OVERVIEW OF LOCATION MANAGEMENT IN CELLULAR NETWORK

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Abstract : Location management is a key issue in personal communication service networks to guarantee the mobile terminals to continuously receive services when moving from one place to another. In this paper we study different static and dynamic location management technique used in current cellular system and how total cost is calculated from location update and paging cost. Topic covers include location management architecture, location management procedures, static and dynamic location areas and location management in 3G.

I. INTRODUCTION

Location management is basically a procedure required to maintain the location information of each subscriber. It is required to efficiently handle the establishment of incoming calls. In a cellular network the subscribers can roam any where throughout the network and possibly in other networks. In order to be able to route incoming calls to mobile subscribers, the network needs the current location of each subscriber, in terms of the particular cell that the subscriber is currently camped on [1]. To manage the mobility of subscribers, location management procedures are used.

Location management consists of two procedures.

1) Location Update is use to inform the network about the current location of the subscriber.
2) Paging is used to inform about the target user of incoming calls. It is initiated by network. In paging a message is broadcast in different paging areas of current location area to know about target users.

In a cellular network cells are grouped together to form a location area. User can move within a location area without any location update but when subscriber moves to new location area then it has to inform the network.

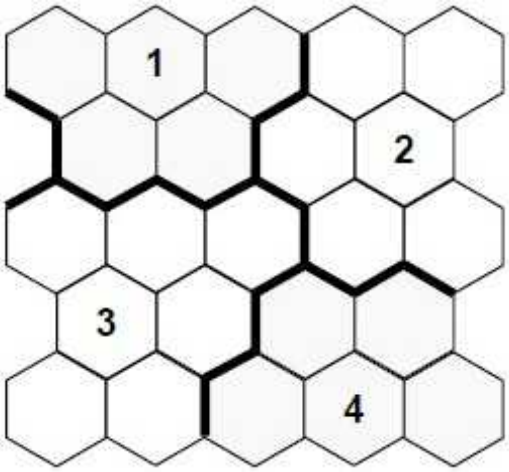

Fig 1.Network partitioned into location area

II. LOCATION MANAGEMENT STANDARDS

Electronic and Telephone Industry Associations (EIA/TIA) Interim Standard IS-41, and the Global System for Mobile Communications (GSM) Mobile

Application Part (MAP) are two standards used in current cellular network.

Currently these two standards use two level hierarchal databases. Home location Register (HLR) and Visitor Location Register (VLR) are used to maintain the information about the use. HLR maintain the record of all users' services in addition

to the location information of network. Visitor Location Registers (VLRs) download data from the HLR about the current users which are within the VLR's specific service areas [4]. Each VLR is designed to only monitor one LA and each LA has one VLR servicing it. Each VLR is connected to multiple Mobile Switching Centers (MSCs) to do handoffs in network and to locate user easily. For LUs always-update method is used by IS-41 and GSM

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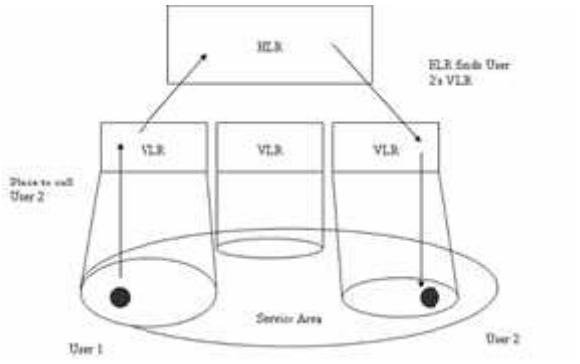

Fig 2. HLR/VLR architecture,Example of class process

III. LOCATION MANAGEMENT PROCEDURE

The continued growth of wireless communication systems and expansion of network subscription rates, signals increased demand for the efficient location management [2]. The study of location management aims to reduce the overhead required in locating mobile devices in a cellular network. In location management there are two parameters in which network cost is involved. These two parameters are Location Update and Paging. Careful location update and paging strategies must be applied so that processing and communication cost must be minimized. In location management mobility models are also used to estimate the movement of a user in a network.

