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# Performance Enhancement of Channel Efficiency in Wireless Mesh Networks

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***Abstract:*** **The wireless Networks were working on two modes i.e. Infrastructure mode and AdHoc Mode. These modes were configured on IEEE 802.11 Standard. Many researchers and authors have been working on the MAC (Medium Access Layer) to increase the performance of Wireless Networks. The MAC protocol enables the data service for transmission and receiving the payload across the PHY data service. The implementation of the mobility model relies on the standard parameters from the related research disciplines, such as transport planning or traffic modeling. The resulting mobility models would rely on a NAM (Network Animator) area. In this paper beholding the affect of channel interference on 802.11 standard with focusing on the two standards namely 802.11a and 802.11n standards. The Proposed Algorithm interacts with 802.11a and 802.11n standards which are opted by Access points and Clients. This Algorithm is dynamically assignment of the channels so that minimize the sum of interference. The advantage of channel assignment is causing minimum of delay. The Frequency switching has been implemented in this paper by using channel separation approach and this approach on the proposed Algorithm. The clients accessing these access points on the self selecting search by using AODV Protocol and traffic send by the clients are HTTP, FTP and CBR. This traffic sends by different clients and on the basis of traffic was simulated the experimental test bed and increase the throughput with minimum of delay on the wireless networks.**

***Keywords: 802.11, Channel Assignment, Channel Selection, FTP, HTTP, CBR.***

## I INTRODUCTION

The wireless mesh networking has most important key position for providing access to different wireless and wired devices shown in figure 1.

Specially, the wireless devices talk to other devices by specific frequency spectrum.

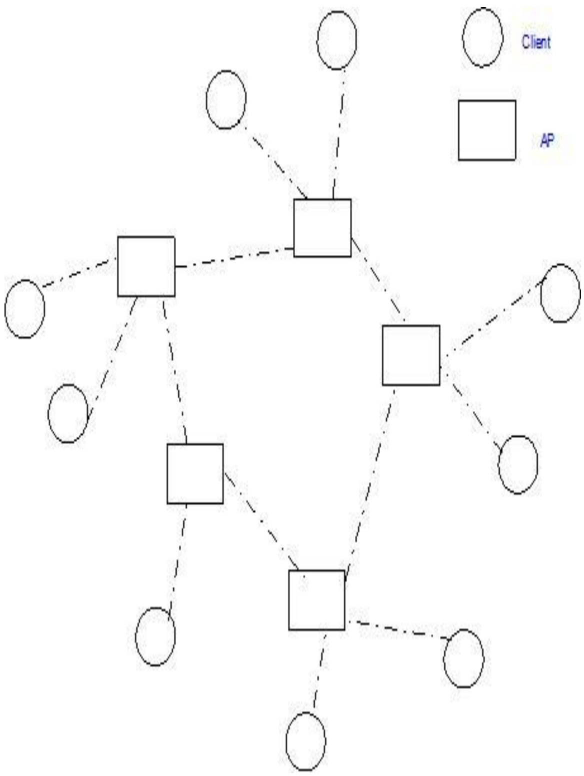


Figure 1. Infrastructure based wireless mesh networks.

The frequency spectrum adjusted according to the standard defined by IEEE. The number of IEEE standards [2] defined by the IEEE expert committee and the frequency range of these devices shown in table I.

TABLE I. IEEE 802.11 STANDARD AND ITS SPECIFICATIONS [2]

| ***Standard*** | ***Description*** | ***Transmission Range*** | ***Maximum data rate*** |
|---|---|---|---|
| 802.11a | It is an extension of 802.11 and uses an orthogonal frequency division multiplexing encoding scheme rather than FHSS or DSSS. | 5 GHz | 54 Mbps |
| 802.11b | Is an extension to 802.11 that applies to wireless LANS and uses only by DSSS | 2.4 GHz | 11 Mbps |
| 802.11g | It applies to wireless LANs and is used for transmission over short distances | 2.4 GHz | 54 Mbps |
| 802.11n | 802.11n builds upon previous 802.11 standards by adding multiple-input multiple-output (MIMO). | 2.4 GHz | 600 Mbps |
| 802.11ac | 802.11ac builds upon previous 802.11 standards, particularly the 802.11n standard, to deliver data rates of 433Mbps per spatial stream | 5 GHz | 6.7 Gbps |
| 802.11ad | 802.11ad is a wireless specification under development that will operate in the 60GHz frequency band and offer much higher transfer rates | 60 GHz | 6.93 Gbps |

For WMN deployment, the amount, type, and locations of network devices has to be selected, as well as the used equipment [3].In the wireless devices parameter, the frequency of each wireless device has adjusted manually or automatically. In WMN, Access Points (APs) closer to the mesh portal require more bandwidth to forward packets of other APs. The access points act as routers and to leading the packets from source node to destination node. However, the IEEE 802.11 MAC provides roughly equal amount of transmission opportunities to each station regardless of its type [3].

