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A Channel Splitting Technique for Reducing Handoff Delay in Wireless Networks

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***Abstract*— Handoff management plays an important role in next generation wireless network for providing the Quality of Service to the mobile users. Wireless Mesh Network (WMN) is the most promising and cost-efficient next generation wireless network for providing large-scale internet based wireless access. The Intergateway handoff is a major concern to guarantee continuous communications in Internet-based Wireless Mesh Networks (WMN). The previous system focus on intragateway handoff designed for single-hop wireless access network that supports only low handoff delay but there is no consideration for reducing the long handoff delay in WMNs due to the existence of multi-hop wireless links. In this paper, we are reducing the long handoff delay factor by proposing a channel splitting technique in multihop wireless link. By using channel splitting technique, the handoff delay in WMNs is guaranteed and channel utilization is improved. The data traffic is reduced and hence high throughput is achieved. The NS2 simulated results shows that handoff performance can be improved by our proposed handoff technique.**

***Index Terms*—Wireless Mesh Network, Intergateway handoff, Multihop, Channel Splitting.**

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I. INTRODUCTION

The next generation wireless network has most promising features and wide range of functionalities. The Wireless Mesh Network (WMN) is one of the cost-efficient for providing large scale internet access. WMN have the potential to deliver internet broadband access, wireless local area network coverage and network connectivity for stationary or mobile host. WMN provides the multi-hop and multi-path connection to form a wireless environment of MESH framework so that the occurrence of single point can prevent the failure[1][2].

In Fig. 1, WMN is composed of combination of mobile Mesh Clients (MCs) and static Mesh Routers (MRs). Mesh Routers form a wireless multi-hop backbone network. Mesh Router access the network via a Mesh Router which serve as the wireless access point(AP). Some Mesh Router act as a gateway. Mesh Router which are connected to internet entry points to other Mesh Routers via ingle-hop or multi-hop wireless links. Wireless communication is without a doubt a very desirable service as emphasized by the tremendous growth in both cellular and wireless local area networks. primarily, the ones that are compliant with the IEEE 802.11 family of standards, popularly known as Wi-Fi [1].

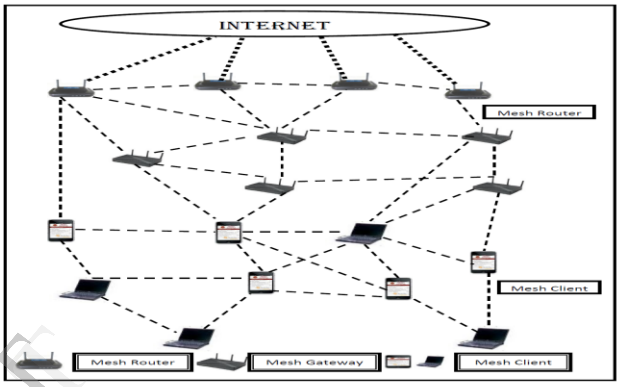

Fig. 1 Wireless Mesh Network

This paper focus on handoff design in WMN. There are two types of handoff in WMN 1) Intergateway handoff 2) Intragateway handoff. The Intergateway handoff occurs when Mesh Client access the internet via different gateway ,then the intergateway handoff process has two steps

i. Link-layer handoff
ii. Network-layer handoff

In the link-layer handoff process the Mesh client moves to the new subnet after choosing new Access Point and then it obtains a new IP address and establish new route to the new gateway and act as Home Agent (HA). Intergateway handoff has only Link-Layer handoff since no IP address changes when Mesh Client moves within subnet. So there is no need of updating the IP in Home Agent. The Link-Layer handoff in Intragateway handoff is same as Intergateway handoff. In this paper we focus on only intergateway handoff design in WMN. In the Network-layer handoff, if the signalling packet is End-To-End (ETE) delay is short enough, then the movement of Mesh Client is transparent to applications. Due to the delay of channel access over multi-hop links there exists a very long handoff delay in multi-hop WMN and it degrades the throughput of the network.

