REDUCING HANDOVER DELAY BY PRE-SELECTIVE SCANNING USING GPS

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Abstract

IEEE 802.11 based mobile communication towers is used very much in many personal and industrial purposes as it provides a continuous connectivity to Mobile Nodes (MNs) and allows them to change their attachment point from old Access Point (A)P to new AP while needed. But one main problem of continuous connectivity is handover latency which consists of scanning, authentication and re-association phases. Scanning is the most time consuming part of handover process. In this paper, we introduce a pre-scanning mechanism using Global Positioning System (GPS) to reduce handover delay. In our method, scanning is completed almost before actual handover starts. From the simulation results, it can be seen that our proposed mechanism reduces handover delay by a great deal.

KEYWORDS

IEEE 802.11, GPS, handover, Pre-scanning.

1. INTRODUCTION

IEEE 802.11b based wireless and mobile networks [1], also called Wi-Fi commercially, and are on a demand for their extensive range of applicability, economical rates and applicability. But due to their limited coverage range, it results in frequent handoffs, even in moderate mobility scenarios. Handoff, an inherent problem with wireless networks, particularly real time applications, has not been well addressed in IEEE 802.11, which takes a *hard handoff* approach [2]. Here a mobile host (MH) has to break its connection with its old access point (AP) before connecting to a new AP, resulting in prolonged handoff latency called *link switching delay*. Now-a-days*, soft handoff* procedure is in use. Here a mobile node is connected to its old AP till it makes connection with the new AP. This effectively reduces the packet losses incurred by hard handoff. A schematic diagram showing hard and soft hand off is given in Figure 1.

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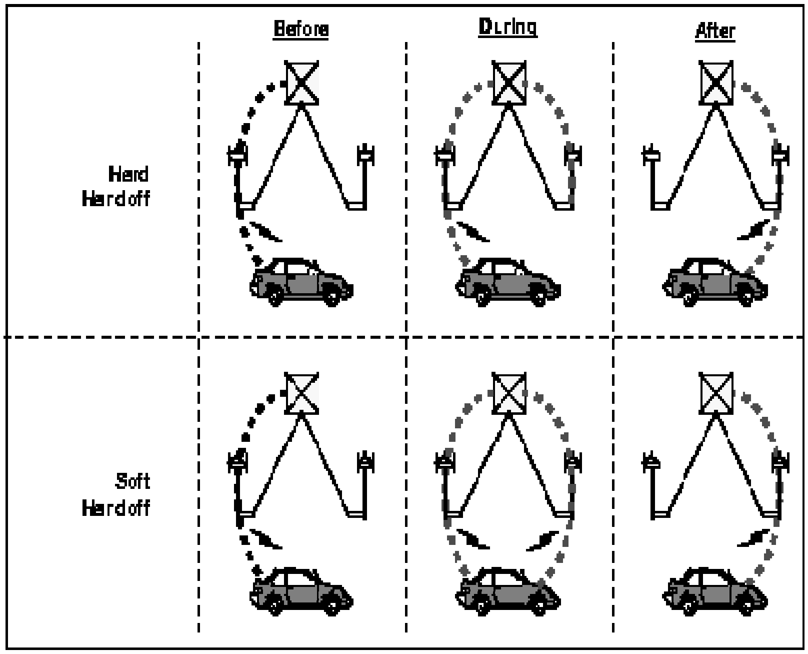

Figure 1. Diagram showing mechanism of hard and soft handoff

In recent years, there are many wireless technologies being implemented starting from 2G and 3G cellular system (e.g. GSM/GPRS,UMTS,CDMA2000), metropolitan area networks (e.g., IEEE 802.16,WiBro), wireless local area networks WLANs (e.g., IEEE 802.11a/b/g, Hiper-LAN), and personal area networks (e.g. Bluetooth). All these wireless networks are heterogeneous in sense of different radio access technologies, the communication protocols that they use and the different administrative domains that they belong to. The actual trend is to integrate complementary wireless technologies with overlapping coverage so as to provide the expected ubiquitous coverage and to achieve the Always Best Connected (ABC) concept.

