Incorporating AP Selection and Call Admission Control for Seamless Handoff Procedure

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Abstract

A complete handoff procedure of a mobile node in wireless network includes access point (AP) selection, call admission control (CAC), and IP address allocation. Most current handoff schemes only deal with the Layer-3 address allocation, that is, the IP address re-allocation. Without the integration with AP selection and CAC, the mobile node (MN) may be disconnected before a new IP address is allocated, which makes seamless handoff impracticable.

*In this paper, an integrated system is proposed. Firstly, AP selection is accomplished by choosing the AP with the smallest number of users associated with. We gather the information of active users on each AP through the modified beacon frames. Then, both call admission and a new IP address pre-fetch are operated through the DHCP relay simultaneously. Particularly, Fairness-enhanced Limited Fractional Guard Channel Policy (**FLFGCP**) for CAC scheme and two additional thresholds, Dropping Probability Threshold (**DPT**) and Blocking Probability Threshold (**BPT**), are explicitly defined. Both **DPT** and **BPT** are applied to balance the dropping probability of handoff calls and blocking probability of new calls respectively. An OMNET++ simulation which demonstrates the applicability of cooperating the AP selection and call admission control for seamless handoff is included.*

Key words: AP selection, Handoff, Call Admission Control, Fairness-enhanced LFGCP

I. Introduction

With the rapid growth of the deployment of wireless devices, mobile users can easily access the Internet resources via various wireless technology, such as IEEE 802.11[1] and 802.16[2]. As the mobile node (MN) moves, how to provide a seamless handoff is most concerned to users. A complete handoff process involves AP selection, call admission control (CAC), and IP address allocation. Several schemes have been proposed for AP selection in IEEE 802.11 networks, as reported in [3-8]. Once an AP is associated, it should guarantee the service provision via a scheme of call admission control (CAC). Various CAC schemes can be found in [9-12]. Eventually, a new IP address is allocated. Due to the time complexity of address allocation, several address pre-allocation methods have been proposed, as reported in [13-16]. As a result, how to efficiently provide all three handoff functions in an integrated way deserves a research effort.

Conservatively, the three phases of handoff: AP selection, CAC, and IP address allocation are performed in sequence following the disconnection of wireless access, as shown in Figure 1. The duration of handoff could be too long to support real time services, such as VoIP and VOD. In addition, in CAC phase, it is necessary to differentiate handoff calls from new calls to the AP to allow the ongoing services higher priority. Due to the inevitability of link layer processing delay and configuration delay, the operations of all three phases should be performed as soon as possible once the requirement of handoff is determined.

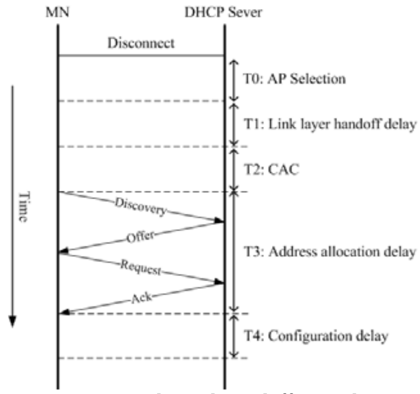

Figure 1. Traditional Handoff Procedure

In our integrated approach, while the Signal-to-Noise Ratio (SNR) is below 30%, AP selection scheme will be triggered to choose an AP with smaller number of users associated with. The figure of associated users at AP, together with the IP address of its DHCP server, is included in the modified beacon frames. Both call admission and IP address pre-fetch are performed through the DHCP relay simultaneously. As the DHCP request arrives via DHCP relay, it is regarded as a handoff call by the DHCP server. Otherwise, the request from an AP is treated as a new call. The CAC engine is embedded in the DHCP server to determine the call admission. A novel CAC policy, fairness-enhanced Limited Fractional Guard Channel Policy (FLFGCP) as well as two additional thresholds: Dropping Probability Threshold (***DPT***) and Blocking Probability Threshold (***BPT***) are explicitly defined in the proposed system. Both ***DPT*** and ***BPT*** are applied to balance the dropping probability of handoff calls and blocking probability of new calls respectively. As a result, most tasks for processing a handoff are accomplished before the disconnection takes place. Thus, the duration of disconnection will be significantly reduced, with the inevitable link layer handoff delay and configuration delay remain, as shown in Figure 2.

