QUANTATIVE ANALYSIS & EVALUATION OF VARIOUS VOIP CODECS OVER MRMC WMN

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ABSTRACT

Wireless Mesh Networks (WMN) have emerged as important architectures for the future wireless communications. WMNs consist of mesh routers and mesh clients, and could be independently implemented or integrated with other communication systems such as the conventional cellular systems. Traditional WMNs were based on a single-channel or single-radio interface. In this paper, We begin with an examination of possible radio usage policies that determine which radio a node uses to transmit to a particular neighbor and when to bind the radio to a particular channel in MRMC networks. The goal of various CA algorithms is to pick a feasible CA that optimizes some suitably chosen performance metric. Here, we proposed to evaluate the performance of two different routing protocols namely Hybrid Wireless Mesh Protocol and Weighted Cumulative Estimated Transmission Time against two channel assignment schemes namely common channel assignment and Minimum Interference Channel Assignment algorithms for varying traffic load in terms of different performance metrics using NS2 network simulator

Keyword : - WMN, MRMC, CA, MICA, WCETT, HWMP.

I. INTRODUCTION

Wireless Mesh Network (WMN) is a promising wireless technology for several emerging and commercially interesting applications, e.g., broadband home networking, community and neighborhood networks, coordinated network management, intelligent transportation systems. It is gaining significant attention as a possible wayfor Internet service providers (ISPs) and other end-users to establish robust and reliable wireless broadband service access at a reasonable cost. The major categories in the multi-hop wireless networks are the ad hoc wireless networks, WMNs, wireless sensor networks, and hybrid wireless networks.

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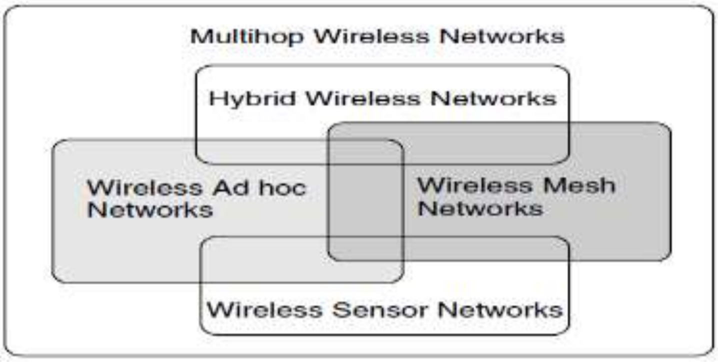

Figure 1: Illustration of wireless multi-hop networks

The primary advantages of a WMN lie in its inherent fault tolerance against network failures, simplicity of setting up a network, and the broadband capability. Unlike cellular networks where the failure of a single base station (BS) leading to unavailability of communication services over a large geographical area, WMNs provide high fault tolerance even when a number of nodes fail. Table 1 compares the wireless ad hoc networks and WMNs. The primary differences between these two types of networks are mobility of nodes and network topology.

Some of the benefits and characteristics of wireless mesh networks are highlighted as follows:

- **Increased Reliability :** In WMNs, the wireless mesh routers provide redundant paths between the sender and the receiver of the wireless connection. This eliminates single point failures and potential bottleneck links, resulting in significantlyincreased communications reliability [2]. Network robustness against potential problems, e.g., node failures, and path failures due to RF interferences or obstacles, can also be ensured by the existence of multiple possible alternative routes. Therefore, by utilizing WMN technology, the network can operate reliably over an extended period of time, even in the presence of a network element failure or network congestion.

- **Low Installation Costs** : Recently, the main effort to provide wireless connection to the end-users is through the deployment of 802.11 based Wi-Fi Access Points (APs). To assure almost full coverage in a metro scale area, it is required to deploy a large number of access points because of the limited transmission range of the APs. The drawback of this solution is highly expensive infrastructure costs, since an expensive cabled connection to the wired Internet backbone is necessary for each AP. On the other hand, constructing a wireless mesh network decreases the infrastructure costs, since the mesh network requires only a few points of connection to the wired network. Hence, WMNs can enable rapid implementation and possible modifications of the network at a reasonable cost, which is extremely important in today's competitive market place.

- **Large Coverage Area :** Currently, the data rates of wireless local area networks (WLANs) have been increased by utilizing spectrally efficient modulation schemes. Although the data rates of WLANs are increasing, for a specific transmission power, the coverage and connectivity of WLANs decreases as the end-user becomes further from the access point. On the other hand, multi-hop and multi-channel communications among mesh routers and long transmission range of WiMAX towers deployed in WMNs can enable long distance communication without any significant performance degradation.

