International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Performance Analysis on Hybrid Wireless Mesh Network Topology using Interference Aware Bandwidth Reservation

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Abstract**:** ***Ubiquitous of modern era which utilises Hybrid Wireless Mesh Network (HWMN) topology which gave birth to ample of modern application which demands reliability, fault tolerance and scalability. HWSN topology utilises minimum of two or multiple standard network architectural topologies, in a fashion that the resultant network architecture doesn't depict any particular topologies like bus, star or ring but as a combination of any of those standard topologies. Prime motive of the proposed Optimised Channel Assignment Algorithm (OCSA) is which focuses on priority oriented interference minimization for all the trees which are existed, and constraint in terms of delay for evolving tree addition. Interference Aware Bandwidth Reservation (IABR) provides controllability over data flow admission for end-to-end optimal bandwidth accommodation in Multi-Radio Multi-Channel (MRMC) wireless mesh network. Proposed Priority Based Interference Aware Bandwidth Reservation (PBIABR) utilises disseminated and polynomial-time heuristic oriented assignment in channel to minimize interference in WMN with the awareness of channel priority as a primary consideration. Interference and Priority of the channel are made indirectly proportional to each other. For the channel of high priority the path which has low interference is opted. In PBIABR the whole path delay constraint of tree is sub organised into multiple node, based on delay to identify the best node which embodies minimal interference. Dominant Performance Parameters (DPP) like Throughput, Packet Size, Propagation Interval and Average Energy under HWSN Scenario. All the DPP parameters are analysed for multiple flow parameters for Interference Aware Bandwidth Reservation (IABR) and Proposed Priority Based Interference Aware Bandwidth Reservation (PBIABR) conditions. Simulation results have been captured using Network Simulator 2 tools for HWSN creation and crafted to same readings as a graph for deep analysis. The proposed simulation results for hybrid scenario highlights a considerable performance hike for the performance parameters like Throughput (bps) vs Packet size (bytes), Average Energy (joule) vs Interval (sec) and Residual Energy (joule) vs Interval (sec) under PBIABR conditions compared with IABR simulation outcome. The results have been analysed for comparative study of each parameter deeply. Inference from the comparative analysis highlights the performance parameters of PBIABR is efficient than IABR.***

Index Terms**:** ***Hybrid Wireless Mesh Network, Interference Aware Bandwidth Reservation, Priority Based Interference Aware Bandwidth Reservation, Dominant Performance Parameters and Multi Station Access Unit.***

Revised Manuscript Received on 30 July 2019.

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I. INTRODUCTION

Wireless Mesh Network (WMN) became a striking preference for wireless communication because of its flexible features it embodies. Independent, self-healing and self-configuring are the attractive natures of wireless mesh network. Wireless Multi Hop Networks (WMHN) such as Wireless Mesh Networks (WMNs) and Mobile Ad hoc Networks (MANETs) are already present were as one of the relatively recent advent is wireless mesh networks [1-3].

A. Wireless Mesh Networks (WMN)

As the word coined as Wireless Mesh Network (WMN) in the field of communication jargon network is established with radio nodes which are organized in a mesh topology. WMN is also a contemporary to wireless ad hoc based network. Prime components of WMN are mesh routers, clients and network gateways. Wireless standards like IEEE 802.11, IEEE 802.15 and IEEE 802.16, cellular technologies or hybrid of those are implemented while establishing a well structured WMN.

B. Mesh Network Infrastructure (WMI)

Wireless Mesh Architecture (WMA), came into boom to modern applications which demands to be cost effective and high bandwidth applications. Wireless Mesh Infrastructure (WMI) came into existence where the peer radio devices which are incapable to establish the linkage to Wireless Local Area Network Access Point (WLAN-AP). The entire distance travelled by the packets over the communication channel is split into calculated hops of short range. The nodes are positioned intermediately plays a vital role to enhance the signal where the message exist and also forwards the data chunks with the help of created routing table over the network.

C. Channel Allocation (CA)

Management of radio energy resources for Wireless Cellular Network (WCN) is important. Allocation of channel schemas to assign bandwidth to access point, base station and terminal devices [4]. The prime objective of CA is to attain maximum spectral efficiency by progressive utilization of single frequency to multiple orientations. The spectral efficiency is measured in bit/s/Hz. The factor of interference should be made into consideration by CA to maximum extent to attain best data communication in the network. Well structured CA techniques include Dynamic Channel Allocation (DCA) and Fixed Channel Allocation (FCA).

