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Various Location Update Strategies in Mobile Computing

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ABSTRACT
Managing location information of mobile devices is a very much important task in mobile computing systems. In cellular network, coverage area is divided into cells. Everyday mobile companies try to accommodate more users by reducing size of cells. Location management is one of the most important and fundamental issue in mobile computing. When the user changes location, an update occurs. The main goal of any location management strategy is to provide efficient search-updates. In this paper we have discussed various location management strategies in mobile computing.

General Terms
Mobile Computing

Keywords
Mobile Computing, Location Management, Location Update, Profile Based Location Update

1. INTRODUCTION
Location management is the most important issue in the current as well as next-generation wireless mobile networks. When we talk about the term mobile computing, it gives us first impression that we have computing power anytime and anywhere. At the beginning of the 1970s, mobile users could only roam locally or regionally, while international roaming was possible only after the 1990s [10]. As with the increase in mobile devices and population (users of mobile devices), it affects the Quality of Service (QoS). In the 3G and 4G wireless communication systems, both voice and data services have been supported [9]. The basic mechanisms of these two schemes are very similar. Both of them manage the user mobility by a two-tier hierarchical database system consisting of Home Location Register (HLR) and Visitor Location Register (VLR)[5]. A mobile user permanently registers to an HLR with the user profile. The VLR stores user information currently residing in its charge area. When a user enters a new register area (RA) charged by a new VLR, the mobile terminal is required to send an update message to the new VLR. The new VLR will exchange information with user's HLR through a global-title-translation procedure and obtains the user's profile. It is anticipated that the core networks for 4G systems will be all packet switched. In order to deliver packets to the moving users, the system must have an efficient way to locate them when call requests arrive. This concept is known as mobility management for wireless communication system. Generally, in a wireless communication network, the covered service areas are partitioned into cells, and the cells are aggregated into groups geographically, which are called location areas (LAs). To deliver services to a user, all the cells in the LA covering that user will be paged to establish the radio link connection. The smaller LA size can facilitate networks to trace users more efficiently and reduce transmission delay or packet loss significantly [9]. When we think about the 3G and 4G data in mobile computing, in next generation the use of mobile network will be more for data transfer as compared to traditional voice communication. In 3G/4G systems, the services would be user oriented, namely, the networks would provide specific services for specific users. In order to provide user-oriented services, the system needs to store the user profile which records the necessary information. We can observe that many users follow some daily routines. If the system knows the routines in advance and uses the information to predict the user's location, then the registration traffic could be reduced. As long as the user follows the pattern, no explicit registration is necessary and the network can organize the system resource more efficiently, thus we can reduce the spectrum consumption caused by the location updates. On the other hand, a user may change his/her fixed route due to traffic or weather reasons.

2. VARIOUS STRATEGEIS
Various location update strategies are available in the mobile computing. Mainly these strategies are divided into two i.e. (1) Always Update Strategy and (2) Never Update Strategy. Further they are divided into specific strategies like (1) Distance Based Location Update (2) Time Based Location Update (3) Movement Based Location Update (4) Hybrid Strategies and (5) Profile Based Location Update [7]. To understand these strategies we need to work on wireless mobile networks. The figure below shows Appropriate wireless mobile network architecture.

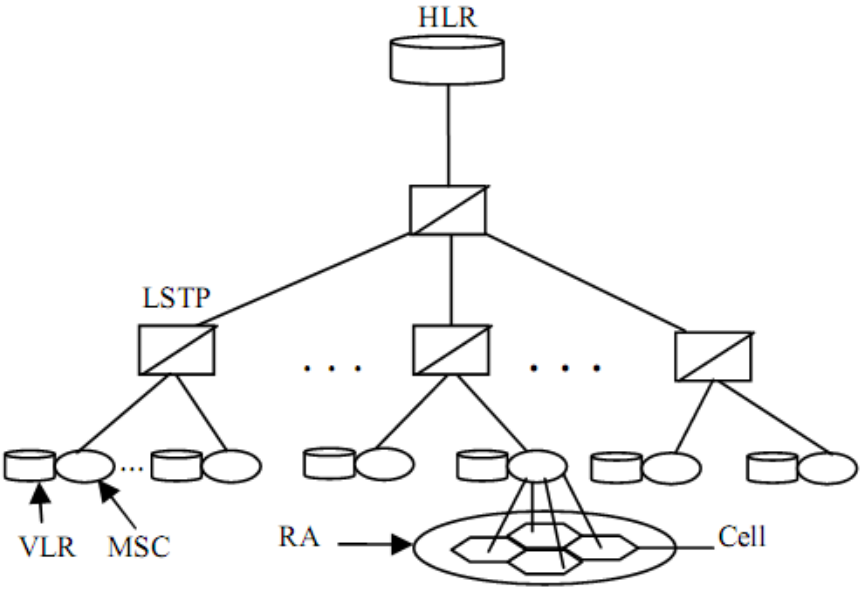

Fig. 1 : Wireless mobile networks architecture[5]

