

*Location, Handoff
Management and HLR-VLR*

Location and Handoff Management

- The current point of attachment or location of a subscriber (mobile unit) is expressed in terms of the cell or the base station to which it is presently connected.
- The mobile units (called and calling subscribers) can continue to talk and move around in their respective cells; but as soon as both or any one of the units moves to a different cell, the location management procedure is invoked to identify the new location.

Location and Handoff Management

- The location management performs three fundamental tasks:
 - (a) location update,
 - (b) location lookup, and
 - (c) paging.
- In location update, which is initiated by the mobile unit, the current location of the unit is recorded in HLR and VLR databases.
- Location lookup is basically a database search to obtain the current location of the mobile unit and through paging the system informs the caller the location of the called unit in terms of its current base station.
- These two tasks are initiated by the **MSC**.

Location and Handoff Management

- The cost of update and paging increases as cell size decreases, which becomes quite significant for finer granularity cells such as micro- or picocell clusters.
- The presence of frequent cell crossing, which is a common scenario in highly commuting zones, further adds to the cost.
- The system creates *location areas* and *paging areas* to minimize the cost.
- **A** number of neighboring cells are grouped together to form a location area, and the paging area is constructed in a similar way.

Mobility Management

- Location Management
 - Search: find a mobile user's current location
 - Update (Register): update a mobile user's location
 - Location info: maintained at various granularities (cell vs. a group of cells called a registration area)
 - Research Issue: organization of location databases
 - Global Systems for Mobile (GSM) vs. Mobile IP vs. Wireless Mesh Networks (WMN)
- Handoff Management
 - Ensuring that a mobile user remains connected while moving from one location (e.g., cell) to another
 - Packets or connection are routed to the new location

Handoff Management

- Decide when to handoff to a new access point (AP)
- Select a new AP from among several APs
- Acquire resources such as bandwidth channels (GSM), or a new IP address (Mobile IP)
 - Channel allocation is a research issue: goal may be to maximize channel usage, satisfy QoS, or maximize revenue generated
- Inform the old AP to reroute packets and also to transfer state information to the new AP
- Packets are routed to the new AP

Tradeoff in Location Management

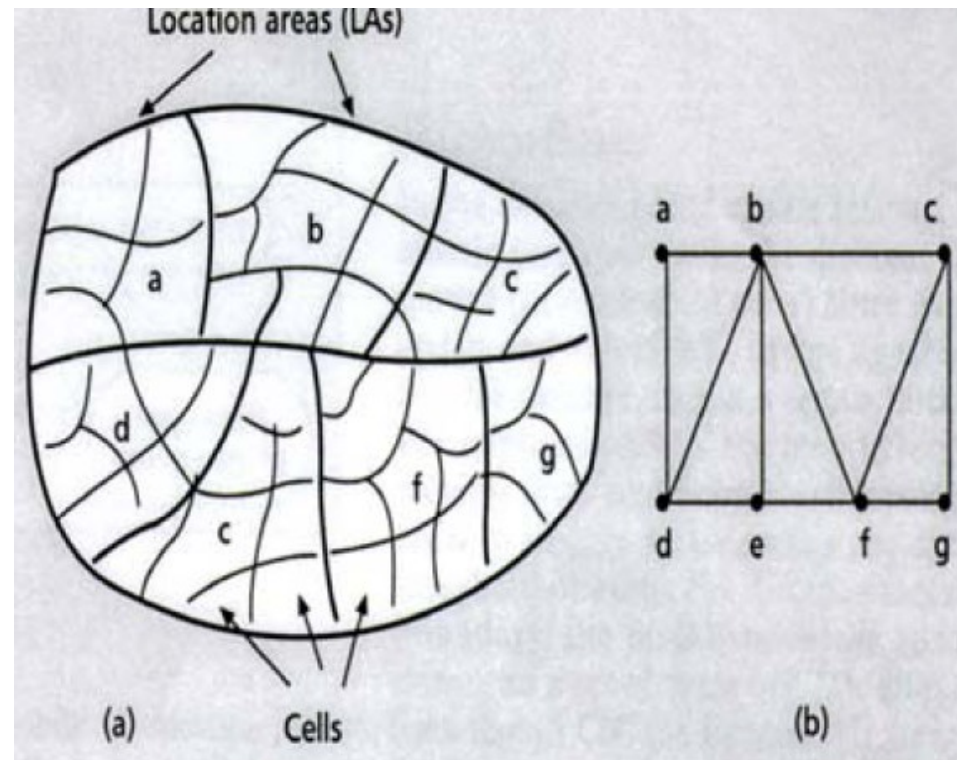
- Network may only know approximate location
- By location update (or location registration):
 - Network is informed of the location of a mobile user
- By location search or terminal paging:
 - Network is finding the location of a mobile user
- A tradeoff exists between location update and search
 - When the user is not called often (or if the service arrival rate) is low, resources are wasted with frequent updates
 - If not done and a call comes, bandwidth or time is wasted in searching

