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Network Condition Based Handoff In Wlan For Avoiding Unbeneficial Handoffs

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Abstract

In Wireless Local Area Networks, mobile stations frequently performs handoff due to factors like signal strength, load balancing, and frequencies engaged etc. This frequent handoff could interrupt the ongoing services that cause poor performance and this should be minimized for smooth operation. In this paper we have proposed a handoff algorithm that considers the network condition along with RSS for avoiding unbeneficial handoffs. Also we have presented numerical methods for estimating network condition of 802.11 WLAN. The simulation result shows that, the proposed algorithm reduces the number of unbeneficial handoffs significantly. The proposed handoff algorithm is suitable for both mobile and fixed stations.

Keywords: Handoff, Delay, Monitoring Network Condition, available bandwidth.

Introduction

The Number of IEEE 802.11 network grows continuously due to its low cost implementation and high performance. It is used widely for providing Internet services to the users in different places like university campuses, airport, schools, park and hotels etc. The only limitation in WLAN is its shortest coverage area which may not suitable for users moving with high speed. The mobile station with high velocity may goes out of coverage area frequently and the stations may not get any service until it enters into any one of the access point's coverage. To overcome this issue multiple access points can be used for covering large service area. In this scenario mobile stations with high velocity may perform frequent handoffs for continuing its ongoing services. Handoff is a process of disconnecting old access point and connecting to the new access point for continuing the service. Normally in RSS based handoff; handoff will be triggered, when the mobile station moves far away from the old access point and moving closer to another access points. In this case we can have two possibilities of handoff: 1) L2 Handoff and 2) L3 Handoff. During the handoff process, if the old and new access point belongs to the same subnet, then it is said to be L2 handoff. During the handoff process if the old and new access point belongs to the different subnet then it is said to be L3 handoff as shown in Figure 1.

As discussed in [1], during L2 handoff, the mobile station connects to a new access point by checking, if a subnet change has occurred or not. It has to check its L2 cache for the availability of a valid value in the subnet ID field for the new access point. If it is available, the MN compares this value with the subnet ID value of the old access point. If the values are different, then the subnet ID of old access point and new access point are different and hence mobile node has to perform L3 handoff. Else if the old and new access point belongs to the same access point then it has to perform L2 handoff. In this case handoff procedure will not include a subnet discovery phase, if L2 cache already has such information.

If L2 cache contains no information about the subnet ID the mobile station has to initiate the subnet discovery procedure. During the subnet discovery procedure, The MN sends a DHCP request to the Dynamic Host Configuration Protocol (DHCP) server. The DHCP server responds with a DHCP acknowledgment which includes IP address of the relay agent of the subnet in which the mobile station is currently connected. Using this IP address the subnet ID field in the L2 cache will be updated. After updating L2 cache the mobile station performs either L2 or L3 handoff based on the updated subnet ID. In L2 handoff mobile station has to perform two phases namely, discovery phase and authentication phase. During the discovery phase mobile station has to start the discovery process by switching between all channels defined by the standard for getting information about the surrounding access points.

The scanning process can be divided into two types namely active and passive scanning. In active scanning, the mobile station scans every channel one by one by sending probe request frames and waits for responses from available access points. Normally, the proactive scanning requires 400ms for detecting all nearby access points because; the mobile station must wait for the minimum channel time on each channel. In case of passive scanning the mobile station waits for beacon frame sent by all access points. Passive scanning is simple and it consumes less power or bandwidth, but it takes more time than the active scanning because mobile station has to wait at least one beacon frame interval on each channel. This passive scanning is mat not suitable for real time applications.

However, both L2 and L3 handoffs consumes considerable time during handoff process. So, it is clear that performing frequent handoff is not good for both mobile stations and networks for smooth operation, since handoff procedure creates additional complexity and unwanted traffics. In literature, large number of papers has been published for minimizing handoff delays, but only few papers have been published to minimize the number of unwanted handoffs. In this paper we have proposed a handoff algorithm which considers both network condition and RSS together that benefits both fixed and mobile stations. Also we have presented a simple network condition detection method that uses network allocation vector.

This paper is organized as follows: In section "Related Works" we did review on related works, in section "Proposed Handoff Algorithm" we propose a handoff algorithm which considers the network condition, in section "Network Condition Detection Method" we present numerical methods for network condition detection, simulation results are given in section "Simulation Results" and finally in last section we did conclude our work.

