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Hybrid Multi-Channel Assignment for Heterogonous Wireless Mesh Network

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ABSTRACT— Wireless mesh networks offer many advantages in terms of connectivity and reliability. Traditionally, Wireless mesh networks based on either purely static or dynamic channel allocation approaches in wireless mesh network. However, there are limitations in wireless mesh networks, such as lower through-put and delay in the channel allocation scheme. This paper is focus on the hybrid multichannel multiradio wireless mesh networking architecture, where each mesh node has both static and dynamic interfaces which efficiently utilizes multiple wireless interfaces to achieve better throughput. Adaptive Dynamic Channel Allocation protocol (ADCA), will considers optimization for both throughput and delay in the channel assignment. Our simulation result show that compared to MMAC, ADCA reduces the packet delay considerably without degrading the throughput.

KEYWORDS—wireless Mesh Network, multiradio, multichannel, channel allocation.

I. INTRODUCTION

WIRELESS MESH NETWORK$_S$ [1] are promising technology for next generation wireless networking ,the backbone of wireless mesh network's provide good solution for user to access the internet anywhere anytime. WMN$_S$ facing one major problem are the capacity reduction due to wireless interference. In recently wireless mesh network equip with multiple radios, which can be configured to different channel, and thus reduce the network interference. The major challenges in multiradio multichannel Wireless mesh networks are assignment of channel to interface of mesh routers so that network throughput can be maximized.

The current two channel allocation approaches are static channel allocation and dynamic channel allocation approach. In static channel allocation, [2] a channel assigned permanently to each interface of every mesh router. In dynamic channel allocation [3], an interface is allowed to frequently switch from one channel to another channel. Both strategies have their relative strengths and weaknesses.

In this paper focus on hybrid architecture, this combines the advantages of static and dynamic allocation approaches. In this architecture, one interface from each router uses the static channel allocation strategy, while the other interfaces use the dynamic channel allocation strategy. The links working on dynamic channel enhance the network connectivity and network's adaptivity the changing traffic while the links working on the static channels provide high throughput paths from end-users to the gateway. Therefore, this hybrid architecture can achieve better adaptivity compared to the pure static architecture without much increase of overhead compared to the pure dynamic architecture.

In this paper, we discuss many important issues in the hybrid wireless mesh network. 1) The system architecture, where one radio works as static interface and the other radios work as dynamic interfaces in each node. 2) The channel allocation for dynamic interfaces: multichannel medium access control protocol MMAC [4] is currently one of the most efficient dynamic channel allocation protocols. However, the channel assignment in MultichannelMAC protocol is considered for network throughput but delay is high in this protocol. Adaptive Dynamic Channel Allocation protocol (ADCA) was proposed, which considers both throughput and delay in the channel assignment. Compared with MMAC protocol, ADCA protocol is able to reduce the packet delay without degrading the network throughput.

The remainder of the paper is organized as follows. Section II describes the network model. Section III discusses analytical model. Section IV discusses dynamic channel allocation protocol. Section V Performance Evaluation and Section VI conclude the paper.

II.NETWORK MODEL

In this paper, we propose to use the hybrid architecture to achieve both adaptively to changing traffic and low channel switching overhead. Let G (V, E) be the network topology, where V is the set of mesh routers and E represents pairs of mesh routers that are within radio communication range. Assume each mesh node has multiple interfaces. In the hybrid mesh architecture, one interface of each mesh router work on fixed channels, and let the other interfaces of mesh router be able to switch channel frequently.

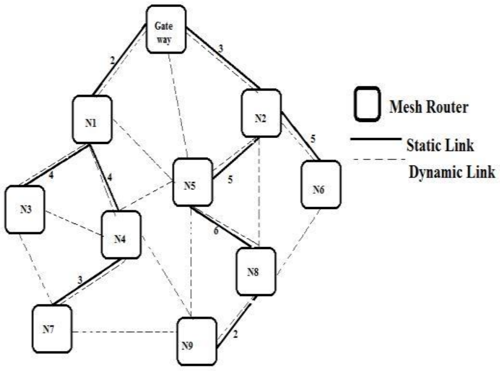


Fig 1. Hybrid architecture

Fig.1 illustrates a hybrid multiradio multichannel wireless mesh network. Most mesh router including the gateway has 3 interfaces, and a some boundary mesh router *{N3; N7; N9; N6}* have 2 interfaces. For each mesh router, one interface works as static interface, and the others work as dynamic interfaces.

