Optimization of Handoff Delay and Location Prediction of Mobile Station using GPS Integrated SIM Module in Cellular Networks

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***Abstract*—Booming development in cellular networks provides faster and seamless services to mobile user. Mobility management is an important issue in the area of mobile communication. Within the cellular networks, movement track of mobile station (MS) is provided by the location management. Location of mobile station has great attention and has potential for application and services to improve both location-based services and cellular network performance. So, several researchers are worked to develop methods and algorithms which increase the positioning accuracy and execution time [2][3][4][5][6]. In GSM network, MS has to activate the GPS mobile app to find the location of MS while it is traveling. But using this app, the network can find only the location of BS under which the MS currently resides. This paper discusses a new terminology which is used to know the exact location of a MS while it is moving. During a call, while a MS is travelling from one cell to another; this proposed network system can predict the next location of MS. This efficient location prediction leads to optimize the handoff delay and paging operation.**

***Index Terms*—GPS module, mobile station, base station, visitor location register, location prediction, location management, optimization and handoff delay.**

I. INTRODUCTION

As shown in the Fig 1, in cellular network, a geographical area is divided into cells. Each cell has its own cellular tower called Base Station (BS). Several base stations are controlled by Base Station Controller (BSC) which comes under a Mobile Switching Center (MSC). Each MSC belongs to a data base called Visitor Location Register (VLR).VLR assigns a temporary mobile subscriber identity to every MS in the area, and so it has to be updated each time when the MS travels from one cell to another cell.

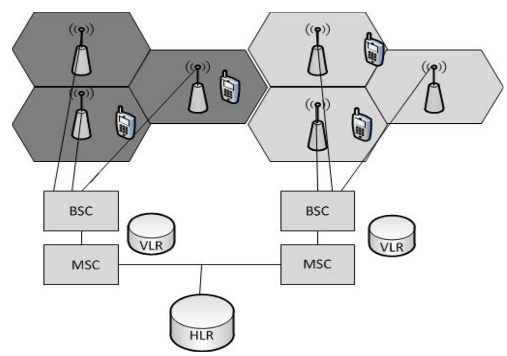

Fig. 1: Cellular Network architecture

In cellular network, the system keeps track of the location of MS through an up-to-date profile of it stored in various databases namely VLR and Home Location Register (HLR). A MS profile consists of not only its current location information, but also service information, such as billing and authentication.

In cellular network, mobile movement prediction defines as the prediction of the next movement of the MS in a networked environment. The MS can be able to access the network services while it is moving from one location to another. There are methods in mobility management to store and update the location information of mobile station which are served by the system. A very few research works have been done in the area of location prediction.

II. RELATED WORK

This section discusses the related work done by various renowned researchers. A detailed study starting from quality of service (QoS), mobility management and handover management has been carried out. The techniques addressing the issues in above mentioned fields have been explained.

The authors in [1] have proposed a predictive mobility and routing management scheme using the models movement circle and movement track models as well as the Markov chain model. They developed a class of mobile motion prediction algorithms which consists of two algorithms: regularity-pattern detection algorithm and a motion prediction algorithm for supporting services pre-connection, routing pre-arrangement and resources pre-allocation. The algorithm is simple and fast in practice.

In [7], the researchers introduced a hybrid UTDOA and A-GPS positioning technique in mobile network. A novel future location prediction algorithm was developed. ICMP consists of three main prediction levels such as cell-to-cell, sector-to-sector and intra-sector predictions. The achieved algorithm ICMP provides the requirements of future prediction of mobile station's location which is used to enhance both LBS based on mobile network operators and mobile network allocation resources.

Authors in [8] describe a simple Multi Layer Perception (MLP) model which is able to resolve non-linearly separable problems. To build a multilayer perception, a number of neurons are connected in layers where each of them is able to identify small linearly separable sections of the inputs and is used to get the final output in the network. Their paper shows the regular and uniform pattern which can be extended for random data.

