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Weight Aware Channel Assignment with Node Stability in Wireless Mesh Networks

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***Abstract*—Wireless Mesh Network (WMN) is one of the next generation wireless networks' contemporary technologies. This study proposes a novel weight and node stability method for the channel assignment to enhance WMN. Node Stability (NS) is the major concern to support real-time transmissions in wireless networks. Given the enormous bandwidth demand and the dynamic change in traffic, most wireless network routes are unstable, resulting to storming, loosing and delaying processes. In this paper, stability problem in WMN is addressed. First the main factor that causes the instability is presented. In order to overcome these problems, a new method called WACA, which contains a weight aware channel allocation with node stability.**

***Index Terms*— Wireless Mesh Networks, Weight Aware Channel Assignment, throughput, network, wireless network, node stability.**

I. INTRODUCTION

Wireless Mesh Network (WMN) has evolved as the key to its low-cost and operating capabilities. IEEE 802.11 standard is adapted to wireless transmission in wireless mesh networks [1, 2]. Wireless router nodes and mobile stations are the types of nodes in mesh network. To form a wireless backbone, wireless routers are interconnected. In the proposed algorithm, multiple factors are considered. The characteristics of these algorithms are as follows.

1. All the existing channels in a WMN is used in allocation of the channel. Most of the available channel allocation schemes use orthogonal channels.
2. Appropriate transmission weight follows the algorithm. It shows the number of nodes that depend on the path.
3. Distance and channel separation are combined to measure the interference impact.
4. The receiving node mobility is also considered for channel assignment. The structure of the network may vary when the receiver arrives, leaves or moves. In that case, channel assignment has to be performed.

WMN is normally seen as MANET with extension in connectivity. But the major difference in WMN has static architecture and less mobile [3]. Mesh routers transmits the data through a gateway that connects the particular node to internet. So gateway may become the singlepoint failure [4]. To address this issue, numbers of gateways can be installed to distribute the weight or traffic. So that the performance can be improves. Routing methods have a key role in impacting the performance of the network [5]. The aim is to identify the proper route based on the routing metrics.

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The routing metric should have network stability, it has to capture the network characteristics and forwarding loops must be avoided. In most of the routing algorithm, node stability is not considered as the performance metric. The probability of rerouting increases, node instability occurs [6]. This may cause fluctuations. Node stability may cause the performance degradation and delivery in out of order, jitter, loss or unacceptable high delays. In this paper new routing technique is proposed by considering the node stability and weight of the channel [7]. It considers the stability index and loop free forwarding. It reduces route flap.

II. Factors Causing Instability

As the instability of the network increases, packet losses and network latency increase. Factors leading to instability in the networks are discussed as follows.

A. Interference

Intervention is the principal factor that causes instability to impair the network's performance. The channels in wireless networks are distributed across nodes. The interference with intraflow is generated by nodes that are simultaneously shared with a common channel for data transfer [7].

B. Routing algorithms

Mainly in link state routing algorithms, the advertisement messages to update the routes utilize more resources in the network leading to route flap. As a consequence, the performance is degraded causing an unstable network [8].

C. Congestion

It is the queue at the middle nodes. The packet arrival rate is higher than the forwarding rate, and the transmission nodes can be used. Topology, number of flows, flow characteristics, canal capacity and data rate available are the variables causing congestion [9].

D. Route flapping

The transmission of packets [10 to 13] creates needless delays. The emergence and removal of routes in an intermittent way in the routing table are among the primary signs of network stability. The number of disappearances and reappearances can determine the degree of the network instability. The WMN multiple hop infrastructure is believed to be two sets of nodes in this chapter with mesh routers and gateways [14-15]. The mesh routers provide a wireless backbone for exchanging communications between users and the internet. For each interface, mesh routers are equipped with multiple radios and numerous channels. The Route Table (RT), which holds the routing data of each destination, is maintained by all network nodes [16-18].

III. WACA - NS Model

The proposed traffic-aware channel assignment with node stability is in five phases. Figure 1 shows the process flow scheme for WACA-NS. It's like this.

1. Training and identification of the network
2. Allocation of minimum channel
3. Metric quality link
4. Stability of the node leveraging algorithm for the stability index
5. Loop free transmission

A. Training and identification of the network

The node in the network transmits HELLO packets regularly in order to contain its node ID via all radio interfaces accessible. The neighbour ID which received the HELLO packets and the channel assigneed for the particular interface is recorded by all nodes within its transmission range. All nodes in a network have to create a neighbouring table with all information. Neighbors are directly connected to the node within their range of communication. Each node can identify its many connection neighbours using the neighbouring identification phase. Based on the interference the optimal path is chosen. If the route is disconnected, redirect the link with theMinimum Variation Channel Allocation algorithm (MVCA).

