A Review on various Voices over IP codecs for WMN

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Abstract- *Wireless Mesh Networks (WMN) are believed to be a highly promising technology and will play an increasingly important role in future generation wireless mobile networks. Wireless Mesh Networks have emerged as a highly flexible, reliable and cost efficient solution for wirelessly covering large areas and for providing low-cost Internet access through multi-hop communications. It is anticipated that they will not only resolve the limitations of wireless ad hoc networks, local area networks, personal area networks, and metropolitan area networks but also significantly improve such networks' performance. there has been a tremendous proliferation of VoIP services in both residential homes and corporate offices. Providing VoIP users with true mobile phone services having the freedom of roaming requires wide area wireless coverage, and multihop wireless mesh networks have been considered a practical solution for wide area coverage.*

Keywords- *WMN, MRMC, VOIP.*

I. INTRODUCTION

Today wireless is becoming the leader in communication choices among users. Nowadays the development of the next-generation wireless systems that aims to provide high data rates. wireless mesh networks (WMNs) play a significant role in supporting ubiquitous broadband access Wireless mesh networking has emerged as a promising design paradigm for next generation wireless networks. Different from traditional wireless networks, WMN is dynamically self-organized and self-configured. This feature brings many advantages for the end-users, such as low up-front cost, easy network maintenance, robustness, and reliable service coverage. The major categories in the multi-hop wireless networks are the ad hoc wireless networks, WMNs, wireless sensor networks, and hybrid wireless networks.

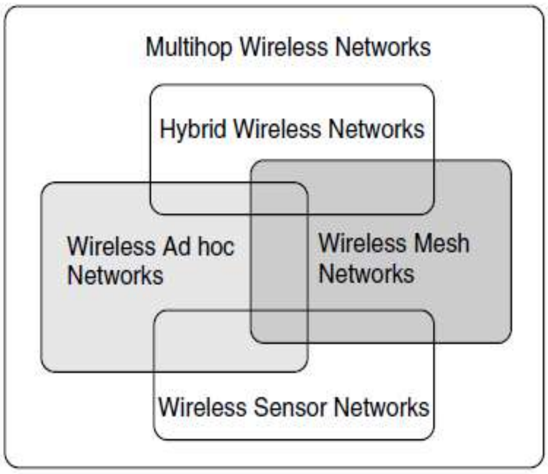

Figure 1: Illustration of wireless multi-hop networks

A. Wireless Mesh Network

WMNs 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. 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.

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

B. Wireless Mesh Network Architecture

WMNs consist of two types of nodes: Mesh Routers and Mesh Clients.

- Wireless mesh router [2] contains additional routing functions to support mesh networking. To further improve the flexibility of mesh networking, a mesh router is usually equipped with multiple wireless interfaces built on either the same or different wireless access technologies. In spite of all these differences, Moreover, the gateway/bridge functionalities in mesh routers enable the integration of WMNs with various existing wireless networks such as cellular, wireless sensor, wireless-fidelity (Wi-Fi) worldwide inter-operability for microwave access (WiMAX)[1] .
- Mesh Clients are the Conventional nodes (e.g., desktops, laptops, PDAs, Pocket PCs, phones, etc.) equipped with wireless network interface cards (NICs), and can connect directly to wireless mesh routers .

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.

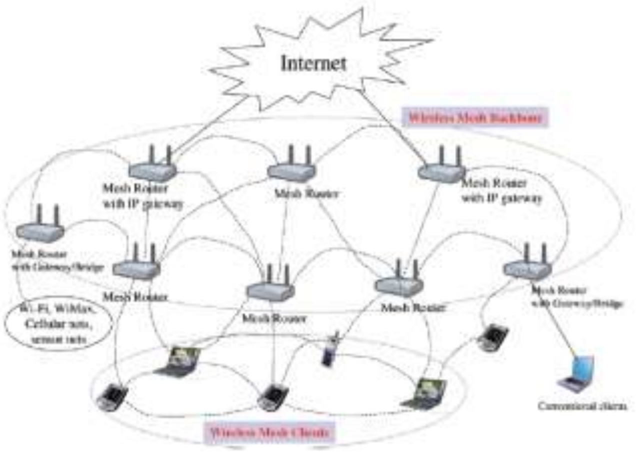

Figure 2: Infrastructure/backbone WMNs

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. The primary advantage of this architecture is its simplicity, and its disadvantages include lack of network scalability and high resource constraints.

