# Location Management in Wireless Network

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# Contents

# List of Figures

# Abstract

Mobility support is the most beneficial aspect of wireless networks. A mobile user can move around the network and remain connected from anywhere of the network. To keep the mobile terminals connected in spite of mobility, the network has to keep track of mobile terminals which will be used to find mobile terminals when incoming calls have to be forwarded towards the mobile terminals. Network also has the requirement of being efficient in keeping these location hints and faster finding as the number of mobile user are increasing drastically over the world. Moreover there are security issues like authentication, authorization, encryption are also related to this operation. These sophisticated requirements resulted in new challenge in wireless networking named Location Management. Location Management consists of both keeping track of mobile terminals and finding the exact location of mobile terminal when call has to be forwarded towards the mobile terminal. Keeping track of mobile terminal is done by a process named Location Update and finding mobile terminal is done by other process named Paging. Both Location Update and Paging are been hot topic of research since their introduction. In this report, we classify the different approaches of Location Update and Paging. We also include a brief discussion of each of those classes.

# Chapter 1

# Introduction

Wireless network is the fastest growing technology over the last few years. Ease and flexibility in using wireless technology means the growth in use of this technology will increase further even at higher rate. Wireless technology enables the user to be connected even if when he is not at her desk or at home. A wireless network user can move from place to place while maintaining communication with others. This property is called *Mobility* of the user. Wireless technology supports certain mobility of the user which is very much desirable and advantageous for the users. This facility however adds extra complexity in the life of wireless network engineers. Network engineers are faced with various challenges to support this mobility of the users subject to very low bandwidth, high interference and variable link performance in wireless environment. These challenges introduced the concept of mobility management.

## 1.1 Mobility Management

*Mobility Management* is the set of procedures used to support user mobility in wireless network. Mobility management ensures an user remain connected while he is moving from one place to other place. Mobility management generally consists of two parts. *Location Management* refers to maintain the location of a mobile terminal and page the calls towards that specific mobile terminal. *Handoff Management* on the other hand involves maintaining an users connection as he moves, changing his network access point to the network [1]. Location management can be divide into two parts, first one is location registration or location update and the final one is, paging or location finding. The general approach of location management is to maintain a database either central or distributed and keep the locations of the mobile terminals either periodically or measuring some parameter. This database is then used to find a mobile terminal and forward calls to them. *Location Update* refers to the action needed to maintain a consistent database with the locations of the mobile terminals. *Paging*, on the other hand, means locating the mobile phone actually and forwards the incoming call to that specific mobile terminal [1]. Plenty of messages are transmitted for these purposes and called signaling messages.

Compared to the wired networks, wireless network has some serious drawbacks. Bandwidth in wireless network is extremely scarce. Interference in wireless network is several times higher than wired network. A 1MB link in wired network exerts almost same capacity independent of external factors. A wireless link, however, does not exert same capacity as it is affected by external factors such as rain, fog, humidity, temperature, presence of other wireless channel and so on. Thus any service in wireless network needs extreme care as resource is very low and variable. Thus, goal of an efficient location management scheme is to maintain and provide locations of mobile terminals at low cost. Low cost in this case refers to using less number of signalling messages and using less time.

## 1.2 Location Management Basic

A wireless communication system must keep track of the users to forward the incoming calls a mobile terminal. To specify the location of a mobile terminal a wireless network usually divided into some Location Areas. *Location Area* (LA) is a part of a wireless network within which no location update has to be done. In case of a cellular network, one Location Area generally consists of several cells. A mobile unit can freely move within on Location Area but has to notify the network when it moves to a new Location Area. The network then probes every cells in a Location Area to locate certain mobile terminal [7]. Effect of large Location Area is low frequency of location registration. However, large Location Area means more cells within one Location Area and needs more paging messages while forwarding an incoming call to a specific mobile terminal. Thus size of an Location Area determines the trade off between location update cost versus location finding cost.

In this report, we have documented the taxonomy and philosophy of various Location Management schemes. describes some preliminary terms about wireless networks that are necessary to understand these report. focuses on taxonomy and parts of Location Management schemes. describes different Static Location Update strategies. we discuss about Dynamic Location Update strategies. has different paging mechanisms. Finally, concludes with summary and future research on Location Management.

