Optimal Channel Allocation Mechanism to Improve the QoS in Wireless Networks

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ABSTRACT
Large deployment of IEEE 802.11 wirelesses LANs (WLANs) is perceivable in the present world. In order to reduce interference in the spectrum, the 802.11 standard specifies the use of several orthogonal channels. It is established that the static channel assignments are inadequate to handle the traffic variations effectively, besides some of the channels being underutilized in these types of networks. So we need to employ a dynamic channel allocation algorithm, to determine the optimal channel to be used at any given time and place. If a channel allocation scheme does not consider the other sensitive network issues such as bandwidth allocation, power available at the node etc., it may increase medium access contention and co-channel interference, adversely affecting the aggregate capacity of the network. This paper envisages a channel assignment scheme with the objective of maximizing bandwidth with fairness consideration to equalize the bandwidth assignment of flows**.** Here we propose an adaptive channel allocation scheme for 802.11 networks which takes into account the available bandwidth at each node and also provides the throughput and the QoS to the wireless services. Computer simulation of our proposed adaptive scheme, using the ns2 software reveals a perceptible improvement of data throughput performance over fixed assignment algorithms.

Keyword: IEEE 802.11, Bandwidth, Adaptive channel assignment, Quality of Service.

1. INTRODUCTION
Channel assignment is a prime issue to be addressed in multi-channel wireless networks. It is a strategic coordination and mapping between the channels and the links. The objective of channel assignment is to minimize the levels of interference and noise. However there are the following practical constraints in the assignment of the channels: (i) Limited number of available channels. (ii) Constant need for maintaining the network in connectivity. (iii) Limited number of radios per node less in proportion to the number of orthogonal channels.802.11 makes a provision for multiple orthogonal channels in a given spectrum in order to alleviate the contention in a specified channel and also minimize the interference caused by other wireless traffic using the same channel. 802.11a gives an
scope for 12 fully orthogonal channels in a 5GHz spectrum while 801.11b permits 3 channels in the 2.4GHz spectrum.

The nodes in a static mesh network are configured in such a way to use a specific fixed channel at the time of deployment. They never change their transmitting channel during their use, if otherwise not directed. This aspect may lead to the physical locations where utilization of some channels is far greater than the others. In addition to the scope for the availability of multiple nodes in an area configured to transmit on the same channel, the traffic in any specific area at a given time on any channel exhibits temporal and spatial locality. Variation in traffic is noticeable over prolonged periods of time in terms of the number of users on each channel and the quantity of traffic they generate. As a result, a wireless network with static channel allocation for each link experiences at certain times greater level of contention and interference than at other times. Still, a link which can dynamically change its channel depending on temporal and spatial traffic can obtain optimal performance by adapting to the present interference and contention levels on each channel. By dynamically selecting which link each channel in the network should be on, the amount of contention and interference confronted by the link between any two nodes at any specific time can be minimized.

The whole issue is one of choosing the best channel for any specific link at any given time. Assuming that the traffic displays temporal and spatial locality, the available bandwidth at each node can be analyzed and thus we can determine the choice of channel to be used in that area. We can predict the channel offering best performance basing on certain features of the traffic on each individual channel at any specific point in space/time. This prediction becomes useful in ranking the available channels and picking up the best channel suitable for us. Having decided on how to pick the best channel, experiments can be built to contrast the performances achieved on the dynamically chosen channel against a statically allocated channel. Here, the overhead and frequency of switching the channels are some important issues to be considered.

Performing certain experiments which correlate properties of the packets on the wireless channel is necessary to understand the methods of picking the best channel. The following is the summary of our assumptions and goals:
Assumptions:
• Traffic characteristics vary over a period of time on a channel.
• These characteristics demonstrate some level of short term temporal and spatial locality.
• Some of these characteristics with the possibility of their variation and temporal/spatial locality and the obtainable performance on that channel can be correlated.
• These characteristics are measurable and we can rank a cluster of channels depending on the performance achieved on each.

Goals:
• To determine which traffic properties on a channel are correlated with obtainable performance on that channel.