The traffic volume in the wireless mesh backbone in a large-scale WMN can be very large and can vary

from one mesh router to another, thus posing significant challenges on the MAC design [1]. This paper is documenting as follows. The section 2 describes related research and section 3 defines Algorithm part. The Experimental Setup have been developing and presenting in section4. Section 5 has been presenting the results and discussions. Section 6 presents the conclusion and future work.

## II. RELATED WORK

Earlier published research on WMN deployment design has concentrated into methods to use of multiple radios and advanced antennas, advanced routing, optimization algorithms, evaluating WMN capacity, and develop MAC modifications. Generic approaches to handle multiple optimization criteria in WMN deployment design do not exist and the following related proposals deal with a limited part of the field. Modifying the MAC protocol is one method to increase WMN performance but it does not remove the need for WMN deployment design. Methods in this work are designed for IEEE 802.11s, and can be generalized for MAC protocols retaining the basic nature of IEEE 802.11.

In [4], the authors show that using a single radio, there exists only minor interference with channel separation of four channels. According to Robinson et al., when the number of radios is increased, also larger channel separation is required. The advantage of source routing is that intermediate nodes [5] do not need to maintain up-to-date routing information in order to route the packets they forward, since the packets themselves already contain all the routing decisions. In order to maintain routes, AODV normally requires that each node periodically transmit a HELLO message, with a default rate of once per second. Failure to receive three consecutive HELLO messages from a neighbor is taken as an indication that the link to the neighbor. The 802.11s [6] wireless Mesh standard and implements a single broadcast domain and thus integrates seamlessly with other 802 networks. In particular, 802.11s supports transparent delivery of unicast, multicast, and broadcast frames to destinations. The optional 802.11s congestion control concept uses a management frame to indicate the expected duration of congestion and to request a neighbor mesh station to slow down.

The Authors [7] is assumed that each message packet contains the location of both the source and the destination. As the messages propagate through the network, every intermediate node could easily compute. This Paper [8], presented an autonomous network reconfiguration system (ARS) that enables a multiradio WMN to autonomously recover from local link failures to preserve network performance. The ARS (autonomously reconfigure system) its local network settings channel, radio, and route assignment for real-time recovery from link failures. The accurate link quality information from the monitoring protocol is used to identify network changes that satisfy applications' new QOS demands or that avoid propagation of QoS failures to neighboring links. The deployed the standard 802.11 into WMN Networks by Timo Vanhatupa, Marko H., Timo D[9]. Then the WMN further worked on two algorithms channel assignment and uses minimizing the number of mesh Access Points.

The WMN channel assignment algorithm is genetic algorithm designed for static channel assignment. The target is to optimize existing network by selecting radio channels optimally. It is assumed that locations of APs have been designed by the network administrator to cover required areas. Each AP contains one or more wireless interfaces that may operate on allowed WLAN channels. The second Algorithm checks the necessity of each mesh point based on the WMN fitness.

The algorithm operation is very simple. First, the fitness calculation is configured according to user preferences and the algorithm calculates the initial fitness of the network. Then, the algorithm checks each mesh point in random order by calculating the WMN fitness with and without the particular mesh point. If fitness is higher without the mesh point, it is disabled. Otherwise the mesh point is left to the network. The Author [14] worked on the Asymmetric networks that had used both terrestrial and satellite links.

It also proposed a new formula that calculated the throughput of the TCP over Asymmetric networks. The authors also assumed that retransmission does not happen because they had used enough buffering on the client and satellite link. The author also worked on TCP window size and steadily changes at every interval by 1 when acknowledgment received. There were many approaches using to improve the performance of TCP protocol [15]. The paper explained the two approaches i.e. TULIP and MACAW.

The TULIP protocol overcomes the congestion problem locally whereas the MACAW protocol uses backoff policy that maintained contention window. If any loss occurred then it reduces to one half of the contention window.

