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AP selection method considering WLAN condition

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Abstract

This document discusses AP selection method utilizing the number of frame retransmissions in addition to received signal strength (RSSI). In a real environment, WLANs are congested by lots of mobile nodes, and sometimes influenced by other WLAN devices. They result in deterioration of communication quality. In such environment, each mobile node has to select an AP with better performance for keeping its own communication stable. To enable this, we employ the number of frame retransmissions and RSSI as selection indexes. We then describe an architecture design and implementation for our proposed scheme.

Table of Contents

1. Introduction

Wireless LANs (WLANs) based on the IEEE 802.11 specification [1] provide high data transmission and simple, low-cost installation. For this reason, WLANs have been spreading rapidly in both private and public spaces, so that these WLANs will overlap to provide continuous and wide coverage as the underlying basis of ubiquitous networks. In such ubiquitous WLANs, mobile nodes (MNs) can access the Internet from everywhere and at anytime.

In WLANs, an MN requires not only permanent access to the Internet, but also seamless movement between access points (APs) without degradation of communication quality, i.e., seamless mobility is essential. Furthermore, in such ubiquitous WLANs, each AP will independently provide wireless Internet connectivity based on IEEE 802.11 technology. That is, the WLAN coverage consists of different IP subnets due to independent management by different organizations and operators. In such a situation, even if a mobility support technology applying to AP is developed and standardized, from now on, it will be difficult to replace all APs, which have been spreading, with new APs that support mobility technology. Moreover, since existing APs may not be able to accept such technologies due to restrictions such as lower CPU performance or less memory, update of APs' software for supporting mobility technology is also not realistic. Therefore, it is desirable to provide a seamless mobility technology without modification of APs.

To achieve such seamless mobility, the following two requirements must be satisfied: (1) selection of an AP with better performance from among multiple candidate APs and (2) preservation of communication quality during handover. For (2), we proposed a handover management scheme based on the number of frame retransmissions [2-4]. In the proposed scheme, an MN is assumed to move between WLANs with different IP subnets. In [2], we first employed multi-homing architecture to prevent a disruption period due to handover processes. That is, since an MN with two WLAN interfaces (a multi-homing MN) can connect to two APs simultaneously before starting handover, an MN never experiences a disruption period due to handover processes. Next, to properly switch the two associating APs based on each wireless link quality, the number of frame retransmissions was introduced as an indicator for detecting the wireless link condition. Although the Received Signal Strength Indicator (RSSI) is generally used as an indicator of a wireless link quality, we showed that the RSSI is insufficient to detect wireless link condition precisely because it is incapable of detecting the degradation of communication quality due to radio interference [5]. On the other hand, we showed that the number of frame retransmissions could promptly and reliably detect the performance degradation due to reduction of the RSSI and radio interference. Therefore, the proposed handover management method based on the number of frame retransmissions can preserve communication quality during a handover.

Selection of an AP with better performance from among multiple candidate APs, however, remains unresolved. For example, in the method proposed in [2], even if an MN has two WLAN interfaces to eliminate a disruption period due to handover process, there is no guarantee that the MN can select an AP with better performance for a handover. In ubiquitous WLANs, the MN may find multiple candidate APs at one time and needs to select an appropriate AP from among them. At this time, if an AP with better performance is not selected appropriately, the communication quality may degrade after a handover. In the current general AP selection, an MN selects an AP with the strongest RSSI. However, since numerous APs and MNs will exist in high-density ubiquitous WLANs, radio interference, which degrades communication quality, occurs frequently due to both the lack of the number of channels and heavy traffic in the AP. Thus, an AP selection method considering not only RSSI reduction but also radio interference caused by other WLAN devices is essential for achieving seamless mobility.