B. Allocation of minimum channel

In MVCA, a new f(l) rate and the maximum number of modifications permitted to the channel are taken into account. Collision domain use needs to be recognised in order to identify the radio to be allocated to a new channel. Total collision domain use for a connection is,

$$l = \sum \frac{f(l)}{c(l)} \; \forall l \epsilon L \tag{1}$$

$c(l)$ is link l's collision domain. Once the connection is totally utilised, the priority thatue Q adds up in decreasing order of priority all the links in the data transmission line. The flow capacity and associated interference level offer priority for a connection.The number of changes made in the channel should not exceed the maximum number of changes allowed. Depends on the flow rate (or) the traffic conditions channel is allotted in MVCA. Therefore, traffic aware channel allocation can be possible using the MVCA algorithm. To increase algorithm performance, traffic-aware channel allocation is supplied to the node stability.

C. Metric quality link

Link Quality Metric (LQM) is the link features that are saved in the routing database. The interference ratio and congestion level function. Interference Ratio determines interference level by use of SNR and signal-to-interference plus noise ratio. Interference rate is used to compute the interference level. The interference Ratio for a node $'i'$ on a link $'l'$ is defined as,

$$IR\ (i) = \frac{SINR(i)}{SNR\ (i)} \tag{2}$$

$$SINR(i) = \frac{P}{Noise + \sum_{i \in_{N-j}} \tau_i\ p_i} \tag{3}$$

$$SNR\ (i) = \frac{P}{Noise} \tag{4}$$

$P \rightarrow$ signal strength
$N \rightarrow$ set of nodes
$i \rightarrow$ source node
$j \rightarrow$ destination node
$\tau_i \rightarrow$ total time the node 'i' occupies the channel
Congestion Level (CL) is related to link utilization (U(l, t)) during the time t.

$$\mathrm{U}\ (l, t) = \frac{\sum_{K \in success\ (l,t)} size\ k}{Bandwidth} \tag{5}$$

success (l, t) is the set of packets successfully traveled in the link l during the time t, size 'k' is size of the packet 'k' (k∈ success (l, t)).

$$CL\ (l, t)\ =\ \beta U\ (l, t)\ +\ (1 - \beta)\ CL\ (l, t-1)\ where\ \beta\ \in\ [0, 1] \tag{6}$$

$$LQM\ =\ (1 - (\tfrac{1}{2})n)\ \times\ IR +\ (\tfrac{1}{2})n\ \times CL \tag{7}$$

D. Stability of the node leveraging algorithm for the stability index

The stability index is calculated using the connection quality history, which comprises the present link quality as well. If the quality of the connection is less than the threshold value, the connection can be accepted. If the measure of the link quality exceeds the threshold value, it should be regarded an unsatisfactory connection. The link which offers changes as an acceptable link and unacceptable link will not be considered for routing packets since this change will create oscillations leading to network instability. To improve the stability of the node, Stability Index Factor Algorithm (SIFA) is introduced. By watching the oscillations such as acceptable link and inacceptable link, persistence of the connection and quality of the link, SIFA computes the stability index factor of the link. The quality of the link is only to verify whether the quality of the link improves or deteriorates. SIFA must be executed by all the nodes in the network which is considered as mesh routers. It starts by adding the links as acceptable or unacceptable by checking the quality metric of the link as similar as or greater than the predefined value in the routing table. If the link is acceptable, it is updated in the routing table with the stability index factor as 1. If it is not acceptable that the stability index factor 0 was added to the routing table as well. The process performed in SIFA to find node stability is shown in Figure 2.