This also solves the problem of hidden station problem. The Author [21] assumed a wireless mesh network model that comprising a number of mesh users connected via number of mesh routers. The mesh user uses the same channel for transmitting the mesh traffic and the use of multiple radios per node operating on multiple orthogonal channels would reduce interference effects.

The proposed routing scheme is structured in a manner similar to AODV except that the control packets collect essential information to evaluate the quality metric, which forms the basis for route selection. The author investigated the performance of the network by means of number of active neighbors of the transmitters and interference between receiving nodes.

## III. PROPOSED ALGORITHM

The proposed Algorithm aims is to minimum interference and to assign channels in wireless Access points and nodes with minimum network broadcast message, it adds its own channel information and re-broadcasts the updated message to its neighbors.

A client generates data packets and a Access point receives packets from its relay node at the upper layer and forwards them to its destination Client at the lower layer. The description of the proposed Algorithm is as given in the table on next page.

**Important notations**
l: is the link in between communicating nodes
CN: Channel Number
k: Number of orthogonal channels
C: Channel
Y: Interference

**(1) Monitoring period $t_{m}$ and Channel Assignment C**
**for every** link j **do**
measure link-quality **($l_q$)** using passive monitoring;
**end for**
send monitoring results to an Access Points **$A_p$** and Clients **$C_l$**;
for Channel Assignment
$C_{i,j}^{k}$ {
1: (i,j) nodes uses channel k
0: not used or supposed to assigned when it becomes 1 }

**(2) Failure detection and group formation period $t_f$**
**if** link l violates link requirements γ **then**
request a group formation on channel c of link l;
**end if**
participate in a Access Point **$A_p$** if a request is received from the Client **$C_l$**;

**(3) Planning period ( M,$t_p$ )**
**if** node i is elected as a Access Point **$A_p$** **then**
send a planning request message (c ,M ) to a Access Point **$A_p$**;
**else if** node i is a Access Point **$A_p$** **then**
synchronize requests from reconfiguration groups $M_n$
generate a reconfiguration plan (p) for $M_i$;
send a reconfiguration plan p to a leader of $M_i$;
**end if**

**(4) Reconfiguration period (p , $t_r$)**
**if** p includes changes of node i **then**
apply the changes to links at t;
**end if**
relay p to neighboring members, if any

**(5) Channel Assignment and Interference (C, X)**

**if** X is the interference of number of orthogonal channels k then
$X_i^k$ = { if ŕ is the radios of channel k then
1: Interference and 0: no Interference
}
Add from (1),

$C_{i,j}^{k} \leq X_i^{k} \in Y$ (Y represents interference on same channel)

$$\sum_{k \in K} C_{i,j}^{k} = 1 \qquad C_{i,j}^{k} + C_{x,y}^{k} - 1 \in Y_{i,j \in x,y}$$

$$Y = \min \sum_{k \in K} C_{i,j}^{k} + \sum_{k \in K} C_{x,y}^{k} k$$

**(6) Channel Separation (SC)**

SC <i,j> channel separation between i and j
CN: Channel Number
Y: Interference
**if** all nodes have not assigned channels
Find Ci ϵI, Cj ϵ J such that
SC <i,j> ϵ min Y
**if** the channels are assigned
Ci=I and Cj=J
and eliminate all unused channel number (Ci and Cj) ϵ min Y
**end if**
**end if**
**End**

## IV. EXPERIMENTAL SETUP

The Network topology defined in this scenario shown in figure 2 explained the access points, positions their frequencies and coverage areas. This multi radio multi channel scenario deployed on the 1000 m x 1000 m square area with connecting wireless link and composed by different clients in a coverage range of 20 meters by using NS2.34 Simulator [9]. This Access points will be used in IEEE 802.11a standard with frequency of 5.8 GHz and the clients will be able to communication at 2.4 GHz with IEEE 802.11n standard. The clients is able to access the access points (APs) via radio propagation model i.e. two ray ground. The data traffic for clients is a UDP stream with a packet size of 1024 bytes and round trip time is set to 2ms. The transmission rate is set to 11 Mbps. The speed of the client to move one direction to another for data transmission is 1 to 17 m/s.

