An Improved Mobility Management Technique for IEEE 802.11 based WLAN by Predicting the Direction of the Mobile Node

Shubhajeet Chatterjee[1], Debabrata Sarddar[2], Joydeep Saha[1], Soumyanil Banerjee[1], Arijit Mondal[1], Dr. Mrinal K. Naskar[2]

1. Department of Electronics and Communication Engineering, Institute of Engineering and Management, Salt Lake, Kolkata-700091, West Bengal, India
chatterjeeshubhajeet@gmail.com, joydeepsaha007@gmail.com, soumya_nil@yahoo.com, amondal29@yahoo.com

2. Department of Electronics & Telecommunication Engineering, Jadavpur University, Kolkata – 700032, West Bengal, India
dsarddar@rediffmail.com, mrinalnaskar@yahoo.co.in

Abstract — **In wireless local area network (WLAN), mobility management becomes a sophisticated issue of research due to the limited coverage of the Access Points (AP). For the successful communication between the mobile nodes (MN), every node should be connected with an access point (AP) during their operating mode, irrespective of their mobility. When a MN travels into the coverage area of its current AP, no special technique is required to maintain the connectivity. But when a MN travels out of the coverage area of its current AP and tries to associate with another AP, a delay occurs during the handover of connection which leads to a failure of connection. Throughout the last few years plenty of researches had been done to reduce this handover delay by reducing the scanning delay as the scanning process causes 90% of the total handover delay. In this paper, we propose a new scanning technique where the most potential AP is chosen according to the direction of the MN. First, we fit a polynomial equation along the trajectory of its motion and then to predict the direction of motion, we analyze the slope of the trajectory. Our simulation results show the effectiveness and accuracy of our proposed scheme in practical field.**

Keywords- Next Generation Wireless Systems (NGWS), AP (Access point), MN (Mobile node), IEEE802.11.

I. Introduction

In recent days, IEEE 802.11 based wireless local area networks (WLAN) have been widely deployed for business and personal applications. IEEE802.11b and IEEE802.11g operates in the 2.4GHz ISM band and use 11 of the maximum 14 channels available and are hence compatible due to use of same frequency channels. The channels (numbered 1to14) are spaced by 5MHz with a bandwidth of 22MHz, 11MHz above and below the centre of the channel. In addition there is a guard band of 1MHz at the base to accommodate out-of-band emissions below 2.4GHz. Thus a transmitter set at channel one transmits signal from 2.401GHz to 2.423GHz and so on to give the standard channel frequency distribution. It should be noted that due to overlapping of frequencies there can be significant interference between adjacent APs. Thus, in a well configured network, most of the APs will operate on the non-overlapping channels numbered 1, 6 and 11.

The main issue regarding WLAN is mobility management. Whenever a MN moves from current AP to a new AP it requires to handover its connection to the new AP. For successful implementation of seamless Voice over IP communications, the handover latency should not exceed 50ms. But, the search for a new AP and subsequent registration takes enough time (measurements indicate MAC layer handover latencies in the range of 400ms) which is completely unacceptable and thus must be reduced for wireless networking to fulfill its potential. With the advent of real time applications, the latency and packet loss caused by mobility became an important issue in Mobile Networks. The most relevant topic of discussion in mobility management is to reduce the IEEE 802.11 link-layer handover latency.

The handover procedure consists of three logical phases: scanning, authentication and re-association.

When a mobile node is moving away from its current AP, it initiates the handover process when the received signal strength and the signal-to-noise-ratio have decreased significantly. The MN now begins MAC layer scanning to find new APs. It can either opt for a passive scan (where it listens for beacon frames periodically sent out by APs) or chose a faster active scanning mechanism wherein it regularly sends out probe request frames and waits for responses for T_{MIN} (min Channel Time) and continues scanning until T_{MAX} (max Channel Time) if at least one response has been heard within T_{MIN}. Thus, $n*T_{MIN} \leq$ time to scan n channels $\leq n*T_{MAX}$. The information gathered is then processed so that the STA can decide which AP to join next. The total time required until this point constitutes 90% of the handover delay. Authentication is necessary to associate the link with the new AP. Once the MN has been authenticated with the new AP, re-association can be started. Previous works has shown re-association delay to be around 1-2 ms. The range of scanning delay is given by:-

