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Analysis 0f Location Management Schemes for Cellular Networks

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ABSTRACT

Present generation cellular networks provide different services to the mobile users. The movement of the users is highly dependent on individual characteristics. To offer an uninterrupted service to the mobile users, continuous tracking of their location is very important. This can be achieved by the proper location management schemes. Location management in cellular networks has been an important issue for research since few years .We presents a simple analysis comparing location update schemes that have been proposed for determining location or paging areas which are suboptimal and costly for operators. Therefore, much research in cellular networks has been focused on these schemes, which show good amount of cost optimization. The analysis is used to compare the relative performance of the schemes and to illustrate the tradeoff between the costs of frequent location updates and paging.

Keywords: **Location Areas (Las), Location Management (LM), Location Updates (LUs).**

1. INTRODUCTION

Cells in a network are grouped into Location Areas (LAs). Users can move within these LAs, updating their location with the network based upon some predefined standard. When a user receives a call, the network must page cells within the LA (also referred to as polling) to find that user as quickly as possible. This creates the dynamics behind much of Location Management (LM), and many of the reports and theories discussed within this paper. The network can require more frequent Location Updates (LUs), in order to reduce polling costs, but only by incurring increased time and energy expenditures from all the updates. Conversely the network could only require rare LUs, storing less information about users to reduce computational overhead, but at a higher polling cost. Additionally, LAs themselves can be optimized in order to create regions that require less handoff and quicker locating of users. The goal of LM is to find a proper balance between all of these important considerations. This paper discusses LM schemes, from past and current static LM methods, to current progress and advances in dynamic LM.

2. STATIC LOCATION MANAGEMENT

Presently, most LM schemes are static, where LUs occur on either periodic intervals or upon every cell change. However, static LAs incur great costs with the ping-pong effect. When users repetitively move between two or more LAs, updates are continuously performed unnecessarily. In these static LAs, cells are constant in size, uniform, and identical for each user. The current static LM standards are IS-41 and GSM MAP.

2.1 STATIC LOCATION UPDATE

Three simple static Location Update schemes exist in static LM, being always-update, never-update, and static interval-based. The third of these is the most commonly used in practical static LM systems. One scheme involves the user updating its location upon every inter-cell movement, and is named always-update. This will incur significant energy and computational costs to both the network and the user, especially to the most mobile users. This may be particularly wasteful, as if a user makes frequent, quick movements within an LA, beginning and ending at the same location, many LUs will occur that might be unnecessary, especially if few or no calls are incoming. However, the network will always be able to quickly locate a user upon an incoming call, and extensive paging will not be necessary. The converse method would be to never require the user to inform the network of inter cell movements, only updating on LA changes, and is named never-update. In this scheme, resources are saved as constant updates are not required, but paging costs rise substantially. This occurs as every cell within the user's LA may need to be checked during paging due to the lack of information, which causes excessive overhead for users with a high incoming call frequency. These two schemes are generally unused in real-world systems, but help to provide an illustration to network administrators as to the costs of LM, the problems that occur when thoughtless LU methods are used, and a baseline that every newly developed LU scheme must show improvements over.

The final static LM technique discussed requires each user within the network to update at static, uniform intervals. This attempts to provide a balance between the extremes of the previous schemes, as the network will neither be overwhelmed with LUs nor wholly unaware of users' locations. However, users with rapid rates of movement may move into new LAs between updates, which causes locating that user to be very difficult. Conversely, an inactive user will not move at all, but will still regularly be sending unneeded LUs. While LA optimization could mitigate these problems, as discussed in the following section, such improvements are impossible under static LM schemes where LAs are uniform and constant.

