AN EVALUATION ON DIFFERENT VOIP PRODUCTS ON CHANNEL AND ROUTING SCHEME OVER WIRELESS MESH NETWORKS

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ABSTRACT

In the recent past, there has been a tremendous increase in the popularity of VoIP services as a result of huge growth in broadband access. The same voice-over-Internet protocol (VoIP) service poses new challenges when deployed over a wireless mesh network, while enabling users to make voice calls using WiFi phones. Packet losses and delay due to interference in a multiple-hop mesh network with limited capacity can significantly degrade the end-to-end VoIP call quality. In this paper, the effect of four different VOIP audio compression strategies namely G.711, G.723.1, G.729A and GSM..EFR is examined on to evaluate the performance Weighted Cumulative ETT (WCETT) and Hybrid Wireless Mesh Protocol (HWMP) routing protocol under Minimum interference channel allocation (MICA) scheme over multi-radio multi-channel wireless mesh network. Performance in multi-hop MR-MC Wireless Mesh Networks is known to degrade with the number of hops for UDP traffic. Voice codecs are the algorithms that enable the system to carry analog voice over digital lines. The choice of voice codec is important because it has to fit the particularities of the transport network. Compressing voice signals while keeping the quality perceived by users at acceptable levels represents a daunting challenge. The methods that have been proposed for the compression of audio signals, which are referred to as voice codecs. Voice codecs are the algorithms that enable the system to carry analog voice over digital lines. There are several codecs, varying in complexity, bandwidth needed and voice quality. There are also several key challenges associated with VOIP is to choice efficient voice codec for radio interfaces in a multi-radio wireless mesh network.

Keyword: - *WMN, MRMC, CA, MICA, WCETT, HWMP, VOIP etc….*

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1. 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 way

for Internet service providers (ISPs) and other end-users to establish robust and reliable wireless broadband service access at a reasonable cost.

WMNs consist of mesh routers and mesh clients as shown in Figure 1. In this architecture, while static mesh routers form the wireless backbone, mesh clients access the network through mesh routers as well as directly meshing with each other. the nodes in the mesh network automatically establish and maintain network connectivity. This feature brings many advantages for the end-users, such as low up-front cost, easy network maintenance, robustness, and reliable service coverage. Consequently, through an integrated wireless mesh network, the end-users can take the advantage of multiple wireless networks.

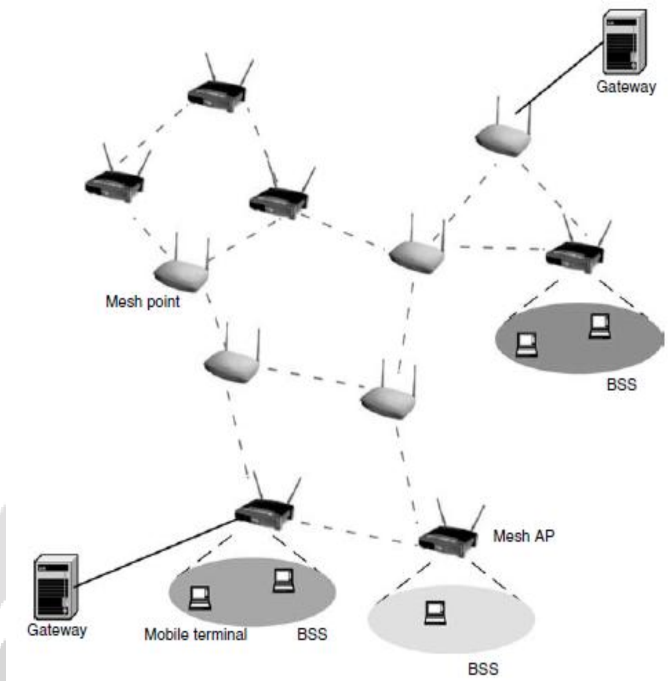

Figure 1: Illustration of wireless Mesh Network

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.

TABLE 1. Comparison 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.