D. Network Interference (NI) along the Channel

The alarming factor of interference results in modification of the signal as it propagates alongside a channel between a transmitter module and the receiver module. It refers to additive useless signal to constructive signal. Some of the well known examples that are in Communication, especially in the field of telecommunications, interference is the external or internal addition of unreliable signals which alters or deforms a signal as it traverse along a channel medium. Few interference which are predominant in data communication follows Inter symbol interference (ISI), Co-Channel Interference (CCI), Inter Carrier Interference (ICI), Common-mode interference (CMI), which are due to the cause Doppler effective shift in Orthogonal based Frequency Division Multiplexing (OFDM) modulation [5-6] etc.

II. RESEARCH MOTIVATION FROM EXISTING WORKS

Previous research work related to interference control which aids in understanding the research flow and to compare Interference Control (IC) using many techniques.

The solution for mesh network was emerged from Quality-of-Service (QoS) which is designed specifically for Single-Radio Single-Channel (SRSC) Mesh Networks. Proposed work for SRSCMN which can be pragmatically made functional to Multi-Radio-Multi-Channel (MRMC) circumstances, but it lacks the capability to utilize the cable-less channel capability of MRMC capacity for efficient load balancing and for improvised flow admit-ability [7].

Effective study of Channel Assignment (CA) for broadcast performance analysis and depicted that channel assignment can disturb the broadcast performance significantly. Most importantly, this work depicted that a channel assignment which accomplishes well for uni-cast and cannot be able to achieve well for broadcast or multicast topology [8].

Study of problem towards on-line joint Quality-of-Service (QoS) routing and channel assignment for optimization in terms of performance particularly in MRMC mesh networks. This essential issue in aiding QoS for evolving multiple Multi-Media (MM) application. But this work flips towards compromising priority based allocation to achieve effective bandwidth reservation [9].

Compared to traditional data applications and channel assignment, Distributed Channel Assignment need demanding quality to placate user service necessities. However, distributed broadcast media and restricted resource craft it tough path to devise efficient Quality of Service (QoS), solutions for applications in the field of MM in WMN. Interference exists among flow and even links of an individual flow in Distributed Channel Assignment in MRMC mesh network, which has immense impact on the performance of most demanded MM applications [10].

III. SIMULATION SCHEMA

Every node is designated to operate with Pent-Oriented Radio Interfaces. One radio interfaces is dedicated towards Control Interfaces (CI) functionality and the remaining quadruple is dedicated for Data Interfaces (DI). The lowest hardware level layer and Media Access Control (MAC) layer protocol is specified as per IEEE 802.11b/g protocol. The Channel Capacity (CC) was designated to 11Mpbs. The interference and the transmission range were set to 200m and 100m respectively. Data Channel assignment was set to 11, which comprises three-non-overlapping channels and Octa-partly oriented overlapping channels.

For the purpose of Interference Aware Bandwidth Reservation (IABR) and Priority based Interference Bandwidth Reservation (PBIABR), research analysis the hybrid network topology of 100 wireless routers over the wide span of 1000m x 1000m area. Progressive multicast session is formed by creating newly evolving multicast tree the hybrid network topology. Multicast Tree (T_n) evolving to the newly evolved multicast session is created by the random selection of 10 leaf nodes. Based on optimised Heuristic Algorithm the utilized channel of the every individual node is determined on the Multi-Cast (MC) based tree network. The Parent Node (PN) of the MC tree generates 100 MC packets per second. The dimensional weight of individual packet is set to 1024 bytes. Upon reception a MC packet from the PN, the available node present in the tree utilizes its channel to share the packet to its identified Child Nodes (CN). The mentioned data's have been made as a setup utilizing Matrix Laboratory (MATLAB). That simulation environment information has been directed to NS2 simulator collect traces for each packet transmission.

A. Wireless Mesh Skeletal Network Creation for Hybrid Architecture.

Random distribution of 100 outer nodes have been as shown in the Fig. 1. The encircled spot over the simulated graph portrays as a random movements of hybrid nodes over the dimensional span of 1000m x 1000m.

