IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 2, May 2011
ISSN (Online): 1694-0814
www.IJCSI.org

Minimization of Handoff Latency by Vector Analysis Method

Debabrata Sarddar[1], Shubhajeet chatterjee[2], Ramesh Jana[1], Hari Narayan Khan, Shaik Sahil Babu[1], Utpal Biswas[3], M.K. Naskar[1].

1. Department of Electronics and Telecommunication Engg, Jadavpur University, Kolkata – 700032.

2. Department of Electronics and Communication Engg, Institute of Engg. & Managment college, saltlake, Kolkata-700091.

3. Department of Computer Science and Engg, University of Kalyani, Nadia, West Bengal, Pin- 741235.

Abstract

Due to rapid growth in IEEE 802.11 based Wireless Local Area Networks(WLAN), handoff has become a burning issue. A mobile station (MS) requires handoff when it travels out of the coverage area of its current access point (AP) and tries to associate with another AP. But handoff delays provide a serious barrier for such services to be made available to mobile platforms. Throughout the last few years there has been plenty of research aimed towards reducing the handoff delay incurred in the various levels of wireless communication. In this paper we propose a method using the GPS(Global Positioning System) to determine the positions of the MS at different instants of time and then by applying vector analysis method on the trajectory of MS path to determine the potential AP(s) where the MS has maximum probability of travelling in the future. This will result in a reduction of number of APs to be scanned as well as handoff latency will be reduced to a great extent.

Keywords: *IEEE 802.11, Handoff latency, GPS (Global Positioning System), Vector resolution, Neighbor APs.*

1. Introduction

IEEE 802.11 based wireless local area network (WLAN) are widely used in domestic and official purpose due to its flexibility of wireless access. However, WLANs are restricted in their diameters to campus, buildings or even a single room. Due to the limited coverage areas of different APs a MS has to experience handoff from one AP to another frequently.

1.1 Handoff

When a MS moves out of reach of its current AP it must be reconnected to a new AP to continue its operation. The search for a new AP and subsequent registration under it constitute the handoff process which takes enough time (called handoff latency) to interfere with proper functioning of many applications.

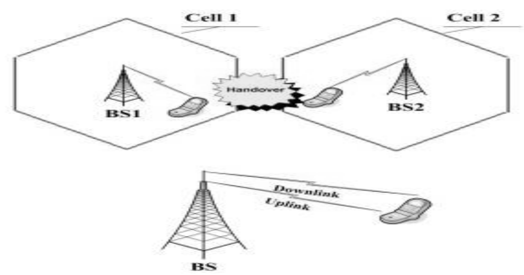

Figure 1. Handoff process

For successful implementation of seamless Voice over IP communications, the handoff latency should not exceed 50ms.It has been observed that in practical situations handoff takes approximately 200-300 ms to which scanning delay contributes almost 90%.This is not acceptable and thus the handoff latency should be minimized.

Three strategies have been proposed to detect the need for hand off[1]:

*1)mobile-controlled-handoff (MCHO):*The mobile station(MS) continuously monitors the signals of the surrounding base stations(BS)and initiates the hand off process when some handoff criteria are met.

2)network-controlled-handoff (NCHO):The surrounding BSs measure the signal from the MS and the network initiates the handoff process when some handoff criteria are met.

*3)mobile-assisted-handoff (MAHO):*The network asks the MS to measure the signal from the surrounding BSs.the network make the handoff decision based on reports from the MS.

Handoff can be of many types:

Hard Handoff: In this process radio link with old AP is broken before connection with new AP. This in turn results in prolonged handoff latency which is known as link switching delay.

Soft Handoff: This mechanism is employed nowadays. Here connection with old AP is maintained until radio link with new AP is established. This results in reduced handoff time in comparison to hard handoff as shown in figure 2.

