Avoidance of Bottleneck in PCS Network

Sidhi Pandey[1], Alka[2], Pratima Singh[3]

[1, 2, 3] (Computer Science & Engineering, Institute of Technology & Management, India)

Abstract:

This paper contains the concept of Personal Communication Service (PCS) network and schemes to avoid bottleneck in PCS network. One of the key issues in mobile communication is to find the current location of mobile terminal (MT) to deliver the services, which is called as location management. In this paper we will discuss various schemes for improving location management in PCS network and focus on surveying the location management mechanisms in PCS system.

Keywords: De-registration, hand-off, HLR/VLR, Location Management, Mobile terminal, MSC, PCS.

1. Introduction:

Cellular communication has been experiencing a rapid growth in recent years. From its introduction in the early 1980s, cellular communication has been evolved from a costly service with limited availability toward an affordable alternative to wired telephone service. This wide acceptance of cellular communication has led to the development of a new generation of mobile communication network called personal communication services, which can support a large mobile subscriber population while providing various types of services unavailable to traditional cellular system [1].Personal Communication Services networks provide wireless communication services that enable mobile terminals to transfer any form of information between any locations at any time. To support user mobility, the Personal Communication Services networks have to store and maintain location information of mobile stations so that an incoming call can be delivered to the target Mobile Station. The operations on location information consist of location updates and location queries. An update occurs when a Mobile Station changes location. A query occurs when a Mobile Station needs to be located, e.g., to deliver an incoming call to this Mobile Station. The widespread deployment of Personal Communication Services will lead to a tremendous increase in the number of updates and queries to the location database. Thus, a key challenge to location management is to develop efficient database architecture so that the location data can be readily available for signaling such as call setup and routing [1].

2. Location management:

In cellular systems a mobile unit is free to move around within the entire area of coverage. Its movement is random and therefore its geographic allocation is unpredictable. This situation makes it necessary to locate the mobile unit and record its location to Home Location Register and Visitor Location Register when a call has to be delivered to it. Thus, the entire process of the mobility management component of the cellular system is responsible for two tasks:

2.1 Location Management:

It is identification of the current geographical location or current point of attachment of a mobile unit which is required by the Mobile Switching Center to route the call.

2.2 Hand-off:

It is transferring (handing off) the current (active) communication session to the next base station, which seamlessly resumes the session using its own set of channels.

The entire process of location management is a kind of directory management problem where current locations of MU are maintained continuously. Location management involves tracking of Mobile Terminal's location, moving from place to place so as to provide those services timely. Two basic operations in mobility tracking are: location update and paging. Basically, whenever Mobile Terminal moves out of its current LA, its geographical location information is updated to the nearest Base Station. On a call arrival, the network searches the called Mobile Terminal by sending polling signals to the vicinity of last reported location of Mobile Terminal. This searching process is called paging. The total Location Management cost is generally calculated by summing up the cost of location update and paging. Normally, the Location Update costs higher than paging. The network can require more frequent Location Updates, in order to reduce paging cost. Inversely, the network may require rare Location Updates, storing less information about user mobility to reduce computational overhead, but at a higher paging cost. To reduce the total location management cost, it is essential to provide good trade-off among paging and Location Update operations One of the main objectives of efficient location management schemes is to minimize the communication overhead due to updating of Home Location Register. The other related issue is the distribution of Home Location Register to shorten the access path, which is similar to data distribution problem in

distributed database systems. Motivated by these issues, recently a number of innovative location management schemes have appeared in the research world.

The location management approaches can broadly be classified as: Centralized approaches and Distributed approaches. Centralized approach keeps information only on one node in the mobile network. For example, existing location management standards, IS-41 and Global System for Mobile Communication are centralized approaches. Location lookup and update operations are simple in this case but they suffer from severe problems like congestion, central point failure etc. In Distributed approaches user information is distributed among many nodes in the network. This has better stability in comparison to centralized approach but location lookup and update operations are somewhat complex in this case. However, many schemes have come forward to solve this problem [7].