Registration Area (RA) and the Basic HLR-VLR Scheme

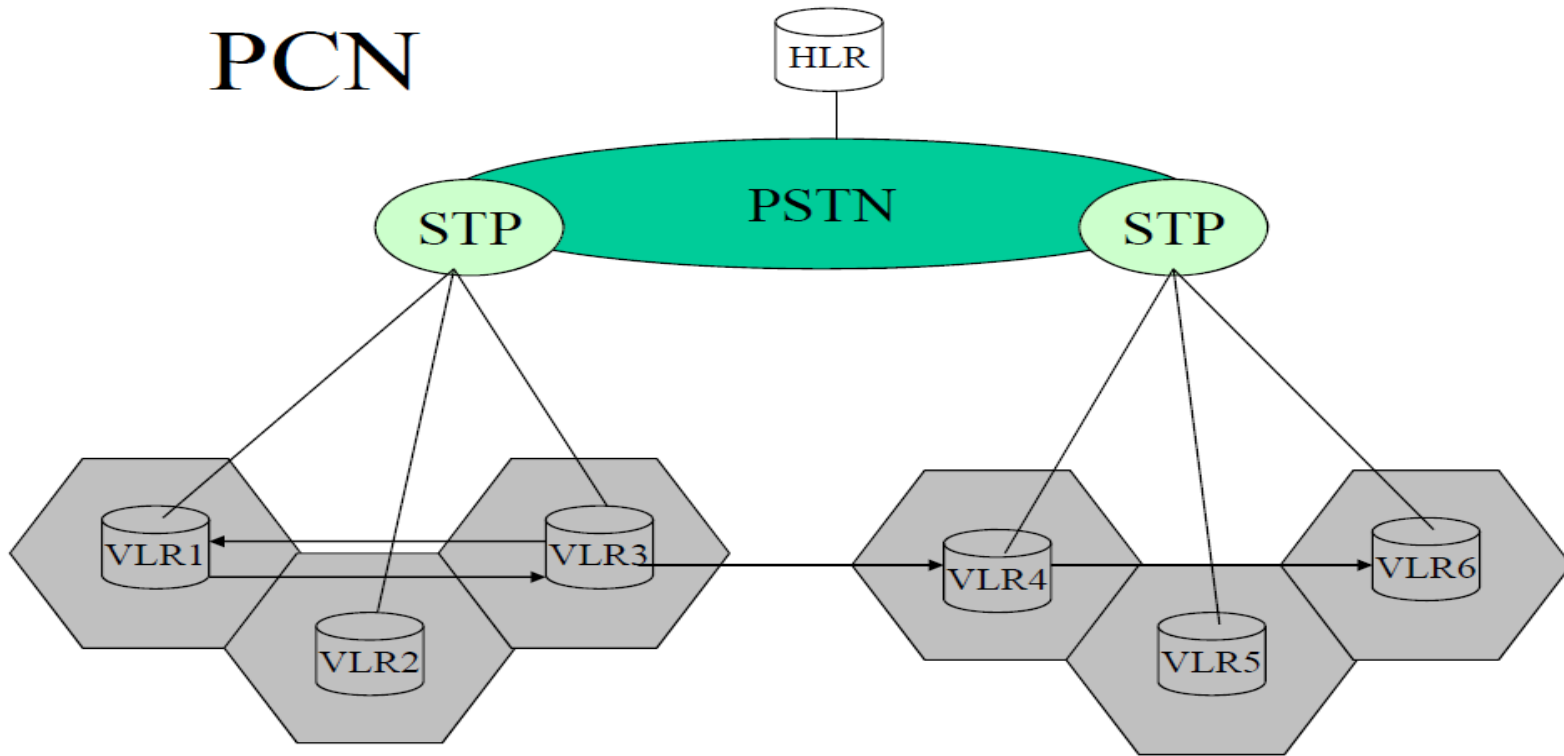
- Current Personal Communication Service (PCS) networks (i.e., cellular networks such as GSM) use RA-based basic HLR-VLR schemes:
 - The service coverage area is divided into registration areas (RAs), each with a visitor location register ([VLR](#))
 - Each RA covers a group of base stations (cells).
 - A user has a permanent home location register ([HLR](#))
 - Base stations within the same RA broadcast their IDs
 - If ID is sensed different by the mobile terminal then a terminal, location update is sent to the VLR of the current RA.
 - When crossing a RA boundary, an update is sent to the HLR.
 - A search goes by HLR->VLR->cell->paging (by the base

