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An Activity based Selective Paging Scheme for Reporting Centre in Cellular Mobile Networks

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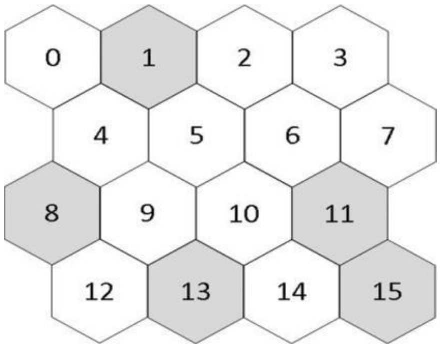
ABSTRACT
The main aim of cellular mobile communication is to discover existing location of mobile terminals to distribute the service, which is well-known as location management. The LM involves tracking of (mobile terminal's) MT's up-to-date location, which moves freely across different cells in order to provide them services. Every MT undergoes same number of updates when passes through a specific region. One such scheme is reporting centre in which, some of the cells are designated as reporting centres and all close by cells up to the next reporting centre belong to vicinity of same reporting centre. MT updates its location whenever it crosses vicinity of its current reporting centre, which happens no more than when it enters into another reporting centre and therefore a LU is triggered. To deliver a call, network pages current reporting centre and its whole vicinity simultaneously to locate the target MT. We have applied prediction-based selective paging on reporting centre scheme in cellular mobile networks, which reduces paging cost without affecting the location update cost. Paging cost along with LM cost for both the conventional and proposed schemes will be updated consequently which gives the results.

General Terms
Cellular mobile network, reporting center, location management (LM), location update (LU), mobile terminals (MT), registration, paging Keywords are your own designated keywords which can be used for easy location of the manuscript using any search engines.

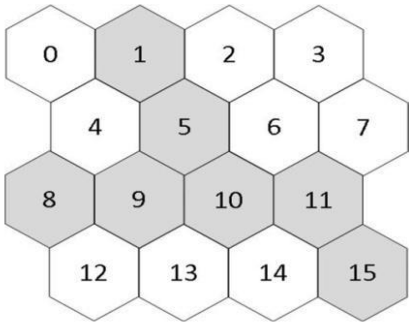
1. INTRODUCTION

A solid line of barrier, known as the reporting cells form which means a user will have to enter one of the reporting cells to get to the other side. For example, in Fig.1 (b), cells 1, 5, 8, 9, 10, 11 and 15 are reporting centres. Vicinity of reporting centre 1 consists of cells 0, 2, 3, 4, 6, 7 and 1 itself. Likewise, vicinity of reporting centre 9 consists of cells 0, 4, 12, 13, 14 and 9. An MT in cell 13 must cross a reporting centre to enter into cell 6 and therefore LU will be triggered. A cell may fall under vicinity of more than one reporting centres [11]. For illustration in fig.1 (b), cells 2, 3, 6 and 7 fall under the vicinity of reporting centres 1, 5, 10 and 11. That means whether the reporting centres of an MT is either cell 1, 5, 10 or 11, these four cells will for all time be paged whenever a call arrives of that MT. Under reporting centre scheme, non reporting cells may be bounded or unbounded [12]. Fig.1 (a) and (b) shows bounded and unbounded non reporting cell configurations respectively.

Here an activity based model have been made which gives a appropriate scheduled movements to MTs and have applied prediction-based selective paging on reporting centre scheme in cellular mobile networks, which reduces paging cost without moving the location update cost. Paging cost and LM cost for both the conventional and proposed schemes will be updated as a result [2] [12].



(a) Unenclosed non-reporting cell arrangement



(b) Enclosed non-reporting cell arrangement

Fig.1 Cell Configuration

2. BACKGROUND STUDY

A number of methodologies have been proposed for location management. Most of these schemes aim to reduce either location update cost or paging cost. Very a small number of them have reduced both location update cost and paging cost [11].

