Lecture 12

CS 621
Mobile Computing

Other Location Management Strategies

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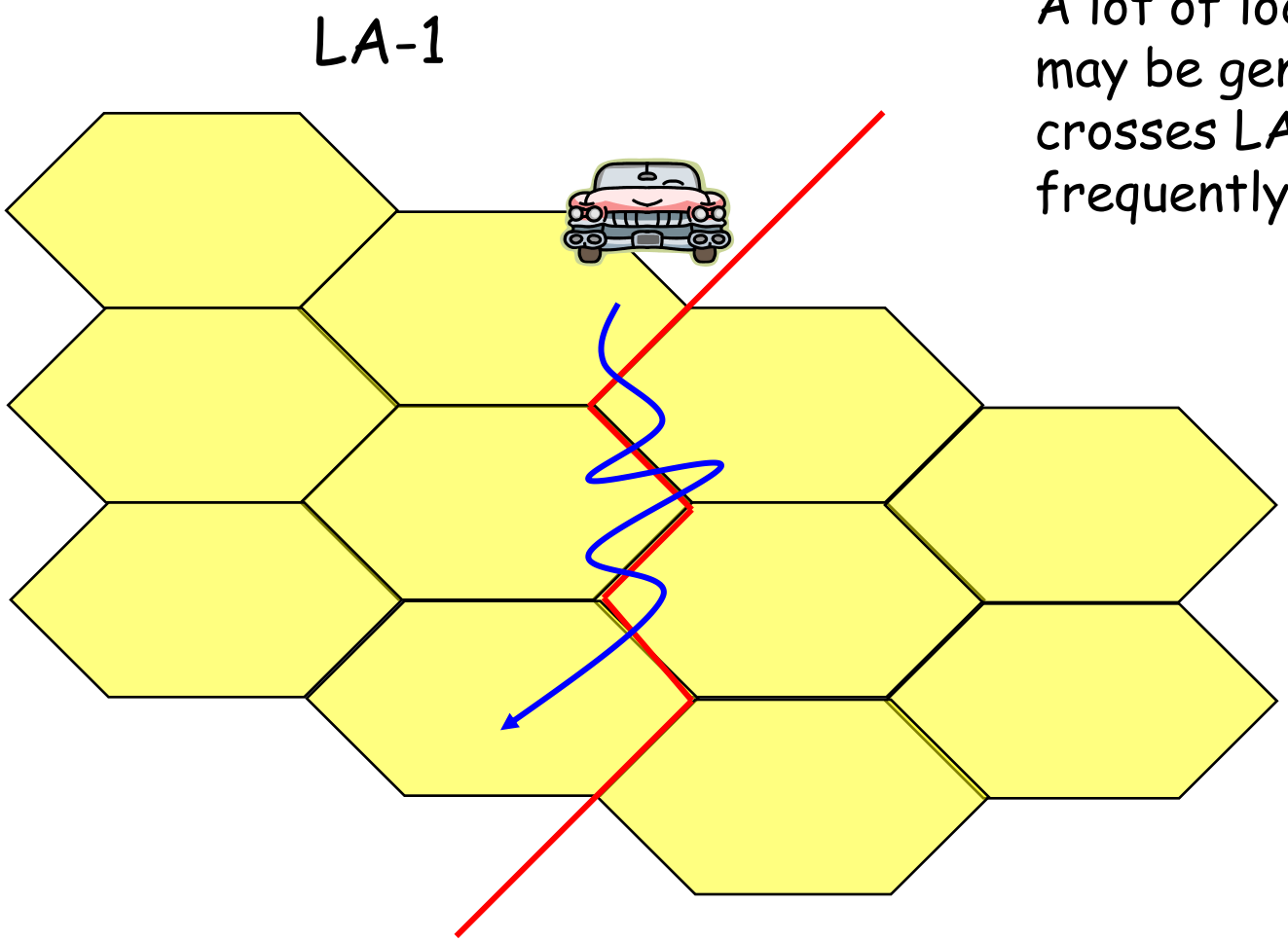
Several slides and images in this presentation have been taken from Prof. Nityananda Sarma's class notes/ppt.
Several images have been taken from the book Mobile Communication by Jochen Schiller.

Ping-Pong Effect



A lot of location updates may be generated if a user crosses LA boundary frequently.