Registration Areas in a PCN

- The figure on the right shows a PCS network
 - RA topology
 - RA graph model



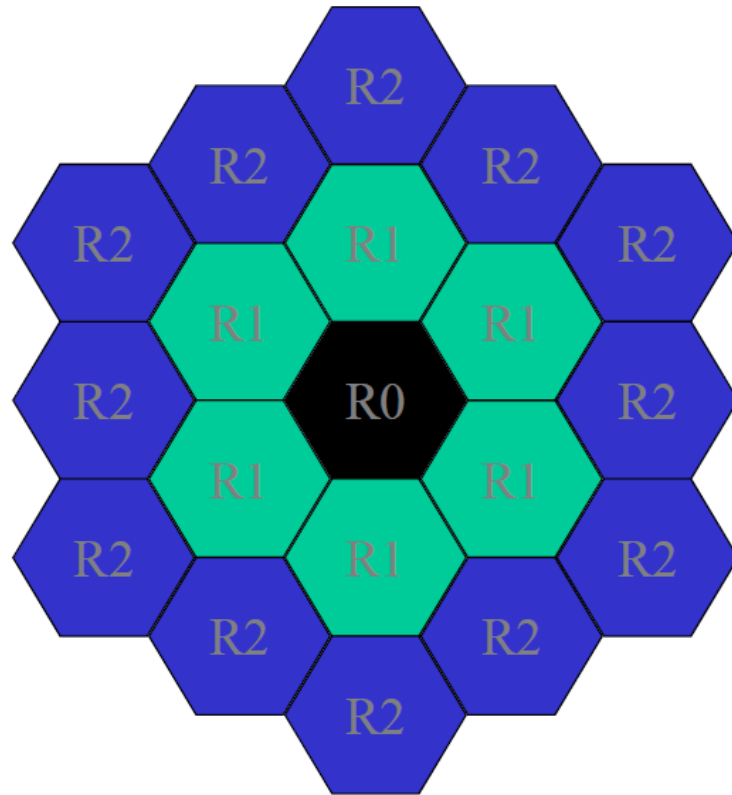
PCN



PSTN: Public Switched Telephone Network
STP: Service Transfer Point

HLR: Home Location Register
VLR: Visitor Location Register

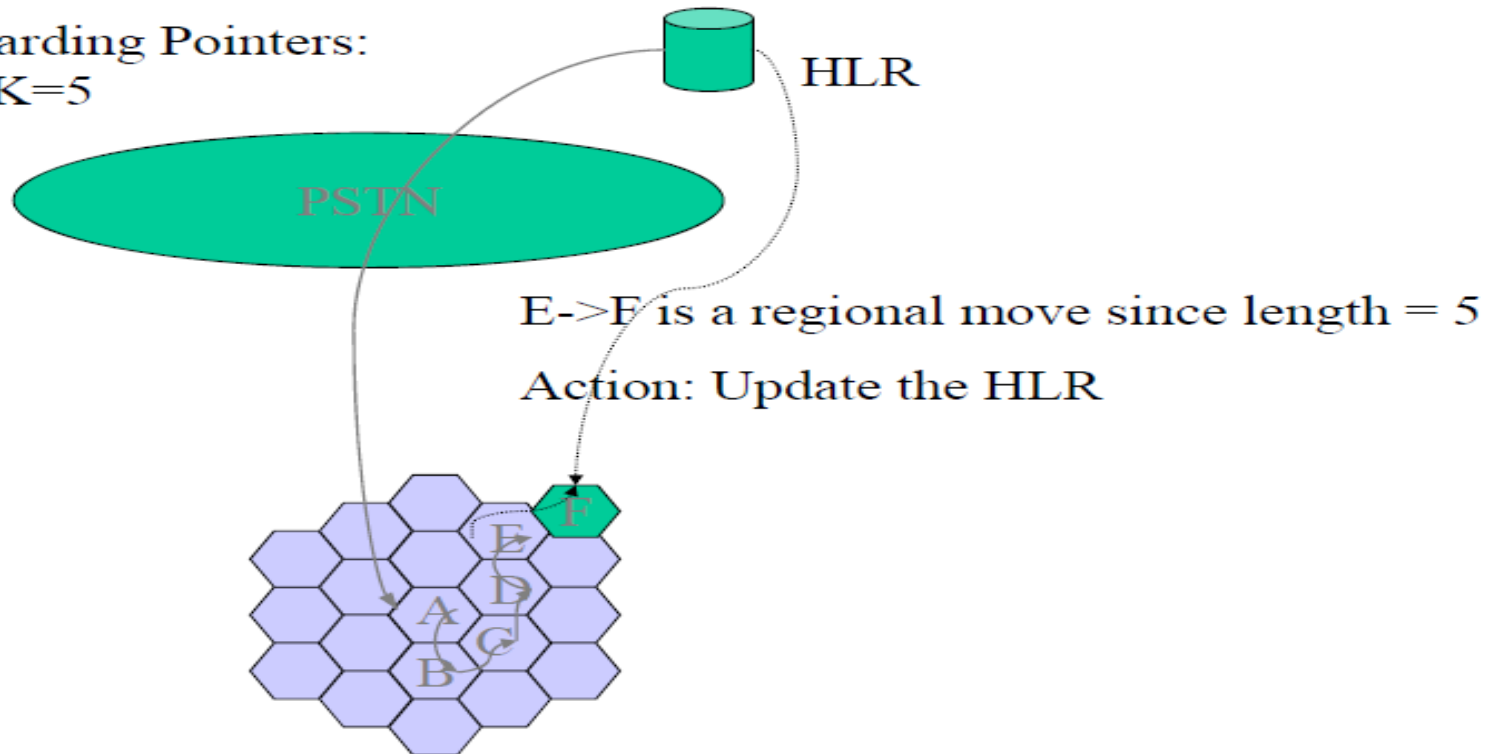
Hexagonal
Network
Coverage
Model for PCN



Forwarding Pointers (Ref [1])

- Update (upon crossing a RA boundary)
 - When the length of forwarding pointers $< K$:
Set up a pointer between the two involving VLRs
 - When the length of forwarding pointers $= K$:
Update information to the HLR
- Search
 - HLR \rightarrow VLR0 \rightarrow \rightarrow VLRi \rightarrow cell \rightarrow paging

Forwarding Pointers:
with $K=5$



A->B->C->D->E are all local movements since the length of the forwarding chain is less than $K=5$

Action: Put a forwarding pointer between the two involving VLRs

How Big Should K be for Forwarding Pointers?