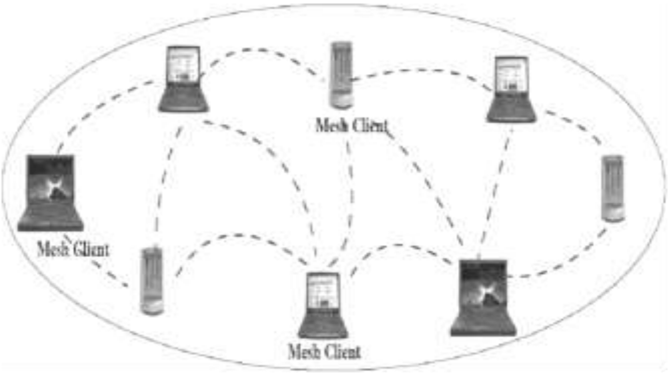

Figure 3: Client WMNs

3) Hybrid Wireless Mesh Networks

This WMNs architecture is a special case of hierarchical WMNs where the WMN utilizes other wireless networks for communication. For example, the use of other infrastructure-based WMNs such as cellular networks, WiLL networks, WiMAX networks, or satellite networks. Examples of such hybrid WMNs include multihop cellular networks; throughput enhanced wireless in local loop (TWiLL) networks, and unified cellular ad hoc networks. A practical solution for such a hybrid WMN for emergency response applications is the CalMesh platform. These hybrid WMNs may use multiple technologies for both WMN backbone and back haul. Since the growth of WMNs depend heavily on how it works with other existing wireless networking solutions, this architecture becomes very important in the development of WMNs[3,4].

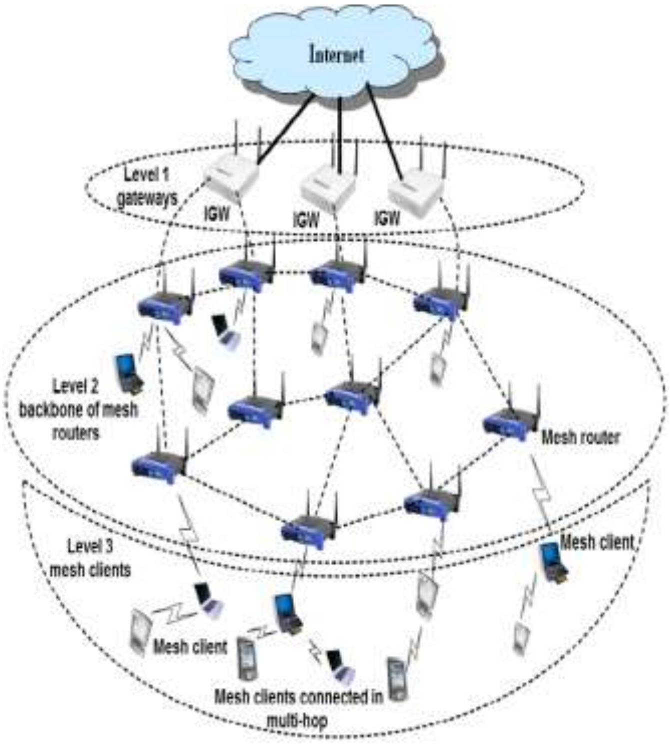

Figure 4: Hybrid WMNs.