# Chapter 2

# Preliminaries

In this chapter we define some basic terms that are used throughout the report. A *Network* is a set of connected systems to facilitate information and computation sharing. In a *Computer Network*, the connected systems are computers. A computer network is said to be *Wired Network* if all the connections among the computers are done using some wires. When wireless links are used, the network is called *Wireless Network*. An wireless network is said to be *Mobile Network* if the connected devices can change their positions and communicate from different location. In a *Cellular Network* the total network is divided into some cells.

The device that is used by an user to be connected to mobile network and continue his communication is called a *Mobile Terminal* (MT). Mobile terminal and mobile device have the same meaning and used interchangeably throughout the report. *Base Station* (BS) is a tower or antenna that is used to transmit or receive signal in a single cell [7]. *Base Station Controller* (BSC) coordinates several Base Stations. It handles channel allocation, controls handoffs, performs paging and works as an interface between Base Station and central network. *Mobile Switching Center* (MSC) coordinates several BSCs. MSC handles basic call setup, call switching, call routing, Billing and mobility management. It also manages communication with other networks.

As mobile devices move around different cells in a network, they must register their new location to enable the network to forward to calls towards the devices. Location Management

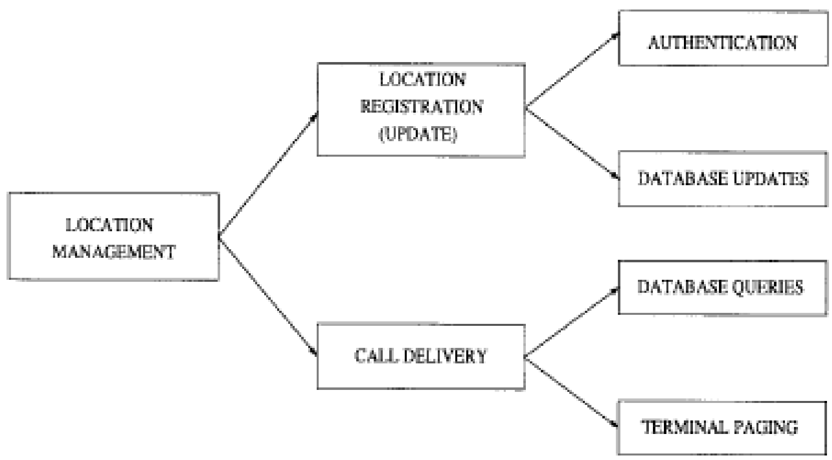



Figure 2.1: Location Management Operations. [1]

is a two-stage process. Details operations of Location Management is shown in Fig 2.1 [1]. Location update is the process where mobile terminal periodically notifies the network of its new attachment point. Network will then authenticate and store mobile terminal's location. In the second stage called paging, network is queried about the user location and this information is used to forward the incoming call towards the mobile terminal. General technique of Location Management involves using a database. The location of each mobile terminal is tracked and stored in this database. Various signaling messages are transmitted during location update and paging among different network components. As the number of mobile users increases, amount of signaling messages also increases. So, new and improved scheme is needed for location management for efficient working of wireless network.

# Chapter 3

# Location Update

Location update is used to inform the network about the uncertainty of a mobile terminal. Each mobile device has to update its location from time to time. The exact procedure however differs among different location update schemes. Location update procedure begins with an update message sent the mobile device itself. Then the location database is updated after some signaling messages. A key issue in location update is, when should a mobile terminal send an update message? If the updating process is less frequent than required, the network may clog into paging phase and send paging message to huge number of cells. The result would be large paging delay. Location update schemes can be divided into two main classes: Static Location Update and Dynamic Location Update. Static Location Update is dictated by network topology. On the other hand, Dynamic Location Update is done based on the user's call and mobility pattern [29]. Each class has various number of sub-schemes. Fig. 3.1 shows a details view of location update strategies [5].