- The cost “saving” due to forwarding for a location update operation is τ where τ is the cost of accessing a remote registrar (approximately).
- The “increased” cost per search operation is $K\tau$ to follow the forwarding pointers of length K .
- Let λ be the call arrival rate (incurring search) and σ be the mobility rate (incurring location update). Then the increased cost due to search operations per unit time is $\lambda K\tau$, while the cost saving due to update operations per unit time is $\sigma\tau$
- When $\sigma\tau > \lambda K\tau$, or $\sigma/\lambda > K$, it makes sense to have forwarding pointers. In other words, K should be bounded by σ/λ , the reciprocal of λ/σ , or the reciprocal of the call to mobility ratio (CMR)

What's the problem of this analysis?

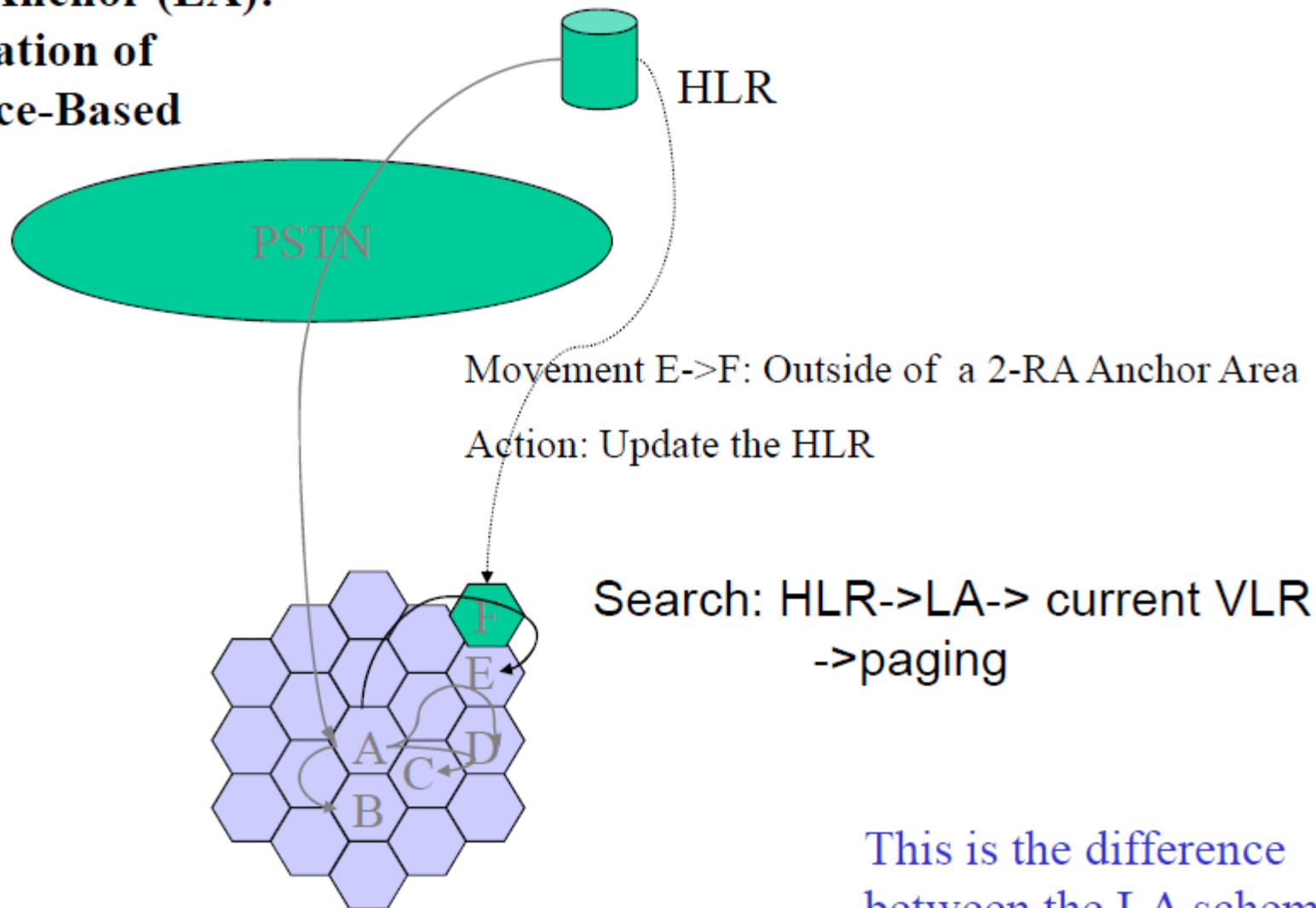
Dynamic Location Update

- Location update algorithms can be static or dynamic
 - With static, an update is triggered because of crossing of RA boundaries, e.g., the basic HLRVLR scheme
 - With dynamic, update or not depends on a user's call and mobility patterns
- Dynamic Location update schemes:
 - Time-Based, Movement-Based, Distance-Based

Dynamic Location Update Schemes

- Time-Based: A mobile terminal updates in every T time units
- Movement-Based: A mobile terminal counts the number of boundary crossings and performs the update when a threshold is exceeded (e.g. $M=6$)
 - Forwarding pointers can be considered as a variation of it.
- Distance-Based: A mobile terminal tracks the distance (in terms of RAs) it has moved since the last update.
 - Update is performed when a distance threshold is exceeded
 - Mobile terminal needs some knowledge of the network topology
 - Local Anchor can be considered as a variation of it.