The main approaches to location updating, paging and mobility modeling will be discussed here.

A. Location Update

Location update is used to inform the location of a device to the network. For this device has to register its new location to the current base station so that incoming calls can be forwarded to it. As location management is very costly exercise because in this network bandwidth and core network communication is used and modification of location databases is done so a wide variety of schemes have hence been proposed to reduce the number of location update messages required by a device in a cellular network.

The location management techniques are discussed as follows

1) Static Location Update

In this location updates occur with same frequency. It does not depend upon the characteristics of users. In this scheme cost reduction is less but computational complexity is efficiently reduced because individual user tracking and parameterization is not needed in this scheme.

1.1) Always Update Scheme

In this scheme location update is done whenever user moves to new location. In this no paging is need whenever a new incoming call arrives as the network always has complete knowledge user's location. Always update scheme is good in if call arrival rate is high or user mobility is less. If users have high mobility then this scheme is not perform well because so many location updates is needed.

1.2) Never update scheme

In this scheme mobile device never update its location. Whenever a call arrives so many paging messaging are broadcasts in order find the location of mobile device to forward the call. Always update scheme minimize the paging cost whereas never update scheme minimize the location update cost but increase paging cost.

1.3) Static interval based update scheme

In this scheme location updates are done after regular interval of time. It ignores the exact cell or Location Area where the mobile station is at any moment in time. It is most commonly used in today's network.

2) Dynamic Location Update

In these schemes location updates are done according to the dynamic behavior of users. These schemes allow per-user parameterization of the location update frequency. Location updates can be performed from any cell in the network. For location updates

mobility pattern and call arrival of user are considered

2.1) Time based location update

In this scheme threshold value T of time is set. The location updates are performed after time T. It is similar to static scheme but difference is that the timer value can be modified in dynamic location update. The timer value is modified on the per user basis so that redundant update messages sent are minimized. The paging strategy is also very simple for this scheme. By this scheme use computational is minimized but overhead increases if user moves a little distance or not moved at all. Whenever there is an incoming call for a mobile station, the system will first search the cell the mobile station last reported to, say _. If it is not found there, the system will search in cells i+j and i-j starting with j=1 and continuing until the mobile station is found [2].

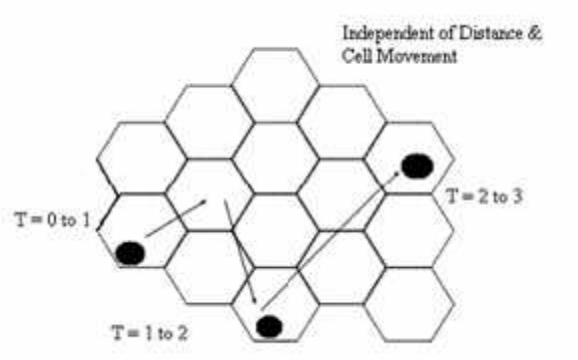

Fig 3. Time-based Threshold Location Update

2.2) Movement base location update

In this scheme threshold value say M of user movement is predefined. When user moves in more than M cells then location update is performed. When an incoming call arrives for a mobile station, the cellular system will page all the cells within a distance of M from the last reported cell [2].The value of M is optimized on per-user basis according to the mobility pattern of user and call arrival rate. If the users are constantly moving in network then this scheme wok similar to always update scheme. This scheme works better than the time based update scheme.

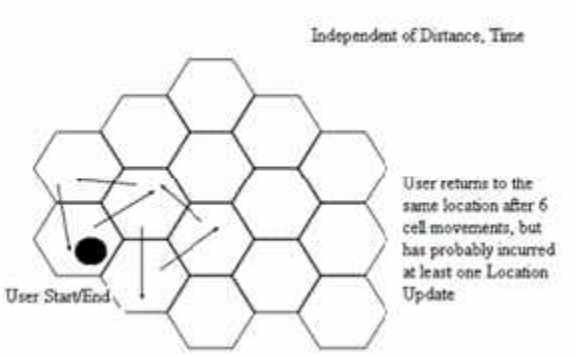

Fig 4. Cell-based Threshold Location Update

2.3) Distance based Location update scheme

In this scheme threshold value of distance say D is predefined. When user reaches the distance D then Location update is performed. When an incoming call arrives for a mobile station, the cellular system will page all the cells within a distance of D from the last reported cell [2]. The value of D is optimized on per-user basis according to mobility pattern and call arrival rate of user. This technique is also not a perfect technique because computational complexity is increased as to calculate a distance some concept of coordinate system are used.