• To implement a mechanism for a judicious choice of the channel of a link dynamically considering the appropriate characteristics of the channel.

•To evaluate the performance gains achievable through the deployment of the dynamic algorithm of channel allocation.

In order to accomplish the proposed goals, a wireless ad-hoc network with dynamic channel allocation along with the prior understanding of bandwidth available at each node, is proposed, implemented and evaluated. We can conduct some experiments first using this network to rank all the available channels based on the achievable performance by estimating the best possible set of properties about each channel. Next, we can construct a channel allocation engine that can choose and dynamically allocate the best channel for the existing links in our network considering the appropriate set of properties in terms of the current channel utilization. Then we can evaluate this allocation engine for its offered performance gains.

2. LITERATURE SURVEY

A Channel reservation procedure is proposed by A.K.Mahani et.al to reduce the total transmission delay without additional bandwidth for single as well as multichannel CRF [1]. They use the concept of queuing which is used by them here to separate packet as per the destination address. The proposal of the algorithm is based on the RTS and CTS concepts utilized for sensing the channel and data transmission to receiver. We make use of this (RTS and CTS) mechanism to assign allocation of channel hop by hop. We adopt the queuing concept to collect and store the received data at the node. A.H.Mohsenian Rad et.al proposed a system where each router has multiple NICs and every NIC is assigned a different orthogonal frequency channel is proposed. The proposed system enhances the performance gains in terms of efficiency and fairness corresponding to the number of available frequency channels or NICs per router.

Binary vector [2] is used in channel assignment, where 1 indicates channel assignment and 0 indicates non assignment.Krishna and Iyengar proposed a variation of the Distributed Dynamic Channel Allocation [3] scheme (M-DDCA). This modified algorithm is an outcome of the concept of reusability which enhances the system capacity virtually. They use the reservation factor [3, 13] to alter the number of reserved channels dynamically corresponding to the average probability of dropping or blocking. The channel division in groups is done based on the mutual exclusion property. A three-type division of the cells as hot, medium and cold is done for the purpose. Type of cell, mobility and location [11,12,13,14] of the user are considered in channel reservation.

Bandwidth dependant [6,7,10] end-to-end protocol by Claudio Cicconetti et.al proposed for making and reserving path reservation. They included CAC (Call Admission Control) [6] also at individual nodes to ensure sufficient and required resources to allow the flow of traffic over a link. The basis of this CAC is the data sub frame divided into a number of equal time intervals, each associated with the group of links. Defining the groups enables simultaneous activation of all the links in the same group. The another system which is proposed by Habiba Skalli et.al where a channel assignment method drastically reduces interference and noise in the context of multi-radio mesh network. MESTIC is a channel assignment strategy [4] based on the node of the rank which is assigned prior to the nodes. The rank of each node is taken into consideration in proportion to the load / traffic at the nodes, the number of hops it makes from the gateway and the number of utilized radio interfaces per node. We utilize MesTic strategy for its employment of default radio for the maintenance of connectivity among different nodes. The system proposed by Andre Herms et al proposed the system for reserving bandwidth [5] depending on lock based admission management and control. Here, the local station makes a request to the network neighbor, which in turn responds to the local station.

Boukerche. A et.al. Proposed a dynamic protocol of channel allocation for wireless and mobile networks based on Quality of Service. The proposed mechanism on channel reservation [8] provides the QoS for different transmissions of data in wireless networks.
Marina et al. proposed a CLICA, which translates the problem of channel assignment into problem of coloring. In CLICA [9], a weighted conflict graph is created corresponding to the protocol model and is used to demonstrate the status of conflict channels. Though CLICA minimizes the maximum interference of every link, it also has the adverse effect of reducing the expansibility of channel assignment considerably.

3. EXISTING SYSTEM

The literature survey has discussed many mechanisms that are proposed for Dynamic channel allocation. The prior works has focused more on when the channels are allocated to different requests. Even though there are several schemes available for effective channel allocation, there is still scope for improvement as the wireless communication has issues over different factors such as Bandwidth, Delay, and Throughput etc. Our proposed model allocates the channels to requests based on the available bandwidth at each node in the given route.

