A WLAN Handoff Scheme based on Selective Channel Scan using Pre-collected AP Information for VoIP Application

SungRae Kim, KyungJoon Kim, JaeJong Baek, JooSeok Song
Department of Computer Science
Yonsei University, Seoul, Korea
Email:{ksr200, theboy, jjb27, jssong}@emerald.yonsei.ac.kr

Abstract

Recently, many researchers have investigated the Voice over IP (VoIP) service over Wireless Local Area Networks (WLANs). One of the important challenges is to reduce the handoff delay in WLANs. Especially, the channel scan delay, which takes the largest portion of the WLAN handoff delay, is too long to support the delay-sensitive VoIP service. We propose a selective channel scan based on the pre-collected channel information of the neighboring access points (APs) to reduce the channel scan time. Mobile Stations (MSs) collect the channel information of neighboring Access Points (APs) when the VoIP is not used. When the VoIP service is used, MSs perform the selective channel scan mechanism based on the collected channel information. We use the handoff trigger based on the Inter-Arrival Time (IAT) of VoIP packets instead of Received Signal Strength Indication (RSSI). We evaluated the performance of the proposed scheme through computer simulations. The simulation results show that our scheme reduces the handoff delay enough to support the VoIP service over WLANs.

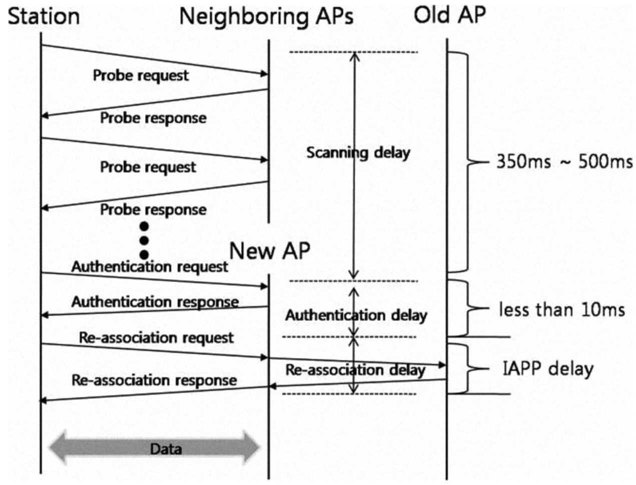

Figure 1. The WLAN handoff procedure and delay

1 Introduction

Nowadays, many users use the Voice over IP (VoIP) service over the wired network but users want to use the VoIP service over the wireless network too. Providing the VoIP service over the wireless network is more difficult than the wired network. However, recently the wireless technology has been improved enough to support the VoIP service. Especially, Wireless Local Area Networks (WLANs) are easy to install and support high data rates. One drawback of WLANs is small coverage area. The drawback can be overcome by handoff between Access Points (APs). However, it takes hundreds millisecond of delay for handoff from one AP to another AP. The delay of hundreds millisecond is tolerable to the TCP application but it causes call disruption to the VoIP. The delay time of WLANs handoff consists of the scan delay, the authentication delay and the re-association delay. Figure 1 shows the handoff procedure and the delay of the WLANs.

Among the delay factors of the WLAN handoff, the scan delay takes approximately 95% of the WLAN layer-2 handoff delay. Generally, people do not recognize the call disruption for the delay under 50 *ms*[9]. Therefore, we have to reduce scan delay so that the WLAN handoff latency is maintained under 50 *ms* to guarantee the QoS. In this paper, we propose the selective channel scan based on the pre-collected information and the handoff trigger based on the VoIP packet loss.

978-1-4244-5700-7/10/$26.00 ©2009 IEEE

2 WLAN Handoff Trigger and Channel Scan

There are three handoff trigger methods. One method is to trigger handoff by checking the number of frames which have not been acknowledged. This method is efficient when Mobile Stations (MSs) transmit frames continuously, but it is hard to detect loss of frames without communication. Another method checks beacon messages for fixed intervals[3]. Typical interval between beacon messages is 100 *ms*[2]. If the handoff is triggered when MSs do not receive a series of five beacon messages, the delay for trigger is 500 *ms*. The other method which is generally used is based on the Received Signal Strength Indication (RSSI). In this method, the handoff is triggered when the RSSI is maintained under the threshold value.

The AP scan delay takes most of WLAN layer-2 handoff. There are two kinds of scan methods. One method is the passive scan and the other method is the active scan.

