Grenze International Journal of Engineering and Technology, Jan Issue

Traffic Aware Channel Assignment for Dynamic Wireless Mesh Networks

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***Abstract*—In a Wireless Mesh Network (WMN), the interference of neighbouring nodes on the same way and neighbouring paths causes a significant reduction in network capacity. Channel assignment is a useful technique for combining numerous orthogonal channels to minimize the number of interfering nodes and increase network capacity. It aims to find an appropriate route among channels and radio interfaces at each node in order to reduce interference and increase network capacity. While channel assignment reduces interference, it also causes certain important challenges that affect network performance.To improve the performance, Traffic Aware Channel Assignment is proposed. In this algorithm, initially, packets can be routed through the existing path. If any route disconnection is identified, the connection can be rerouted using Minimum Variation Channel Allocation. As a result, among the proposed strategies for channel assignment in wireless mesh networks, Traffic Aware Channel Assignment is selected as the most appealing strategy based on all performance criteria examined.**

***Index Terms*— Wireless Mesh Networks, Traffic Aware Channel Assignment, data rate, throughput, network, channels, wireless network.**

I. INTRODUCTION

Wireless mesh networks attracted more interest from research groups and industry. Among wireless networks, WMN is familiar to allow communication to other networks anytime, anywhere. WMN can remove wires and cables thus it can reduce the cost for installation and maintenance. When mesh routers have numerous radios, one of the more difficulties is assigning channels to radios. By properly designing and allocating channels to radios, interference can be avoided and throughput enhanced when using many radios. The allotment of channels and the routing of those channels are separate. Nodes that share a shared channel with their neighbours must share channel capacity. The amount of bandwidth available on each link is determined by the number of nodes sharing the same channel. The way in which the channel is allotted to a link affects the available bandwidth on a link. So, it is good to study the channel assignment problem together with routing.
The basic method is to find a solution for routing. Through routing, the flow rate on each link can be determined. Channel assignment is based on the flow rates, if there are variations in the load, channel assignment must be recomputed. But often re-computations are not acceptable in channel assignments. The newly assigned channel

Grenze ID: 01.GIJET.8.1.83

will not consider the current assignment. To enforce this new assignment, the channel needs to change the radios too. The network's connection is affected by channel switching. It takes time for the routing system to detect that the prior link is no longer active. The routing procedure will take time to use the new channel's links when a radio is assigned to a new channel. Packet losses may occur as a result of this, resulting in an increase in recurrence and a drop in throughput. Raychaudhuri et al. [1] demonstrated experiments and showed that switching of the channel can break the connectivity of the network up to 55 seconds. Crichigno et al. [2] presented a survey on channel assignment algorithms. Most of the existing approaches have not considered the reconfiguration of WMN once the traffic flow changes. Franklin et al. [3] assume the presence of link layer synchronization between the nodes. Link layer synchronisation allows nodes to distribute the data transmission across many time slots while avoiding conflict. Rezgui et al. [4] proposed a distributed channel reassignment algorithm to cope up with the traffic changes. The interference prevents concurrent data transmissions in the neighbouring links. If there are L numbers of links in a set, no two links are allowed to transmit simultaneously.

The performance of WMN is strongly influenced by gateways interference and congestion that lead to noteworthy losses and delays in packages. The multiple input multiple output (MIMO) systems [5] [6] are used to increase the performance of Network Directional and Smart Antenna. Cao et al. [7] proposed cooperative communications. Routing can positively or negatively impact performance. The objective of the routing is to discover better routes depending on the routing methods given. The routing protocol should have beneficial impacts on network stability, collect mesh network features, calculate pathways appropriately and prevent loops to achieve improved network performance.

Traffic-aware assignment of channel permits the interface channel depending on current traffic. Sridhar et al. [8] suggested a measure for the interference route that would calculate total traffic on all WMN interference routes. Channel Interference Metric (CIM) is computed using the formula, as follows,

$$\text{CIM} = \sum_{j=1}^{k} Channel\ utilisation\ table\ (i, j) \tag{1}$$

$'k'$ is the scope of interference. Each node can keep the channel use table so that the total data transmitted by the 'j' node on the channel can be traced. Taking into consideration traffic transport and route loss, the protocol model is enhanced and Chiu et al. [9] suggest it. The interference channel index (CII) is calculated using the protocol model as,

$$CII = \sum_{j=1}^{k} \frac{channel\ utilisation\ table\ (i,j)}{j^{y}} \tag{2}$$

$'y'$ is exponential route loss. The load Aware Channel Assignment (LACA), introduced by Raniwala et al. [10], was designed in order to decrease interfaces based on traffic load. But the interfaces were organised according to their rankings by Skalli et al. [11]. The ranking format comprises the load of traffic, the distance from the gateway and the number of node interfaces.

$$Rank\ of\ a\ node = \frac{Traffic\ load\ on\ a\ node}{Distance \times Number\ of\ interfaces} \tag{3}$$

Sarasvathi et al. [12] presented centralize rank base channel assigned (CRB-CA) to enhance the mesh-based traffic and interference aware channel assignment (MesTic) ranking algorithm by adding the link quality to the load of connections, distance and quantity.

$$Rank\ of\ a\ node = \frac{WCETT\ of\ a\ node}{Distance \times Number\ of\ Interfaces} \tag{4}$$

Where the WCETT is weighted cumulative time expected. Athanasiou et al. suggested centralised load-conscious channel assignment [13] evaluates the load as regards the channel condition and number of users concerned and the transport load. Bakshi etc. [14] planned a traffic conscious CA algorithm, depending on the load on the channel. A low-traffic pathway for the solution of congestion in connections is found. The feasibility of the recognised road will be monitored in the central node. If a connection has any congestion, or if the chosen path is not possible, the node assigns it to other least traffic channels [15-18]. Each node has its own node in Mohsenian Rad et al. [15]

The paper is organized as follows: section 2 describe the proposed model, section 3 ilustrate the results and the performance of the system and the article is concluded at section 4.

