Adaptive Location Management Strategy Combining Distance-Based Update and Sectional Paging Techniques

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Abstract

In this paper, we develop a new adaptive scheme in which an optimal distance-based update threshold is selected not only as a function of the call-to-mobility ratio, but also as a transitional directivity index \(\omega\); a new parameter introduced to give some measures of the mobile’s traveling patterns. It is assumed that when \(\omega > 1\), the mobile has a greater tendency of roaming “outwards” and hence a higher probability of transition to the next ring during each movement. As a result, the defined threshold will be reached sooner incurring more update costs. A corresponding sectional paging scheme is therefore proposed to predict mobile’s likelihood of residency utilizing the information given by the estimated \(\omega\). Provided that the prediction of location probability is reliable, a movement pattern with increasing directivity will justify having increased update thresholds without incurring additional paging costs. As far as the mobility characteristics are concerned, the introduction of the directivity index has successfully demonstrated its ability to make optimum decisions on a distance-based update threshold. Its advantage becomes even more significant when the theoretically determined “ideal” optimal threshold is not obtainable due to certain restrictions imposed by the network during times of high system loading. Simulation results reveal that the additional information made available about a roaming mobile’s transitional directivity could be critical to ensure that the best available sub-optimal threshold is realizable.

1. Introduction

Despite a growing interest in other wireless technologies, the need for efficient operation in personal communications services (PCS) networks is still present given that the number of subscribers has continued to increase in recent years. Developing an efficient location management technique is an important step in working towards the determination of an optimal solution to the problem of managing mobility. With the irregular nature of the cell sizes in a cellular network, the behavior of mobile movement changes from cell to cell and from user to user. Thus, the need for designing an adaptive algorithm for tracking a roaming mobile becomes imperative. This action involves not only storing and/or retrieving information from the location database, but also sending paging signals whenever necessary to locate a roaming user. The biggest challenge in framing location management is to find the most favorable tradeoff between the location updates (or information) load and the searching load — the two parameters are frequently referred to as location registration cost and call delivery (or paging) cost.

In the sphere of location update, there are two classifications based on static and dynamic technologies. With the static algorithms, the locations of the reporting centers are fixed. This somehow has made the option less favorable due to the inflexibility of the technique in capturing the varying characteristics of different users. In contrast with dynamic algorithms, location updates are performed based on each individual mobile user’s call and mobility patterns. Depending on how the threshold is defined for the updates, time-based, movement-based and distance-based techniques, being adaptive respectively to time, boundary crossings and distance traveled, are the three most commonly used methodologies among the many alternatives that have been proposed in the literature and which were well summarized in [2].

One general problem with most existing updating schemes is the requirement of reliable call-to-mobility ratio (CMR) information for performance optimization of the adaptive schemes. While it might be possible to anticipate the frequency of movements relatively easily, it is difficult to obtain realistic statistical anticipation about the call arrival characteristics. This observation motivates the formation of the research work. The idea is to explore the possibility of making the selection of an optimal threshold process adaptive to some new parameters other than CMR.

In a basic distance-based scheme, the update threshold is a measure of the separation in distance between the mobile’s current location and its last registered cell. Thus,
we argue that the frequency of update would depend more on direction rather than the rate of traveling; specifically, the more directive the roaming pattern is, the sooner the threshold will be reached thus incurring more update loads. Consequently, given that the mobile has a distinct roaming pattern (i.e. defined by the level of directivity), the formation of a location probability distribution will be of higher precision. It is important to remember that the main challenge in location management is to find an adequate tradeoff between the location load and the paging load. As a result, the networks' capability in locating a roaming mobile within the defined time constraints also influences greatly the required frequency of location updates. Subsequently, provided that the prediction of location probability is reliable, a movement pattern with increasing directivity will justify having increased update thresholds without incurring additional paging load to the system.

In this paper, we focus on making the proposed scheme adaptive in response to mobility patterns, more specifically to the periodic change of transition directions. The extension will be based on a distance-based strategy with the anticipation of movement directions being realized with the introduction of a transitional directivity index $\omega$. The idea is to explore the possibility of making the selection of optimal threshold an adaptive process to $\omega$. It aims to demonstrate how variations in the roaming characteristics would affect the selection of an optimal updating threshold (i.e. incurs a minimal operational cost), and consequently, to study whether the information revealed by the transitional directivity index alone is sufficient to give reliable predictions for the mobility patterns and subsequently the location probability distributions.