In [10], authors adopt a prediction algorithm that aims to reduce handoff latency by minimizing the frequent switching between the base stations with respect to the movement of the mobile station. They focus on reducing handover-related issue by using location-based information.

III. MOBILITY MANAGEMENT

Mobility is an aspect of user behavior which impacts wireless networks as well as wired ones. The role of mobility management in cellular networks provides seamless services to the MS while it travels. Mobility management consists of two components: location management and handoff management. The former component defines how to locate a mobile node, track its movement, and update the location information, while the later component focuses on the change of a mobile access point during data transmission.

HLR (Home Location Register) and VLR (Visitor Location Register), the two types of databases are used in cellular networks. On the arrival of a mobile call, the system needs to find the location of the MS by searching it among the base stations. This location finding is called paging. While a MS is traveling from one cell to another, it should register its location and update its information in VLR.

IV. LOCATION MANAGEMENT

Mobility management is the operation of tracking mobile nodes irrespective of their present location. There are two basic operations: Location update and Paging.

A. Location Update

Location update is the process to inform the location of a mobile station to the network. Each mobile station has to update its location from time to time while it is moving. This procedure begins with an update message sent the mobile itself. Then VLR is updated after some signaling messages.

Each MS should send location update message whenever some predefined threshold has been reached. The threshold may depend on MSs mobility and calling pattern optimized performance on a MS basis.

B. Paging

Paging means searching and finding a MS when a call is directed towards it. Location update is done by MS while paging is done by the network. The network should able to determine the exact location of a MS to forward the incoming call to that MS. Paging is generally done by sending query from the network to the cell where the MS may reside. All the MSs in that cell listens this query and only the called one reply back.

The second and third generation mobile systems are servicing using radio spectrum. Higher bandwidth and coverage area promotes the devices with multi-network interface facility. The multi-network interface devices are capable of accessing services of various networks. Due to the higher bandwidth, large data rate and smoother and quick handoff, 4G devices have the facility of multi-network interface facility. But in all coverage area in which the mobile station travels, 4G services and networks may not be available.

V. HANDOFF MANAGEMENT

Each cell in the cellular networks is capable of providing telecommunications services to MSs roaming with them. Each cell can only serve up to a certain geographical area and number of MSs. Handoff happens when a MS is reached across any of above two limits.

When a MS travels from one cell to another, a handoff takes place between the two cells. All services provided by the previous cell are transferred to the target cell when handoff takes place. A handoff may be automatically happened when the number of MSs in a particular cell has already reached the maximum capacity of a cell.

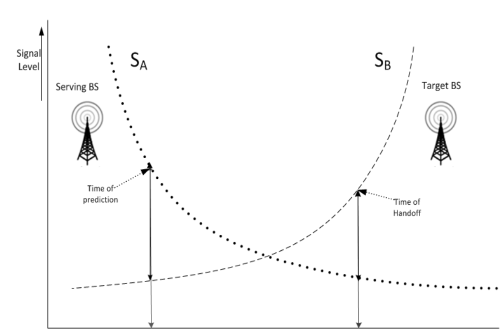

Fig. 2: Handoff Management

In the above Fig 2, there are two base stations, serving BS (BS_S) and target BS (BS_T). S_A and S_B are the signal strength of BS_S and BS_T. While a MS is moving from BS_S, if the received signal from target BS_T is not stronger than the received signal from the source BS_S then there is a ping-pong type movement at the middle point. But if the received signal from target BS_T is stronger than the received signal from the source BSS then handoff is happened at the time of handoff t_{HO}. In this proposal at the time of prediction t_P, location can be predicted when a MS is traveled from BS_S to BS_T.

