Profile Forwarding Scheme in PCS Network

Rajeev R. Kumar Tripathi[1], G.S. Chandel[2], Ravindra Gupta[3]

Abstract— The PCS network uses two-tier database architecture to locate a mobile terminal (MT). This two tier architecture has: Visitor Location Register (VLR) and Home Location Register (HLR). In HLR, profile of an MT is permanently stored while VLR is used as a cache memory. Each VLR may serve one or more registration area (RA). When an MT comes in a new VLR, profile of newly joined MT is fetched from the HLR and stored in the VLR. In existing location management, there is a single HLR. During busy hours this single HLR may be in bottleneck state. This situation leads to call miss routing. When a call is initiated, the current location of called MT is fetched from the HLR. In the conventional location management and call delivery scheme, the HLR is always queried. When an MT only performs movement, location registration process is executed and finally HLR is updated. This paper is proposing a concept of MT profile forwarding scheme to avoid the HLR from the bottleneck and call misrouting. In the conventional scheme if both called and calling MT are residing in the same VLR, to get the current location of the called MT, the HLR is queried. This is known as tromboning problem. The proposed scheme is efficient in both the cases: location management and call delivery. In the proposed scheme, entire coverage area of a PCS network is divided into zones. Each zone has its own HLR. When an MT moves from one HLR to other HLR its profile copy is made available to the HLR. The serving HLR stores this profile in its database on temporary basis.

Index Terms— Home Location Register, Visitor Location Register, Location Management, Call Delivery.

1 INTRODUCTION

The PCS network is based on two tier database architecture: Home Location Register (HLR) and Visitor Location Register (VLR). In the HLR, profile of an MT is stored permanently. Several VLRs are connected with the HLR. One or many Registration Areas (RAs) are served by a single VLR. Each RA has ten to hundred cells. Cell is the smallest coverage area in the network. Each cell has a dedicated Base Station (BS)[1-4]. The PCS network allows Base System Controller (BSC) as a functional component to manage a group of BSs.

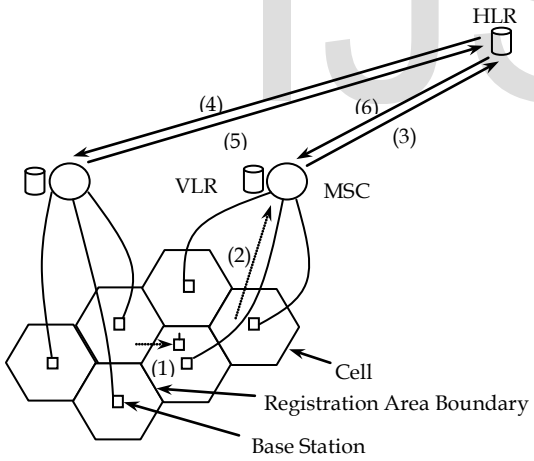

Fig1. Location registration in PCS Network

When an MT leaves an RA and comes into an RA being served by a new VLR, the MT initiates a location registration procedure. The location registration procedure has the following steps [1-3].

Step1: The MT sends location registration message to the nearest Base Station (BS).

Step2: The BS either sends this location registration message to the BSC if it exists in the network or to the MSC/VLR directly. If BSC exists in the network it further passes this message to the MSC/VLR.

Step3: The new MSC/VLR updates this information in the VLR database. The VLR informs the HLR about the change in the location of the MT.

Step4: When the HLR receives this information, it updates the current location of the MT in its database and acknowledges the new VLR with MT profile. Information sent to the new VLR with acknowledgement is used to authenticate the MT, and the new MSC comes to know that what are the various services that the MT is availing from the network? The HLR sends the registration cancellation message to the old VLR from where the MT is detached.

Step5: On reception of this message, the old VLR removes the MT profile from its database and acknowledges the HLR.

