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Runtime Optimization of 802.11 based Wireless Mesh Network by Multi-Radio Multi-Channel

Er. Navneet Kaur[1], Er. Gurjot Singh[2]

Asst. Prof., Dept. of Computer Science & Engineering, Chandigarh Engineering College, Landran, Punjab, India [1]

Asst. Prof., Dept. of Computer Science & IT, Malwa College, Bondli, Samrala, Punjab, India [2]

Abstract: Established WMNs work in single-radio single-channel (SR-SC) design in which single network interface card (NIC) is setup in every router and one basic radio channel is shared by every mesh router. In this engineering, system continues from low limit and throughput because of successive back offs and collision impacts, consequently Single-Radio Multi-Channels (SR-MC) had been intended to upgrade the WMNs execution. In SR-MC design each cross section switch needs to switch between channels progressively with shifting activity load in the system, while incorporating with connecting network hubs to guarantee trade of data for some timeframe through a typical channel yet such coordination can be accomplished by tight time synchronism among mesh nodes, however in a multi-hop WMNs it is hard to accomplish such synchronization among hubs. A satisfactory answer for decrease the high inactivity and at the same time upgrade throughput and diminish end-to-end delay of WMNs is to utilize Multi-Radio Multi-Channel (MR-MC) engineering. In MR-MC WMNs design, various interchanges can happen in the meantime, and diverse channels doled out to connecting connections can convey information packets without impedance. In the wake of authorizing SR-MC WMNs and MR-MC WMNs in Qualnet test system, results are assessed in view of parameters such as throughput and end-to-end delay. Results demonstrate the critical distinction between these two situations. MR-MC WMN gives the better result as contrast with the SR-MC WMN. MR-MC WMN is considerably more suitable for the calamity administration in the broadband web application. But in present eon scalability is also a major factor for the optimization of the network so in this paper effect of scalability on SR-MC and MR-MC wireless mesh networks is optimized.

Keywords: WMN (Wireless Mesh Network), SR-SC (Single radio-Single Channel), SR-MC (Single radio-Multi Channel), MR-MC (Multi radio-Multi Channel).

I. INTRODUCTION

Network topology and various bounces in WMNs, has been excogitated as a principal innovation for some applications notwithstanding group and neighbor hood organizing, broadband home systems administration, metropolitan region systems administration and undertaking organizing [2].The normal WMNs structure comprises of three unique components of remote system:
Mesh Clients (portable or others), network gateways (network gateways with gateway/bridge functionalities) and Mesh access point (mesh router). Mesh nodes associate with cross section routers with remote or wired connection. All mesh router show information for rest of the mesh router and some routers have supplementary productivity of being system passages. These gateway routers are generally associated by means of wired connections which transmit the information from web to the cross section routers.

Different charming points of interest of WMNs are self-design, self-recuperating, empowering speedy sending, self-association, cost viability and simple support. Numerous qualities of remote adhoc systems are acquired by WMNs however mesh routers are generally fixed when contrasted with the adhoc networks. Along these lines, energy is the main restraint for adhoc networks as there is no such restraint in routers deployed in WMNs.

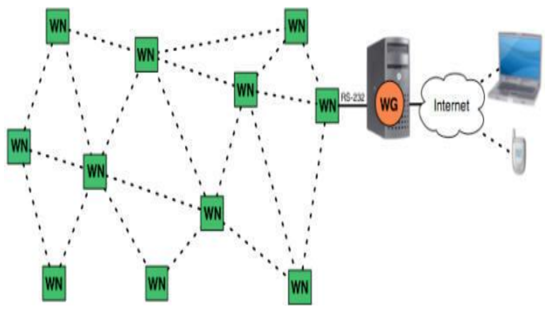

Figure 1: Wireless mesh network architecture having basic network component

Conventional WMNs work in single-radio single-channel (SR-SC) design in which one network interface card (NIC) is setup in every router and one basic radio channel is shared by each mesh router. In this design, system perseveres from low limit and throughput because of successive back offs and data collisions, generally for real-time scenarios, for example, CBR, VoIP, VBR transmission in multihop WMNs [3-4]. Actually, the IEEE 802.11a and the IEEE 802.11b/g band turnout to have 12 and 3 non-interfering channels, separately.
In spite of the fact that there exist an extraordinary degree of obstruction in these non-covering directs in the present resource IEEE 802.11 equipment, by utilizing enhanced

