Analysis, Design and Comparative study on Location Updating Strategies in Mobile Computing

Ph.D. Synopsis

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By

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Index

1 Abstract

In today's fast decision making life it is compulsory for all of us to be in touch with the regular updates in terms of everything like education, technology, office routines, banking, regular transactions of business etc. For this purpose it is also mandatory to be active throughout the day. Almost all persons needs data on his / her fingertips and all the time. Now, it is also impossible that a person can sit in front of his computer / laptop throughout the day. As he / she has to roam outside the office also for routine work.

In the above situation, now a day's people use to have mobile computing devices which serves as a hand held computing device even when the person is moving from one place to another place. To get updated with the Calls / SMS / Mobile data - the device require to update its location. Regular update of location costs bandwidth and battery consumption. Managing location information of mobile devices is a very much important task in mobile computing systems. In cellular network, coverage area is divided into cells. Everyday mobile companies try to accommodate more users by reducing size of cells. Location management is one of the most important and fundamental issue in mobile computing. When the user changes location, an update occurs. The main goal of any location management strategy is to provide efficient search-updates. [9]

Location Update Management (LUM) is one of the most important activities in cellular network. LUM should be less costly at the same time highly efficient. In this research work, we have analyzed Time Based Location Update Strategy using Qualnet simulator. At present, Location Update is performed for every node at fixed interval. This interval is fixed and remains same for all the situations. For example, if Location Update is performed every minute instead of every two minutes, the total number of location updates will be double. In reality, a location update task consumes resources. If we decrease the interval and set it to a small value then a large number of location update will waste network resources. If we increase the interval and set it to a large value then there is a possibility that location updates are postponed. A perfect value of interval is very difficult to found. At present, fixed values are used for various timers and various thresholds. In this research work, we will try to find most appropriate value of interval dynamically considering various parameters like no. of location updates succeed, no. of location updates failed, no. of location updates actually required etc.

2 Brief description on the state of the art of the research topic

Over the last two decades, researchers have done work on location management and its cost related issues where they have discussed major four strategies in location update namely (1) Time Based Location Update [3] (2) Distance Based Location Update [1] [2] [3] (3) Movement Based Location Update [3] (4) Profile Based Location Update [3] [4] [5]. Some of researchers have also discussed combination of two strategies i.e. Hybrid Location Update [6] and through which they have tried to reduce the cost of location update. Major cost involved behind the location management is divided into two major parts namely (1) Paging cost [7][8] and (2) Location update cost. Some of the researchers have tried to reduce the Paging cost and through which they have made overall cost reduction. Some of the researchers have made reduction in Location Update cost. In literature review study major four policies for the location update have been checked. Out of four policies in real world two policies are applicable namely Time Based and Movement Based [As per source from Nokia Solution Network]. From discussion as well as from some papers it was concluded that to implement Distance based Location Update is very much difficult in real world because now a day's telecom companies try to accommodate more and more number of cells which in result accommodate more number of mobile stations. Another important aspect that needs to be cover here is that in today's world people are changing location so rapidly such that real distance based update can't be possible.

In profile based location update procedure, the profile of each user has been maintained by the telecom company in their database. With the help of this policy, the default location of the user has been maintained in the database of the company. The most important aspect that will come into picture is that here no location update cost will be maintained as the location of the user is fixed. Here the cost becomes higher when the user is not at his / her usual location and out for some special case.

In Time Based Location Update policy, the location of the user has been updated after a pre-defined time period. Here a fix time period say 't' seconds are defined and after each and every 't' seconds the location of the user will be updated. Here if the user has not changed the location during the given time period 't' at that time unnecessary location update occurs.

In Movement Based Location Update Strategy, the location of the user has been updated after fix number of movements in the cells. Here a variable 'm' will be defined with a fix value. If the user crosses number of boundaries more than 'm' at that time location update occurs. Here the

drawback is if the user crosses the boundary at a very nearby location at that time unnecessary location update occurs.