- **Automatic Network Connectivity :** Wireless mesh networks are dynamically self-organized and self-configured. In other words, the mesh clients and routers automatically establish and maintain network connectivity, which enables seamless multi-hop interconnection service. For example, when new nodes are added into the network, these nodes utilize their meshing functionalities to automatically discover all possible routers and determine the optimal paths to the wired Internet [6]. Furthermore, the existing mesh routers reorganize the network considering the newly available routes and hence, the network can be easily expanded.

TABLE1: Compression between the wireless ad hoc networks and WMNs

Issue	Wireless Ad Hoc Networks	Wireless Mesh Networks
Network topology	Highly dynamic	Relatively static
Mobility of relay nodes	Medium to high	Low
Energy constraint	High	Low
Application Characteristics	Temporary	Semipermanent or permanent
Infrastructure Requirement	Infrastructureless	Partial or fully fixed infrastructure
Relaying	Relaying by mobile nodes	Relaying by fixed nodes
Routing performance	Fully distributed on-demand routing preferred	Fully distributed or partially distributed with table-driven or hierarchical routing
Deployment	Easy to deploy	Some planning required

A. Wireless Mesh Network Architecture

The architecture of WMNs can be classified into three main groups based on the functionality of the nodes:

1) Hierarchical Wireless Mesh Network

In a hierarchical WMN, the network has multiple tiers or hierarchical levels in which the WMN client nodes form the lowest in the hierarchy. These client nodes can communicate with a WMN backbone network formed by WMN routers. The architecture is shown in Figure 2, where dash and solid lines indicate wireless and wired links, respectively.

2) Flat or Client Wireless Mesh Networks

In a flat WMN, the network is formed by client machines that act as both hosts and routers. Here, each node is at the same level as that of its peers. The wireless client nodes coordinate among themselves to provide routing, network configuration, service provisioning, and other application provisioning. This architecture is closest to an ad hoc wireless network and it is the simplest case among the three WMN architectures.

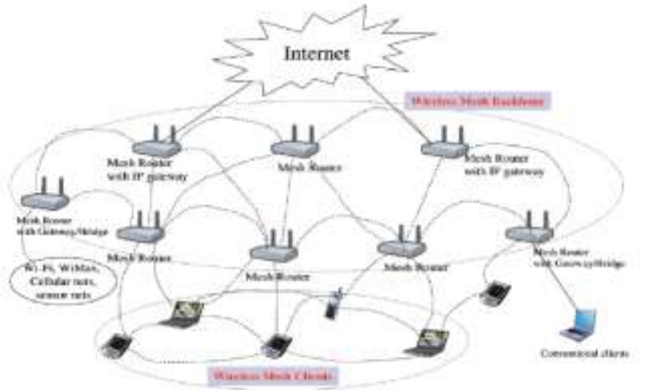

Figure 2: Infrastructure/backbone WMNs

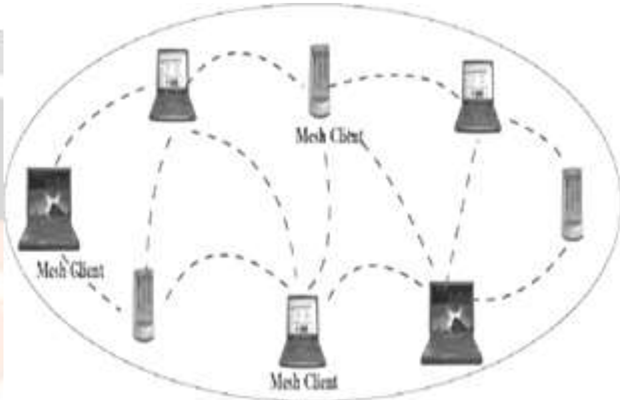

Figure 3: Flat WMNs

3) Hybrid Wireless Mesh Networks

This architecture shown in Figure 4 [11] is the combination of infrastructure and client meshing. Mesh clients can access the network through mesh routers as well as directly meshing with other mesh clients. While the infrastructure provides connectivity to other networks such as the Internet, Wi-Fi, WiMAX, cellular, and sensor networks and the routing capabilities of clients provide improved connectivity and coverage inside the WMN.