The static channel allocation interfaces will constitutes a major portion of the traffic in the network while maximizing the network throughput from end-users to gateways. The proposed algorithm, construct a load balanced tree for each gateway. The main goal of the tree construction is to allocate bandwidth fairly to each mesh node with regard to the user-gateway throughput. aims at maximizing the network throughput from end-users to gateways. Each link can assign channels, after the topology have been constructed. The links closer to the gateways are given first priority to be allocated with less congested channels. The tree topology with thick lines is shown in fig.1 and we call these links as *static links*.

Dynamic interfaces work in an on-demand fashion. The data transmission in Two dynamic interfaces that are within radio transmission range of each other will able to communicate by switching to a same channel. hese links are called as *dynamic links*. All possible dynamic links in dotted lines are illustrated in fig.1. each dotted line in figure only implies that the pair of nodes are able to communicate because they are within radio transmission range of each other, but they need to switch to the same channel before they can transmit data. A dynamic channel allocation protocol was proposed in this paper, which optimizes for both throughput and packet delay.

III. ANALYTICAL MODEL

The network consists of N MeshRouter (MR) nodes and one gateway (G). Packets are forwarded in multihop fashion to or from the gateway. We consider omnidirectional traffic, i.e., the traffic that only goes from the MR to the gateway. Each MR has two links, Tr for relay packets and Ts for packets originating from the node itself. The forwarding rule [5] at each mesh node is described as follows:

1- If Tr is empty, it sends one packet from Ts. (Ts always has packets to be transmitting)

2- If Tr is not empty, it sends a packet from Tr with a probability of Qi or a packet from Ts with a probability of 1-Qi. Qi is forwarding probability for node i.

A. Throughput and Delay Analysis

The calculation of per node throughput as the number of packets originating from node i successfully received by the gateway. It can be obtained by counting the packets, which are received successfully by the gateway without being blocked in any intermediate nodes. Thus, need for calculation is the blocking probability at each intermediate MeshRouter. Based on queuing theory analysis, it is given as

$$P_i^b = \begin{cases} \dfrac{\frac{[1-\rho_i]\rho_i^k}{1-\rho_i^{k+1}}}{\frac{1}{k+1}} & ,\text{if } \rho_i^k \neq 1 \quad \rho_i^k \text{if} = 1 \end{cases} \qquad (1)$$

Where ρi is the intensity of traffic given above. Thus, we can state the throughput of node i, as below:

$$Q_i = \begin{cases} \sigma_i^2 & ,if\ |n_i^u| = 0 \\ \sigma_i^2 \prod_{i \in n_i} [1 - P_i^b] & ,if\ |n_i^u| > 0 \end{cases} \qquad (2)$$

Where $|n_i^u|$ is number of nodes in the uplink path from node i to the gateway. The average throughput is obtained as follows:

$$mean(S) = \frac{\sum_{i=1}^{N} S_i}{N} \qquad (3)$$

To calculate the delay which a packet from node i encounter, and then need to compute the waiting time of a packet in each Tr. For first obtain the steady state queue size of Tr in node i as follows (using M/M/1/K analysis):

$$L_i^r = \begin{cases} \frac{\rho_1}{1-\rho_1} - \frac{\rho_1\left[k_{\rho_1}^{k}+1\right]}{1-\rho^{k+1}} & ,if\ \rho_i \neq 1 \\ \frac{k(k-1)}{2(k+1} & ,if\ \rho_i = 1 \end{cases} \quad (4)$$

The following expression for the waiting time of a packet in Tr of node i:

$$w_i^r = \frac{1}{\mu_i^r} + \frac{L_i^r}{\lambda_r[1-P_\beta^r]} \quad (5)$$

Then obtain Di by summing the waiting times spent in the intermediate nodes and the transmission times (i.e.), for traversing the i hopes:

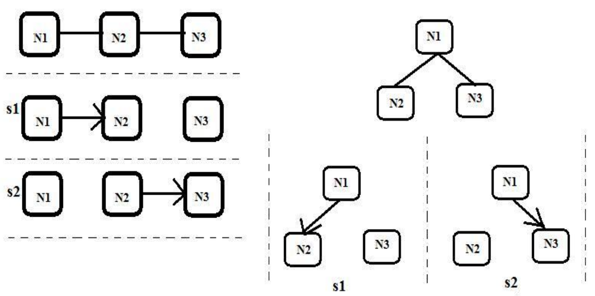
$$D_i = \begin{cases} \tau & ,if\,|n_i^\mu| = 0 \\ \tau\, n_i^\mu \sum_{i\, n_i^\mu} w_i^r & ,if\ |n_i^\mu| > 0 \end{cases} \quad (6)$$