## 3.1 Static Location Update

Static Location Update schemes have their location update frequency dependent on network topology which is independent of user mobility or calling behavior. Static schemes offer lower computational cost but they are less efficient than dynamic schemes [7]. Various Static

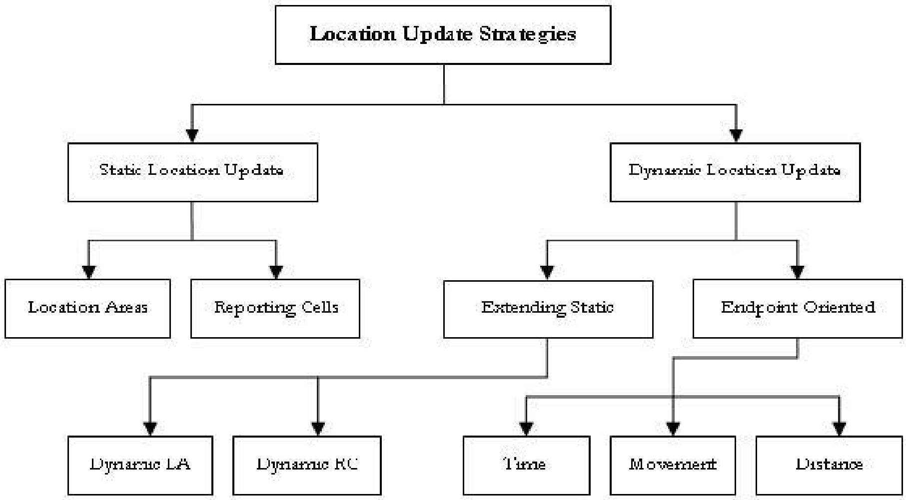



Figure 3.1: Different Location Update strategies. [5]

Location Update Strategies are discussed below.

### 3.1.1 Never Update

The most naive approach is not to update at all. This means there will be no location update overhead associated with this location management strategy. The network would then page every cells for the desired mobile terminal. This scheme works good when there is low number of mobile terminals and cell number is also low. As the number of mobile terminal increases, this strategy becomes the most inefficient.

### 3.1.2 Cell-Based Update

Cell-based or Always-update is the simplest location update strategy where a mobile terminal has to update its location whenever it enters into a new cell. This scheme requires huge number of location update messages compared to no paging as the network has total knowledge of the mobile users in the cell level. This scheme may waste a large amount of resources when mobility of mobile terminals are much higher than call arrival rate. However, this scheme may perform quite well for mobile users with low mobility and high call arriving rate. Moreover this scheme forms a basis of many advanced location management schemes like Location-area based [15] or profile-based schemes [12, 16].

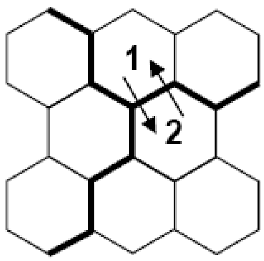
### 3.1.3 Reporting Cells

Location update on each cell causes huge amount of location update messages. To reduce this overhead a scheme is proposed by Bar-Noy et. al. [4]. In this scheme, a mobile terminal has to update its location only if it visits one of a set of predefined cells called the *Reporting Cells*. The set of reporting cells is defined statically and same for all mobile terminals. When a call arrives for a mobile terminal, searching for that mobile terminal is done around the vicinity of the reporting cell from which last update has been done by mobile terminal. Reporting topology may have two different versions. The cells may be bounded or unbounded. The bounded topology requires more number of reporting cells but reduces search space. Unbounded reporting cells however requires less number of reporting cells but intelligent paging scheme may be needed to search unbounded search space. Selection of reporting cells without any mobility consideration results in very poor performance of this scheme. If the mobile user does not enter into any of the reporting cells, its location will be completely unknown and require maximum number of paging messages. Some mobile user may however may enter into same set of reporting cells again and again causing excess location update overhead. Even with the full knowledge of the network, selection of the optimum set of reporting cells is an NP-complete problem [4].

