A NEW ALGORITHM FOR CALL SETUP FROM A FIXED WIRELINE TO A ROAMING MOBILE STATION IN AN ADJACENT NETWORK

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ABSTRACT
The objective of the paper is to propose a new algorithm for call setup from a fixed wireline to a roaming Mobile Station in an adjacent network. Hence forth, fixed wireline is referred to as fixed line. The method adopted includes introduction of a new node into the GSM network, namely, AHLR that will be present in the network of every operator spanning the area that is treated as native for the AHLR. The paper will introduce the existing algorithm in GSM along with implementation diagram and location update procedure for call setup from a fixed line to a roaming Mobile Station in an adjacent network. The result of the paper includes proposed algorithm for call setup from a fixed line to a roaming mobile station in an adjacent network in the form of implementation diagram and location update procedure for the proposed algorithm. The paper indicates advantages and disadvantages of the proposed algorithm over the existing algorithm. It is followed by conclusions.

Keywords: Call Setup, GSM, Roaming, THLR, AHLR, HLR.

1. INTRODUCTION
In a GSM (Global System for Mobile Communications) network, HLR (Home Location Register), VLR (Visitor Location Register), MSC (Mobile Switching Center), and BSS (Base Station System) are important elements [1]. The network also includes interfaces to GMSC (Gateway Mobile Switching Centre), LTE (Local Telephone Exchange), MS (Mobile Station), Fixed Lines and other types of devices. The communication between devices that include at least one mobile station involves data to traverse across all the above mentioned elements. Particularly, when the MS to whom the call is made by a fixed line is in roaming mode, HLR of the MS is contacted to know the location of the MS.

[2] introduced THLR (Temporary Home Location Register). This paper introduces AHLR (Adjacent Home Location Register). The proposed new algorithm assumes the presence of both THLR and AHLR in every network. The idea is that whenever fixed line calls a MS which is in roaming mode in adjacent network to that of fixed line, then, due to the presence of AHLR in the adjacent network, call to HLR can be avoided for call set up between fixed line and MS. In fact, apart from AHLR, also present will be THLR. If the MS is not present in THLR, then AHLR is searched. If the MS is not present in AHLR also, then only HLR will be contacted.

2. LITERATURE REVIEW
A world wide network architecture standard for mobile communications is proposed by [3]. [3] reports on some of the internetworking requirements which would be necessary at the BSS boundary to enable radio access systems in USA and in Japan to offer a broad set of network services that are available in a GSM network. [4] indicates the advantages and challenges of HLR in a GSM network [5] proposes an integrated QoS architecture for GSM networks. It discusses an integrated QoS architecture for GSM networks using the Internet mobility and QoS. The required entities, distribution of functionalities and interfaces are studied using new GSM packet and high speed circuit switched data features in [5].

3. EXISTING ALGORITHM FOR CALL SETUP FROM A FIXED LINE TO A ROAMING MOBILE STATION IN AN ADJACENT NETWORK
[2] included the existing method for mobile call termination. The method indicated in [2] and the existing algorithm for call setup from a fixed line to a roaming mobile station in an adjacent network are same. So, the literature and figures under section titled existing method for mobile call termination given in [2] is reproduced below.

The following are the existing algorithm, implementation diagram and location update procedure for mobile call termination as in [1]. X1, X2 and X3 are different geographical areas. The relevant steps in the algorithm are followed with an alphabet in brackets which indicates
the corresponding communication in the implementation diagram depicted in Fig. 1.

The connection setup path is $a \rightarrow b \rightarrow g \rightarrow j \rightarrow k$.

### 3.3 Location Update Procedure

Let us assume that the MS whose host network is $X_3$ moved from $X_1$ to $X_2$. Then, it makes a location update request to VLR (new) through BSS (new) and MSC (new). The VLR (new) sends a location update message to HLR in $X_3$. The service and security related data for the MS is downloaded to the VLR (new) from HLR. The MS is sent an acknowledgement of successful location update. The HLR requests VLR (old) to delete data relating to the relocated MS [2]. The GMSC of the fixed line always connects to HLR of the dialed mobile number by the fixed line. For that reason, it’s arrow is left open ended.

Figure 2 depicts the location updating process for algorithm in Section-A of III as in [1]. MS moves from $X_1$ to $X_2$. It’s HLR is located in $X_3$.

