

Movement Pattern Based Adaptive Location Management

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Abstract

Movement pattern based location management provides a major role in personal communication service (PCS) system. In the conventional two level GSM system, whenever the mobile station (MS) is crossing the present cell it has to register with the Home Location Register (HLR). This involves the use of costly bandwidth between the Mobile Switching Center (MSC) and the HLR. In this paper the technique for reducing the costs during the location tracking and location update is proposed. Taking the regular movement pattern of the users it creates the block and the user registers with the HLR only after crossing the block instead of crossing the single cell. The block register (BR) is introduced between the block and the HLR in two level system to maintain the blocks, thus creates three level architecture. In this architecture some signaling cost values between the MSC-BR, BR-HLR and BR-BR are maintained to get the better performance. In this proposed system the aim is to set the value between the MSC and BR and the two BR as small as possible and the value between the BR and the HLR must be higher to get the better performance.

1. Introduction

The Personal communication service (PCS) network provides the efficient communication to the mobile subscribers [1,2,3]. This kind of network supports cellular architecture. Generally GSM standard is used in our discussion. It consists two kinds of databases: HLR (Permanently stores the user's information), VLR (Stores current location of user in its service area).

When the current mobile station (MS) changes its location from current MSC to the new MSC it has to register with the HLR. The messages are exchanged between the HLR and the new VLR and the previous VLR to record the current location of the MS in the databases. This process of location update is called the **Location Registration** process [2, 4]. Similarly, when the call is initiated the messages are exchanged among the VLR of the calling MS and the HLR and the VLR of the called MS to locate the called MS. This process is called the **Location Tracking/Call Delivery** [2,4]. But, if the number of PCS subscribers are increased then HLR will be overloaded and then it creates bottle neck [1,2,4] problem. The second problem is the costs for registration process and call delivery process in standard system are very high. The main aim of our proposed system is to reduce the cost. Several researches are proposed to reduce the costs. The study in [1][2] presented the dynamic hierarchical database architecture for location management in PCS network. In this research the third kind of register DR is introduced between the HLR and the VLR. DR stores the location pointers which indicate the current location of the MS. In [5][13][14] the authors proposed

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that the regular movement of the user is repeated day by day. Such a pattern of MS is taken and modeled at the HLR and downloaded at the mobile terminal for verifying the correctness. The model assumes that the past patterns will be repeated in future. When the model is trained up the frequency of update will be reduced.

2. Proposed System

The proposed system consists the idea of **MOVEMENT PATTERN BASED ADAPTIVE LOCATION MANAGEMENT**. This particular system is introduced to decrease the cost of registration and location tracking process in PCS network. In 2 level architecture the third layer is introduced between the HLR and the MSC/VLR. If we accumulate several MSCs into one block we can reduce the cost for registration and location tracking because the registration with the HLR in this case will be performed only after when the MS is changing the block. The concept of creating the block is discussed in the following section:

2.1. Movement Pattern:

The regular movement data of the user or MS for training is prepared at HLR for the successive 5 days from the cell crossing data[5]. From those data it is decided that whether the movement is regular or not. Then training of data is performed to get the exact performance. This training process is very fast and it is found that the prediction of the correct movement direction is easily achieved. The multilayer neural network model[6,7,13,15] is used to train the data. If it is found that the movement is regular then collect the MSCs into one block. It is repeated for BLOCK_SIZE number of times. If the BLOCK_SIZE is 5 then one block contains 5 MSCs of one user. Then the block register(BR) is assigned for that block.(a)Neural network takes two inputs: user id, MSC ID from the 2day's record. (b) Then the model is trained to capture the movement pattern. (c)The output gives the floating point numbers. It is easy to define simple threshold output function to get the output as 0,1 or -1 and matches with the data from 2 day's record. (d) (a)-(c) is repeated for BLOCK_SIZE number of times for each user. (f)after one iteration of (d) a block is incremented by 1.This simulation process has tested using the MAT LAB. The data for training, program and the corresponding training plot are shown in the following:

TABLE- I

MSC ID	NEXT MOVEMENT	MS ID/User ID
3	-1	1
2	-1	1
1	1	1
2	0	2
2	-1	2

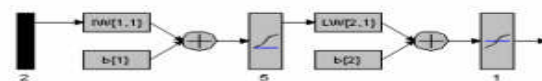


Fig 1:Neural Network Model

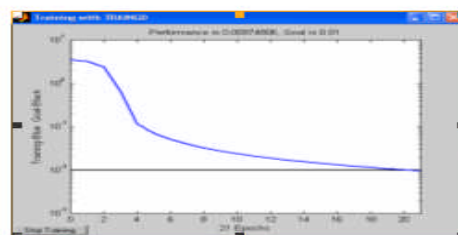


Fig. 2: Training Plot

The training procedure is very fast gives the right prediction.

