

A Survey on Location Management Strategies in Cellular Networks

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Abstract— Now-a-days wireless networks have become very popular as they support mobility. Mobile users can access services irrespective of their locations. Wireless networks use cellular architecture for better efficiency. To support mobility the networks must have some mechanism to find terminal's current position. Location management in cellular network is related to keeping track of mobile terminals. It consists of two operations: Location updating and paging. There is a cost associated with each operation and total location management cost is sum of update cost and paging cost. There is always a trade-off between the two costs, so it is required to define a strategy which can minimize total location management cost. The paper reviews different location update and paging strategies.

Keywords— Location management, cellular network, location management cost, location updating, paging, location areas, reporting centers.

INTRODUCTION

Today mobility has become very important. There is tremendous growth in the number of people having access to mobile phones. So, wireless communication and wireless networks have become very popular as they support mobility. They provide a wide range of services like voice calls, video calls, data and many others to the users irrespective of their locations. To support such a large number of users and efficiently utilize wireless resources, wireless networks use cellular architecture. In cellular architecture whole coverage area is divided into a number of sub areas. Each sub area is called a cell. For each cell there is a fixed base station. Terminals can access network via base station of the cell in which it is currently residing. As the terminals are free to move anywhere from one cell to another, to provide services to a terminal network must have information about its current location i.e. the cell where the terminal is currently residing. So suppose a call arrives for a terminal it can be forwarded to the base station and it can provide service to the terminal.

Thus, location management [8, 11] is an important issue in cellular networks. It consists of two operations: location updating and paging. In update operation, when a terminal moves from one location to another it needs to inform the network about the change and in paging operation, when a terminal require any service, network will page a number of cells depending upon the last update operation, so that it can find the exact location or cell of the terminal and provide required services.

LOCATION MANAGEMENT COST

Each of the location update and paging operations has a cost associated with it [8, 11]. Total location management cost is the sum of both the costs. Suppose update operation is performed more frequently, then update cost will be more. At the same time network will have better knowledge about the terminal so paging requires less effort and paging cost will be lower. There are two extremes: Always-Update and Never-Update. In always update, when terminal moves from one cell to another location update is performed. So, update cost will be high but there is no paging cost because network always knows current location of each terminal. While in never update, terminal never performs location update. Network will have to page all cells in the network to find out exact location of the required terminal. Thus update cost is negligible while paging cost is very high. Thus there is always a trade-off between update cost and paging cost. So, some strategy is required which can balance both the costs and in turn minimize the total cost.

LOCATION MANAGEMENT STRATEGIES

Location update schemes can be classified as global and local [8]. In global scheme, all terminals are required to perform update operations at same set of cells and it is based on aggregate mobility pattern of all terminals while in local schemes each terminal is free to decide when and where to perform update operation. A local scheme is also called per user based scheme and it is based on mobility of each terminal. In Another way, location update schemes can be categorized as static and dynamic [8, 9]. In static scheme,

terminal is required to perform update operation at predetermined set of cells irrespective of its mobility. In dynamic update each terminal can perform update operation at any cell depending upon its mobility.

Location areas [12] and reporting centers [11] schemes are global and static. Time-based, distance-based and movement-based schemes [8, 15] are the example of per user based dynamic schemes. A global scheme can be dynamic, like time-varying location areas. Also per user based scheme can be static, e.g. individualized location areas.

A. LOCATION AREAS

The approach is global and static. In Location Area [12], the whole coverage area is divided into number of sub areas, called location area. Each location area consists of a number of contiguous cells. Update operation is performed when terminal crosses location area boundary. Here every cell broadcasts location area identity (ID) of the location area to which it belongs. So, every terminal can determine its current location area and check where it has moved to a new location area or not by comparing its own location area ID with the broadcast one. A terminal performs location update when terminal moves from one cell to another cell which is in a different location area. Suppose there is a service area with three location areas as shown in Figure 1. If a terminal moves from cell B to cell D update is required. In paging, all the cells of the location area, which was last updated by the terminal, are required to be paged.

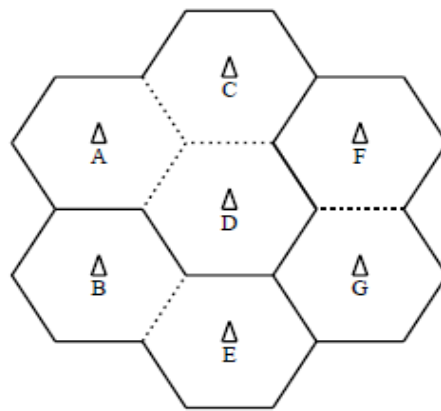


Figure 1: A Service Area with Three Location Areas [7]

The whole service area should be divided in such a way that both the location update cost and paging cost are minimized. With the size of network, it becomes computationally difficult to check for every possible solution and find the best one is an NP-complete problem.