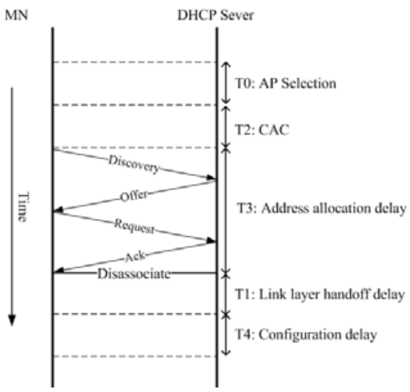

Figure 2. The Proposed Handoff Procedure

The rest of this paper is organized as follows. The proposed system architecture, operational procedure, and algorithms of FLFGCP are presented in Section 2. Section 3 illustrates the evaluation of the proposed system as compared to the traditional handoff procedure. Finally, conclusions and future works are included.

II. An Integrated Seamless Handoff System

The proposed procedure integrates AP selection, CAC scheme, IP pre-fetch mechanism into a seamless handoff system.

No matter what kind of AP deployment, how to select an AP for better performance is essential. In the proposed AP selection scheme, the AP with fewest associated users is chosen as the target AP. The number of associated users is embedded in the modified beacon frame with element ID 99, as shown in Figure 3. The modified beacon frames also carry the IP address of the local DHCP server for the purpose of upcoming IP address pre-fetch. Once the MN decides which AP to be associated with, it delivers the DHCP request to the DHCP server of target network via DHCP relay, as depicted in Figure 4. If the MN is granted, the DHCP server will distribute an IP address and inform the MN by via ACK message.

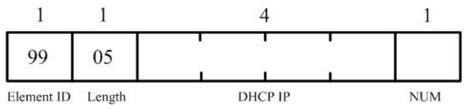

Figure 3. Contents of Information Element of ID 99

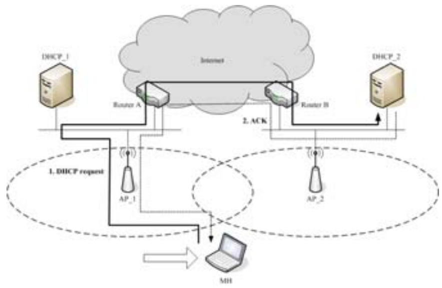

Figure 4. IP Address Pre-fetch

By taking into account the fairness, an enhanced version of Limited Fractional Guard Channel Policy (LFGCP), called **FLFGCP**, is presented to determine the admission of access. In the CAC engine, which is operated in the DHCP server, the DHCP requests via DHCP relay are considered handoff calls, while the DHCP requests from local APs are considered as new calls. Both Dropping Probability Threshold (***DPT***) and Blocking Probability Threshold (***BPT***) are explicitly defined for balancing the dropping probability of handoff calls and blocking probability of new calls respectively. The algorithm of FLFGCP is shown in the following:

```
1   if ( a handoff call arrives )
2       if ( Num_Of_Occupied_Channels < C )
3           admit the call
4       else
5           reject the call
6   if ( a new call arrives )
7       if ( Num_Of_Occupied_Channels < T )
8           admit the call
9       else if ( Num_Of_Occupied_Channels < C ) && ( DP < DPT )
10          admit the call
11      else if ( Num_Of_Occupied_Channels < C ) && ( BP > BPT ) && ( random (0,1) ≧ β )
12          admit the call
13      else
14          reject the call
```

TABLE 1: TIME MARKS ALONG THE MN MOVES

	Associtae with G1	Disassociate with G1	Associtae with G2	Disassociate with G2	Associtae with G3	Disassociate with G3
Traditional Scheme	2.9042	36.3649	39.2766	72.8529	75.7645	109.3369
Proposed Scheme	2.9042	31.8786	31.8827	68.3666	68.3708	109.3369

TABLE 2: TIME ALLOCATED IN EACH STAGE

	Associtae with G1	Stay in G1	Handoff to G2	Stay in G2	Handoff to G3	Stay in G3	Connection Time
Traditional Scheme	2.9042	33.4607	2.9117	33.5763	2.9116	33.5724	100.6094
Proposed Scheme	2.9042	28.9744	0.0041	36.4839	0.0042	40.9661	106.4244