Here, during various literature review no researcher has tried to address all four policies and not compared four policies for cost reduction. Through the proposed algorithm and model we have defined 6 MS, 6 BSCs and 1 MSC taken.

3 Definition of the problem

- Comparison of all four policies and finding out the best policy among all four policies has been considered as a novel problem.
- The proposed model accompanied with comparison of policies and also applied with Dynamic Time Based Location Update.

4 Objective and scope of work

- To simulate various scenarios of cellular networks
- To evaluate various parameters from simulation results.
- To evaluate various existing location update strategies.
- To design a novel location update strategy for performance improvement purpose.

5 Original contribution by the thesis

The entire work in this synopsis, as well as thesis is the original work, with research papers as the back bone. The proposed model has been visualized as a collection of various modules, each of which with relevant publications. The details of the associated papers are as follows:

Paper Presented /Published:

(1) A paper on “Wearable Computer Applications A Future Perspective” has been published in International Journal of Engineering & Innovative Technology, Volume 3, Issue 1 ISSN : 2277:3754 of July 2013.

(2) A Paper on “Various Location Update Strategies in Mobile Computing" presented in National Conference on Emerging Trends in Information & Communication Technology

(NCETICT-2013) held on 12th October, 2013 at Marwadi Education Foundation's Group of Institutions, Rajkot, followed by publication in conference proceedings in International Journal of Computer Applications with ISSN No. : 0975-8887 in March, 2014.

(3) A Paper on "Importance of Paging Cost Reduction for Location Management in Mobile Computing" presented in National Conference on Emerging Trends in Engineering, Technology and Management (NCEETM) held on 31st January, 2014 at Indus University, Ahmedabad, followed by publication in conference proceedings with ISBN No. : 978-81-923049-9-1.

(4) A Paper on "Profile Based Location Update Strategy in Mobile Computing" presented in National Conference on Emerging Trends in Information & Communication Technology (NCETICT-2014) held on 5th November, 2014 at Marwadi Education Foundation's Group of Institutions, Rajkot, followed by publication in conference proceedings in International Journal of Advance Networking Applications (IJANA) with ISSN No. : 0975-0290 in November 2014.

(5) A Paper on "Location update procedure in mobile computing" has been published in International Journal of Sciences and Applied Research (IJSAR), Volume 1, December 2014 edition ISSN (Online) : 2394-2401 and ISSN (Print) : 2394-384x.

(6) A Paper on "Location Aware routing Schemes for Mobile Adhoc Networks" presented in International Conference on Recent Trends in Engineering Science and Management (ISBN : 978-81-931093-2-0) (ICRTESM-15) held on 15th March, 2015 at Jawaharlal Nehru University, New Delhi, followed by publication in conference proceedings in International Journal of Advance Research in Science and Engineering (IJARSE) with ISSN No. : 2319-8354 in March 2015 Special Issue.

(7) A Paper on "A Study of Routing Protocols for MANETs" presented in International Congress on Information and Communication Technology (ICICT-2015) held on 9th and 10th October, 2015 at Hotel Golden Tulip, Udaipur, followed by publication in conference proceedings through Springer.

(8) A Paper on "Opportunistic Location Update – A Novel Cost Efficient Reactive Approach to Remove Pauses in Cellular Networks" presented in International Conference on Communication and Networks (COMNET 2016) held on 20th and 21st February, 2016 at Ahmedabad Management Association Hall, Ahmedabad under CSI Ahmedabad Chapter

and ACM Ahmedabad Chapter, followed by publication in conference proceedings through Springer.

(9) A Paper on “Simulation based analysis of Location Update Strategies in mobile computing with Analytical Model" presented in International Conference on Computing for Sustainable Global Development (IndiaCom 2016) held on 16th to 18th March 2016 at New Delhi followed by publication in conference proceedings through IEEE.