4. SYSTEM ARCHITECTURE

There are 3 Phases in system design:

1. In 1st phase the available routes from source to destination were estimated at the higher layers and sent to the lower layers for further actions.
2. The available bandwidth at each node is calculated in phase-2. And then we calculate the effective bandwidth of the route for the available routes. Depending on the size of data to be transmitted, the route which is best suitable for data transmission in terms bandwidth available is selected.
3. Phase 3 is channel assignment phase; it is a hop by hop channel allocation scheme. If there is already a channel allocated between a link, the same channel is used for transmission else it sends an RTS [request to send] message to the other available channels and assigns a channel with a CTS [clear to send] reply. If channel is available the request is kept in the queue and transmitted later depending on availability of channel using RTS-CTS Mechanism.

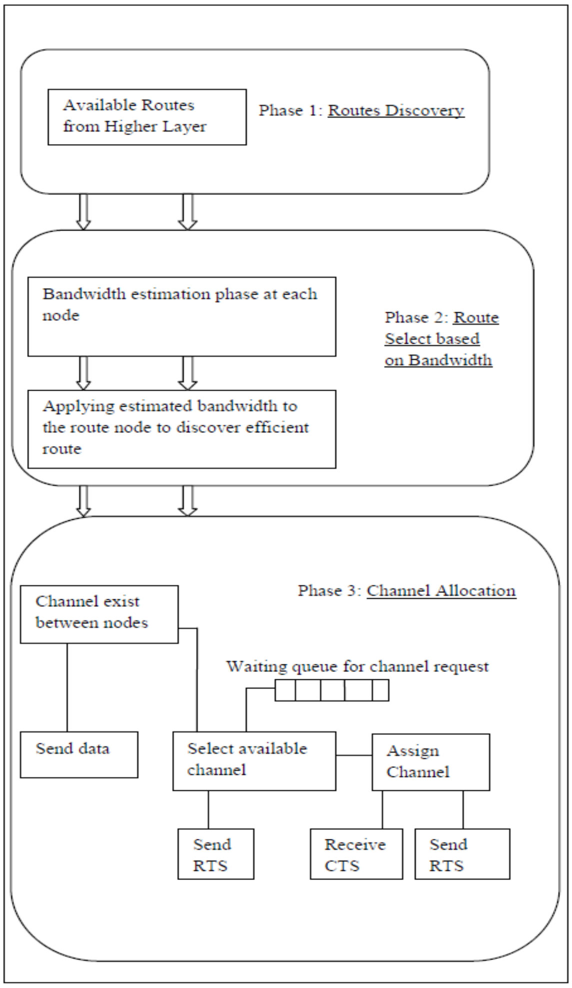

Figure 1: Channel Assignment Phases

5. PROPOSED ALGORITHM

In the proposed algorithm, slots are allocated to the nodes in proportion to their requirement of bandwidth. The algorithm in its input has a list of connections comprising of information related to the path from source to destination and the data-rate, which can be obtained from higher layers. Three factors are considered for bandwidth estimation:

- Channel bandwidth available at the node
- The idle time of the channel
- The total test time.

The bandwidth available at nodes can be evaluated:

$$B_{ni} = B_{ch}*(t_{I\_ch} / t_{tot})*0.8 \text{ ……………. (1)}$$

Where B_{ni} is the remaining available bandwidth of node i, B_{ch} is the bandwidth of the wireless channel, t_{I_ch} is the idle time of the channel, t_{tot} is the total test time, and 0.8 is the weight factor.

Algorithm:

Pick packet P at the head of the output queue.