3. Conventional HLR/VLR scheme:

In this section we will describe the existing standard of location management along with the approaches to overcome its drawbacks. The two popular standards used are Global System for Mobile Communication and IS-41. They make use of two types of registers namely, Home Location Register and Visitor Location Register. These two registers are used to store the location information of the mobile terminals [3]. Figure 1 shows the basic architecture under this two-level hierarchy.

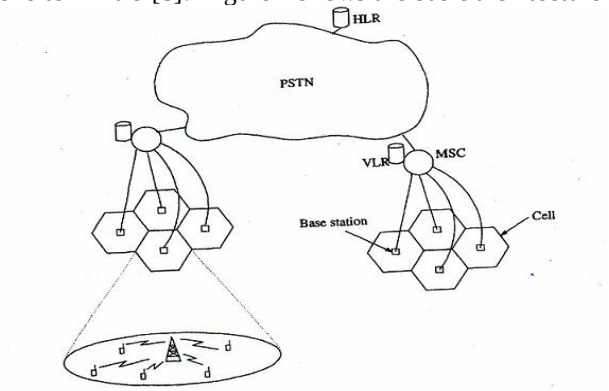

Figure 1: Standard Personal Communication Network architecture

The Home Location Register stores the user profiles of its assigned subscribers. These user profiles contain information such as the type of services subscribed, the quality-of-service requirements and the current location of the mobile terminals. Each Visitor Location Register stores replications of the user profiles of the subscribers currently residing in its associated LA. In order to effectively locate a mobile terminal when a call arrives, each mobile terminal is required to report its location whenever it enters a new LA. This reporting process is called location update. On receiving a location update message, the Mobile Switching Center updates its associated Visitor Location Register and transmits the new location information to the Home Location Register. We call this register update process as location registration. The Home Location Register will acknowledge the Mobile Switching Center for the successful registration and it will also deregister the mobile terminal at the Visitor Location Register of old LA. In order to locate a mobile terminal for call delivery, the Home Location Register is queried to determine the serving MSC of the target mobile terminal. The Home Location Register then sends a message to this Mobile Switching Center which, in turn, will determine the serving base station of the mobile terminal by paging all cells within its associated LA. This location tracking scheme requires the exchange of signaling messages between the Home Location Register and the new and old Mobile Switching Center's whenever the mobile terminal crosses an LA boundary. This may result in significant traffic load to the network especially when the current location of the mobile terminal is far away from its Home Location Register and the mobile terminal is making frequent movements among LA's. Besides, the Home Location Register may experience excessively high database access traffic as it is involved in every location registration and call delivery. This may result in increased connection set up delay during periods of high network utilization [3].

The major steps of the IS-41 location registration scheme are as follows (Fig 2)

Step 1: The mobile terminal moves into a new LA and sends a location update message to the nearby base station.

Step 2: The base station forwards this message to the new serving Mobile Switching Center.

Step 3: The new Mobile Switching Center updates its associated Visitor Location Register, indicating that the mobile terminal is now residing in its services area and sends a location registration message to the Home Location Register.

Step 4: The Home Location Register sends a registration acknowledgement message to the new Mobile Switching Center/ Visitor Location Register together with a copy of the subscriber's user profile.

Step 5: The Home Location Register sends a registration cancellation message to the old Mobile Switching Center/ Visitor Location Register.