Key design criteria in this respect include simplicity, scalability, reliability, efficiency/cost measures and power consumption at mobile terminals. Therefore, apart from proposing a relatively easy-to-implement technique, the proposal should also allow the network to cope with large variations in traffic loading without too much compromise on the quality of service (QoS) provisioning and cost measures. A constrained dependence on specific network entities is also necessary to ensure that the scheme operates with some guaranteed reliability independent of certain unpreventable infrastructure failures.

Section II begins by highlighting the relevance of this work to the operations of location management in the context of cellular networks. A more thorough explanation is given to justify the operations of the designed techniques. Followed by a brief summary of the related works. Section III then gives a brief description of the simulation philosophy in addition to defining various details for the setting of parameters. Based on the simulation results, discussions were included in section IV to examine the significance and effectiveness of the introduced transitional directivity $\omega$ in selecting the optimal threshold; specifically, we wish to determine whether the information provided by $\omega$ alone is sufficient to give predictions for mobility patterns in a distance-based scheme. Following this in section V, possible areas for the application of the designed technique are suggested. Section VI previews some of the extension work that is under investigation to further improve performances. The paper concludes in section VII with a summary recapping the main uses of the proposed scheme.

2. Adaptive scheme theoretical rational

2.1. Related works

Despite its importance, there seems little research on the potential of utilizing such directivity information. Classified under static update schemes, [4] proposed a probabilistic location update scheme (PLU); in which, the mobile registers with a probability of $P$ that varies according to the call and mobility characteristics of individual users upon entering a new cell. Basically, the key conclusion obtained from the paper illustrates that as mobility increases (i.e. with decreasing CMR), the probability of needing a location update at the cell decreases. This somehow is complementary with our justification which states that the more direct the mobility pattern is, the less paging load is required since the probability of predicting the correct location of a roaming mobile would be higher. Thus, in terms of categorizing the mobility characteristics, while one is using the mobility rate information with respect to call arrivals, the other focuses on mobility directions. Both however are aiming at reducing the necessary updating loads by increasing the probability of accurate prediction.

A recent publication [6] proposed a direction-based location update scheme with a line-paging strategy for PCS networks. Basically, the scheme works as follows: whenever the mobile enters a new cell, it determines whether a change of roaming direction has occurred since the last movement. An update will be registered only if the answer is affirmative, and hence the name “directional-based” location update scheme. Upon a call arrival, the last registered cell will be the first place the system looks, the search then extends in both directions until the mobile is found. To set some upper bounds of paging loads, the search discontinues after reaching a time threshold $T$. Because it is unlikely that mobiles always travel in an “absolute” straight line, there will be a fair amount of updates. As a result, this seems to contradict the goal of reducing the amount of location updates in designing an efficient location management technique. The other problem that would be encountered in the scheme proposed in [6] is its complexity (i.e. heavy signaling and
high computational load) that result from the necessary computation after each movement. As the scheme depends on the prompt detection of change of roaming direction by the mobile in order to make the corresponding paging strategy feasible, additional loading and power consumption will be imposed on the mobile terminals. Consequently, the schemes appear to have optimal performances in a system whose call arrival rate is a lot more frequent than its mobility rate.

Our scheme functions similarly in the sense that directivity aspects of the traveling characteristics are taken into consideration. However, we allow at the same time a certain degree of freedom in the traveling directions, directivity being in the sense of a granular tracking rather than a specific traveling direction. Basically, the aim is to find the significance of the introduced parameter; specifically to determine not only the limitations it creates but also the various factors that could influence its performance.

A few earlier references [5, 13] also utilizes the collected information about a mobile’s direction of traveling obtained at the previous update time to form a distance-based update boundary. However, while the works might provide a good framework of the distance-based scheme, those proposed strategies are a lot more complex and require much more system intelligence. This paper intends to identify the fundamental operational issues, and to propose an update alternative with minimal underlying assumptions about network’s capabilities. In brief, the key idea of the proposed scheme is to adjust the distance-based threshold \( d \) adaptively only when it is detected that the roaming mobile has demonstrated a change in certain traveling direction or movement pattern. Though it might ultimately be worth further extending the overall framework by allowing the coexistence of different threshold-based techniques, in the mean time, the focus is on anticipating the mobile’s roaming characteristic using the estimated transitional directivity measures \( \omega \). In addition, it should be noted that the thresholds chosen for scenarios where the probability of call arrivals can be anticipated would be different from those where such expectation is not realizable. Thus, the resultant costs are always maintained within a reasonable range where applicable.