N(size of packet)=SIZE(P);

For all node N in network do

//estimate bandwidth at each node

$Bni = B_{channel} *(tc_{hannel\ idle} / t_{total})*0.08$

end for

Find all multiple path ($PATH_i$) from sender(S) to Receiver(R)

For each $PATH_i$

link _capacity =Bandwidth($PATH_i$[0]);

// $PATH_i$ [0] is first node in $PATH_i$

For each remaining node in Path i is $PATH_i$[j]

if (link_capacity>Bandwidth($PATH_i$[j]))

link_capacity=Bandwidth($PATH_i$[j]);

end if

end For

available_Bandwidth[i]=link_capacity;

end For

For all available bandwidth[i]

Select the bandwidth i which fits the packet size N;

end For

For each node n in selected path

if (link available between node n and n+1)

use the same channel;

else

For each channel C_i at node visited

if (C_i = =assigned)

Send RTS to Node next in the path n+1;

Receive CTS from node n+1;

Assign channel C_i ;

Send data packet P ;

Break;

end if

end For

if(C_i not available)

Assign channel C_i which least used;

end if

end if

end For

In the algorithm proposed, if a link has been established for a specific path, the same channel is used. In case of non-availability of the link, several other nodes might be in wait for the one node called *waited-node* to give up the channel at the same time. When the waited-node forfeits the channel, the important problem of which node first uses this node and this channel, surfaces. The issue can be addressed by defining a queue to store the addresses of nodes which are waiting for the channel (called *waiting-node*). Thus, waited-nodes utilize the queue to store the addresses of waiting-nodes. After the waited-node surrenders the channel, it can be used by the first node in the queue to route to the waited-node. The waited-node rejects further addresses of other nodes when the queue is full and will notice the node which wants to store the address. Since the length of the queue cannot be too large, it causes the nodes to wait for long and impair the performance of the network.

We illustrate the working principle of BA-Adaptive Channel Allocation by considering a simple example in Fig. 1a. where the input connectivity graph and estimated bandwidth are shown. First the routes between S and R are found, let it be

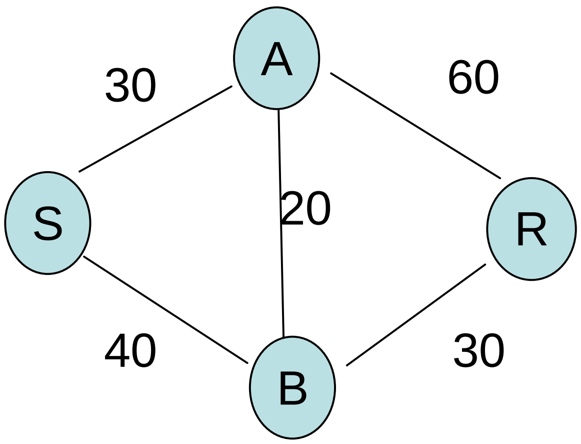

Fig.1a.. Connectivity and bandwidth Available

1. $S \rightarrow A \rightarrow R$
2. $S \rightarrow B \rightarrow R$
3. $S \rightarrow A \rightarrow B \rightarrow R$
4. $S \rightarrow B \rightarrow A \rightarrow R$

According to equation (1) the bandwidths are estimated, and bandwidths with minimum are added to the path.

1. $S \rightarrow A \rightarrow R \quad - 30$
2. $S \rightarrow B \rightarrow R \quad - 30$
3. $S \rightarrow A \rightarrow B \rightarrow R \quad - 20$
4. $S \rightarrow B \rightarrow A \rightarrow R \quad - 20$

If the data to be transmitted is 30 then, it can choose either path (1) or path (2). If the data to be transmitted is 50 then, it has to choose more than one path because the maximum available bandwidth is 30. So out of the required 50, 30 can be sent in path (1) or (2) and the next 20 can be sent in path (3) or (4). This way the data can be sent simultaneously and fast.

After selecting the path, the sender sends the RTS packet to make the channel idle and in turn the receiver/intermediate node sends CTS and then the channel is assigned. After the channel is assigned, the data is transmitted. The channel is closed when there is no further data transmission.