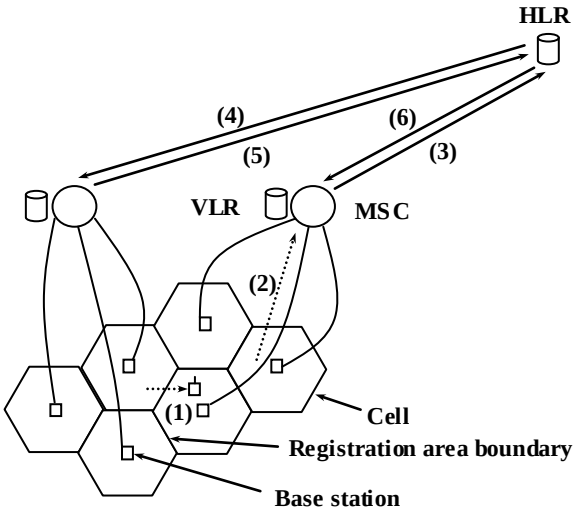

Figure 2: Location registration

Step 6: The old Mobile Switching Center removes the record for the mobile terminal at its associated Visitor Location Register and sends a cancellation acknowledgment message to the Home Location Register.
The IS-41 call delivery scheme is outlined as follows (Fig. 3)

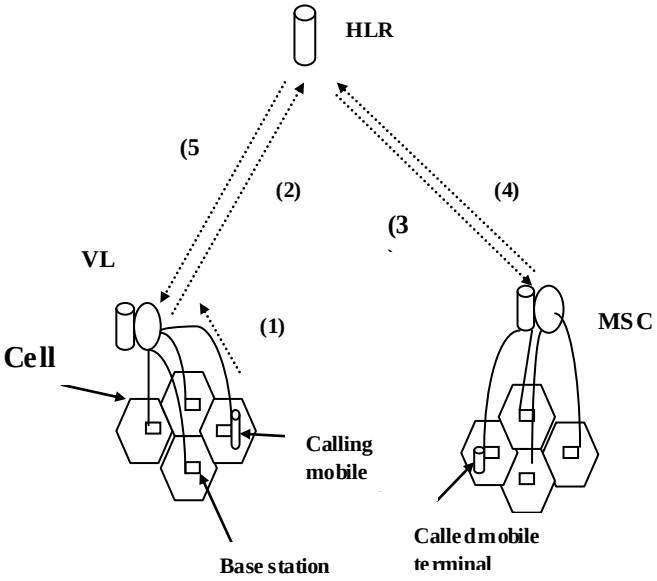

Figure 3: Call delivery

Step 1: The calling mobile terminal sends a call initiation signal to its serving Mobile Switching Center through the nearby base station.
Step 2: The Mobile Switching Center of the calling mobile terminal sends a location request message to the Home Location Register of the mobile terminal.
Step 3: The Home Location Register determines the current serving Mobile Switching Center of the called mobile terminal and sends a route request message to this Mobile Switching Center.
Step 4: The Mobile Switching Center determines the cell location of the called mobile terminal and assigns a temporary location directory number to the called mobile terminal. The Mobile Switching Center then sends this Temporary Location Directory Number to the Home Location Register.
Step 5: The Home Location Register sends the Temporary Location Directory Number to the Mobile Switching Center of the calling mobile terminal. The calling Mobile Switching Center can now set up a connection to the called Mobile Switching Center through the PSTN.

IS-41 and Global System for Mobile standards imply centralized approach, which has some disadvantages: Since every location request as well as location registration is serviced through an Home Location Register, it becomes overloaded. Due to the above reason, traffic on the links leading to the Home Location Register is heavy, which increases time required to establish connection to the mobile host. Any Home Location Register system failure causes all mobiles registered with Home Location Register to be unreachable even though mobile host may be roaming and away from Home Location Register region. Thus Home Location Register is a single point of failure in the network.

4. Modified HLR/VLR Scheme:

In conventional approach when a Mobile Terminal moves from one LA to another LA, which are served by different Visitor Location Register s, for registration of Mobile Terminal at new Visitor Location Register a signal message is transferred to Home Location Register from it, which sends a signal message to old Visitor Location Register to deregister the Mobile Terminal and upon getting an acknowledgement of De-registration from old Visitor Location Register, Home Location Register acknowledges to new Visitor Location Register for registration. This De-registration method is referred to as *explicit de-registration***.** The explicit De-registration scheme may produce significant signaling traffic in the network and require many accesses to the database involved. Due to the increasing number of mobile subscribers, the access rate to the Home Location Register and the Visitor Location Registers is expected to be very high and the databases could possibly become the bottle-neck of the future mobile systems.

