

Handoff Latency Minimization by Relative Distance Method

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Abstract: A mobile station (MS) undergoes handoff when it travels out of the coverage area of its current access point (AP) and tries to associate with another AP. In this paper we propose a method using GPS (Global Positioning System) to minimize the number of APs to be scanned by the MS during each handoff procedure. The entire geographical area is considered as a two dimensional plane divided into hexagonal coverage areas. Average Distance (d) is defined as the distance travelled by the MS in a time interval t_d (where t_d is defined as the total time delay in scanning, authentication etc. for a new AP). A new hexagonal area of side ' b ' is created within the pre-existing hexagonal cell of side ' a ' by excluding the area covered by the MS in time t_d (as defined by ' d '). A new variable ' s ' is defined which keeps track of the MS within the cell and when $s > b$ handoff occurs. To minimize the number of APs to be scanned, cell sectoring approach is adopted in which every hexagonal cell is divided into 6 equal segments of 60° each. This will result in a reduction of number of APs to be scanned and the handoff latency will also be reduced to a great extent.

Keywords: IEEE 802.11, GPS (Global Positioning System), cell sectoring, MS (Mobile Station), neighbour APs

I. Introduction

In recent years, IEEE 802.11 based wireless local area networks (WLAN) have been widely deployed for business and personal applications. Users are always connected to the best available networks based on their service needs [1]. Quality of service (QoS) demanding applications like Voice over IP (VoIP) and multimedia need seamless handover. Applications such as VoIP require a delay of less than 150ms and packet loss less than 3%. So it is a very important to support seamless mobility management. Mobility management has two parts: (i) Location management and (ii) Handoff management. Among these two, Handoff management is the most challenging issue. It is the process by which users keep their connections active when they move from one AP to another. Two types of handoffs can occur as shown in Figure 1.

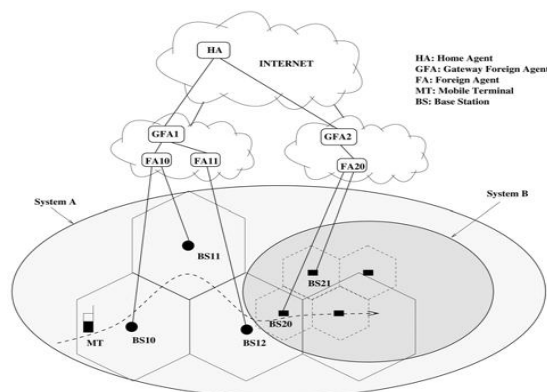
1. *Horizontal handoff:* Handoff between two BSs of the same system. It can be further classified into

a. *Link-layer handoff:* Horizontal handoff between two BSs, under same Foreign Agent (FA), e.g., the handoff of a MT from BS10 to BS11 (Figure 1).

b. *Intra-system handoff:* Horizontal handoff between two BSs that belong to two different FAs and both FAs belong to the same system and hence to same Gateway Foreign Agent (GFA), e.g., handoff of MT from BS11 to BS12 (Figure 1).

2. *Vertical handoff (Inter-System Handoff):* Handoff between two BSs, belong to two different systems and two different GFAs, e.g., the handoff of the MT from BS12 to BS 20 (Figure 1).

Figure 1 Different types of hand-offs in the integrated NGWS architecture



II. Related Works

In past few years, some neighbour graph and GPS based Handoff procedures have been proposed. In [2] & [3], authors use GPS based access point maps for handoff management. In [4], authors propose selective channel scanning mechanism using neighbour graphs. They scan neighbour APs and collect their respective channel information. They need changes in network infrastructure and use of IAPP. Chung- Sheng Li et al. in [5] focus on neighbour graph cache mechanism for link layer2 handover. In [6], Handoff Minimization using vector analysis method has been proposed. In [10], Handoff Minimization using cell sectoring method has been proposed. In [7], S. Kyriazakos et al. propose an algorithm to resolve the well-known ping-pong and far-away cell effects using the MN's movement and its velocity. They gave a brief description of the mechanism without providing any performance evaluation. J Pesola et al in [8] present a location assisted algorithm to manage handover between WLAN and GPRS networks.