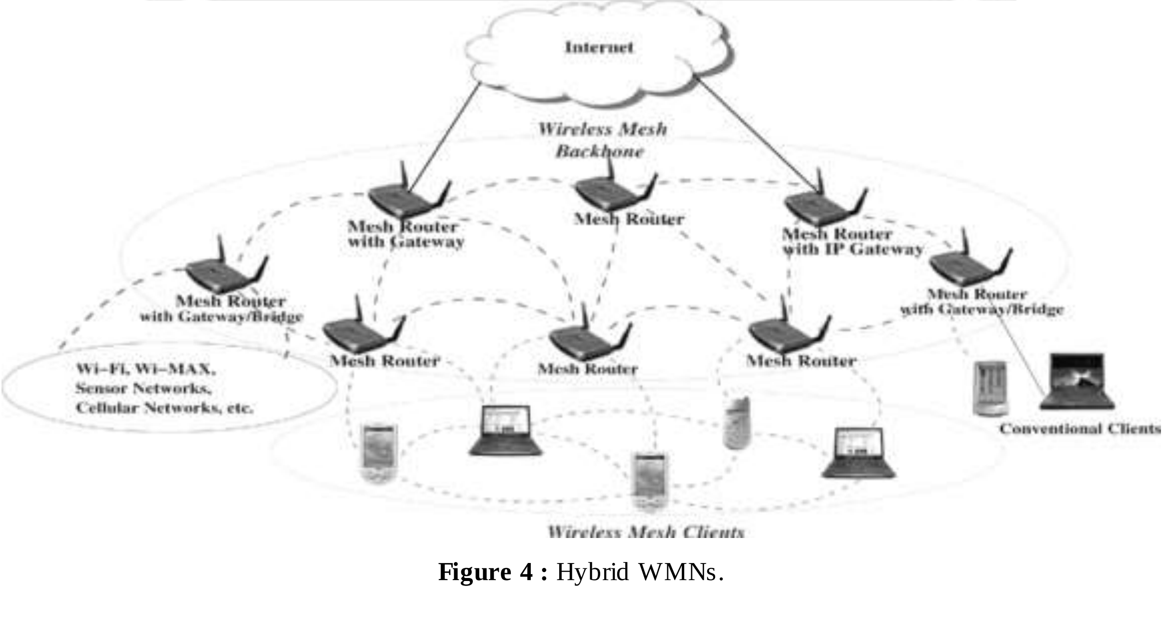

Figure 4 : Hybrid WMNs.

B. Routing Protocols for Multiradio

Choosing the best performing routing metric in a WMN is difficult because of the three major factors present in a WMN. These factors that affect routing performance are:

(i) relay-induced load,

(ii) asymmetric wireless links, and

(iii) high link loss. Due to the asymmetry of the links

and high link loss, the shortest path routing seldom performs better.

n this WMN environment, the expected transmission count (ETX) routing metric is found to be a suitable routing metric to achieve high throughput. The ETX routing metric is designed to find a path based on (i) the packet delivery ratio of each link, (ii) the asymmetry of the wireless link, and (iii) minimum number of hops. The above-mentioned objectives add to advantages such as energy savings and spectrum usage.

Expected Transmission Count (ETX)

This metric calculates the expected number of transmissions (including retransmissions) needed to send a frame over a link, by measuring the forward and reverse delivery ratios between a pair of neighboring nodes [9]. To measure the delivery ratios, each node periodically broadcasts a dedicated link probe packet of a fixed size. The probe packet contains the number of probes received from each neighboring node during the last period. Based on these probes, a node can calculate the delivery ratio of probes on the link to and from each of its neighbours. The expected number of transmissions is then calculated as

ETX = 1/df × dr ----------------(i)

where df and dr are the forward and reverse delivery ratio, respectively. With ETX as the route metric, the routing protocol can locate routes with the least expected number of transmissions. Note that the effects of link loss ratios and their asymmetry in the two directions of each link on a path are explicitly considered in the EXT measure. Measurements on wireless testbeds [7, 9] show that, for the source-destination pairs that are with two or more hops, use of ETX as the route metric renders routes with throughput significantly higher than use of the minimum hop count.