To maximize the spectrum utilization of cellular architecture, handoff mechanism is extremely important in cellular networks. As a MS moves through the coverage area of the cellular system, handoff transfers an ongoing call from To maximize the spectrum utilization of cellular architecture, handoff mechanism is extremely important in cellular networks. As a MS moves through the coverage area of the cellular system, handoff transfers an ongoing call from one cell to another. While a MS is switching between cells, an efficient handover mechanism and location prediction method is used to improve the performance of cellular network. In this paper a new algorithm is introduced which can optimize handoff delay and predict the new location of MS.

As the increase of the usage of mobile devices, location prediction is more essential which will reduce the time of searching the location of MS. Location prediction of MS also optimize the handoff delay. When a MS is travelling and attending a call simultaneously, in the present scenario the network cannot identify the exact location of MS using running GPS application. But it can identify the BS under which the MS locates. This proposal describes an algorithm which discusses the functionality of GPS module in the SIM of MS.

In this paper, a new location prediction algorithm is introduced. When a MS is moving from one cell to another, continuous movement of MS from cell to cell is monitored by the GPS integrated SIM module in the MS. The Fig 2 describes the location prediction point and handoff point denoted by t_P and t_{HO} respectively.

VI. PROPOSED ARCHITECTURE

Fig 3 discusses the proposed architecture which consists of mixture of wired and wireless components. A new additional component, prediction server is introduced along with base station controllers, base stations and mobile stations. The prediction server which resides along with each MSC, stores the special information of all MSs of all BSCs come under the specific MSC.

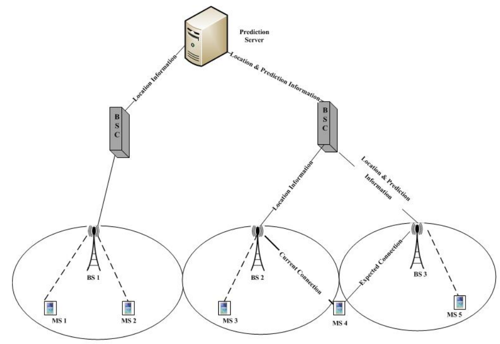

Fig. 3: System Architecture

A. Location Finding

But in this architecture, the network system gets only the location of BS under which MS resides. There is no other alternate method for finding the exact location of the MS. Also the network system cannot predict easily the location of MS. Many research works are progressed in this area.

But in this proposal, a new method of location finding is introduced. During the time of travelling, MS informs its exact location to the system via BSC at regular intervals of time using the GPS module which is integrated inside its SIM. At regular intervals of time, MS passes the information to the prediction server about its ID, longitude and latitude and ID of current BS under which MS resides through its BSC. After registering the information from the MS to the prediction server, that information can be managed automatically or manually by the server.

B. Location Prediction

In a GSM cellular network, MSC checks the database of VLR for the location area of a MS. MSC broadcasts a message to MS via the BSC that is paging request. The MS responds to the page request and BSC allocates a traffic channel and sends a message to the MS to tune to the channel. The MS generates a ringing signal and, after the subscriber answers, the speech connection is established. In this network, MS has to activate the GPS mobile app to find the location of MS while it is travelling. But using this app, the network can find only the location of BS under which the MS currently resides.

This new proposal introduces a methodology for finding the location of MS. During a call when a MS is travelling from one location to another, a set of latitudes and longitudes of MS are registered to the prediction server through its current BS at regular intervals of time

While a MS is travelling from one cell to another, the signal strength of the current BS is lower than the signal strength of the destination. The information from the MS is registered continuously in the prediction server during the regular intervals of time. Using curve fitting and interpolation, from the path of movement of MS, create a fitted line by joining these registering points.

This new proposal discusses an algorithm to calculate the perpendicular distances to each neighboring BS from the fitted line. From the set of distances, the minimum distance can be calculated. Thus, the minimum distance Dmin represents the minimum distance of MS from the target BS. Instead of several searching operations in VLR by MSC, the predicted location is informed to MSC directly by BSC. During the call while it is travelling, this type of method of location prediction will be very efficient.