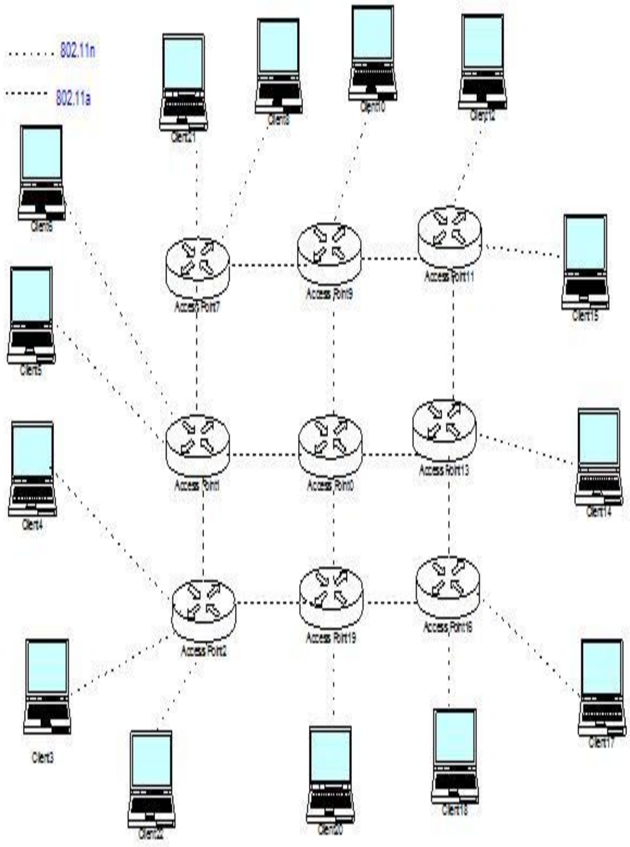


Figure 2. Experimental Setup with Mesh clients and Mesh Access Points.

The selected channels include 7, 8, 9, and 11 for covering the orthogonal and adjacent channel cases.

Each access points (APs) is tuned on a specific radio resource and each user can choose the AP to connect to. Each user can select one AP among all the ones whose coverage area includes the user's position (i.e. x, y and z positions). Two users selecting different access points (APs) that operate on the same frequency will interfere if they are in the range of both access points (APs).

Initially the connection is setup in between the Client 6 to Client 10 with CBR traffic. There are three access points have been used i.e. 7, 8 and 9. The channel selected from these access points are channel number 7 and 8 for transmission of data. The connection is setup in between client 3 to client 14 with a traffic type HTTP; the hop 2, 18 and 16 has been transmitting from source to destination clients. The traffic type FTP has configured on the 20 and 12 clients with a transmitting rate 11 Mbps and 54 Mbps by using 18, 13, 11 hops.

The channel is selected in between these access point (8, 13 and 11) is channel number 7 and 8. The channels share the frequency band so that sending and receiving clients transmitted/receiving the packets. The packets are placed on each channel and every node was responsible for maintaining the queue. Queues are served in order. A queue is inspected before an actual frequency switch; if the queue is empty the next queue in turn will be inspected.

## V. PERFORMANCE RESULTS

The performance results has been evaluated from the studied experimental setup and implemented in the ns2 simulator [9]. The module consists of the scheduling controller that handles the selection of the channel and in the current transmission slot contends the next transmission time using the channel selection approach. The routing table information hop count, destination node and source node information stored by AODV protocol[13]. By using xgraph utility of NS2 simulator; the evaluated graphs are shown in following subsections 5.1, 5.2.

### *A. Throughput*

Experimental results of 3x3 square networks topology structure shown in given below figure3. The throughput is the main performance evaluation metric adopted in the proposed research. Throughput measures the effective payload rate of successful transmission over the networks and counted in mega bit per second (Mbps).

In Just before 20 s, a higher bit rate stream is started i.e. 34 Mbps with little interference. After 20s, the bit rate comes down and the average data in between 13 Mbps and 15 Mbps including interference in the nodes. The interfering nodes are co-located within the nodes and operate on the different channels. The average

Throughput is received from the network is 15 Mbps i.e. maximum from the previous studies and also shown in the figure.