Papers Submitted :

10) "Simulation based analysis for effects of GSM Call during mobility and Location Update" submitted in IEEE conference at INDIACOM 2017, New Delhi.

6 Methodology of research, results / comparisons

6.1 Methodology of research

This research work has been carried out using simulation approach. Various networking simulators are available like NS2, NS3, Opnet, NetSim, Qualnet etc. every simulator provides facilities to implement specific types of computer networks. This research work requires implementation of cellular network. Qualnet provides best support as far as implementation of cellular networks is concerned. Qualnet is more realistic in cellular networks with provision to modify API of GSM Architecture. Various location update strategies are also analyzed through analytical modeling to identify the best method complexity wise. Various network simulators are compared as below.

Sr.no	Tools/feature	Glomosim	Quelnet	OMnet++	Ns-2	Opnet Modeler	J-sim
1	Interface	Parsec C-based language	Parsec C++-based language	C++	C++/OTCL	C or C++	Java
2	User support	Poor	Excellent	Good	Excellent	Excellent	Excellent
3	License	Open source	Commercial	Free for educational use only	Open source	Free for Academic limited use	Open source
4	Scalability	Large	Very large	Large	Small	Medium	Small
5	Learning time	Moderate	Easy to learn	Moderate	Long	Long	Moderate
6	Availability	T/W/AD	T/W/AD/WSN A	T/W/AD	T/W/AD	T/W/WSN	T/W/AD/WSN A
7	Developed	Developed at University of California,It is written in the Bargrodia, & Gerla, 1999	Derived from the GloMoSim that was first released in 2000 by SNT	The Principle author is Andre Varge from Technical university of Budapest and it is publicly available since 1997	REAL network simulator 1989	First proposed by MIT in 1986 and initially developed by MIT of technology 1987 using C++	Distributed Real Time Computing Laboratory of the Ohio State University and by Illinois University in 2005
8	Mobility	Support	Support	No	Support	Support	Support
9	Applicability	Net./Sys	Net. /Sys.	Net. /Sys.	Net. /Sys.	Net. /Sys.	Network
10	Platform	Linux of Java 1.3 or higher versions, Parsec Compiler, GlomoSim software	Qualnet Simulator and SDL protocol developer.	OmNet++Runs on Linux, Mac OS x, other Unix-like systems and on and window XP, Win2K, Vista, 7	UNIX, Mac OS X, Microsoft Window Cygwin	C, C++ and Opnet modeler software.	VI. a GUI platform for real-time sharing of Mat lab designs and simulations
11	Graphic Interface support	Limited GUI	Excellent GUI	Good GUI	Limited GUI	Excellent GUI	Good GUI