Furthermore, given that the traveling pattern of a mobile can now be predicted with the introduction of a new mobility characterizing parameter, it seems unnecessary to have the roaming mobile paged on a per-ring basis as it is almost certain that some of the paging signaling will be redundant. Thus, a corresponding cell-grouping methodology alternative is proposed with the intention of improving the performance of sequential paging.

In summary, the main justifications for the introduction of the directivity parameter are two fold: (1) to reduce the location updates, (2) to ensure the mobile can be paged more efficiently within the constraints set in time and in signaling load. Hence, to reduce the updating load without having to sacrifice paging performance.

2.2. Network framework

It has been generally assumed (where Markovian movements are considered) that the transition probabilities to all neighboring sides are the same. However, with the widespread usage of mobile terminals, such an assumption becomes somewhat unrealistic when many of the movements have in fact demonstrated a traceable purpose (i.e., are activity-oriented). Therefore, it seems imperative to consider the transition probabilities of moving forwards, sideways, and backwards to be different in order to model the movement characteristics more realistically and hence propose the introduction of \( \omega \). Based on a ring-structured cellular system, Figure 1 gives a brief illustration of the state diagram used to model the transitional probability of movements.

![Fig. 1. The state diagram illustrating the inter-ring transition probabilities in a hexagonal cell.](image)

While each state represents the actual “ring” the mobile is currently residing, the arrows indicate the probability of transiting to its adjacent states. Thus, for an update threshold of \( d \), given that a mobile has moved to a ring (or state) \( s \), the transitioning probabilities of going forward, sideways, and backward will be \( q_{s,s+1,d} \), \( q_{s,s,d} \), and \( q_{s,s-1,d} \) respectively. With the assumption of random movements (i.e., the same probabilities to all sides), the general expressions become:

\[
q_{s,s,d}^{(i)} = \frac{2s+1}{6s} \quad (1)
\]

\[
q_{s,s-1,d}^{(i)} = \frac{1}{3} \quad (2)
\]

\[
q_{s,s+1,d}^{(i)} = \frac{2s-1}{6s} \quad (3)
\]

Note that the probability of moving to an adjacent inter-ring cell is always equal to 1/3. In other words, for each cell in the network, there are always two cells of the 6 neighbor that belong to the same ring.

Given that mobile communications are now used so universally, it seems non-realistic to assume that the probability to all sides will be the same. Therefore,
instead of assuming that the mobile is moving to all neighboring cells with an equal probability, it is now assumed in this framework that the outwards transition probability will have an additional factor $\omega$. Consequently, to maintain equilibrium, the transition probabilities of moving sideways and backwards will also vary accordingly. Again, given that a mobile has moved to a ring $s$, the general expressions derived for calculating the probability of entering adjacent rings are shown for the transitioning probabilities of going forward, sideways and backward in eqs. (4) to (6), respectively.

$$q^{(1)}_{s,d-\ell,d} = \frac{2\omega s + \omega}{6s}$$  (4)

$$q^{(1)}_{s,r,d} = \frac{2[(3-\omega)s] - \omega}{3(4s - 1)}$$  (5)

$$q^{(1)}_{s,s-\ell,d} = \frac{2[(3-\omega)s^2] - 3s + \omega/2}{3s(4s - 1)}$$  (6)

As a result, the probability of transition will now depend not only on the mobile’s current state (i.e. $s$) of residence, but also on $\omega$, its directional characteristics. In addition, when $\omega = 1$, the two sets of equations (i.e. (1)-(3) and (4)-(6)) will become the same.

### 2.3. Operational philosophy

To ensure that the operational cost is always maintained at its possible minimal, the update threshold $d$ is, in this design, dynamically adjusted in response to changes in directivity characteristics. Generally, if $\omega$ is found to be different from its previous values taken at the sampling time, $d$ will be changed to ensure that the specific mobility patterns are taken into consideration. Thus, different from other studies [7, 9, 10] where the same transitional probability to all neighboring cells is assumed in modeling the movements, the research work focuses on determining the impact that variations in the inter-ring transitional probability would have on the updating strategy by means of the optimal threshold selection.

Effectively, this sets the threshold to be adaptive to the mobile's roaming direction in addition to the usual cell residence time (CRT) and call arrival distributions. Our aim is to draw conclusions on the impact $\omega$ has on the selection of the optimal threshold. The key question we tried to answer was to what extent does the directivity of the traveling characteristics mainly directions affect the determination of an optimal threshold set up for cost minimization.