Expected Transmission Time (ETT) ----------------(ii)

One major drawback of ETX is that it may not be able to identify high-throughput routes, in the case of multi-radio, multi-rate wireless networks. This is because ETX only considers the packet loss rate on a link but not its bandwidth. ETT has thus been proposed to improve the performance of ETX in multi-radio wireless networks that support different data rates. Specifically, ETT includes the bandwidth of a link in its computation [6],

ETT = ETX × S/B----------------(iii)

where S and B denote the size of the packet and the bandwidth of the link, respectively. ETT considers the actual time incurred in using the channel. In order to measure the bandwidth B of each link, a node sends two probe packets of different sizes to each of its neighbours every minute. The receiver node measures the difference between the instants of receiving the packets, and forwards the information to the sender. The bandwidth is then estimated by the sender node by dividing the larger packet size by the minimum of 10 consecutive measurements.

Weighted Cumulative ETT (WCETT)

What ETX and ETT have not explicitly considered is the intra-flow interference. WCETT was proposed [9] to reduce the number of nodes on the path of a flow that transmit on the same channel. Specifically, let Xc be defined as the number of times channel c is used along a path. Then WCETT for a path is defined as the weighted sum of the cumulative expected transmission time and the maximal value of $X_c$among all channels, i.e.,

$$\text{WCETT} = (1-\beta)\ \sum_{i=0}^{n} ETT_i \ +\ \beta\ \sum_{1}^{C} MAX_c\ X_c \text{----------------(iv)}$$

where β (0 <β<1) is a tunable parameter. Moreover, the two terms also represent a trade-off between achieving low delay and high throughput. Reducing the first term reduces the delay, while reducing the second term increases the achievable link throughput. The tunable parameter β is used to adjust the relative importance of the two objectives.

C. Voice over IP

The Internet has burgeoned into a worldwide informationsuperhighway during the past few years and wroughtsignificant changes in the telecommunications arena. Thisunprecedented growth motivated the development ofinnovative applications with high bandwidth and lowend-to-end delay requirements. One of the applicationsthat thrived is Voice over IP (VoIP). VoIP, also known asIP or Internet telephony, is the technology that enablespeople to use the Internet as the transmission mediumfor voice communications. Beginning as a frolic amongcomputer enthusiasts, VoIP has set off a feeding frenzy inboth the industrial and scientific communities. VoIP has the potential to revolutionize telephone communications.The trend toward voice communications overthe Internet is mainly fuelled by the salient advantagesInternet telephony offers. VoIP opens up exciting possibilitiesfor users. In particular, it paved the way for monetarysavings. It is cheaper for end-users to make an Internettelephone call than a circuit-switched call since most VoIPproviders offer affordable long distance and internationalcalling. In addition, VoIP offers service flexibilitysince there are no dependencies between the applicationand the underlying network. VoIP users can already enjoya variety of features, which they previously had to payfor, for free. Some of these features are voicemail, callerID, call conferencing, call waiting and call forwarding.

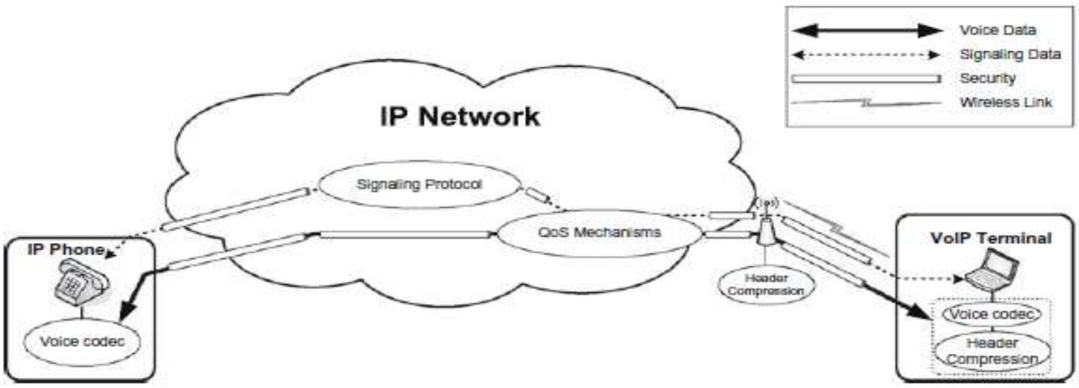

Figure 5. General VoIP architecture.

