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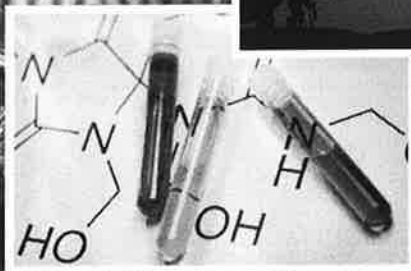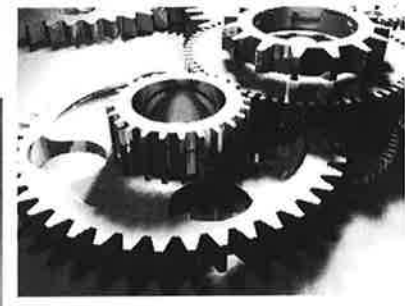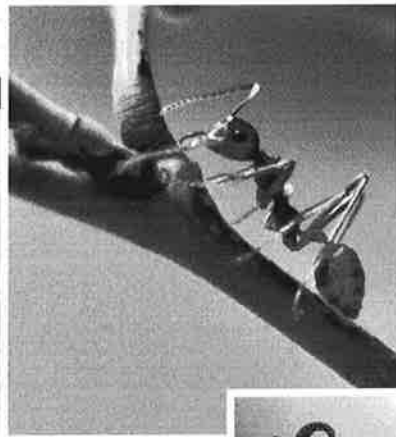
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An Efficient Medium Access Control (Mac) Fowarding Technique For Multihop Network

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Abstract

The function of Medium Access Control (MAC) protocol in network communication is to efficiently facilitate the use of available channels when more nodes (i.e. laptop, PC, smart phones and etc) involving in transmission activity in the network. The protocol uses the well-known Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) mechanism to allow all nodes in the network to communicate between each other without collision. This mechanism has been standardized in IEEE 802.11 and it is proven to provide the better performance of throughput for single hop communication. The node which is uses CSMA/CA mechanism will perform a handshake (the exchange of RTS and CTS signalling packets) prior initiates any packet transmission. The handshake is very crucial in order to avoid the collision caused by simultaneously transmission to the single receiver. However, this mechanism undergoes bad throughput performance when directly implemented for multihop communication. The reason behind this poor performance is due to the inefficient forwarding in CSMA/CA mechanism which is caused larger signalling overheads. The exchange of RTS and CTS signalling that required at each hop throughout the multihop network eventually will cause the larger overheads and throughput degradation. Therefore, an efficient forwarding operation is proposed in this work to reduce the signalling overheads and ultimately allows a smooth forwarding of packet in the multihop network without any collision. In this work, the multihop network performances are evaluated analytically in terms of throughput and overhead. Through the simulation, it is proven that the proposed forwarding technique provides significant improvement in throughput and overhead.

Keywords: Medium Access Control (MAC) protocol; Signaling; Overheads; Multihop communication

INTRODUCTION

Wireless communication between network nodes has become more popular in recent years and has been integrated into people's daily life, e.g. wireless Internet connection, hands free and etc. Wireless Mesh Network (WMN) is a wireless communication network that consists of network nodes connected in mesh-style topology. It become an emerging technology and plays an important role in the next generation wireless communication. WMN architecture is built based on the principles of multihop communication with addition of mesh topology to link all the nodes inside the network (Zhang et. al., 2007). Due to the low cost, ease of deployment and regardless of physical layer (PHY) being used, WMN can provides wide network coverage with seamless roaming, the internet connection to remote and rural areas and solving blind spot problem for the existing wireless and mobile communication networks such as WiMAX and 3G networks. This type of infrastructure is considered relatively stable, can provide reliable services and fairly inexpensive.

A WMN is characterized by self-organizing, self-configuring and self-healing capabilities, with the mesh nodes in the network automatically establishing and maintaining mesh connectivity among themselves (Akyildiz and Wang, 2005). Typical WMN architecture consists of mesh routers (MRs), mesh clients (MCs) and single or multiple Internet gateways (IGWs) as shown in Figure 1. The MRs acting as bridges in order to forward packets until it reach their destination (Siddiqui and Hong, 2007). The MRs having minimal mobility are wireless nodes linked to one another to extend the coverage area and formed the backbone whereas the MCs can be connected to MRs in traditional way and can roam easily. If a MC needs to communicate with another node that is not within its

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communication range, it forwards the packet to its nearest MR. The packet is then forwarded over the MR backbone according to routing protocol, until it reaches a MR that can forward the packet to the destination node.