Implicit De-registration and timeout/polling deregistration were proposed to reduce signaling traffic and database load due to deregistration. But the comparative study done by Z. Mao, it has been found that by using group deregistration strategy deregistration cost can be reduced significantly. Since this strategy reduces the cost of message transferring as well as database operation which will ultimately reduce total cost of location management. In modified HLR-VLR scheme we try to ignore explicit De-registration message to old Visitor Location Register and its acknowledgement to Home Location Register. Hence when new Visitor Location Register finds a new mobile unit it simply sends a message to Home Location Register which acknowledges the new Visitor Location Register to register it. So signal no. 5 & 6 of fig. 3 can be avoided.

5. Multi HLR Architecture Scheme In PCS Network:

In conventional HLR-VLR scheme, De-registration of a Mobile Terminal from a Visitor Location Register is always explicit. Explicit in the sense that stale entries of Visitor Location Register s are removed with the help of Home Location Register. Actually Home Location Register sends De-registration message to the Visitor Location Register to remove the stale entries when a Mobile Terminal changes its Visitor Location Register. This explicit De-registration increases the total cost by increasing the traffic load. To reduce the traffic load following De-registration strategies were proposed [2].

(A) Distance Based De-registration Scheme.
(B) Time-Based De-registration Scheme.
(C) Polling-Based De-registration Scheme.
(D) Group De-registration Scheme.
(E) Movement-Based De-registration Scheme.

Performance analysis of De-registration strategies in Personal Communication Network shows that the group de-registration scheme is best scheme among time and polling based de-registration schemes.

In the proposed architecture, we have several HLRs zone wise or circle wise instead of a single Home Location Register. It reduces the storage overhead of the Home Location Register. Each Home Location Register can serve more than one Visitor Location Register and each Visitor Location Register can serve more than one RAs. Simply we can say that this architecture contains several conventional HLR-VLR architectures. For each Mobile Terminal we define two types of HLRs: a resident-HLR and a serving-HLR. Resident-HLR is the Home Location Register where Mobile Terminal often resides. While on move, it can enter into the RA being served by another Home Location Register (serving-HLR). When Mobile Terminal will be served by the Home Location Register other than resident- Home Location Register, we will refer it as roaming. In the proposed architecture we define following types of move as:

5.1 Intra-VLR-Resident-HLR Move:

In this type of move, the Mobile Terminal changes its RA and the new RA is still being served by the same Visitor Location Register. The serving Visitor Location Register is being served by the resident-HLR. Now it is obvious that the location update is taking place only at Visitor Location Register not at resident-HLR.

Intra-VLR-Resident-HLR move is shown in fig (4). An Mobile Terminal residing in registration area RA1 moves to another registration area RA2. RA1& RA2 are being served by the same Visitor Location Register, VLR1. The VLR1 is being served by the resident-HLR. Due to movement of Mobile Terminal, this location update is changed at VLR1 not at resident-HLR

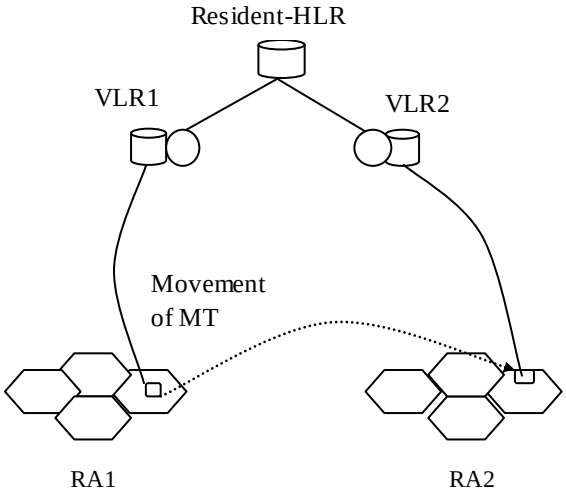

Figure 4: Intra-VLR-Resident-HLR move

5.2 Intra-VLR-Serving-HLR Move:

In this type of move, the Mobile Terminal changes its RA and the new RA is still being served by the same Visitor Location Register. The serving Visitor Location Register is being served by the serving-HLR. Again this information is only updated at Visitor Location Register not at serving-HLR and resident-HLR.