Various components of Wireless mobile network architecture are (1) HLR – Home Location Register (2) LSTP - Local Signaling Transfer Point (3) VLR – Visitor Location Register (4) MSC – Mobile Switching Center (5) RA – Registration Area. Here the smallest component is Cell. RA can become from combination of various nearby cells. RA is connected with MSC and MSC maintains the VLR. MSC is also connected with LSTP and finally LSTP is connected with the HLR.

When we talk about Mobile Computing we need to consider Cellular network as our base. Various components and its details are given in figure 2.

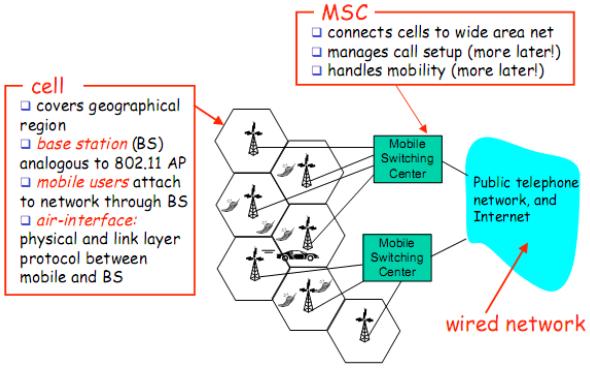

Fig. 2 : Components of Cellular Network

Whenever we talk about location update strategies, we need to consider the cost factor for update. Cost factor is again divided into mainly two parts (1) Location Inquiry (Paging cost) and (2) Location Update Cost. Different strategies have different cost factors. Sometimes paging cost goes down while sometimes the cost goes down with location update . Location management cost could be divided into following factors.

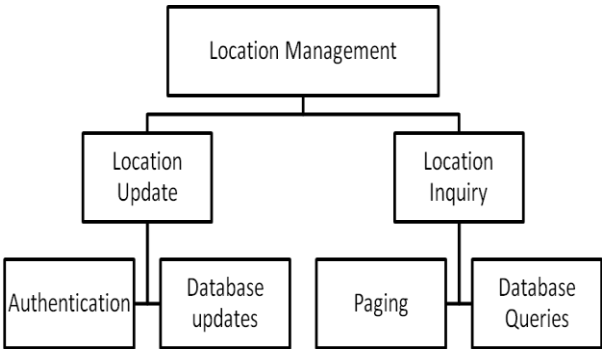

Fig. 3 : Cost Components [7]

The total cost of the above two cost components — location update and cell paging — over a period of time T, which can be determined by simulations can then be averaged to give the average cost of a location management strategy. Following equation could be used to calculate the total cost of a location management strategy. [7]

$$\text{Total cost} = C * N_{LU} + N_P$$

Here, N_{LU} is the number of location updates performed during the given time period T, N_P is the number of paging performed during the time T, and C is the constant which represents cost ratio of location update and paging.

Now we would discuss above mentioned strategies in detail. Starting with two divisions i.e. (1) Always Update Strategy and Never Update Strategy, we would also discuss all the other strategies.

2.1 Always-update Strategy

In this type of strategy each mobile terminal's location would be updated whenever it enters to a new cell. The main benefit of this strategy would be that the current location of each user would always be known. Therefore, search operation would not be required whenever there is a call . This would be a benefit on one hand whereas on the other hand it would create a problem on other side i.e. it would require more resources because it would update the location at each and every cell movement. Here the paging cost would be zero but location update cost would be very high. This kind of strategy would be very much valuable when user's mobility is very less or when the cell size is comparatively very large.

2.2 Never-update Strategy

This strategy is totally opposite to the above mentioned strategy i.e. Always update strategy. Here, the location update would never be performed. The main benefit of this strategy would be that since location would never be updated so the location update cost would be zero. This is benefit on one side, but the problem on other side would be that the overhead cost of paging would be more. This kind of strategy would be very much valuable when user's mobility is very high or when the cell size is comparatively very small.