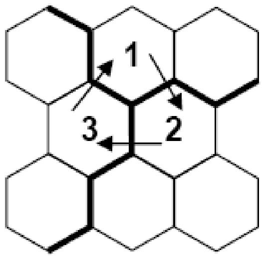
### 3.1.4 Location Area

Location update technique based on location area is very popular and it is used in current GSM [18] and IS-41 [8] network technologies. In this scheme, whole network is divided into location areas where each location area may contain a group of cells. Then the lotion update may occur like cell-based scheme or periodically. In location update like cell-based scheme, the mobile terminal has to update its location whenever it crosses boundary of a location area. Network then has to page every cell in the location area to find a mobile terminal.

On the contrary, periodic location location update causes the mobile device to send location update message at regular time intervals containing its current location area [26]. Although this method is simpler, it ensures no specific location area for a specific mobile terminal. Network may need to capture sophisticated paging across multiple location areas. Moreover it does not depends on user mobility pattern and may not be suitable for all the users with diverse mobility. The boundary crossing method may be more efficient when mobility of users are much scattered and diverse. This scheme also has some weaknesses. The most well known problem is ping-pong effect which occurs when a mobile user repeatedly crosses same set of boundaries [9]. Ping-pong effect is shown in fig. 3.2. When a user resides at the




(a) 2-cell configuration




(b) Generalised configuration

Figure 3.2: Ping-pong effect. [7]

boundary of more than one location areas, mobile terminal may move back and forth into each location area causing much location update without any real actual mobility. To counteract this problem, some schemes has been proposed such as Two Location Area (TLA) and Three Location Area (TrLA) techniques. These scheme follows the principle of allocating two or three location areas to specific mobile terminals. Mobile terminals then need no location update if they crosses boundary of these two or three location areas. These schemes improve the performance at the increase of computational overhead. We briefly discuss two techniques.

### Two Location Area Update Strategy

In the two location area algorithm (TLA) [12], each mobile terminal has some built in memory to store the addresses for the most recently visited location areas. Network location database also has extra memory to store the corresponding two locations. Initially when a mobile terminal joins the network, it updates both its local memory and location database of the network. If the mobile terminal moves to a new location area, it checks for the new location area in the memory. If the address of this new location address is found in memory then no update message is sent. Otherwise the address of recently left location area by the mobile terminal is kept with the address of new location area and an update message is sent to the network. Network also keeps the addresses of two location areas visited by mobile terminal. So, the network always has the knowledge of the two most recently visited location areas by any mobile terminal. However, network do not have the knowledge about exactly which location area holds any specific mobile terminal. Thus when a call arrives, an important question is to which location area should be paged first. One option is to page both of them simultaneously. Another option is to randomly select one location area and page it first. If the mobile terminal is not in that location area then the other location area is paged by network. However observation says that latest-LA-first strategy incurs better performance than other options where the latest (in terms of network's view) location area is paged first.

### Three Location Area Update Strategy

Two location area strategy significantly improves performance but a mobile terminal may reside at a point which is at the boundary of three cells. Thus ping-pong effect may still affect the performance. Three location area (TrLA) is an effort to compensate this ping-pong effect [9]. Here a mobile terminal keeps the address of three location areas in its local memory. The set of these three location areas is called Big Location Area, BLA. Location update procedure is very much similar to that of two location area. There are also several alternative process for paging in TrLA with same philosophy as in TLA.

## 3.2 Dynamic Location Update

Dynamic Location Update schemes rely on different strategies for different users. This difference is dictated by some parameter. Dynamic schemes results in better performance compared to static schemes at the cost of higher computational complexity. If any dynamic location update strategy is followed, a user may send location update message from any cells at any time. Dynamic Location Update has been area of interesting research for the last few years. Various Dynamic Location Update schemes are summarized below.

### 3.2.1 Dynamic Reporting cells

Reporting cell based update strategy is also considered in static location update methods where a set of cells are specified as reporting cells. Mobile terminals have to update their location whenever they crosses any of the reporting cells. In static scheme, the set of reporting cells are predefined and same for all mobile terminals. This static scheme exerts its weakness when a mobile terminal moves repeatedly between two reporting cells. In dynamic scheme however, the set of reporting cells may be different for each mobile terminal. The set of reporting cells is chosen on a per-user basis depending on each terminal's mobility pattern and calling behavior. To determine the set of reporting cells, a set of parallel topologies has been fixed. These topologies are evolved through the use of genetic algorithm [25]. This strategy results in near optimal solution although it incurs high amount of computation overhead and looses implementation flexibility.