One of the major advantages of WMN lies on fault tolerance capability against network failures. Unlike other wireless networks, failure of a single node (i.e base station or access point) leading to unavailability of communication services over a large geographical area. The WMN provide high fault tolerance even when a number of MRs fail (Zhang et. al., 2007). If some MR nodes in the network are down, the forwarded traffic can be delivered to the destination via some other intermediate MR nodes. This implies that the WMN provides the network with higher fault tolerance to the failures of MR nodes and links.
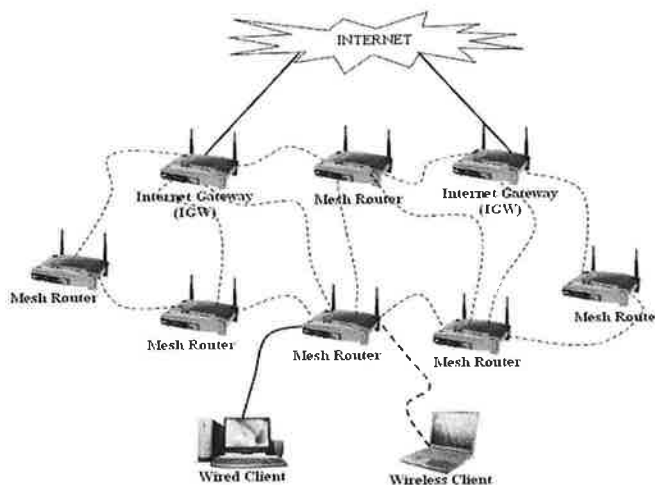

Figure 1. Wireless Mesh Network Architecture

Medium Access Control (MAC) protocols employed in multihop WMNs to resolve contentions for accessing the shared medium which is encountered many issues especially exposed node problems in multihop communications (Akyildiz and Wang, 2005). Apart from that as the number of hops in WMNs increases, the optimal overall throughput of existing MAC protocol and its derivatives are not achievable. So, the enhancements of the existing IEEE 802.11 Distributed Coordination Function (DCF) MAC protocol have been proposed in this work. Since the source node in WMN relaying its data packets over multiple hops until reach destination node, the large number of overhead due to signaling at each intermediate hop will degrade the throughput significantly.

In this paper, we are focusing on how to reduce the large signaling overhead problems in multihop networks. This can be done by reducing the number of signaling packets needed at each intermediate hops until the data packet reaches its destination in multihop WMNs. This approach is expected to reduce the signaling overheads thus improve the performance significantly.

PROBLEM STATEMENT

One of the reasons behind throughput degradation in multihop communication is number of signaling packet that required when transmitting a data packet from one node to destination via multiple intermediate nodes. As shown in Figure 2, let's consider source node A has data packet to be transmitted to destination node E. Since node E does not include node A's transmission range, node A has to transfer its data packet via some intermediate to reach its destination. In this case, the data packet must go through three intermediate nodes, which are node B, node C and node D in order to reach the destination. When the existing MAC protocol employ in this type of multihop communication, the four way signaling handshake (i.e RTS/CTS/ACK/DATA) will be performed at every each intermediate nodes thus increasing the delay and reduce throughput. This is the nature of

IEEE 802.11 MAC protocol that is initially designed for single hop transmission in mind. However, this approach degrades the throughput of WMN significantly.
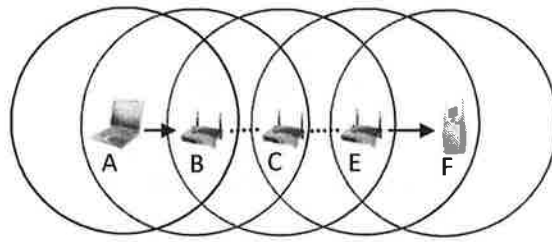