Figure 1 : Comparison of Various Simulators

6.2 The model and its components

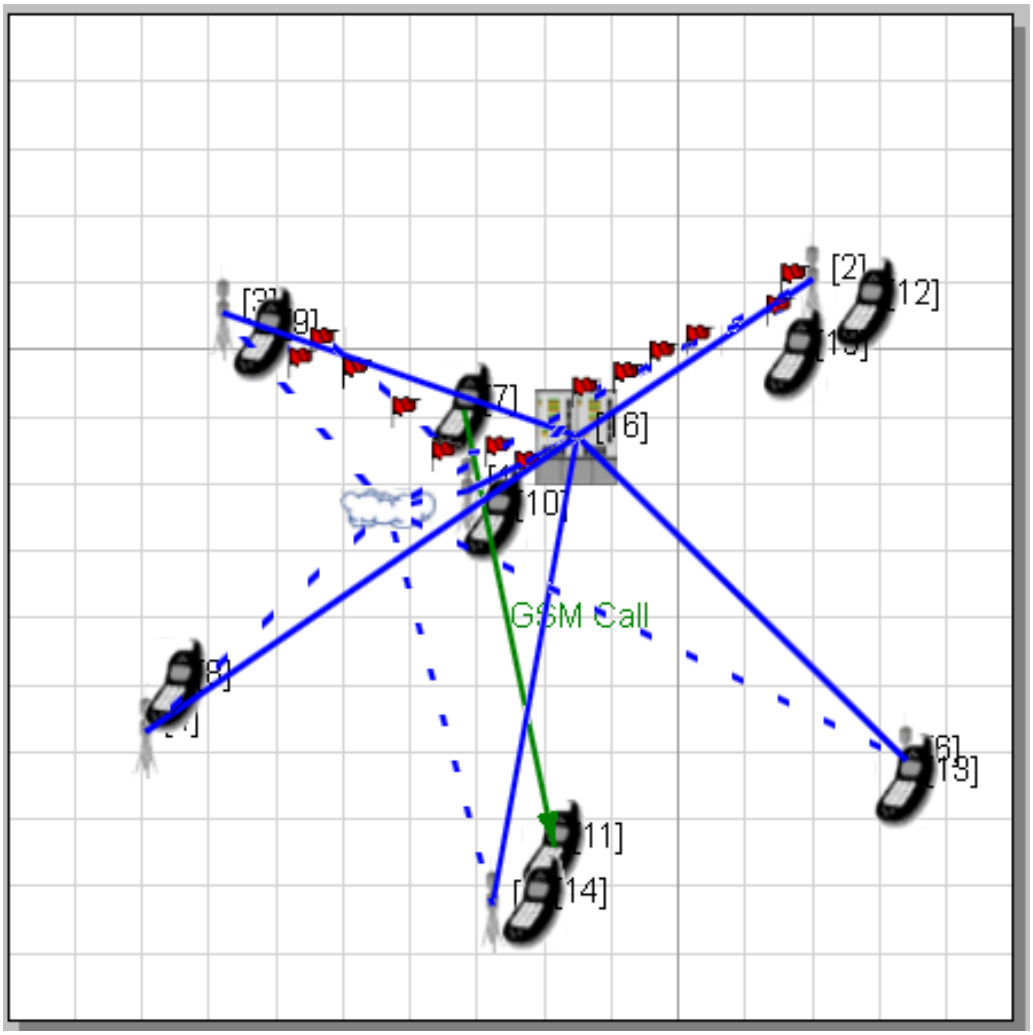

Figure 2 : Model for Simulation

Here in the above model we have taken one Mobile Switching Center (MSC) defined as (16). One wireless subnet has been taken. Total 6 Base Station (BS) has been taken defined as (1 to 6). Total 9 Mobile Stations (MS) has been taken defined as (7 to 15). Throughout the whole work we have taken this model as base model for our work.

6.3 Scenario Generation

Simulation has been carried out with different scenarios. Various scenarios are created with reference of amount of mobility as well as amount of network congestion. Mobility is implemented with increasing / decreasing amount of time to travel a specific distance by a MS. At the same time new distance is added to be travelled within a fixed amount of time. Congestion is implemented with

increasing / decreasing number of simultaneous calls.

At basic level, 6 scenarios are prepared as below.

Scenario No.	Congestion	Mobility
1	No congestion. 2 MS are busy. 1 call between MS 7 and MS 11	Low Mobility MS 7 moves 2898 meters in 300 seconds MS 11 moves 3019 meters in 300 seconds
2	No congestion. 2 MS are busy. 1 call between MS 7 and MS 11	Moderate Mobility MS 7 moves 5439 meters in 300 seconds MS 11 moves 5296 meters in 300 seconds
3	No congestion. 2 MS are busy. 1 call between MS 7 and MS 11	High Mobility MS 7 moves 9051 meters in 300 seconds MS 11 moves 8778 meters in 300 seconds
4	Moderate congestion. 4 MS are busy. 1 call between MS 7 and MS 11 1 call between MS 14 and MS 15	Low Mobility MS 7 moves 2898 meters in 300 seconds MS 11 moves 3019 meters in 300 seconds MS 14 moves 2774 meters in 300 seconds MS 15 moves 2403 meters in 300 seconds
5	Moderate congestion. 4 MS are busy. 1 call between MS 7 and MS 11 1 call between MS 14 and MS 15	Moderate Mobility MS 7 moves 5439 meters in 300 seconds MS 11 moves 5296 meters in 300 seconds MS 14 moves 4887 meters in 300 seconds MS 15 moves 5270 meters in 300 seconds
6	Moderate congestion. 4 MS are busy. 1 call between MS 7 and MS 11 1 call between MS 14 and MS 15	High Mobility MS 7 moves 9051 meters in 300 seconds MS 11 moves 8778 meters in 300 seconds MS 14 moves 7713 meters in 300 seconds MS 15 moves 7753 meters in 300 seconds