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recurrence channels as a part of equipment for multi-channel this issue can be explained. Thus, to improve the execution of WMNs SR-MC WMN has been planned [5-6]. On examination with the SR-SC WMNs, the SR-MC WMNs mitigates the impedance, diminish the delay and system throughput is expanded. In SR-MC design each cross section router needs to switch between channels progressively with changing movement load in the system, while incorporating with connecting network nodes to guarantee trade of data for some timeframe through a typical channel yet such coordination can be accomplished by tight time synchronicity among mesh nodes, yet in a multihop WMNs it is hard to accomplish such synchronization among mesh nodes. Also, item equipment is not yet accessible with quick channel exchanging proficiency (in the request of 100 µs). It is portrayed that the postponement in using so as to exchange the channels the item equipment NICs [7, 8] of 802.11 can be 100 ms.

A sufficient answer for lessen the high dormancy and at the same time upgrade throughput, diminish jitter and data drop proportion of WMNs is to utilize Multi-Radio Multi-Channel (MR-MC) engineering. In MR-MC WMNs engineering, various correspondences can happen in the meantime, and diverse channels relegated to adjoining connections can convey information packets without obstruction however with the utilization of MR-MC design there exists numerous channel task issues. At the point when channels are appointed appropriately, it can update the working of WMNs on impedance decrease, availability, system limit expand, vitality proficiency, portability strength, and so forth.

A. Multi-Radio Multi-Channel (MR-MC) WMNS

In MR-MC WMNs, each lattice router/nodes is setup with numerous network interface cards and all NICs can take a shot at different recurrence channels. A sample of MR-MC WMN with six remote mesh nodes (access focuses), five recurrence channels and three NICs per switch is appeared in Fig 2 and node 4 is communicating simultaneously with nodes 2,3,6 due to the presence of MR-MC per node. The number demonstrates the assigned channels that are reused spatially.

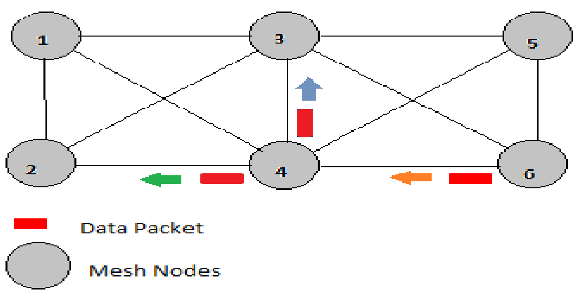

Figure 2: MR-MC WMN example

The MR-MC design has pulled in consideration of the specialists because of moderated obstruction, high throughput and successful data reception proportion and diminished jitter in WMNs. As determined before, accessible channels inside the IEEE 802.11a and IEEE 802.11b/g recurrence groups are constrained to 12 and 3 individually. This means same channels can be appointed to some intelligent connections however the channel ought to be relegated appropriately so that the coherent connections having same channel ought not to be near one another, else it will build the obstruction rate and hence the meddling connections won't be dynamic all the while. Also, the NICs available are limited and thus NIC to transmit/get the information packets need to share some sensible connections in a switch. At the point when the same NIC is utilized by two legitimate connections as a part of a switch for correspondence, they require same recurrence channel however they won't be dynamic in the meantime. Therefore, it greatly mitigates their compelling limit. The limit of dynamic connections can be expanded by tossing some coherent topology joins. Nonetheless, when a few connections are deactivated, it might build the quantity of jumps through some directing ways and might be some topological connections are not associated appropriately. Subsequently, numerous elements should be inspected in MR-MC like designation of channels and interfaces, the quantity of sensible connections which ought to be doled out among the neighboring switches, and through which legitimate connection the information packets ought to be sent.