Figure 2. Multihop Transmission via intermediate nodes

The amount of signaling packets is needed to transmit a single data packet in multihop network increase proportionally with number of hops. The latency caused by signaling overhead will drop the throughput significantly. A smooth and efficient data forwarding operation is require in order to improve the throughput in multihop WMN. This will reduce the signaling overhead thus improve the throughput accordingly. Therefore, an enhanced MAC protocol which is efficiently forward the data packet is introduced and presented in this paper. In our approach the RTS and CTS signaling exchange is only occurred at first hop when the node contending for the shared channel. Whereas at the subsequent hops, it will initiates its transmission according to the proposed technique and reduce the signaling overheads.

PROTOCOL DESCRIPTION

The novelty of the proposed protocol is its efficiency in enabling the forwarding operation in collision free manner. This approach reduces the amount of signaling overhead that needed when the nodes relay the data packet to the nearest gateway in multihop fashion.

In this paper, we have proposed a simple enhancement to existing 802.11 MAC to reduce the amount of signaling packet that requires at each intermediate node. Since every each node in the network has the omnidirectional characteristic, thus they can overhear the transmission activity which is going on around them. This advantage is used to convey the data packet to subsequent nodes.

The Figure 3 illustrated the forwarding operation of proposed protocol. As shown in this figure, the data packet from client A has to be relayed via some intermediate nodes until it reaches its nearest internet gateway (i.e. node n). According to proposed protocol, the mRTS and mCTS signaling exchange only will be performed at first hop when the source node initiates the transmission. This exchange is requires to get an access to the channel. Upon successful transmission at first hop, the data packet will be relayed through subsequent relaying nodes to IGW1 without initiating the mRTS control packet. Therefore the mRTS control packet that needed at each intermediate relaying node can be suppressed accordingly.

Let assume node A will broadcast the mRTS control packet to start its transmission to node B. Next, node B will permit this transmission by responding the mCTS control packet back to it. Due to the overhearing capability, each of the neighboring nodes in the vicinity of node B (i.e. node C) will overhear this mCTS control packet. In order to identify the next relaying node, the RID mechanism is applied in this protocol. According to the MAC addresses and RID that contain in mCTS control packet, node C is able to recognize the next relaying node for that respective data packet. Thus, once node C overhears mCTS control packet, it will activate the timer to send the invitation and asked for the data packet to be forwarded (will explain in next paragraph). The timer will be activated to be equal to the time taken by node B to receive the DATA packet from its upstream node and until it transmits mACK packet. All the neighboring nodes (in the vicinity of the node B) will be notified on upcoming forwarding operation through the mACK packet which is sent by node B at the end of its transmission.

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the use of IEEE 802.11 PHY. The transmission rate is constant and packets are forwarded in a multihop fashion to the gateway. For ease of explanation and without loss of generality, we consider unidirectional traffic, i.e., traffic only going from mesh nodes to the gateway. We assume that each mesh router has a fixed transmission rate at 54 Mbps and range of 100 meters. Thus only two routers can set up a link (i.e within communication range) and communicate between them whenever possible. As for the mesh clients, some of them are associated to a certain mesh router forming a cell.

PERFORMANCE RESULT

Figure 4 and 5 depicts the variation of delay and throughput as a function of number of hops respectively. It can be observed from both results that the proposed protocol outperforms IEEE 802.11 MAC protocol. As depicts in figure 4, the delay which is consumed by the proposed protocol to transmit the data packet from source to destination is 7.37 ms, meanwhile the delay consumed by the existing protocol to transmit its data packet from source to destination is 8.27 ms. This is shows that the proposed protocol can reduce the delay approximately 10.88% when it transmit its data packet through 10 hops.
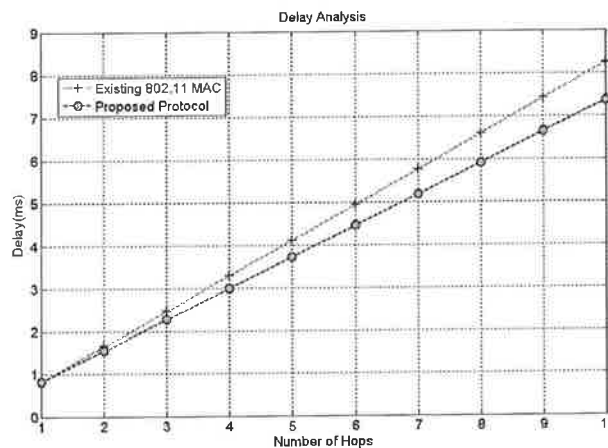

