

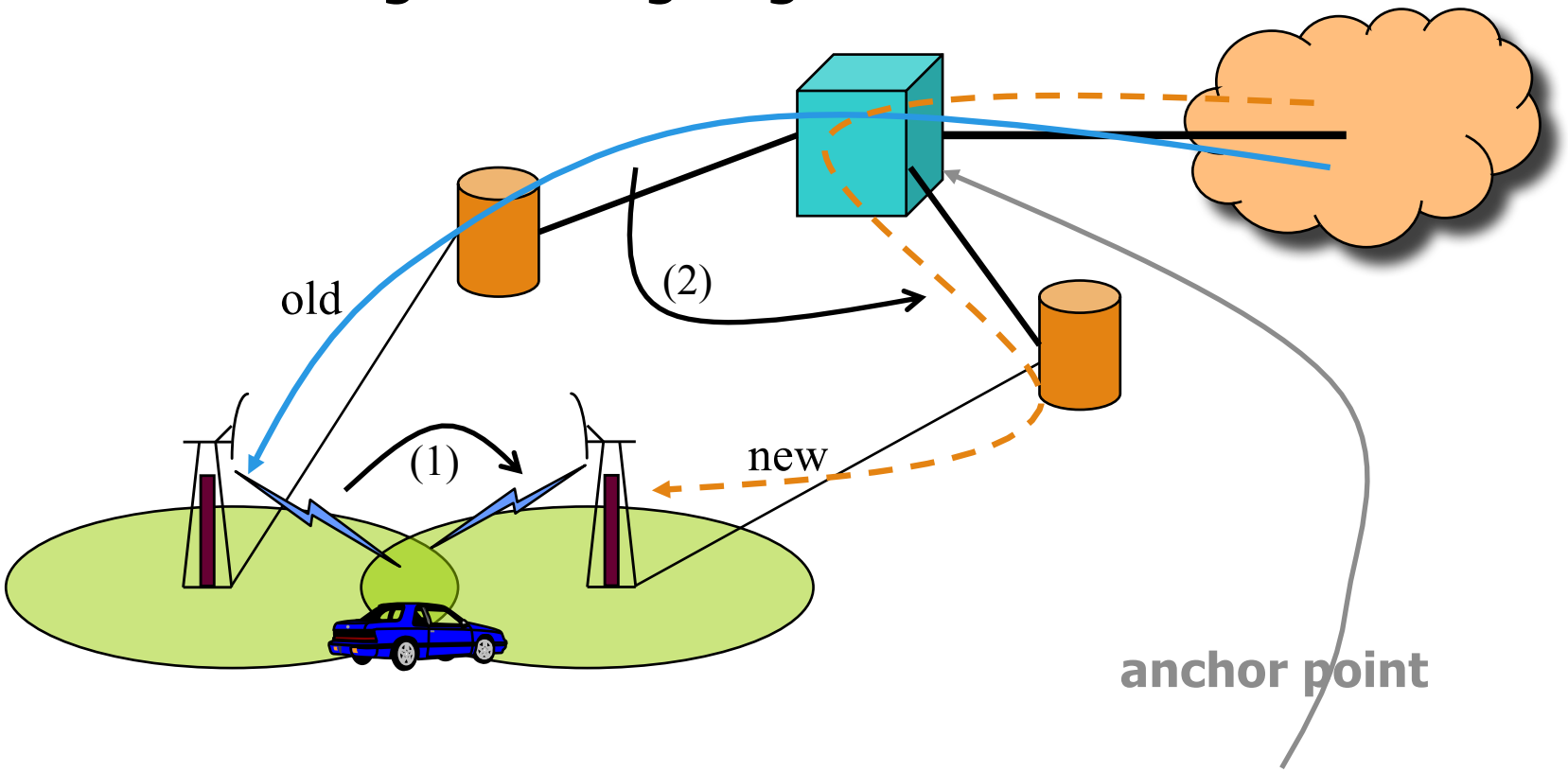

Lecture 12

Wireless Network Operations (2)
Mobility Management

Two Issues in Handoffs

The anchor point is some network entity that is “fixed” and can be used to track the MS

1. Handoff decision and initiation
2. Restructuring the on-going connection

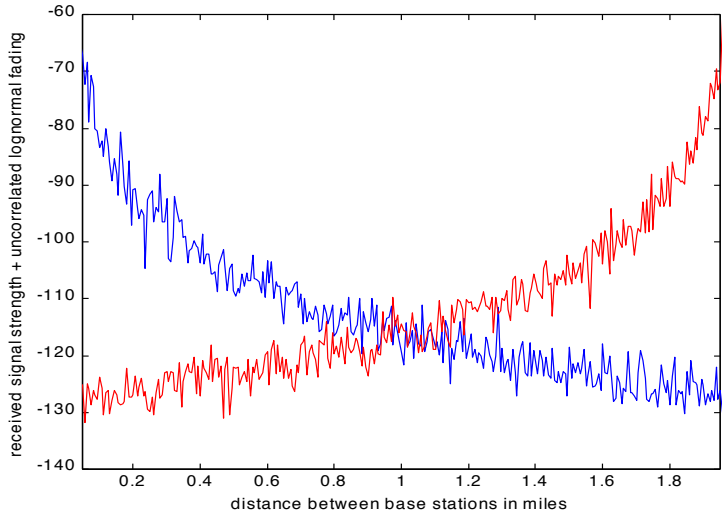


Handoff Decision

- When should a MS switch its connection from the current BS to a new BS?
  - If the MS persists with the current BS for too long, its connection could be broken
    - Important for voice calls
    - How about data?
  - If the MS persists with the current BS for too long and keeps increasing its transmit power, it could increase co-channel interference or intra-cell/inter-cell interference
  - If the MS switches its connection too soon, it may not be the right decision and it may have to change it – increased signaling load
- Handoff is the mechanism by which a MS makes a switch of its current point of access
- Ideally, there must be EXACTLY one handoff at the cell edge