Javid Taheri, Albert Y. Zomaya [3] proposed simulated annealing method to identify optimal location area configuration so that total cost can be minimized. Simulated annealing is based on annealing process of physics. This method can be applied to many optimization problems. This paper applies the same method. Here some parameters are required to be defined carefully for better result. One is initial solution. Here method used is: First a cell is selected randomly, and LA is formed with this cell then neighbor of the cell is added to the LA with probability 0.5. This process is repeated until all cells are not assigned to a LA. Another parameter is modifying a solution. Here approach used is: Any random boundary cell is selected, then any neighbor cell of the selected cell which does not belong to the same LA is selected and the randomly selected boundary cell is moved to the LA area of the neighbor cell selected. This method considers mobility weight and call-arrival weight of cells to identify optimal configuration and tries to minimize total location management cost. The experimental results on different network configurations show that the method creates LA configuration such that total location management cost is much less as compared to always update and never update strategies.

Ki-Dong Kim, Sung Soo Kim, Eui-Seok Byeon, Hwan Kim V. Mani, Jae-Ki Moon and Si-Hwan Jang [4] proposed a method that uses simulated annealing method with a new parameter called compact index (CI) to find optimal configuration of location areas. The given method uses compact index to select starting solution and neighbor solution. The compact index is given by the ratio of number of adjacent boundaries and the total number of boundaries in the given network. The value of compact index varies between 0 and 1. Now, suppose we have two randomly generated solutions and we need two determine which solution to use as initial solution which could lead to better final solution. For this the given method calculates compact index of the two solutions and chose the solution with minimum compact index. In the same way the compact index is used to determine whether to accept or reject the new solution generated. If the compact index of new solution is less than the current solution then it is accepted as a current solution otherwise the solution is rejected. These methods provide cost efficient location area configuration. Also evolutionary algorithms like genetic algorithm, taboo search, ant colony optimization etc. algorithm have been proposed [14, 16] to find optimal configuration.

B. REPORTING CENTERS

Reporting cell scheme is also global and static. In reporting cell approach, certain cells are selected from all cells and these cells are considered as reporting cells. Other cells are called non-reporting cells. Here base station of each cell broadcasts whether it is a reporting cell or not so that mobile terminal can determine whether it is in a reporting cell or not.

Vicinity of every reporting cell includes those non-reporting cells that can be reached from the reporting cell without crossing any other reporting cell. Also each cell is in its own vicinity. Vicinity of a non-reporting cell is the maximum of vicinity values of all the reporting cells to which the non-reporting cell belongs. Figure 2 shows a service area with four reporting centers B, C, D and G. Vicinity of D is A, E, F and D.

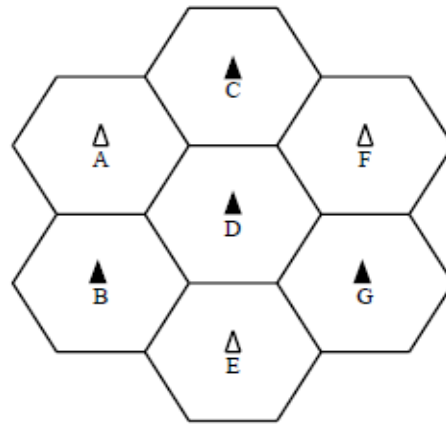


Figure 2: A Service area with Four Reporting Cells [7]

In this approach update is performed when a terminal enters a new reporting cell. When network has to find a terminal's current location it will page all cells within the vicinity of reporting that was last reported by the terminal through update operation.

Here some way is required to identify optimal reporting cell configuration and determine set of reporting cells such that total location management cost is minimized. As the size of network increases, it becomes difficult to try out all solutions and select the best and it is an NP-complete problem.

Falguni Mehta, Prashant Swadas [5] proposed simulated annealing approach to select reporting cells in order to minimize the total cost. It uses generic simulated annealing method which is modified to solve the given problem of reporting cells. Here important parameters are initial solution, generate new solution and initial temperatures are considered. To generate initial solution the method uses mobility and call-arrival weight of cell. If mobility weight is less than call-arrival weight then the cell is considered as reporting cell otherwise it is non-reporting cell. To modify solution, n out of total N is selected randomly and their status is randomly selected. To select initial temperature, Z solutions are selected randomly and average of cost and average of cost difference is calculated which are used to calculate initial temperature. The simulation result shows that the given approach produces much better result than always update and never update strategies.

C. TIME-BASED LOCATION UPDATE

In this scheme [8, 15] every terminal updates its location periodically, say every t unit of time. Whenever system requires locating a terminal first it will page the cell last reported by terminal, let the cell be c . Next it will page cell $c+i$ and $c-i$, here ring topology is considered. Here the cells where to perform update are not predetermined so the scheme is dynamic. Also value of t can be determined on individual basis. The scheme is very easy to implement but each terminal performs update irrespective of its mobility or call arrival rate so the performance is not that good as other schemes. It is inefficient when terminal has travelled a very small distance or not changed its position at all from last updated location.