Figure 4. Delay analysis

Moreover as depicts in figure 5, the throughput which is achieved by the proposed protocol in order to transmit the data packet through 10 hops is 2.9 Mbps, meanwhile the throughput achieved by existing protocol is only 2.1 Mbps. This is shows that the proposed protocol can improve the throughput approximately 38.1%. Since the existing IEEE 802.11 MAC was designed with one hop communication in mind, it suffers throughput degradation when applied for multihop topology as shown in Figure 3. This observation is due to the smaller delay per payload which is experienced by proposed protocol. Moreover the proposed protocol outperforms the existing when number of hops increasing as shown in Figure 4 and 5. Obviously this observation shows that the proposed protocol reduced the delay caused by signaling overhead.
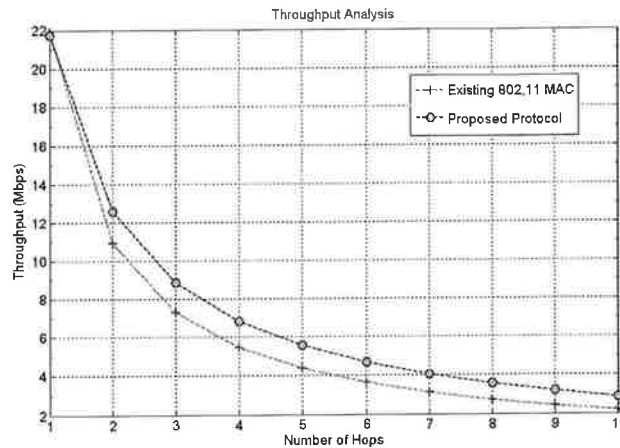
Figure 5. Throughput analysis

CONCLUSION

By presenting the problem encountered in an IEEE 802.11-based multihop network, it can be concluded the current version of this MAC protocol does not function well in multihop WMNs. In order to overcome the problem, we have proposed an efficient forwarding operation to forward the data packet with a fewer signaling overhead. Therefore, a set of enhancement to the existing IEEE 802.11 DCF MAC was introduced to reduce the amount of signaling overhead required at every hop until the data packet reaches its destination. The analytical models were developed and the multihop WMN performances are evaluated in terms of throughput and delay. It proven that proposed protocol outperforms the existing IEEE MAC protocol in throughput of multihop WMN.

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Date: 31ˢᵗ October 2012

Dear V.R Gannapathy, M.K Suaidi, M.S Johal, A.T.I Fayeez, S.K Subramaniam,
S.S.S Ranjit.

An Invitation To Participate In The 2ⁿᵈ USM- PSU International Conference On Arts And Sciences 2012 (ICAS 2012)

Greetings from the Social Transformation Research Platform, Universiti Sains Malaysia, Malaysia and Prince of Songkla University, Pattani Campus, Thailand.

Congratulation!

I am glad to inform you that your paper entitled **"An Efficient Medium Access Control (Mac) Fowarding Technique For Multihop Network"** has been accepted for oral presentation at the **2ⁿᵈ USM-PSU International Conference On Arts And Sciences 2012 (ICAS 2012)**, which is scheduled to be held on 2ⁿᵈ, 3ʳᵈ and 4ᵗʰ December 2012 at the PARKROYAL, Penang.

On behalf of the organizing committee, we sincerely wish to invite you to our forthcoming conference and look forward to seeing you in Penang, Malaysia.

For further information please do not hesitate to contact us at 046533093 / 3037.

Thanking you in advance.

Yours truly,

PROFESOR OSMAN MOHAMAD

Chairman

2ⁿᵈ USM- PSU International Conference On Arts And Sciences 2012 (ICAS2012)

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