Retrieval Number: B2246078219/19©BEIESP
DOI: 10.35940/ijrte.B2246.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

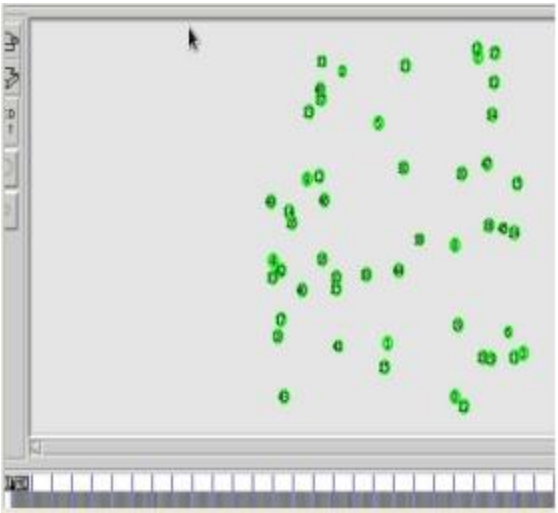

Fig. 1. Hybrid node creation for IABR and PBIABR analysis.

B. Multicast Packet Distribution over the Wireless Mesh Network under Hybrid Topology.

Each node transmits a data packet of weight 1024 bytes. The parent nodes transmits to its child nodes and this process continues till the data is made multicast to all the nodes in the Wireless Mesh Network which is crated under Hybrid Topology. Fig. 2, portrays the Multicast Packet distribution scenario for HWMN.

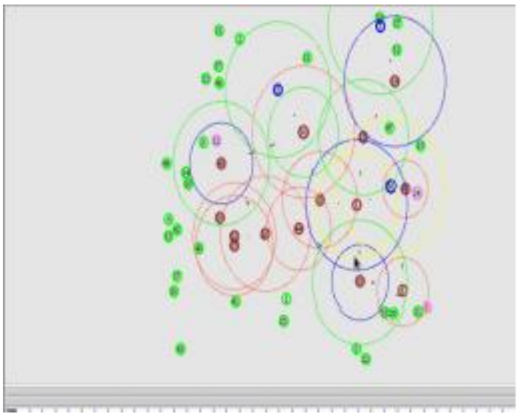

Fig. 2. Hybrid Wireless Mesh Network Multi-Cast data packet transfer for IABR and PBIABR analysis.

IV. BANDWIDTH RESERVATION SCHEMA

A. Interference Aware Bandwidth Reservation – IABR.

Interference Aware Bandwidth Reservation (IABR) schema for individual flow reservation of bandwidth in WMN. IABR propose a approach which is model oriented and it elegantly grasps the impact of both inter-intra based flow channel interference and thus provide appropriate estimation of bandwidth [11-12]. IABR is primarily concentrated towards MRMC networks and exploit diversity in link (the availability of ample of links between neighbouring nodes) [13-14]. Fig. 3., depicts the technical flow of utilised in Interference Aware Bandwidth Reservation (IABR).

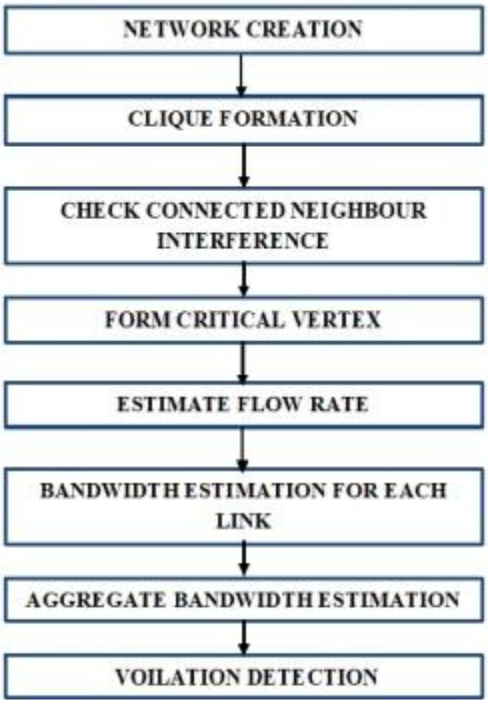

Fig. 3. Interference Aware Bandwidth Reservation – IABR technique.