II. RELATED WORK

M Labrador et al. [1], work on TC in WMNs generally can be categorized to centralized and distributed approaches. The centralized TC approach have a central server that is responsible for periodically information collection and adaptation. However, the scalability of such kind of approach may be an issue to be addressed. Due to Given large number of nodes (e.g., hundreds of nodes), in conjunction with only a reasonable set of interfaces per node and limited number of channels available in the network, the information of the whole network to be transferred is astronomical. On the other hand, distributed TC algorithms have not based on central server, in which every node controls the topology by using its local information.

According to KN Ramachandran et al. [2], In MR-MC WMN, along with power control (PC), TC is linked with channel assignment (CA) in many ways. In handling the connectivity issue in MR-MC WMNs, the CA decision can actually modifies the network topology, which is a main difference between the SR-MC networks. The problem of TC in MR-MC WMNs has automatically been handled in conjunction with CA .

L Li et al. [3], presented some collective TC and routing protocols have been proposed recently . The result of them show that the collective optimization measures increases the performance of the whole network significantly. So, how to jointly optimize TC, CA, and routing is also a main task that must be deal with.

JA Stine [4], proposed another main technology is Directional antennas that one of the viable means to increase the performance of WMNs including enhance capacity, and range of communications, reduce the interference, conserve the energy and resolving collisions .

PH Pathak et al. [5], presented the difference between Topology Control(TC) and Power Control (PC) is defined: TC may affect layers upper than PC, by choosing not to make some node adjacencies visible to the network layer (e.g., by filtering at the MAC layer). On the other hand, PC almost in every results has some effect on the topology. Moreover, the goal of PC may not be same as TC but for power conservation etc.

R Ramanathan et. al. [6], presented different centralized optimal procedures forr Topology control of multihop wireless networks using transmit power. There are two centralized optimal procedures for creating connected and bi-connected static networks with aiming of minimizing the maximum transmitting power level for every node.

H Skalli et al. [7], discuss different channel assignment strategies for multiradio wireless mesh networks. There are two main methods to measure interference. The first is based on topology characteristics, for example by counting number of neighboring nodes using the same channel The second is based on measuring traffic load carried in neighborhood rather than only the number of neighboring nodes using the same channel .

L Chen et al. [8], proposed a joint topology control and routing (JTCR) protocol for MR-MC networks to make use of both channel diversity and spatial reusability, which addressed collective topology control and routing problem in an IEEE 802.11-based MR-MC wireless mesh networks. An Equivalent Channel Air Time Metric (ECA TM) was developed to quantify the difference of various adjustment candidates.

J Tang et al. [9], examined interference-aware TC and QoS routing in multi-channel wireless mesh networks based on IEEE 802.11 with dynamic traffic. They described a original definition of co-channel interference to accurately capture the influence of the interference.

Q Liu et al. [10], developed three-step solution starts by constructing a set of routing trees and seek to balance the traffic among tree links. In the second step, it performs interface allocation for each node in the tree with the objective of balancing traffic load among the links served by every node. Finally, it performs channel allocation and antenna orientation to minimal interference while covering all the intended neighbors of the node.

T Johansson et al. [11], identifies the problem of TC has been studied deeply for wireless ad hoc networks and power control is the main issue to construct interference optimal topologies through careful tuning of the node transmitting power.

III. RESULTS AND DISCUSSION

The Wireless mesh network comprising of 30 mobile nodes is constructed in NS-2 simulator with the use of TCL Script in the topological boundary area of 1500 m*1000 m. Antenna chosen is Omni Antenna: Omni direction antenna is antenna which radiates radio power uniformly in all direction in one plane. UDP agent is as a transport layer agent. With UDP agents CBR traffic is attached. Propagation model is two ray ground. This model is mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and other conditions.

Throughput : Throughput is the ratio of total number of delivered or received data packets to the total duration of simulation time. Figure 6 shows the impact of narrow band voice codecs on the throughput when the pause time is varied over MRMC MWN. Simulation results shows WCETT routing protocol that is specifically designed for WMN, gives better performance for G.729A and GSM.EFR. Simulation graph shows that as pause time of mesh client nodes increase the performance metric throughput decreases