In the network-layer, handoff delay is fuelled by the increase in signaling packet ETE delay, which can account for up to 80% of the total intergateway handoff delay. Hence, the multihop ETE delay of signaling packets is a main component of the long intergateway handoff delay in

Internet-based WMNs, particularly when the backbone traffic volume is high. this critical issue is ignored in existing WMN handoff solutions that mostly focus on shortening the link-layer channel scanning delay [3], optimizing Mobile IP [4] for better network-layer handoff support [5] and improving multihop routing in the mesh backbone [6]. Therefore, this paper focuses on reducing the long ETE delay of handoff signaling packets in multihop WMNs. Particularly, we consider the improvement of the intergateway handoff performance by intelligently splitting channel resources to reduce the medium access delay and queuing delay of handoff signaling packets at each MR. Some packets, including handoff signalling packets, may be dropped by MRs due to buffer overflow or retry threshold exceed, leading to the failure of handoffs. Therefore, the transmission design of handoff signaling packets in the wireless mesh backbone is crucial to the intergateway handoff performance in WMNs.

To overcome this problem we propose a channel splitting technique to split each channel in the wireless mesh backbone into two channels by means of the frequency division multiple-access technique: a data channel and a control channel. The data channel is used to transmit data packets, whereas the control channel is specialized for delivering handoff signaling packets and other control packets. There are also other channel splitting methods proposed previously[7, 8, 9] it has not been well designed to reduce both the link-layer and network-layer handoff latencies in Internet-based WMNs.

In our proposed handoff design, data packets and signalling packets are delivered in separate channels. They do not interfere with each other; thereby, the handoff latency can be maintained within a certain level regardless of the background data traffic.

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II. RELATED WORK

A. Traditional Handoff Process

In the traditional handoff process when a Mesh Client (MC) detects that the RSS from the current Access Point (AP) is below a certain threshold value, then the channel scanning process begins for finding the new Access Point. The MC switches its transceiver to the first channel and sends a Probe Request message. Mean while, it starts the ProbeTimer. When the Probe Timer expires, the MC proceeds to scan the next channel. Having finished scanning all the channels, the MC processes all the received Probe Response messages and determines the AP with the best RSS value as its new AP. Then, the MC switches to the new AP's channel and sends an Authentication Request message to the new AP, which replies an Authentication Response message. After being approved by the new AP, the MC sends a Reassociation Request message to the new AP and then receives a Reassociation Reply message from the new AP to complete the link-layer handoff. If the new AP is connected to a new subnet in the Internet via a new gateway, a network-layer handoff is also needed to update the IP address and/or the routing path between the new gateway and the MC. To initiate the network-layer handoff, the MC first obtains a new IP address either from the new AP or the new gateway. In that case the MC obtains a new IP address from the new AP based on the Mobile IP [10] process. Then, the MC searches an available route to the new gateway and sends a Registration Request message to its HA in the Internet for address update. The HA updates the new IP address of the MC in its database and sends a Registration Reply message to the MC. The whole handoff process is finished when the MC receives data packets from the new AP via the new gateway. During the entire handoff process, several network-layer signaling packets, such as Route Request/Response and Registration Request/Reply, are generated to facilitate the continuous communications of MCs, which may potentially compete with the data packets of other MCs to access channels in the multihop wireless mesh backbone.