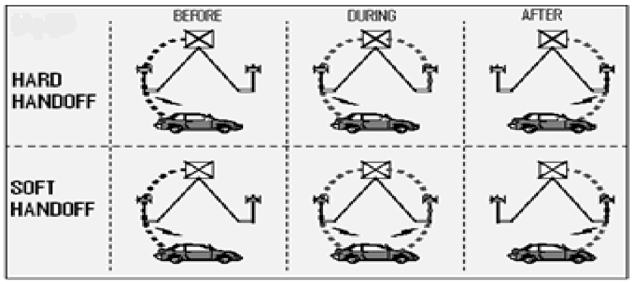

Figure 2. Hard & soft handoff

In NGWS(next generation wireless system),two types of handoff scenarios arise: horizontal handoff, vertical handoff[2][3].

- *Horizontal Handoff:* When the handoff occurs between two BSs of the same system it is termed as horizontal handoff. It can be further classified into two:
  - *Link layer handoff* : Horizontal handoff between two BSs that are under the same foreign agent(FA).
  - *Intra system handoff* : Horizontal handoff between two BSs that belong to two different FAs and both FAs belong to the same gateway foreign agent (GFA) and hence to the same system.
- *Vertical Handoff* : When the handoff occurs between two BSs that belong to two different GFAs and hence to two different systems it is termed as vertical handoff as shown in figure 3.

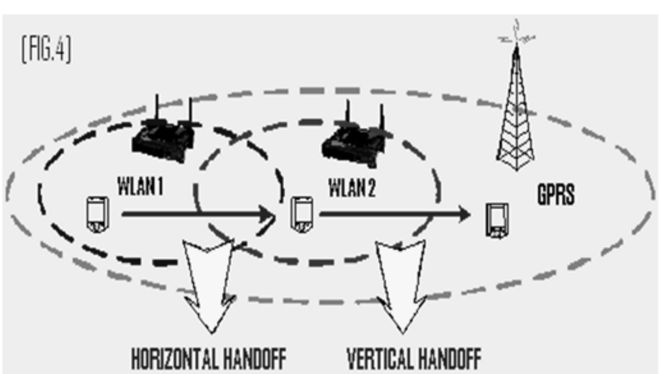

Figure 3. Horizontal & vertical handoff

1.2 Handoff Mechanism

The handoff process is composed of the following three stages:

Scanning: The scanning process constitutes the bulk (almost 90%) of the total handoff time [4]. As the MS starts moving away from the AP the *Signal-to-Noise-Ratio* (SNR) start decreasing and this phenomenon triggers the initiation of handoff. The MS has to establish a radio link with a potential AP before the connectivity with the current AP is detached. This is accomplished by means of a MAC(Medium Access Control) layer function called *scanning*.

Authentication: After scanning, The MS sends authentication frames to inform the AP (selected by the scanning process) of its identity. The AP then responds by sending an authentication response frame indicating approval or rejection

Re-association: It is the process by which association transfer takes place from one AP to another. This process follows the authentication process depending on the authentication response sent by the AP.

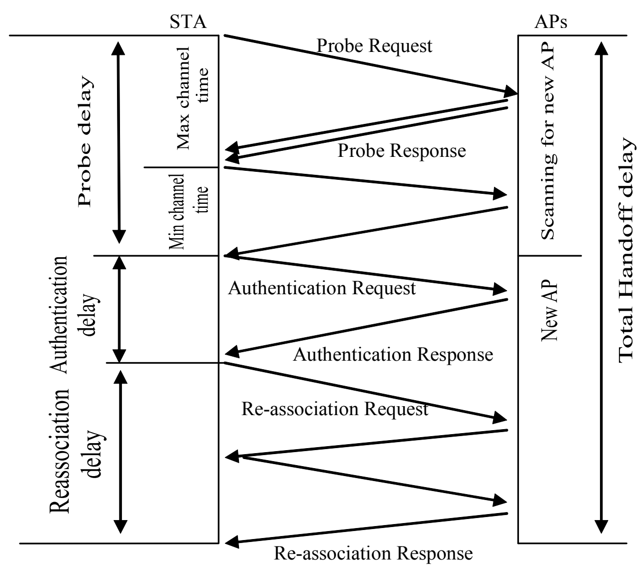

Figure 4. The handoff process

1.3 Global Positioning System

The *Global Positioning System* (GPS) is a space based global navigation satellite system which is used in map making, land surveying, navigation, geocaching and in other fields. A GPS receiver is able to calculate its position