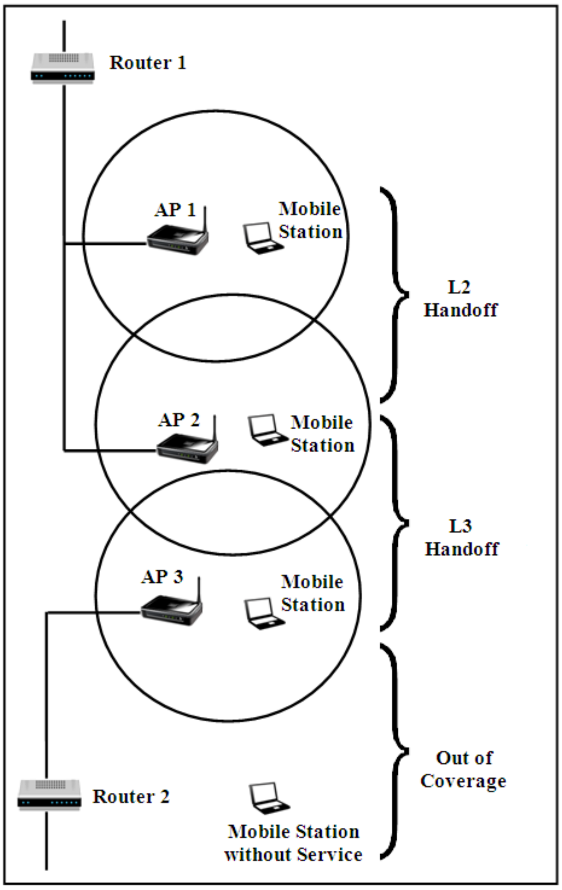

Figure 1: Layer 2 and Layer 3 Handoff Environment

Related Works

The metropolitan area networks have been analyzed in [2] for understanding the performance. Quick authentication strategies are summarized in [3] and summary of quick roaming inside or across IEEE 802.11 Wireless-LANs have been presented. Also, the paper analyses the importance of IEEE 802.11f and they have tried to reduce the latency by quick authentication in inter domain handovers by analyzing three techniques, easy extension of IAPP, inter-domain proactive key distribution and pre-authentication over multiple domains for minimizing latency concerned in authentication throughout the handover process. In [4], new way to cut back the delay by probe procedure has been proposed and they gave a different way to reduce the L2 handoff by permitting access routers to send few details which may be useful for fast handoff decision like frequency, ESSID and authentication data etc.

In the literature, huge number of works has been done for reducing the L3 handoff delay. In [15], efforts have been put for reducing L3 handoff delay by proactively reserving the new IP address for the new subnet before disconnecting the old access point. Also, they acquire a new IP address and update the SIP session before performing the L3 handoff. But their work requires changes to the DHCP protocol and the network infrastructure which is not so easy to implement practically. In [5,4], DRCP a new protocol is developed to replace the DHCP protocol. It reduces the address allocation to few hundred milliseconds which is still too big for real time applications.

In [14], we have proposed a cooperative handoff method for reducing handoff latency. In [6], the work states that a mobile station will record the visited subnets which can be useful throughout the handoff of process to guess the access point that provide service for a long time. This strategy will increase complexity for the mobile stations, since mobile stations are limited in resources it is tough to record, calculate and predict throughout the roaming. The performance of L2 and L3 handoff in wireless networks are investigated by several authors but analyzing the performance of L2 and L3 handoff alone is not a straightforward task. Because, at the time of writing this paper, several wireless standards are approved and respective hardware may available in the market for public usage.

The access point selection schemes in the literature for load balance among access points uses various metrics to determine the access point load. In [7], the sum of the reciprocal of data rates from connected clients is used to predict the load of an access point. It was pointed out in [8] that always selecting the least-loaded access point may not provide optimal solution. The weighted sum of estimated throughput and available data rate is used as the parameter to make handoff decisions. Applying these schemes in real WLANs is a challenging task, since most of the work requires modifications to WLAN clients, which is not possible for WLAN operators. However, most of the above handoff schemes achieve throughput fairness among clients which reduces overall network throughput. Achieving airtime fairness among clients is good, since the clients choose different physical data rates based on the channel condition.

In [9] and [10], the authors proved that airtime fairness can be achieved by implementing proportional fairness. But these schemes have not specified how to implement airtime or bandwidth allocation in WLANs. In [11], handoff is jointly adapted with rate adaptation and content resolution for implementing proportional fairness. The selection of target access point among the available access points is done by adjusting their physical data rate and minimum contention window sizes to achieve proportional fairness. To improve the performance variance and to achieve airtime fairness, several works have been proposed in the past.

However, in our work we have focused only on reducing the number of unbeneficial handoffs and improving the overall throughput of the mobile station. Any one of the above mentioned handoff schemes can be combined with our proposed algorithm to achieve better airtime fairness, overall network throughput and handoff latency.