In addition, they have successfully delivered average delay of the network can be found by taking into account the delay of packets.

$$mean(D) = \frac{\sum_{i=1}^{N} Q_i D_i}{\sum_{i=1}^{N} Q_i} \quad (7)$$

IV.DESIGN OF ADAPTIVE DYNAMIC CHANNEL ALLOCATION

The network throughput of wireless mesh networks can be dramatically increased by utilizing multiple channels instead of a single channel. Multichannel MAC protocol [4] is a dynamic channel allocation protocol for WMN, where each mesh node has a single dynamic interface. In Multichannel MAC, the time is divided into fixed-length intervals, each of which consists of data interval and control interval. In the data interval, set of the mesh nodes transmit and receive data on the negotiated channels (or data channel).In the control interval, any two nodes that have data to transmit communicate on a default channel (or control channel) to negotiate the channel to use in the data interval.



(a) **(b)**

Fig 2: Unnecessary Delay of MMAC When Traffic is Below Saturation

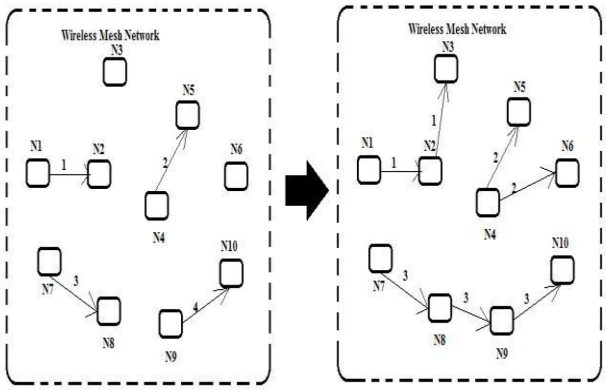
Multichannel MAC improves the network throughput at the cost of increasing packet delivery delay. When the traffic load is below saturation level, Multichannel MAC may cause unnecessary packet delay, which can be shown by the examples in Fig.2. In Fig.2 (a), assume node N1 has some data to send to *N3*. Let the maximum bit rate of each interface be *R*, and assume the traffic rate is less than *R*=2. According to MMAC, in the first time interval S_1, the packets are transmitted from *N1* to *N2*, and then in the second interval S_2, the packets are transmitted from N2 to *N3*. Therefore, the packet delay is around two intervals. On the other hand, if we assign *N1*, N2 and N3 with the same channel, and use 802.11 to resolve contention in this sub network, the packets can be transmitted from *N1* to N3 within one interval. In Fig.2 (b), assume *N1* has some data to both *N2* and N3, with the aggregate traffic rate of less than *R*. We can see that MMAC still needs two intervals to complete the transmission, while it can actually be done in one interval by assigning the same channel to all the three nodes. *N1* just needs to alternatively data to be transmitting N2 *and N3* to avoid collision.

The reason why Multichannel MAC causes unnecessary packet delay in the above cases is that only set of nodes negotiate common channels in each interval, and thus each packet can be transmitted at most one hop away in one interval. If more than two nodes enable to negotiate a common channel, the transmission packet delay can be reduced dramatically. For example, in both cases of Fig.2 (b), if *N1*, N2, and *N3* can negotiate a common channel together, then all the transmissions can be completed in one time slot. Next, discusses the design of Adaptive Dynamic Channel Allocation protocol (ADCA).

ADCA uses the similar framework with Multichannel MAC. It divides time into permanent length intervals. Each interval is further separate into control interval and data interval. Let S_c, S_d be the length of control interval and data interval respectively (Obviously, we have $S = S_c + S_d$) and *S* be the interval length. In the control interval, all the nodes are switch to the negotiate channels and same default channel. In the data interval, the nodes working on the same channel transmit and receive data among each other. In MMAC, *S* is set to 100*ms*, and S_c is set to 20*ms*, which is long enough for nodes to negotiate channels when network traffic is saturated level. Our proposed protocol uses the same parameter settings (*S* and S_c), but is different in the channel allocation scheme during control interval.