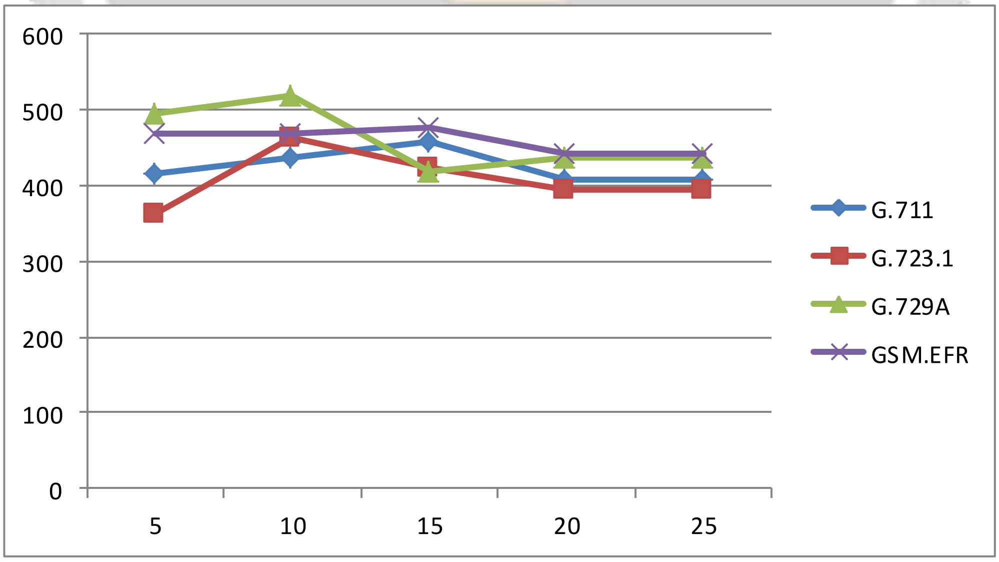

Figure 6 Throughput versus pause time.

PDR : PDR also known as the ratio of the data packets delivered to the destinations to those generated by the CBR sources. Figure 7 shows the effect of audio compression schemes on packet delivery ratio against WCETT routing protocol when the pause time is varied. Simulation results shows that for higer traffic load, WCETT routing protocol gives better performace for GSM.EFR.

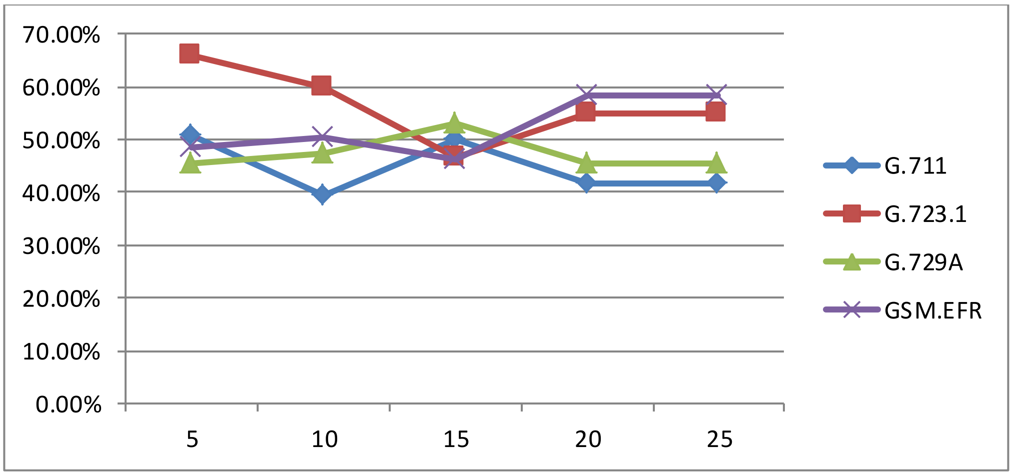

Figure 7: PDF versus pause time.

IV. CONCLUSION

In this paper, we have discussed the key challenges associated with assigning channels to radio interfaces in a multi-radio wireless mesh network. we have provided a taxonomy of existing routing and channel assignment schemes. One of the important challenges still to be solved is the question of how many interfaces to have on each mesh router. In other words, given the physical topology and the traffic profile of the network, how can we optimize the number of radios on the different nodes. . From the simulations results, it is observed that as the traffic load increases, the throughput in the case of HWMP protocol decrease under both considered channel assignment strategies. The packet delivery ratio of WCETT is higher than HWMP under both cosidered common channel assignment.

WCETT protocol uses the weighted sum of the cumulative expected transmission time and the maximal value of efficient channels among all channels. Thus, we can conclude that Simulation results shows WCETT routing protocol that is specifically designed for WMN, gives better performance for Minimum interference channel assignment (MICA).

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