### 2.4. Possible derivation of $\omega$

A specific mechanism for the assignment of a directivity index to various mobility characteristics (i.e. the directions of traveling in particular) is outside the scope of the paper. Thus, details of this will not be discussed other than to briefly highlight one of the possible implementations that we have currently under evaluation.

The basic idea was to set up two thresholds, one for distance, and the other for time. Once the distance threshold is reached, the actual time taken is compared with the time threshold to see whether it approximates to what was first anticipated. An affirmative answer would suggest that there is no change to the directivity assigned during the last registration update. If on the other hand the difference is significant, that suggests a great possibility that the mobile’s traveling pattern was altered and the path is now either more “focused” if the threshold was reached in a less time, or more “diverse” if the threshold was reached in longer time. The directivity index being assigned to the mobile will then require to be adjusted to reflect such changes. Figure 2 gives a condensed illustration of the concept.

### 3. Simulation framework

Figure 3 provides a brief illustration of the operation of the simulation.

For each $\omega$, a set of total costs consisting of updating and paging costs is generated for the 10 possible threshold values simulated. It was indicated by [10] that a movement number of 300 would be sufficient to illustrate the maximum number of boundary crossings between call
arrivals. In addition, to smooth out the variations causing the probabilistic nature of the distribution functions, it is assumed that there is a total of 100,000 users roaming in the system simultaneously, and thus running 100,000 iterations.

![Simulation framework diagram](image)

Fig. 3. A brief illustration of the simulation framework

At the end of the iterations, we should have obtained two matrices, one for the expected number of updates $E_{u}(m)$ and the other for residency characteristics of the mobile $y(i,m)$. Effectively, the obtained statistics can be used to calculate the cost for firstly, different values of CMR and secondly, different values of $\omega$. From these, the optimal threshold $d$ can be obtained from the plotted chart.

The issues we wish to address are two fold: (1) the precise impacts of the mobility rate and the transitional directivity index on the selection of optimal threshold, (2) the inter-dependency between the two parameters. Specifically, could the information provided by $\omega$ be sufficient to compensate for the absence of reliable data about call arrival characteristics?

### 4. Numerical results and discussions

As a general rule, the selection of an optimal threshold depends on two factors — mobility rate and roaming directivity. These two parameters form an AND function for optimal system performance. The aim of this paper is to determine how closely these two “approaches” correlate with each other; specifically, to examine whether one factor weighs more than the other and if so, how a compromise can actually be formed between the two variables.

#### 4.1. Effects of CMR

With $\omega$ fixed, Figure 4 shows the impact of CMR on the selection of optimum $d$.

![Impact of CMR on selection of $d$](image)

Fig. 4. Impact of CMR on the selection of $d$.

Generally, the smaller the CMR, the higher the mobility rate (respective to the call arrival rate) and thus, the greater the update cost for a fixed threshold. Thus, for fixed $d$ and $\omega$, it is evident that the greater the CMR, the lower the expected update cost (per call arrival). Intuitively, an increasing CMR suggests a lower number of boundary crossings between call arrivals and thus, less updates will be required to maintain the reachability of the roaming mobile. The impact of CMR however seemed to have diminished with increasing $d$. In fact, it was observed that when CMR is high (say >5), the update cost would be almost negligible for all values of $d$. However, provided that the network conditions (i.e., the loading constraints) permit, it still would be optimal practice to perform updates at the completion of every movement. Since the call arrival rate is relatively frequent, it is necessary to minimize the required paging load where possible.

It seems reasonable to state that efficient location management is particularly important for handling mobile users with low CMRs. In such scenarios, since the mobility rate is high, the issue is to reduce update without having to suffer the resultant paging cost. Correspondingly, the proposed scheme should be designed such that the selection of optimal threshold is an operation sensitive to even small variations in CMRs.

#### 4.2. Effects of CMR

Figure 5 shows the impacts of $\omega$ on the selection of optimum $d$. 

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Generally speaking, the effect of $\omega$ has a greater impact than mobility rate. A low CMR would however indicate, almost by default, the incursion of high update cost. Obviously, for a fixed threshold, the higher the directivity, the more wasteful the system resources are going to be. Thus, it would be wise to increase the threshold appropriately to minimize such impacts. What needs to be done then is to quantify more precisely the variations in optimal threshold caused by changes in directivity.