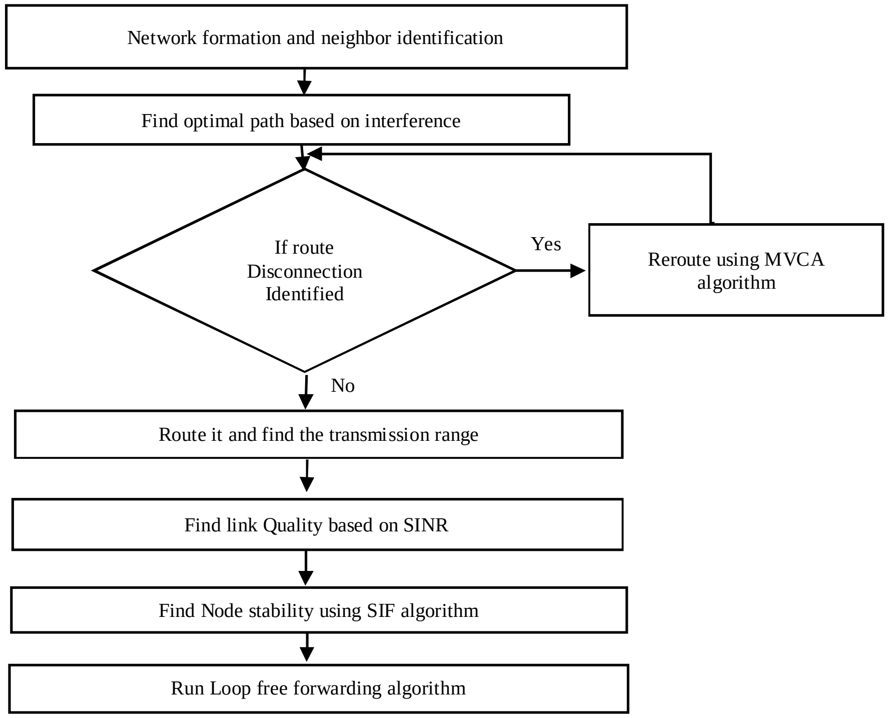

Figure 1 Process flow diagram for TACA-NS

Link l should present in the routing table of node ($l \in RT$)

1. If l is not in the routing table($l \notin RT$), consider l as new link.
2. Check the measure of connection quality. If it is below value(ε), the link should be considered as an acceptable link and the routing database should be updated with the link stability index factor 1. The link will be an inacceptable link if the LQM is larger than the threshold value and will be updated as a stability index factor in the routing table for the link as 0.
3. If the link already existing, check the LQM at time t+1.
4. If (LQM (t+1) = LQM(t)) < threshold, consider the quality of the link is not changed. So, stability index factor at time t+1 is the present stability index factor incremented by 1, else link quality is changed.
5. If (LQM (t+1) < LQM (t)), consider the quality of the link is improved and the stability index factor at the time t+1 is the present stability index factor incremented by 2.
6. If (LQM (t+1) > (LQM (t)), consider the link quality is degraded. Though link quality is degraded, if it is less than the threshold value then the stability index factor at time t+1 is set as half of the present stability index factor. If it is above the threshold value set the stability index factor for SIF at the time (t+1) as 0.

By using the SIFA, the stability of the node can be checked and link quality and network stability can be improved. However, the performance is decreased if there is a loop in the network. So loop-free transmission is required to increase network performance.

E. Loop free transmission

The packets are routed indeterminately over the same path due to the presence of a loop. Loops can cause network traffic to increase the packet loss and the availability of bandwidth to decrease. Loops might generate paths which are unneeded. Free forwarding algorithm (LFFA) is included to prevent loops in the TACA-NS circuit. Loops are a serious issue in routing protocols. In LFFA, a spanning tree is constructed when a router leaves or joins the mesh network or in case of node failure. LFFA picks a gateway between the several gateways and forms the overall tree root. The transmission node selection system saves all links to the chosen node and all links utilised for receipt of the chosen node are deleted from the transmission list. The transmission list will also be used. The packet transmitted from the node is not returned. This ensures that the packet sent from the node is not returned again.