Proposed Handoff Algorithm

The QoS may fail due to any one of the two reasons: 1) bad network condition of the current access point; and 2) the condition of networks in between the source and destination of the ongoing application is bad. Our proposed handoff algorithm is presented in the form of pseudo code in Fig. 1 which performs as follows. If any one or more number of ongoing applications failed to provide the QoS for particular time duration, the handoff process has to be initiated if and only if the current Access points' condition is bad enough. If the handoff process is initiated, then the mobile station has to search the nearby access points using active scanning method. The replies from various access points will be collected by the mobile station and the respective access points will be added to a list A1. If more than one access point replies, then, based on the required RSS threshold, it will be shortlisted into another set A2.

```
if application is loosing QoS for time > Ť
    get the required bandwidth Đ_req;
    get the acceptable packet delay ¥_req;
    if the condition of current AP α ∈ A is bad enough
        scan for available AP α ∈ A_1;
        for each AP α ∈ A_1
            if RSS_α > Threshold
                add AP α to set A_2;
            endif
        end for
        for each AP α ∈ A_2
            get the available bandwidth Đ_α of α;
            get the packet delay ¥_α of α
            if Đ_α > Đ_req & ¥_α < ¥_req
                add AP α to set A_3;
            end if
        end for
        if |A_3| > 0
            if realtime application
                b = max_α{¥_α | α ∈ A_3};
            else
                b = max_α{ Đ_α | α ∈ A_3};
            end if
            perform handoff with b;
        else
            stay back in current AP
        end if
    else
        stay back in current AP
    end if
end if
```

Figure 2: Proposed Handoff Algorithm

The network condition of each access point in the set A2 has to be estimated. The access points that contain enough bandwidth (i.e. unused bandwidth greater than the required minimum bandwidth of the mobile station) and satisfy the packed delay requirement of the ongoing applications have to be shortlisted into a set A3. If there is no real time application at mobile station during handoff, then access point in A3 with maximum available bandwidth has to be selected as target access point among available access points from set A3for handoff. Else, if the ongoing application in the mobile station is a real time application (i.e. time sensitive), then the access point with minimum packet delay will be selected among available access point from set A3. In bad case, if the set A3 is empty, then the handoff process has to be dropped and the mobile station has to stay back in the current access point.

Our handoff algorithm avoids the unbeneficial handoff in two ways: 1) it initiates handoff if and only if the current access point status is proved to be bad enough; and 2) it check the status of destination access point prior to the handoff process and it performs handoff if and only if the condition of destination access point is good enough. Another advantage in our proposed handoff algorithm is, if the current access point's condition is bad enough then the fixed stations in the overlapped regions can able to perform handoff for selecting access point with enough unused bandwidth and with minimum latency over time. In case of legacy RSS based handoff schemes, the fixed satiations could always get connected with an access point with good RSS level (i.e., the nearest access point). This will degrade the QoS dramatically in fixed stations.

Network Condition Detection Method

The network status may be changed over time due to many reasons like sudden arrival of large number of mobile stations into a particular geographical place, flow of unwanted traffics and few other reasons. In 802.11 WLAN, network status can be detected by estimating two things: 1) available bandwidth and 2) network access delay. In this section we have proposed numerical methods for estimating both available bandwidth and network access delay which are developed from the previous work in [12]. The available bandwidth of a link can be calculated as

$$ABW = BW_{max} - FR_{mean}FS_{mean}$$

Where, FR_{mean} is the mean frame rate which can be calculated using channel busy time per second b, average number of trials of a transmission NTT_{avg}, time length of a successful transmission L_{suc} and length of a collision L_{col} as

$$FR_{mean} = \frac{b}{\frac{(NTT_{avg} - 1)L_{col}}{2} + L_{suc}}$$

Then, the BW_{max} is the maximum bandwidth (total bandwidth) calculated as

$BW_{max} = \lambda_{max}FS_{mean}$

Where, λ_{max} is the maximum frame arrival rate allowed by the system and FS_{mean} is the mean frame size. Further the time length of a successful transmission L_{suc} can be calculated as