2.2. Design of 3-level System:

In 3-level architecture the BR (block register) which is introduced between the HLR level and the block level. Block is a collection of MSCs according to the regular user's movement pattern. One MSC controls several cells which is called the location area(LA) of one MSC. Each block is handled by its nearest block register(BR).BR periodically compute and stores the location information distribution strategy for its associated MS and updates its pointer according to the movement of the MS. In 2level architecture HLR points to the MSC directly but in 3 level architecture the HLR points to the BR and BR points to the currently serving MSC by two kinds of pointers: Local pointer and Remote pointer[2,4].The BR periodically checks the pointer configurations. The pointers are the entries in the directory table of the BR. When the BR receives the location request message it makes a table lookup process and then forward the request to the appropriate location. But the BR does not involved in the processing of the registration/call delivery process so it gives the lower cost as compared to the HLR and the VLRs [2]. Whenever a MS moves from one block to another block, shown in Fig3 it has to register for its new location.

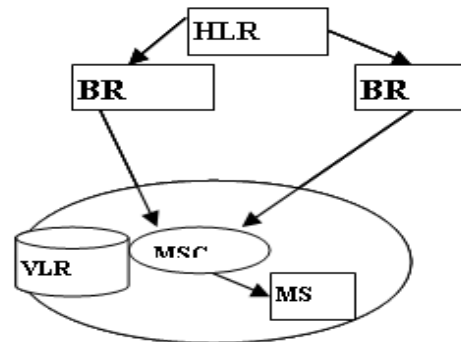


Fig. 3: 3 level architecture

2.2.1 Registration Process:

There are two kinds of registration: *intra-block registration* and *inter-block registration*. When the MS moves in the same block it is called the *intra-block registration* process and when the MS moves from one block to another block it is called the *inter-block registration* [2]. Here, the intra-block and inter-block registration processes are described by diagram.

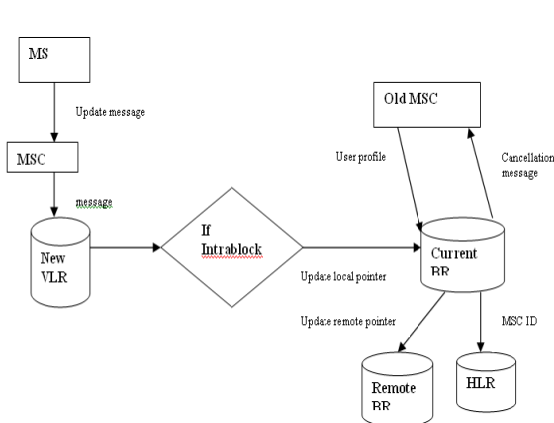


Fig. 4: Intra-Block Registration

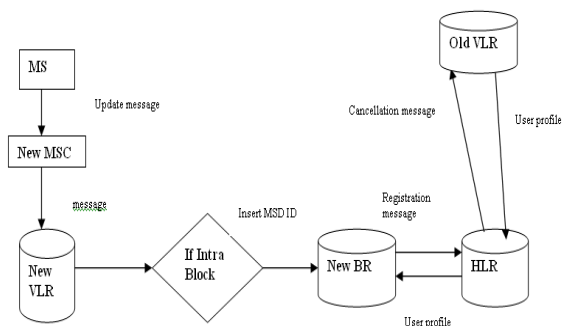


Fig. 5: Inter-Block Registration

2.2.2 Location Tracking/Call Delivery Process:

The idea of call delivery process can easily achieved from the flow diagram shown in Fig 6.