The first part of the algorithm, from line 1 to line 5, deals with the handoff calls. If all the capacities (***C***) are not occupied, the handoff calls always have the priority. The second part, from line 6 to line 14, deals with the new calls. If ***C*** of the AP is below the threshold (***T***), the new call will be admitted, otherwise it is subject to be rejected. In line 9 and line10, if the dropping probability (***DP***) of handoff calls is low, the new calls are also admitted due to the considerable resources are reserved for handoff calls. Line 11 and 12 indicate that, though ***DP*** is higher than ***DPT***, the new call could be approved because the blocking probability (***BP***) is exceeded. To balance the ***DP*** and ***BP***, a new call is admitted in a random fashion. The value of ***β*** is increased as the increase of ***DP***, with ***DP*** as default value, to preserve the capacity for handoff calls. The larger the dropping probability, the higher priority of handoff calls, as opposed to new calls. Finally, in line 13 and 14, the new call is rejected if the capacity has been consumed and the ***DP*** and ***BP*** are already balanced.

III. System Simulation and Evaluation

The evaluation environment is simulated using OMNet++. The simplified experimental environment consists of six APs in three groups and a number of random users being associated with each AP, as shown in Figure 5. The targeted MN moves from left to right, and two occasions of handoff requests. As the MN movers, it chooses one of two candidate APs from each group. Over a total 109.3369 seconds of constant movement, both the connection time and disconnection time are measured. The time spent in handoff is also monitored. The procedure is repeated for 22 times. We calculate the average time with the highest and lowest time being excluded.

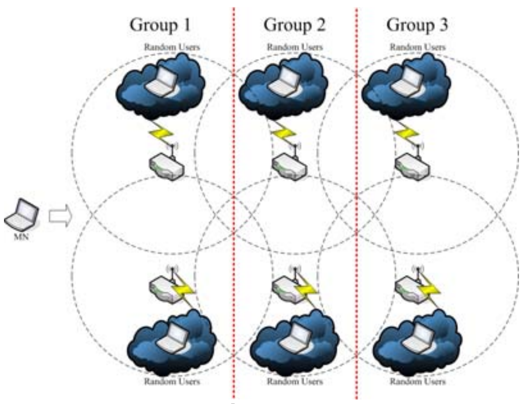

Figure 5. Evaluation Environment

The total disconnection time includes the time of the MN attempting to associate with an AP in Group 1, the time during the switches (from Group 1 to Group2 and from Group 2 to Group 3), and the time of the MN leaving Group 3 on 109.3369 seconds. Initially, in the case that the MN just entered into the Group 1, no AP is associated with, hence both traditional handoff scheme and the proposed scheme spend about the same time to establish the connection, which costs is 2.9 seconds, as shown in Table 1.

The comparisons of time spent in each stage as the MN moves between traditional handoff scheme and the proposed handoff schemes are presented in Table 2. Due to the MN with the proposed handoff scheme attempts to associate with the next AP while the SNR is below 30%, the time of the MN stays in Group 1 is less then the time for the case of traditional handoff scheme. In addition, the MN with the proposed handoff scheme can not discover any AP while the SNR is below 30% in Group 3. Thus, the time of the MN stays in Group 3 is longer than the time of it stays in Group 2. Under the proposed handoff scheme, the time of AP selection, IP address allocation, and CAC are pre-processed before the disconnection occurs. Accordingly, the handoff duration can be reduced to near 0.004 seconds, as in contrast to more than 2.9 seconds using traditional handoff scheme.

IV. Conclusion

In this paper, a seamless handoff scheme with the integration of AP selection, call admission control, and IP address allocation is proposed. AP selection is accomplished by choosing the AP with the smallest number of users associated with. Both call admission and a new IP address pre-fetch are operated through the DHCP relay. Particularly, Limited Fractional Guard Channel Policy (FLFGCP) for CAC scheme and two additional thresholds, Blocking Probability Threshold (***BPT***) and Dropping Probability Threshold (***DPT***), for the purpose of balancing the blocking probability of new calls and dropping probability of handoff calls are explicitly defined. Finally, we demonstrate the applicability of the integrated approach by the simulation using OMNET++.

The results of the evaluation indicate that the proposed handoff scheme is efficient. The effects of pre-processing AP selection, CAC, and IP allocation can significantly reflect the time reduction for AP switch. the handoff duration can be reduced to near 0.004 seconds, as in contrast to more than 2.9 seconds using traditional handoff scheme. A further study might be to expand the simulation to cope with a more complicated environment, such as taking into consideration the moving speed of the mobile node. The availability of the mobile node as it moves promptly does deserve future research effort.

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