D. MOVEMENT-BASED LOCATION UPDATE

In this scheme [8, 15] basic idea is to perform update when a terminal crosses certain number of boundaries between cells, say m . For this a counter may be used which is increased by 1 as terminal crosses a boundary. When it reaches m , update is performed and counter is reset to 0. Here there is no predetermined set of cells so the method is dynamic and value of m can be determined on the basis of individual's mobility. When a call arrives system will page the cells at distance m from last reported call. It is easy to

implement. Suppose given threshold value is 2. So, terminal will perform update operation when it crosses two boundaries. Here paging requires searching in neighbor cells only.

E. DISTANCE-BASED LOCATION UPDATE

In this scheme [8, 15] location update is performed when a terminal covers a certain distance, say d from last reported cell. Value of d can be determined on individual basis using mobility pattern. In paging operation network will page all cells within the distance d from the last reported cell. The method may perform better than time or movement based but difficult to implement. Here every user is required to keep information about its last updated location and also some coordinate system so that it can calculate the distance between current and last updated location.

F. PROFILE-BASED LOCATION UPDATE

In this scheme [15, 18] network uses each individual user's mobility pattern for location update and paging. The network and terminal maintains information about locations where a terminal is more likely to be found based on history of the terminal. If user moves according to the pattern no location update is required. This method can efficiently reduce the total cost but it is difficult to implement.

Alok Sahelay, Ramratan Ahirwal, and Y. K. Jain [1] proposed a method which uses a fact that user activities are normally fixed at particular location and for particular time period. This scheme uses a special table called mobility data table (MDT), which is stored at visitor location register (VLR). This table stores information about user's locations for every time slots and this information are used to find the user's current location.

Here time is divided into slots of one hour. Every mobile terminal has cache memory. Mobile terminal maintains an MDT table and at the starting of each time slot it enters its current cell ID in MDT. Then the terminal can send this MDT to VLR database whenever channel is idle e.g. at midnight. This control signal is transferred when channel is idle and is not being used by actual data transmission, otherwise location management cost could increase. Initially network has no information about user mobility so when call arrives whole area is paged as per convention method. When network finds the terminal the cell ID is stored in MDT at corresponding time interval. When next time call arrives and network has non empty MDT for that time interval, network first pages the cells present in MDT in given order. If terminal is found at cell more than once then entry in MDT is swapped with leftmost cell and if terminal is not found in the cells then conventional paging is used. This method reduces the paging cost significantly.

PAGING SCHEMES

After location update, network has to determine exact location of a terminal to forward call intended for it. So, it requires paging a number of cells. Here the cells to be paged i.e. paging area should be small to reduce cost associated with paging.

A. SIMULTANEOUS PAGING

The scheme [15, 18] is also known as blanket paging scheme. Here whenever paging is to be performed all cells in the location area when user was last reported, are paged simultaneously. This does not require any extra information but it involves paging a large area. So this method is useful if call rates are low.

B. SEQUENTIAL PAGING

In sequential paging [15, 18] all cells are not required to be paged. It divides the location area into paging areas and each paging area is searched one by one. As extreme case, each cell forms a paging area which is to be paged one by one according to the probability of finding user in every cell, but it may involve large delays, so a paging area size is used more than one. Here determining size of paging areas and order of paging are crucial tasks.

Madhubanti Maitra, Partha S. Bhattacharjee, Debashis Saha and Amitava Mukherjee [17] proposed a rule based paging scheme which with movement based location update which efficiently reduces paging cost and total location management cost.

Pragyan Acharya, Sudhansu Sekhar Singh [2] proposed a different approach called bloom filtering for paging operation. It uses two components: Bloom Filter Identity Vector (BFIV) for each terminal and Cell Vector for each cell. Here every terminal is assigned an n -bit identity vector called BFIV. Each terminal periodically sends the identity vector to the cell in which it is currently residing. This is performed periodically. On the other side each base station receives BFID of different terminals periodically and maintains combination of these BFIDs as cell vector.

When location of terminal is to be found the BFID of the terminal and last updated Cell Vector of each cell are used. Suppose a call arrives for a terminal, to find out its current cell bit by bit comparison of BFID of the terminal and Cell Vector of each cell is performed. Suppose i^{th} bit of BFID is 1. If the i^{th} bit of cell vector is also 1 it shows that the cell contains at least one terminal with BFID having 1 at i^{th} bit and so the cell may have the required terminal. If the i^{th} bit of cell vector is 0 it shows that all terminals in the cell are having BFIDs with 0 values at i^{th} bit. So that cell is not required to be paged. Mathematically a cell is paged if bit by bit

multiplication of BFID and Cell Vector is same as BFID of terminal. Experimental results show that compared to sequential and simultaneous paging, paging cost incurred in the scheme is much less. Also the method doesn't involve any overhead related to storage and processing requirement of terminal.

CONCLUSION

Because of the mobility requirement in today's world, location management in wireless networks has become an important and interesting area of research. The paper reviews different location update and paging related schemes which are the two operations involved in location management in cellular networks. Various static and dynamic update strategies and many paging strategies have been proposed in past years with the aim of reducing total location management cost, each having its advantages and disadvantages. Taking into consideration various aspects like time, feasibility, complexity, quality of result etc. research in this direction will remain active and further research can be carried out with new and improved techniques.

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