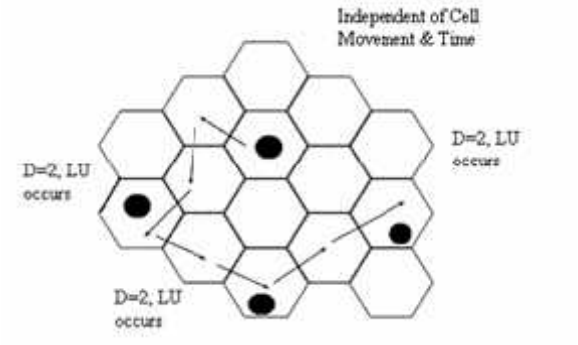

Fig 5. Distance – based Threshold Location Update

2.4) Profile based location update scheme

In this scheme for each user a file is maintained by the network according to mobility pattern. The network compiles the list of the cells which are most frequently accessed by the user. The location update is performed by the network only if user moves outside of the cells which are commonly in the list. This technique is good if the predictions are made accurate. The list size should be small otherwise paging cost outweighs the cost reduction provided by the profile-based scheme.

B. Paging

Paging is another parameter of location management. In paging message called paging message, is broadcast to locate the current cell of recipients of call when an incoming call is arrived. It is desirable to minimize the size of this paging area, to reduce the cost incurred on the network with each successive paging message [3]. Ideally the paging area will be restricted to a known group of cells, such as with the currently implemented location area scheme [3].

The most common paging techniques are as follows:

1) Simultaneous Paging

In this paging scheme, to find the current cell of recipient of call, every cell in the recipient's location area is paged simultaneously. The simultaneous paging is called blanket paging and is currently used GSM network implementation. This method finds the users quicker than other paging scheme but paging cost of this scheme is high which make this scheme inefficient.

2) Sequential Paging

In this scheme location area is segmented into paging areas and every paging area is polled one by one. This scheme has poor performance if user is in frequently occupied location. In that case every cell has to be paged and there is a long delay in call establishment. The number of cells per paging area is a factor which needs to be optimized and may lead to excessive call delays, particularly in large networks [3]. The performance of sequential paging depends upon the order by which each area is paged.

3) Intelligent Paging

This scheme is variation of sequential paging. In this scheme probability metrics is established and paging order is calculated probabilistically on the basis of that metrics.

Intelligent paging aims to poll the correct paging area on the first pass, with a high probability of success. This efficient ordering of paging areas requires a comprehensive knowledge of user residence probabilities. This scheme has too much computational overhead incurred through updating and maintaining the metrics.

IV. MOBILITY MODELS

It is another parameter used in location management to estimate the movement of user in the network. The different mobility models are discussed as follows.

A) Random walk

It is a model in which direction of user movement is completely random. This model is regularly used to model the movement of user in cellular networks. Every neighboring cell is visited with the same probability.

B) Fluid flow

This model describes the aggregate traffic. This model states that the amount of the traffic flow out of the area is proportional to the population density of area, length of area and average velocity of movement. This model is difficult to apply in situation where individual movement patterns are desired.

C) Markovin Model

This model describes individual movement. In this model a mobile subscriber either remains within the region or move to the adjacent region according to transition probability distribution.

V. STATIC/DYNAMIC LOCATION AREAS

Location areas in static location management are static location areas. Static location areas are fixed collection of cells. Each user is provided same location area without any customization. Every user roams through static location area subject to same no. of location updates. It is the easiest solution to physically divide the network.

When user repetitively move between two or more adjacent Location area's then Location update schemes will cause a large number of Location updates where as distance moved is small or zero absolute cell. This is called ping pong effect.