B. Priority Based Interference Aware Bandwidth Reservation – PBIABR.

PBIABR technique involves a scattered and polynomial based time heuristic assignment in channel to minimize interference in WMNs [15]. This approach formulates the channel assignment problem by preventing interference in WMNs, and then provides the most favourable solution to the problem which are assigned for channel assignment. PBIABR algorithm minimizes the interference effects by taking priority as a prime factor for existing multicast sessions.

Dissimilar to previous CA algorithms, the existing method utilizes all accessible channels of the WMN to perform effective CA were as most CA algorithms in WMN's only use non-overlapping channels [16].

V. PERFORMANCE ANALYSIS UNDER IABR AND PBIABR TECHNIQUES.

Performance Analysis on Throughput vs. Packet Size.

The production rate or the rate at which the data can be processed is coined as Throughput. In-terms of communication network or data communication throughput deliver the sense as the error-free message delivery over the data communication medium. Throughput is fundamentally synonymous towards digital bandwidth consumption. A measurement criterion for the parameter throughput is in bits per second (bit/s or bps), data packets per second (p/s or pps) or in general data packets per time slot. The aggregate throughput or system throughput is the accumulative summation of the data parameter that are intended to deliver to every other terminal's in a network.

Communication system's throughput is affected by various factors like, available processing power of the system components, including the limitations of underlying physical medium and terminal-user behaviour. When multiple protocols' overheads are considered, utilised consumed rate of propagated data can be expressively lesser than the zenith attainable throughput. Throughput is measured in terms of data packets for our scenario. In general, as size of packet increases, throughput also increases but after a certain limit of channel acceptance conditions [17], it will be decreased due to insufficient bandwidth at that point of time interval. Hence we opt for appropriate bandwidth allocation to maintain throughput at maxima.

Simulation results for the hybrid allocation for bandwidth reservation for the multiple flows and the resultant fields has been plotted to analyse the low stability under IABR and PBIABR conditions respectively. Throughput vs. Packet Size flow Throughput which is measured in bits per second vs. Packet Size which is measured in bytes for the hybrid scenario is as depicted in Fig. 4. Graphical representation for. Throughput (bps) vs. Packet Size (bytes) for Hybrid Scenario under IABR and PBIABR analysis is obtained from simulation results using Network Simulator 2.

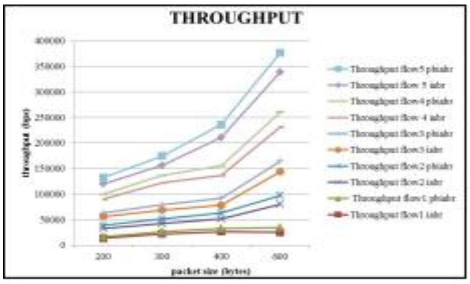

Fig. 4. Throughput (bps) vs. Packet Size (bytes) for Hybrid Scenario for IABR and PBIABR.

The behaviour of bandwidth reservation has been studied for, five different flows ranging from 0 bps to 400000 bps i.e. throughout range with the stepping range of 50,000 bytes. Under this functional range of behavioural analysis of both IABR and the hybrid Allocation on PBIABR algorithm is studied effectively. 2-D graph have been inferred by taking Packet Size which is measured in Bytes along the horizontal axis and Throughput which is measured in Bits per Second along the vertical axis as the skeletal margin to plot graph layout. As inferred from the analysis the throughput for all the flows is high in Hybrid PBIABR than in IABR. Packet Size vs. Throughput. With the inference derived from the graphical analysis, bandwidth is properly allocated in hybrid mode of Hybrid PBIABR approach than the hybrid mode of IABR approach.

Performance Analysis on Average Energy vs. Interval.

Average Energy is the collective mean of accumulative available energy of all the nodes at that instance [18-20]. The accumulated data for the multiple criterion IABR and PBIABR of Average Energy which is measured in Joules vs Time Interval which is measured in Seconds have been plotted after analysis. Fig. 6., portrays the graphical representation of the Average energy vs. Interval analysis for Hybrid Scenario for IABR and PBIABR. The functional energy range for the effective average energy analysis is ranging from 0 to 0.5 joules with the stepping rang of 0.05 joules for precise analysis.