IEEE 802.11b standards have become increasingly popular and are experiencing a very fast growth upsurge. They are widely being deployed for variety of services as it is cheap, and allow anytime or anywhere access to network data. However, they suffer from limited coverage area problem [3] and it is necessary to use this technology in the most prudent manner.

A Wireless Local Area Network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum), and usually provides a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network.

Essentially, a WLAN is an extra backbone to the connection between a mobile client and an access point, which transmits and receives radio signals between them. An access point can be either a main, relay or remote base station. A main base station is typically connected to the wired Ethernet. A relay base station relays data between remote base stations, wireless clients or other relay stations to either a main or another relay base station. A remote base station accepts connections from wireless clients and passes them to relay or main stations. Connections between "clients" are made using MAC addresses.

The entire handover procedure can be divided into scanning, authentication and re-association. In the first phase, the mobile node (MN) scans for AP's by either sending Probe Request messages or by listening for beacon message. After scanning all or specified number of channels, an AP is selected which has the frequency channel with the highest Received Signal Strength Indication (RSSI) and Carrier to Interference (CI) ratio. Then the selected AP exchanges authentication messages with the MN. Finally, if the AP authenticates the MN, it sends Re-association Request message to the new AP and handover gets accomplished. The handover region between two approximated hexagonal coverage area cells for mobile communication is shown in Figure 2 (figure taken from Mobile- man).

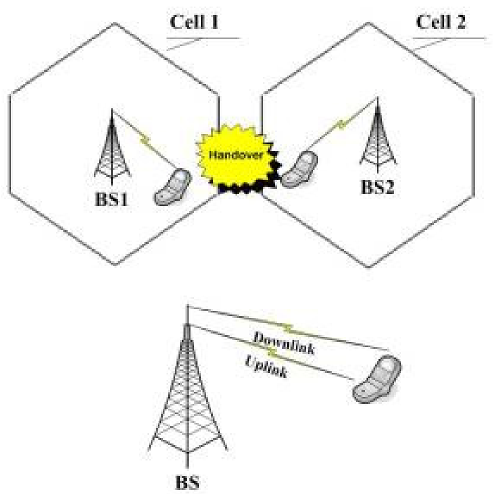

Figure 2. The handover region between two approximated hexagonal coverage area cell

Handoff delay is the time taken to complete the handoff between two cells. There are three steps encompassing this delay. They are probe delay, authentication delay and re-association delay. Probe delay is the time that MN takes to complete a scan of available networks and to build its priority list. It is required to send somewhere between 3 to 11 messages in order to complete this task. Authentication delay is the time taken by the MS for re-authentication to the AP as chosen from its priority list. Depending on the type of authentication, either 2 or 4 packets need to be exchanged. Re-association delay is the time taken by the MS to signal the AP that the handoff is complete. It is required that a minimum of 2 packets be exchanged. 90% of the handoff delay comes from channel scanning. The range of scanning delay is given by the equation:

$$N \times T_{min} \leq T_{scan} \leq N \times T_{max}$$

where N is the total number of channels according to the spectrum released by a country, T_{min} is Minimum Channel Time, T_{scan} is the total measured scanning delay, and T_{max} is Maximum Channel Time. The total handoff process is given in Figure 3.

Considering heterogeneous wireless networks such as B3G or 4G networks, with the BSs in the cellular network with one access technology and APs from WLANs using a different one, we can say that a vertical handover (VHO) is the mechanism by which an ongoing connection is transferred from one BS to an AP and vice versa.

VHO can be classified in two categories namely upward-downward handover techniques and imperative-alternative handover techniques. An upward VHO occurs from a network with small coverage and high data rate to a network with wider coverage and lower date rate. On the other hand, a downward VHO occurs in the opposite direction. As an example for this classification let's consider the case of two of the most important current wireless technologies: 3G cellular networks and WLANs. The WLAN system can be considered as the small coverage network with high data rate while the 3G cellular system is the one with wider coverage and lower data rate.

An imperative VHO occurs due to low signal from the BS or AP. In other words, it can be considered as an HHO. The execution of an imperative VHO has to be fast in order to keep on-going connections. On the other hand, a VHO initiated to provide the4 user with better data-rate is called the alternative VHO.