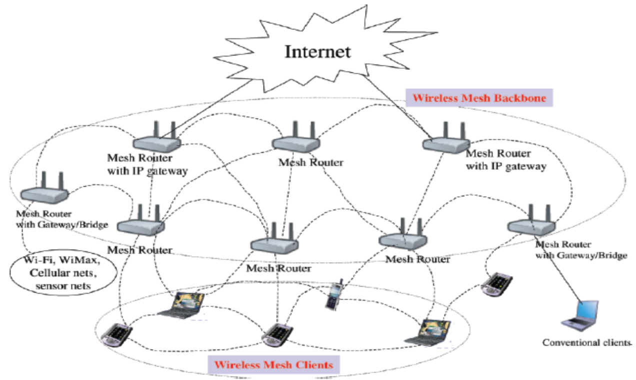

Figure 2: Infrastructure/backbone WMNs

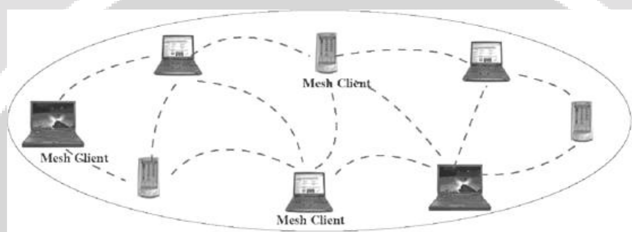

Figure 3: Flat WMNs

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.

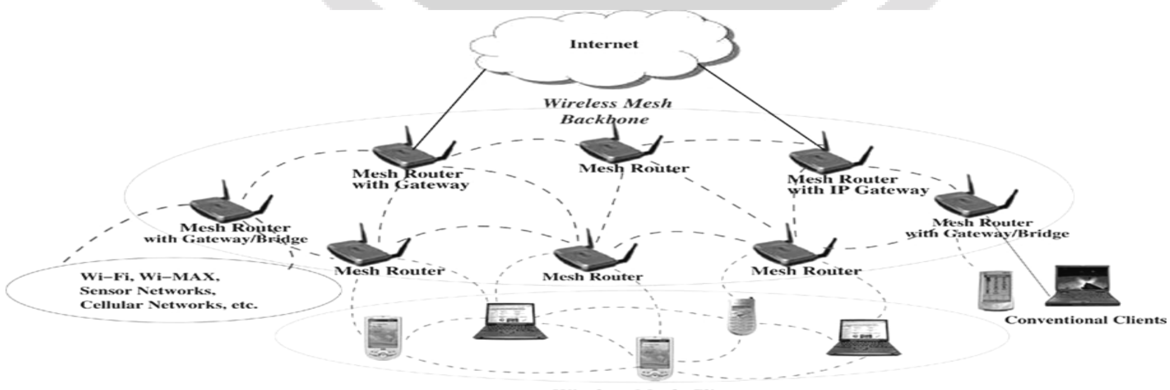

Figure 4 : Hybrid WMNs.

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.

in 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

$$ETX = 1/df \times dr$$

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)

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],

$$ETT = ETX \times S/B$$

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.,

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

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. Channel Assignment Schemes for WMNs

Channel Assignment (CA) in a multi-radio WMN environment consists of assigning channels to the radios in order to achieve efficient channel utilization (i.e. minimize interference) and, at the same time, to guarantee an adequate level of connectivity. The problem of optimally assigning channels in an arbitrary mesh topology has been proven to be NP-hard based on its mapping to a graph-coloring problem [4]. Therefore, channel assignment schemes predominantly employ heuristic techniques to assign channels to radios belonging to WMN nodes.

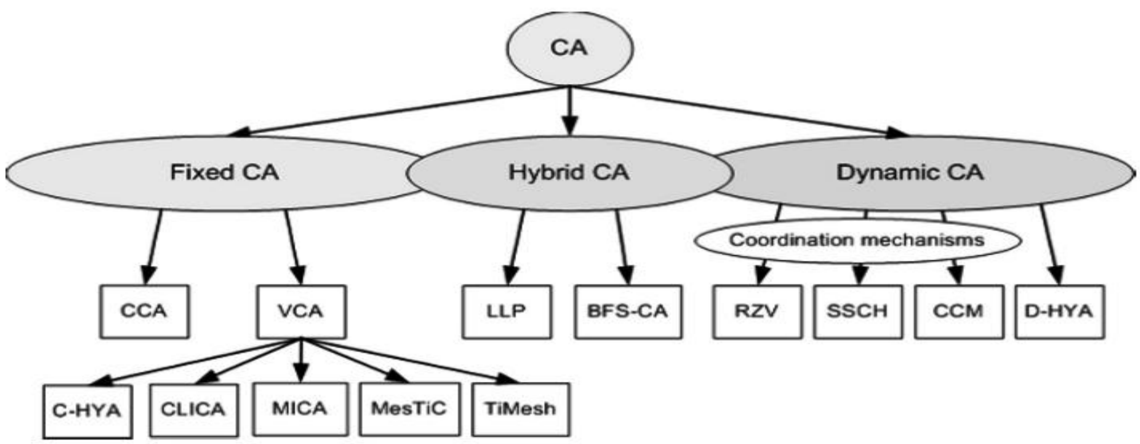

Figure 5: Taxonomy of channel assignment schemes in wireless mesh networks.