978-1-4673-1953-9/12/$31.00 ©2012 IEEE

Authorized licensed use limited to: Wayne State University. Downloaded on September 22,2020 at 16:17:38 UTC from IEEE Xplore. Restrictions apply.

n × Tmin ≤ Tscan ≤ n × Tmax

Where N is the total number of channels according to the spectrum released by a country, Tmin is Min Channel Time, Tscan is the total measured scanning delay, and Tmax is Max Channel Time. Here we focus on reducing the scanning delay by minimizing the total number of scans performed.

We have organized the rest part of this paper as follows. Sec 2 describes the related works, Sec 3 describes our proposed approach. The simulation results are given in Sec 4 and finally concluding remarks are presented in Sec5.

II. RELATED WORKS

A lot of researches have been dedicated for mobility management in IEEE 802.11 based WLAN. In [1], authors propose the preemptive resume priority (PRP) M/G/1 queuing network model to support the mobility in NGWS that characterizes the spectrum usage behaviors with the three design features: 1) general service time distribution of the primary and secondary connections; 2) different operating channels in multiple handoffs; and 3) queuing delay due to channel contention from multiple secondary connections. In [2], the authors proposed a handover algorithm in which the handover decision is performed based on stored information. In [3], authors present the traditional hysteresis based and dwelling-timer based E-HY and E-DW algorithms to support both VHO and HHO decisions and apply them to complex heterogeneous wireless environments. Recently a number of cross layer protocols and algorithms have been proposed to support seamless handover in NGWS. Authors of [4] propose solutions towards enabling and supporting all types of mobility in heterogeneous networks by inserting a new cell coverage area. In [5], a handover algorithm using multi-level thresholds is proposed. The performance results obtained, shows that an 8-level threshold algorithm operates better than a single threshold algorithm in terms of forced termination and call blocking probabilities. A novel mobility management system is proposed in [6] for vertical handover between WWAN and WLAN. The system integrates a connection manager (CM) that intelligently detects the changes in wireless network and a virtual connectivity manager (VCM) maintains connectivity using end-to-end principle. Authors of [7] propose a handover algorithm by fitting a curve along the positions of MN. In [8], a handover algorithm developed for alignment with IEEE 802.11s and 802.11i, keeping protocols at the station side operable with no changes and applied to generic multihop wireless networks. A received signal based handover scheme is explained in [9]. Another handover process is proposed in [10] based on distance measurement method. In [11], a tightly coupled interworking architecture is proposed to support seamless and proactive vertical handoff scheme aims to provide always the best quality of service (QoS) for users where both the performance of applications and network conditions are considered in the handoff process. Another handover process is proposed in [11] based on distance measurement method.

III. PROPOSED WORK

In this paper we propose a novel mobility management protocol for IEEE 802.11 based WLAN which will reduce the scanning delay by reducing the number of APs to be scanned during the handover process. We utilize Global Positioning System (GPS) to implement our mechanism.

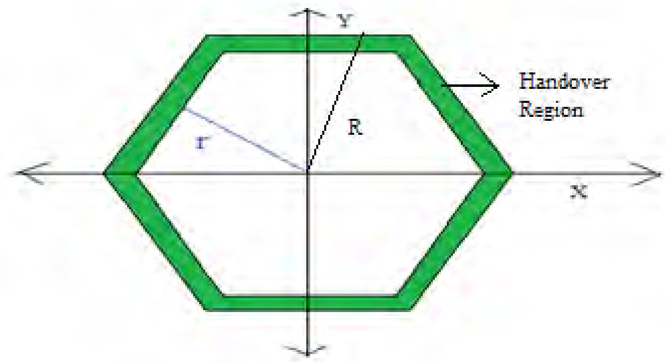

Figure 1: Hexagonal cell coverage of radius R.

For our proposed work we consider the coverage area of the AP as regular hexagonal cell of size R with the AP situated at the center. We also consider a Cartesian coordinate system at the center of the cell, as shown in figure 1.