In addition, four essential issues that ought to be considered in different limitations of MR-MC WMNs and physical topology of the switches are outlined in [11], i.e., interface task, arrangement of coherent topology, steering and portion of channels. System availability and set of legitimate connections is controlled by the intelligent topology. Task of sensible connections to the NICs in each cross section router is chosen by interface task. Dynamic channel for each legitimate connection is chosen by the channel allotment calculation. In conclusion, the transmission of data packets ought to be done over which intelligent connection is dictated by directing. In the wake of investigating the issues said above in the MR-MC engineering, current correspondence conventions planned should be progressed.

In WMNs the MAC protocols can be partitioned into two distinct gatherings: single-channel and multi-channel MAC conventions [13-14]. Outlining a satisfactory conveyed multi-channel MAC convention is challenging assignment in MR-MC WMNs. Despite the fact that a considerable measure of channel task calculations as of now exists in MR-MC WMNs yet at the same time productive channel task must be intended for keeping up the focused topology and proficient range use.

In routing layer, the routing conventions which are designed for adhoc networks can be deployed as a part of WMNs, yet at the same time outlining productive routing conventions for WMNs is a dynamic territory of exploration. In WMN routing algorithms obliged to acknowledge system topology to choose obstruction free routing way and the routing way determination is interlaced with rate adjustment, evasion of impedance and asset designation in multi-hops. A MR-MC routing conventions not just need to choose a way among various

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cross section hubs [14], yet it additionally needs to choose the most fitting divert or NIC in the system. The calculations intended for routing ought not just choose the high-throughput legitimate connections with less jitter, additionally give relieved obstruction among abutting nodes. Consequently, MAC/routing joint enhancement and productive outline of cross-layer are [15] fundamental for MR-MC WMN.

Sr. No	Paper	Tool Used	Pro	Con
1	Minimum Interference Channel Assignment in Multi-Radio WMN.	Ns-2	Open source	User has to write script for all the things.
2	VoIP capacity over wireless mesh networks, in Proceedings of 31st IEEE Conference on Local Computer Networks	Qualnat simulator	Full Graphical User Interface to accomplish almost all the job	Commercial simulator

II. RELATED WORK

A few propositions have been made to alter the MAC layer to bolster multi-channel systems. The methodology taken by the majority of this body of research is to and an ideal channel for a solitary packet transmission, basically maintaining a strategic distance from impedance and empowering numerous parallel transmissions in an area as opposed to all these past recommendations, our engineering does not perform channel exchanging on a packet by-packet premise; our channel assignment goes on for a more drawn out length of time, for example, a few minutes or hours, and thus does not require re-synchronization of imparting system cards on an alternate channel for each packet. This property of our design makes it doable to execute utilizing merchandise equipment of 802.11 standard.

According to [18] Anan Prabhu Subramanian, Himanshu Gupta, Sanur R.Das and Jing Cao. Thinks about plots for thick and sparse systems and brings out intriguing elements. The fragmentary obstruction mitigates with expansion in number of radios per node, however this pattern saturate past a specific number of radios. This immersion point is achieved smaller number of radios for inadequate systems than for thick system for the same number of channels. This is on the grounds that the denser system can possibly bolster more simultaneous transmissions than the sparse system.

According to [7] Ashish Raniwala and Tzi-Cker Chiuch purposed Multi-channel remote cross section system engineering (called Hyacinth) is that prepares every lattice system hub with different 802.11 system interface cards (NIC's). Examination between the conveyed and unified channel task calculations demonstrate that brought together channel task calculation shows improvement over the circulated, this demonstrates the execution misfortune because of appropriation of insight is little.