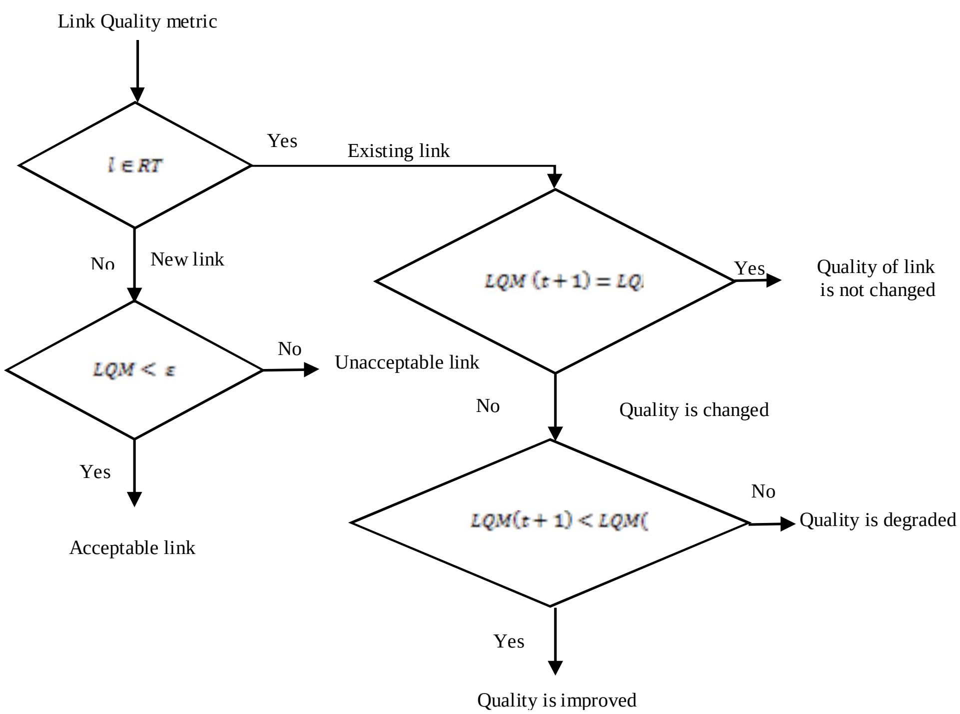

Figure 2 Process flow diagram for SIFA

IV. PERFORMANCE EVALUATION

Figure 3 shows that WACA-NS outperforms TACA. Performance analysis of throughput and data rate for flow 3 is given in Table 2. The simulation findings suggest that, compared to TACA, the WACA-NS performance is enhanced by an average of 7%.

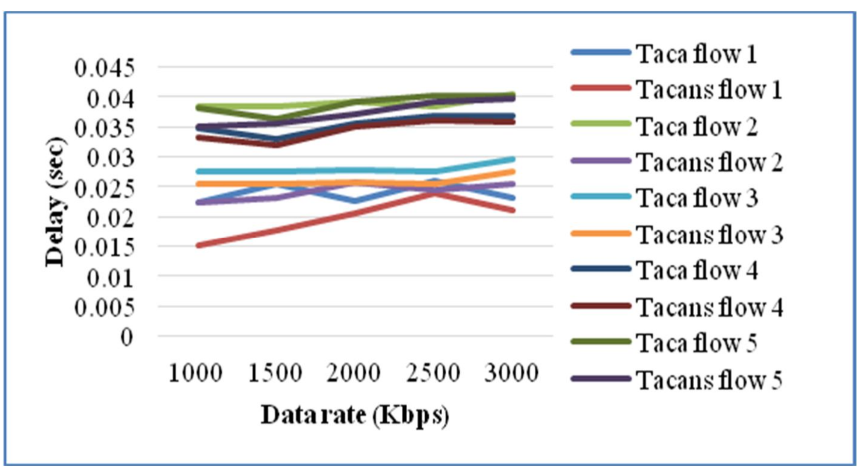

Figure 3 Comparison of WACA-NS performance based on throughput

The latency and the data rate of the WACA-NS performance were examined. WACA-NS performance is compared with TACA and shown in Figure 4. This is because WACA-NS only takes into account the node's stability in pushing the packet.

It will not consider the minimum number of hops. Performance analysis of delay and data rate for flow 3 is given in Table 1. Delay is reduced to an average of 1.8% in WACA-NS when compared with TAC.

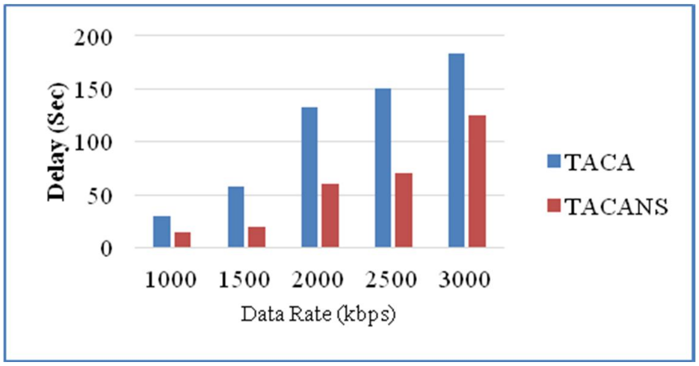

Figure 4 Comparison of WACA-NS performance based on delay

TABLE I. COMPARISON OF WACA-NS BASED ON DELAY

Data rate (Kbps)	Delay (Sec)	
	WACA	TACA-NS
1000	0.0273	0.0270
1500	0.0279	0.0273
2000	0.0281	0.0277
2500	0.0282	0.0280
3000	0.0295	0.0285

The effect of average energy with an increase in time is analyzed in Figure 5.WACA-NS outperforms TACA with an increase in time. To route a packet the channel assignment must consider the metrics which represent the node stability along with the metrics that minimize interference and congestion. Thus, by considering the stability factor of nodes, the channel assignment algorithm can minimize the average energy consumption in WMN and the network performance can be improved.