2.3 Distance Based Location Update [11][4]

It is a simple strategy for location update. Here the mobile base station would keep track of each mobile terminal for distance (in number of cells) it has travelled since its last update. Whenever the terminal travels number of cells from predefined cell size say for example D, at that time location update would occur. When this policy is used, the management is needed to be done per user basis. Here initially the counter would be set to 0 in the initial cell. Now, when the mobile unit would move and cross the cell boundary that counter would increase by 1. When that counter would cross a value greater than D, location update would be done. This strategy would be better for the users who generally move less and move within specific distance i.e. < D. In that case few updates would occur and we would get exact location of the user. Here the paging cost would also be low, because the latest location would be recorded as and when needed. Figure 4 shows Distance based location update with D=2. [7]

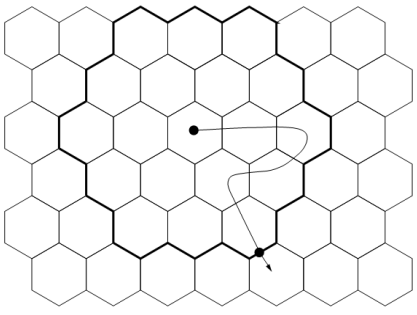

Fig. 4 : Distance Based Location update with D=2

Figure 5 gives an illustration of the same.

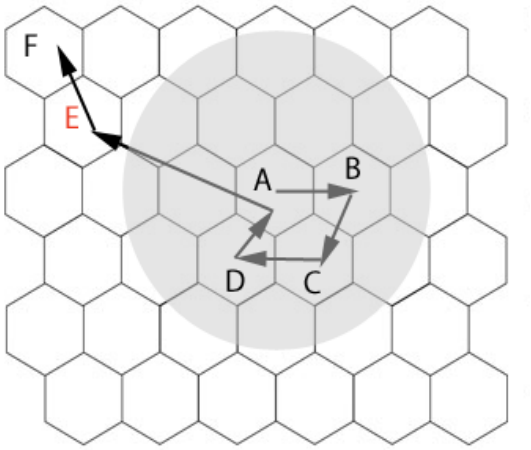

Fig. 5 : Residing area is Gray

Here A is the starting point and user moves from A -> B -> C -> D -> E -> F direction. Here the location update would be performed when the user reaches to E.

The main drawback here would be that if the user crosses the boundary very frequently, unnecessary location updates would occur.

2.4 Time Based Location Update [7]

This is also a simple strategy for location update. Here the mobile base station would update the location of user after a particular time period say T. This strategy is comparatively easy to manage because each base station requires maintaining its internal clock only. The other benefit is the value of T could be set different for each user according to each user's mobility pattern or call arrival pattern. There would be one more benefit due to the nature of periodic signaling. The network would know that the mobile terminal is powered-off or outside the coverage area if it does not perform a location update at per the scheduled time. The main drawback would be even though the user is stationary (non-moving) the location update would occur and it would increase the location update cost. Furthermore, mobile users' location uncertainty cannot be bounded: when a call arrives, the search operation cannot be limited to a set of cells. Similar discussion can be found in [1].

The main advantage of this type of strategy would be that it is not dependant on Location Areas (LA). Another advantage would be lower paging cost because at time t location would definitely update. The main drawback here would be sometimes if the user is stationary at that time unnecessary updates would be performed.

2.5 Movement Based Location Update [7]

In this strategy the base station needs to keep track of the mobile user for number of cell movements or the number of cell boundary crossing. Here, one counter is managed, it will be set to zero initially, and incremented with 1 each and every time the user crosses the boundary. Now, when the counter becomes>M at that time update is done.

Figure 6 shows Movement based location update with M=2. [7] and Figure 7 is an example of the same.