7 Achievements with respect to objectives

- **To simulate various scenarios of cellular networks**

Scalable Network Technologies (SNT) have developed a communication simulation platform (QualNet) which is useful tool for planning, testing and training the behavior of a real life communication networks. In real world simulation tools are cost effective method for developing, deploying and managing the systems. Mostly in networking world it is quite difficult to test each and everything at real level. Here, the simulations gives facilitates user to evaluate basic behavior of the network and also allows to test combinations of various features of network. Qualnet gives facility to design protocol, create scenarios and also allows to analyze the performance of the network.

This research work uses QualNet's built in mechanisms to simulate cellular networks – To establish scenarios with MS, BTS, BSC and MSC. Qualnet has C++ based API to implement GSM architecture and related mechanisms. Location update strategies implemented with this API is used to achieve other objectives.

- **To evaluate various parameters from simulation results**.

The QualNet analyzes various parameters and represents in graphical forms. Here in this research work, number of location updates made at MS, BTS, BSC are important. The built-in graphical analyzer is used to evaluate various parameters.

- **To evaluate various existing location update strategies.**

Various existing location update strategies are evaluated with rank based algorithm. Every scenario of a cellular network is evaluated across five parameters: Routing protocol, Number of infrastructure stations, Congestion of Cell, Mobility, Energy and memory saving. Every parameter is a goal and every goal has a support associated with it. If value of a parameter is improved, it can be said that the goal is achieved better. Based on this, all parameters of all scenarios are evaluated for all location update strategies. The location update strategy which has best value of the total goal achievement is ranked 1st. in our results, we have noticed that time based location update strategy performs best as compared to other location update strategies.

- **To design a novel location update strategy for performance improvement purpose.**

GSM architecture has various timers to repeat certain events at regular intervals. So far most of the timers have fixed values which don't change our time as per cellular network situations.

We have set dynamic calculation for following timers.

Default value of T3210 Timer (DefaultGsmLocationUpdateRequestTimer) is 10 Seconds
Default value of T3211 Timer (DefaultGsmLocationUpdateFailureTimer) is 10 Seconds
Default value of T3212 Timer (DefaultGsmPeriodicLocationUpdateTimer) is 360 Seconds

These timers are having static values and they don't change as per cellular network's situations. We are proposing a Dynamic Time-Based Location Update Strategy by calculating values of these timers with reference of the network performance. The main three parameters are used as a part of dynamic timers calculation are, Total Time – T, Total No. of Location Updates Success – LAS and Total No. of Location Updates Failed -LAF.

8 Proposed Algorithms

8.1 Selection of Best Location Update Strategy

Various existing location update strategies are evaluated with rank based algorithm. Every scenario of a cellular network is evaluated across five parameters: Routing protocol, Number of infrastructure stations, Congestion of Cell, Mobility, Energy and memory saving. Every parameter is a goal and every goal has a support associated with it. If value of a parameter is improved, it can be said that the goal is achieved better. Based on this, all parameters of all scenarios are evaluated for all location update strategies. The location update strategy which has best value of the total goal achievement is ranked 1st. in our results, we have noticed that time based location update strategy performs best as compared to other location update strategies.