2. RELATED WORK

Wireless mesh network (WMNs), with multiple hops and mesh topology, has been emerging as a key including broadband home networking, community networking, business organization networking, and metropolitan area network [1]. Traditional WMNs operate in single-radio single-channel (SR-SC) architecture where each mesh router has only one NIC card and all the mesh routers share one common radio channel. In such a networking , the network suffers from low performance and capacity due to frequent packet collisions and back offs, especially for real-time applications such as VoIP transmission across multi hop WMNs [2].

According to [16], The SR-MC architecture can help to reduce the interference and increase network performance. A required function of the SR-MC solutions are there for each router to dynamically switch between channels along with dynamic network traffic, while coordinating between neighboring nodes to ensure communication on a common channel for some period. However, this type of coordination is usually based on tight time synchronization between nodes, which is difficult to realize in a multi hop WMN. It is noted that the latency in switching the channels with the use of commodity hardware 802.11 NICs can be up to 100 ms.

According to [17], IEEE 802.11a band assign 3 and 12 non-overlapping frequency channels, respectively. Though still there exist significant interference between these standard non-overlapping channels in the current IEEE 802.11

hardware, this problem can be handled by providing better frequency filters in hardware for multi-channel use. So, the use of single-radio multiple-channels (SR-MC) has been proposed to enhance the performance of WMNs.

According to [19], In such architecture, every mesh router is equipped with multiple NICs and each NIC can operate on multiple frequency channels. In MR-MC architecture, multiple transmissions/receptions can occur concurrently, and neighboring links allocated to different channels can carry traffic free from interference. However, MR-MC architecture use poses some new issues. In general, these issues include topology control, power control, channel allocation, link scheduling, and routing

According to [20], the number of available channels is limited to 3 or 12 in IEEE 802.11 frequency bands. This implies that some logical links may be assigned to the same channel. In such case, interference occurs if these logical links are closer to each other, and so these interfering links cannot be active at the same time. Furthermore, the number of available NICs is also limited, and hence some logical links within a router require to share a NIC to transmit and receive the data packets. Furthermore, the physical topology of the routers and other constraints in MR-MC WMNs, four important issues that needs attention are summarized in i.e., logical topology formation, interface assignment, channel allocations, and routing decisions.

According to [21], the authors consider the issues with the MR-MC architecture, existing communication protocols, ranging from routing, MAC, and physical layers, need to be revised and enhanced. In physical layer, techniques, mainly focus on three research areas: enhance transmission rate, enhancing error resilience capacity, and increasing re configurability and software controllability of radios. In order to improve the capacity of wireless networks, many high-speed physical techniques, such as OFDM, UWB, and MIMO, have been discovered.

According to [22], In MAC layer, depending on which network node takes responsibility for the coordination of medium access, MAC can be categorized into two major types: centralized MAC and distributed MAC. In WMNs, due to its distributed nature, distributed MAC is preferred. The MAC protocols for WMNs can be classified into two types: single-channel and multi-channel MAC protocols.

According to [23], To select a routing path in WMNs, the routing algorithm requires to consider network topology, and the routing path selection is to twist with resource allocation, interference reduction and rate adaptation in multiple hops. An MR-MC routing protocol not only require to select a path between different nodes, but it also require to select the most effective channel or radio node on the path.

According to [24], TC is considered as an additional protocol layer between the routing and MAC layer in the protocol stack. The routing layer is required for finding and maintaining the paths between source/destination pairs in the network, and for routing packets toward the destination at the intermediate nodes on the route. Two-way interactions may occur between the routing protocol and TC protocol. The TC protocol, which create and maintains the list of the all immediate neighboring nodes, can send a route update in case it detects that the neigh borers list is considerably changed, and hence leading to a faster response time to topology changes and to decrease packet-lost rate.

