계층적 위치 지역을 이용한 동적 위치 관리 기법

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Dynamic Location Management with Hierarchical Location Area

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요 약

This paper introduces a dynamic location management with hierarchical location area, which helps in reducing location update(LU) and paging cost and hence total location management cost. Users are assigned to appropriate location area level utilizing the call-to-mobility ratio(CMR) value. CMR values are calculated each time a user enters a new cell by computing its mobility rate and incoming call rate, which are the two key factors for defining the size of the location area.

1. Introduction

Cellular network consists of a group of fixed base station (BS) covering the service area and interconnected by a fixed backbone network. The coverage area of one BS, determined by terrain and radio propagation characteristics, is referred to as a cell. Each cell contains a fixed BS and a number of mobile subscribers.

The task necessary to manage individual communication session in a cellular network can be divided into three categories [1]; call processing, mobility management and radio resource management. Mobility management contains two components: location management and handoff management[2]. Location management enables network to discover the current attachment point of the mobile user for call delivery whereas handoff management enables the network to maintain a user's connection as the mobile terminal continues to move and change its access point to the network.

In the current cellular systems, networks are portioned into location areas (LA), where each LA may consist of one more cells. Two fundamental operations of location management associated with a LA are location updating (LU) and paging. Location updating occurs when an MH (mobile host) enters a new LA so that any incoming call to the MH can be routed to the correct LA. Paging occurs when the network alerts the MH of an incoming call. The messages are broadcasted in the current LA of the MH. There is a trade-off between both operations, where in order to minimize the LU, the frequency of entering a new LA has to be decreased resulting in larger size of LA. However increase in size of the LA propagates costs on paging, where incoming call has to be broadcasted to larger area.

With an increasing population of MH and rapid growth of coverage areas, the signaling traffic of cellular networks is expanding rapidly. The main solution for supporting the growing population is to reduce the cell sizes and to increase the bandwidth reuse [ELM]. As a result, LU and paging signaling take up valuable bandwidth in the wireless network and high load on the location management mechanism. This motivates the development of optimized location management scheme that use efficient network resources and radio bandwidth.

Most cellular standards currently in use (e. g. IS-41, MAP, GSM) rely on geographic based strategy. LAs are assigned such that the combined control bandwidth usage is minimized globally. Therefore the

chosen LA is not optimal for all MH's. In this paper, we propose a dynamic location management, where each MH is defined into an appropriate LA depending on the MH's CMR(call-to-mobility ratio).

This paper is organized as follows. In section 2, we summarize various existing schemes that have been proposed to optimize location management mechanisms. Then in section 3, our proposed scheme is introduced in section 3. Finally, section 4 concludes the paper.

2. Related Works

Various schemes that have been proposed to optimize location management mechanism can be divided into two categories. The first category includes incremental improvements to the current static LA approach. It includes schemes that optimize the LA design to reduce the cost of LU and paging. Other LA-based schemes consider profile information of each mobile user where the system searches for a mobile user by paging sequentially sub-areas of the LA where the MH resides. The LA approach is not flexible enough to adapt to different mobile users mobility patterns and communication requirements.

The second category includes dynamic location management, where mobile users perform update operations based on either the elapsed time, number of crossed cells or the traveled distance since the previous update. In all these methods the selected threshold for performing an update operation is adapted to the individual MH mobility patterns and communication traffic. However, these schemes have to collect mobility information for predicting its location, requiring large databases and causes significant computational load on the system. This makes them complicated and difficult to implement.

In this paper, we present a new location management scheme that combines the concept of LA with the history of user mobility and incoming call rate, which are two key factors for deciding size of the LA. It guarantees a low rate of update and paging operations at each cell of the system for each MHs.

3. Proposed Scheme

As described earlier in this paper, current cellular network assigns identical LA to each and every MHs. However, MHs that are highly mobile signals more LU than others, requiring larger LA size, whereas MHs with many incoming calls receives more paging signals, requiring smaller LA size. In order to solve these diverse patterns of MHs, dynamic assignment of LA is needed.

3.1 Call-to-Mobility Ratio(CMR) and Hierarchical LA

The concept of call-to-mobility ratio (CMR) is employed[3] to characterize MH and to divide them into different categories. CMR is defined as the ratio between the average number of calls to a user, *Cpag*, and the average rate of LA crossings, *Clup*, of that user and is expressed as,

$$CMR = \frac{C_{pag}}{C_{lup}} \quad (1)$$

where highly mobile MH with low incoming calls will have lower CMR value than a lowly mobile MH with highly incoming calls. With this value, each MH can be categorized into an appropriate LA size, where MH with low CMR value is assigned with large LA size whereas MH with high CMR value is assigned to a small LA size.

In this paper, 3-Level LA sizes are defined, where LA sizes of Level 1 is larger than the sizes of Level 2 and so on. Thus, a MH with a CMR value lower than a threshold value *T1* is assigned to Level 3 whereas a MH above a threshold value *T2* is assigned to Level 1. A MH with mobility value similar to incoming call rate is assigned to Level 2, where the CMR value is between *T1* and *T2*.

LA Level	Description
1	Highly mobile MH with few incoming calls (CMR> *T2*)
2	Mobility value similar to the incoming call rate (*T1*.<CMR< *T2*)
3	Many incoming calls with low mobility (CMR< *T1*)

[Table 1] LA Level

3.2 Proposed Algorithm

As MH moves into a new cell, each cell stores following parameters with the MH sending its LU frequency of the assigned LA during time t when assigned to a certain LA level (LAL), $Clup,t_{LAL}$. The following parameters are stored in each cell in a mobility history table (MHT).

- Mid: unique MH id
- $MLAL_i$: LA Level during time t
- Ms: time when MH enters the cell
- Me: time when MH leaves the cell
- $Cpag,t$: the arrival rate of incoming calls during time t

With above data, CMR of individual MH can be calculated for certain time and if the MH's mobility or incoming rate has been changed, the LA Level is re-assigned to an appropriate LA Level. Using LRU(Least Recently Used) algorithm, parameters stored in the MHT are updated so that more accurate assignment of LA Level can be achieved.

Following algorithm in this paper is used to calculate the CMR of a MH, as it moves into a new cell.

```
DynLocMgt()
Begin
  // MH enters into new cell
  // Update MHT parameters using LRU algorithm
    if(Mid.Cpag,t < T1)
        Assign to LA Level 3
    else
      if(T1 < Mid.Cpag,t < T2)
        Assign to LA Level 2
    else
      if(Mid.Cpag,t > T2)
        Assign to LA Level 1
  End
```

4. Conclusion

The proposed dynamic location management algorithm with hierarchical location area level helps assign appropriate LA sizes for individual MHs, using each MH's mobility and incoming call rate. Since wireless bandwidth is a scarce resource and is fixed, a large part of that bandwidth is wasted due to LU and paging signals and this algorithm reduces this overhead. For the future work, above algorithm has to be simulated to justify our scheme and furthermore threshold values to allow dynamic resizing of LA sizes in each LA Level has to be researched.

References

[1] Ahmed Abutaleb, Victor Li, "Location update Optimization in personal communications systems", Wireless Networks, 1997.

[2] Ian F. Akyildiz, Joseph S. M. Ho, and Wenye Wang, "Mobility Management in Next-Generation Wireless Systems", Proceeding of the IEEE, Vol. 87, No.8, August 1999.

[3] Leonardo P. Araujo and Jose Roberto Boisson de Marca, "Paging and Location Update Algorithms for Cellular Systems"