RSS based Handoff Decision

BS_1 BS_2

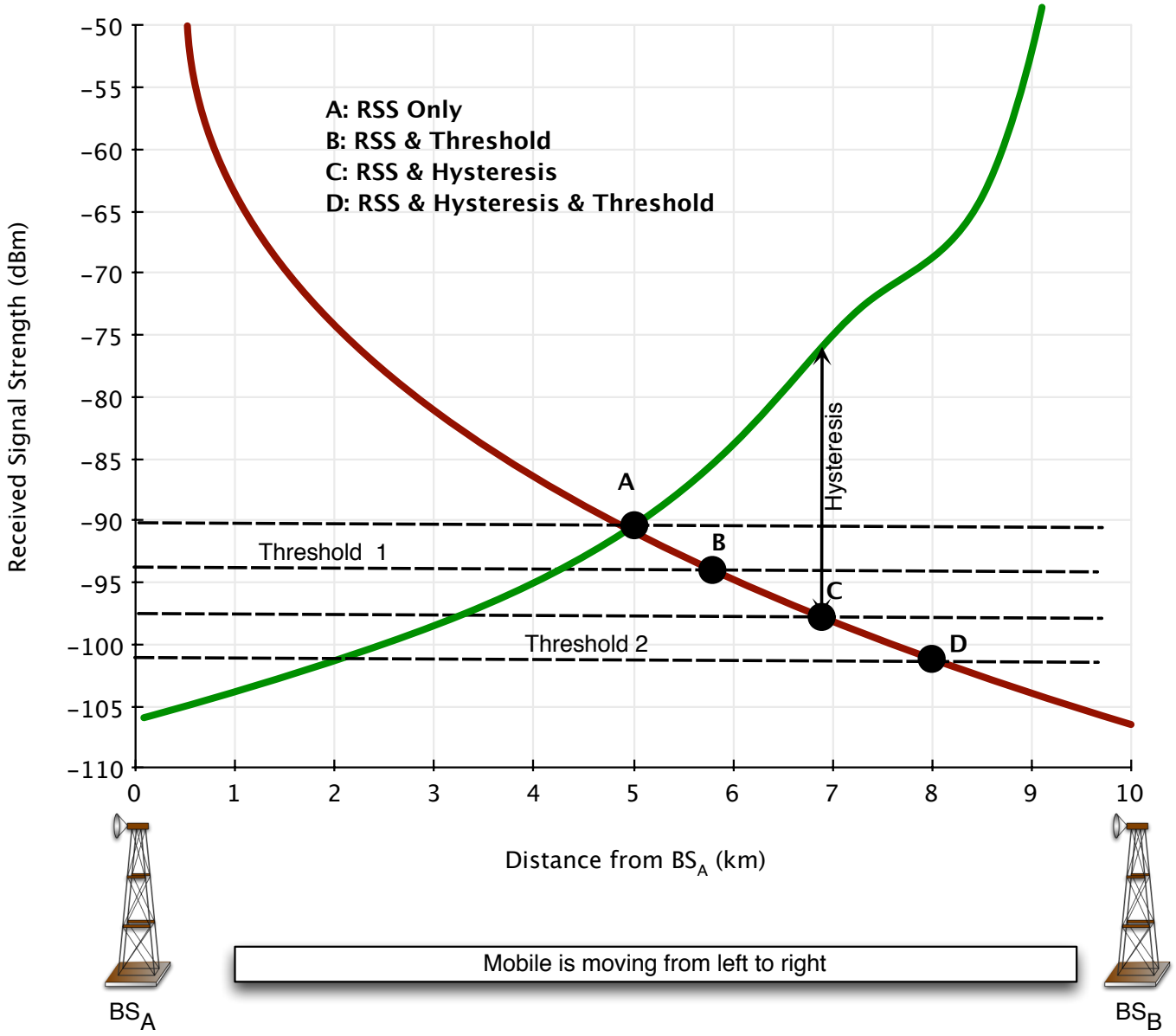


- The received signal strength (RSS) is most commonly used in RRM algorithms
- RSS based algorithms
  - Largest relative signal strength
  - Relative signal strength with threshold
  - Relative signal strength with hysteresis
  - Relative signal strength with hysteresis and threshold

Traditional algorithms

- *Received Signal Strength*: The base station with the the largest strength is selected (choose BS B_{new} if $P_{new} > P_{old}$).
- *Received Signal Strength plus Threshold*: RSS of a new BS exceeds that of the old BS, RSS of old BS is below a threshold T (choose B_{new} if $P_{new} > P_{old}$ and $P_{old} < T$).
- *Received Signal Strength plus Hysteresis*: RSS of new BS is larger than that of the old BS by a hysteresis margin H (choose B_{new} if $P_{new} > P_{old} + H$).
- *Received Signal Strength, Hysteresis and Threshold*: RSS of a new BS exceeds that of the old BS by a hysteresis margin H, and RSS of old BS is below a threshold T (choose B_{new} if $P_{new} > P_{old} + H$ and $P_{old} < T$).
- *Algorithm plus Dwell Timer*: A timer is started at the instant when the condition in the algorithm is true. If the condition continues to be true till the timer expires, a handoff is performed.