The following is the step wise location update procedure for algorithm in Section-A of III. The relevant steps in the following algorithm are followed with an alphabet in brackets which indicates the corresponding communication in the implementation diagram depicted in Fig. 2.

1. **Start.**
2. MS whose HLR is in $X_3$ moves from $X_1$ to $X_2$.
3. It contacts the BSS(new) in $X_2$ for resource allocation (a).
4. BSS(new) contacts MSC(new) for resource allocation (b).
5. MSC (new) contacts VLR (new) for resource allocation (c).
6. VLR (new) contacts HLR of MS in $X_3$ for information about MS (d).
7. HLR updates the location of MS in its database and then sends requisite information to VLR(new) (e).
8. VLR (new) forwards the information to MSC (new) (f).
9. MSC (new) forwards the information to BSS (new) (g).
10. BSS (new) communicates to MS that the necessary resources are allocated (h).
11. HLR communicates to VLR (old) that it may delete entry corresponding to MS (i).
12. End of Algorithm.

4. TEMPORARY HOME LOCATION REGISTER
[2] introduced an element called THLR (Temporary Home Location Register) into the GSM architecture. Whenever, MS enters roaming mode, the THLR of the visiting network requests the HLR of MS to send the entire record pertaining to MS. HLR responds by sending the record to THLR. This happens immediately after the MS entered the roaming mode. The record in THLR is deleted whenever MS leaves the respective visiting network. But, if MS continues to be in roaming mode, the process of having a copy of the record of HLR of MS in the THLR of the concerned visiting network continues. This process stops only when the MS returns to its home network.

The following is the structure of THLR as given in [2]: IMSI (International Mobile Subscriber Identity) whose width can be a maximum of 15 characters.
- MSISDN (Mobile Station International Subscriber Directory Number) whose width can be a maximum of 15 characters.
- Visiting MSC/VLR whose width can be a maximum of 15 characters.
- Call Management Services which is a Boolean Value.
- Messaging Services which is a Boolean Value.
- GPRS which is a Boolean Value.
- Billing which is a Number.

5. ADJACENT HOME LOCATION REGISTER
This section introduces a new element called AHLR into the GSM architecture. Whenever, MS enters roaming mode, the AHLR of the network that is adjacent to the visiting network requests the HLR of MS to send the entire record pertaining to MS. HLR responds by sending the record to AHLR. This happens immediately after the MS entered the roaming mode. The record in AHLR is deleted whenever MS leaves the network adjacent to that of the network in which AHLR is present. But, if MS continues to be in roaming mode, AHLRs of all adjacent networks of the network in which the MS is in roaming mode will request for record of MS from its respective HLR and will append to their own databases to handle calls from fixed lines in their respective networks to the MS. This process stops only when the MS returns to its home network.

The following is the structure of AHLR:
- IMSI whose width can be a maximum of 15 characters.
- MSISDN whose width can be a maximum of 15 characters.
- Visiting MSC/VLR whose width can be a maximum of 15 characters.
- Call Management Services which is a Boolean Value.
- Messaging Services which is a Boolean Value.
- GPRS which is a Boolean Value.
- Billing which is a Number.

6. PROPOSED ALGORITHM FOR CALL SETUP FROM A FIXED LINE TO A ROAMING MOBILE STATION IN AN ADJACENT NETWORK
The following are the proposed algorithm, its implementation diagram and location update procedure for call setup from a fixed line to a roaming mobile station in an adjacent network.

Consider two networks X1 and X2 which belong to two states that border each other. Host networks of two states which border each other make up a very good example. Also, consider a network X3 which does not have X1 and X2 as its borders. If a fixed line in X2 calls MS which is in X1, but whose host network is X3, then the HLR of MS in X3 is contacted though the MS is present in X1 which is bordering X2. Note that the MS is currently in roaming mode.

We, herewith propose an algorithm which will ensure that the GMSC will not contact HLR of MS if MS is in a network that is adjacent to its network. The relevant steps in the following proposed call setup algorithm are followed with an alphabet in brackets which indicates the corresponding communication in the implementation diagram depicted in Fig. 3.