In the network there is no any inconsistent information about the MT. The HLR has always the correct information about the current location of the MT. The MT profile is cached in the new VLR and the same is deleted from the old VLR. In the location update, three databases are being accessed as:

- At new VLR, when MT is coming in the RA of this.
- At the HLR, when new VLR sends the location update.
- At the old VLR, when the HLR sends registration cancellation

As the number of database access increases, cost of location update also increases in the same proportion.The IS-41 call delivery procedure has the following steps:

Rajeev Ranjan Kumar Tripathi received his B.Tech. Degree from UPTU in 2005 in Computer Science & Engineering. He is pursuing his M.Tech. (Information Technology) from SSSIST, Sehore, M.P., India.

Gajendra Singh Chandel received his Bachelor of Engineering Degree in Information Technology from Oriental Institute of Science and Technology, Bhopal, M.P., India. He has completed his M.Tech (Master of Technology) in Information Technology from Lakshmi Narain College of Technology, Bhopal, M.P., India. Presently he is Ass. Professor in SSSIST, Sehore, M.P., India

Ravindra Gupta is Ass. Professor in Computer Science & Engineering in SSSIST, Sehore, M.P. India

Step 1: When an MT initiates a call, the call initiation signal is sent to the serving MSC by the BS of the cell in which the MT is residing. The call initiation signal may also be sent to the serving MSC by a nearest BS if the MT is at boundary of two cells.

Step 2: The MSC of the calling mobile terminal sends a location request message to the HLR to get the current location of the called mobile terminal.

Step 3: The HLR determines the current serving MSC of the called mobile terminal and sends a route request message to this MSC.

Step 4: The MSC determines the cell location of the called mobile terminal and assigns a Temporary Location Directory Number (TLDN) to the called mobile terminal. The MSC then sends this TLDN to the HLR.

Step 5: The HLR sends the TLDN to the MSC of the calling mobile terminal. The calling MSC can now set up a connection to the called MSC through the PSTN.

2. Problem Associated with Existing Location & Call Delivery Scheme

The PCS network implies centralized approach, which has following disadvantages:

Since every location request as well as location registrations are serviced through the HLR, HLR becomes overloaded.

- Due to the above reason, traffic on the links leading to the HLR is heavy, which increases time required to establish connection to the MT.
- Any HLR system failure causes all MTs registered with HLR to be unreachable even though mobile host may be roaming and away from the HLR region. Thus HLR is a single point of failure in the network.

In this conventional location management scheme, we have defined the two types of move [1-3]:

2.1. Intra-VLR Move

In this type of move, the MT changes its RA and comes in a new RA. The new RA is still being served by the same VLR as the old RA.

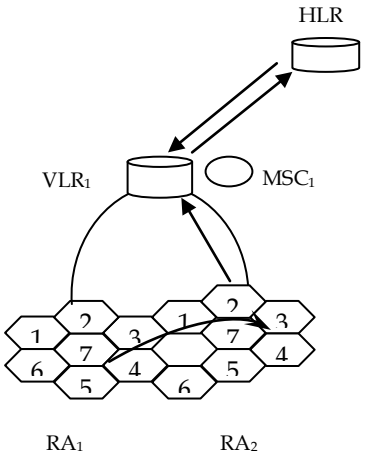

Fig2. Intra-VLR move

In this type of move, location of MT is updated at the VLR end not at the HLR. This move is shown in figure 2.

The MT is residing in cell no. 7 of the RA_1. On move it comes in the cell no. 4 of the RA_2. Both RA_1 and RA_2 are being served by the same VLR; VLR_1.This change in the location of the MT is updated to the VLR_1 only. The HLR has the information that the MT is being served by the VLR_1. As the MT is not changing the VLR, the HLR is not updated.