by precisely timing the signals sent by the GPS satellites. The receiver uses the received messages from the satellites to determine the transit time of each message and calculates the distance to each satellite. These distances are then utilized to compute the position of the receiver. For normal operation a minimum of four satellites are necessary. Using the messages received from the satellites the receiver is able to calculate the times sent and the satellite positions corresponding to these points.
Each MS is equipped with a GPS receiver which is used to determine the positions of the MS at different instants of time. This will provide knowledge about the MS's movement within 1 to 2 meter precision.

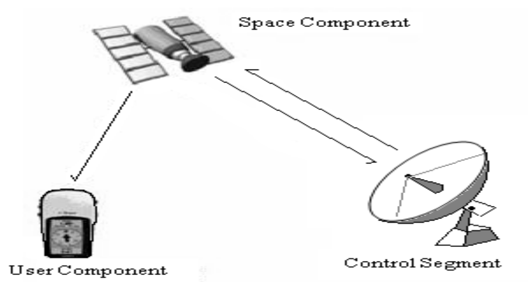

Figure5. Components of GPS

In section II we take you through the various works that have already been done to achieve successful handoff and in section III we introduce a new method using the statistical regression over the movement of MS by which we intend to reduce the handoff delay to the range of a few milliseconds. This is followed by performance evaluation of our proposed technique using simulations in section IV after which in section V we propose a few areas in which further improvement can be made.

2. Related works

A number of different schemes have been proposed to reduce handoff latency in IEEE 802.11 wireless LANs. Authors of [8] aimed at reducing the authentication process which contributes very little to the handoff time.
In [5] authors present a useful method using a neighbor graph and a non overlap graph. This concept was used to reduce total number of channels to be scanned and the waiting time on each channel. However the complexity of implementation of the algorithm was a major setback. In [6] a channel mask scheme was introduced where a selective scanning algorithm was proposed along with a caching mechanism. In [7] authors propose selective scanning algorithm using neighbor graphs. This method requires changes in the network infrastructure and use of IAPP. Moreover, these processes involve channel scanning of all neighboring APs and do not consider the position or velocity of MS to select potential APs. Hence these methods are more power consuming and are less effective for reducing handoff.

3. Proposed Works

3.1 Hexagonal cell concept

Due to fading of signal strength (*fast fading* due to scattering from interfering objects & *slow fading* due to long term spatial and variations, inversely proportional to the square of the distance) we consider that each base station services a circular area (depending on the height of the antenna and power of its signal) beyond which signal strength becomes lower than usable levels. In an idealized model we approximate the overlapping circular cell areas by hexagonal cells that cover the entire service region through frequency reuse concept where every cell marked similarly can use the same frequencies being out of range from each others' signal strength. To find the threshold point (after this point the handoff is required) we will consider another small hexagon in the hexagonal cell as shown in figure 6.