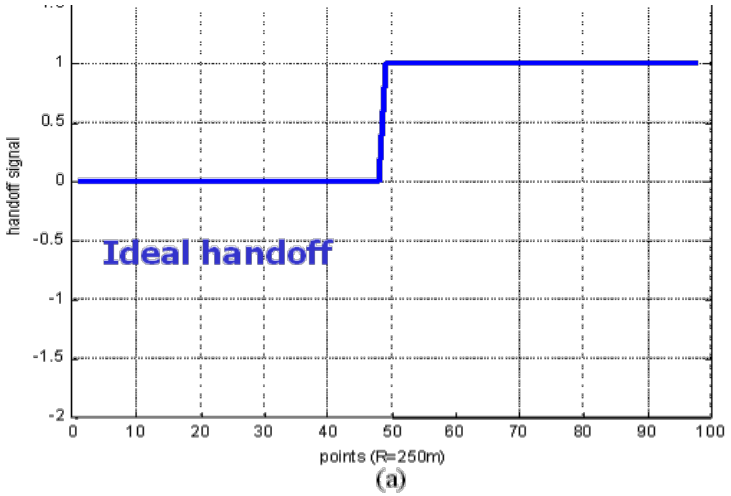
Handoff Initiation Criteria

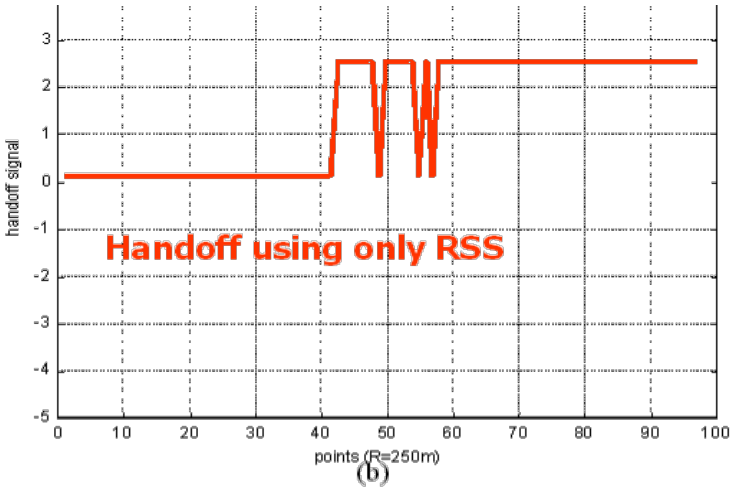


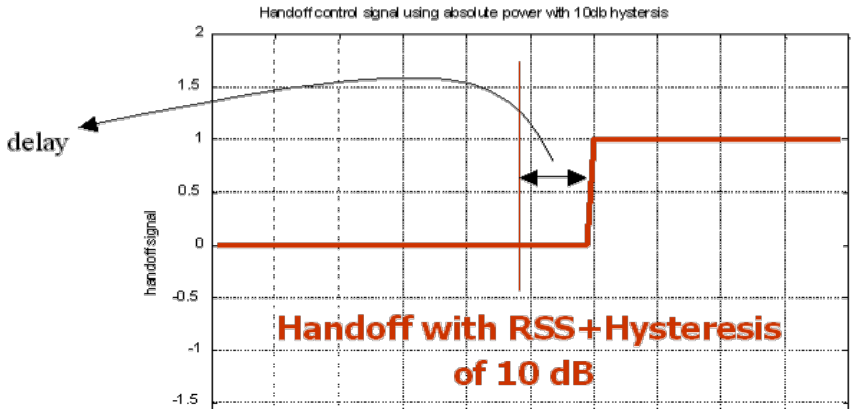
The Ping-Pong Effect

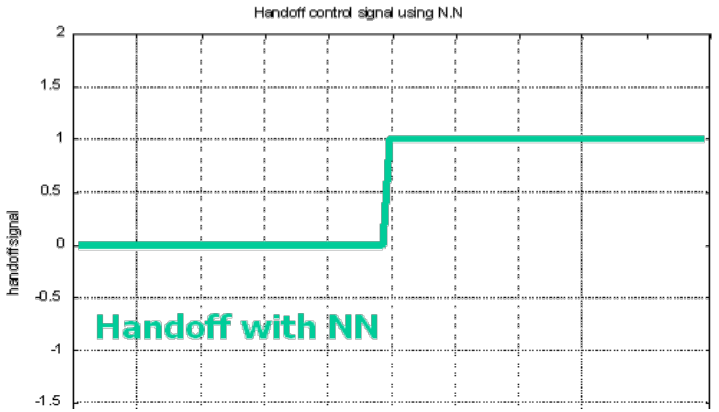
- Repeated handoffs back and forth between two base stations
  - Caused by not setting some parameters of handoffs like hysteresis and threshold wisely
  - Results in large system loads, multiple interruptions in voice transmissions and instability

Simple simulations of handoff









The Soft Handoff Concept in CDMA

- The MS *simultaneously* maintains connection with two or more points of access to the fixed network
  - Eventually, one of them is picked as the strongest connection and a handoff is made to that cell
- Why Soft Handoff?
  - Positive feedback power control problem
    - Cells use the same frequency
    - MS moves away from a BS and keeps increasing its transmit power
    - The interference in the neighboring cell increases
      - This forces MSs in the neighboring cell to increase their Tx power (How do they know they should increase the power?)
      - The interference increases further
- Soft handoff guarantees that the MS is always connected to the strongest BS

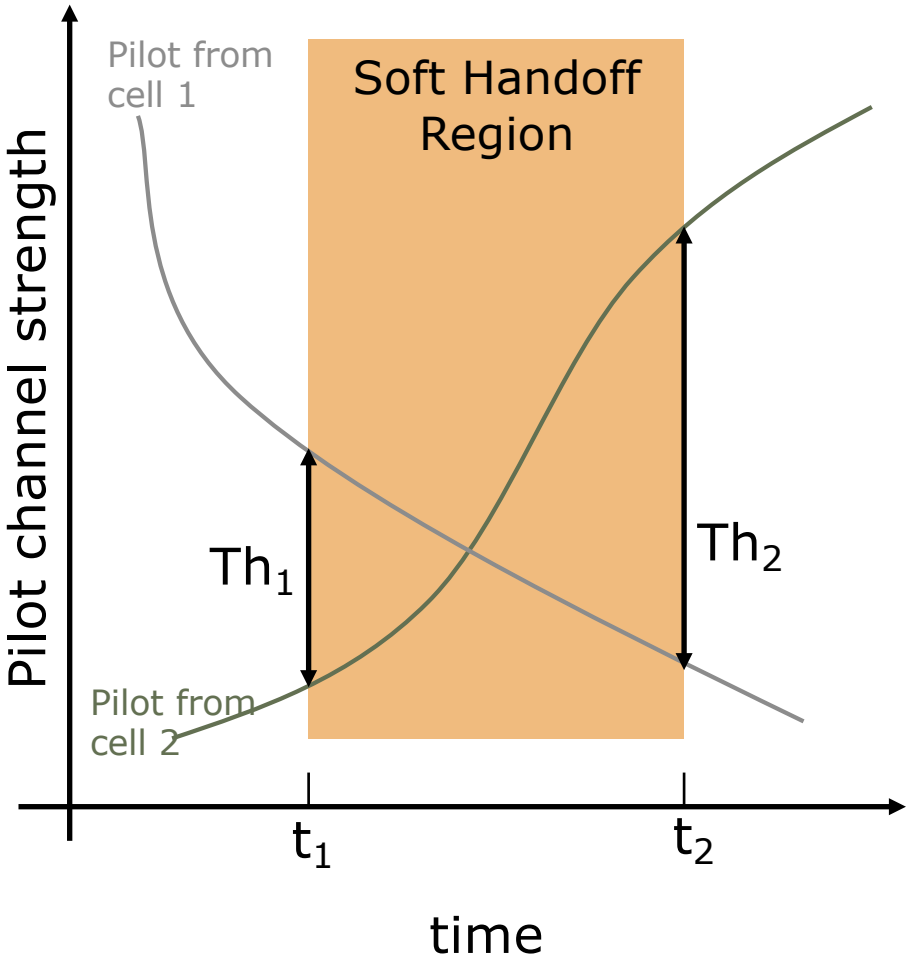
The Active Set

- Contains the pilot channels associated with the forward traffic channels assigned to the MS
  - Usually there is exactly one pilot in the active set
  - During handoff, there may be many pilots in this set
- The maximum number of pilots in the active set is 3
  - This is restricted by the number of RAKE fingers
  - If pilots can share a finger, you can go up to 6 pilots
- The BS informs the MS of the active set using two messages
  - Channel assignment message
  - Handoff direction message (HDM)

Handoffs in UMTS

- The MS maintains a list of cells that it is currently using or may likely use
- Active Set
  - All cells that are simultaneously involved in a communication during soft handoff
  - The MS coherently demodulates the received signals from these cells
  - It contains two or more cells in FDD mode, but only one cell in TDD mode
- Monitored Set
  - These are cells not in the active set, but in the neighbor list and monitored by the MS
- Detected Set
  - Cells not in either the active or the monitored set, but detected by the MS anyways