According to [6] P.Kyasanur and N.H. Vadiya mentioned that successive direct exchanging in remote lattice organizes unfavorably influences the end-to-end delay execution.

According to [5] A.Raniwala, K.Gopalan and T. Chiuch mentioned that with one and only radio for each node, channel exchanging is required. This exchanging delay develops as the quantity of channels is expanded. For instance the exchanging delay for the present 802.11 equipment ranges from a couple of milliseconds to a couple of hundred milliseconds.

III. PROBLEM STATEMENT

Wireless mesh networking is a rising innovation that empowers multi-hop remote availability to various ranges where introducing links is costly or troublesome. Multicast is a type of correspondence that conveys data from a source to multiple destinations in the meantime in a satisfactory way. In a single channel WMNs, all clients impart and convey to one another through same channel.

In such kind of system, the throughput of multicast corrupts altogether as the system size increments. A node with a single half-duplex radio is confined to get to one channel at once and in this manner can't transmit and get at the same time. The utilization of single, half-duplex radio per node adds to the fast corruption of transmission capacity and throughput in single-channel WMNs. A standout amongst the best ways to deal with accomplish high throughput and diminish end-to-end delay in WMNs is to utilize frameworks with Multi Channels and Multi Radios (MC-MR) per mesh node. A MC-MR mesh node might transmit and get on various channels in the meantime utilizing two unique radios, and along these lines build the throughput and diminish the end-to-end delay.

As Multi-channel Multi-radio defeat the issues of single channel WMNs but still the channel interference problem is faced in this network as the network grows whether the MR-MC WMNs will behave in the same way or the channel interference or some other factor will mitigate the performance of the MR-MC WMNs.

The major areas to work upon are:

1. Scalability Factor of WMNs.
2. Channel Assignment Strategies to reduce channel interference.

IV. EXPERIMENTAL SETUP

The simulator used for the optimization is Qualnet. The terrain dimension is set to 1500 x 1500 m. Then as the WMNs was optimized on the scalability factor so the number of nodes was varied in different scenarios as 9,18 and 27 mesh nodes and two wireless subnets are used in the scenario. One subnet is deployed at 802.11a radio type and this subnet is associated with 3 mesh nodes (node 1, 2 and 3) and other subnet is deployed at 802.11b radio type and this subnet is associated with all the 9, 18 and 27 nodes in 3 different scenarios respectively. Node 1, 2 and

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3 are designed as the mesh access points. Except these all the nodes in all the scenarios are designed as mesh points. The IEEE 802.11b/g and IEEE 802.11a standard provide 3 and 12 non-interfering frequency channels respectively so the nodes connected with the 802.11a subnet are relegated three diverse non-interfering channels of 802.11a band and the nodes appended with the 802.11b subnet are allocated three non-interfering channels of 802.11b band. The CBR data traffic is sent from mesh node 7 to mesh node 8 where mesh node 7 is in the scope of access point 3 and mesh node 8 is in the scope of access point 2.

A. Simulation Parameter

The network scenario which was designed contains following basic network entities presented in table:-

S.No	Parameters	Values
1	Area	1500*1500 m
2	Propagation channel frequency	2.4 GHz
3	Propagation Model	Statistical
4	Path loss Model Selection	Two Ray
5	Shadowing Model	Constant
6	Radio Type	802.11a,802.11b
7	Simulation Time	500 sec
8	Data Traffic Type	CBR
9	Packet size	512 bytes
10	Number of nodes	9,18 and 27 respectively

V. RESULT AND DISCUSSION

After implementing SR-MC WMNs and MR-MC WMNs with varied number of nodes in Qualnet simulator various parameters like throughput and end-to-end delay was analyzed and the results obtained are discussed below:
A) Throughput of Single-Radio Multi-Channel WMNs and Multi-Radio Multi-Channel WMNs