For example, A (caller) calls B (callee), in GSM network, MSC searches the location of B in VLR , passes that information to the corresponding BSC, then BSC sends beacons to all MSs existing under that BSC. Then callee B responds to the beacon and informs its location to the MSC through BSC. But in this proposal, the location attributes of callee are informed to the prediction server. Then MSC can take the exact current location of MS directly and give the request to the concerned MS through the current BSC.

VII. CELL GRAPH

Because of the important use of graph theory in Mathematics, Science and Technology, it is becoming increasingly significant. To prove fundamental results in pure mathematics, powerful methods of graph theory are used.

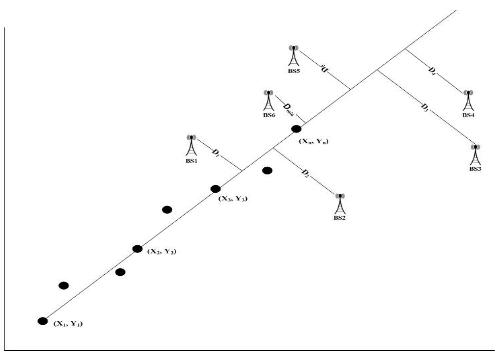

Fig. 4: Location Prediction Using Cell Graph

In this proposal, graph theory is applied for modelling the problem. Here, the geographical area of cellular networks is modelled using the graph theoretical approach and it is termed as Cellgraph represented by Gcell. Each cell in this cellgraph is similar as a node in a graph.

Fig 4 shows set of latitudes and longitudes of MS at regular intervals of time. Using the curve fitting and interpolation we can fit a line which will give the path of the movement of the MS. And then the proposed system will calculate the perpendicular distance to each BS from the fitted line. The BS with the minimum perpendicular distance, Dmin, will be chosen as the predicted BS.The detailed algorithm for prediction is given below

Cell Graph	:	G_{cell}
Current Cell	:	$C_{cr} = \{id, lat, lon\}$
Predicted Cell	:	$C_{pr} = \{id, lat, lon\}$
K th Cell	:	$C_k = \{id, lat, lon\}$
Location Vector	:	$V_{loc} = \langle (x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n) \rangle$

Algorithm 1 Prediction Algorithm

Input : $G_{cell}, C_{cr}, V_{loc}$

Output : C_{pr}

```
Start
using all coordinates, (x_i, y_i) ∈ V_loc find
X̄ = Σ x_i / V_loc.size()
Ȳ = Σ y_i / V_loc.size()
a = Σ(x_i − X̄)(y_i − Ȳ) / Σ(x_i − X̄)^2
b = Ȳ − aX̄
Obtain y = ax + b
D_min = ∞
C_pr = null
for all Cell,C_k ∈ C_cr.adjacent() in G_cell do
    D_k = distance(C_k, y = ax + b)
    if D_k < D_min then
        C_pr = C_k
        D_min = D_k
    end if
end for
return C_pr
Stop
```

Algorithm 2 Distance Computing Algorithm

Input : C_i , $y = ax + b$

Output : D_k

```
Start
distance = |aC_i.lat − C_i.lon + b| / √(1 + a^2)
return distance
Stop
```

VIII. RESULT ANALYSIS

In this proposal the movement of a mobile node is traced using the network simulator NS2. Fig 5 represents the simulation of movement tracking of a mobile node. In this figure, there are six base stations BS1, BS2, BS3, BS4, BS5, BS6 and one mobile node. The mobile node starts from its initial position and moves randomly. Using the network simulator NS2, the track of movement of mobile node is traced.