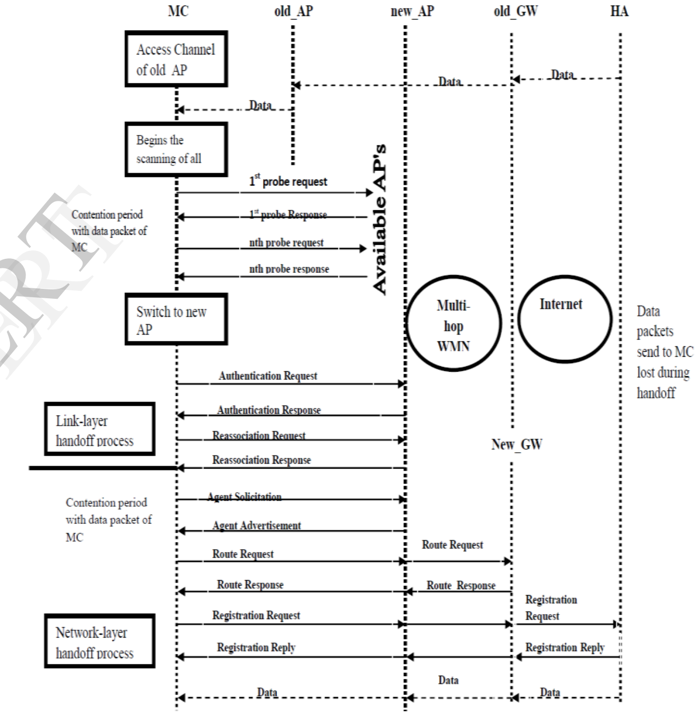

Fig. 2 Traditional Handoff Process in WMNs

Figure 3 is the traditional handoff process graph which was plotted between number of handoff Vs handoff delay in the traditional network. The graph shows that the handoff delay is high when the number of handoff is increased. In the traditional method only single queue is designed which increases the traffic load and degrades the throughput of the network.

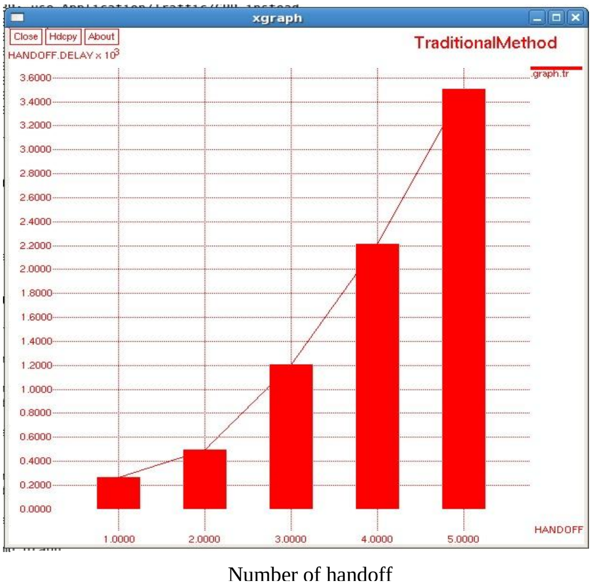

Fig. 3 Traditional Handoff Process Graph

B. WMN Handoff Management

Various solutions on WMN handoff management have been proposed to optimize the handoff process in order to shorten the handoff latency [11]. [12] points out that the channel scanning delay accounts for more than 90% of the overall link-layer handoff delay. Hence, different link-layer handoff schemes are proposed on improving the channel scanning process to reduce the link-layer handoff delay [9], [11]. [12] designs a flat routing protocol which is triggered by an MN's reassociation to decrease the overall handoff latency. [13] allows MNs to probe the neighboring APs by accessing the common control channel to shorten both the probe delay and the authentication delay. [14] introduces the concept of temporary IP addresses to shorten the delay of applying a new Care-of Address. [3] presents a new WMN mobility management scheme to reduce the signaling cost as well as to shorten the handoff latency. [4] provides a solution to reduce the route discovery delay in the WMN network-layer handoff. [15] uses more than one AP to handle the moving clients to realize fast handoffs in WMNs. To sum up, existing WMN handoff schemes do not consider to resolve the wireless channel access contentions between handoff signaling packets and data packets during a handoff process. Hence, the handoff delay can be very long during the network-layer handoff, which generates handoff signalling traffic that needs to be delivered over the multi-hop wireless mesh backbone. In this paper, we propose a channel splitting technique to address the above unconsidered issue. The contribution of our work mainly lies in the following points:

- Designing a channel splitting technique to shorten both the link-layer and network-layer handoff latency.
- Proposing two designs for the splitting channel medium access control (MAC) in the wireless mesh backbone network to improve the performance of both handoff and data throughput.

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III. PROPOSED DESIGNS IN THE WIRELESS MESH BACKBONE BASED ON CHANNEL SPLITTING

We propose a channel splitting technique for delivering the handoff signaling packets through a split control channel in the wireless mesh backbone. We use IEEE 802.11 carrier sense multiple access with collision avoidance (CSMA/CA)-based MAC protocol to avoid collision in the channel.