In the passive scan, MSs listen to beacon messages generated by APs every 100 *ms*. When there are 11 channels and MSs listen to beacon messages for 100 *ms* per one channel, the scan delay is 1.1 second. This 1.1 second delay only for channel scan is too long to guarantee the QoS.

In the syncscan proposed by Ramani and Savage each AP broadcasts beacon messages according to the predefined schedule[7]. MSs receive the beacon messages by switching channels when beacon messages are broadcasted on the channel. The merit of the syncscan is that MSs do not need to wait for long time. However, APs have to be synchronized exactly and if two or more APs use the same channel, they can interfere with each other.

Meanwhile, in the active scan, MSs do not wait to receive the beacon information from APs. MSs broadcast probe request messages to each channel and wait for probe response messages. The proactive scan scheme proposed by Haitao Wu et al. adopted active scan but MSs do not scan all channels at once[9]. In the proactive scan, MSs perform the active scan for only one channel and return to the old AP and receive the buffered packets. After receiving the buffered packets, MSs scan the next channel. A drawback of the proactive scan is that whole handoff delay becomes longer because MSs must return to the old AP and receive the buffered packets for a while. Once, a handoff has been triggered, it means that the channel condition with the old AP is not good enough. Besides, it is not guaranteed that the buffered packets will be delivered to MSs without any error. In addition, the buffering at APs causes additional delay and jitter for VoIP packets. Though the buffered VoIP packets are delivered, the VoIP packets become useless if the VoIP packets do not arrive within the valid time. Also, the TCP can suffer from performance degradation cased by frequent handoffs. Whenever WLAN handoffs are triggered the TCP window size is reduced so that the throughput of the TCP is decreased.

In the selective channel scanning using neighbor graph proposed by Hye-Soo Kim et al. MSs perform the selective channel scan using the neighbor graph of APs[4]. The neighbor graph cache mechanism proposed by Chung-Sheng Li et al. stores additional information about APs for fast association[6]. However, in these schemes, there is no priority among neighboring APs and additional equipments should be installed. In the location-based fast handoff approach proposed by Chien-Chao Tseng et al. MSs can derive prospective APs using location information[8]. In the scheme, MSs must measure their position using global positioning system (GPS) or other localization technique. In the indoor tracking-based handoff mechanism proposed by CheolHee Lee et al. MSs measure their position using the WLAN interface based on the RSSI of multiple APs[5]. MSs perform handoffs to neighboring APs using location information. However, if location of APs is changed, environment parameters must be updated.

3 Proposed Scheme

Most WLAN handoff schemes use the handoff trigger based on the RSSI. However, the RSSI becomes unstable as MSs go away from the associated AP. Therefore, MSs can not figure out proper handoff time with only the RSSI information. In addition, strong signal only does not guarantee the QoS of the VoIP service. Though a AP has a good RSSI, if the AP has not enough resources because many MSs are associated with the AP, the QoS of the VoIP service is not guaranteed.

In our handoff scheme, we use handoff trigger based on packet loss. In the VoIP service, call disruption longer than 50 *ms* makes communication difficult[9]. Thus, we initiate handoffs when MSs do not receive enough VoIP packets for fixed interval. In our scheme, the application layer controls the WLAN handoff. The application can control the handoff through the IEEE 802.21 Media Independent Handoff (MIH)[1]. Therefore, it is possible to distinguish the VoIP packets from packets of other applications. Also, layer-2 information like Inter-Arrival Time (IAT) can be transferred to the application layer through the MIH. The VoIP application requires handoff trigger that initiate handoff as soon as the VoIP service faces any problems. However, this causes frequent handoffs and it may result in throughput degradation to the TCP. For the reason, MSs use different handoff trigger for the VoIP and the TCP in our scheme. We will call a period when the VoIP is busy as busy state, and a period when the VoIP is not busy as the idle state. In our scheme, MSs use the handoff trigger based on the RSSI in idle state but the VoIP application control the WLAN handoff in busy state. Therefore, our scheme does not affect the TCP when the VoIP is not busy.

Typically, the movement pattern of users has a tendency in a limited area. If MSs know such a movement pattern of users, MSs can predict the users' route and the next AP. If MSs know the channel of the next AP, MSs do not need to perform full scan for all channels. MSs can reduce channel scan time by scanning from the channels of known neighboring APs. We define such a channel information of neighboring APs as AP history (APH) and management program as AP History Manager (APHM) which can be accessed by VoIP applications. The BSSID of the associated AP and the channel information of neighboring APs are stored in the APH. The APH does not store BSSID of neighboring APs because there can be multiple APs using the same channel and MSs can get BSSID through channel scan. It is critical to try to associate with APs without the channel scan because sometimes the APs may have some problems.