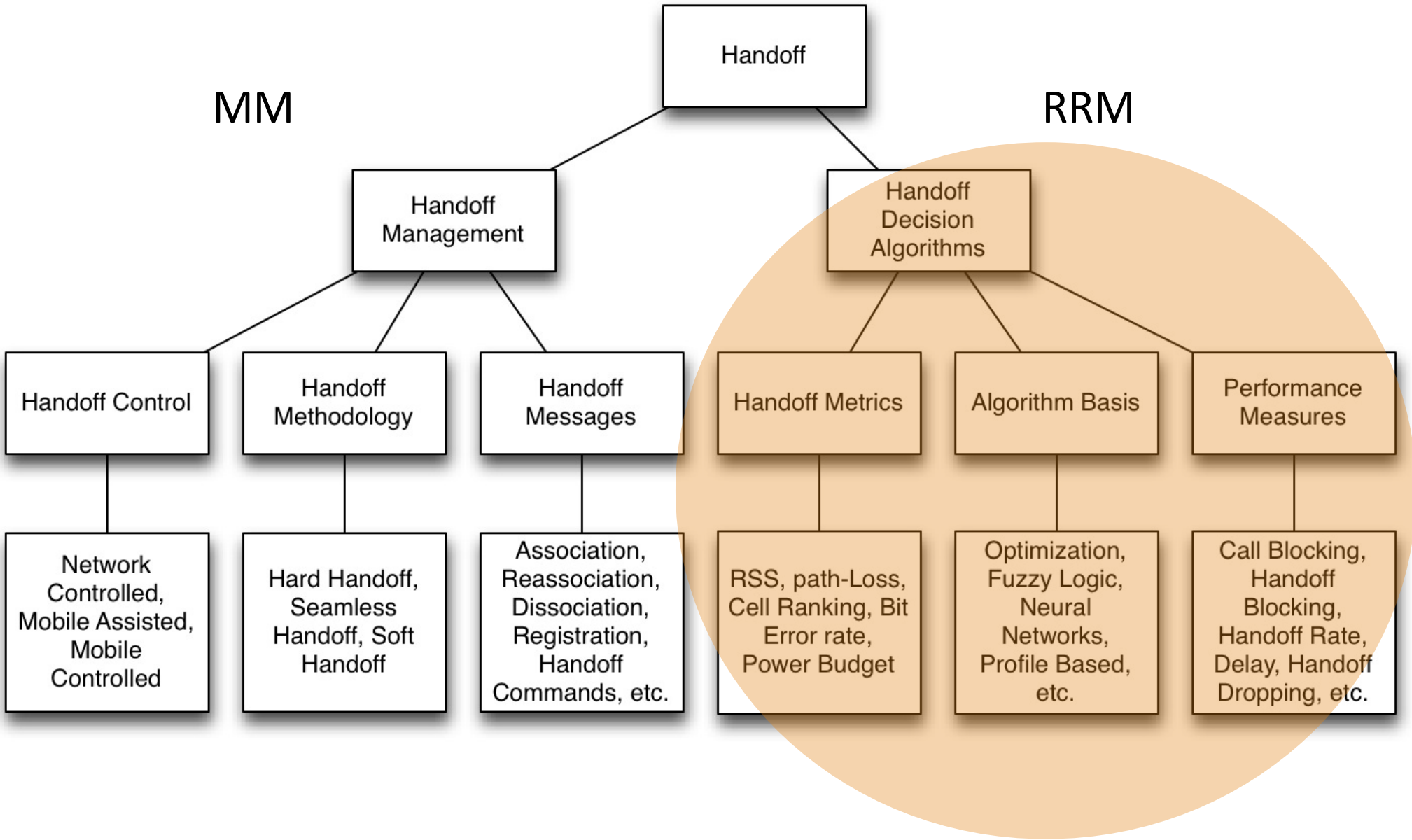
Basic idea in UMTS



- There is a permissible number of cells in the active set
- Initially Cell 1 is the only member of the active set
  - At t_1 the difference in power between the pilot from cell 1 and cell 2 is less than a threshold Th_1
  - Cell 2 is included in the active set
- The MS is now communicating with two cells simultaneously
  - At t_2 the difference in the pilots becomes larger than another threshold Th_2
  - The pilot from cell 1 becomes unusable and it is dropped from the active set

Handoff decision algorithms in WiFi

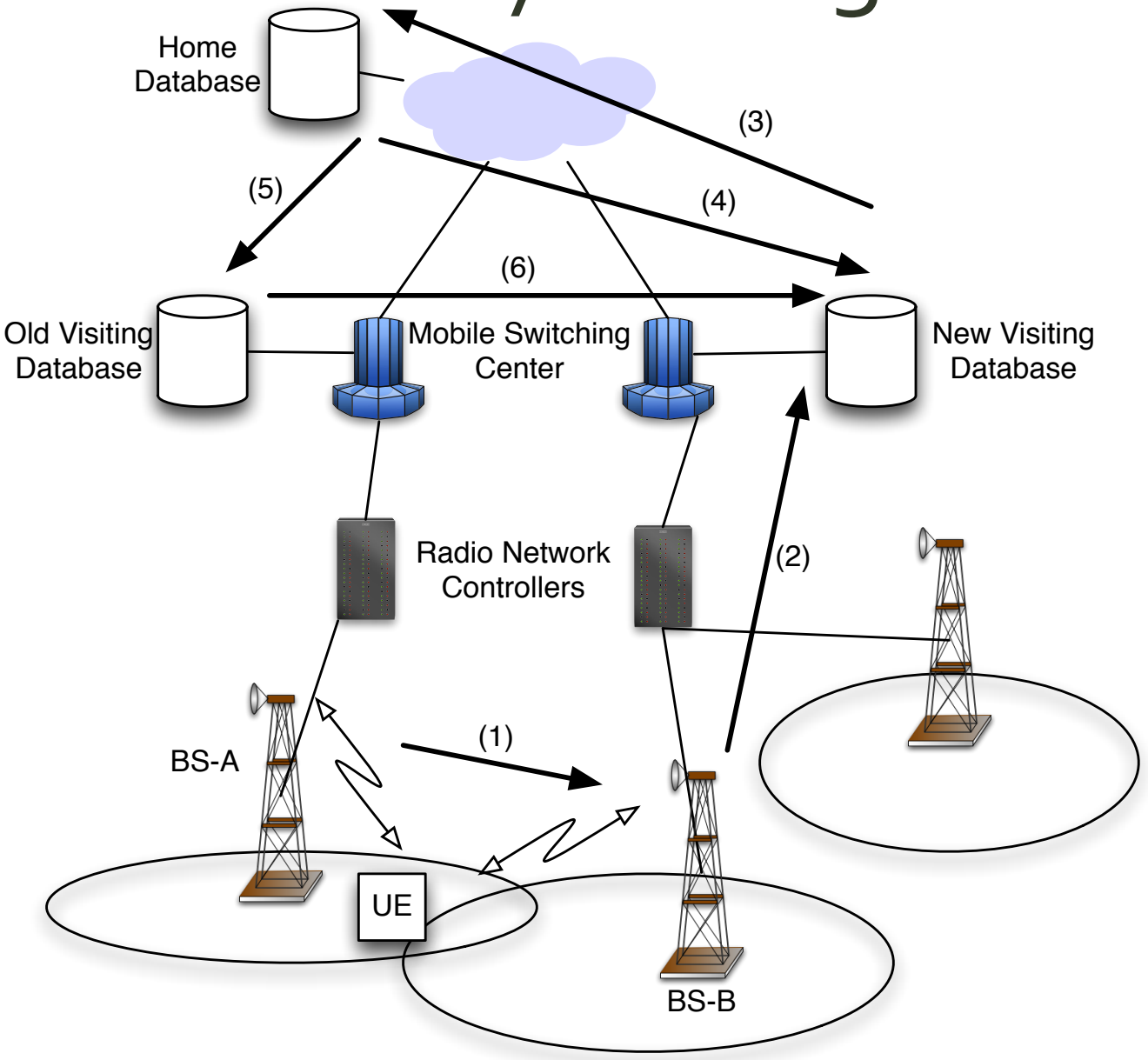
- Most algorithms are based on the RSS
- Most algorithms are proprietary
  - In IEEE 802.11, most MSs simply use either the RSS or the SNR to make handoffs
    - Some vendors use load
  - There are no defined thresholds or hysteresis margins