- **Single Channel Transmission Technique:**

In this design, both the RTS/CTS reservation and the transmission of data packets are carried out on the data channel. The control channel is only used to transmit signaling packets, such as Agent Solicitation, Agent Advertisement, Registration Request, and Registration Reply.

All the data packets only compete on the data channel. Therefore, the two types of packets no longer affect each other. This method is applicable to the situation when the total number of handoffs in the WMN is high and a separate split channel is required to deliver the high volume of signaling packets to guarantee handoff delay. In addition, if the channel utilization of both channels is high, a high network throughput can be achieved.

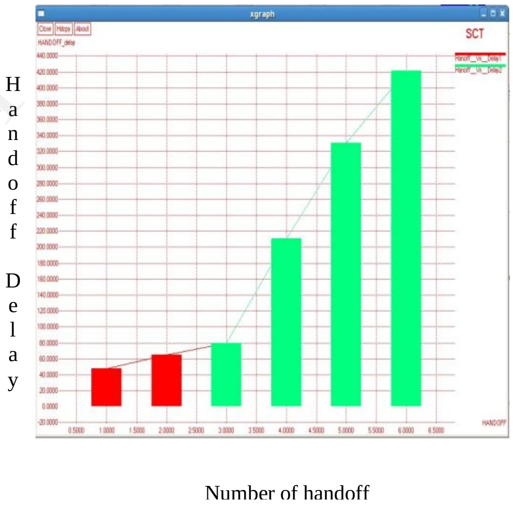

Fig. 4 Single Channel Transmission Bar Graph

In SCT design two networks are created (Wi-Fi and WiMAX) and the handoff delay is calculated in each network and a bar graph is plotted using NS2. Figure 4 shows the single channel transmission bar graph plotted between the number of handoff and the handoff delay in the network. In the above graph the red colour shows the handoff delay in the Wi-Fi network and the green colour shows the handoff delay in the WiMAX network. The handoff delay is less in SCT design compared to traditional handoff method.

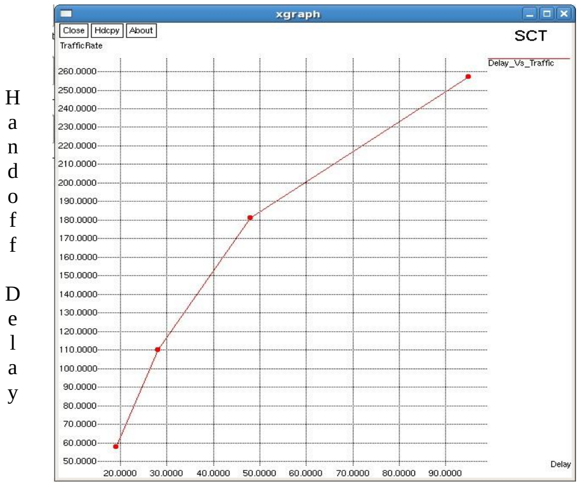

Fig. 5 SCT Handoff Delay Vs Data Traffic

Figure 5 shows that a line graph is plotted between handoff delay vs. Data traffic in SCT design to show that the loss of data due to high handoff is less.

- **Combined Channel Transmission:**

When an MR has a data packet to send, the MR first checks the state of the data channel. If the data channel is idle, the MR performs the RTS/CTS reservation process on the data channel. However, when the data traffic load is high in the wireless mesh backbone, the data channel may be in the busy state most of the time. Under such situations, our proposed CCT scheme is designed to make use of the idle periods on the control channel to finish the RTS/CTS reservation in advance; therefore, the next data transmission can be executed right after the previous data transmission.

In our proposed CCT design, MRs can determine to deliver the RTS/CTS reservation packets either on the control channel or on the data channel dynamically, depending on the backbone traffic load, thereby improving the overall channel utilization and data packet ETE delay. This design can utilize the data channel with high efficiency because the time required to reserve the data channel is consumed in the idle period of the control channel. Therefore, the RTS/CTS overhead on the data channel is reduced, and the overall channel throughput is improved. Therefore, the RTS/CTS overhead on the data channel is reduced, and the overall channel throughput is improved. The CCT design can be applied to the WMN where the handoff traffic volume in the mesh backbone is low, leaving sufficient idle periods on the control channel for data channel reservation. A suitable pseudo algorithm are developed for this combined channel transmission technique and the algorithm is implemented in NS2 C++ coding. Using the pseudo algorithm the data traffic in the network can be improved and 80% throughput is achieved.