According to [25], the authors work on TC in WMNs generally can be categorized to centralized and distributed approaches. The centralized TC approach has 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 a central server, in which every node controls the topology by using its local information.

According to [26], the authors identify the problem of TC has been studied deeply in wireless ad hoc networks and power control is the main issue to construct interference optimal topologies through careful tuning of the node transmitting power.

According to [27], 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 modify the network topology, which is a main difference between the SR-MC networks. The problem of TC with MR-MC WMNs has automatically been handled in conjunction with CA.

3. RESULTS AND DISCUSSION

A detail simulation model based on NS-2 has been used in the evaluation, and in order to perfectly evaluate the effect of different voice codecs while the WCETT routing protocol is used under different pause time scenarios over MRMC WMN. The Wireless mesh network comprising of 30 mobile nodes is constructed in a 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 directional antenna is an antenna which radiates radio power uniformly in all directions 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 a mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and other conditions.

Parameter	**Value**
Simulation area	1500m x 1000m
Antenna	Omni antenna
No. of nodes	30
No. of interfaces/ node	2
Voice codecs	G.711, G.723.1, G.729A and GSM.EFR
Max queue length	50
Traffic	FTP
Routing protocol	WCETT, HWMP
Transport Layer	UDP
Channel Assignment Strategies	MICA

A. Effect of VOIP codecs on Throughput for HWMP and WCETT protocols

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 against two different routing protocols WCETT (reactive) and HWMP (hybrid) routing protocols for MICA channel assignment scheme over MRMC MWN. Simulation results show WCETT (reactive) routing protocol that is specifically designed for WMN, gives better performance than HWMP (hybrid) protocol for G.723.1.

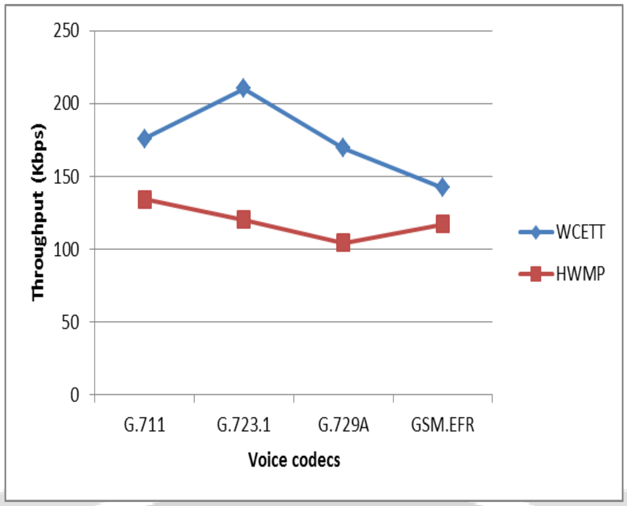

Fig 6: Throughput v/s voice codecs.

B. Effect of VOIP codecs on PDR for HWMP and WCETT protocols

Figure 7shows the effect of audio compression schemes on the packet delivery ratio againstHWMP and WCETT routing protocol for MICA channel assignment scheme over MRMC WMN. Simulation results show that for G.729A and GSM.EFR, WCETT routing protocol gives better performance for HWMP routing protocol.

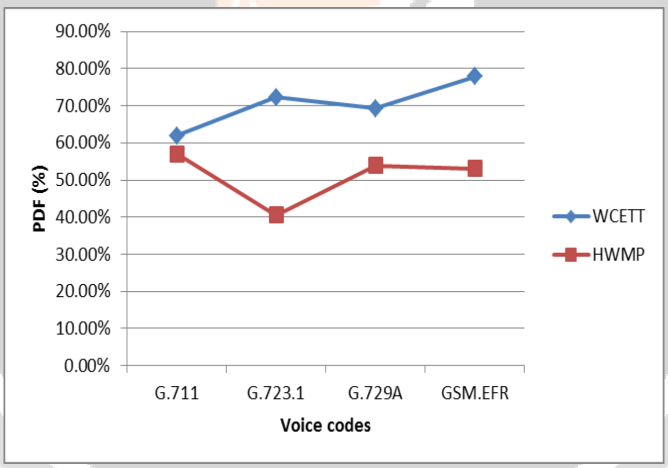

Fig 7: PDF v/s voice codecs.