MM
RRM
Handoff
Handoff Management
Handoff Decision Algorithms
Handoff Control
Handoff Methodology
Handoff Messages
Handoff Metrics
Algorithm Basis
Performance Measures
Network Controlled, Mobile Assisted, Mobile Controlled
Hard Handoff, Seamless Handoff, Soft Handoff
Association, Reassociation, Dissociation, Registration, Handoff Commands, etc.
RSS, path-Loss, Cell Ranking, Bit Error rate, Power Budget
Optimization, Fuzzy Logic, Neural Networks, Profile Based, etc.
Call Blocking, Handoff Blocking, Handoff Rate, Delay, Handoff Dropping, etc.

Mobility management

- For a message to reach a MS
  - There should be a knowledge of where the MS is currently
    - A route must be set up to the MS accordingly
    - **Location management**
  - There must be adjustments made to track the MS as it moves while connected
    - The route must be redefined efficiently when the MS changes its point of access to the fixed infrastructure
    - **Handoff Management**

Generic Mobility Management



Steps in Mobility Management (1)

- Mobile decides and initiates handoff (NCHO?)
  - RSSI, RSSI Hysteresis, BLER, etc.

Radio Resource Mgt

- Mobile registers with "new" visiting database
  - Announcement of handoff
  - First information to a network entity

Location Management

- New Visiting Database communicates with Home Database to obtain subscriber profile and for authentication
  - First information exchange between network entities about the changed location of the mobile

Steps in Mobility Management (2)

- Home Database responds to New Visiting Database
  - Authentication of mobile
  - Database update for redirecting messages
  - New visiting database includes mobile in its list
- Home Database asks Old Visiting Database to flush packets intended for mobile
  - Packets that may have been routed to the old visited network while the mobile was making a handoff need to be dropped or redirected
- Old Visiting Database flushes or redirects packets to New Visiting Database
  - Old Visiting Database removes mobile from its list

IS-41 and GSM-MAP

- Two standards to handle mobility
- GSM-MAP
  - MAP = Mobile Application part
  - Used by GSM-like systems
- IS-41
  - IS = Interim Standard
  - Used by North American Systems
  - IS-136 and IS-95 systems use IS-41 for signaling and mobility management
- Mobile IP or variations
  - For 3G and 4G networks

Comparative Table of Network Elements involved in Mobility Management

Generic	GSM	Mobile-IP
Home Database	Home Location Register	Home Agent
Visiting Database	Visiting Location Registor	Foreign Agent
Registration	Registration Procedure	Registration
Handshake between Visiting and Home Databases	Prepare HO SS-7	Registration action by Foreign Agent
Flush	Clear Command	None exists

Location Management

- As soon as the MS powers up it has to “register” or “associate” itself
  - Voice systems
    - MSs are NOT connected till there is a call
    - But the MS needs to be located for incoming calls if it is “on” while it is on the move
  - Data systems
    - MSs are connected ALL the time
    - To deliver packets efficiently, the MS must be located
- If the MS is not powered up, or unreachable the network should know what to do
  - Busy tone, buffering packets, etc.

Components of location management

- Location updates
  - Messages sent by the MS regarding the changing points of access to the network
  - The “anchor” is updated whenever these messages are transmitted
  - The anchor is usually the home database
- Paging
  - The location updates are not continuous
  - There is some uncertainty as to the exact cell in which the MS is located
  - The MS is “paged” to determine its exact location if there is an incoming call
- Location information dissemination
  - Procedures to store and distribute the location information of MSs

Issues in location management

- Tradeoffs between
  - Cost of the number and frequency of location updates
  - Cost of paging
- Case I:
  - Number of location updates is too frequent
  - Number of incoming messages few
  - Network load is too costly
    - Signaling consumes bandwidth
    - Processing and database updates are costly
- Case II:
  - Number of location updates is few and infrequent
  - A larger area needs to be paged in order to locate the MS
  - Resource waste
    - Paging in cells where the MS is not
  - Delay
    - Depending on how the paging is performed, the response from the MS may be delayed
    - e.g. Paging is performed in the cell in which the MS is located ***after*** paging other cells

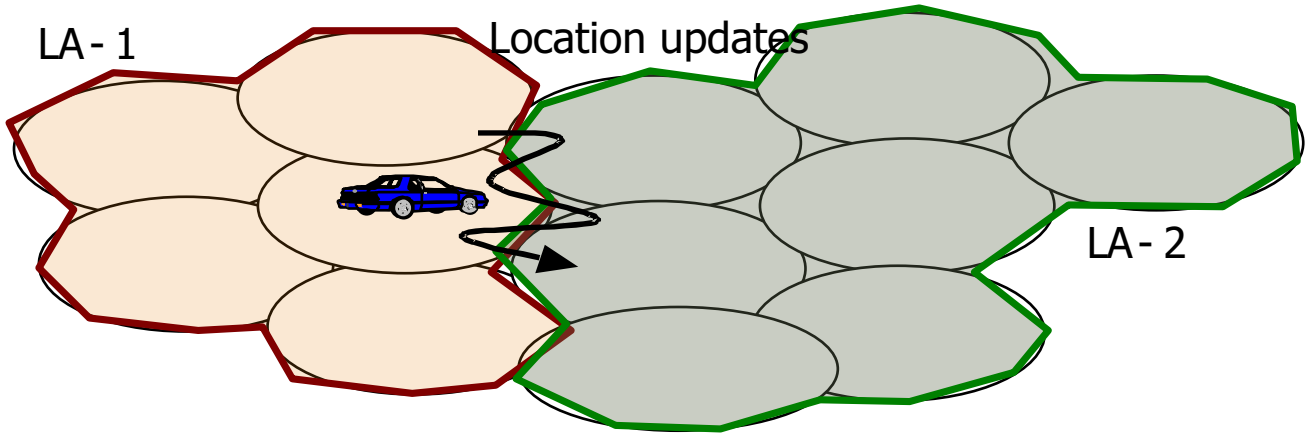
Location update algorithms (1)