Let us say the white region as region 1 and the green region as region 2. Now within the incircle of the cell we do not consider any handover while the circumcircle defines the reach of the individual APs [1]. The region within them covers a sufficient distance to complete the handover and is known as handover region.

A. Handover Initiation

Handover is initiated depending upon the location of MN. If the MN is in region 1 (white region) then it does not require handover i.e. it can successfully maintain its link with the current AP. But if the MN is in region 2 (green) then it requires handover as the signal strength is too weak to continue the communication.

The location of the MN is measured with help of GPS and stored in the node cache as long as it is travelling in region 1. Let us say, at time $t=t_o$ the position of MN is denoted by (x_o, y_o) with respect to the origin. Our knowledge of co-ordinate system provides that the distance (D) of the MN from the current AP (0,0) can be given as,

$$D = \sqrt{\{(x_0^2) + (y_0^2)\}}. \quad \ldots\ldots (1)$$

Based on the value of D, the handover is initiated.

If $D \geq r$ handover is initiated i.e. MN is in handover region i.e. green region in figure 1.

If $D < r$ handover is not required i.e. MN is in region 1 or white region in figure 1.

B. Polynomial Generation

As the handover is initiated, the mobile node generates a polynomial to describe its own trajectory. It uses the position co-ordinates stored earlier in the cache, to generate the polynomial. Say, the n numbers of position coordinates are stored in the cache as (x_i, y_i), where i= 0,1,2…n.

Let us now generate a polynomial function $f(x)$ of degree n, using Lagrange's interpolation formula, such that,

Authorized licensed use limited to: Wayne State University. Downloaded on September 22,2020 at 16:17:38 UTC from IEEE Xplore. Restrictions apply.

$y_i = f(x_i)$ … (2)

Since f(x) is a polynomial of degree n, it can be expressed as,

$$f(x) = a_0(x-x_1)(x-x_2)(x-x_3)\ldots(x-x_n) + a_1(x-x_0)(x-x_2)(x-x_3)\ldots(x-x_n) + \cdots + a_n(x-x_0)(x-x_1)(x-x_3)\ldots(x-x_{n-1}) \quad \text{…. (3)}$$

Now, a_i can be determined by using relation (2).

Putting $x = x_0$ in (3) and using (2) , we get

$$a_0 = \frac{y_0}{(x_0-x_1)(x_0-x_2)(x_0-x_3)\ldots(x_0-x_n)}$$

Putting $x = x_1$ in (3) and using (2), we get

$$a_1 = \frac{y_1}{(x_1-x_0)(x_1-x_2)(x_1-x_3)\ldots(x_1-x_n)}$$

Proceeding in the same way, we have,

$$a_i = \frac{i}{(x_i-x_0)(x_i-x_2)(x_i-x_3)\ldots(x_i-x_n)},$$

Where i= 0,1,2,…,n.

Substituting the values of a_i in (3), we get

$$f(x) = \frac{(x-x_1)(x-x_2)(x-x_3)\ldots(x-x_n)}{(x_0-x_1)(x_0-x_2)(x_0-x_3)\ldots(x_0-x_n)} * y_0 + \frac{(x-x_1)(x-x_2)(x-x_3)\ldots(x-x_n)}{(x_1-x_0)(x_1-x_2)(x_1-x_3)\ldots(x_1-x_n)} * y_1 + \ldots + \frac{(x-x_1)(x-x_2)(x-x_3)\ldots(x-x_n)}{(x_n-x_0)(x_n-x_2)(x_n-x_3)\ldots(x_n-x_n)} * y_n \quad \text{…. (4)}$$

Eqn. (4) can be written in general polynomial form as,

$$f(x) = K_0 + K_1x + K_2x^2 + \cdots + K_nx^n. \quad \text{…. (5)}$$

Eqn. (5) represents the polynomial that describes the MN trajectory.