$L_{suc}=T_{RTS}+T_{CTS}+T_{DATA}+T_{ACK}$

Where, T_{RTS} is the transmission time of RTS frame, T_{CTS} is the transmission time of CTS frame, T_{DATA} is the transmission time of DATA Frame and T_{ACK} is the transmission time of ACK frame. The value of FR_{mean}, b and NTT_{avg} can be derived from NAV using the below relation

$$NAV = \frac{(NTT_{avg}-1)FR_{mean}L_{n,c}}{2} + FR_{mean}L_{nav}$$

Where L_{nav} is the NAV duration of a successful transmission and $L_{n,c}$ is the NAV duration for a collision. The available bandwidth $ABW= BW_{max} - FR_{mean}FS_{mean}$ can be solved by using the above equation as

$$ABW = B0 - FS_{mean}\frac{NAV}{T_n + \frac{(NTT_{avg}-1)L_{n,c}}{2}}$$

Also the packet delay t of a network that works in DCF mode can be calculated as
$t=WT_q+WT_m+WT_{cw}+AT_f$

Where, WT_q is the queuing delay, to is the time wait by the frame for medium become idle, WT_{cw} is the time to reduce the contention window counter to Zero and AT_f denotes the air time required for transmitting the frame. The mean of WT_m can be calculated as

$$E[WT_m] = \frac{b(P_cT_{col} + (1-P_c)L_{suc})}{2}$$

Where, p_c is the collision probability denoting the number of collisions among all the trials to send a frame can be given as

$$P_c = \frac{NTT_{avg}-1)}{NTT_{avg}}$$

The mean WT_{cw} can be obtained as

$$E[WT_{cw}] = \frac{b * \upsilon\ (CW_{min})}{2}$$

Where, CW_{min} is the minimum contention window and b is the busy time per second. The $E[AT_f]$ can be calculated as

$$E[AT_f] = \sum_{i=1}^{s-1} p_1^i \upsilon(2^i\, CW_{min}) + p_0T_s\sum_{i=1}^{s-1} p_1^{i-1} + L_{col}\sum_{i=1}^{s-1} p_1^i + p_1^{S-1}\, E(t_{send}^{(S)})$$

The work in [13] explores the inherent problems in WLAN protocol which models the exponential backoff process as a Markov chain and it presents the discrete probability distribution for MAC layer packet service time. Also two models M/G/1/K and M/M/1/K are used for estimating WT_q. The M/M/1/K gives a good approximation for nonsaturated state than the saturated state. So, we can take M/M/1/K model for calculating WT_q as follows

$$WT_q = \frac{FR_{mean} t_a^2}{(1 - FR_{mean}\ t_a)}$$

Where t_a is the sum of WT_m, WT_{cw} and AT_f.

Simulation Results

Our proposed handoff algorithm is simulated and compared with legacy RSS based handoff algorithm. The simulation topology is as shown in Fig. 2, in which three access points are located, namely AP1, AP2 and AP3. Initially the mobile station was connected with AP1 whose condition is very bad. While moving towards AP2, at the time T1 it detects AP2 and its estimation result shows that the condition of A2 is good enough. So it starts the handover procedure and connected with AP2. At time T2 it detects A3 and its estimation result shows that the condition of A3 is bad. Hence, the mobile station stay backs in A2. After a while the mobile station reaches the border of A2 at T4. At T4 no more access points other than AP3 is detected and hence it connects to the AP3 with poor performance. The RSS based algorithm initially connected with AP1 and when it reaches T1, it redetects AP2 but it was not connected with AP2, since signal strength of AP2 is lesser than AP1. Then at T2 and T3 the mobile station was connected with AP2, since at T2 and T3 the signal strength of AP2 is greater than AP1 or AP3. Finally at T4 the mobile station got connected with AP3, since no more access points are detected at T4. The data rate achieved by the mobile station is compared with RSS based handoff algorithm in Fig. 3 and the packet delay achieved by the mobile is compared in Fig. 4. Similarly, the data rate and packet delay achieved by the fixed station is compared in Fig.5 and Fig.6 respectively.

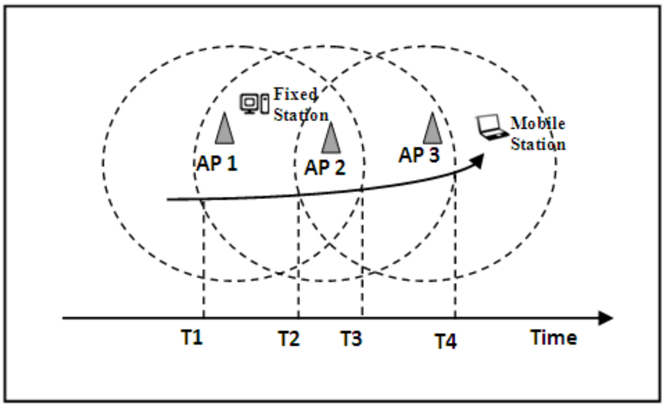

Figure 1: Simulation Environment.