Local Anchor (LA): A Variation of Distance-Based



Movement E->F: Outside of a 2-RA Anchor Area
Action: Update the HLR

Search: HLR->LA-> current VLR
->paging

This is the difference
between the LA scheme
vs. a pure
distance-based scheme

Local Movement: within the 2-RA Anchor Area

Update Action: Update the LA (VLR A)

Update Time Interval for Time-Based Schemes

- Suppose T is the time interval for performing a location update
- Assume a search operation performs an expanding ring search
- Let λ be the call arrival rate and σ be the mobility rate. Then the maximum area to be searched is a circle of radius $\sigma * \min(1/\lambda, T)$ cells.
- Normalize each update operation with a cost of 1
- Normalize each search operation with a cost of $\sigma * \min(1/\lambda, T)$
- The cost of time-based management per unit time is:
 - $C = \lambda * \sigma * \min(1/\lambda, T) + 1/T$
- When $1/\lambda < T$, $C = \sigma + 1/T \approx \sigma$
- When $1/\lambda > T$, $C = \lambda * \sigma * T + 1/T$. Take $dC/dT=0$, $T_{opt}=1/\sqrt{\sigma\lambda}$, implying that when either σ or λ increases, T_{opt} decreases

LeZi Update

- Based on a compression algorithm by Ziv and Lempel
- LeZi is a **path-based** update algorithm by which the movement history, not just the current location, is sent in an update message from the mobile user to the location database server
 - The history has a list of IDs of the zone (LA or cell) the mobile terminal has crossed.
 - The location database keeps the history in compact form by means of a search tree structure (called a **LeZi trie**)
- Can be part of the user's profile
 - On a call arrival, prediction of the current cell is given and selective paging is performed