- Static Algorithms
  - Network topology decides the updates
  - Most common approach is based on the “location area” (LA) concept
    - BSs are grouped into LAs
    - Each BS periodically broadcasts its LA over a control channel
    - When the MS discovers that the LA identifier has changed, it will initiate a location update with the new identifier
    - The databases are updated

Example of Static Location Updates in GSM

- The LA in GSM consists of all BTSs that are controlled by a BSC
- Location updates are performed
  - When the MS powers up and detects a change in LA identifier
  - When the MS crosses the boundary of a LA
  - Periodically after some time elapses
    - This time is determined by the network

Problems with static location updates



- If a MS frequently crosses a LA, it can lead to the ping-pong effect
- Common solution
  - Use a dwell timer
  - Use a biasing factor to define the cell boundary

Location update algorithms (2)

- Dynamic Algorithms
  - State-based
    - MS decides to make an update based on its current state
    - State information includes
      - Time elapsed since the last update
      - Distance traveled
      - Number of calls received
      - Number of LA's crossed
  - User-profile based
    - Maintains a sequential list of LAs where the MS is usually located (e.g. Oakland, Wilkinsburg, Monroeville)

Paging

- Broadcasting a message to the MS requiring it to respond in a group of cells where it is expected to be located
- Blanket paging
  - Page all cells in a LA simultaneously
  - Response is received in the first paging cycle – delays are reduced
  - Used in GSM
- Closest cells first
  - The cell in which the MS was last seen is paged first followed by the first ring of cells and so on
  - Sometimes several rings of cells are paged simultaneously like blanket paging

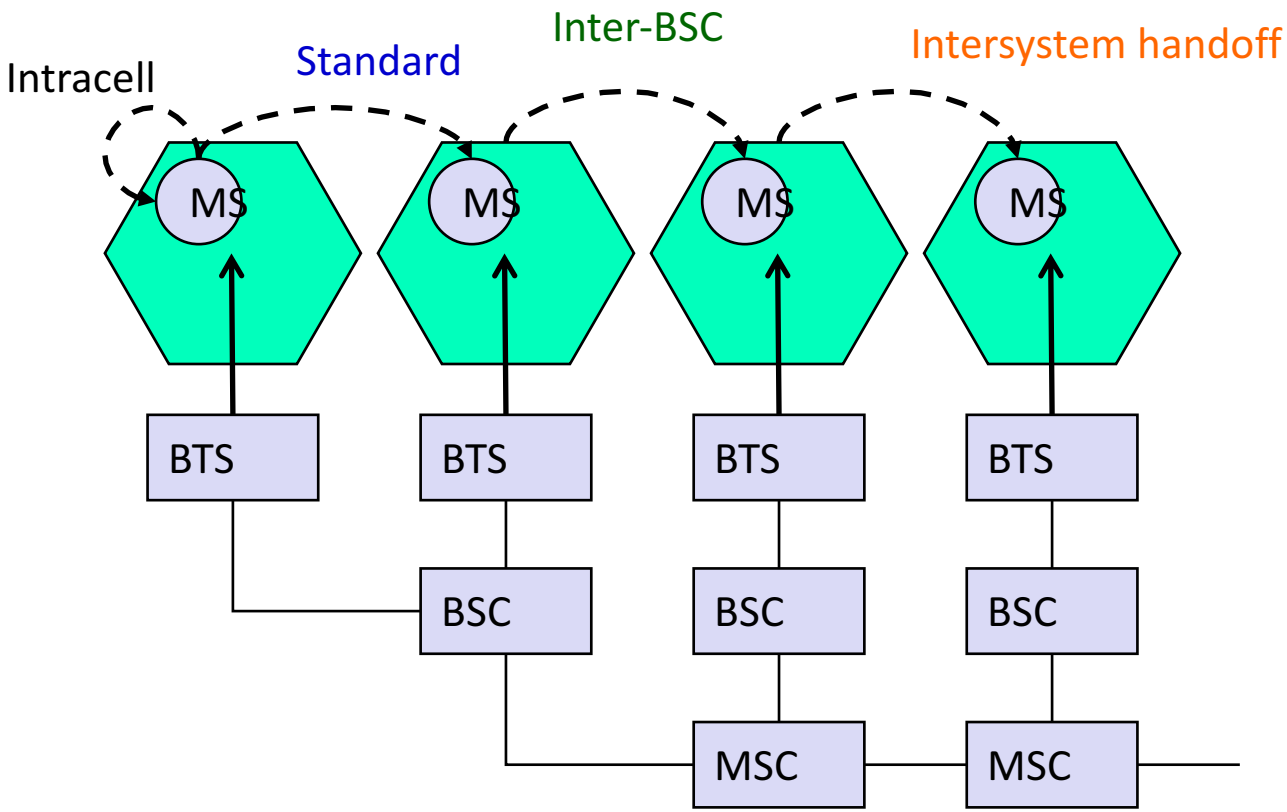
Location information dissemination

- At the bare minimum, the anchor in the network needs to be updated about the location of the MS
  - A single anchor for all MSs can lead to bottlenecks and failure
- The “home database” maintains all information associated with a MS
  - The MS identification
  - Authentication keys
  - Subscriber profile
  - Accounting
  - Location as determined by the “visiting database”
- The “visiting database” keeps track of MSs in its serving area and what happens to them
  - A single VDB may serve several LAs