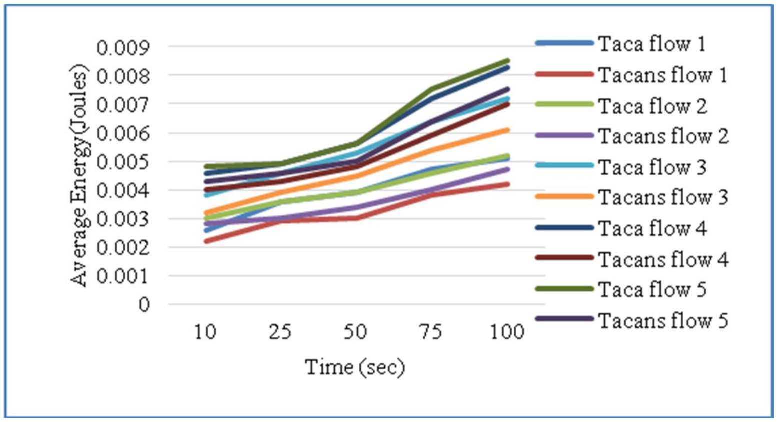

Figure 5 Comparison of WACA-NS performance based on average energy

TABLE II. COMPARISON OF WACA-NS BASED ON AVERAGE ENERGY

Time (Sec)	Average Energy (Joules)	
	WACA	TACA-NS
0	0	0
10	0.0035	0.0032
25	0.0041	0.0035
50	0.0048	0.0041
75	0.0054	0.0051
100	0.0060	0.0052

Table II shows the performance of average energy with an increase in time for flow 3. From simulation results, it is concluded that WACA-NS is improved to an average of 12% average energy consumption when compared with TACA.

TABLE III. COMPARISONS OF WACA-NS BASED ON RESIDUAL ENERGY

Time (Sec)	Residual Energy (Joules)	
	WACA	TACA-NS
0	100	100
10	99	99.9
25	98	99.5
50	97.7	99
75	97.1	98.9
100	96.3	98.3

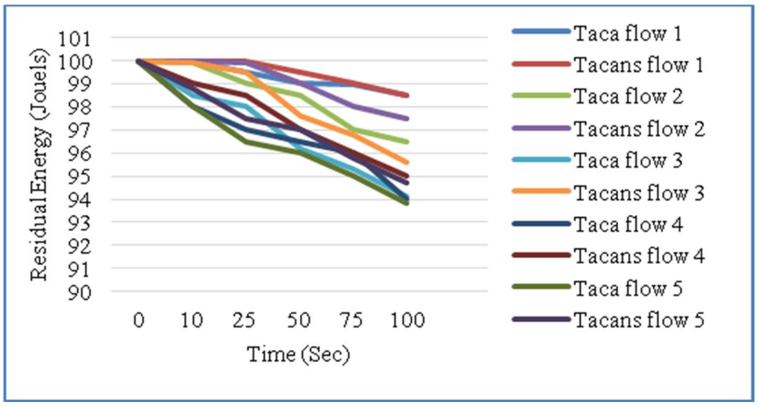

Figure 6 Comparison of WACA-NS performance based on residual energy

Figure 6 analyses the influence of residual energy with time increasing. The channel method may enhance the residual energy of WMN by taking account of the node stability factor and improve network performance. The comparison of the WACA-NS with an increase in time for flow 3 is shown in Table 3. The findings of simulation suggest that the average residual energy consumption of WACA-NS compared to TACA has been improved by 1.3%.

V. CONCLUSIONS

A new distributed channel allocation is presented in this paper. To improve the throughput, the path forwarding weights are considered and it is arranged in decending order. The proposed algorithm considers the reassignment problem also. To avoid channel reassignment very oftern node stability is performed. The programme therefore chooses the most stable nodes to calculate the path. Simulation indicates that current routing strategies are carried out by the algorithm weight aware channel assignment with node stability.

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