A location management scheme where with each LU message from a MS, a LA is distinct for the MS based on subscriber mobility history is. As long as a mobile moves within its present LA, no update message is triggered. Only when a mobile moves out of its present LA, a LU is triggered and a new LA is defined for the MS. This algorithm also considers speed and call entrance probability of the subscriber to define the LA size. Since this algorithm tries to reduce LM cost for individuals, it significantly outperforms static algorithms, but it requires more processing power as compared to stationary algorithms. This algorithm reduces this overhead at the cost of some added logic and memory in the MS and network [1].

An intelligent LM scheme by taking User Profile History to reduce the location update cost by combining Back-Propagation Algorithm and Cascaded Correlation Neural Network. This scheme reduces the LM cost significantly [2].

An algorithm to reduce paging cost using speed adaptive policy. It uses speed distribution and random walk model to develop look-up tables for mobile users. These tables are worn to find out subarea size to be paged. Paging area is further reduced by introduction of 120 degree paging zones. A paging agent was used to store previous VLR address and helps to find out optimal paging zone [3].

Authors propose a hybrid location update scheme in which, movement-based and time based location update approaches are combined for the improvement of QoS. This technique has two parts: first time then movement, and first movement then time. The effectiveness of the proposed scheme is checked with CMR, velocity and time. In Zheng, authors proposed an adaptive location update area design for wireless cellular network under 2D Markov walk model, and this scheme is helpful for LU area design [4].

Authors analysed the performance of various LM schemes such as one step pointer forwarding scheme, IS-41 and pointer forwarding techniques. It was experiential that each LM scheme has its own specialization, utilization and testability and it is based on CMR and threshold values [5].

A location management scheme using mobility in sequence of mobile users in wireless mobile networks. In this scheme, the location registration process caches location information of visited cells to reduce the duplicated registrations, the paging process exploits the zone of user movement patterns to predict the paging area and, therefore to reduce the paging cost in location explore procedure [8].

A application that based on an MT's movement model that captures mobility behaviour, the network can expect the location of MT at cell level because many trips of MTs follow routinely trajectories. If MT visits an expected cell, the target cell Δ, before a certain movement threshold is reached, its movement counter is reset to zero. Otherwise the mobile terminal will trigger a location update message when the mentioned threshold is reached. This scheme reduces signalling traffic [9].

3. WORK DONE

Work carried out in this research can be summarized as follows:

- We have applied prediction-based selective paging on reporting center scheme in cellular mobile networks, which reduces paging cost without affecting the location update cost.
- The activity-based mobility model is implemented using Java (jdk1.7) for simulation purpose [21] [22].

3.1 An Activity Based Mobility Model

Generally, MTs do not move across cells in fully random fashion. The vital principle is an individual's daily activity pattern, including such activities as going to work-place or school. In activity based mobility model, an MT moves to a particular cell at a particular time (following same or dissimilar paths each time).

3.2 Simulation setup

Number of Cells=49

Number of MTs=100, Every MT is initially assigned a Home randomly

Number of Colleges=5

Number of Work Places=5

Number of Fitness centres=4

3.3 Schedule Movements

6:00 AM Home to Fitness centre (Only FIT MTs)

7:00 AM Fitness centre to Home (Only FIT MTs)

8:00 AM Home to College (Only Students)

10:00 AM Home to Work place (Only Workers)

14:00 PM College to Home (Only Students)

17:00 PM Work place to Home (Only Workers)

Initially, every *MT* will be assigned a home randomly. Every *MT* will initially be placed at its home. There will be *Fitness centres*, *work places*, *colleges* and *home* assigned to *MTs* [9]. MTs will move from source to destination cell timely. Paging cost and LM cost for both the schemes will be updated accordingly.LU cost will remain same in both the schemes. Path between every source cell to destination cell will be determined at runtime. An *MTMover* thread will move each MT by one cell towards its destination until it reaches its current destination. On every move, it is checked that if the new cell is a reporting centre. If yes then if it is not the current reporting centre of the moved MT then an LU operation is performed by the MT. The *Clock* will rise the time *10*seconds in each two seconds. *Clock* thread will invoke *MTMover* thread. The *CallGenerator* thread will keep initiating calls to randomly picked MT. Called MT will be paged according to VLR database entry. Its database at VLR level will be restructured if essential.