In Adaptive Dynamic Channel Allocation protocol, each dynamic mesh interface maintains multiple queues in the link layer with one queue for each neighbor. The data to be transmitted to each neighbor are buffered in the corresponding queue. The first step of channel negotiation in Adaptive Dynamic Channel Allocation protocol is similar to Multichannel MAC protocol. For each dynamic mesh interface, if it has data to be sent, it selects a neighbor that it needs to communicate with and tries to negotiate a common channel with the neighbor. There are more criteria for selecting neighbors.

Multichannel MAC consider only throughput, we may select the neighbor with the longest queue. However, this method may cause starvation. Therefore, we augment it with some fairness considerations, that is, we evaluate a neighbor's priority by considering both its how long the queue and queue has not been served. As a result, during this step, pair of nodes has negotiated common channels with each other such as the example in Fig.3 (a).



(a) **(b)**

Fig 3: Adaptive Dynamic Channel Allocation

Different from MMAC, ADCA enables further channel negotiation among nodes. The example in Fig.3 illustrates how our protocol works. Assume the network traffic is below saturation. In Fig.3 (a), set of nodes negotiate channels according to MMAC. Then further channel negotiations are performed as illustrated in Fig.3 (b). There are three cases illustrated in the figure. 1) N1 has some data to send to N3 through *N2*. N1 and N2 got the right to transmit data on a common channel, whileN2 and N3 did not. In this case, N2 can further negotiate with N3 so that N3 works on the same channel with N1 and N2. 2) N4 has some data to both N5 and N6. N4 and N5 got the right to transmit data on a common channel, while N4 and N6 did not. In this case, N4 can further negotiate with N6 so that N6 *works* on the same channel with N4 and N5. 3) N7 has some data to N9 through N8. N7 and N8 got the right to transmit data on a common channel, while N9 got the right to transmit data to N10 on a common channel. In this case, N8 can negotiate with N9 so that N7, N8, N9, and N10 work on the same channel.

Compared with Multichannel MAC, Adaptive Dynamic Channel Allocation protocol can negotiate common channels among more than two nodes in each interval when network traffic is not saturated. As a result, ADCA protocol has the potential to reduce packet delay while satisfying the imposing traffic. When the traffic is near saturated, ADCA will behave similar to Multichannel MAC. Multichannel MAC is only optimized for maximizing the network capacity. In contrast, Adaptive Dynamic Channel Allocation protocol optimizes for both throughput and delay with regard to the imposing traffic load. Therefore, ADCA is adaptive to the network traffic.

V. PERFORMANCE EVALUATION

The simulation work that has been implemented is done in Network Simulator3. The Dmesh was used to support for multichannel and multiradio interfaces. In this section evaluate the Adaptive Dynamic Channel allocation protocol by comparing it with Multichannel MAC without increase in overhead and achieves lower delay.

A. *Evaluation of Adaptive Dynamic Channel Allocation*

The ADCA protocol first construct the simulation on a random topology of 50 nodes in a 1200*m* £ 1200*m* area. Each node has at least 2 neighbors and at most 8 neighbors. To compare with Multichannel MAC, each mesh node has only one interface, which can switch channels dynamically. Then generate 25 UDP flows with the same data rate in the network, each with dynamic source and dynamic destination. In fig .4 shows the node creation in network simulator.

TABLE 1. Simulation Parameter

Parameter	Value
Application Type	Constant Bit Rate(CBR)
Transport Type	User Datagram Protocol(UDP)
Examined Protocol	Adaptive Dynamic Channel Allocation(ADCA)
Simulation Time	250 Seconds
Packet Size	512 Bytes
Simulation Area	1200×1200 M
Propagation Model	Two Ray Ground
Antenna Model	Omni Directional Antenna

Simulation Parameter: Table 1 show that all parameters for simulation Environment