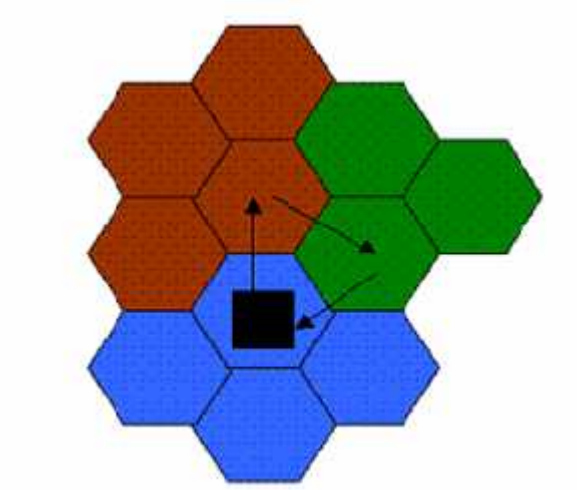

Fig 6. Low absolute movement, high number of LA changes

The optimal static LA size algorithm states that in a network with uniform cell size, cell shape, and user movement speed, the ideal number of cells per LA is

$$N_{opt} = \sqrt{\frac{vC_{lu}}{\pi RC_{pg}}}$$

R is the cell radius
V is the speed of a user
Clu is the LU cost
Cpg is the paging cost per call

This algorithm use fluid flow model. This equation states that high user speed and LU costs indicate that having a large number of cells per Location Area is preferable, while a large cell radius and high paging costs imply that a small number of cells per Location area are optimal [2].
Dynamic location areas are the areas which are need not to be of fixed size. Network is divided into location areas according to the mobility pattern of user and probability. Dynamic location areas can be easily customized. The mobility patterns are updated at regular interval according to user movement. Dynamic location areas are basically irregular in shape. In dynamic location area data already available on network is cost by which cost is educe as no mechanism is needed to collect the data.

The total cost of location management is the sum of the location update and paging costs.

CostLM = CostPage+ CostLU = λ.Ncells.Cpg+ CostLU

Where
λ = call rate
Ncells = number of cells in the paging area
Cpg = const. cost per paging message
CostLU = Clu/TLA

Where
Clu = cost per location update
TLA = dwelling time within the current LA

Therefore the total cost of LM is:

CostLM = CostPage+ CostLU = λ.Ncells.Cpg+ Clu/TLA

VI. LOCATION MANAGEMENT IN 3G

In 3G three level hierarchal scheme is used. In 3G Gateway Location Register (GLR) is use to handle the VLR updates. The GLR contains roamer's subscriber profile and location information, and handles mobility management within the visited network [4]. In 3G hierarchal location management is used so that internetworking signaling can be reduced for location management. In first location update GLR download the subscriber information from HLR. By using this information GLR handles the location update from VLR. In 3G network is partitioned into Gateway Location Area (G-LA). Each G-LA has N location areas. By using this network increases but efficiency also increases.

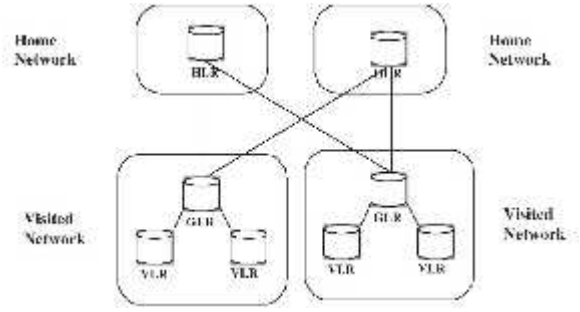

Fig 7

VII. CONCLUSION

This paper concludes that static location updates are becoming increasingly out of date. But when cost or resource availability is an issue then these techniques are still used. These days for cellular location management dynamic schemes are preferable. But these schemes are still only theories. Location Update and Paging are the two parameters used for location management. There must be a trade-off between these two parameters for a reasonable cost to the network.

As the number of mobile users increase, transition from 2G to 3G is occurring. By 3G complexity of network increases but efficiency also increases.

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