II. ROUTING AND CHANNEL ASSIGNMENT PROTOCOLS

Unlike ad hoc wireless networks, most of the nodes in WMNs are stationary and thus dynamic topology changes are less of a concern. Also, wireless nodes in WMNs are mostly access points and Internet gateways and thus are not subject to energy constraints. As a result, the focus is shifted from maintaining network connectivity in an energy efficient manner to finding high-throughput routes between nodes, so as to provide users with the maximal end-to-end throughput. In particular, because multiple flows initiated by multiple nodes may engage in transmission at the same time, how to locate routes that give the minimal possible interference is a major issue. The issue of locating interference-free routes can roughly divided into two complimentary approaches. First, some of the PHY/MAC attributes have been utilized to define better route metrics that yield high-throughput routes[11].

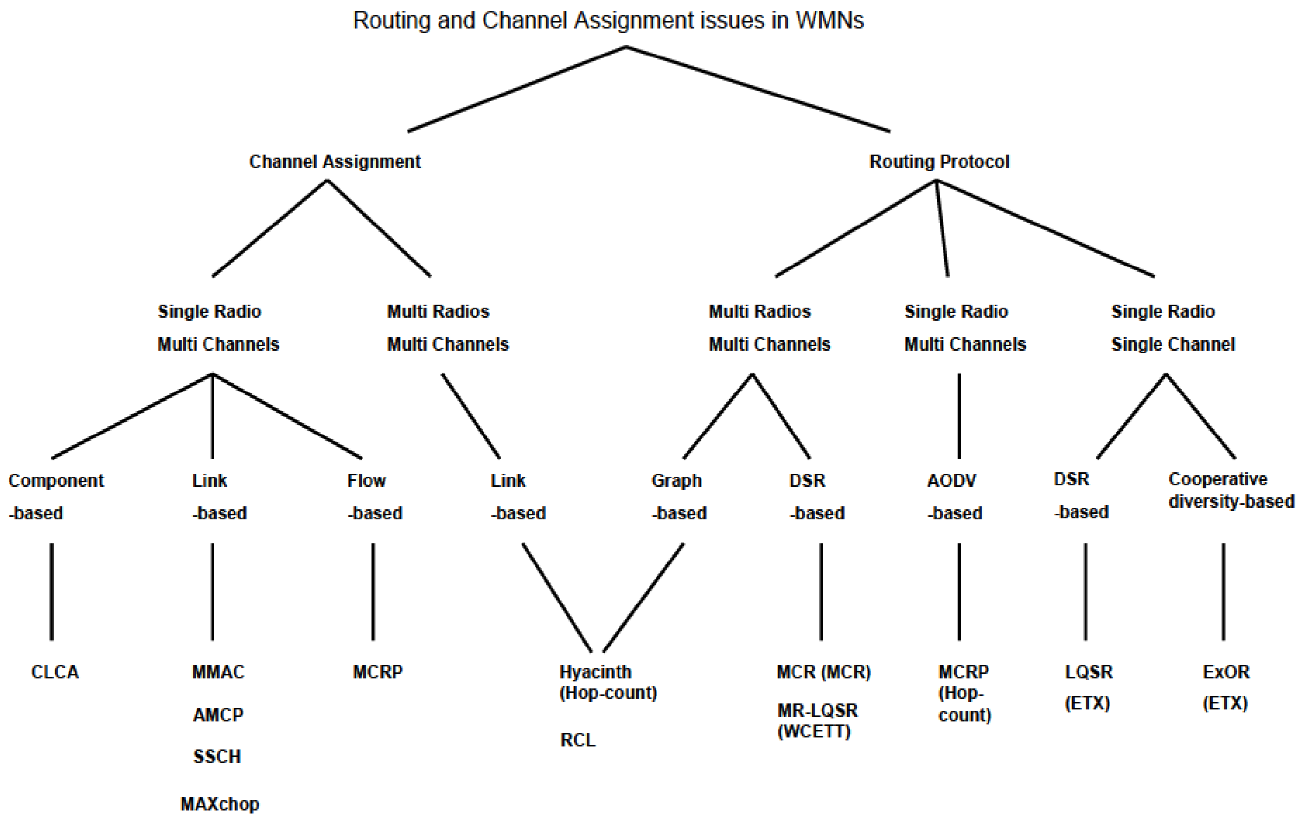

Fig. 4: A taxonomy of routing and channel assignment protocols for WMNs.