One of the most important reasons of handoff failure is the handoff latency caused by channel scanning and excess wireless traffic. Many measures have been taken in order to minimize handoff failure, but handoff failure is still an issue unsolved in the cellular world. Here we propose to minimize the handoff failure probability by effectively placing a WLAN AP in the handoff region between two neighbouring cells. We also perform the channel scanning (required for horizontal handover between the two base stations) within the WLAN coverage area, thus minimizing the handoff failure due to scanning delay.

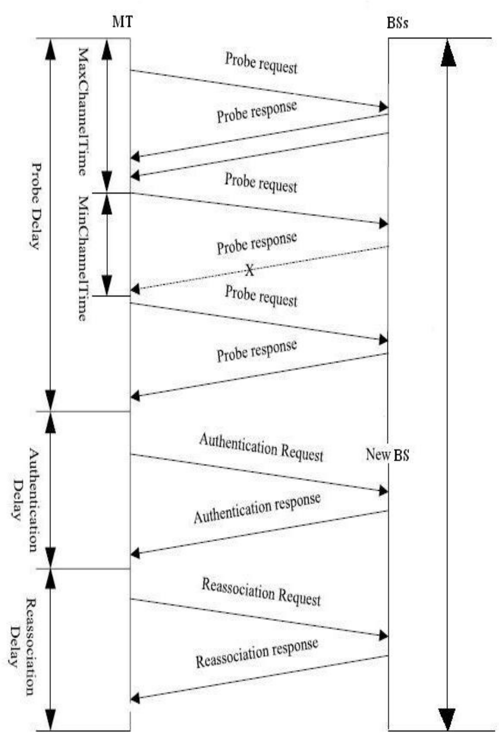

Figure 3. The total handoff procedure with proper sequence of the steps

1.1.5. GPS system

To generate a GPS map, the MN with GPS generates an AP map while it travels within a network. The MN records the latitudes and longitudes of the neighbour Access Point and used channel of each AP by Basic Service Set ID (BSSID). When a MN enters into a new network, it downloads its GPS map from server. By these AP map and GPS map, the minimum distance between MN and each neighbour AP can be found from server. Certain APs whose distance from MN is less than threshold are chosen as neighbours and AP's co-ordinates, IEEE 802.11 channel corresponding to that AP, AP's Service Set ID(SSID) and IPv6 prefix are statically configured. By these AP and GPS map, we can locate the MN's position in a network and whether a MN moves or not. Basically we can calculate the distance between two points in a network by GPS.

Let us denote the previous and the current co-ordinates of an MN as (lat1, long1) and (lat2, long2) respectively. Considering R (=6371 km) as the radius of the earth, the distance d between the two points is calculated by the formula:

$$\text{haversine}(d/R)= \text{haversine}(\Delta_{lat})+\cos(lat1) \times \cos(lat2) \times \text{haversine}(\Delta_{long}) \quad (2)$$

Where the haversine function is given by haversine(x) $=\sin^2(x/2)$. Let h denote the haversine(d/R). One can then solve for d by either simply applying the inverse haversine or by using the arcsin function $d=R \times \text{haversine}^{-1}(h) =2R \times \arcsin(\sqrt{h})$. If d is greater than 1 meter, we consider that the MN has moved and has to send to the GPS server a LU message, which includes the identity of its current AP and its current co-ordinates. The MN can know its position information from GPS within an error of 1-2 meters. With prediction it is possible to reduce latency and packet loss. Thus GPS allows us to anticipate movement calculation with the help of which the need to wait for beacon signals from other FAs is eliminated. Also handoff target areas are discovered in advance.

Here we propose a pre-scanning mechanism using GPS by which we can almost eliminate scanning part of handover delay because we complete scanning almost before MN enters into a new cell. In section 1.1 we discuss on IEEE 802.11b handover procedure. We divide the rest of the sections as follows. In section2 we describe our related work and in section 3 we propose a new scheme of pre-scanning using GPS. In section 4 we demonstrate simulation results and in section 6 we shall give a brief conclusion

2. RELATED WORKS

In real-time application, many scientists have proposed many mechanism to improve handover latency in IEEE 802.11b based networks. In [2] and [3] many techniques to reduce handoff latency as well as packet loss are described. In [4] a common method to decrease handoff delay is proposed. In [5] authors proposed a location-aided algorithm to manage handover between WLAN and GPRS network. Depending upon velocity, direction and on-going traffic of MNs, it can estimate the time when a handover is needed. In [6] an MN generates an AP map to use it for handover in a test aided wireless network.