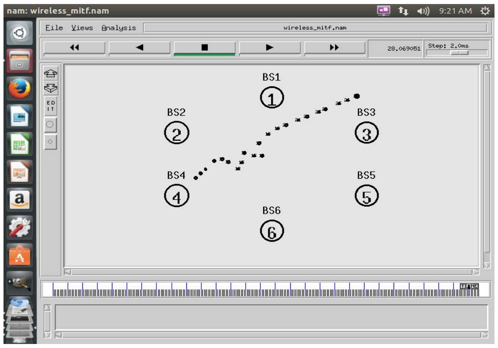

Fig. 5: NS2 Simulation of Mobile Node Movement

The following table shows the X and Y coordinates of the mobile node which are traced by the simulation tool NS2.

TABLE I: *Location Coordinates of Mobile Node*

x coordinate	y coordinate
63.1522	263.152
75.0912	275.091
98.9914	298.991
119.6530	303.640
136.1650	294.910
161.1290	276.531
171.1050	293.976
178.4150	320.798
203.1300	314.164
225.1170	312.947
216.8020	348.385
240.7090	375.589
264.7050	390.780
288.1330	401.098
320.1650	415.204
343.4100	425.442
373.9770	438.904
391.9150	446.804
427.2410	462.361
449.5710	472.195
475.1960	483.480

Using the X and Y coordinates of mobile node given in the above table, the following chart is created. Using the curve fitting(least square method) line of best fit is obtained which gives the ideal path representing the movement of the mobile node which is explained in Algorithm 1. The line obtained from the above coordinates using this Algorithm is $y = 0.5678x + 221.35$

Then calculate the perpendicular distance to each BS from the fitted line and find BS with minimum perpendicular distance, D_{min} using Algorithm 2. And it will be chosen as the predicted BS.

TABLE II: *Perpendicular Distance from each BS to the line* $y = 0.5678x + 221.35$

BS	x coordinate	y coordinate	Distance
BS1	250.0000	480.000	101.473523
BS2	0.0000	380.000	137.9532066
BS3	500.0000	380.000	108.9259875
BS5	500.0000	200.000	265.4538317
BS6	250.0000	100.000	228.974148

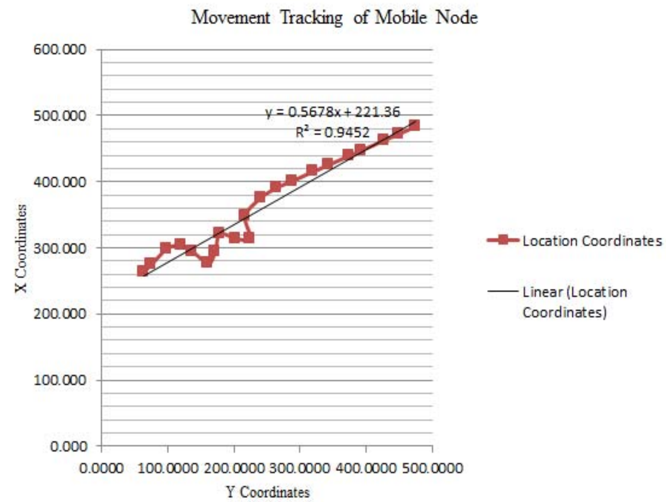

Fig. 6: NS2 Simulation of Mobile Node Movement

From TABLE II distance from BS1 can be taken as the minimum distance. So BS1 is the next predicted location of MS.

IX. FUTURE WORK

For implementing this location prediction method, a new prediction server can be installed along with MSC. All BSCs can communicate directly with this prediction server. Mobile ID, Base ID, latitude and longitude of mobile can be passed as the arguments to the prediction server. Implementation of this method using these data will prove the accuracy of the location prediction, efficient optimization of handoff delay and effective execution of paging operation in cellular networks.

X. CONCLUSION

This paper has adopted an algorithm that aims to predict the location and reduce the handoff delay while a MS is in a call and switching between BSs. For implementing this proposal, additional two components are to be added in the existing architecture. First is SIM with integrated GPS module and second is prediction server which is used for storing the movement location details of MS frequently. Addition of these two hardware components make the system be efficient and cost effective.

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