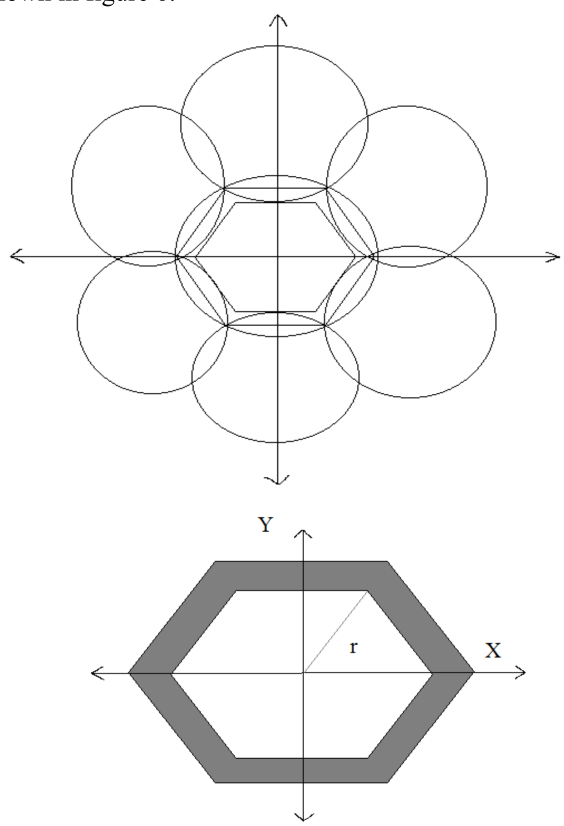

Figure 6. hexagonal cell structure

We assume the entire area of a cell to be a two dimensional plane. Thus we define two mutually perpendicular coordinate axes namely the X and Y axes with the AP as the origin. The position namely the X and Y coordinates of a MS can be obtained via a GPS. Let us say the neighbor APs by means of (any arbitrary value as the exact coordinate is not required).

Table.1 AP coordinates

AP	coordinate
AP_1	(0,b)
AP_2	(α, β)
AP_3	$(-\alpha, \beta)$
AP_4	(0, -b)
AP_5	$(-\alpha, -\beta)$
AP_6	$(\alpha, -\beta)$

Let us say the white region as region 1 and the grey region as region 2. Now within the incircle of the cell we do not consider any handoff while the circumcircle defines the reach of the individual APs. The region within them covers a distance R*(1-0.5√3) which is sufficient to complete the handoff for normal cell size R and MS velocity.

3.2 Handoff initiation

Let us consider the current AP as the origin of the co-ordinate system. As long as the MS is travelling in region 1 we note the (x, y) coordinates of the MS via the GPS. Let us suppose this scanning of MS's position by GPS starts at time $t=t_o$ sec and let the initial position of the MS be denoted by (x_o, y_o) with respect to the origin. This process is repeated after a fixed time interval of T sec. At each initial position we have to check either it requires handoff or not. Our knowledge of co-ordinate system provides that the distance from the current AP(origin) is,

$$D = \sqrt{(x_0-0)^2+(y_0-0)^2}$$
$$= \sqrt{x_0^2+y_0^2}$$

If D<r it does not require handoff i.e. MS is in region or white region.

If D>r it requires handoff i.e. MS is in region 2 or green region.

3.3 Vector Analysis method

The initial position is(x_0,y_0) and after a small time interval t the next position is(x_t,y_t). The distance between final position(x_t,y_t) and initial position (x_0,y_0) is constant, say R.our Cartesian co-ordinate knowledge provides us,

$$\text{Slope} = \tan\theta = (y_t-y_0)/(x_t-x_0)$$
$$\theta = \tan^{-1}\{(y_t-y_0)/(x_t-x_0)\} \qquad 0^o < \theta < 180^o$$

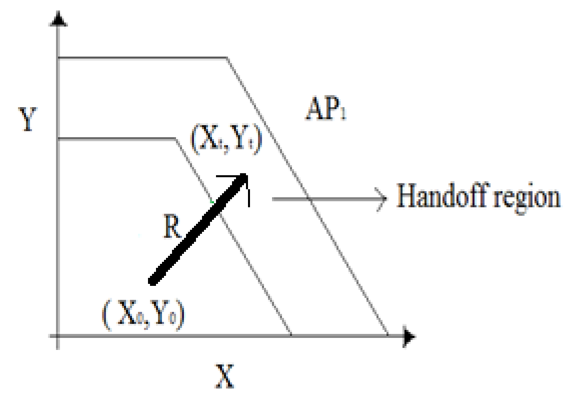

Figure 7. Trajectory Path of MS

If we consider the trajectory path of MS as a vector then it can be resolute as r cosθ and r sinθ in horizontal and vertical direction, respectively as shown in figure 7.