For roaming mobiles having the same CMR statistical characteristics, the cost of update becomes a function of $\omega$ (Figure 5(d)). In other words, for the same number of mobile transitions, those that were estimated to have a more “directive” traveling pattern (i.e. higher $\omega$), would reach the same predefined threshold more quickly thus resulting in a greater cost due to the more frequent incursion of updates. Hence, the threshold will be reached faster and consequently, incur a higher updating cost to the network.

Fig. 5 (d). Impacts of $\omega$ on the selection of $d$ for CMR = 0.05

It is also encouraging to see that in terms of their proven ability in selecting the optimal threshold, both parameters CMR and $\omega$ seem to be able to reach the same decisions. In addition, the actual cost of update would vary in accordance the traveling direction of the roaming mobile $\omega$. In other words, it is observed that while the total cost $C_T$ is a function of $d$, $d$ is a function of CMR and $\omega$. Thus, even with the same threshold, the actual update cost would vary depending on the estimated value of $\omega$.

However, when moving away from the optimal threshold, it is observed that the performance differences become significant with varying CMR and $\omega$. In fact, the simulation results show that the selection of sub-optimal thresholds afterwards will be different. This behavior somehow makes the introduced adaptive scheme particularly promising for applications. In reality, due to the large number of subscribers that are connected to the network simultaneously at any instant of time, the network might have to set some constraints on the maximum allowable update rate (i.e. a minimum executable threshold) to maintain the total signaling loads within a reasonable range. As a result, the roaming mobiles might not always be given permission to perform updates at their
ideal frequencies. Thus, as the differences increase with
varying CMR and $\omega$, the additional information made
available about $\omega$ becomes significant in making such
sub-optimal decisions.

For a mobile that is experiencing high mobility rate,
ideally the threshold should be increased to decrease the
update cost. The overall performance however, might not
always improve. In fact, the actual improvement depends
greatly on the mobile's traveling patterns. For example, in
a scenario where the mobile moves fast in a circular
motion, given that paging delay is constrained, more cells
are likely to be paged than is necessary when the threshold
is set high.

4.3. Effects of U/V

Generally, the dependence of $\omega$ in the selection of
optimal threshold becomes more obvious when the ratio
between the unit update cost $U$ and the unit paging cost $V$
changes. Figure 6 illustrates the impact varying U/V
definitions have on the sensitivity of the directivity index.

![Fig. 6. Impacts of U/V on the selection of $d$ (a) U/V=1 (b) U/V = 5 (c) U/V = 10 (d) CMR =10](c)

Generally, for smaller thresholds, the performance
showed the predominant contribution was from the
definitions of unit update cost. Simulation results show
that as U/V increases, it is no longer necessary to have the
optimal threshold settled at some small values. In fact, the
optimal threshold increases in value with increasing U/V
ratios.

The sensitivity to U/V definitions however becomes
insignificant for high CMRs (Figure 6(d)). One
justification for such system behavior is that when the
threshold is high, the main cost would have come from
paging. Thus, the variations in unit update would no
longer have significant influence on the system
performance. Note also that the update cost is highest
when the threshold equals to 1. The need to have an
efficient location management technique is reinforced as a
significant reduction in the update cost is evident even
when the threshold is merely increased by one unit. The
improvement in performance however stabilizes
eventually with increasing thresholds.
In the case where $U$ and $V$ are both set to unity, the total cost is really only a measure of the number of required updates between call arrivals. Thus, in a real system where there are millions of subscribers connected to the network simultaneously at any instant of time, an appropriate assignation of the unit cost of updating and paging will be required to ensure that a reasonable performance is guaranteed.

In summary, it is found that as far as mobility characteristics are concerned, the actual transitional direction of roaming mobiles plays a significant role in selecting the optimal threshold in addition to the usual perception about mobility rate. As an additional selection criterion, the threshold will increase if the movement characteristics have been found to be relatively stable. On the other hand, if a traceable movement pattern were not able to be clearly identified due to a greater tendency to directional changes, the selection of the optimal threshold would be more conservative. In other words, the range for acceptable thresholds would be wider. Effectively, the more directives the mobile’s roaming characteristics inherit, the more precise the prediction of the possible locations upon call arrival, and hence the lesser need for frequent registrations during movements.