C. *Predicting the direction*

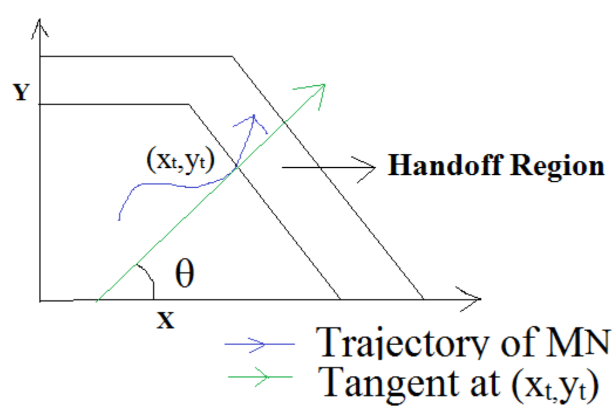

Figure 2: Predicting the direction of the MN.

Now, the mobile node can predict its direction of motion by analyzing the slope of its trajectory. Trajectory equation is obtained from equation (5) as polynomial $f(x)$.

The direction of motion at the handover region is predicted by calculating the slope of the trajectory at the handover initiating point(x_t, y_t), as shown in figure 2.

$$slope = s = \frac{df(x)}{dx}\ at\ (x_t, y_t), \quad \text{…. (10)}$$

Where,

slope = $s = \tan\theta$

Direction of the MN at the handover region indicates the neighbor AP towards which the MN is heading when it travels out from the cell i.e. the coverage area of the current AP.

D. *Selection of AP*

The mobile node finds the most potential neighbor AP based on the value of s and θ. It is evident that for various values of s i.e. tanθ, the MN would head towards different neighbor APs. To optimize this selection process, we fixed the range of θ for each neighbor AP, as shown in figure 3. The relation between the angular range and the neighbor APs is shown in table 1 [12]. This table is stored in the cache memory of the mobile node. The MN chooses the potential AP from its cache and the scanning process is completed. After this, the authentication and the re-association will be performed to complete the total handover process.

This will effectively reduce the handover latency, as the number of channels scanned will be lower.

To further hasten the process we can look to pre-authenticate with the best option so that we now effectively reduce the handover time to little over the re-association time.

E. *Proposed Algorithm*

The proposed scheme can be implemented in practical field by using the following algorithm.

*/ We define D as the distance covered by the MN in a fixed time period */

/* We define R as diametric range of access point (AP) coverage area */

/* We define r as handover distance of the cell */

1. begin
2. While access point connectivity not changed
3. begin
4. Find the position coordinate of MN (x_i, y_i) with help of GPS.
5. Calculate the distance,
$D=\sqrt{x_i^2+y_i^2}$
6. If D < r,
6.1 The MN does not take any action of vertical handover
7. Else
7.1. Generate the polynomial f(x) to express the trajectory path of the MN.
7.2. Find the slope at the handover initiating point(x_t, y_t) .
$$tan\,\theta = s = \frac{df(x)}{dx}\ at\ (x_t, y_t)$$
7.3. The potential AP is chosen based on θ value from the table 1.
*7.4. End */ end of else*
*8. End */ end of while loop*
*9. End */ end of program*

Authorized licensed use limited to: Wayne State University. Downloaded on September 22,2020 at 16:17:38 UTC from IEEE Xplore. Restrictions apply.

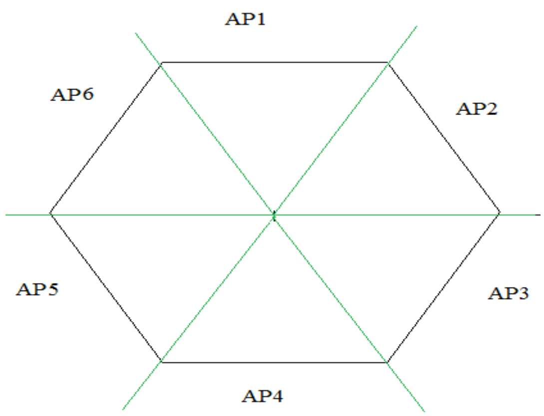

Figure 3: Angular division in the cell

Table 1: Relation between the Angular range and Neighbor AP

Slope Angle (θ)	Neighbor AP
$0^0 \le \theta < 60^0$	AP2
$60^0 \le \theta < 120^0$	AP1
$120^0 \le \theta < 180^0$	AP6
$180^0 \le \theta < 240^o$	AP5
$240^0 \le \theta < 300^0$	AP4
$300^0 \le \theta < 360^0$	AP3