Channel assignment (CA) schemes predominantly employ heuristic techniques to assign channels to radios belonging to WMN nodes divides into two categories.

A. Fixed Channel Assignment Schemes

Fixed assignment schemes assign channels to radios either permanently, or for time intervals that are long with respect to the radio switching time. Such schemes can be further subdivided into common channel assignment and varying channel assignment.

II. VOICE OVER IP

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. The more bandwidth a codec requires, normally the better voice quality is. One problem that arises in the delivery of high-quality speech is network efficiency. Albeit it is feasible to provide high-quality speech, this comes at the expense of low network efficiency. Most domestic PSTN operate with voice sampled at 8 kHz and an 8-bit non-linear quantization scheme according to ITU-T G.711 , which encodes at 64 kb/s. Nonetheless, a much lower bitrate is desirable for a number of applications on account of the limited capacity or in order to maximize the amount of traffic that can be carried over the network.

There exist several codecs that compress voice to as low as 2.15 kb/s, quality is well below that of G.711 though [12].

Narrowband codecs

- **G.711**

G.711 is a Pulse Code Modulation (PCM) scheme that produces one 8-bit value every 125 ls, resulting in a 64 kb/s bitstream . Each audio data is encoded as eight bits after logarithmic scaling [4,5]. This standard has two forms, l-Law (used in North America and Japan) and A-Law (used in Europe and the rest of the world). An A-Law G.711 PCM encoder converts 13 bit long linear PCM samples into 8 bit compressed PCM (logarithmic form) samples, and the decoder does the conversion vice versa, whilst an l-Law G.711 PCM encoder converts 14 bit linear PCM samples into 8 bit compressed PCM samples. The G.711 is the standard codec used in H.323 and the Integrated Services Digital Network (ISDN) network.

- **G.723.1**

G.723.1 is a dual rate speech codec standard from ITU-T, originally developed for videophones that deliver video and speech over regular phone lines (PSTN) . It was designed for the ITU-T H.323 and H.324 audio and videoconferencing/ telephony standards for compressing the toll quality speech. G.723.1 was standardized in 1996 as a part of the overall H.324 family of standards and can operate at two bit rates:

- 6.3 kb/s (using 24 byte chunks) using a Multi Pulse-Maximum Likelihood Quantization (MPC-MLQ) algorithm.
- 5.3 kb/s (using 20 byte chunks) using an AlgebraicCode Excited Linear Prediction (ACELP) algorithm.

The implementation of G.723.1 Annex A also includes silence compression techniques to reduce the transmitted bitrate during the silent intervals of speech. The additional advantages that accrue from the use of Voice Activity Detection (VAD) consist in using lower processing loads and bandwidth during silence intervals.

- **G.726**

ITU-T G.726 superseded ITU-T G.723 . It works at four bitrates, i.e., 16, 24, 32 and 40 kb/s. Specifically, this codec is recommended for the conversion of a single 64 kb/s A-law or l-law PCM channel encoded at 8 kHz to a 16, 24, 32 or 40 kb/s channel. It works based on the principle of ADPCM. Nonetheless, the 16 and 24 kb/s encoding rates do not provide toll quality speech. Therefore, ITU-T G.726 recommends that the 16 and 24 kb/s rates should be alternated with higher data rate encoding to provide an average sample size of between 3.5 and 3.7 bits per sample.