III. Proposed Method

Our proposed method includes three parts: Minimization of the number of APs to be scanned using GPS technology, Selective Channel Scanning and Pre Authentication.

A. Minimization of number of APs to be scanned

Here we utilize GPS technology to implement our mechanism. We assume hexagonal coverage area with the AP at the center of each cell. The instantaneous velocity (v) of the MN is determined by GPS technology. After the call has started, we measure the distance travelled (Δx) by the MN in every interval of 5 ms with the help of GPS. The MN's instantaneous velocity is $v = \Delta x / 5$. We assume that the approximate maximum handoff delay in the scanning, authentication and re-association phase of a single AP be t_{delay} ms as per the latest proposed algorithm. The potential AP searches can be made up to a certain distance after which the MN performs the handover process. The distance ' d ' which is required in order to carry out the remaining portion of the handover procedure is given by the equation: $d = v \times t_{\text{delay}}$

Therefore, ' d ' is a variable parameter. Let ' a ' be the cell size. Each time ' d ' is calculated, MN also calculates the side of the hexagon (Fig 2) which is symmetrical with the cell but situated (imaginary) at a distance ' d ' inside the cell. Let us assume that the size of the new hexagon is ' b '. The parameter ' b ' can be calculated by simple geometry.(Fig 3)

$$\begin{aligned} BP = CQ &= d \times \cot(60^\circ) \\ &= d / \sqrt{3} \\ \text{So, } b &= a - 2 \times (d / \sqrt{3}) \end{aligned}$$

Figure 2 Hexagonal coverage area

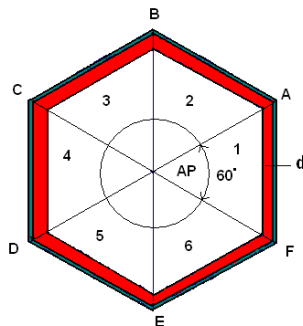


Figure 3 Calculation of the size of 'b' using simple geometry

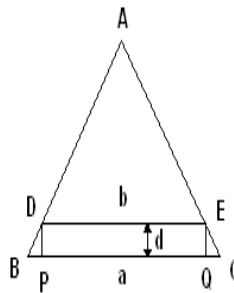
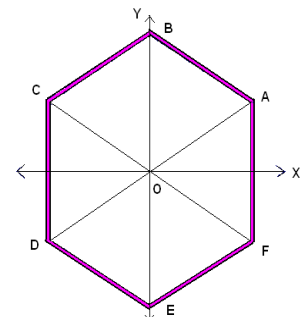


Figure 4 Visualization of the cell in 2D space



The entire hexagonal cell is divided into six sectors with each sector having an angle of 60° as shown in the Figure 2. The sectors are numbered serially from 1 to 6. It can be visualized as a two dimensional space with the origin as the AP having 4 quadrants about it and the X and Y axis as shown in Figure 4. Let the initial coordinate of the MN be (x, y)

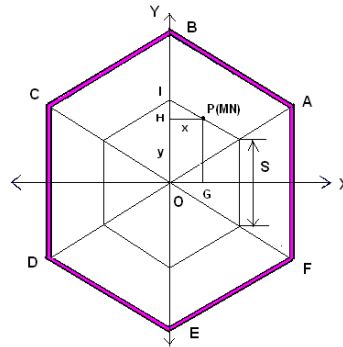
The angular displacement of the MN can be calculated by the following procedure:

- (1) If $x > 0$ and $y > 0$ then $\Theta = \arctan(y/x)$
- (2) If $x < 0$ and $y > 0$ then $\Theta = 180^\circ - \arctan(|y/x|)$
- (3) If $x < 0$ and $y < 0$ then $\Theta = 180^\circ + \arctan(|y/x|)$

(4) If $x > 0$ and $y < 0$ then $\Theta = 360^\circ - \arctan(|y/x|)$

It is from the value of Θ that the sector, in which the MN is situated at that instant, can be determined.

Figure 5 P(MN) shows the position of MN



A hexagon symmetric with the cell is drawn (Figure 5) The MN is situated on the side of the hexagon. Using GPS technology the side of this hexagon is calculated by the following geometrical procedure.

Let this variable length be 's'.