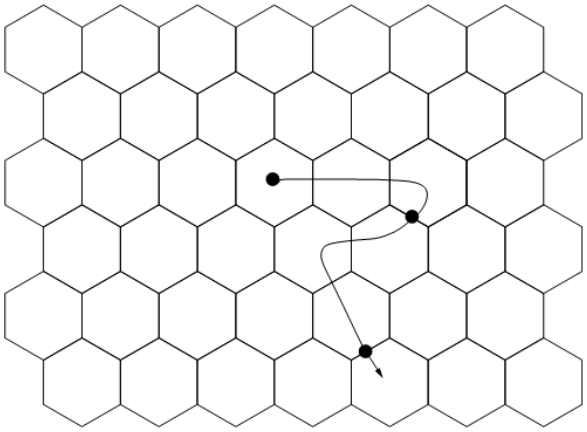

Fig. 6 : Movement Based Location Update with M=2

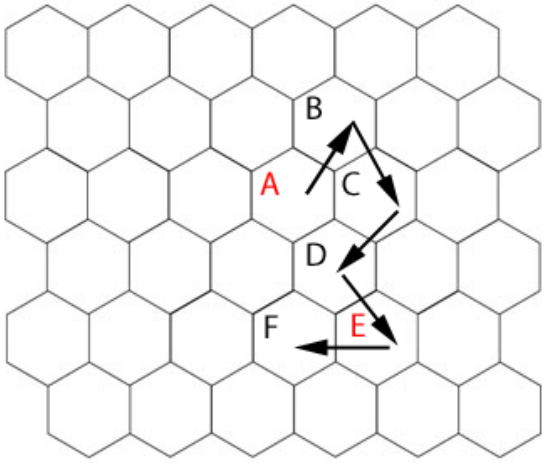

Fig. 7 : Movement Based Location Update with M=4

Here A is the starting point and counter is zero. Now user moves from A -> B -> C -> D -> E -> F direction. Counter at E is 4 thus, at E the location update would be performed when the user crosses the boundary from D to E.

The main drawback of this kind of strategy is when user travels around the boundary at that time unnecessary updates may happen. Figure 8 illustrates the same.

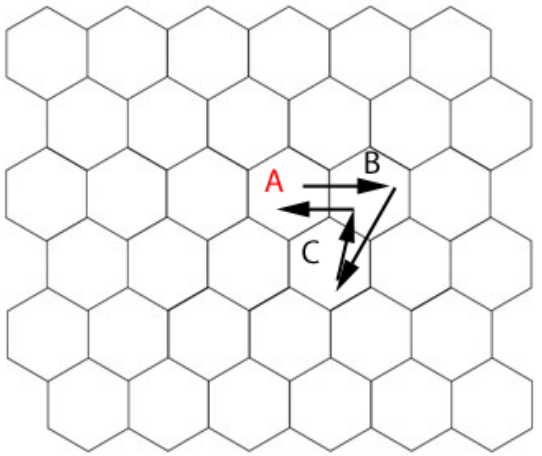

Fig. 8 : Problem with Movement Based Location Update

Here A is the starting point and counter is zero. Now user moves from A -> B -> C -> A direction. Counter at A is 4 thus, at A the location would be updated which would be an unnecessary update.

2.6 Profile Based Location Update

The Profile Based Location Update scheme has been proposed in [8] and [2]. In this scheme each user's profile would be maintained and from that profile the location of the user would be traced out. The main idea behind this strategy is that the mobility pattern of majority of subscribers could be easily predicted. This type of strategy would be useful when the user is working in same geographical area for maximum hours of his / her daily routines. To find out the probability of the user's profile location long term statistical data would be useful.

To create the profile of each user the following operations could be performed:

For each time period (t_i, t_j), the system maintains a list of location areas, [(a_1, p_1), (a_2, p_2), ……., (a_k, p_k)] here A_f is the location area, and P_f is the probability that the subscriber is located in A_f. It is assumed that the location areas are ordered by the probability from the highest to the lowest, that is, $p_1 > p_2 > \ldots\ldots > p_k$.

If the subscriber moves within the recorded location areas, a_1, a_2, … a_k, during the corresponding period (t_i, t_j), the subscriber does not need to perform location update, otherwise the subscriber reports its current location, and the system will track the subscriber as in the classical location area strategy. Therefore location updates could be significantly reduced.

Here in this type of scheme the main benefit would be that if we know the user's location based on its profile and if the user is in that location area only at that time no location update would be required. Sometimes it may happen that user changes his / her daily routine due to some circumstances, at that time we would need to do paging to search the latest location of the user.

2.7 Hybrid Location Update [3]

Hybrid Location updates strategy discussed in [3]. In this paper authors have suggested combination of two strategies to reduce the cost. Here they have combined two types of

strategies i.e. Time Based and Distance Based. In that they have first used Time Based Location Update and then Distance Based Location Update Separately. After that they have proposed a new scheme i.e. TAN (First T then N) and NAT (First N then T).

3. CONCLUSION

In this paper we have studied various location update strategies. Here we have identified that these strategies are useful for location update in mobile computing environment. Presently in GSM generally Time Based Location Update is used and in CDMA Distance Based Location Update is used. It has been found that each strategy which gives an optimum solution in reduction of cost would be the best. It has also been found that the use of a strategy also depends on the mobility of the user. If the user's mobility is less time "Distance Based Location Update" Strategy would prove to be the best whereas if the user's mobility is more "Time Based Location Update Strategy" would be the best. If the user is doing a job for a fixed period of time the most suitable strategy would be "Profile Based Location Update". It could also be concluded that if one or more strategies were combined some cost reduction would be attained.

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