C. Effect of VOIP codecs on Average End to End Delay for HWMP and WCETT protocols

Figure 8 shows the Average delay for two different routing strategies under MICA channel assignment scheme when voice compression schemes are varied. Simulation results show that audio G.729A and GSM.EFR compression scheme takes minimum time than G.711 and G.723.1 schemes for MRMC wireless mesh network.

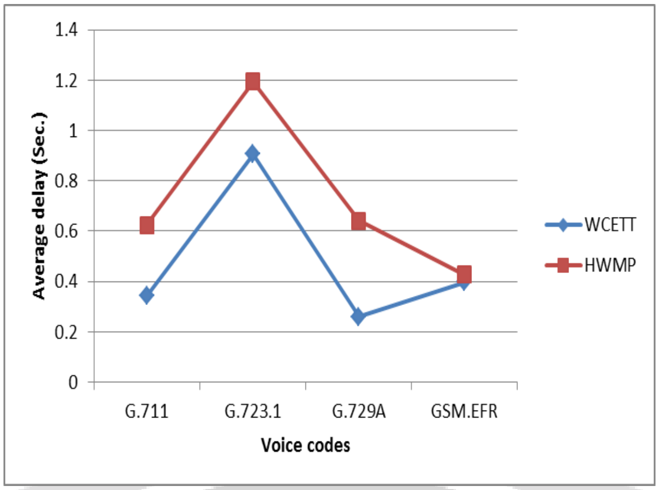

Fig 8: Average delay v/s voice codecs.

D. Effect of VOIP codecs on Routing Overhead for HWMP and WCETT protocols

Figure 9 shows the routing overhead for different audio compression strategies under MICA channel strategy against two routing protocols of different category specifically designed for MRMC WMN. Simulation results shows that for voice compression scheme G.729A and GSM EFR, WCETT routing protocol gives better performance as compared to hybrid schemes over multi radio multi channel WMN.

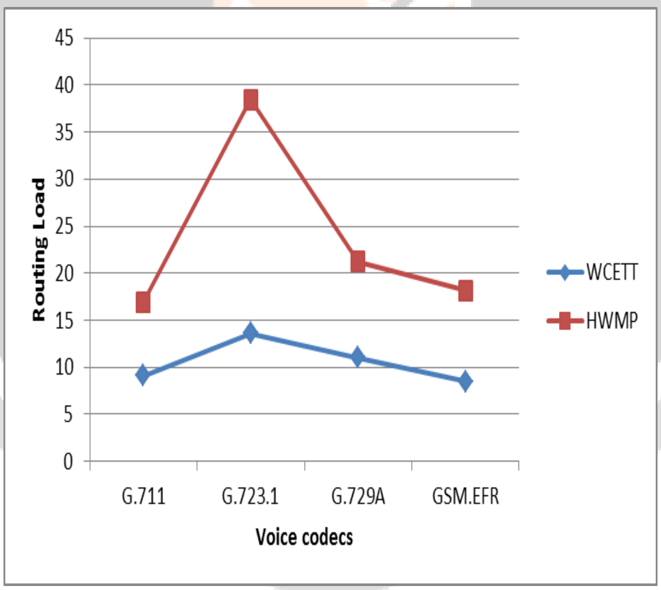

Fig 9: Routing overhead v/s voice codecs.

4. CONCLUSIONS

Voice codecs are the algorithms that enable the system to carry analog voice over digital lines. There are several codecs, varying in complexity, bandwidth needed and voice quality. In this report, the effect of four different VOIP audio compression strategies, namely G.711, G.723.1, G.729A and GSM..EFR is examined on to evaluate the performance Weighted Cumulative ETT (WCETT) and Hybrid Wireless Mesh Protocol (HWMP) routing protocol under Minimum interference channel allocation (MICA) scheme over multi-radio multichannel wireless mesh network. We have identified the key challenges associated with VOIP is to choice efficient voice codec for radio interfaces in a multi-radio wireless mesh network. Performance in multi-hop wireless networks is known to degrade with the number of hops for UDP traffic. From the simulation results, it is observed that VOIP audio compression scheme, namely G.729A and GSM.EFR voice compression codecs has best all-round performance under minimum interference channel allocation scheme scenario of reactive routing protocol namely WCETT. WCETT protocol uses the weighted sum of the cumulative expected transmission time and the maximal value of efficient channels among all channels

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