Terminal Paging

- Terminal paging or paging is the process of determining the exact location of a particular MS by the network
- In each polling cycle/search iteration, polling signals are sent over the downlink control channel to all cells where the MS is likely to be present
- All MSs listen to the page mesg, and only the target MS sends a response mesg back over the uplink control channel.
- Each polling cycle has a timeout period. If the target MS replies before the timeout, paging process is terminated successfully.
- Otherwise, another group of cells is chosen in the next polling cycle

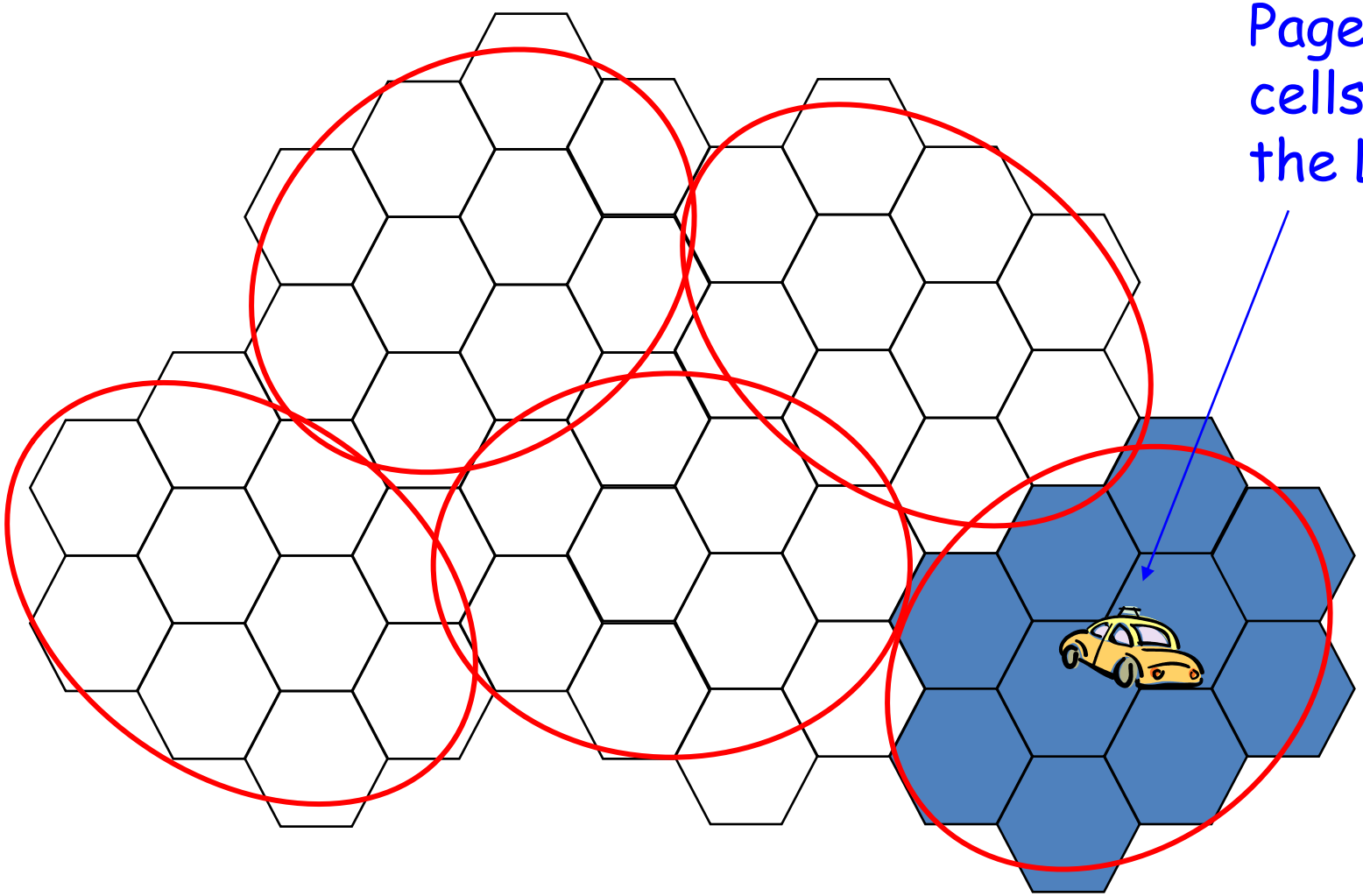
Terminal Paging (Cont'd)