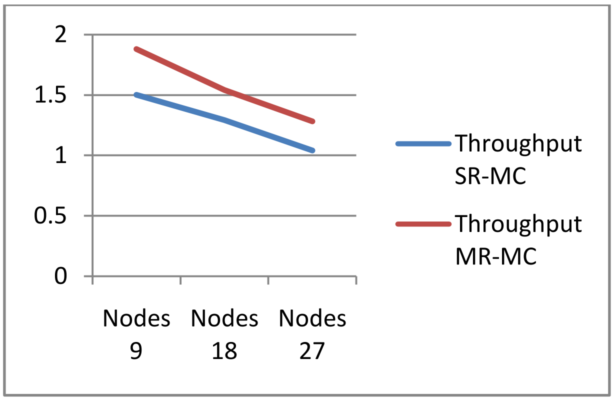

Figure 3 : CBR Server Throughput (bits/s)

It is analyzed that with the less number of mesh nodes throughput of the MR-MC WMNs increases as compared to the SR-MC WMNs because with the use of the multiple radio networks are able to make use of most frequencies available from the radio spectrum. This would give opportunity to do multi transmission at high speeds without clogging. But when the network grows the throughput of the network start mitigating as with the increase of the number of mesh nodes use of the NICs and channels also increases and till now channel assignment strategies are not so efficient that they can cope with the big network sizes so channel interference inversely affects the scalability of both the WMNs.

B) End-to-End Delay in Single-Radio Multi-Channel WMNs and Multi-Radio Multi-Channel WMNS

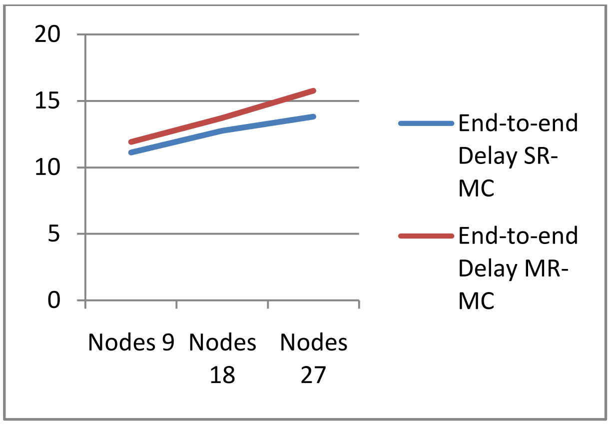

Figure 4 : CBR Server Average End-to-end Delay (s)

In MR-MC because of the vicinity of numerous radios distinctive channels can correspond all the while and with this the end-to-end delay in the system can be diminished.

This is demonstrated by the above graph that end-to-end delay in multi-radio multi-channel is diminished when contrasted with single-radio multi-channel WMNs because of different transmissions in the meantime with less impedance. But scalability effects the end-to-end delay directly in both the WMNs i.e. as the network grows end-to-end delay is also increasing because as there is increase in the number of nodes channel interference also increases.

VI. CONCLUSION

In this paper, we have researched distinctive methodologies and the potential outcomes for usage of 802.11 based WMN to optimize execution of wireless multi-hop mesh networks. In the wake of examining an arrangement of proposed arrangements, a multi-radio multi-channel was picked.

This methodology has numerous preferences when contrasted with single-radio multi-channel. Did it need to work, as well as improvements must be done to get a huge increment in execution contrasted with the traditional single-radio single-channel setup.

The parameters like throughput and end-to-end delay of the wireless mesh networks can be redesigned greatly by utilizing multi-radio multi-channel approach as opposed to utilizing single-radio multi-channel approach with various information traffics like CBR, VBR, VoIP and so forth. But when the scalability of both the networks is analyzed

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ISO 3297:2007 Certified
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the results came out that the scalability is directly proportional to the end-to-end delay and inversely proportional to the throughput of both the WMNs. Further this work can be reached out by assessing the execution of multi-radio multi-channel on other quality of service factors or by actualizing any network attack.

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