Movement of MTs will be distinct as follow:

- From 17 to 06 O'clock, stay at home

- At 06, leave for Fitness centre (Only fit MTs)

- At 07, leave for Home (Only fit MTs)

- At 08, leave for College (Only students)

- At 10, leave for Work place (Only Workers)

- At 14, leave for Home (Only Students)

- At 17, leave for Home (Only Workers)

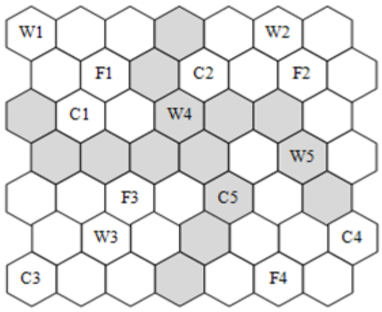


Fig.2 (a) an activity based illustration

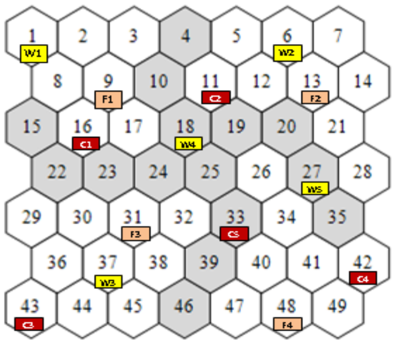


Fig.2 (b) an activity based illustration with assigned spaces

This time table will be followed for one week and results will be analysed.

At any moment, possible move from a cell (shown in bold) can be determined from following 2D-array:

Table 1. Movements of MT's

Network	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
1(Odd)	0	1	2	3	4	5	6	7
2(Even)	0	8	9	10	11	12	**13**	14
3(Odd)	0	15	16	17	**18**	19	20	21
4(Even)	0	22	23	24	25	26	27	28
5(Odd)	0	29	30	31	32	33	34	35
6(Even)	0	36	37	38	39	40	41	42
7(Odd)	0	43	44	45	46	47	48	49

Note: Remember that first row and first column i.e. 0th row and 0th column are not used at all.

Determine *row number* of source/destination cell:

Let us say source node is 13 and destination cell is 37 (i.e. W3), then

Source cell: ceil(13/7)=2

Destination cell: ceil(37/7) =6

Determine *column number* of source/destination cell:

Let us say source node is 13, then

Source cell:

ceil(13/7) = 2

=> 7*(2-1) = 7

=> 13-7 = **6**

Destination cell:

ceil(37/7) = 6

=> 7*(6-1) = 35

=> 37-35 = **2**

Thus row and col. no. of source cell are 2 & 6 i.e. index is [2,6]

And row and col. no. of destination cell are 6 & 2 i.e. index is [6,2]

- If *x* co-ordinates of source & destination are same then-
Move vertically, one cell each time so that difference between x reduces every time by 1

The variable *sign* = '+' or '-' tells whether to decrement or increment at every step

- If *y* co-ordinates of source & destination are same then-
Move vertically, one cell each time so that difference between y reduces every time by 1

The variable *sign* = '+' or '-' tells whether to decrement or increment at every step

- If both remain same then-
Go no where

- If both change then-

assign values to xsign and ysign where

xsign = '+' or '-' tells *x* field of MT needs to be incremented or decremented

ysign = '+' or '-' tells *y* field of MT needs to be incremented or decremented

Now invoke the move_generator method:

while x_{source} and y_{source} become equal to $x_{destination}$ and $y_{destination}$ do as follow:

If row number is odd then

If xsign=+ and ysign=+ then Best move will be *cell[x+1,y]*

If xsign=- and ysign=+ then Best move will be *cell[x-1,y]*

If xsign=+ and ysign=- then Best move will be *cell[x+1,y-1]*

If xsign=- and ysign=- then Best move will be *cell[x-1,y-1]*

If row number is even then

If xsign=+ and ysign=+ then Best move will be *cell[x+1,y+1]*

If xsign=- and ysign=+ then Best move will be *cell[x-1,y+1]*

If xsign=+ and ysign=- then Best move will be *cell[x+1,y]*

If xsign=- and ysign=- then Best move will be *cell[x-1,y]*

When to perform LU operation:

3.4 Arrays used

Following array contains the IDs of all the reporting cells:

Rep_Cntr_IDs[]=
{4,10,15,18,19,20,22,23,24,25,27,33,35,39,46};

WorkPlace[] = {0,1,6,37,18,27};

It means W1 is located in cell-1 i.e. cell whose cell-id is 1, W2 is located in cell-6, W3 is located in cell-37, W4 is located in cell 18 and W5 is located in cell-27. The 0^{th} index is not used at all so that cell-id of W3 can be determined simply as *WorkPlace[3]*

Similarly other arrays are:

College [] = {0, 16, 11, 43, 42, 33};

FitnessCenter[] = {0,9,13, 31,48}

4. CALCULATIONS

4.1 Location management cost

A number of LM schemes have been proposed by various researchers so there must be some structure that can be second-hand to symmetry one scheme by means of the other. LM cost function comprises of two main components: updating cost and paging cost. Updating cost is the cost due to location update performed by MTs in the network whereas paging cost is caused by the network during location inquiries while locating an MT [1]. There are some other parameters that influence the total LM cost such as cost of database management in LU operation, cost in terms of wired line (backbone) network bandwidth used (that connects base stations to each other). Mostly these costs are assumed to be constant for all LM schemes. So combination of LU and paging cost are measured to be sufficient to compare different LM schemes.

Total LM Cost = (C×NLU) + (NP)

Where NLU denotes the number of location updates performed during simulation time T, NP denotes the number of paging operations performed during time T and C is a constant, which is the ratio of single LU cost to the cost of paging solo cell. It is said that the cost of a LU is ten times the cost of a paging operation. In light of this fact, we used C=10.
Reporting center scheme decreases LU cost but increases the paging cost. In unbounded non-reporting cell configuration, since the vicinity of reporting centers are not bounded therefore paging cost may enlarge noticeably as compared to bounded non-reporting cell configuration [11]. This paper presents a simple norm for clustering reporting centers in bordered nonreporting cell configuration that decreases total LM cost but since clustering always increases the paging cost therefore a successive paging scheme is proposed which, when combined with clustering technique, curtails both updating cost and paging cost resultant into remarkable reduction in total LM cost.

4.2 Paging cost

In attempt to locate target MT as quickly as possible, multiple methods of paging have been proposed by the researchers. The most basic method used is Simultaneous paging, where every cell in the MT's LA is paged at the same time [7] [9]. If LA contains large number of cells, this scheme costs terribly high. In Sequential Paging, cells within an LA are paged one after the other, in order of decreasing user dwelling possibility. If the user resides in an infrequently occupied location, long delay may occur in finding the MT. Intelligent-Paging (optimized version of Sequential Paging) calculates the specific paging areas to poll sequentially, based upon a dwelling probability matrix. However, this scheme has too much computational overhead incurred through updating and maintaining the matrix [19]. Rule-based paging scheme is a knowledge based approach, where the current interaction of the MT with the network is represented as a set of facts, which is used to predict the location of MT when a call arrives.

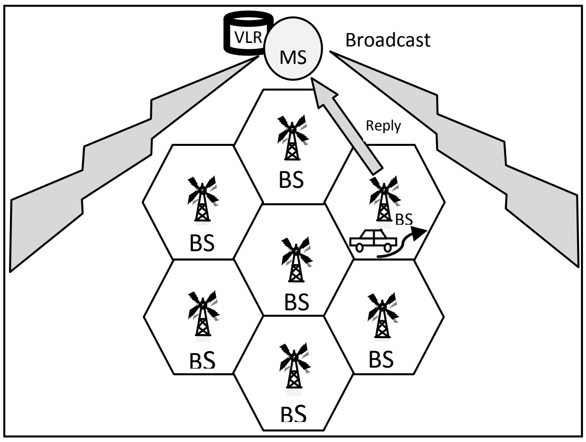


Fig.3 Paging method

Since each MSC is connected with an LA and there are more than one cell in each LA. Therefore on a call arrival, a mechanism is necessary to determine the current cell of the called MT so that the call can be delivered to him. This is achieved by paging process in which, the MSC broadcasts polling signals to all cells contained by the LA of the called MT.