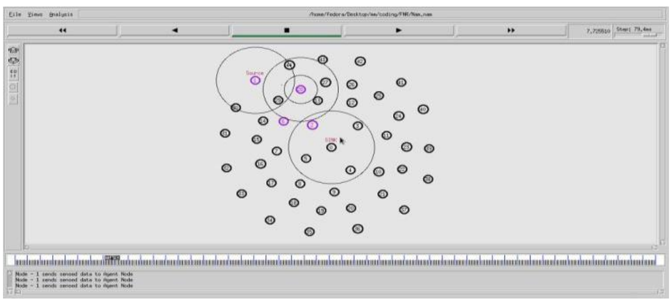


Fig.4: Node Creation

The packet size in each flow is set to 1024 bytes. In this paper analyze two protocols 1) MMAC, a multi-channel MAC protocol; 2) ADCA, an adaptive dynamic channel allocation. For both MultichannelMAC and ADCA, use 2 orthogonal channels. By using the same parameter in [4], we set the time interval to 75*ms*, and the control interval to15*ms*. These two protocols are compared with regard to throughput and delay in Fig.5 and Fig 6.

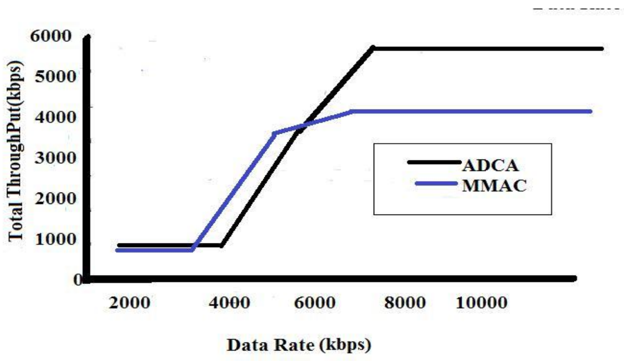


Fig .5: Network Throughput

Network throughput or throughput is the average rate of successful message delivery over a communication channel. Fig. 5 shows the Network Throughput for both MMAC and ADCA protocols. In comparison with MMAC, ADCA dramatically increases network throughput. From the simulation results, finally conclude that ADCA is able to achieve high throughput than MMAC without impacting the network throughput.

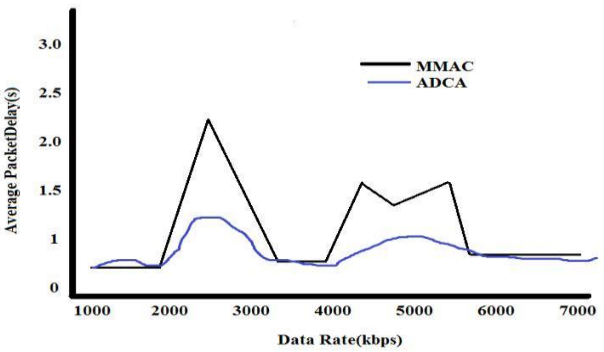


Fig .6: Packet Delay

Fig. 5 shows the packet delay for both MMAC and ADCA protocols. In comparison with MMAC, ADCA dramatically decrease network interference. From the simulation results, finally conclude that ADCA is able to achieve lower delay than MMAC.

VI. CONCLUSION

In this paper, the channel allocation problem in multichannel wireless mesh network where each mesh node equipped with multiple radios have been formulated and addressed. An Adaptive dynamic channel allocation protocol was presented in this paper that assigns the channels to communication links in the hybrid wireless mesh network with the objective of maximizing the network throughput and reduce the packet delay. The simulation results have shown that, the effectiveness of the above approaches will improve the network throughput and reduce the packet delay.

REFERENCES

[1] I. F. Akyildiz, X. Wang, and W. Wang, "Wireless mesh networks: A survey," in *Computer Networks*, 2004.

[2] A. Raniwala, K. Gopalan, and T. Chiueh, "Centralized channel assignment and routing algorithms for multi-channel wireless mesh networks," in *MC2R*, 2004.

[3] M. Alicherry, R. Bhatia, and L. Li, "Joint channel assignment and routing for throughput optimization in multi-radio wireless mesh networks," in *MobiCom*, 2005.

[4] J. So and N. Vaidya, "Multi-channel mac for ad hoc networks: Handling multi-channel hidden terminals using a single transceiver," in *MobiHoc*, 2004.

[5] T.Liu, W.Lio, "Location Dependent Throughput and Delay in Wireless Mesh Networks",*IEEE Transactions on Vehicular Technology*, 57(2):1188-1198, 2008.

[6] Yong Ding, Kanthakumar Pongaliur,and Li Xia," channel allocation and routing in hybrid wireless mesh network" ,*IEEE Transactions on Mobile Computing, vol 12 ,no.2, feb 2013.*