### 3.2.2 Selective Location Area Based Update

Location Area based update scheme is a popular scheme where cells are grouped into location area and location update is dictated by the topology of location area. In static location area based technique, the topology of location area is fixed and same for all mobile terminal. Static scheme may cause unnecessary location update when a user resides for small amount of time within a location area. This problem has been approached in selective location area based update strategy. The philosophy that lead development of selective location area based update is a user may go through a number of location area during his way to and from work. He stays however for a short amount of time in most of the location areas. The location area which contains his home and office is most important and it may be enough to update location on those two location areas. It has been shown analytically that the residence time of a mobile terminal in each location area follows geometric distribution [23]. In [23], a graph model has been proposed by considering each node as location area and edges as interconnections among location areas. Genetic algorithms may then be used to obtain a near optimal solution. To implement selective location area based update, the residence probability and transition probability is needed which may be obtained by observing mobility of users for a standard time such as one day. These probabilities may then be used to determine the high residence location areas and location update may be triggered in those location areas where residence probability is higher than a certain threshold.

### 3.2.3 Threshold-based

Threshold-based schemes follow the philosophy that each mobile terminal should send location update message whenever some predefined threshold has been reached. The threshold may depend on user's mobility and calling pattern enabling optimized performance on a per user basis. The most common threshold-based schemes are movement-based, time-based and distance-based.

#### Movement-based Strategy

The movement-based update scheme requires mobile terminal to update their location after a given number of boundary-crossings to other cells in the network. This boundary-crossing threshold may be assigned per-user basis, optimized for individual movement and call arrival rates [2]. Fig. 3.3 shows a movement-based scheme where a movement threshold of two is used. Here the mobile terminal updates its location every two crossings between cells. Movement-based update can be implemented if mobile terminal has only a counter to count

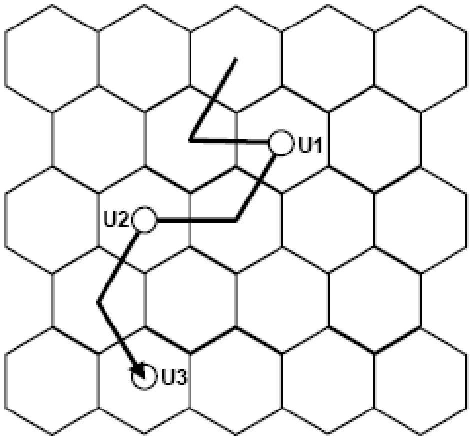



Figure 3.3: Movement-based location update. [7]

the number of cell boundary crossing. Cell Identification Code based system can also be used to implement movement-based update strategy [13]. The required paging area can constrained to a neighborhood of radius equal to the distance threshold around the last updated location. The paging area requirement is reduced through this scheme. However unnecessary updates may still be performed as a result of repeated crossings over the same cell boundary. It has been shown that the movement-based scheme to perform better than the time-based scheme under a memory-less (random) movement model [3].

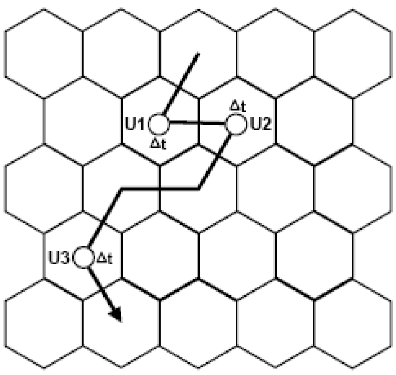



Figure 3.4: Time-based location update. [7]