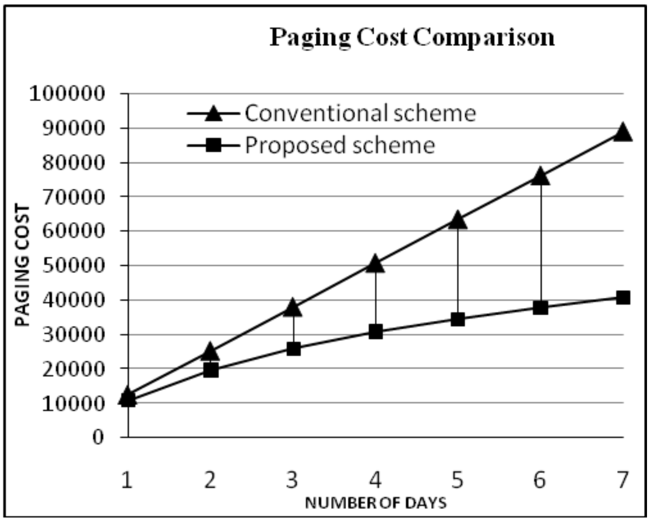
5. STUDYING THE EFFECTS OF SELECTIVE PAGING ON REPORTING CENTRE SCHEME USING AN ACTIVITY BASED MODEL

5.1 Comparison Of Paging Cost

Table 1. Cumulative Paging Cost involved during the week

Till Day-No.	Conventional scheme	Proposed scheme
Till Day-1	12690	10929
Till Day-2	25449	19669
Till Day-3	38237	25898
Till Day-4	50991	30860
Till Day-5	63644	34510
Till Day-6	76399	37926
Till Day-7	89188	40797

Graphical observation-

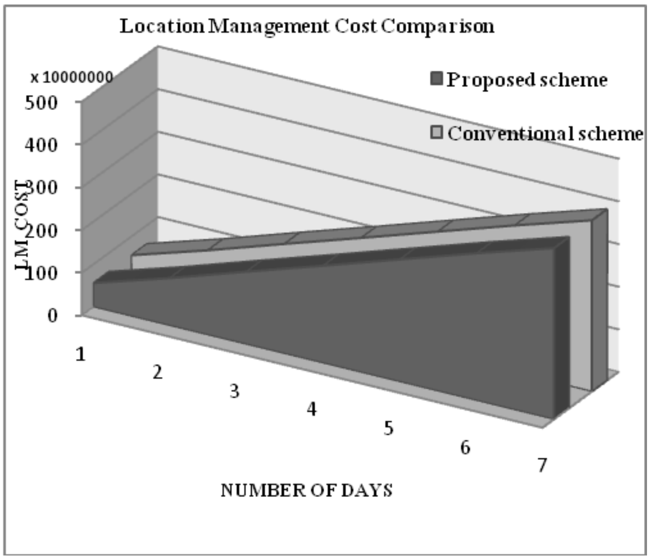


5.2 Comparison Of Location Management Cost

Table 2. Cumulative Location Management Cost

Till Day-No.	Conventional scheme	Proposed scheme
Till Day-1	560802190	560800429
Till Day-2	1114202909	1114197129
Till Day-3	1703612697	1703600358
Till Day-4	2282936751	2282916620
Till Day-5	2869448924	2869419790
Till Day-6	3452300879	3452262406
Till Day-7	4009871298	4009822907