Id	Support	Goal	Parameters
G1	1	Location updates with reference of routing protocol	Throughput Per Min
G2	2	Location updates with reference of Number of infrastructure stations	total_cells / Total_infrastructure_stations Fixed in Network
G3	4	Location updates with reference of Congestion of Cell	Total_calls / Cell Per Min
G4	5	Location updates with reference of Mobility	Average_speed Per Min
G5	3	Location updates with reference of energy and memory saving	1 / Average_energy_consumed_station Per Min

Algorithm Parameters are listed below:

N: Total number of Scenarios

M: Total number of Location Update Strategies

P: Total number of goals per location update strategy.

Support(Gi): The Importance of Goal Gi while evaluating a location update strategy.

Value(Gi): Value of Goal Gi

Value(LiSj) Sum value of Li with reference of all goals for a scenario Sj.

Value(Li) Sum value of Li with reference of all goals for all scenarios.

Rank(Li) Rank of Li location update strategy.

Algorithm:

For each location update strategy L1 to LM with index i

Value(Li) = 0

For each scenario S1 to SN with index j

Value(LiSj) = 0

For each goal G1 to GP with index k

$$\text{Value(LiSj)} = \text{Value(LiSj)} + (\text{Support (Gk)} * \text{Value(Gk)})$$

End

Value(Li) = Value(Li) + Value(LiSj)

End

End

Note:- the location update Strategy L, with highest value of Value(L) can be considered as the best location update strategy which has Rank(L) to 1.

8.2 Dynamic Time-Based Location Update Strategy

GSM architecture has various timers to repeat certain events at regular intervals. So far most of the timers have fixed values which don't change our time as per cellular network situations.

We have set dynamic calculation for following timers.

Default value of T3210 Timer (DefaultGsmLocationUpdateRequestTimer) is 10 Seconds

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Default value of T3212 Timer (DefaultGsmPeriodicLocationUpdateTimer) is 360 Seconds

These timers are having static values and they don't change as per cellular network's situations. We are proposing a Dynamic Time-Based Location Update Strategy by calculating values of these timers with reference of the network performance. The main three parameters are used as a part of dynamic timers calculation are, Total Time – T, Total No. of

Location Updates Success – LAS and Total No. of Location Updates Failed –LAF. Based on the Failure Ratio calculated as below various values of Timers are set at every T seconds. Here T is 60 Seconds.

Failure Ratio -FR = (LAF/LAS)/100
T3210 = (FR * 10)/100
T3211 = (FR * 10)/100
T3212 = (FR * 360)/100

9 Conclusion

Selection of best location update strategy is a big challenge for a cellular network because different parts of a cellular network have different traffic patterns. This research work evaluates time based, distance based and movement based location update strategies to identify the most appropriate one. On an average, time based location update can be selected for general situations where distance based and movement based policies are more selective to specific situations. One advantage of time based location update is that it can be applied with every mobile station easily where distance based and movement based location update strategies require mobile station to have distance, movement specific sensors.

GSM architecture has various timers to repeat certain events at regular intervals. So far most of the timers have fixed values which don't change our time as per cellular network situations. Three most important timers are Request Timer, Failure Timer and Update Timer. These timers need to be maintained precisely. This research work finds a light weight algorithm to select dynamic values of these timers. Comparison of various location update strategy result is summarized here.

Sr.	Scenario Type	Time Based	Distance Based	Movement Based
1	High Mobility of MS	Poor performance. Least Expensive.	Average performance. Moderate Expensive.	Best performance. Heavily Expensive.
2	Avg Mobility of MS	Average performance. Least Expensive.	Average performance. Moderate Expensive.	Best performance. Heavily Expensive.
3	Low Mobility of MS	Average performance. Least Expensive.	Average performance. Moderate Expensive.	Average performance. Heavily Expensive.

We can easily say that time based location update strategy provides average performance with least cost. At the same time other location update strategies are comparatively more expensive.

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