5. Application and implementations

The most profound advantage of the proposed technique should probably be the fact of its simplicity, from both the viewpoints of operations and implementations. For a start, the adaptive technique will be relatively easy to implement in the sense that the resource and intelligence required for the determination of an optimal update is minimal. In addition, as the network learns adaptively of the mobile’s roaming characteristics (e.g. the transitional directivity), no prior registration of such statistical information from mobile to network will be required.

Upon the first registration of a mobile’s update, each individual user is assigned a “grouping” directivity index according to the specific movement pattern in terms of directions demonstrated by the mobile’s roaming history. Associated with the index is an optimal update threshold to be used by the mobile as a guide to decide whether an update is required after each cell boundary transition. The “matching up” of the two parameters is obtained from one of those “Figure 5”-like cost plots evaluated for varying thresholds for the specific $U/V$ definitions given by the system infrastructure. Thereafter, the appropriateness of the assigned directivity index will be checked against the actual movement every time an update is registered. On the network side, once a change occurs in the matching between $\omega$ and $d$, a beacon message will be sent to all mobile users announcing such change of optimal $d$ since their last registrations. At times when changes in $\omega$ were detected, a notification of the corresponding new update threshold could be sent as part of the acknowledgment signaling through piggybacking such that the additional controlling signaling is minimized.

6. Future Work

No special concern has been directed as for to the occurrence of ping-pong effects. One of the possible solutions that we are currently evaluating is to combine the operational concepts of a movement-based updating strategy with the scheme. The issue can be tackled by a couple of different approaches; one is to make the system adaptive to individual schemes and the other (preferable) is to combine the merits of each to form a more complete solution to the problem of location management as a whole. For the latter, what could be done is to give each cell two identities. Firstly, to assign cells an absolute cell ID to maintain a record of past movement history. Thus, whenever the mobile moves back to a previously updated cell, a duplicated update procedure will not be required. Secondly, to assign cells a temporary ring ID for the minimization of the combined updating/paging cost. Therefore, while minimizing the impact of possible ping-pong effects, the original scheme can be used to optimize the selection of threshold. Further, such an application can be extended so that where the geographical distributions of transitional directivity weighting are traceable, relevant parameters can be dynamically adjusted to achieve better system performances.

As far as paging is concerned, for an inconsistent or untraceable roaming characteristic (i.e. $1 \leq \omega$), the optimal strategy would be to page the roaming mobile on a per-cell basis, such that it ensures the required paging load incurred is always restrained at a minimum. However, this could result in a high paging delay that is undesirable in a real system. In order to better manage the operations of sequential paging, a switching mechanism between ring- and sectional-based paging schemes should be incorporated such that the actual scheme of application could be dynamically adjusted according to the directivity information being fed back to the network. In addition, [13] presents a predictive distance-based scheme taking full advantage of the correlation between a mobile’s current velocity and location and its future velocity and location. The reliability of the correlation model seems to be something that is worth further exploration. Any such gathered information should help to increase the precision of the prediction made about the probability distribution of user locations. Thus, while keeping the number of cells to be paged in each polling cycle the same, the probability of finding the location is increased.
7. Conclusions

With the incorporation of a transitional directivity index, it is found in this paper that the selection of an optimal threshold in the sphere of location management is no longer only a function of the call-to-mobility ratio. As far as mobility characteristics are concerned, the actual transitional direction of roaming mobiles also plays a significant role in selecting the optimal threshold particularly for distance-based update schemes. The newly introduced parameter which is capable of giving some measures of the mobile’s traveling patterns has successfully demonstrated its ability of making optimum decisions on an update threshold. Given that it is difficult to anticipate reliable call arrival characteristics, the making available of an alternative would be of particular advantage. Its applications are even more significant when the theoretically determined “ideal” optimal threshold is not obtainable due to certain restrictions imposed by the network during times of high system loading. Simulation results reveal that the additional information made available about roaming mobile’s transitional directivity could be critical to ensure that the best available sub-optimal threshold is realizable. In addition, for a constrained acceptable paging delay, the corresponding sectional paging scheme proposed also shows notable reductions in the total paging costs for mobiles traversing with a high directivity index. Such improvement however becomes less obvious with a lowered directivity index value. All in all, the simulation results were satisfactory. They not only gave some significant insights into the mobility problem, but also provided some possible new directions for designing better strategies for updating locations. We found that a transitional directivity index offers a satisfactory alternative to aid this purpose. Simulation results prove the relation between the directivity index and the “to-be-selected” update threshold is close.

8. References