2.2. Inter-VLR Move

In this type of move, the MT leaves the RA and comes into a new RA. The RA is being served by the new VLR. In this move, the new VLR is updated, the HLR is informed about this change and the HLR updates the location information of the MT. The HLR sends location cancellation message to the old VLR to remove the entry of this left MT. In the figure 1, inter-VLR move is shown. In the inter-VLR move, old and new VLR databases are accessed along with the HLR, hence this move is more costly than the previous one. The HLR sends location cancellation message to the old VLR to remove the entry of the left MT, this is termed as explicit de-registration scheme. When an inter-VLR move occurs, the MT is in roaming. In the roaming an interesting situation arises when a call is initiated by an MT for other MT while residing in the same VLR. To get the current location of the called MT, the HLR is queried even though location of the called MT can be determined by the current serving VLR. If routing of initiated call is made through the serving VLR, a sufficient cost incurred in call delivery can be saved. In the next section profile forwarding scheme is being discussed.

3. Profile Forwarding Scheme

Single HLR architecture severely suffers from the problem of bottleneck. During busy hours when subscribers frequently change the location, location registration process increases the volume of traffic in the network. The HLR implementations are commercially available. If an HLR supports approximately 300,000 customers and if each user with the above mentioned traffic profile submits approximately 20 HLR operations per day including location updating, routing, authentication and network attachment then for a network with 300,000 subscribers, the offered load on HLR will thus be approximately 6,000,000 operations per day. SONOFON GSM report shows that, approximately 12-13% of the operations are performed during busy hours, i.e. about 800,000 queries per hour (222 transactions per second). This peak value even may be 50% higher. Such a heavy load cannot be supported by stand alone HLR. As a consequence the HLR suffers from bottleneck and cannot guarantee the quality of service [1]. To remove the bottleneck from the HLR, we are proposing an idea of profile forwarding scheme. This architecture is still a centralized approach [3]. In this architecture, we are separating the HLR zone wise or circle wise. We have classified the entire coverage area of the network either in zone wise or in circle wise. In each zone or circle, we have one HLR. Conceptually each zone

or circle is treated as if it is entire network. This HLR may serve many VLRs. Its architecture is same as shown in the figure 1. In this proposed architecture, we have two types of HLR: Resident-HLR and Serving-HLR. Resident-HLR is the HLR where the MT often resides. The profile of an MT is permanently stored at this HLR. On move, the MT may change the HLR. Serving-HLR is the HLR where the MT resides when it leaves the circle or zone. It is a case of roaming. In this proposed architecture we have the following types of move described as [1, 5, 6]:

3.1. Intra-VLR-Resident-HLR Move

In this move, the MT changes the RA not the VLR. This move is shown in the figure 3. The MT is moving from RA_1 to RA_2 of VLR_1 of resident-HLR. After this move, VLR_1 updates the location of the MT, indicating that it is now in RA_2. This move does not affect the resident-HLR.

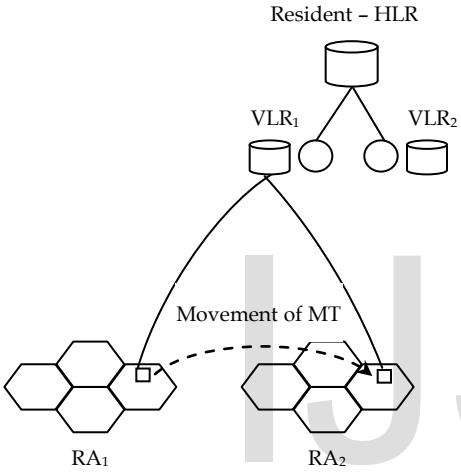

Fig3. Intra-VLR-Resident-HLR Move

3.2. Intra-VLR-Serving-HLR Move

This is a case when the MT is performing movement while residing in the serving-HLR (in roaming). When this move occurs, the MT changes its RA but the serving VLR remains same. This move is shown in the figure 4. The MT moves from RA_1 to RA_2 but the serving VLR_1 is same. In this type of move only VLR_1 is updated. This move does not affect both the serving-HLR and resident-HLR.