Graphical observation-



5. RESULTS

All the results when number of MTs are 100-

Cumulative statistics till the end of Day-1

Number of calls generated: 716

Number of page Faults: 611

Paging cost in conventional scheme: 12690

Paging cost in proposed scheme: 10929

LU cost: 560789500

LM cost in conventional scheme: 560802190

LM cost in proposed scheme: 560800429

Cumulative statistics till the end of Day-2

Number of calls generated: 1436

Number of page Faults: 1089

Paging cost in conventional scheme: 25449

Paging cost in proposed scheme: 19669

LU cost: 1114177460

LM cost in conventional scheme: 1114202909

LM cost in proposed scheme: 1114197129

Cumulative statistics till the end of Day-3

Number of calls generated: 2156

Number of page Faults: 1418

Paging cost in conventional scheme: 38237

Paging cost in proposed scheme: 25898

LU cost: 1703574460

LM cost in conventional scheme: 1703612697

LM cost in proposed scheme: 1703600358

Cumulative statistics till the end of Day-4

Number of calls generated: 2877

Number of page Faults: 1674

Paging cost in conventional scheme: 50991

Paging cost in proposed scheme: 30860

LU cost: 2282885760

LM cost in conventional scheme: 2282936751

LM cost in proposed scheme: 2282916620

Cumulative statistics till the end of Day-5

Number of calls generated: 3596

Number of page Faults: 1852

Paging cost in conventional scheme: 63644

Paging cost in proposed scheme: 34510

LU cost: 2869385280

LM cost in conventional scheme: 2869448924

Number of calls generated: 4316

Number of page Faults: 2012

Paging cost in conventional scheme: 76399

Paging cost in proposed scheme: 37926

LU cost: 3452224480

LM cost in conventional scheme: 3452300879

LM cost in proposed scheme: 3452262406

Cumulative statistics till the end of Day-7

Number of calls generated: 5037

Number of page Faults: 2140

Paging cost in conventional scheme: 89188

Paging cost in proposed scheme: 40797

LU cost: 4009782110

LM cost in conventional scheme: 4009871298

LM cost in proposed scheme: 4009822

Table 3. Location management cost with conventional and proposed schemes, when no. of MTs are 40, 60, 80,100,130 and 200

DAYS	No. of MTs	40	60	80	100	130	200
DAY 1	CONVENTIONAL	224320876	336481314	448641752	560802190	729042847	1121604380
	PROPOSED	224320171.6	336480257.4	448640343.2	560800429	7290405577	1121600858
DAY 2	CONVENTIONAL	445681163.6	6684721745	8912962327	1114202909	1448463782	2228405818
	PROPOSED	445678851.6	668518277.4	891357703.2	1114197129	1448456268	2228394258
DAY 3	CONVENTIONAL	681445078.8	1022167618	1362890158	1703612697	2214696506	3407225394
	PROPOSED	681440143.2	1022160215	1362880286	1703600358	225680465.4	3407200716
DAY 4	CONVENTIONAL	913175900.4	1369762051	1826349401	2282936751	2967817776	4565873502
	PROPOSED	913166648	1369749972	1826333296	2282916620	2967791606	4565833240
DAY 5	CONVENTIONAL	1147779570	1721669354	2295559139	2869448924	3730283601	5738897848
	PROPOSED	1147767916	1721651874	2295535832	2869419790	3730245727	5738839580
DAY 6	CONVENTIONAL	1380920352	2071380527	2761840703	3452300879	4487991143	6904601768
	PROPOSED	1380904962	2071357444	2761809925	3462292406	4487941128	6904524812
DAY 7	CONVENTIONAL	1603948519	2405922779	3207897038	4009871298	5212832687	8019742596
	PROPOSED	1603929162	2405863744	3207558325	4009822907	5212769779	8019645814

6. CONCLUSIONS

The LM involves tracking of (mobile terminal's) MT's up-to-date location, which moves freely crossways different cells in order to supply them services. By applying prediction-based selective paging on reporting centre scheme in cellular mobile networks, which reduces an MT moves towards a destination cell at a specific time (following same or different paths each time). Hence results reveal that the proposed scheme predicts user location with paging cost without affecting the location update cost. Paging cost and LM cost for both the conventional and proposed schemes keep posted accordingly. In this activity based mobility model, high accuracy occurs and reduces paging cost outstandingly.

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