**Time-based Strategy**

The time-based strategy requires mobile terminals to update their location at constant time intervals. This time interval may be different on a per-user basis to optimize and to minimize the number of redundant update messages sent. This can be implemented if the mobile terminal can maintain a simple timer, allowing efficient implementation and low computational overhead. Figure 3.4 illustrates time-based scheme, with the updates (U1, U2 and U3) performed at each time interval $\Delta t$, regardless of individual movements. It has been shown in [14] that signalling load may be significantly reduced using a time-based scheme, the network can also be able to determine if a mobile terminal is detached if it does not receive an update for a long time. The analysis of the time-based location update scheme for the performance, independent of user mobility constraints can be found in [21]. According to [21] time-based update strategy outperforms the location area method used in current systems. The time-based scheme does however causes a high degree of overhead in a number of situations, such as when a user has only moved a very small distance or has not moved at all [25].

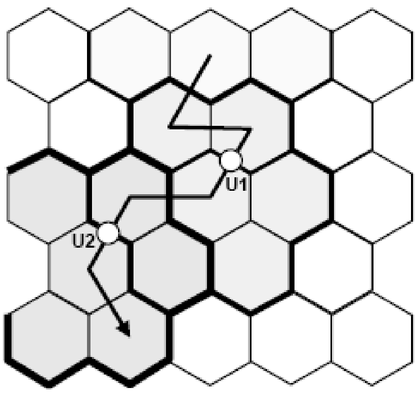



Figure 3.5: Distance-based location update. [7]

#### Distance-based Strategy

In a distance-based scheme, mobile terminals perform a location update when it has moved a certain distance from the cell where it has last updated its location. Again, this distance threshold may be determined optimally on per-user basis according to movement and call arrival rates. Distance-based update system is shown in Figure 3.5. Here the location is only updated when the user travels more than a certain distance from the previous location of update. The beneficial point of This scheme is that it does not requires an update when an user repeatedly moves between a small subset of cells, provided these cells reside within the distance threshold. Distance-based scheme significantly outperform the time-based and movement-based schemes under both simulation and theoretical analysis [3, 1].

Distance-based update strategies are very much difficult and needs sophisticated method to implement in a real-world network [10]. Each mobile terminal is required to keep track of its location and determine the distance from the previously updated cell. This not only requires the mobile terminal to retain information about its starting position, but also to possess some technique to determine new location, allowing the calculation of distance between the two locations. A possible approach may be to make every terminal Global Positioning System (GPS) enabled.

### 3.2.4 Profile-Based update scheme

Profile-based update strategy tries to take advantage of user mobility. In this method, the network maintains a profile for each mobile terminal [16, 27]. The profile includes a list of location areas which are probable candidate to be visited by a that specific mobile terminal. The list is sorted according to the visiting probability of the mobile terminal with most probable at the start of the list [12]. On a location update, the list is given to the mobile terminal. Location update is not necessary as long as mobile terminal resides within that any location area which has an entry in that list. When a mobile terminal enters into a location area which is not in the list, a location update message is sent to the network. When mobile terminal has an incoming call, the list is paged sequentially with most probable first.

Profile-based scheme exhibits good performance when the predictability of network is high [30]. However with low efficiency in prediction, the cost of sending large profile location area list may be larger than the improvement resulted by profile-based scheme.

### 3.2.5 Predictive Distance-Based Update

Predictive distance-based update strategy is slight improvement over distance-based update scheme discussed in 3.2.3. In predictive distance-based scheme, the mobile terminal has to report both it's location and velocity during location update process. These information is then used to predict mobile terminal's location at future [11]. The predicted location is made available to both network and mobile terminal. Mobile terminal keeps track of current location and whenever it finds significant deviation from the location prediction by the network. A location update message is sent then to report this deviation. The network responds on this location update message. Upon an incoming call, the predicted location is paged first and then locations paged sequentially based on the distance from predicated location with shortest distance first. Numerical results are present in literature which show that predictive distance-based update scheme.

### 3.2.6 State-Based Update

State-based update scheme follows the principle of updating the location depending on the state at which currently the mobile terminal is residing. The state information may comprise various parameters such as time since last update, movement since last location update, distance between current location and the location where last locatio update message has been sent, velocity, acceleration of mobile user and many other parameters. Considering different parameter set results different location update schemes. Rose analyzed the performance of state-based location update scheme taking time and distance as parameter [19]. He used a time varying gaussian process to model user mobility. Obtained result shown 10 percent improvement of state-based update over normal time-based update strategy.