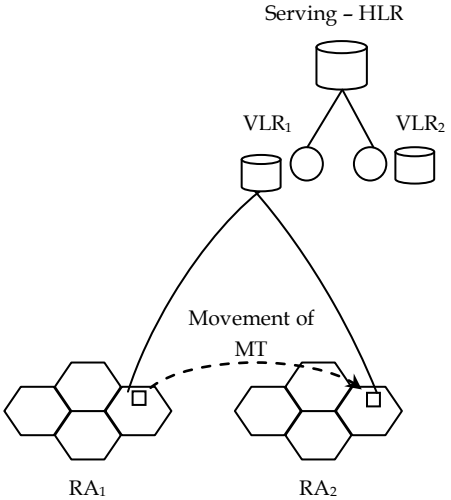

Fig4. Intra-VLR-Serving-HLR move

3.3. Inter-VLR-Resident-HLR Move

In this move, the MT changes the RA along with the VLR. This move is shown in the figure 5. The MT is moving from RA_1 of VLR_1 to RA_2 of VLR_2 of the resident-HLR. This move causes the initiation of the location registration process of IS-41. The MT is registered at the VLR_2, the resident-HLR is updated and pointing that the MT is in VLR_2 and the VLR_1 deletes the profile of the MT.

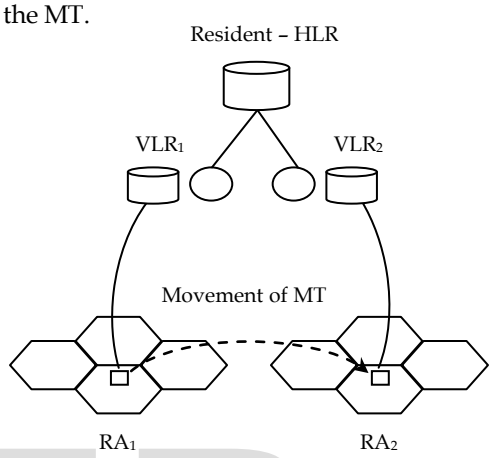

Fig5. Inter-VLR-Resident-HLR move

3.4. Inter-VLR-Serving-HLR Move

This is a case when the MT is performing movement while residing in the serving-HLR (in roaming). In this move, the MT changes the RA along with the VLR. This move is shown in the figure 6. The MT is moving from RA_1 of VLR_1 to RA_2 of VLR_2 of the serving-HLR. This move causes the initiation of the location registration process of IS-41. The MT is registered at the VLR_2, the serving-HLR is updated and pointing that the MT is in the VLR_2 and the VLR_1 deletes the profile of the MT. In this move the resident-HLR remains unchanged.

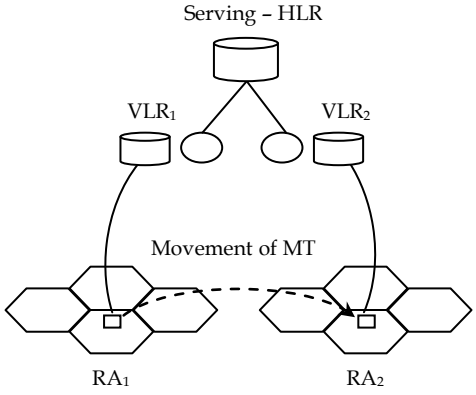

Fig6. Inter-VLR-Serving-HLR move

3.5. Inter-VLR-Inter-HLR Move

In this type of move HLR is changed. This type of move occurs into three cases.

3.5.1. MT moves from resident-HLR to serving-HLR

This is the case when the MT goes outside the home region and resides into the serving-HLR. This move is shown in the figure 7.