2.2 STATIC LOCATION AREAS

Location Areas in static LM are themselves static as well. They are effectively the easiest solution to physically dividing a network, providing the same LA to every user, without any customization. These function as static LU schemes do: sub optimally, but sufficiently for most networks. However, their perhaps most egregious flaw is their vulnerability to the ping-pong effect. Given that these static LAs are set and cannot change, users may repetitively move between two or more adjacent LAs, which for many LU schemes will cause a large number of LUs with a small or zero absolute cell distance moved. Figure 1 demonstrates such an example, where the user may simply be moving around a city block, but may be incurring an LU on every inter-cell movement due to each movement crossing an LA boundary. As will later be discussed, dynamic LA schemes can both decrease occurrence of ping pong effects and provide more flexible and personalized LAs, albeit at their own costs. However, as would logically follow, current static LM standards and schemes do not use these modifications, instead being implemented as seen in the following section.

2.3 LOCATION PARAMETERS

While evaluating schemes to design LAs or determining the optimal updating standard of LUs for users may seem of higher importance, paging and user mobility can also be briefly examined to assist in improving LM and refining models. Although LU costs are generally higher than paging costs, these paging costs are not insignificant. Additionally, poor paging procedures and ineffective mobility modeling and prediction may lead to either significantly delayed calls or decreased QoS, neither of which are acceptable to a user.

2.4 PAGING

In the attempt to locate recipients of calls as quickly as possible, multiple methods of paging have been created. The most basic method used is Simultaneous Paging, where every cell in the user's LA is paged at the same time in order to find the user. Unless there are a relatively low number of cells within the LA, this will cause excessive amounts of paging. Although this method will find the user quicker than the following scheme of Sequential Paging, the costs make Simultaneous Paging rather inefficient.

An alternative scheme is Sequential Paging, where each cell within an LA is paged in succession, with one common theory suggesting the polling of small cell areas in order of decreasing user dwelling possibility. Unfortunately, this was found to have poor performance in some situations, as if the user was in an infrequently occupied location, not only might every cell be paged, but a large delay could occur in call establishment. Additionally, this method requires accurate data gathering concerning common user locations, which necessitates more frequent LUs and thereby increased costs. Consequently, most real-world Sequential Paging methods simply poll the cells nearest to the cell of the most recent LU, and then continue outward if the user is not immediately found. However, such a method will still be inefficient if the user's velocity is high or an LM scheme is used which specifies infrequent LUs.

3. DYNAMIC LOCATION MANAGEMENT

Dynamic Location Management is an advanced form of LM where the parameters of LM can be modified to best fit individual users and conditions. Theories have been and continually are being proposed regarding dynamic LUs and LAs. Additionally, many are reexamining paging and mobility parameters based upon these developments. Many of these proposals in dynamic LM attempt to reduce computational overhead, paging costs, and the required number of LUs. However, many of these proposals are excessively theoretical and complex, and are difficult to implement on a large scale.

3.1 DYNAMIC LOCATION UPDATE

Many dynamic LU schemes exist, in order to improve upon excessively simple and wasteful static

LU schemes. Additionally, these schemes are intended to be customizable, such that each user will have their own optimal LU standard, greatly reducing the overall number of LU updates.

One of these dynamic LU formats is threshold-based, where updates occur each time a parameter goes beyond a set threshold value. One possible threshold is time, where users update at constant time intervals. This saves user computation, but increases overhead significantly if the user does not move. This time-based scheme is very similar to the common static LU scheme, with the important difference of the time value being modifiable. Another threshold-based scheme requires a user update each time they traverse a certain number of cells. This was found to work better than the time-based scheme, unless the users were constantly moving. In such a case, this method becomes quite similar to the static always-update scheme, where many unnecessary updates might occur. Consequently, a preferable scheme was found, called distance-based. This called for an update only if the user moved a certain radial length of distance. However, this scheme is not perfect, as it requires the cellular device to keep track of such distances, which added much computational cost.

Another dynamic LU scheme is profile-based. This functions by the network compiling a list of the most frequently accessed cells by the user, and only requiring an LU if the user moves outside of these common cells. As would be expected, this scheme is only effective if these predictions can be made accurately and without excessive overhead, but is otherwise inefficient. Additionally, this list must be relatively small, or else paging will become costly.