![Fig. 3: Implementation Diagram](image-url)
6.1 **Algorithm**

The following is the proposed algorithm:

1. **Start.**
2. Dial the mobile number from fixed line.
3. The call goes to local telephone exchange, i.e. PSTN (a).
4. LTE finds that the dialed number is a mobile number and forwards it to GMSC (b).
5. GMSC contacts the THLR of the network in which fixed line is present and sends the mobile number (c).
6. However, mobile number of MS will not be found in THLR as it is not present in X2.
7. So, THLR queries AHLR (d).
8. AHLR will communicate with serving VLR of the mobile station (a).
9. Serving VLR will communicate information about serving MSC of MS to AHLR (f).
10. AHLR forwards that information to GMSC (g).
11. GMSC routes call to serving MSC (h).
12. Serving MSC finds the current location area identity of MS from VLR (i).
13. Serving VLR sends LAI to serving MSC (j).
14. Serving MSC pages the MS through appropriate BSS (k, l).
15. MS responds (m).
16. BSS confirms to MSC that the necessary radio links are established (n).
17. Call is delivered to MS (k, l).
18. When MS answers, complete connection is set up (m).
19. **End of Algorithm.**

6.2 **Implementation Diagram**

Figure 3 depicts the implementation diagram for the algorithm proposed in Section-A of VI.

The algorithm-mentioned in Section-A leads to benefit to all adjacent networks of the network in which a MS is roaming so that the adjacent networks need not contact the HLR of the MS in the host network.

The connection setup path is $a \rightarrow b \rightarrow h \rightarrow k \rightarrow l$.

6.3 **Location Update Procedure**

In the model, when MS moves from X1 to X2, the VLR (new) on receiving information from HLR in X3 will pass that information to THLR in X2. After receiving command to delete information from HLR, the VLR (old) will request for deletion of information about MS from THLR in X1. THLR in X1 will request all AHLRs to delete information about MS.

![Figure 4: Location Update Procedure](image)

The following is the proposed location update procedure for algorithm in Section-A of VI.

1. **Start.**
2. MS whose HLR is in X3 moves from X1 to X2.
3. It contacts the BSS (new) in X2 for resource allocation (a).
4. BSS (new) contacts MSC (new) for resource allocation (b).
5. MSC (new) contacts VLR (new) for resource allocation (c).
6. VLR (new) contacts HLR of MS in X3 for information about MS (d).
7. HLR updates the location of MS in its database and then sends requisite information to VLR(new) (e).
8. VLR (new) updates THLR in X2 as MS is currently in X2 in roaming mode (f).
9. VLR(new) forwards the information to MSC (new) (g).
10. MSC (new) forwards the information to BSS (new) (h).
11. BSS (new) communicates to MS that the necessary resources are allocated (i).
12. HLR communicates to VLR(old) that it may delete entry corresponding to MS (j).
13. VLR (old) communicates to THLR of X1 to delete entry corresponding to MS (k).
14. THLR of X1 communicates to AHLR of X2 to delete entry corresponding to MS (l).
15. THLR of X2 communicates the information about MS to AHLR of X1 so that it can add suitable entry about MS (m).
16. **End of Algorithm.**
7. ADVANTAGES AND DISADVANTAGES

The advantage of the proposed algorithm over existing algorithm is that, if the called mobile is within the network that is adjacent to caller’s network in roaming mode, then the call will be routed through AHR rather than HLR. So, the call need not contact HLR which may be at a remote location. This leads to reduced call setup time as well as better utilization of network resources. The disadvantage is that, if the called mobile number is not found in THLR, then, it has to go to AHR and if the called mobile number is not found in AHR also, then, it needs to contact HLR. So, in this case, the time consumed is more by \( O(\text{size of THLR} + \text{AHR}) \). Another disadvantage is that there are additional elements in the GSM architecture, namely, THLR and AHR which consume resources, though, of a dynamic nature as the record of MS is deleted as MS leaves the network that is adjacent to the caller’s network.

The limitation of the proposed algorithm is that it is efficient only when the called MS is in the network of fixed line. Otherwise, there is overhead of contacting THLR and then contacting HLR.

8. CONCLUSIONS

The conclusion is that the call setup time decreases if the mobile station is in the network adjacent to that of caller’s network in roaming mode. In the cases where it is neither in caller’s network or adjacent network to that of caller in roaming mode, then the call setup time increases as GMSC needs to contact HLR after contacting THLR and AHR unsuccessfully.

REFERENCES