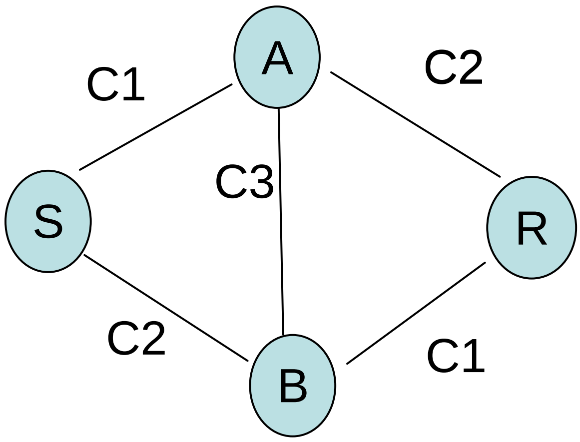

Fig.2. Channel assignment with BA-Adaptive Channel Allocation.

The network is configured such that three channels are available per node. Suppose the source is S and the destination is R, the available multiple paths are considered. After selecting the path S-A-R, the algorithm visits the node S and assigns the channel to S-A. It will not assign the channel afresh, if the channel is already there. Then, the channel C2 is assigned between A-R. Suppose the data is to be sent simultaneously in other path S-B-R, the channel C3 is assigned between S-B and the channel C4 to link B-R as channels C1 and C2 are already in use for the path S-A-R. Channels are assigned to links dynamically in this way as illustrated in Fig.2.

6. RESULTS AND ANALYSIS

We have used the ns-2 network simulator for testing the proposed algorithm with both static and dynamic channel allocation. We compared the throughput vs. time and packet drop probability vs. number of nodes for existing static and dynamic channel allocation with the current proposed BA-ACA [bandwidth aware- adaptive channel allocation]. The simulation is done with a maximum of 20 nodes with queue size 50 and for 300 sec. The results were drawn for the above parameters.

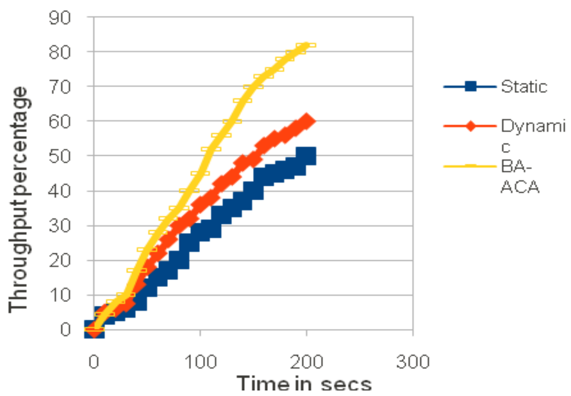

Fig.3 Throughput comparison for static, dynamic and proposed model

In fig.3 we actually compared the throughput of the current system in a time of 200 sec when we use static channel allocation and dynamic channel allocation with our proposed BA-ACA algorithm. The results say that our proposed algorithm performs much effectively than others where it shows more than 80 % throughput.In fig.4 we calculate the packet drop probability ration to the number of nodes for static Ca, dynamic CA and our proposed algorithm BA-ACA.

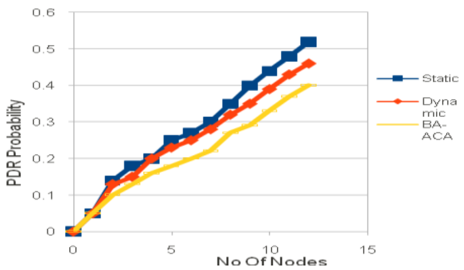

Fig.4 packet drop probability vs. number of nodes for static, dynamic and proposed model

The result says that our proposed algorithm has very less PDR ratio when compared to both static and dynamic channel allocation. The comparisons were given in the graph.

7. CONCLUSIONS

We notice that static channel assignments are insufficient for the requirements of 802.11 networks resulting out of the variations of traffic-load. However, in view of the maintenance of compatibility with the existing protocol standards, we opine that it is neither feasible nor necessary to employ dynamic strategies of channel allocation in order to improve system performance in the context of fluctuations of traffic load. Instead, adaptive assignment schemes can be considered as appropriate alternatives. The projected focus of this paper is on our proposal of an adaptive channel allocation mechanism for 802.11 networks depending on the bandwidth aware algorithm. Computer simulation of the proposed adaptive scheme, using the ns2 software reveals a perceptible improvement of data throughput performance over fixed assignment algorithms.

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