A more advanced scheme, built upon the efforts of previous methods, is called adaptive. Adaptive LU schemes are very flexible and even may differ from each other, as such schemes are designed to take multiple parameters, such as velocity and mobility patterns, to determine the most efficient LAs. In such an example, having knowledge of a user’s past movements combined with the user’s current speed and direction allows strong predictive power when determining a possible future location for paging. Therefore, LUs may not need to be as frequent, thereby reducing the overall LM costs. However, although these adaptive LM schemes are highly successful in terms of reducing LU costs, they are generally too difficult to implement for large networks, requiring excessive computational overhead. Consequently, dynamic LA schemes must be examined as a possibly preferable solution.

3.2 DYNAMIC LOCATION AREA

While static LA schemes are restrictive and inefficient, dynamic LA designs offer much more flexibility, allowing much more customization. To improve on the past schemes, proposes several changes to the static LA methodology. Instead of viewing the network as an aggregation of identical cells, it is now viewed as a directed graph, where nodes represent cells, with physical adjacency shown through graph edges. General movement patterns and probabilities, updated at predetermined intervals, are recorded between these cells based upon handoff information. This allows low overhead while still providing predictive power. Additionally, a smoothing factor of k is implemented to allow individual networks to weight new data as desired, where a low kvalue causes the network to highly weight new data, and a high k-value causes the network to give precedence to previous data. These adapting patterns can be stored, in order to allow further prediction based upon other data such as time. A similar parameter examined is dwell time, which is defined as the length of a user's stay within a cell. This is used to dynamically determine the appropriate dimensions of LAs. A smoothing parameter is also used for dwell times to weight past collected data against new data. The preferable method of collecting dwell times is by having the cellular device report its dwell time to the network upon a handoff.

Within a dynamic scheme, LAs, instead of being constant and circular, can be diverse and may take different shapes, in order to be optimal for individual user parameters and network characteristics. As well, cells are organized within these LAs based upon frequency of use, with the most frequently visited cells being placed in an ordered array. This array can be used in conjunction with known physical topology to design optimal user LAs, constructed such that the users will change LAs and make handoffs as infrequently as possible. To further optimize service for the individual user, call interval times and relative mobility rates are calculated to make low-overhead predictions concerning when LA and cell changes will occur.

3.3 COST ANALYSIS

As seen before, the total cost of LM is equal to the LU cost added to the paging cost. This equation is always true, regardless of which system is used. However, different systems will have different values for these, and the goal is to find an implementable system that minimizes the total.

The paging cost can be fairly simply defined, as the previously as the previously calculated call rate ?, multiplied by the number of cells in the paging area, multiplied by a constant representing the cost per paging message. Consequently, reducing any of these parameters will reduce the overall paging cost. However, the LU cost calculation is somewhat more complicated. Although we can simply say that the LU cost is equal to the cost per LU divided by the estimated dwelling time within the current LA.

3.4 DYNAMIC LOCATION MANAGEMENT ANALYSIS AND DEVELOPMENTS

In the world of dynamic LM, new theories are constantly being proposed to reduce LM costs, or otherwise improve the network quality. Additionally, an experiment was conducted to compare generally static industry standards and a simple dynamic LM scheme, in order to clearly show how dynamic LM is preferable to static LM. The following sections provide this comparative analysis as well as an overview of several of these wide-ranging developments.

4. CONCLUSION

As the technologies used to manage the location static and dynamic in which still the paging cost and LU cost is high. To reduce this we can use basic pager technology i.e. a two-way numeric pager can receive and transmit a message consisting of a few digits, typically a phone number that the user is then requested to call. Pagers are still in use today in places where mobile phones typically cannot reach users, and also in places where the operation of the radio transmitters contained in mobile phones is problematic or prohibited.

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