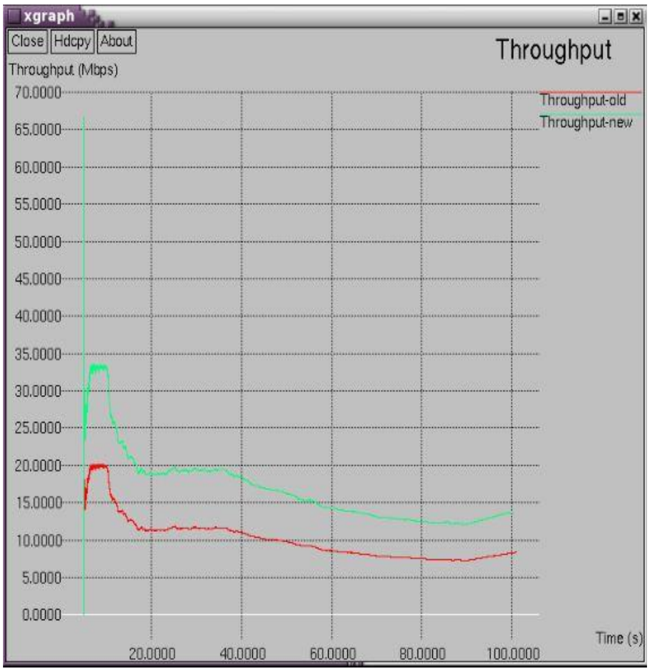


Figure 3. Throughput of WMN.

### *B. End to End Delay*

End to End delay becomes critical in 802.11 networks under load of CBR, HTTP and FTP traffic and a minimum end-to-end delay is achieved by our proposed work is 1.0 millisecond. Figure 4 shows the maximum number of Nodes supported by the network according to the End to End delay when the maximum payload size of IEEE 802.11 data message is used to transmit the traffic type (CBR, HTTP and FTP).

The delay can be reduced for successful sending of data packets and also improves the efficiency of the mesh networks.


Figure 4: End to End Delay of WMN.

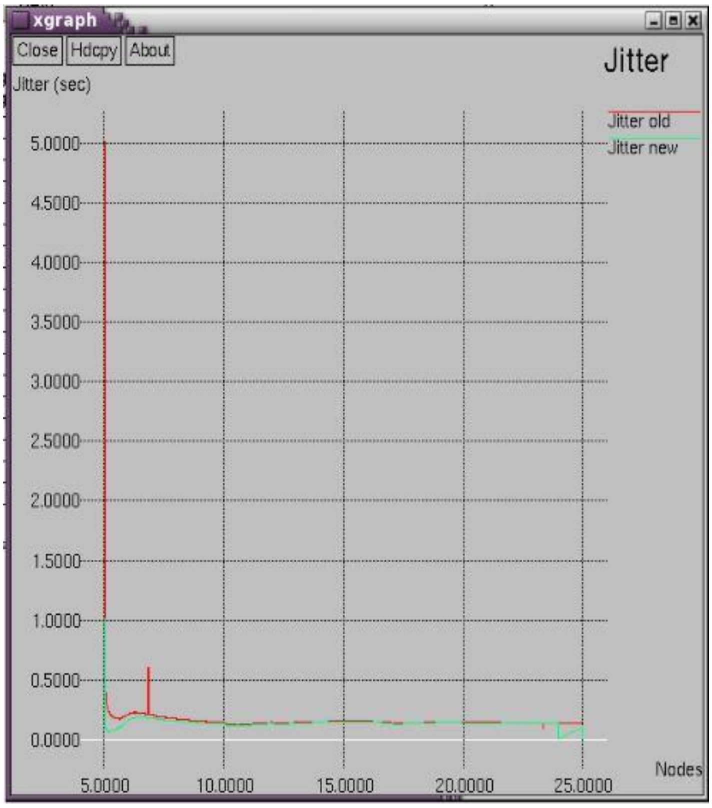


Figure 5: Jitter of WMN.

*C. Jitter*

Jitter defines the delay variations of packets from the sender to receiver side. It means the loss of packets at the receiver side. The sender continuously sends the packets to the destination but at the destination end the packets was dropped. These packets were dropping due to buffer overflow or disconnection at every interval. From the figure 5, it is analyzed that the jitter in the proposed work is minimum of 0.5 seconds. The jitter in the previous work was high at the starting time, it was assumed that three way handshake connection was not properly built. The highest jitter at the initial point is 5.0 and it downwards to 0.5 seconds.

The jitter of proposed work is 0.5 second and then downwards to 0.1 seconds. The overall comparison of two algorithms shown in the figure and it observed that the proposed algorithm performs better than previous work.

## VI. CONCLUSION AND FUTURE SCOPE

Simulation results show that the Wireless Mesh Network gives valuable insight of the grid topology and can be successfully used with the proposed algorithm. In Present scenario will be improving the performance of WMN and comparing to previous algorithm [8]. With multiple channels can drastically improve throughput in multi-radio wireless mesh networks.

Our extensive simulation experiments have demonstrated that the proposed algorithm performs competitively and thus can serve as a practical and scalable solution to the channel assignment problem. In the future work will be extending the algorithm and performing on the real time platform.

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