II. PROPOSED NETWORK MODEL

Each mesh router has four radio interfaces in the network model. Fixed power is provided for the whole radio and the transmission rate is seen as rising. The approach of model based interference is used to successfully transmit the SINR (Signal to Interference and Noise Ratio) at the receiver. If I is the transmitter and 'j' is the recipient, SINR is defined as,

$$SINR_{ij} = \frac{G_{ij}P_i}{\sum_{x\to y\neq i\to j} G_{xj} + n_j} \tag{5}$$

$P(i)$	$\rightarrow$	Power emitted by the sender i
G_{ij}	$\rightarrow$	Gain among the sender and the receiver
n_j	$\rightarrow$	Noise at the receiver
x, y	$\rightarrow$	set of links

The rate of transmission is taken as r_m, the condition to retrieve the information is $SINR_{ij} \geq \gamma_{rm}$, where γ_{rm} is the minimum SINR necessary to retrieve the signal without error. The model base interference method is used to avoid concurrent transmissions in the neighbouring links. The set of link ‘L’ is considered in such a way that none of the two links are transmitted concurrently. Each connection l to flow rate f(l) shall bear f(l)T for a certain time period T. The average size of frame is $'p'$ then, the amount of data transmitted is $\frac{f(l)T}{p}$ packets. The required time is the time required to transmit the frame and overhead. If the time required to transmit the overhead is $\Omega(l)$, then $\Omega(l)$ is given as ,

$$\Omega(l) = DIFS + T \times N + 2T_{plcp} + HLEN + SIFS + \frac{Ack}{F_{ctrl}} \tag{6}$$

$DIFS$	$\rightarrow$	Distributed Inter Frame Space
N	$\rightarrow$	Number of slots
$HLEN$	$\rightarrow$	Header length is the size of IEEE 802.11 header
T_{plcp}	$\rightarrow$	Transmit time for physical layer convergence procedure.
Ack	$\rightarrow$	Size of the acknowledgment frame
F_{ctrl}	$\rightarrow$	Control frame transmit rate
$SIFS$	$\rightarrow$	Short Inter Frame Space

If the information is received without any error, the contention window will be at a minimum for all nodes. The explicit physical layer parameters for IEEE 802.11a are given in Table I.

TABLE I. IEEE 802.11A PHYSICAL LAYER PARAMETERS

Parameter	Value
SIFS	16 µs
Tslot	9 µs
DIFS	34 µs
Minimum contention window size	15
TPCLP	23 µs
HLEN	28 Bytes
ACK	14 Bytes
Rctrl	6 Mbps

III. PERFORMANCE EVALUATION

Figure 1 shows the performance results of TACA. In delay vs. data rate, the delay is decreased. This must be very much essential to provide end-to-end communication with less delay. The reason behind the decrease in the delay is, the loop free forwarding algorithm uses a spanning tree to eliminate the loops, and also spanning tree finds an alternative path too to forward the packets. The network's performance is assessed in terms of output, end to finish, average energy and residual energy.

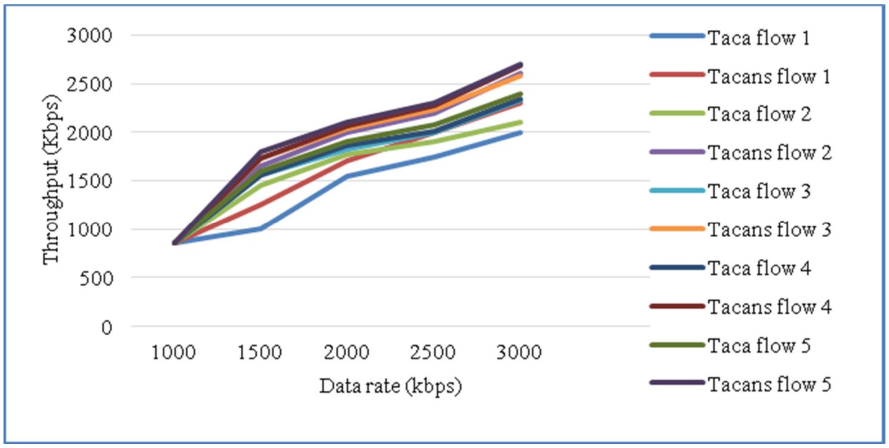

Figure 1 Performance of TACA with respect to throughput.

TABLE II. TACA DATA RATE AND THROUGHPUT

Data rate (Kbps)	Throughput (Kbps)
1000	853
1500	1431
2000	1624
2500	1792
3000	2035

Figure 1 shows that throughput of TACA is outperformed than competitive methods. Performance analysis of throughput and data rate for flow 3 is given in Table 2. The findings of the simulation show that TACA performance has increased up to 7% on average.

IV. CONCLUSIONS

In this paper, Traffic Aware Channel Assignment is designed and implemented. It considers the stability of the node as well as the network. The proposed algorithm has five phases namely Network training and nearby identification, allocation of the minimal change channel, quality metric connection and free shipment of loops. In network formation and neighbour identification phase, nodes are created randomly and Hello packets are broadcast to all the nodes which respond to Hello packets are considered as neighbour nodes, and the information about neighbour nodes is updated in the routing table of the nodes. Initially, packets can be routed through the existing path. The connection may be re-routed using minimum allocation of variation channels if any route disconnection is found. One of the connection quality features to save in the routing database is the link quality metric. It is also the weighted interference-ratio and congestion-level function. Using the proposed algorithm parameters like throughput delay and packet loss is improved with various data rate.

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