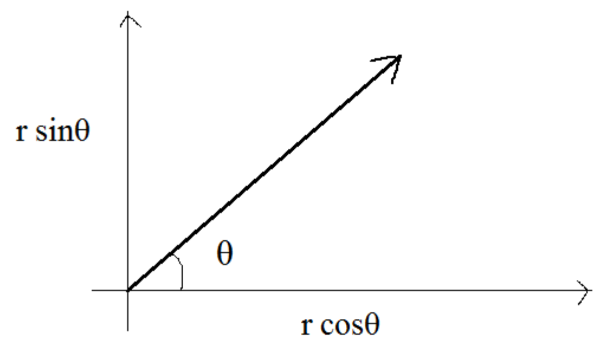

Figure 8. Vector Analysis

Case 1:
If rcosθ ≥ rsinθ then the AP in horizontal direction is the best choice. Let us find out the most potential AP in horizontal direction by the help of coordinate system. We will calculate the nearest AP along Y axis or vertical direction by calculating the difference between ordinate of MS and the neighbour APs. Thus we will find two nearest APs in vertical direction.
If the angle $\theta \geq 90^o$ we will reject the AP with positive abscissa.
If the angle $\theta < 90^o$ we will reject the AP with negative abscissa.
Thus we can find out the best AP where the handoff will be performed.

Case 2:
If rcosθ ≤ rsinθ then the AP in vertical direction is the best choice. Let us find out the most potential AP in vertical direction by the help of coordinate system. We will calculate the nearest AP along X axis or horizontal

direction by calculating the difference between abscissa of MS and the neighbour APs. Thus we will find two nearest APs in horizontal direction.

$\Phi = \tan^{-1}\{(x_t-x_0)/\{(y_t-y_0)\}$ $\quad 0^o < \Phi < 180^o$

If the angle $\Phi > 90^o$ we will reject the AP with positive ordinate.

If the angle $\Phi < 90^o$ we will reject the AP with negative ordinate.

The above process is applicable for linear movement of MS. As we consider a very short time period, it can be said that movement of MS is linear. Although, if it is nonlinear then also we can find out the best AP through this process. We know, when a particle is moving on a non linear path, at any instant the direction of its movement is along the tangent at that point of the curve. we can find out the equation of MS trajectory by curve fitting method[11].

So the equation of MS trajectory can be expressed as,

$$y = f(x)$$

now, if the slope of the tangent of the curve at point $(x_t,y_t)$is $\tan\Psi$ (where the angle between tangent and horizontal positive X axis is Ψ),

$$\tan\Psi = \left[\frac{dy}{dx}\right]_{(x_t,y_t)}$$

Now we will consider any vector along the tangent with arbitrary magnitude(r). It can be resolute as $r\cos\Psi$ and $r\sin\Psi$ in horizontal and vertical direction, respectively and we can follow the previous process.

As we have seen from algorithm, scanning is only required if the best AP cannot be connected due to some reasons (e.g. cellular traffic). In general, the time is taken to connect to the new AP through this method, is about 5ms. A miss tends to induce a *back off delay* (of up to 15ms) plus some scanning time of about 30-40ms. To prevent this, we can use a WLAN router at the handoff region. In this way a miss would not significantly affect the handoff delay. Note here that we do not consider the time to calculate the angle between the mobile trajectory and horizontal direction because it is very small compared to the other time values involved.

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

Thus we can find out the best AP where the handoff will be performed. It may be noted here that while Cartesian coordinate system have already been utilized in some areas, such methods consists of large calculations and predictions which may lead to handoff failure. Whereas here we are able to get the required data through simple computation which obviously takes much less time and also reduces the possibility of errors. Now let us simulate the proposed model and see if it actually works out.