- To avoid call dropping, the MS must be located within an allowable time limits.
- ***Maximum Paging delay*** corresponds to max number of polling cycles allowed to locate the MS
- ***Paging cost*** is proportional to the no. of polling cycles and the no. of cells being polled in each cycle
- Paging cost can be reduced by predicting the current location of the MS

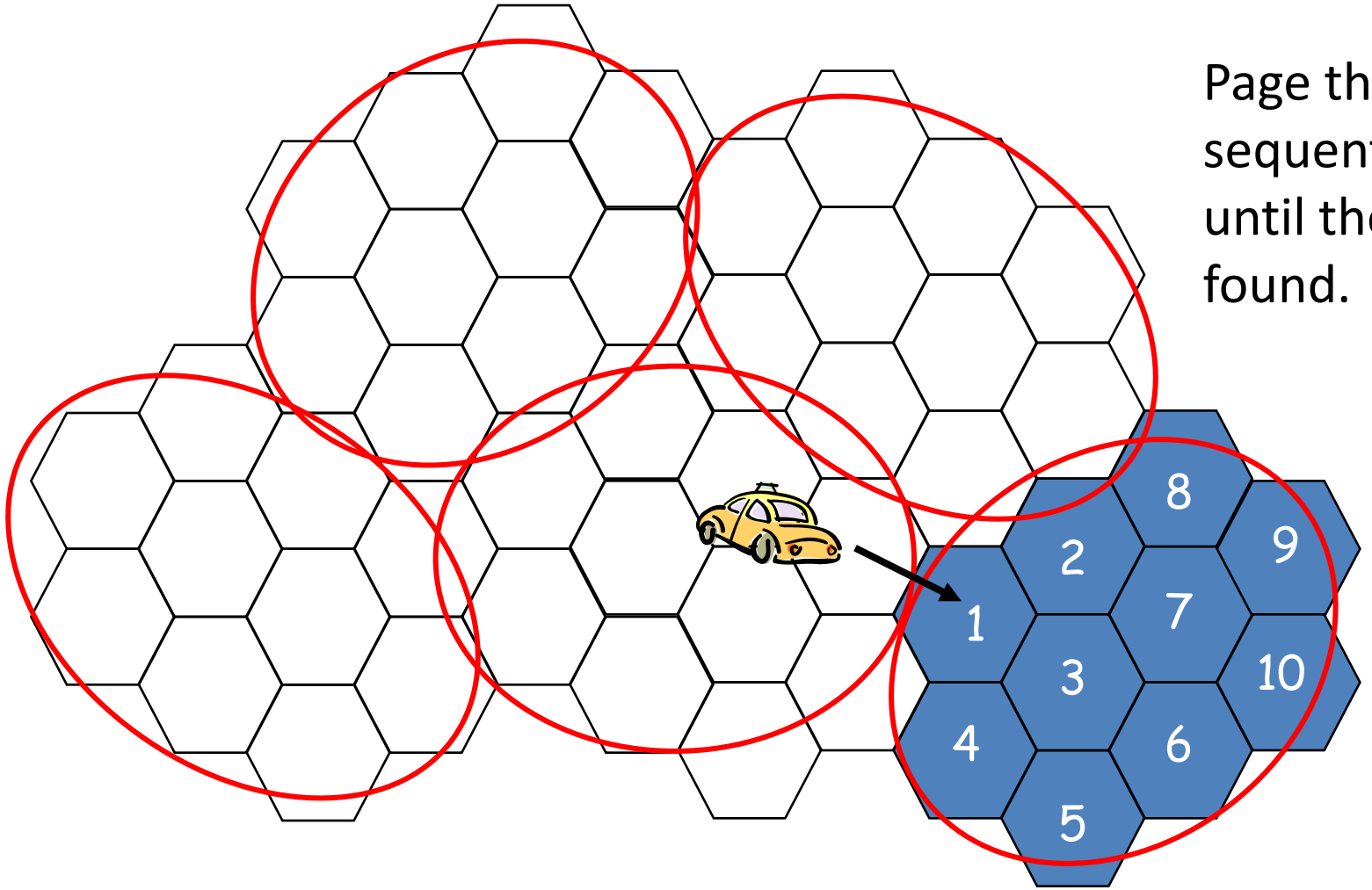
Terminal Paging Approaches

- **Blanket/Simultaneous Paging**: All the cells within the LA in which the MS is located are polled simultaneously
- Single polling cycle, deployed on top of LA based location update scheme (e.g., GSM)
- Drawback: Polling cost is very high (determined by the no. of cells within one LA), Generate Excessive amount of paging traffic
- **Sequential Paging**: Network pages the MS sequentially starting from one cell where the MS last updated its location, moving to next cell in a particular order.
- More polling cycles