In [7] authors proposed a pre-scanning scheme using Neighbor graph cache memory. If MN has T time before handover, and scanning time is Ts. Then total no of times cache is updated with neighbor graph is n=T/Ts. Scanning delay in this mechanism depends upon n. This delay will be minimum if the probability of n being an integer is greater.

In [8] a pre-authentication mechanism using GPS is proposed. In their scheme, authentication is completed during scanning phase. Therefore handover delay can be reduced.

In [9] the authors used a caching scheme to generate a list of MAC addresses of APs adjacent to current. In [3] a selective scanning mechanism using neighbour graph is proposed. There scanning delay has been considered as ‘the time from first probe request message to last probe response message’. Thus client’s processing delay is neglected. In their mechanism, scanning delay is:

$$Ts=N'*rtt+\alpha$$

Where Ts=scanning delay
N’=number of potential channels
Rtt=round trip time
α=message processing time.

3. PROPOSED METHOD

We are proposing a scheme named “PRE-SELECTIVE SCANNING WITH GPS (Global Positioning System)” to reduce the scanning delay which is 90 percent of whole handover delay. Our scheme has the advantage of selective scanning. There are 14 channels used to be scanned. But only first 11 channels of them are used by IEEE 802.11b. But 1,6,11 number channels are not overlapping; therefore most of APs are likely to operate on these three channels. We also use pre-scanning mechanism where we can complete the scanning phase almost before handoff such that scanning delay will not be included in handoff delay. In this way, we can reduce handoff delay drastically. We have also used GPS to calculate the distance between the Mobile Node (MN) and the best AP in the old AP’s neighbourhood area when the MN moves within old base station’s cell. We describe our proposed work in the algorithm form below.

1. After call setup the mobile node will scan once and calculate the scanning time Ts
2. If the MN gets the APs after scanning
2.1. Select the best AP with best signal quality and try to associate with that AP
/* For this case calculate the distance of the MN from nearest AP*/
/* Let the distance between MN and the signal boundary of its nearest AP be **s*/**
/* Let the average velocity of the MN be v*/
/* Let the average handoff latency as stated by previous work be Ts*/
/* If the MN goes to that AP through the shortest path, then it needs s/v time. In that case MN will have T=s/v time before handoff. Therefore in that case ratio of T and Ts is n=T/T*/
2.1.1. If n=1 or n<1
2.1.2. MN will scan selectively immediately and jump to srep 5
2.1.3. Else
2.1.4. Jump to step 2.1.1
2.2. Else
2.3. Jump to step 2
2.4. End
2.5. Authenticate with the new AP
2.6. Re-association
/* Handover complete*/

So, in that case, n=1 means we have time equal to a scan-time before handoff. So, if we can start scanning at n=1, we can complete scanning phase before handoff. If otherwise unfortunately we fail to recognize where n becomes 1 and n will be less than 1, then we have to start scanning immediately though we can’t complete scanning before handoff. But we can reduce scanning delay very much also in that case.

So, here if we can complete the whole scanning phase before handoff, then we can eliminate the scanning phase from handoff delay. Then the only delay will be due to authentication, re-association and processing of devices. The above algorithm is also shown in the flow chart representation in Figure 3.

4. EXPERIMENTAL RESULTS AND SIMULATIONS

To simulate our proposed algorithm, we have found a formula to find scanning delay as function of actual call time before handover. So at every interval of time Ts/100, minimum change of n may be 0, and maximum change of n is 0.1.

So the average change of n = (0+.01+.02+.03+.04+.05 +.06+.07+.08+.09+0.1)/11
=0.05.

So at every interval of time Ts/100, n can be averagely changed by 0.05.