{Where θ is the angle measured from +ve X axis}

F. Comparison with previous works

It may be notified that in last few years, several handover algorithms have already been developed but very few of them support the fast changing nature and the adhoc necessity of the network. A couple of popular algorithms developed in recent years are MDP based vertical handover (VHO) algorithm [13] and SyncScan algorithm for handover [14].

MDP-VHO algorithm is a Markov Decision Process based algorithm where the best AP is chosen by the link reward function and the signalling cost function. Despite its better performances in numerical analysis, it has a very high calculation delay and it is not applicable in continuous time environment of finite connection duration as the handoff decision is performed periodically. We have overcome this drawbacks by using a more realistic model to allow the decision to be performed using GPS whenever there is a state change in the networks.

SyncScan is a low cost technique to perform vertical handover by continuously tracking signal strength from nearby APs while still carrying on communication with a chosen AP. But signal tracking of neighbour APs becomes quite impractical in practical field due to the presence of several obstacles (like tall buildings, trees, mountains etc.). In our algorithm, we have overcome this drawback by tracking the MN via GPS instead of tracking the signal strength of the neighbour APs.

IV. Simulation Result

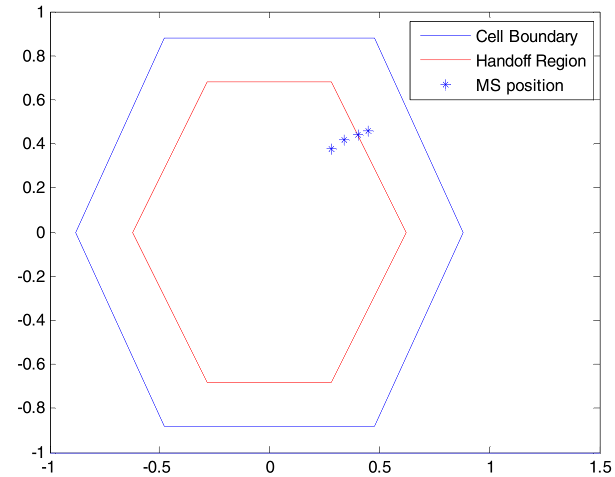

Figure 4: Trajectory of MN in simulation environment.

In this section we will evaluate the performance of our approach. The simulations are performed using the Microsoft Visual C++ and MATLAB version 7.14.

For our simulation, we consider a macro-cellular systems with an arbitrary cell size of a=860m. (or 0.86km.) and the handover distance is r=620m. (or 0.62km.). An arbitrary movement of MN is shown in figure 4. The * line in the figure shows the trajectory path of the MN.

We obtain the position coordinates of the MN from figure 4. The set of X values and Y values are given below.

x = [0.28, 0.34, 0.4, 0.45];

y = [0.38, 0.42, 0.44, 0.46];

To initiate the handover process, we have to measure the distance (d_i) of MN from the centre of the cell for i th set of X value and Y value. When this distance d_i will cross the handover distance r, the handover will be initiated.

$d_1=\sqrt{(0.28^2+0.38^2)}=0.472$, $d_1 < r$

$d_2=\sqrt{(0.34^2+0.42^2)}=0.540$, $d_2 < r$

$d_3=\sqrt{(0.4^2+0.44^2)}=0.594$, $d_3 < r$

$d_4=\sqrt{(0.45^2+0.46^2)}=0.643$, $d_4 > r$

So, now the handover process will be initiated.

According to our algorithm, we will fit a polynomial equation along the trajectory of the motion. Then we will differentiate it at the point where the MN just enters the handover region i.e.(0.45,0.46).