Blanket Paging



Sequential Paging

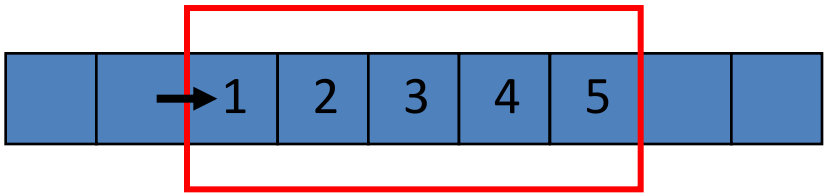


Page the cells sequentially until the user is found.

How to determine paging order?

- Method 1: Shortest Distance First
  - Pages the user starting from the cell where he last updated his location.
  - Move outward in a shortest-distance-first order.
  - Ties are broken arbitrarily.

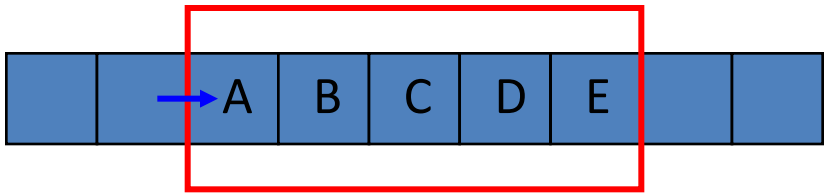
Example: (in a highway)



Last Location Update

How to determine paging order?

- Method 2: Based on Location Probability
  - Estimate the probability that a user is located in each cell within the current LA.
  - Page the cells in decreasing order of probability.
- Example: (in a highway)



Last Location Update

Suppose Prob. Distribution is:

{0.05, 0.2, 0.4, 0.25, 0.1}

Paging order: C, D, B, E, A

Paging Delay

- In our previous example, the **expected delay** is

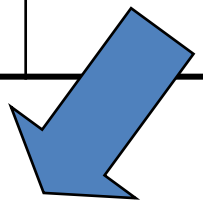
$$E[D] = 0.4 \times 1 + 0.25 \times 2 + 0.2 \times 3 + 0.1 \times 4 + 0.05 \times 5$$
$$= 2.15 \text{ (paging cycles)}$$

- Worst-case delay is **5** paging cycles.

- The expected number of cells to be paged is also **2.15**.
- Worst-case: **5** cells.