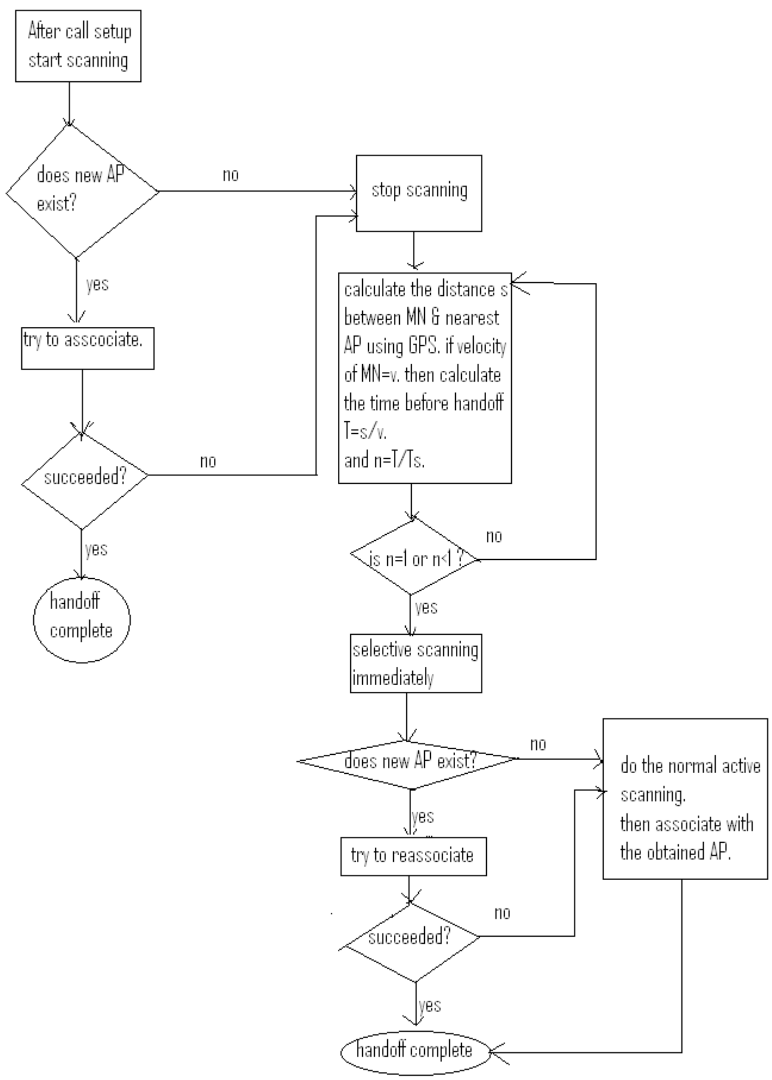

Figure 4.Flow Chart of Pre-scanning Algorithm Using GPS

Let us assume, actual call time before handoff needed is t. So N=t/Ts. If our scheme is applied, then one time will come when n will be just less than 1, in that time the value of n will be:
n=N-.005*nearest upper integer of (200*(N-1)).
And the scanning delay will be
S_d=Ts-t+.005*Ts* nearest upper integer of (200*(t/Ts-1)).

For choosing the value of Ts we can have different combination of values. If we use Basic active scan in our pre-scanning scheme, then Ts=332ms according to [9]. If we use fast active scan in our pre-scanning scheme, then Ts=32.36ms according to [5]. If we use basic selective scan in our pre-scanning scheme then Ts=129ms according to [3]. If we use selective scan using cache in our pre-scanning scheme, then Ts=3ms according to [8].

To evaluate our proposed scheme, we simulate all these four mechanism- basic active scan, fast active scan, basic selective scan, and selective scan using cache.

So, from figure 5, 6, 7 and 8, we can realize that the effective delays are lesser than the previous value because of pre-scanning. The simulation results indicate that the average delays for basic active scanning, fast active scanning, basic selective scanning and selective scanning using cache are .825ms, 0.08ms, 0.35ms and 0.0075ms respectively. So if we use our proposed pre-scanning mechanism, handover delay can be reduced by a great deal.