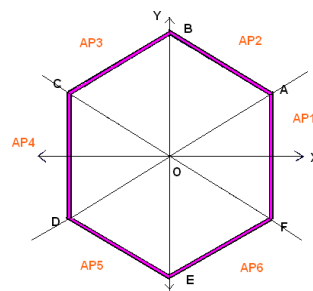
1. If $30^\circ \leq \Theta \leq 150^\circ$ then from Figure. 5 we have, $OG = HP = x$ and $OH = GP = y$. Also $\angle IPH = 30^\circ$ So, $s = OB + HI$
 $= GP + HP \tan(30^\circ)$
 $= |y| + |x| / \sqrt{3}$

2. If $0^\circ \leq \Theta \leq 30^\circ$ and $150^\circ \leq \Theta \leq 180^\circ$ then we have, $s = |x| / \cos(30^\circ) = |x| / (\sqrt{3}/2) = 2|x| / \sqrt{3}$

For the lower half of the cell the related formulae can be obtained by symmetry considerations.

The values of 'b', 's' and Θ are calculated at each interval of 5 ms and each time it is checked whether 's' is equal to 'b' or not. When $s \geq b$, further calculation is stopped. The last calculated value of Θ is taken under consideration. From this value of Θ the BS in which the MN will enter next can be determined.

Figure 6 Sectorized hexagonal cell



From Figure 6 it is clear that,

- If $30^\circ \leq \Theta \leq 90^\circ$ then MN enters BS₂. If $90^\circ \leq \Theta \leq 150^\circ$ then MN enters BS₃. If $150^\circ \leq \Theta \leq 210^\circ$ then MN enters BS₄. If $210^\circ \leq \Theta \leq 270^\circ$ then MN enters BS₅. If $270^\circ \leq \Theta \leq 330^\circ$ then MN enters BS₆. If $330^\circ \leq \Theta \leq 360^\circ$ then MN enters BS₁.

We now know the BS into which the MN is going. Therefore, the MN starts selective channel scanning for this particular BS only.

B. Selective Channel Scanning

Selective channel probing brilliantly reduces the handoff delay by a massive percentage when compared with selective scanning or basic active scanning. Moreover, it was also stated that the MN has to wait for only the 'round trip time' (rtt) for scanning each channel instead of the min channel time or the max channel time. We know that IEEE 802.11 uses 11 out of the 14 possible channels. Out of these 1, 6 and 11 are mutually non-overlapping. When the MN responds to handoff, introducing the pre-scanning mechanism of GPS, it first looks

for the potential AP, when the threshold distance from its present AP has been exceeded then it first scans the channels 1, 6 and 11 if present in that AP. If this fails, it starts scanning the 5 other channels of that AP. As proposed in [8], the expected scanning delay using selective scanning is $t = N \times r + \alpha$ where 't' is the scanning delay, 'N' is the number of channels scanned, 'r' is the round trip time and ' α ' is the message processing time. 'r' is the summation of the time taken for the Probe Request to be sent to the selected AP's and for the Probe Response to be received, which, in our case, is nothing but the Min Channel Time, and has been estimated to be around 3-7 ms.

C. Pre-authentication

To reduce the message processing delay, authentication is done during scanning phase. By this method, the authentication delay vanishes and the message processing delay, α , is composed only of the re-association time. Thus, the parameter ' α ' is reduced by at least half of its initial value and hence the net time delay 't', as proposed in [8], is greatly reduced.