### 3.2.7 LeZi Update

LeZi update scheme is an path-based scheme where mobile terminals send their movement history with location update scheme. Movement history generally consists of location area or cell IDs visited by that mobile terminal. The network then stores the movement history in a digital search tree or by trie. This information is considered as the profile of mobile terminal and used while paging. Ziv-lempel compression algorithm is used to compress and represent movement history of each mobile terminal [6].

### 3.2.8 Activity-based Location Update

Activity-based update scheme follows the same philosophy as predictive distance-based scheme. Mobile terminal sends cell crossing frequency with cell residence time. These information is then used to calculate likelihood of residence in each cell. Cells are added up to a threshold depending on cell residence probability. These list is used when an incoming call comes towards the mobile terminal [24]. The size of the list may varied depending on mobile terminal's mobility and calling behavior.

# Chapter 4

# Paging

Paging means finding a mobile terminal when a call is directed towards it. Location update is done by mobile terminal but paging is done by the network. The network should be able to determine the exact location of a mobile terminal to forward an incoming call to the mobile terminal. Paging is generally done by sending paging query from the network to the cells

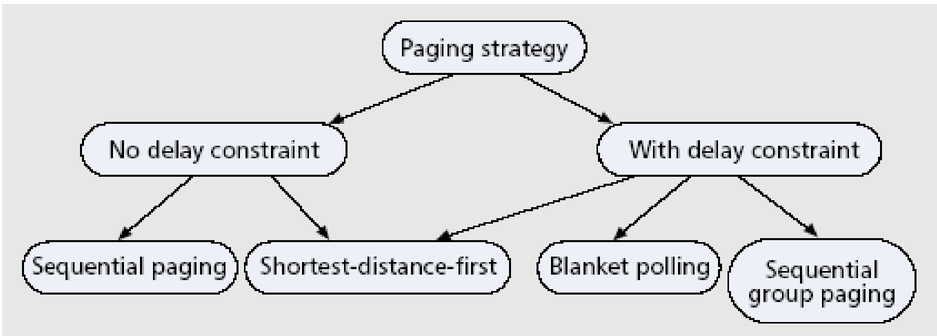



Figure 4.1: Different Paging schemes. [29]

where the mobile terminal may reside. All the mobile terminals listen to this query and only the called one replies back. Sending the query may be send over cycles if the number of cells to be paged are high. The actual number of cycles depends on the strategy taken by the network for paging. The large the paging area is the more messages to be sent for paging, thus reducing the paging area is always desirable [10]. Normally the paging area is restricted to a set of cells as in location area implemented now-a-days [15]. To avoid call dropping, a mobile terminal should be paged within a time period. Thus paging is generally constrained with some delay constraint. So, an optimum paging strategy tries to keep the paging area as small as possible and keeps the paging delay within a limit. In this chapter, we discuss on different paging technique. A classification of paging strategy is shown in fig. 4.1.

## 4.1 Blanket Paging

In Blanket paging scheme, all the cells of the location area where a mobile terminal is currently residing, are paged simultaneously. Thus it is also called Simultaneous Paging. Blanket paging is currently used with location area-based update scheme in current networks [29]. This method is very simple as it does not need any special knowledge other than just the location area where a mobile terminal resides. However simultaneous paging to all the cells may generate excessive paging messages. So, Blanket paging may work well in a network with large cells but low user density and sparse calling but it fails to work well when the network is large with dense population of mobile terminal and frequent calling.

## 4.2 Sequential Paging

Unlike Blanket paging which pages all the cells of the location area simultaneously, Sequential paging divides the total location area into some group of cells, called Paging Area. Each paging area is paged in one cycle. Thus sequential paging though may increase the delay compared to simultaneous paging, incurs lower amount of signaling overhead on the signaling network. Using sequential paging optimizes the performance in terms of network utilization [22]. The delay incurred in paging each paging area will sum up to the total delay for paging. Thus it is desirable to find the mobile terminal within the smallest number of cycles. So, the paging areas should be selected with care for paging. There are several alternatives to select the paging areas for polling. Here we discuss the main two.