The polynomial equation is,

$y=20*x^3-23*x^2+9.2*x-0.83$

$dy/dx= 60*x^2-46*x+9.2$

$dy/dx_{(0.45,0.46)}= 60*0.45^2-46*0.45+9.2$

$dy/dx_{(0.45,0.46)}= 0.65$

so, $\tan\theta=0.65$

$\theta= \tan^{-1}0.65$

$\theta=33.02^0$

According to the angular relations stated table 1, the MN will select the AP2 as the most potential AP and it will hand over its connection to AP2. The handover process is completed.

In order to compare the performance of our Prediction based algorithm with MDP based vertical handover (VHO)

Authorized licensed use limited to: Wayne State University. Downloaded on September 22,2020 at 16:17:38 UTC from IEEE Xplore. Restrictions apply.

algorithm [13] and SyncScan algorithm [14], we evaluate all three algorithms for 10 mobile nodes scenario in the same macro cellular simulation environment. The nodes are placed randomly, and each one moves at a random speed with a maximum speed limit of 20 meters per second. The simulation is carried out for 300 seconds. The sources in the network are CBR (constant bit rate) traffic generators and the data traffic is generated at 20 Constant Bit Rate. The radio data transmission power is set to 35 dBm and the bit rate is 3 megabits per second.

Figure 5 shows the handover latency for different mobile nodes in the simulation environment. When the seamless handovers require a latency of less than 50ms, the simulation results show the average latency of our Prediction based algorithm is only 14.9 ms. which is a significant improvement over the previous algorithms. Notice that in Prediction based algorithm, some nodes (node 3,4 & 8) have very low handover latency as they do not enter in the handover region during the entire simulation period whereas, in MDP-VHO algorithm and SyncScan algorithm, there always exist a finite calculation delay for these nodes irrespective of their handover requirement.

Thus the Prediction based algorithm provides better performance than MDP-VHO and SyncScan algorithm.

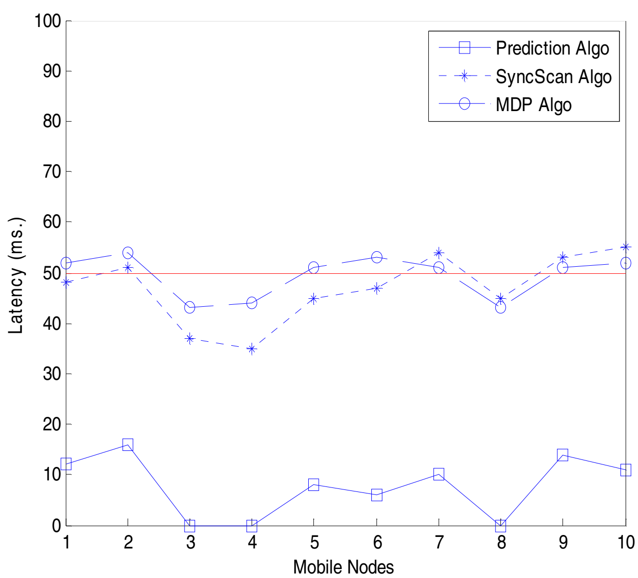

Figure 5: Handover latency in 10 nodes Scenario.

V. Conclusion

In our article we discuss the different types of mobility management procedures and associated problems for Next Generation Wireless Systems (NGWS). Then we describe our proposed mobility management scheme based on instantaneous direction of MN. Our simulation results show that this approach produces a better mobility management by effectively reducing the handover latency.

With all the advantages, there is one important drawback in our algorithm. The current proposal does not do explicit energy management in the mobile nodes. The processor capability and the energy requirement for the nodes are much higher than the regular one. In future work we intend to reduce the computational effort by using appropriate pattern matching and Kalman filtering techniques to generate the polynomial.

References

[1] Wang, Li-Chun; Wang, Chung-Wei; Chang, Chung-Ju. "Modeling and Analysis for Spectrum Handoffs in Cognitive Radio Networks", *IEEE Transactions on Mobile Computing*, pp. 1499- 1513, 2012.

[2] Taehoon Kim; Sang-wook Han; Youngnam Han, "A QoS-aware vertical handoff algorithm based on service history information", *IEEE Communications Letters*, pp. 527- 529, 2010.