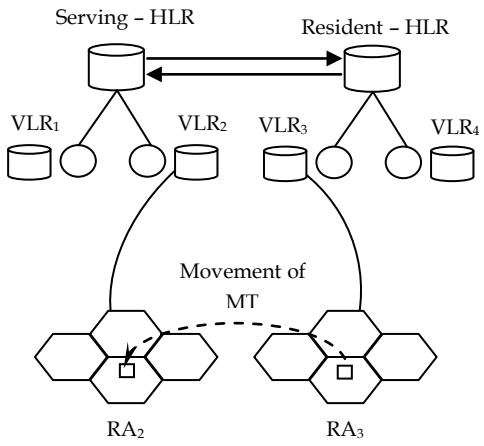

Fig7. Inter-VLR-Inter-HLR move (from resident-HLR to serving-HLR)

The MT moves from RA_3 of VLR_3 of resident-HLR to RA_2 of VLR_2 of serving-HLR. The MT initiates the location registration process of IS-41 and registration of the MT takes place at the VLR_2 of the serving-HLR. The serving-HLR determines the resident-HLR of the MT and informs it by sending an acknowledgement that the MT is currently residing in its zone. On reception of this acknowledgement, the resident-HLR updates the current location of the MT indicating that it is currently residing in the serving-HLR. The resident-HLR sends an acknowledgement back to the serving-HLR with the MT profile. The resident-HLR informs the VLR_3 to delete the MT record. The serving-HLR gets the MT profile and stores this one in to its HLR as if it belongs to it and finally sufficient information of the MT is provided to the VLR_2 for future use.

3.5.2. MT moves from serving-HLR to resident-HLR

This is the case when the MT comes back to its resident-HLR from the serving-HLR. This move is shown in the figure8.

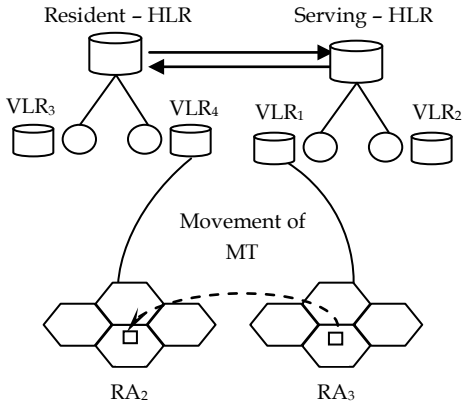

Fig8. Inter-VLR-Inter-HLR move (from serving-HLR to resident-HLR)

The MT is currently residing in roaming in RA_3 of VLR_1 of serving-HLR. On move, it comes back to RA_2 of VLR_4 of the resident-HLR. Due to this movement, location registration process of IS-41 is initiated at the VLR_4. The MT profile is already stored in the resident-HLR on the permanent basis and the resident-HLR has knowledge that this MT was previously in the roaming in the serving-HLR. The resident-HLR sends an acknowledgement to the serving-HLR to delete the profile of the MT stored in the serving-HLR on the temporary basis. The serving-HLR deletes this profile and informs VLR_1 to do the same. When MT resides in the roaming its profile is brought to the serving-HLR and serving-HLR stores this profile on temporary basis. This approach makes the MT entirely local to the serving-HLR and this is further used in proposed call delivery approach. Movement of the MT causes the exchange of MT profile copy and so this approach is called profile forwarding scheme.

3.5.3. MT moves from one serving-HLR to other serving-HLR

This is the case when the MT is moving from one serving-HLR to other serving-HLR. This is shown in the figure 9. When the MT is leaving its resident-HLR and comes to serving-HLR_1, location update will take place as in section 3.5.1. When the MT comes to serving-HLR_2 location will be in the same way as in section 3.5.1 with two more steps.

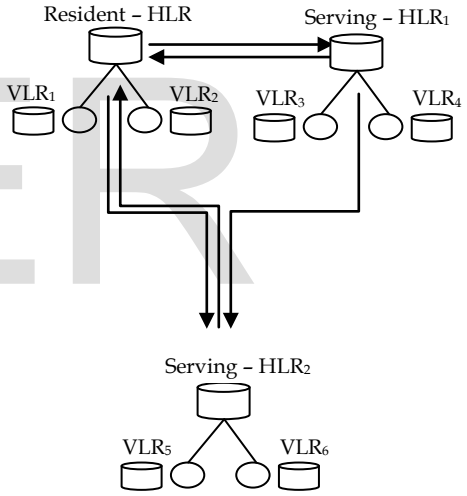

Fig9. Inter-VLR-Inter-HLR move

- The resident-HLR sends the de-registration request to the serving-HLR_1 to delete the MT profile. The serving-HLR_1 deletes the MT profile and informs its VLR to do the same from where the MT has moved.
- The serving-HLR_1 acknowledges the resident-HLR.