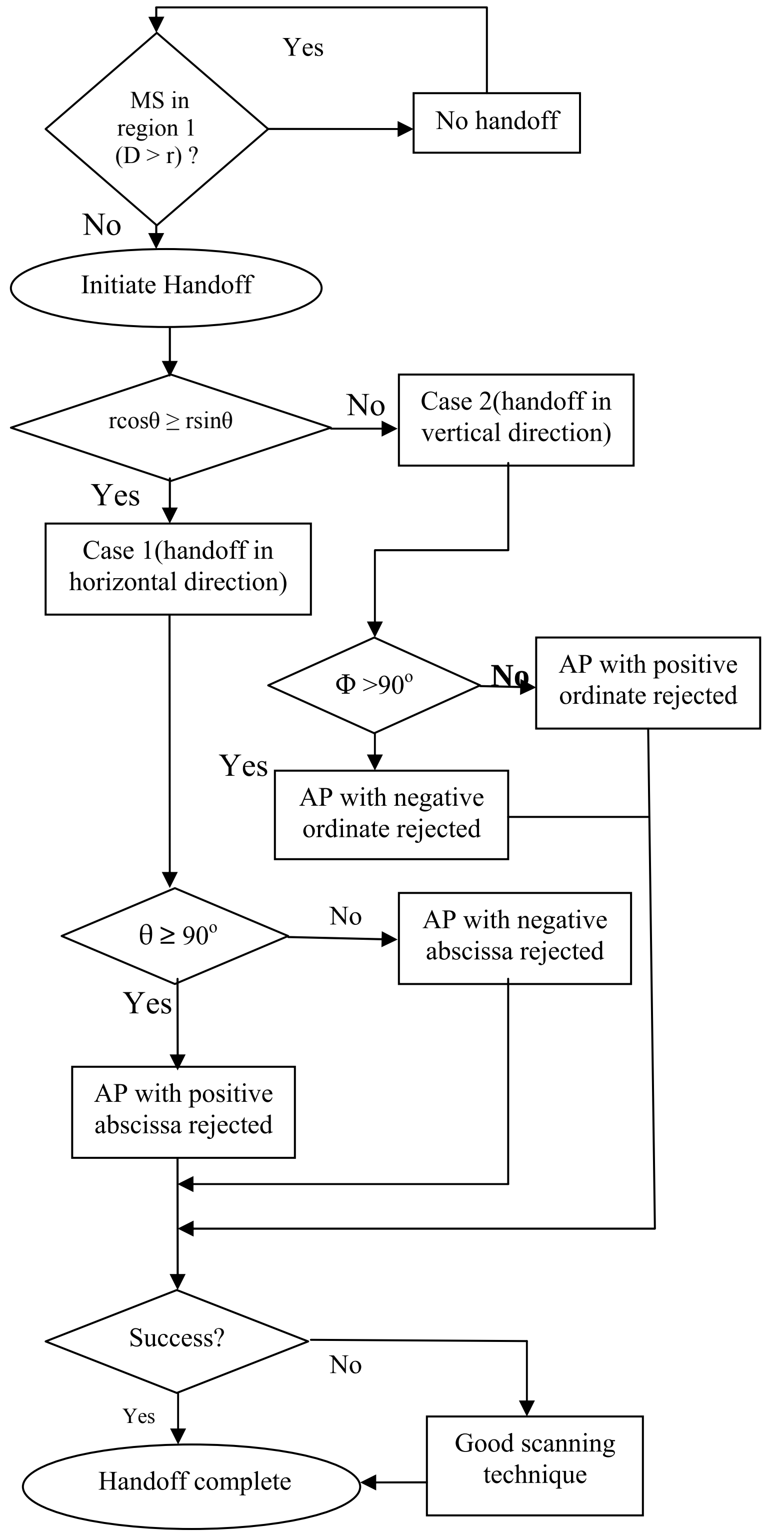

Figure9.Handoff algorithm

4. Simulation Results

We simulate of our proposed method using the flowchart in the subsection of the proposed work. For justifying the practicability of our method in real models we made an artificial environment considering a seven cell cluster, that is seven APs at the centre of seven closely packed cells whose hexagonal structure provides an approximation of its signal sweeping region, and we implemented the vector analysis method in it.
We consider the motion of the MS arbitrarily as shown in Figure.10.

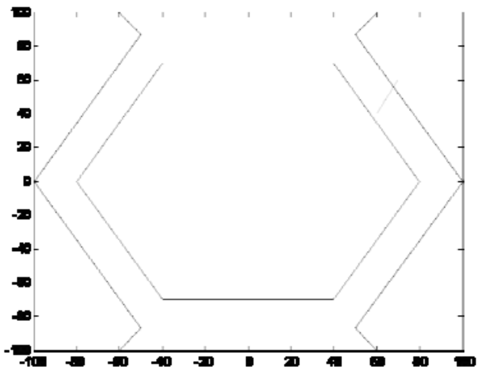

Figure.10

The green line shows the motion of the MS. Now, according to our proposed method we measure the angle of the trajectory path with the horizontal.