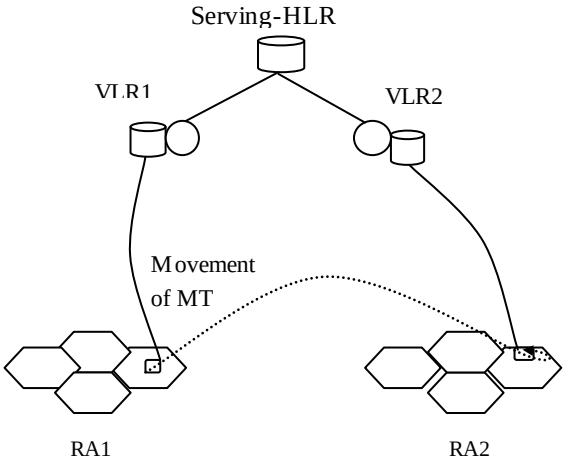

Figure 5: Intra-VLR-Serving-HLR move

Intra-VLR-Serving-HLR move is shown in fig (5). An MT residing in registration area RA1 moves to another registration area RA2. RA1& RA2 are being served by the same Visitor Location Register, VLR1. The VLR1 is being served by the serving-HLR. Due to movement of MT, this location update is changed at VLR1 not at serving-HLR and resident-HLR.

5.3 Inter-VLR-Resident-HLR Move:

In this type of move, the MT changes its RA and the new RA is being served by the new Visitor Location Register. The serving Visitor Location Register is being served by the resident-HLR. Now in this case registration of MT will take place at new Visitor Location Register, de-registration of Mobile Terminal will take place at old Visitor Location Register and finally resident-HLR will update this information in its database.

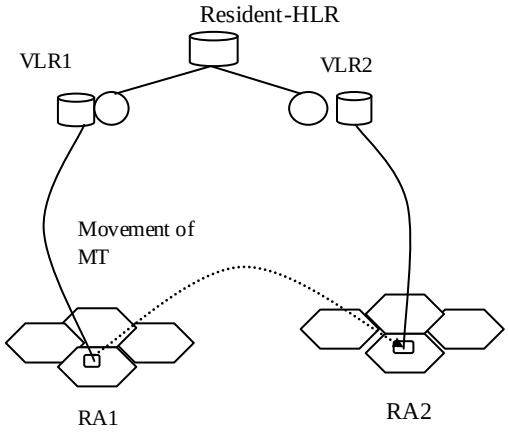

Figure 6: Inter-VLR-Resident-HLR move

Inter-VLR-Resident-HLR move is shown in fig (6). An MT is residing in registration area RA1 which is being served by the VLR, VLR1. This VLR1 is being served by the resident-HLR. On move MT changes its registration area and comes in RA2. This RA2 is being served by the VLR2.Now the registration of Mobile Terminal will take place at VLR2 and De-registration will take place at VLR1. This change in location update will take place on resident-HLR.

5.4 Inter-VLR-Serving-HLR Move:

In this type of move, the MT changes its RA and the new RA is being served by the new Visitor Location Register. The serving VLR is being served by the serving-HLR. Now in this case registration of Mobile Terminal will take place at new VLR, De-registration of Mobile Terminal will take place at old VLR and finally serving-HLR will update this information in its database. However resident-HLR will not be updated. Inter-VLR-Serving-HLR move is shown in fig (7). An MT is residing in registration area RA1 which is being served by the VLR, VLR1. This VLR1 is being served by the serving-HLR. On move Mobile Terminal changes its registration area and comes in RA2. This RA2 is being served by the VLR2.Now the registration of MT will take place at VLR2 and de-registration will take place at VLR1. This change in location update will take place on serving-HLR. Resident-HLR will remain unaffected.