4. Proposed Location Registration Scheme

The proposed location management scheme is an augmentation of IS-41 location registration scheme. Based on the movement of the MT, IS-41 registration scheme is invoked with some more steps. The MT will be either in its resident-HLR or in a serving-HLR (in case of roaming).

In resident-HLR, the MT can perform two types of move: intra-VLR move and inter-VLR move. In this move, the standard IS-41 location registration scheme will used to register the MT.

The IS-41 scheme will be used when the same move is performed in the serving-HLR. When the MT leaves its resident-HLR, its profile copy is made available to the serving-HLR. The serving-HLR stores this MT profile on temporary basis in its database. When MT leaves the service area of the serving-HLR, resident-HLR informs it to delete the MT profile from its database. Every time the resident-HLR has information about the current location of the MT. When MT comes back to the resident-HLR, its profile from the serving-HLR is deleted.

5. Proposed Call Delivery Scheme

In the proposed call delivery scheme, when a call is initiated for an MT, first the VLR of calling MT is searched to get the current location of the MT. If MT is found in this VLR, call is connected. This is called as *hit*. If MT is not found in the VLR it is called as *miss*. In case of *miss*, the HLR of the calling MT is check to get the current location of the called MT. If the called MT is in roaming in the same HLR, a call routable path is returned from the serving HLR instead of consulting the resident-HLR. In this way a significant cost of signal transmission can be saved. If a *miss* occurs at the serving-HLR, resident-HLR is queried to get the current location of the MT. The proposed scheme removes the problem of tromboning in the PCS network. If the calling and called MT both are residing in the same VLR, there is no need to consult the HLR to get the current location of the called MT. If the MT is roaming in the serving-HLR and a call is originated from the same HLR, the current location of the called MT can be determined from the same serving-HLR.

6. Conclusion

In the proposed scheme, the entire PCS network is divided into zones. Each zone has a HLR. Each zone is working as independent network. When an MT is roaming in this zone, profile of the MT is being stored in the serving-HLR on temporary basis. This scheme is although centralized, it is significantly reducing the chance of HLR bottleneck by reducing the offered load. This scheme also reduces the chance of call miss routing. In the conventional call delivery scheme, current location of the called MT is obtained by querying the HLR even though called and calling MTs are residing in the same VLR. In this scheme tromboning problem is entirely eliminated and call delivery is more efficient than the conventional one.

References

[1] RajeevR. Kumar Tripathi, G.S. Chandel, Ravindra Gupta, "Multi HLR Architecture for Improving Location Management in PCS Network", International Journal of Computer Applications (0975 – 8887), Volume 51– No.20, August 2012.

[2] Rajeev R. Kumar Tripathi, Sudhir Agrawal and Swati Tiwari, "Modified HLR-VLR Location Management Scheme in PCS Network," International Journal of Computer Applications (0975 – 8887), vol.6-no.5, Sept 2010.

[3] 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.

[4] Jie Li, Yi Pan, Yang Xiao, "A Dynamic HLR Location Management Scheme for PCS Network", IEE INFOCOM, 2004.

[5] Sarvpal H. Singh, Sudhir Agrawal and Vijay Kumar "Performance Evaluation of Location Management Techniques in PCS Networks," IJCA, vol.15, no-8, Feb-2011.

[6] Sarvpal H. Singh, Vijay Kumar, "A Modified Multi-HLR Architecture for Implicit De-registration Strategies", International Journal of Computer Applications (0975 – 8887) Volume 52– No.3, August 2012.