So, we can find that it follows the case 2 of our proposed method. Now as the angle is less than 90^o it will reject the AP with negative ordinate and choose the best one for it.

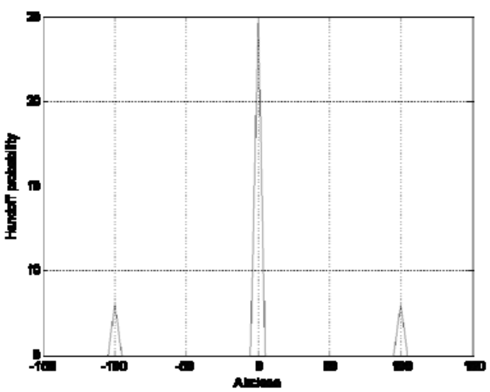

Figure.11

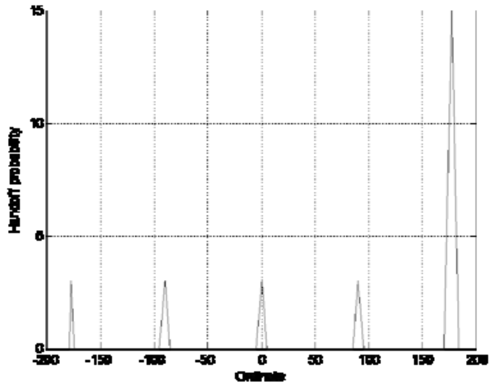

Figure.12

From the flowchart it is clear that the AP_2 is the most effective AP among the all. From that above two pictures we can also see that the most effective AP is (0,177.2) which indicates that the most effective AP is AP_2. Thus we can say our proposed method can be applied successfully. The success of our simulation clearly depicts the applicability of our proposed method.

5. Conclusion

Our proposed method aims at reducing handoff time by reducing the number of APs to be scanned which is accomplished through vector analysis of MS trajectory. This in turn reduces the number of channels to be scanned which brilliantly reduces the handoff delay as is clear from the simulation presented in the above section.
However the proposed algorithm may prove erroneous if the motion of the MS is too much random to be used for prediction purposes. Future works in this field may include research on more refined algorithms regarding vector analysis. It is worth mentioning here that although the proposed work has been presented considering honeycomb structures yet our algorithm would work in a similar manner for other cell structures and neighbor AP locations. Minor changes would be introduced depending on the network topology.

References

[1] Yi-Bing Lin Imrich Chalmatc, "Wireless and Mobile Network Architectures," pp. 17.
[2] AKYILDIZ, I. F., XIE, J., and MOHANTY, S., "A survey on mobility management in next generation all-IP based wireless systems," *IEEE Wireless Communications,* vol. 11, no. 4, pp. 16-28, 2004.
[3] STEMM, M. and KATZ, R. H., "Vertical handoffs in wireless overlay networks," ACM/*Springer Journal of Mobile Networks and Applications*(MONET), vol. 3, no. 4, pp. 335-350, 1998.

[4] J. Pesola and S. Pokanen, “Location-aided Handover in Heterogeneous Wireless Networks,” in Proceedings of Mobile Location Workshop, May 2003.

[5] M. Shin, A. Mishra, and W. Arbaugh, “Improving the Latency of 802.11 Hand-offs using Neighbor Graphs,” in Proc. ACM MobiSys 2004,pp 70-83, June 2004.

[6] S. Shin, A. Forte, A. Rawat, and H. Schulzrinne, “Reducing MAC Layer Handoff Latency in IEEE 802.11 Wireless LANs,” in Proc. ACM MobiWac 2004, pp 19-26, October 2004.

[7] H.-S. K. et. al. Selecive channel scanning for fast handoff in wireless LAN using neighbor graph”, International Technical Conference on Circuits/Systems, Computer and Communications. LNCS Springer, Vol 3260, pp 194-203, 2004.