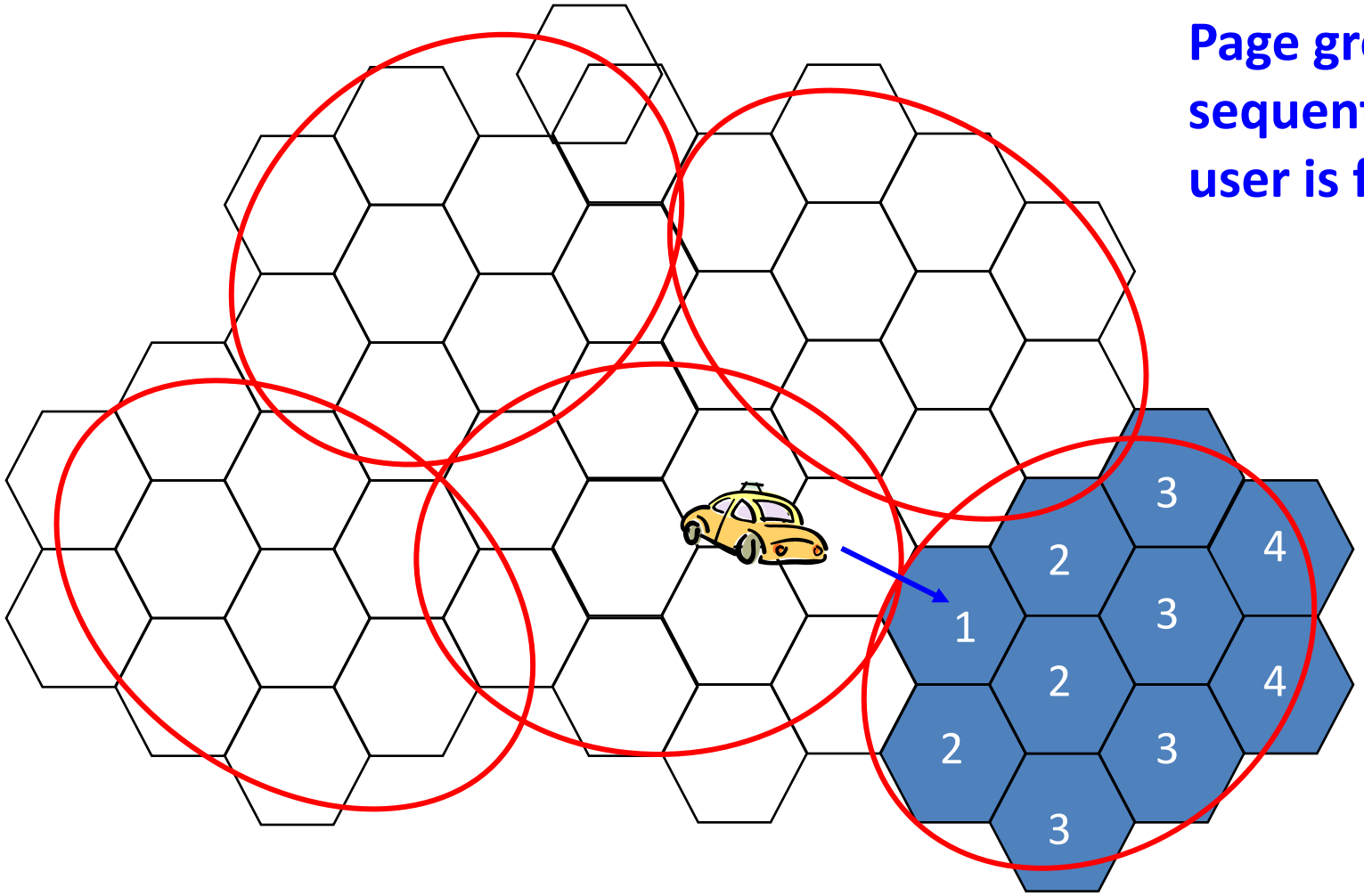
Blanket Paging vs. Sequential Paging

	Blanket	Sequential
Paging cost	Large	Small
Paging delay	Small	Large



Sequential group paging may be used if there is a constraint on paging delay

Sequential Group Paging



Page groups of cells sequentially until the user is found.

Worst case delay is 4 cycles.

Database Management

- Location Update
  - Involves the **updating** of location databases
- Call Delivery
  - Involves the **querying** of location databases
- The cost is very high if the MS is located far away from its HLR.
  - e.g. if the MS is roaming in Europe and its HLR is in INDIA.

Database Management

Three Enhancement Methods:

- Per User Location Caching
- User Profile Replication
- Forwarding Pointers

Per-User Location Caching

- Every time user ***x*** is called, ***x***'s locaton is cached at the VLR in the caller's LA.
- Any subsequent call to ***x*** originated from that LA can reuse this information.
  - No need to contact user ***x***'s HLR.
  - Accordingly, Call Delivery Procedure discussed earlier should be modified (Check How?)
- If the user has changed its location (i.e. LA), then some strategy for cache updation/ invalidation is required

Per-User Location Caching (cont'd)

Cache Invalidation

- Eager Caching
  - Whenever a user moves to a new LA, all cache entries for this user's location are updated.
  - Location update cost increases if a user moves frequently.
- Lazy Caching
  - Cache update is not performed.
  - Two cases can occur: a hit or a miss
  - **In case of a miss**,
    - contact the HLR
    - there is an additional cost, since the cached VLR must be visited first.

User Profile Replication

- Observation:
  - Each user usually communicates frequently with a small number of sources.
- How can we make use of this observation?
- User profiles are replicated at selected databases to reduce the cost of querying the HLR.

User Profile Replication

- When a call is initiated from a certain LA, the corresponding MSC determines if a replication of the called MS's user profile is available locally.
  - If available, no HLR query is needed.
- When the MS moves to another location, the network updates all replications.

Pointer Forwarding

Each time a user moves to a new LA, a forwarding pointer is set up from its pervious VLR to point to the new VLR.

Calls to the user will first query the HLR to determine the first VLR and then follow the chain of VLRs to reach the current VLR.