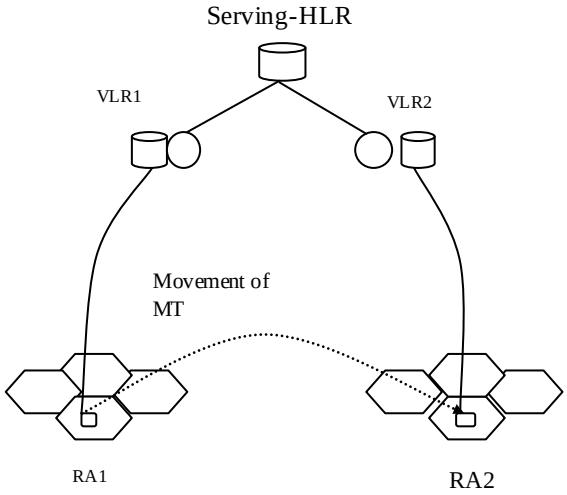

Figure 7: Inter-VLR-Serving-HLR move

5.5 Inter-VLR-Inter-HLR Move:

This type of move occurs into two cases.

1) This type of move occurs when an MT comes back to its resident-HLR from serving-HLR. In this move MT's registration occurs at serving VLR of resident-HLR and this information is sent back to the serving-HLR.

2) On reception of this message serving-HLR de-registers this MT from its database and informs to its VLR (where MT was registered previously) for de-registration.

This case is shown in fig (8). Mobile Terminal is residing in the registration area RA2 of Visitor Location Register2 of serving-HLR. On move Mobile Terminal comes under VLR3 of resident-Home Location Register. In this case both Visitor Location Registers and Home Location Registers change. The Mobile Terminal is now in its resident-HLR. Registration of Mobile Terminal will take place at Visitor Location Register3 and resident-HLR while it's De-registration

will take place at serving-Home Location Register and its corresponding Visitor Location Register where Mobile Terminal was previously resided.

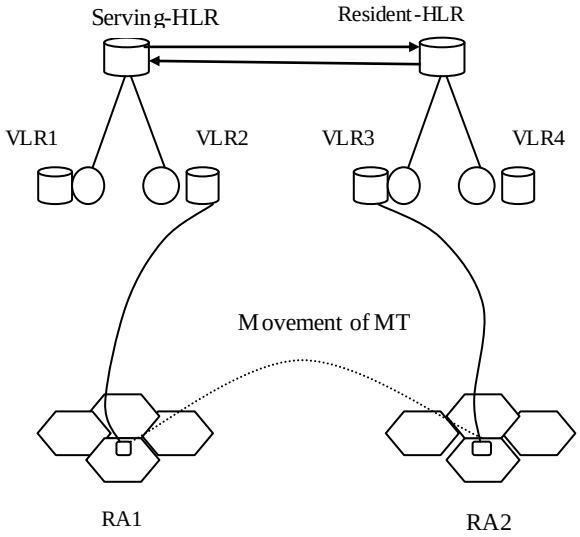

Figure 8: Inter-VLR-Inter-HLR move

3) When a Mobile Terminal moves to another serving-HLR. In this case registration of Mobile Terminal takes place at new serving-Home Location Register and its Visitor Location Register under which Mobile Terminal comes, de-registration occurs at the previous serving- Home Location Register and its associated Visitor Location Register from where Mobile Terminal is coming and resident-Home Location Register is updated.

6. Performance analysis of various location management schemes:

An analytical model to evaluate the performance of the conventional HLR/VLR architecture and a comparison of the same is made with the modified HLR/VLRs. In this analysis, a hierarchical tree of R layers is used, as shown in Fig. 9. The layer R contains the root node and the layer 1 contains the leaf nodes. A database is installed on each node of the tree and the Mobile Terminals are assigned to the leaf nodes. In the HLR/VLRs scheme, the network database, Home Location Register, is situated on the only node of layer R and the Visitor Location Registers are installed on the leaf nodes.

