VLR)
  - Keeps track of the mobile in its current service area
- HLR and VLR communicate with each other during handoff
- When the mobile is executing handoff to a different VLR
  - The mobile terminal registers with the “new” visiting database via a handoff announcement message
  - the VLR communicates with the home database to obtain subscriber profile and authentication
    - ♦ The first information is the new location of the mobile
- If the mobile is successfully authenticated and the handoff is executed, the home data base sends a message to the old VLR to delete the mobile's information (to clear resources)

# Handoff Mechanisms Issues [PK 02]





# Performance Metrics for Handoff Decision [Stallings 02]

- Call blocking probability
  - It is the probability of a new call being blocked, due to heavy load on the BS
  - The MS may be handed over to a neighbouring cell based on traffic capacity and not on signal level
- Call dropping probability
  - It is the probability that a call is terminated by the system (mainly because the BS cannot maintain the minimum required signal strength) and not by the user's hang up
  - It is possible to avoid a handoff, because the call dropping probability of the current channel is low or a handoff to another cell can increase the probability of the call being dropped
- Call completion probability
  - It is the probability that an admitted call is not dropped before it terminates
  - Then a handoff can be avoided and the user left with the current channel
- Probability of unsuccessful handoff
  - It is the probability that a handoff is executed while the reception conditions are inadequate
  - In these conditions the network may decide not to execute the handoff



# Handoff Performance Metrics [Stallings 02]

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- Handoff blocking probability
  - It is the probability that a handoff cannot be successfully completed
- Handoff probability
  - It is the probability that a handoff occurs before call termination
- Rate of handoff
  - It is the number of handoffs per unit time
- Interruption duration
  - It is the duration of time during a handoff in which a mobile is not connected to either base station
- Handoff delay
  - It is the distance the mobile moves from the point at which the handoff should occur to the point at which it does occur