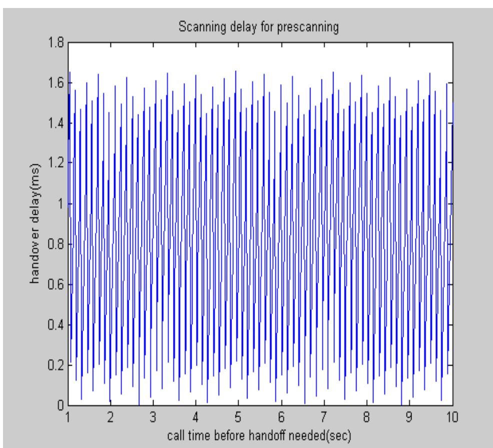

Figure 5.Scanning delay for basic active scan (Ts=332ms)

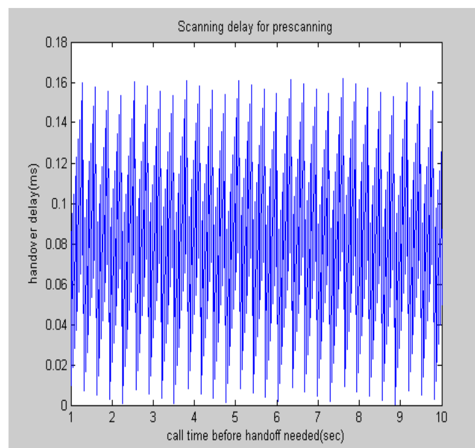

Figure 6. Scanning delay for fast active scan (Ts=32.36ms).

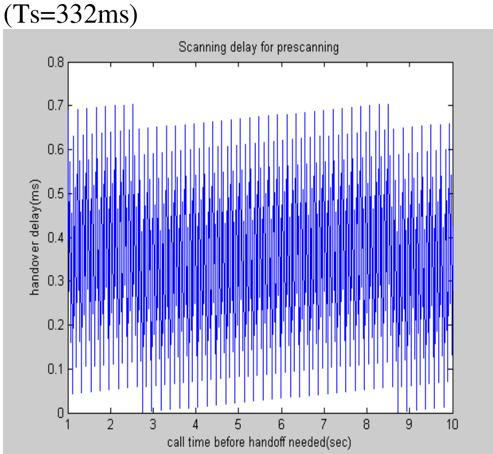

Figure 7. Scanning delay for basic selective scanning (Ts=141ms)

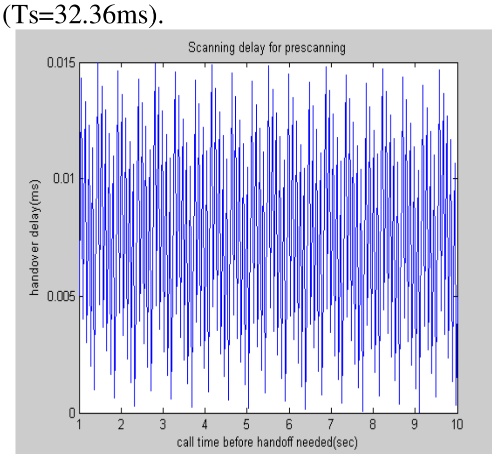

Figure 8. Scanning delay for selective scanning using cache (Ts=3ms)

5. CONCLUSION AND FUTURE WORKS

The new introductions in our paper are connoted as follows. Firstly, we have used just 1, 6, 11 number channel for scanning as most of APs prefer to operate on these three channels because they are not over-lapping. This can reduce scanning delay by a great deal. Secondly, we have proposed a special pre-scanning mechanism by which we can complete scan almost before actual handoff. Thirdly, scanning has not been done many times; it has been done once just when it is needed. Thus we can reduce power consumption. Finally, we have used GPS instead of neighbour graph as GPS is much efficient. Thus we can reduce packet loss very much.

But we can not reduce authentication delay as well as re-association delay. Future simulations may reduce these delays using more powerful algorithm. We have described a pre-scanning mechanism using GPS that supports IEEE 802.11 based mobile communication models in this paper. By this mechanism we can reduce scanning delay very much. As 90% of total handover delay is contributed by scanning phase, therefore our method can reduce handover delay by a great deal.

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