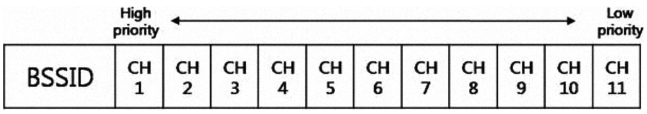

Figure 2. Structure of the APH.

Figure 2 shows structure of the APH. The first slot of the APH is for the channel with the highest priority and the last slot is for the channel with the lowest priority. The APHM does not collect the channel information during the busy state because channel information collection can cause the additional handoff delay. Generally, VoIP devices must be turn on even though they are not busy to receive incoming calls. Therefore, MSs can collect the channel information of APs during the idle state. If MSs have incoming calls during the full channel scan for the APH update, MSs can notify incoming call after the handoff. However, it is less critical than the call disruption during the conversation. Figure 3 shows the handoff procedures of our scheme. The handoff procedure in the idle state is shown below:

1. MSs perform full channel scan.
2. The channel of the AP which has the biggest RSSI value is transferred to the APHM.
3. The APHM updates the APH.
   - If the old AP's BSSID does not exist in the APH, then the APHM creates the index for the old AP and inserts the transferred channel into the first slot.
   - If the old AP's BSSID exist in the APH,
     - if the transferred channel does not exist in the APH, then the APHM inserts the transferred channel into the first empty slot of the old AP.
     - if the transferred channel exists in the APH, then the APHM swaps the transferred channel with the front channel to grant high priority.

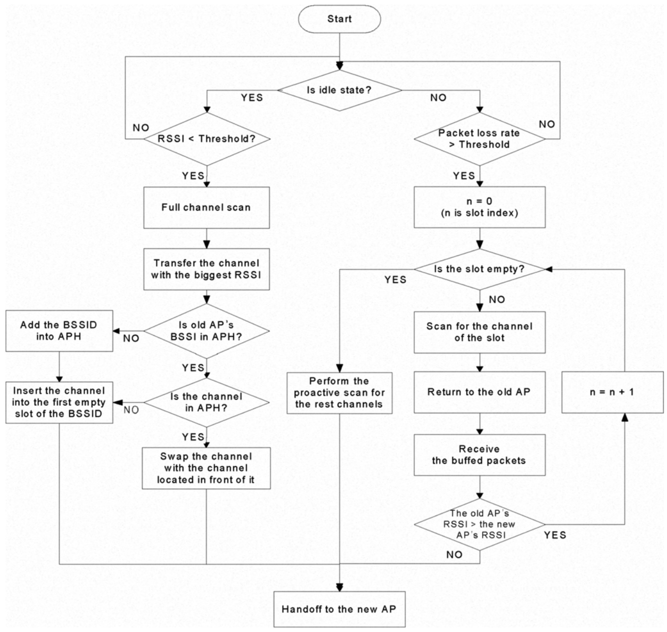

Figure 3. The handoff procedure of the proposed scheme

The handoff procedure in the busy state is shown below:

1. In the busy state, when the 30 % of the VoIP packets are lost for 200 *ms*, the handoff is triggered.
2. MSs bring channel information of neighboring APs from the APH.
   - If there is no available channel information, then MSs perform the proactive channel scan for the rest channels.
   - If there is available channel information, then MSs perform channel scan for the channel.
3. MSs return to the old AP and receive the buffered packets.
4. MSs decide handoff.
   - If the new AP's RSSI value is larger than old AP's RSSI value, then MSs handoff to new AP.
   - If the new AP's RSSI value is equal or little than old AP's RSSI value, MSs repeat handoff procedure for the channel of the next slot from the procedure 2.

We use only the RSSI to decide the handoff because MSs can get the information easily for short channel scan time. However, If other information such as the load on the new AP is available the information can be applied for the handoff decision.

4 Performance Evaluation

We evaluated the performance of the proposed scheme through the NS-2 simulation. Figure 4 shows the scenario of our simulation. We assumed that a MS moveed from the AP1 to the AP5 and coverage of all APs was overlapped. The movement speed of the MS was 1 *m/s*. The MS was supposed to receive 50 packets per second and the MS already collected channel information of the APs. There were no other MSs which are associated with the APs. In the simulation we used the handoff trigger based on the VoIP packet loss and used the proactive channel scan.