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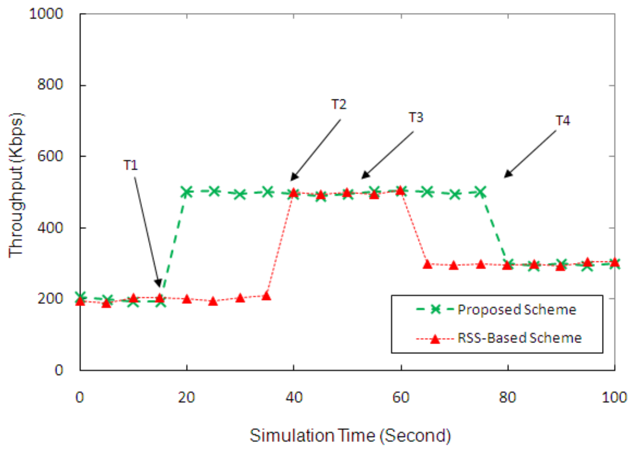

Figure 3: Throughput Achieved by Mobile Station

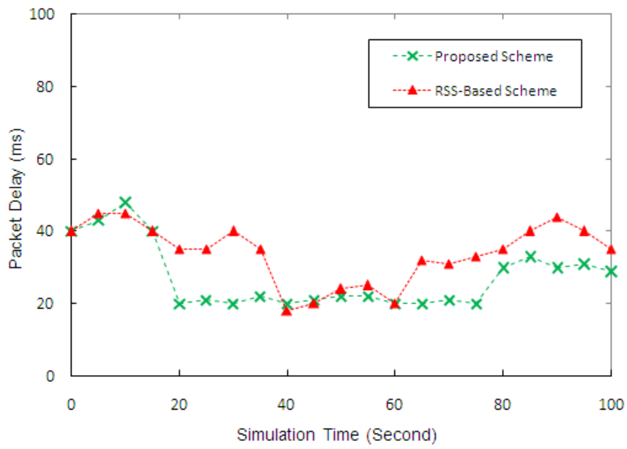

Figure 4: Packet Delay Achieved by Mobile Station

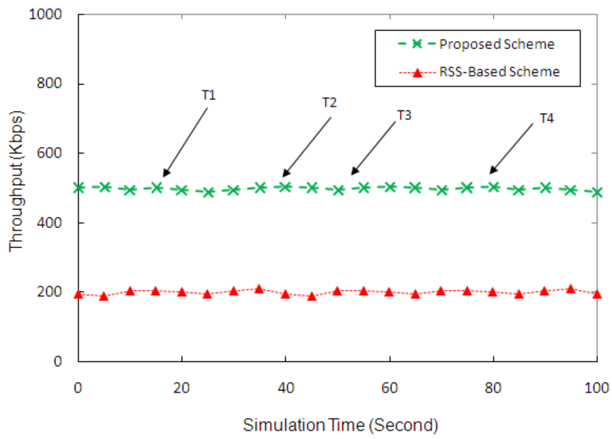

Figure 5: Throughput Achieved by Fixed Station.

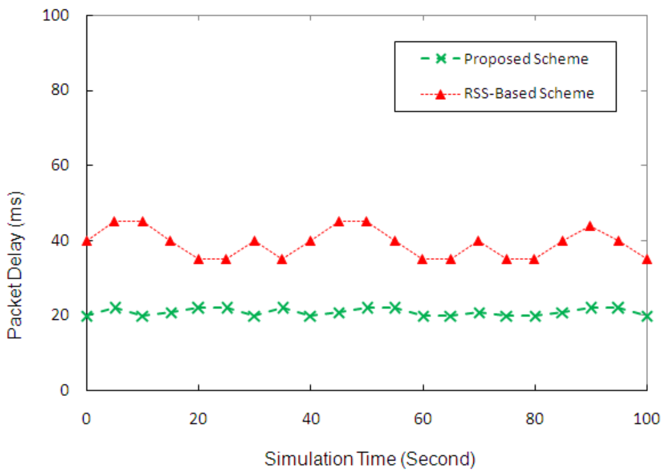

Figure 6: Packet Delay Achieved by Fixed Station

Conclusion

In this paper, we have proposed a handoff algorithm that considers both network condition and RSS for avoiding unbeneficial handoffs and for encouraging beneficial handoffs. The simulation result shows that, the proposed algorithm improves the data rate and latency achieved by both mobile and fixed stations. Also, it reduces the number of unbeneficial handoffs and encourages beneficial handoffs significantly. In future our proposed handoff algorithm has to be improved by considering velocity of the mobile device along with the RSS and network condition for better horizontal handoffs and it should be integrated with vertical handoff algorithms in order to support seamless mobility in integrated heterogeneous overlay networks.

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