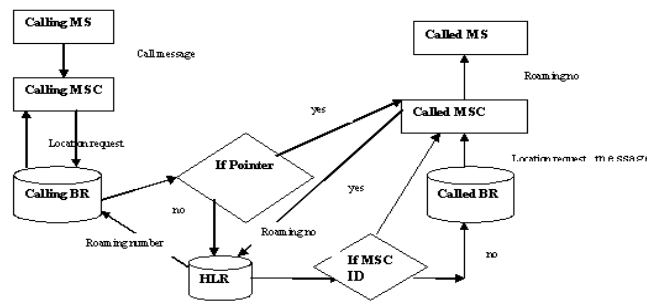


Fig 6: Location tracking process

3. Performance Analysis

To analyze the performance of the proposed system , first the cost equations are generated then these equations are used for the comparative study between different sets of values of signaling cost that are generated between different links of the network.

3.1 Cost Equations:

To get the performance of the proposed system the comparison is made between the proposed system and the GSM standard system [2,4]. There are some parameters which are required to get the performance of the system. These parameters are explained in the TABLE II-III:-

Table II:

Cost Variable	Description
cost_hlr	Update or querying HLR
cost_vlr	Update or querying VLR
cost_br	Update or querying BR
sig 1	Cost for messaging between BR and MSC
sig 2	Cost for messaging between BR and HLR
sig 3	Cost for messaging between two BR
Q	Locality of movement

Table III:

Cost Parameter	Expressions
x1 (Cost for location registration during intra block movement if sending id of the current MSC to HLR is required)	2cost_vlr+cost_br+cost_hlr+6sig1+2sig2(e.g.:1.cost of new VLR/MSC(cost_vlr)2.cost of old VLR/MSC(cost_vlr)3.cost of BR(cost_br)4.cost of HLR(cost_hlr) 5.six messages exchanged between BR and old VLR/new VLR 6. two messages between BR and HLR
x2 (Same as x1 but when sending id is not required)	2cost_vlr+cost_br+6sig1
x3 (Cost for location registration after an inter block movement)	2cost_vlr+2cost_br+cost_hlr+6(sig1+sig2)
y1(cost for location tracking if remote pointer for the called MS is available)	2cost_vlr+cost_br+4sig1+2sig3
y2(Cost for location tracking/call delivery if remote pointer for the called MS is not available and HLR query is required for current serving BR)	2cost_vlr+2cost_br+cost_hlr+4(sig1+sig2)
y3 (Same as y2 but here HLR query is required for	2cost_vlr+cost_br+cost_hlr+4(sig1+sig2)

current MSC)	
y4(Same as y2 but here HLR query is required for current MSC)	$2cost_vlr+cost_br+4sig1$
z(cost for updating the remote pointer)	$Cost_br+2sig3$
for standard GSM system	$C'=(rate_call_arrival+rate_mobility)(4(sig1+sig2)+2cost_vlr+cost_hlr+cost_gtt)$ cost_gtt:cost for global address translation

We will compare the cost of the proposed system with the standard system in the next section. The cost ratio C/C' is called the relative cost ratio.

3.2 Comparative Study Between Different Sets of Values:

In the first phase we are assuming that the signaling cost dominates so for simplicity taking the database access costs as 0. Some random signaling costs are given in table below. The value of sig1 takes(cost between the MSC and BR) 1 because BR is placed as close as MSC. We are comparing the cost ratios between the different sets for all values of CMR (call-mobility ratio). If we plot the cost ratio against CMR where CMR varies from 0-10. Generally the cost ratio increases with the value of CMR. When the CMR is low the mobility rate is high so that the registration cost will be high. In this situation the saving cost will be obtained when the MS changes the BLOCK that means ,the MS registers with the HLR only when it is crossing one block. When CMR is high, the mobility rate is low the cost saving will be obtained from the call arrival. If we take the value in the following way[2] then the cost ratio according to the system.

TABLE-IV

Set	Sig1 (MSC-BR)	Sig2 (BR-HLR)	Sig3 (BR-BR)
	1	5	2
2	1	5	10
3	1	10	2
4	1	10	10

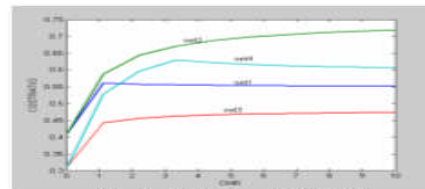


Fig 7 :Plot using TABLE IV

Cost ratio	Set1	Set2	Set3	Set4
	0.56	0.72	0.47	0.61

If the value between the BR and HLR has increased (TABLE V) then the cost ratio will be decreases in our proposed system.