We considered three cases.

- Case 1: Handoff is triggered when more than 20 % of VoIP packets are lost during 200 *ms*.
- Case 2: Handoff is triggered when more than 30 % of VoIP packets are lost during 200 *ms*.
- Case 3: Handoff is triggered when more than 50 % of VoIP packets are lost during 200 *ms*.

Figure 5 shows the number of arrived packets for the handoff from the AP1 to the AP2 according to the handoff trigger schemes. Figure 6 shows the IAT between VoIP packets for the same simulation result with the Figure 5. In case 1, VoIP packets were continuously lost because handoff was triggered too many times by the ping-pong effect. In case 2, the handoff was triggered once and the number of lost packets is the minimum. In case 3, the handoff was triggered too late and many VoIP packets are lost before the handoff. Based on the simulation results, we judge 30 % of packet loss is suitable criteria for the handoff trigger for VoIP.

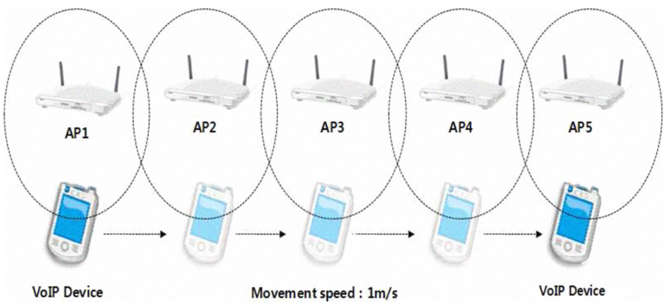

Figure 4. Scenario of the simulation

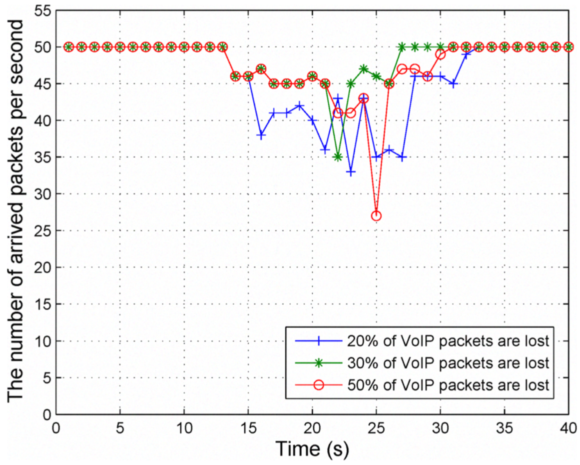

Figure 5. The number of delivered packets according to handoff triggers

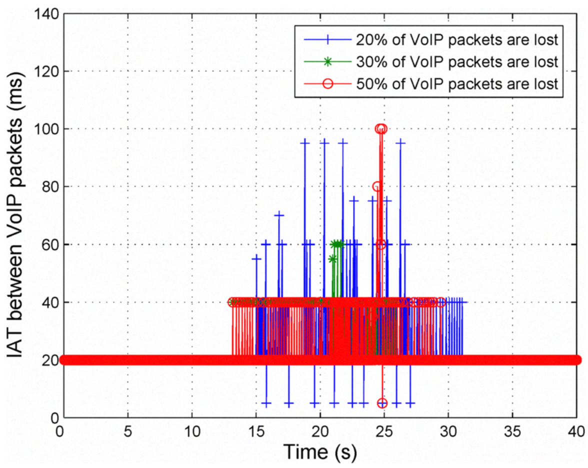

Figure 6. IAT between VoIP packets according to handoff triggers

Also, we performed simulation using different channel scan schemes. Figure 7 shows the number of arrived packets per second for the full channel scan, the proactive scan scheme and our selective channel scheme based on precollected channel information. Figure 8 shows the IAT between VoIP packets for the same simulation result with Figure 7. In the simulation, the handoff was triggered when more than 30 % of VoIP packets are lost for the proactive scan and the selective scan. We used the handoff trigger provided by the NS-2 simulator for the full channel scan. The handoff using selective channel scan and the handoff using proactive scan started the channel scan at the same time but the selective channel scan was finished earlier because it