[8] S. Park and Y. Choi. Fast inter-ap handoff using predictive-authentication scheme in a public wireless lan. Networks2002 (Joint ICN 2002 and ICWLHN 2002), August 2002.

[9] Chien-Chao Tseng, K-H Chi, M-D Hsieh and H-H Chang,” Location-based Fast Handoff for 802.11 Networks”,IEEE Communication Letters, Vol-9, No 4,pp 304-306, April 2005.

[10] Yogesh Ashok Powar and Varsha Apte, “Improving the IEEE 802.11 MAC Layer Handoff Latency to Support Multimedia Traffic”, Wireless Communications and Networking Conference, 2009. WCNC 2009. IEEE Xplore, pp 1-6, April 2009

Debabrata Sarddar is currently pursuing his PhD at Jadavpur University. He completed his M.Tech in Computer Science & Engineering from DAVV, Indore in 2006, and his B.Tech in Computer Science & Engineering from Regional Engineering College, Durgapur in 2001. His research interest includes wireless and mobile system.

Shubhajeet Chatterjeee is presently pursuing B.Tech Degree in Electronics and Communication Engg. at Institute of Engg. & Managment College, under West Bengal University Technology. His research interest includes wireless sensor networks and wireless communication systems.

Ramesh Jana is presently pursuing M.Tech (2nd year) in Electronics and Telecommunication Engg. at Jadavpur University. His research interest includes wireless sensor networks, fuzzy logic and wireless communication systems

Hari Narayan Khan is presently pursuing M.Tech (Final year) in Computer Technology at Jadavpur University. He completed his B.Tech in Electronics & Communication Engineering in 2006 from Institute of Technology & Marine Engineering under West Bengal University of Technology. His research interest includes wireless and mobile system

SHAIK SAHIL BABU
is pursuing Ph.D in the Department of Electronics and Telecommunication Engineering under the supervision of Prof. M.K. NASKAR at Jadavpur University, KOLKATA. He did his Bachelor of Engineering in Electronics and Telecommunication Engineering from Muffa Kham Jah College of Engineering and Technology, Osmania University, Hyderabad, and Master of Engineering in Computer Science and Engineering from Thapar Institute of Engineering and Technology, Patiala, in Collaboration with National Institute of Technical Teachers’ Training and Research, Chandigarh.

Utpal Biswas received his B.E, M.E and PhD degrees in Computer Science and Engineering from Jadavpur University, India in 1993, 2001 and 2008 respectively. He served as a faculty member in NIT, Durgapur, India in the department of Computer Science and Engineering from 1994 to 2001. Currently, he is working as an associate professor in the department of Computer Science and Engineering, University of Kalyani, West Bengal, India. He is a co-author of about 35 research articles in different journals, book chapters and conferences. His research interests include optical communication, ad-hoc and mobile communication, semantic web services, E- governance etc.

Mrinal Kanti Naskar received his B.Tech. (Hons) and M.Tech degrees from E&ECE Department, IIT Kharagpur, India in 1987 and 1989 respectively and Ph.D. from Jadavpur University, India in 2006.. He served as a faculty member in NIT, Jamshedpur and NIT, Durgapur during 1991-1996 and 1996-1999 respectively. Currently, he is a professor in the Department of Electronics and Tele-Communication Engineering, Jadavpur University, Kolkata, India where he is in charge of the Advanced Digital and Embedded Systems Lab. His research interests include ad-hoc networks, optical networks, wireless sensor networks, wireless and mobile networks and embedded systems. He is an author/co-author of the several published/accepted articles in WDM optical networking field that include “Adaptive Dynamic Wavelength Routing for WDM Optical Networks” [WOCN,2006], “A Heuristic Solution to SADM minimization for Static Traffic Grooming in WDM uni-directional Ring Networks” [Photonic Network Communication, 2006], ”Genetic Evolutionary Approach for Static Traffic Grooming to SONET over WDM Optical Networks” [Computer Communication, Elsevier, 2007], and “Genetic Evolutionary Algorithm for Optimal Allocation of Wavelength Converters in WDM Optical Networks” [Photonic Network Communications,2008].