The length of the pointer chain is limited to a maximum value *N*.

This method can reduce the cost of updating the HLR.

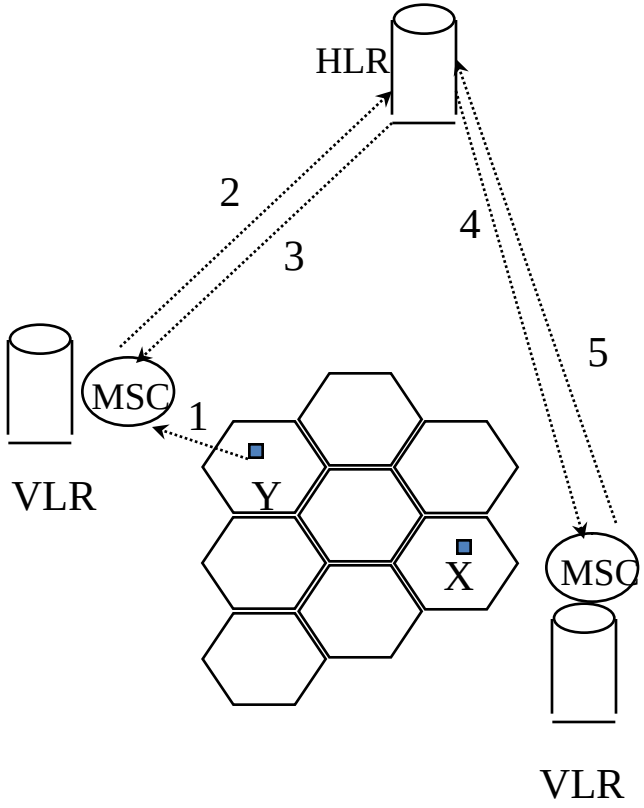
THANKS!

Location Updation

A mobile M moves from position X to Y and updates its location

- 0 : M sends location updation message to BS
- 1 : BS forwards it to MSC
- 2 : MSC looks up in its VLR,

  if M is not found, it queries HLR
- 3 : HLR updates the VLR for M, and sends an ack.
- 4 : HLR also sends a registration cancellation message to the old VLR (at position X)
- 5 : Old VLR sends ack.

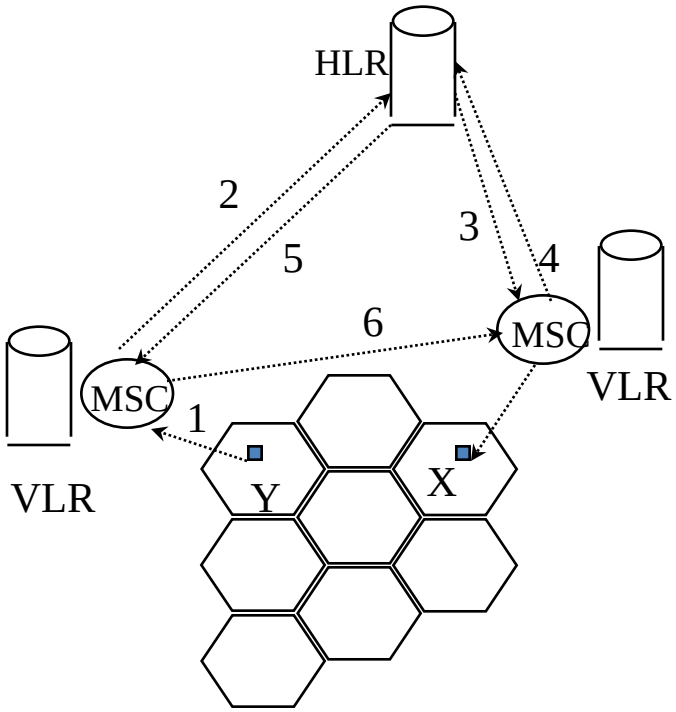


A costly process when Y is far away from its HLR

Search for Call Delivery

A mobile Y sends a call request for X

- 1 : BS sends the call request of Y to MSC
- 2 : MSC forwards it to HLR of X
- 3 : HLR sends it to the last-known MSC of X
- 4 : MSC of X pages its location area, finds X, and sends the information to HLR.
- 5 : HLR sends this information to MSC of Y
- 6 : MSC of Y communicates with MSC of X



sending paging signals consumes radio bandwidth