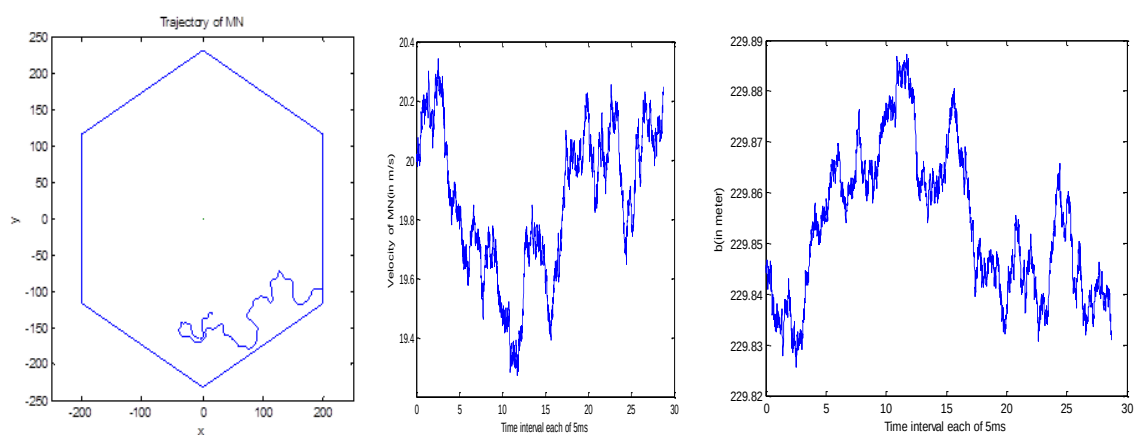
IV. Simulation Results

We have made a sample run of our algorithm to test its functionality. We have recreated our algorithm for the handover of a MN from the cell in which its call originates. The coverage region of the AP is taken as a regular hexagon of length 231m (which satisfies the topological conditions of an AP in urban area). It is assumed that the MN follows a random trajectory and after a certain time moves out of the cell, i.e., it undergoes handoff. At the end of the algorithm we noted the angle at which the MN lies after handover and we compared this with the actual angle that it makes with the previous AP. The result of this simulation justifies the appropriateness of our algorithm. All the coordinates are in meters and are measured in reference to the present AP as the origin and axis shown as in Figure. 4. The initial speed of MN at the origin of call was taken as 20 m/s, and after the algorithm the average speed was recorded as 18.7733 m/s. The average handoff delay time was taken as 50 ms. We have created a totally random trajectory for the MN based on real world consideration, so that on every sample run we get a different trajectory.

As proposed, the algorithm to predict the AP stops as the distance 's' of AP gets larger than 'b'. At this point the predicted angle of MN after handoff was found to be 27.6051 degrees. Therefore, only AP1's channel may be scanned during handover which reduces the handover latency to a great extent. After the handover phase the recorded actual angle that the MN makes with the previous AP is 27.6394 which also correspond to AP1. Thus, this signifies the appropriateness of our algorithm.

A set of sample runs were made by varying the parameters such as cell coverage area or initial velocity of MN and each time the AP was predicted correctly. A graph showing the MN trajectory in our primary sample run is shown in Figure 7. The variation of velocity with time and variation of 'b' with time is also shown.

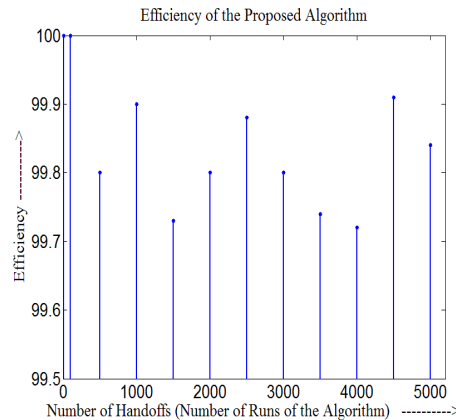
Figure7 Trajectory, Velocity of MN and Variation of 'b' with time



A. Efficiency of the algorithm:

The efficiency of the proposed algorithm is very high and never reduces below 99.7%. Efficiency is defined as the number of successful handoffs divided by the number of handoffs attempted by the MS. Figure 8 shows the percentage of successful handoffs vs. the number of handoffs attempted. The calculated efficiency is more than 99.5% for every sample run of the program. For instance there are only 3 failures out of the 2000 handoffs attempt made by the MS, giving efficiency as high as 99.85%.

Figure 8 Percentage of successful handoffs vs. the number of handoffs



V. Conclusion and Future Works

It can be observed that the proposed cell sectoring method accompanied by selective scanning largely reduces both the handoff failure probability and handoff latency by almost accurately predicting the AP to which the MN is heading. The efficiency is also always above 99.7%. Future work may include issues related to minimizing error due to totally unpredictable movement of the MN and developing more refined algorithms for the same. It is worth mentioning here that although the proposed work has been presented considering hexagonal cell structure yet our algorithm could work in a similar manner for other cell structures and neighbour AP locations as well. Minor changes would be introduced depending on the network topology and cell structure.

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