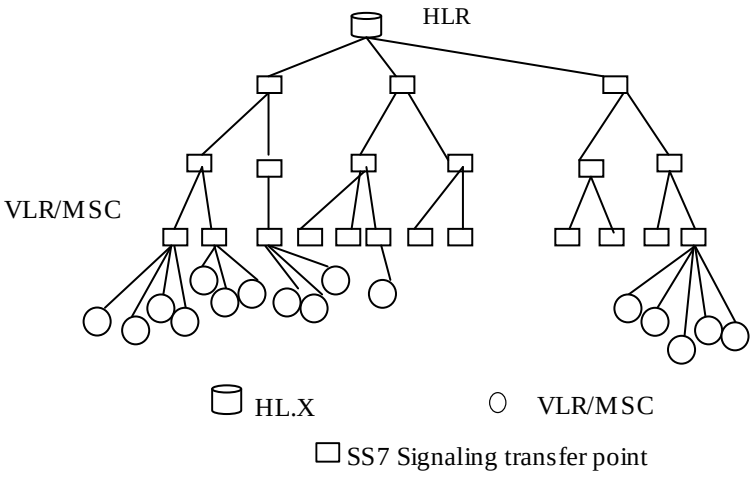

Figure 9: HLR/VLR Architecture

Since total cost consist of location update and location search so total cost is also reduced in modified HLR/VLR scheme. So it can be concluded that proposed modified version of HLR/VLR performs better than the conventional schemes for location management. Also it is observed that the proposed modified HLR/VLR scheme is better than the conventional one as the signaling cost and database updating cost is significantly reduced by using group deregistration strategy for location update only.

Conventional architecture has a single Home Location Register and that's why it suffers from call misrouting and bottleneck during peak load. To remove this, several conventional architectures are group together to form multi Home

Location Register architecture. Now in user profile replication scheme even in high load appropriate information is fetched from Home Location Registers and we significantly minimize the possibility of call misrouting.

7. Conclusion:

In this study, we defined the location management problem and its terminology, reviewed some of the main accomplishments achieved by researchers in the field, and established the fundamental issues that impact this problem. We also attempted to compare the solutions qualitatively according to their effectiveness for different types of updating techniques. That analysis led us to propose a new taxonomy for location management techniques in mobile and wireless environments based on several important factors. In closing, it is worth speculating on the long-term impact of location management issues on mobile and wireless environments and their design. The future for wireless and mobile computing is promising indeed, especially since technological advances continue to support more sophisticated applications for these environments.

References

[1] Guan-Chi Chen and Suh-Yin Lee, "Evaluation of Distributed and Replicated HLR for Location Management in PCS Network," Journal Of Information Science And Engineering 19, 85-101 (2003).
[2] Rajeev R. Kumar Tripathi, Sudhir Agrawal and Swati Tiwari, "Performance Analysis of De-registration Strategy in Personal Communication Network," IJCA, vol.24-no.1, June 2011.
[3] Rajeev R. Kumar Tripathi, Sudhir Agrawal and Swati Tiwari, "Modified HLR-VLR Location Management Scheme in PCS Network," IJCA, vol.6-no.5, Sept 2010.
[4] Sarvpal H. Singh, Sudhir Agrawal and Vijay Kumar "Performance Evaluation of Location Management Techniques in PCS Networks," IJCA, vol.15, no-8, Feb-2011.
[5] S. Mohan and R. Jain, "Two user location strategies for personal communication services," *IEEE Personal Communications*, Vol. 1, 1994.
[6] Haider Safa and Samuel Pierre, "A New Architecture for Improving Location management in PCS Network," Journal of Computer Science1 (2):249-258, 2005.
[7] Sarvpal H. Singh, Sudhir Agrawal and C. Ramakrishna "Location Management optimization schemes for Cellular System," IJCA, vol.4, no-4, july-2010
[8] Rajeev R. Kumar Tripathi, G S Chandel and Ravindra Gupta, "Multi HLR Architecture for improving location management in PCS Network," IJCA, vol.51-no.20, August 2012.