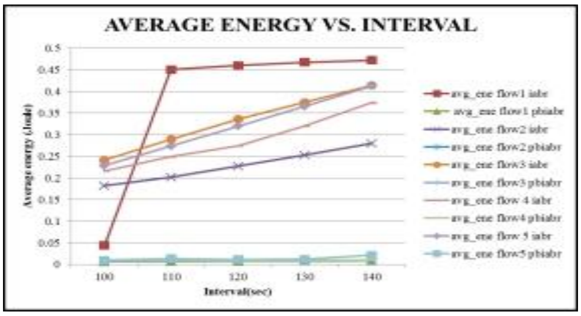

Fig. 5. Average Energy (joule) vs. Interval (sec) for Hybrid Scenario for IABR and PBIABR.

From the inference obtained from the Average energy vs. Interval analysis, we can conclude that the Average energy of multiple flow-rates under hybrid PBIABR schema is utilized to the maximum extent compared to IABR. In all the flow, the PBIABR applied schema depicts a hike over the IABR flows. The effective utilization is due to the channel selective efficiency based on priority allocation by considering individual node delay than in IABR in hybrid mode. Average energy consumption under PBIAR is minimal as it is utilised effectively when compared to IABR, where priority is not taken into consideration. Whereas under PBIABR, the Average Mean Energy consumption is lower, which is a good sign for effective energy utilization.

A. Performance Analysis on Residual Energy vs. Interval.

Residual Energy or the Retaining Energy (RE) of the node is the quantity of energy which prevails even after the data communication is accomplished. Higher the RE, greater the efficiency of the communication circumstance for stable network. RE which is measured in Joules and Interval which is calibrated in Seconds for the Hybrid Mode of mesh communication is as depicted in Fig. 7. The graphical analysis shows the level of retaining energy under PBIABR condition is much appraised than IABR applied communication for bandwidth reservation.

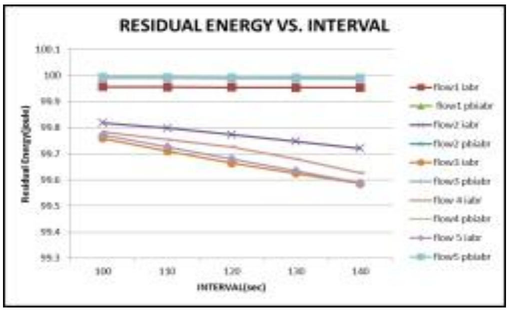

Fig. 6. Residual Energy (joule) vs. Interval (sec) for Hybrid Scenario for IABR and PBIABR.

Inference from flow 5 as a sample of RE vs. Interval analysis, which intensely echoes the high RE of 99.99 joules under PBIABR, over the time frame between 100 to 140 seconds as a margin for analysis.

The node gradually loses the capacity to retain the maximum energy from 99.77 to 99.58 joules under IABR conditions when the time frame increases. It is evident that the PBIABR supportive technique to retain the maximum RE in each nodes.

VI. CONCLUSION

Effective Channel Assignment (CA) Algorithm in existing methodology minimizes interference in WMNs and thereby increases the data communication efficiency. Path delay constraint is noted into account in CA to avoid each node on the tree from inter and intra interference with any other nodes. Unlike IABR channel CA, the projected PBIABR algorithm carefully utilizes partly overlapping channels in CA in addition to nil-overlapping channels. Hence the bandwidth is owed efficiently in PBIABR applied channels. Effective bandwidth allocation is witnessed by providing outstanding load distribution and control over data admission to provide end to end bandwidth guarantee in MRMC Wireless Mesh Network (WMN). Inference from the simulation environmental results highlights a commendable performance difference in hike between Hybrid modes of PBIABR than IABR. Performance hike is highlighted in Throughput vs. Packet Size, Average Energy vs. Interval and Residual Energy vs. Interval under the functional analysis range respectively. Hence PBIABR is the best suited for MRMC Wireless Mesh Network (WMN) to afford the best channel efficiency to promising data communication.

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