[3] Min Liu; Zhongcheng Li; Xiaobing Guo; Dutkiewicz, E. "Performance Analysis and Optimization of Handoff Algorithms in Heterogeneous Wireless Networks", *IEEE Transactions on Mobile Computing*, pp. 846- 857, 2008.

[4] Debabrata Sarddar, Shubhajeet Chatterjee, Ramesh Jana, Shaik Sahil Babu, Prabir Kr, Naskar, Utpal Biswas and M.K.Naskar, "Minimization of Handoff Failure by Introducing a New Cell Coverage Area in the Handoff Region", *International Journal of Computer Science issues (IJCSI)* Vol. 08, Issue 03, No. 1, pp. 577-583, May 2011, ISSN (Online): 1694-0814.

[5] Leu, A. E, Mark, B. L., "Local Averaging for Fast Handoffs in Cellular Networks" *IEEE Transactions On Wireless Communications,* Vol. 6, No.3, pp. 866 – 874, March 2007.

[6] B-J. Chang, J-F. Chen, "Cross-layer-based adaptive vertical handoff with predictive RSS in heterogeneous wireless networks," *IEEE Transactions Vehicular Technology*, vol. 57, no. 6, pp. 3679 -3692, Nov. 2008.

[7] Debabrata Sarddar, Shubhajeet Chatterjee, Ramesh Jana, Shaik Sahil Babu, Hari Narayan Khan, Utpal Biswas and M.K.Naskar, "Fast Handoff Implementation by using Curve Fitting Equation With Help of GPS", *International Journal of Computer Science issues (IJCSI)* Vol. 08, Issue 03, pp. 535-542, No. 1, May 2011, ISSN (Online): 1694-0814.

[8] Kuang-Hui Chi; Yung-Chien Shih; Ho-Han Liu; Jui-Tang Wang; Shiao-Li Tsao; Chien-Chao Tseng "Fast Handoff in Secure IEEE 802.11s Mesh Networks", *IEEE Transactions on Vehicular Technology*, pp. 219- 232, 2011

[9] J.-Y. Pyun, "Context-aware streaming video system for vertical handover over wireless overlay network**,**" *IEEE Trans. Consumer Electronics*, vol. 54, pp. 71-79, Feb. 2008.

[10] Debabrata Sarddar, Shubhajeet Chatterjee, Ramesh Jana, Shaik Sahil Babu, Hari Narayan Khan, Utpal Biswas and M.K.Naskar, " Minimization of Handoff Latency by Distance Measurement Method", *International Journal of Computer Science issues* (IJCSI) Vol. 08, Issue 02, pp. 283-289, March 2011, ISSN(Online): 1694-0814.

[11] Dong Ma; Maode Ma "A QoS Oriented Vertical Handoff Scheme for WiMAX/WLAN Overlay Networks", *IEEE Transactions on Parallel and Distributed Systems*, pp. 598- 606, 2012.

[12] Debabrata Sarddar, Shubhajeet Chatterjee, Ramesh Jana, Hari Narayan Khan, Shaik Sahil Babu, Hari Narayan Khan, Utpal Biswas and M.K.Naskar, "Minimization of Handoff Latency by Vector Analysis Method", *International Journal of Computer Science issues (IJCSI)* Vol. 08, Issue 03, pp. 570-576, No. 1, May 2011, ISSN (Online): 1694-0814.

[13] Stevens-Navarro, E.; Yuxia Lin; Wong, V.W.S "An MDP-Based Vertical Handoff Decision Algorithm for Heterogeneous Wireless Networks", *IEEE Transactions on Vehicular Technology*, pp. 1243-1254, 2008.

[14] Ramani, I.; Savage, S. "SyncScan: practical fast handoff for 802.11 infrastructure networks", *24th Annual Joint Conference of the IEEE Computer and Communications Societies* (INFOCOM 2005), Vol-1,pp. 675- 684, 2005.

Authorized licensed use limited to: Wayne State University. Downloaded on September 22,2020 at 16:17:38 UTC from IEEE Xplore. Restrictions apply.