So far, there have been numerous discussions on AP selection for improving the communication performance of MNs in WLANs[6-10]. In ubiquitous WLANs, since an MN must be able to freely connect with all APs for an inter-domain handover, it is desirable that an AP is not modified in order to maintain compatibility with existing APs. Almost all existing AP selection methods [6-9], however, necessitate some modifications of APs, e.g., additional information should be inserted in the beacon frame transmitted from the AP. Moreover, the modification needs to be implemented in both an AP and an MN. On the other hand, [10] explained that the effects from hidden mobile nodes affect throughput degradation.

In the method proposed herein, although modification of an AP is unnecessary, the method is applied to only IEEE 802.11e, which has not yet become widespread. Therefore, in this article, we focus a new proactive AP selection method based on RSSI and frame retransmissions. Since we have showed that the number of frame retransmissions is useful to detect radio interference in [5], this article describes how to utilize the number of frame retransmissions to AP selection method achieved in end-to-end. The proposed AP selection method enables an MN to select an AP with better performance taking radio interference into consideration by exploiting the number of frame retransmissions in addition to the RSSI.

2. AP Selection Method

Here, we describe the proposed AP selection method. We first describe the concept of the proposed method in Section 2.1. In Section 2.2, we describe the proposed method with flowcharts.

2.1 Concept of the proposed AP selection

This article focuses on a proactive AP selection for a radio interference environment. In the handover method, we proposed in a previous study [11], a multi-homed MN appropriately switches WLAN interfaces (WIFs) according to wireless link condition.
Figure 1 shows an overview of operation between a handover and an AP selection on an MN. An AP selection is performed on the WIF2 during communicating through the WIF1. On the other hand, after a handover, since the communication switched to the WIF2, the AP selection is next executed on the WIF1. That is, the AP selection is always executed on an idle interface.

```
      +-------------------------------------------------------+
      |                      Application                      |
      +-------------------------------------------------------+
        |                 +---------------+
      +-|-----------+     | AP selection  |     +-------------+
      | | IP Layer  |     +---------------+     | IP Layer    |
      +-|-----------+                   |       +-------------+
      | | MAC Layer |                   +------>| MAC Layer   |
      +-|-----------+                  control  +-------------+
      | | PHY Layer |                           | PHY Layer   |
      +-|-----------+                           +-------------+
        | communication
        V                         A
                                  |
                                  | handover
                                  |
                                  V

      +-------------------------------------------------------+
      |                      Application                      |
      +-------------------------------------------------------+
                          +---------------+                 |
      +-------------+     | AP selection  |     +-----------|-+
      |   IP Layer  |     +---------------+     | IP Layer  | |
      +-------------+       |                   +-----------|-+
      |   MAC Layer |<------+                   | MAC Layer | |
      +-------------+  control                  +-----------|-+
      |   PHY Layer |                           | PHY Layer | |
      +-------------+                           +-----------|-+
                                              communication |
                                                            V
```

Fig.1: A handover and an AP selection on an MN

2.2 Details of the AP Selection Method

In this section, we describe the proposed AP selection method. The AP selection method is divided into two main parts: the AP selection procedure and the AP search procedure, as shown in Figures 2 and 3, respectively. In both figures, words in CAPITAL denote the system parameters in the proposed AP selection method. In the AP selection procedure, an MN periodically investigates the wireless link condition of an associating AP and decides whether the wireless link has sufficient wireless link quality. On the other hand, in the AP search procedure, an MN scans candidate APs and selects an AP with better performance from among them.
Hence, MN starts the AP search procedure only when it detects the degradation of the communication quality on the current interface

by exploiting the number of frame retries. That is, MN does not start the AP search procedure even when the RSSI degrades unless the frame retries increases.

```
                          start
                            |
                            V
     send PPC probe packets at PPI ms interval
                            |
                            V
      obtain retry count at each probe packet
                            |
                            V                            no
  # of packets with more than frame retries >= RCT ---+
                            | yes                         |
                            V                             |
          execute procedure of AP search                  |
                            |                             |
                            V                             |
            update network configuration                  |
                            |                             |
                            V                             |
                           end <-------------------------+
```