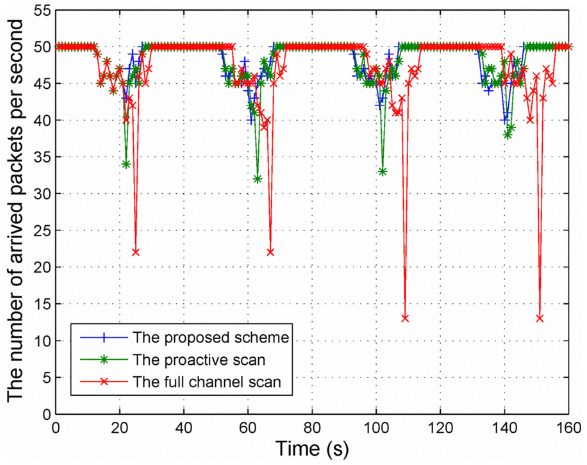

Figure 7. The number of delivered packets according to channel scan schemes

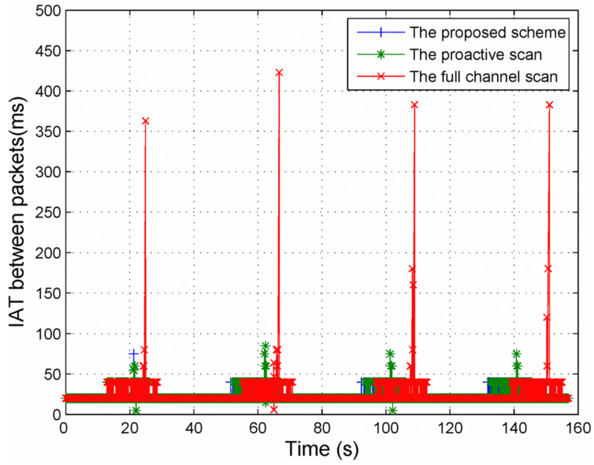

Figure 8. IAT of VoIP packets according to channel scan schemes

scanned fewer channels. In the selective scan, there are few gaps where the IAT between VoIP packets are longer than 50 *ms*. Meanwhile, in the proactive scan, there are many gaps where the IAT between VoIP packets are longer than 50 *ms* because of MSs did channel scan for all channels. The gaps more than 50 *ms* mean possibility of communication problem. The handoff latency of the full channel scan is much bigger than the selective scan and the proactive scan.

5 Conclusion

In this paper, we propose the selective channel scan scheme based on the pre-collected channel information of neighboring APs. The application on MSs collects information of neighboring APs by itself. Therefore, the information update of neighboring APs is done automatically and the proposed scheme requires no additional equipments. MSs perform the channel scan according to the collected channel information of the neighboring APs so that MSs do not need to perform the full scan for all channels. Frequent handoffs cause the TCP to suffer from performance degradation. In the proposed scheme, the handoff trigger based on the VoIP packet loss is used only when the VoIP is used so that the TCP applications are not affected when the VoIP is not used.

6 Acknowledgments

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MEST)(2009-0076476).

References

[1] IEEE 802.21, Media Independent Handover Services.

[2] IEEE 802.11. Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications., 1999.

[3] Agere Systems. *Roaming with ORiNOCO/IEEE 802.11*, December 1998.

[4] H.-S. Kim, S.-H. Park, C.-S. Park, J.-W. Kim, and S.-J. Ko. Selective Channel Scanning for Fast Handoff in Wireless LAN using Neighbor Graph. *ITC-CSCC*, 2004.

[5] C. Lee, S. Seo, and J. Song. An Indoor Tracking-based Handoff Mechanism for VoIP Applications in IEEE 802.11 WLANs. In *Information and Automation for Sustainability, 2008. ICIAFS 2008. 4th International Conference on*, pages 324–329, Dec. 2008.

[6] C.-S. Li, Y.-C. Tseng, and H.-C. Chao. A neighbor caching mechanism for handoff in ieee 802.11 wireless networks. In *Multimedia and Ubiquitous Engineering, 2007. MUE '07. International Conference on*, pages 48–53, April 2007.

[7] I. Ramani and S. Savage. SyncScan: Practical Fast Handoff for 802.11 Infrastructure Networks. In *INFOCOM 2005. 24th Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE*, volume 1, pages 675–684 vol. 1, March 2005.

[8] C.-C. Tseng, K.-H. Chi, M.-D. Hsieh, and H.-H. Chang. Location-based fast handoff for 802.11 networks. *Communications Letters, IEEE*, 9(4):304–306, April 2005.

[9] H. Wu, K. Tan, Y. Zhang, and Q. Zhang. Proactive Scan: Fast Handoff with Smart Triggers for 802.11 Wireless LAN. In *INFOCOM 2007. 26th IEEE International Conference on Computer Communications. IEEE*, pages 749–757, May 2007.