TABLE-V

Set	Sig1 (MSC-BR)	Sig2 (BR-HLR)	Sig3 (BR-BR)
1	1	5	2
2	1	5	20
3	1	20	2
4	1	20	20

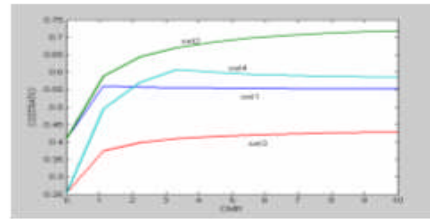


Fig. 8: Plot using TABLE V

Cost ratio	Set1	Set2	Set3	Set4
	0.55	0.72	0.42	0.58

As set3 gives the better result among all the results in TABLE IV. Here also in TABLE V set3 gives the better result. The performance improvement of TABLE V than TABLE IV gives:

$$\begin{aligned}
 \text{performance_improvement} &= \frac{0.47 - 0.42}{0.47} * 100 \\
 &= 10.6\%
 \end{aligned}$$

Observation From Table V:

- ❖ Comparing between set1 and set2 demonstrates that sig3 is used during the location tracking/call delivery process(during the high CMR). At this time signaling messages are exchanged between the two BR. No signaling messages are sent between the two BR during the registration process. So that the smaller value of sig3 gives smaller cost ratio when remote pointers are used.
- ❖ Cost ratio decreases under all CMR values in case of set3 as compared to set1 because the signaling cost between the BR and the HLR (sig2)has increased to reduce the costly HLR access. In this case cost for the standard system will be higher.

Now, if the value between the two BR is placed according to the TABLE IV and the value between the BR and the HLR have increased then the result will be in the following:

TABLE-VI

Set	Sig1 (MSC-BR)	Sig2 (BR-HLR)	Sig3 (BR-BR)
1	1	5	2
2	1	5	10
3	1	50	2
4	1	50	10

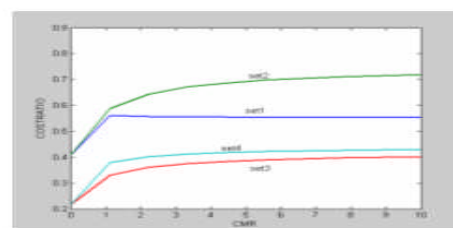


Fig. 9: Plot using TABLE VI

Cost ratio	Set1	Set2	Set3	Set4
	0.55	0.72	0.4	0.42

Observation From Table VI:

- ❖ Set3 gives the better result in TABLE VI than TABLE V.
- ❖ Placing the value between the two BR as 10 and between the BR and the HLR as 50 in set4 (0.42)gives the better result than TABLE V .

❖ Performance improves of set3 from TABLE IV in TABLE VI:

$$performance_improvement = \frac{0.47 - 0.4}{0.47} * 100 = 15\%$$

The performance improvement of set4 using TABLE VI than TABLE IV gives:

$$performance_improvement = \frac{0.61 - 0.42}{0.61} * 100 = 31\%$$

4. Conclusion

In this paper the new concept has been developed to reduce the registration cost of the user. Movement based location scheme helps to create the block which is the group of MSCs so that the registration with the HLR will be performed only after crossing the block. The principle assumption here, is that the user's mobility pattern has recorded for some few days and from that record the next day's prediction has been generated .After training, the blocks are created for particular numbers of MSCs. In standard GSM system the registration is performed only after crossing the location area that is the group of cells. In this proposed paper this prediction is performed using neural network model during the low traffic of the day. After creation of block a block register is maintained to control each block using local and remote pointers. So, the two level GSM standard system is now three level system in which a block register is introduced between the MSC and the HLR.

The performance of the proposed system has calculated by taking different sets of values of signaling cost. Among them the set3 gives the better result in TABLE VI than TABLE IV. Most of the time the messages are send between the MSC and BR .So, that the value between this link must be set as small as possible. The main aim is to avoid the costly access with HLR so, the value between the BR and the HLR is set as high as possible. This technique improves the registration and location tracking cost.

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