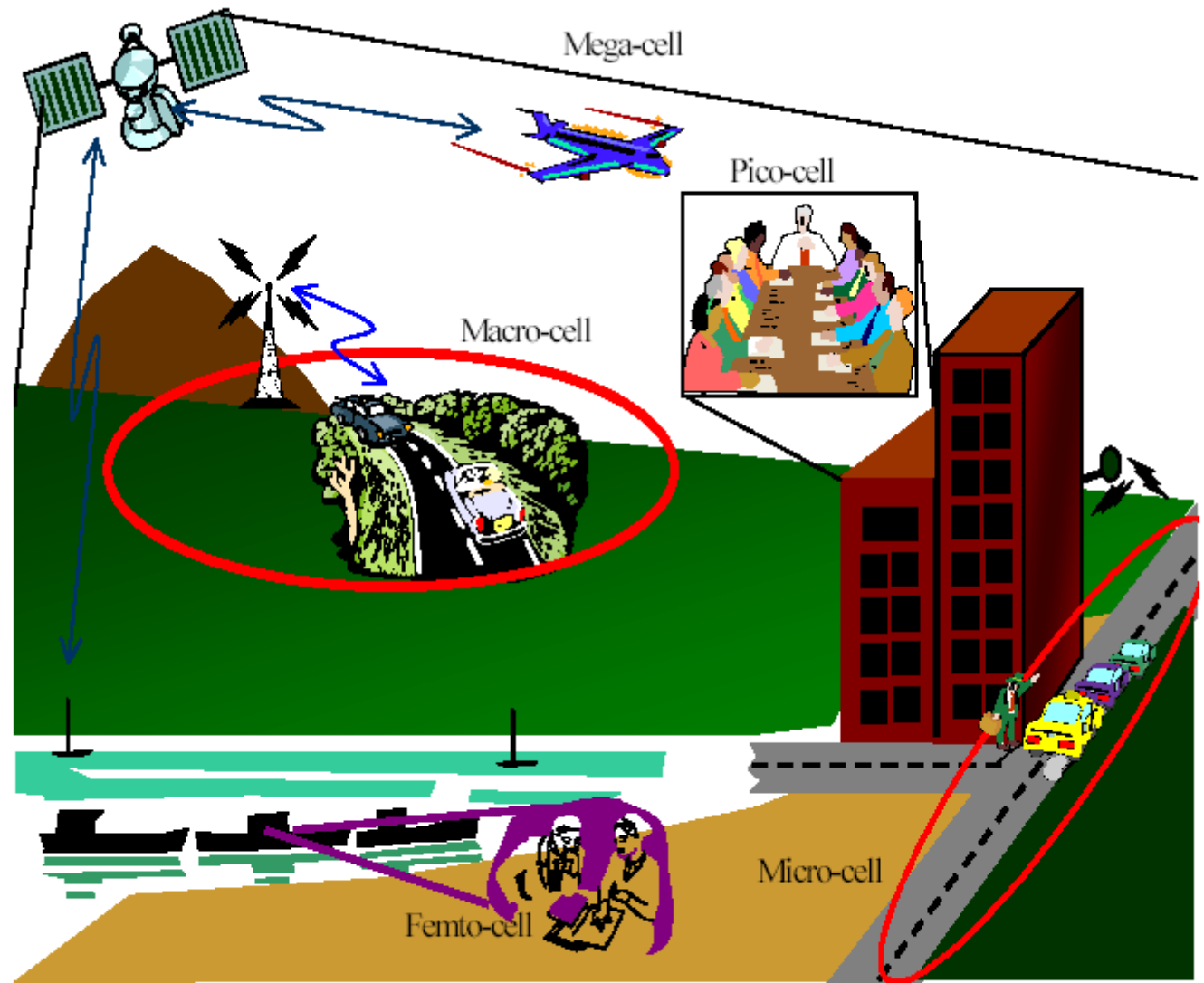
# Cell Hierarchy

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- Extend coverage to areas difficult to be covered by a large cell
  - Urban canyons or indoors environments
    - ♦ low power antennas
- Increase the capacity of the network in higher traffic density (ex. Highways)
- Places using high data rate applications
- Modern deployment of cellular networks uses different cell sizes in order to provide a comprehensive coverage supporting traffic fluctuations

# Cell Hierarchy

- ***Femtocells***
- ***Picocells***
- ***Microcells***
- ***Macrocells***
- ***Megacells***



[PK 02]

Figure 5.6: Cellular hierarchy

# Cell Hierarchy

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- Femtocells
  - smallest unit of the cellular hierarchy
  - used for connection of personal equipment
  - cover only a few meters
- Picocells
  - small cells inside a building that support local indoor net works
  - range of a few tens of meters
- Microcells
  - cover the inside of streets with antennas mounted at heights lower than the rooftop
  - range of hundreds of meters
  - used in urban areas
- Macrocells
  - cover metropolitan areas
  - range of several kilometers
  - antennas are mounted above rooftops
- Megacells
  - cover nationwide areas with ranges of hundreds of kilometers
  - mainly used with satellites

# Class Quiz

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- How is the handoff decision made?
- How is the handoff managed in AMPS?
- What are the cells on different levels in a cellular hierarchy?

# References

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- [Far96] Saleh Faruque. Cellular Mobile Systems Engineering. *Mobile Communication Series*. Artech House Publishers. ISBN 0-89006-518-7.1996.
- [Lee 95] William C. Y. Lee. Mobile Cellular Telecommunications: Analog and Digital Systems. Second Edition. McGraw-Hill, Inc. ISBN 0-07-038089-9. 1995.
- [PK 02] Kaveh Pahlavan and Prashant Krishnamurthy. Principles of Wireless Networks. *Prentice Hall*. ISBN 0-13-093003-2, 2002.
- [Mac 79] V. H. Mac Donald. Advanced Mobile Phone Service: The Cellular Concept. *The Bell System Technical Journal*, volume 58, number 1, pages 15-41, January 1979.
- [Stallings 02] William Stallings. Wireless Communications and Networks. *Prentice Hall*. ISBN 0-13-040864-6, 2002.