Fig.2 Flowchart of AP selection procedure

```
                          start
                            |
                            V
                     make an AP list
                            |
                            V
      remove the APs that were associated with
          immediately preceding WIF1/WIF2
                            |
   no                       V
+--- is there one or more available AP in the list? <---+
|                           | yes                         |
|                           V                             |
|   associate with an AP in order of strong RSSI          |
|                           |                             |
|                           V                             |
|    send PPC probe packets at PPI ms interval            |
|                           |                             |
|                           V                           no|
| # of packets with more than ERC frame retries < RCT --+
|                           | yes
|                           V
+----------------------> end
```

Fig.3 Flowchart of the AP search procedure

In this section, in order to clarify the proposed AP selection method, we assume that an MN with two WIFs (the WIF1 and the WIF2) first communicates through the WIF1, and the WIF2 associates with an AP with better performance at this time. Hence, the AP selection procedure is executed on the WIF2. Initially, the MN starts a timer to control the AP selection procedure, i.e., the AP selection procedure is periodically executed at each AP Selection Execution Interval of APSEI seconds based on the timer. This is because an MN needs to periodically investigate the wireless link condition of the associating AP in order to detect changes in the wireless link quality due to the movement of the MN and radio interference. If the AP selection method is not periodically executed, an MN unfortunately maintains the association with the AP until its wireless link quality clearly degrades, similarly to an AP selection based on the RSSI. This causes severe degradation of the communication quality at handover. When the AP selection procedure is executed, the WIF2 sends probe packets to the AP at constant intervals. The Probe Packet Count (PPC) denotes the number of probe packets for one AP, and the Probe Packet Interval (PPI) indicates the sending interval of probe packets. After sending all of the probe packets, the MN obtains the number of frame retransmissions for each probe packet. If the number of probe packets experiencing more than Experienced Retransmission Count (ERC) retransmissions is less than the Retransmission Count Threshold (RCT), the MN decides that the AP has good wireless link condition and maintains the connection with the AP. After selecting an AP with better performance, the procedure terminates and then the MN executes the AP selection procedure every APSEI seconds.

In contrast, if the number of probe packets that experience more than ERC frame retransmissions exceeds RCT, i.e., the AP associated with the WIF2 is not an AP with better performance, an AP search procedure is executed. As shown in Fig. 3, in the AP search procedure, the MN first makes a list of all candidate APs detected by the WIF2, and removes the APs currently associated by the WIF1/2 from the list. In our approach, to efficiently find an AP with better performance, our proposed method first checks the RSSI of candidate APs because the RSSI can be easily and passively obtained than the number of frame retransmissions. That is, it does not need both establishment of the association with APs and the packet transmission of probe packets. Therefore in our proposed scheme, after temporary sorting the candidate APs based on the strength of the RSSI, the MN investigates the APs by exploiting the number of frame retransmissions in order of high RSSI. If not sorting, the MN may transmit unnecessary packets to an AP with low performance (low RSSI), not to an AP with good performance (high RSSI). Hence, creation of an AP list based on RSSI prevents the unnecessary packet transmissions and shortens the detection time as much as possible. In the flowchart, if the number of packets experiencing more than ERC-times frame retries exceeds RCT, our proposed scheme detects the degradation in the wireless condition of the selected AP degrades and then the investigation is repeated in order of high RSSI until finding an AP with better performance. If an AP with better quality cannot be found, the MN retries the AP search at the next AP selection, i.e., after APSEI seconds.

After finishing these procedures, the MN can select an AP with low radio interference and strong RSSI.

3. Conclusion

In this article, in order to select an AP with better performance from among multiple candidate APs in ubiquitous WLANs, we discussed a proactive AP selection method based on frame retransmissions and the RSSI. In an AP selection based on only the RSSI, an MN cannot always select an AP with better performance in ubiquitous WLANs, because the RSSI alone cannot detect the degradation of wireless link quality due to radio interference. We therefore used the number of frame retransmissions as an index for detecting radio interference in addition to the RSSI and then proposed an AP selection method for the proposed handover management system.

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