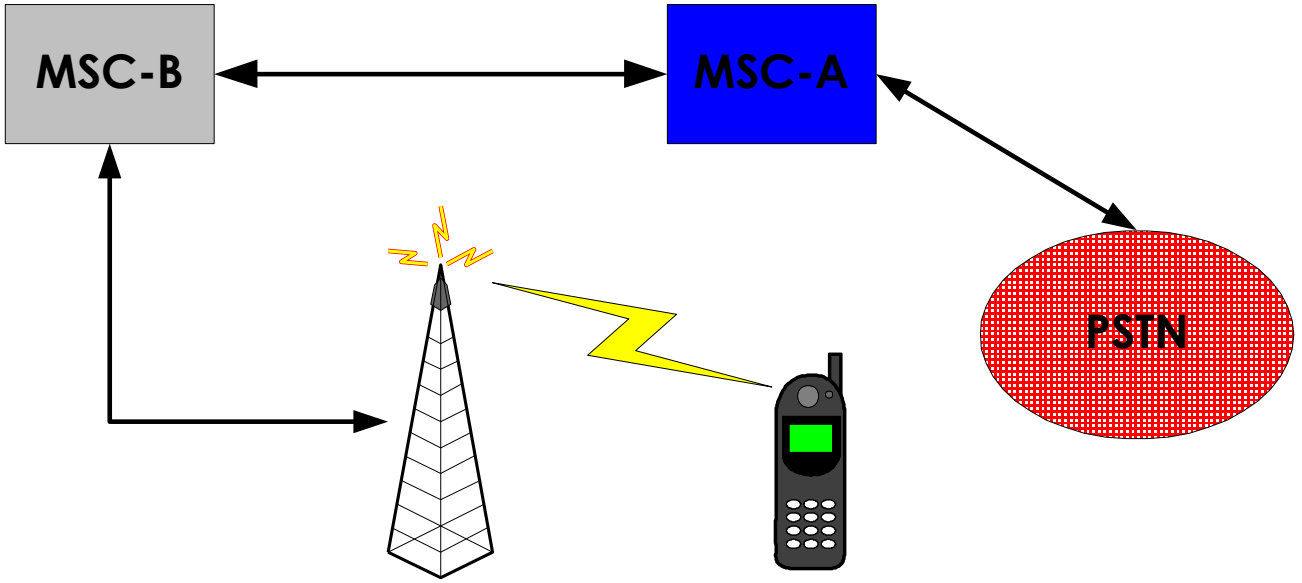
Handoff Management

- Two categories of handoff
  - Intrasystem handoff (3 cases)
    - Intra-cell handoff (different sector of same cell)
    - Standard handoff (cells attached to same BSC)
    - Inter BSC handoff (same MSC)
  - Intersystem handoff
    - Cells attached to two different MSCs
    - Require specialized signaling
    - Three cases
      - A. Handoff Forward
      - B. Handoff Back
      - C. Handoff to a Third

Types of Handoff



Intersystem Handoff – Handoff Forward

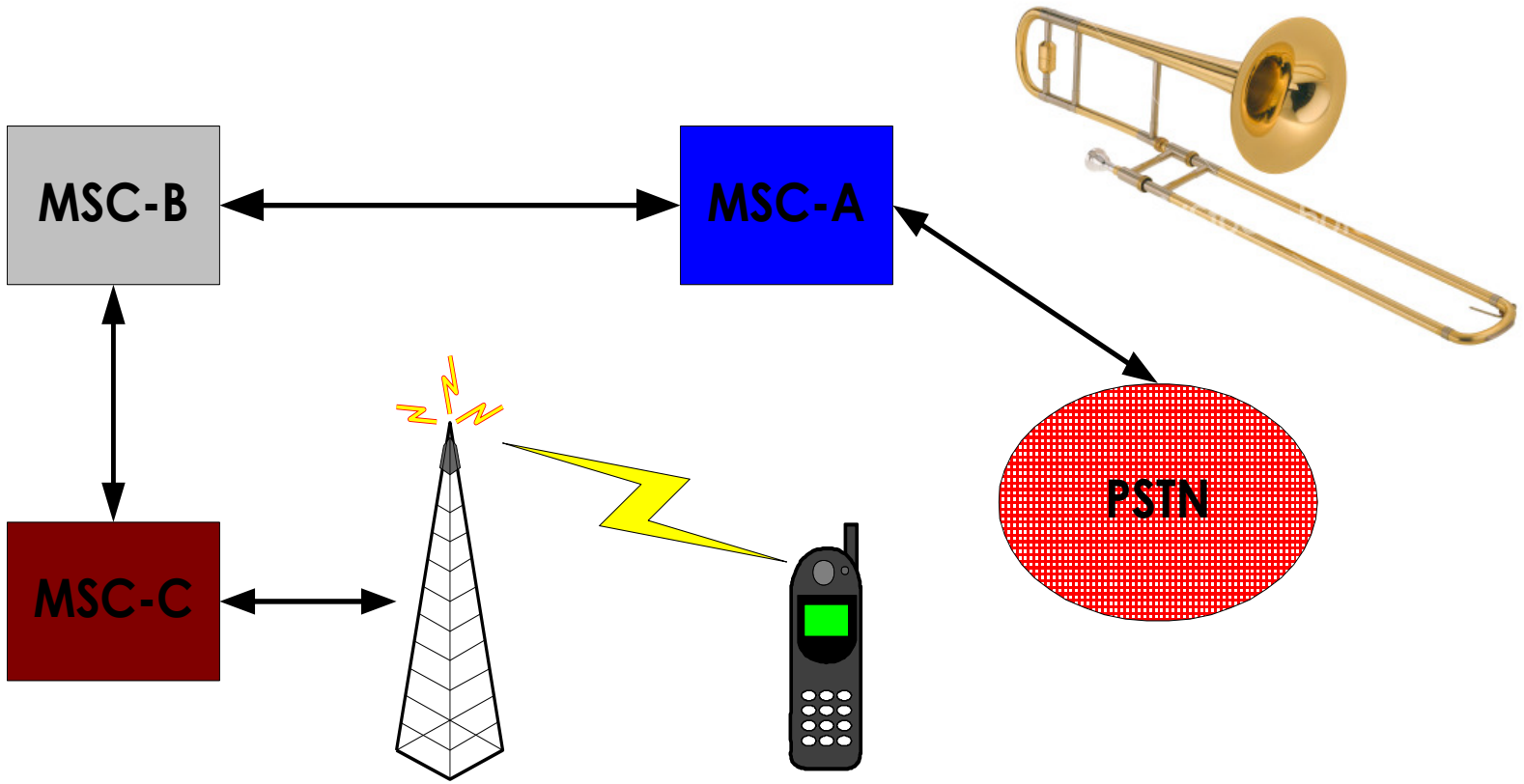


The situation after a handoff forward from System A (anchor system) to System B (serving system).