### 4.2.1 Random Sequential Paging

The simplest ordering of paging areas for polling is the random ordering. In this ordering, a paging area is selected randomly and paged for the mobile terminal [22]. The paging process ends whenever mobile terminal replies from any cell. Although it is not intuitive, random sequential paging results in lower signaling overhead than simultaneous paging. But the performance of random sequential paging is far from optimal.

### 4.2.2 Shortest-Distance-First Sequential Paging

Shortest-distance-first paging strategy keeps track of the cell from where the mobile terminal has last updated its location. The paging starts with the cell from where the update has happened and in each cycle the cells farther from the central cell, from where the last update has happened, is paged. The distance is measured in terms of the number cells away from the central cell. This scheme works best when movement-based or distance-based location update scheme is used because those location update schemes results in bounded paging area and maximum number of paging cycle needed to find a mobile terminal is defined by movement or distance threshold [29].

## 4.3 Intelligent Paging

Intelligent paging is special type of sequential paging. However, the ongoing research and importance of intelligent paging has increased so much that it needs separate attention other than as a sequential paging. In intelligent paging, the order of paging the paging areas are determined according to some predetermined metric, generally the location probability. Paging areas with high probability are paged first as mobile terminal are highly probable to stay in those paging areas. Precise calculation of probability needs knowledge about user residence history and call patterns which is a nontrivial task. Various models have been proposed in literature.

### 4.3.1 Location Probability Paging

This strategy determines the paging order by calculating location probability of mobile terminals. The location of mobile terminal is calculated from location probability distribution. The most probable paging areas are paged first. It has been shown that if no paging delay constraint is given then the optimum paging is to poll the cells in decreasing order of probability [22]. The more uniform the location distribution is, the more paging cost is incurred. However, if any delay constraint is given it is possible to share the idea of blanket paging. Cells are grouped according location probability and a group of cells are paged simultaneously to reduce the signaling delay. Optimal group size can be determined using dynamic programming [17].

### 4.3.2 Velocity Paging

Velocity paging scheme relies on reducing the size of paging area considering the velocity of the mobile user. The user are grouped into different classes based on their velocity when they have last updated their location [28]. When an incoming call comes to the mobile terminal, paging area calculated dynamically considering the mobile terminal's last update location and velocity class. Information of mobile terminals last updated location, time of last update and velocity while last update happened is stored in the location database for this purpose. The fineness of velocity paging scheme is that this paging scheme can be used on top of any location update scheme which can just supply the velocity information of the mobile user. Performance analysis of velocity paging can be found in [20].

# Chapter 5

# Conclusion

Popularity of wireless network is increasing day by day. The main aspects that dictate popularity wireless network are bandwidth and mobility support. Wired networks support much larger bandwidth support than wireless networks. Still wireless network is gaining popularity mainly due to mobility support. Thus mobility management is an important characteristics for wireless network. Location management is an integral part of mobility management and happens to be one of the factor that determines the performance of wireless networks. So, location management is attracting more and more research attention.

In this report, we have summarized different parts of location management and different location management strategies. We conclude this by stating several open issues,

- Several dynamic location update proposes per-user location management strategy. Efficient modeling and storing mechanism for information of huge number of users are necessary.
- Intelligent paging schemes need to calculate some location probability for each mobile terminal. Issues relating how we can determine time varying location probability from past behavior, how can we store location distributions efficiently when they don't follow standard distribution are becoming bottleneck factor.
- Although different location update and paging mechanisms are proposed, there are no

unified tool to compare different strategies. The intractability occurred as different models and assumptions has been made to develop these schemes. A unified test tool is therefore necessary.

- Wireless networks are becoming diverse as the popularity is increasing. This has resulted several alternative wireless technologies with different location management systems. As the mobile terminal has to interact with different networks to support roaming, a generic location update triggering is needed to be implemented in mobile terminal so that same mobile terminal can roam in different networks.

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