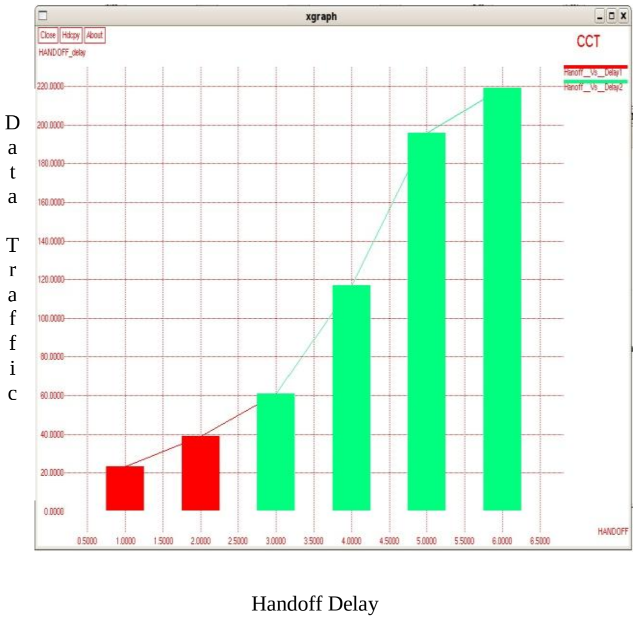

Fig. 6 Combined Channel Transmission Bar Graph

In CCT design two networks are created (Wi-Fi and WiMAX) and the handoff delay is calculated in each network and a bar graph is plotted using NS2. In figure 6 a Bar graph is plotted between the number of handoff vs. handoff delay in the network using CCT design. In the above graph the red colour shows the handoff delay in the Wi-Fi network and the green colour shows the handoff delay in the WiMAX network. The handoff delay is less in CCT design compared to traditional handoff method.

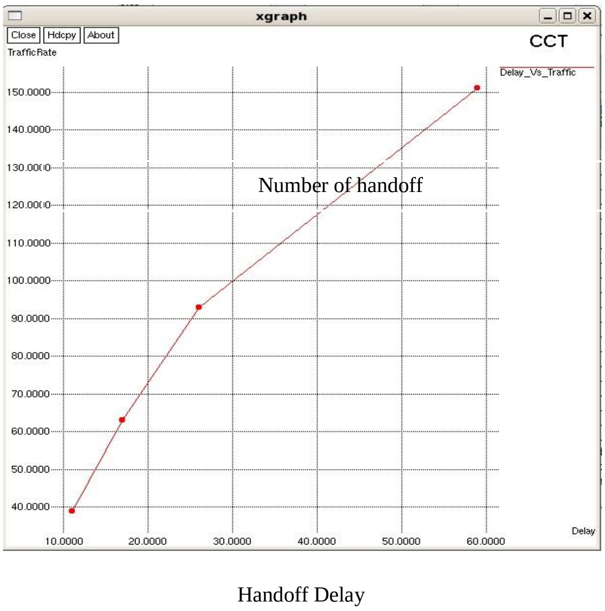

Fig. 7 CCT Handoff Delay Vs Data Traffic

Figure 7 shows that a line graph is plotted between handoff delay vs. Data traffic in CCT design where the loss of data due to high handoff is less.

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IV. CONCLUSION

In this paper, a channel splitting technique is proposed to improve both the handoffs performance in WMNs. We proposed handoff procedures using the channel splitting technique. In our design, the time for the link-layer channel scanning process can be reduced and the contentions between handoff signaling packets and data packets in the multi-hop wireless mesh backbone is eliminated. In addition, we proposed two transmission techniques in the wireless mesh backbone to improve the overall handoff performance as well as the ETE data performance. NS2 simulation results show that the handoff delay, ETE data throughput, and ETE delay can be improved by using the proposed channel splitting technique.

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