Handoff Back

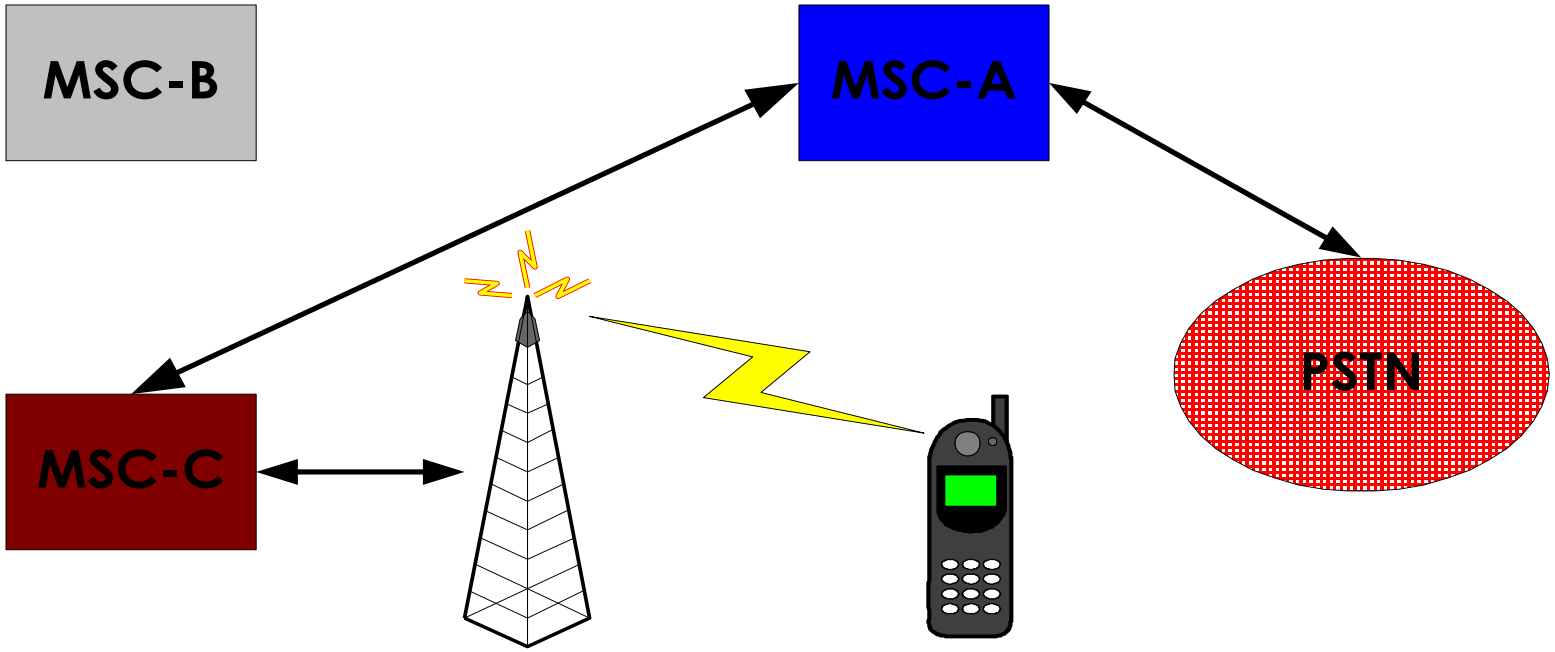
- After a Handoff Forward
  - From MSC-A to MSC-B
- User may move back to a cell attached to anchor MSC-A
  - Use HANDOFF BACK command to prevent call going from MSC-A to MSC-B back to MSC-A in wired network
- Called the “shoelace” effect

Trombone Effect



Simple Case of two Handoff Forwards – results in the call path shown above after handoff forward to System C.
Current Solution is HANDOFF to a THIRD command

Handoff to a Third

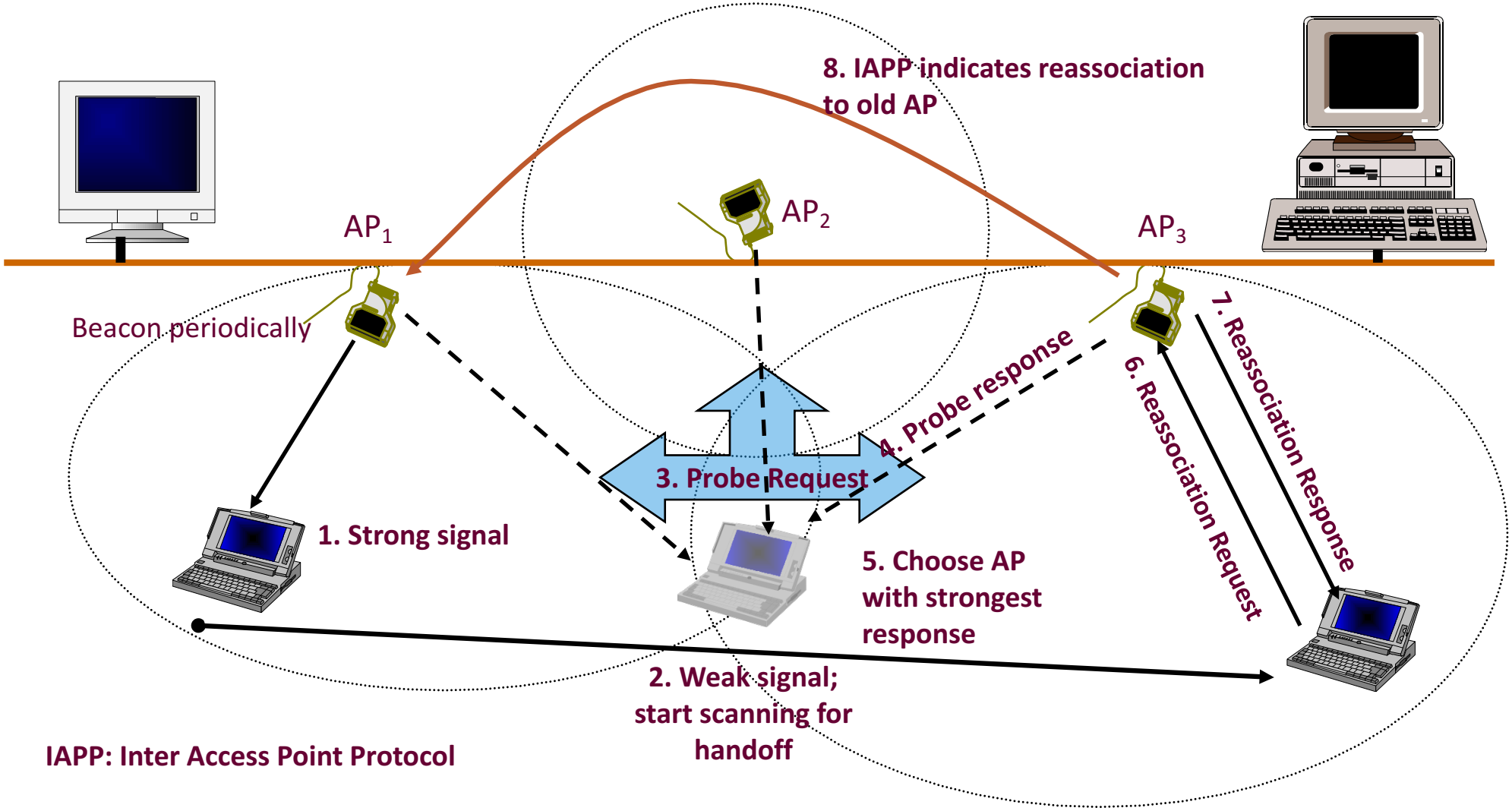


- If there are circuits connecting MSC-A and MSC-C, the system can perform handoff to third with this result.
- Yields better routes in wired network

IEEE 802.11 Mobility Types

- No Transition
  - MS is static or moving within a BSA
- BSS Transition
  - The MS moves from one BSS to another within the same ESS
- ESS Transition
  - The MS moves from one BSS to another BSS that is part of a new ESS
  - Upper layer connections may break (needs Mobile IP)

Handoff in 802.11



Inter-AP Protocol (802.11f)

- APs register with a “Registration Service” in the distribution system
  - They use the IAPP-INITIATE and IAPP-TERMINATE to register and deregister
- An MS in 802.11 can be associated with only one AP
- When the MS sends a reassociation request and obtains an association frame, the new AP sends an IAPP-MOVE-notify packet to the old AP
  - The old AP address is obtained from the registration service
  - If the registration service cannot be located, the AP will issue an IAPP-ADD-notify packet to the broadcast MAC address on the LAN
- The old AP sends an IAPP-MOVE-response packet with any context information it had for the MS