- **G.729/G.729 Annex A**

The G.729 codec allows for stuffing more calls in limited bandwidth in order to utilize IP voice in more cost-effective ways [5]. The basic algorithm of G.729 runs at 8 kb/s and is optimized to represent speech with high quality. It uses the conjugate structure algebraic code excited linear prediction (CS-ACELP) algorithm with 10 ms frames. However, the complexity of this algorithm is rather high. To this end, ITU-T came up with the G.729 Annex A (G.729A) codec, which is a medium complexity variant of G.729 with slightly lower voice quality. The G.729 and G.729A codecs are inter-operable, i.e., speech coded with G.729 can be decoded by G.729A decoder and vice versa. G.729A is a very robust speech codec that works at bitrate of 8 kb/s with very good speech quality comparable to 32 kb/s ADPCM. Like G.729, G.729A is also based on the principle of CSACELP. The Annex B of G.729 adds functionality to the G.729 family of codecs. In essence, it comprises a VAD module, a DTX (Discontinuous Transmission) module which decides on updating the background noise parameters during silence periods, as well as a CNG (Comfort Noise Generation) module[4].

- **G.729 Annex D**

Annex D of the G.729 recommendation was approved in September 1998. This annex describes a lower bitrate codec that operates at 6.4 kb/s. This codec can be employed during periods of congestion, so that operation can continue at 6.4 kb/s with minimal degradation of speech quality, or when more bits are needed by the forward error correction scheme to compensate for channel impairments[4].

- **G.729 Annex E**

Annex E of the G.729 recommendation was also approved in September 1998. This annex delineates a higher bitrate codec that can be used when bandwidth is available in order to improve performance in the presence of background noise and music. G.729E describes a codec operating at 11.8 kb/s that encodes each frame in two different ways and then selects the method that appears to provide the greatest fidelity. The difference between the two methods lies in the algorithm used for the compression. One is based on CS-ACELP, whereas the other features a backward-adaptive Linear Predictive Coding (LPC) synthesis filter[12].

- **GSM-FR**

The ETSI GSM 06.10 Full Rate (FR) codec was the first digital speech coding standard used in GSM (Global System for Mobile Communications) digital mobile phone systems, working on an average bitrate of 13 kb/s. Introduced in 1987, this codec uses the principle of Regular Pulse Excitation-Long Term Prediction-Linear Predictive (RPE-LTP) coding. The speech encoder takes its input as a 13 bit uniform PCM signal either from the audio part of the mobile station or, on the network side, from the PSTN via an 8 bit/A-law to 13 bit uniform PCM conversion. The quality of the encoded speech is quite poor in modern standards, but at the time of its development it was a good compromise between computational complexity and quality. The codec is still widely used in networks around the world[4].

- **GSM-HR**

The GSM 06.20 GSM half rate (HR) codec was introduced in 1994 for use in GSM. It uses the VSELP (Vector- Sum Excited Linear Prediction) algorithm, which translates into a greater need for processing power. GSM-HR's average bitrate is 5.6 kb/s. Since the codec, operating at 5.6 kb/s, requires half the bandwidth of the full rate codec, network capacity for voice traffic is doubled, at the expense of lower audio quality[4].

- **GSM-AMR**

The Adaptive Multi-Rate (AMR) speech codec standard was introduced by the 3rd Generation Partnership Project (3GPP) for compressing toll quality speech (8 kHz). This speech codec was designed with the volatility of the wireless medium in mind for speech compression in the 3rd generation (3G) mobile telephony. This codec operates at eight basic bitrates, 12.2, 10.2, 7.95, 7.40, 6.70, 5.90, 5.15 and 4.75 kb/s, allowing the on-the-fly switch between different rates. It uses the principle of ACELP for all bitrates. Besides, there are two types of VAD and CNG algorithms. Moreover, it was specifically designed to improve link robustness. AMR supports dynamic adaptation to network conditions, using lower bitrates during network congestion, while preserving audio quality at an acceptable level. By trading off the speech bitrate to channel coding, AMR maximizes the likelihood of receiving the signal at the far end. AMR can be considered to be the most widely deployed codec in the world today[12].

III. RELATED WORK

J Tang et al [1], 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.

H Skalli et al [2], discussed 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. [3], 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.

JA Stine et al. [4], proposed directional antennas as 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 .

P.H. Pathak et al. [5], briefly differentiate 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 [6], explained two centralized optimal procedures for creating connected and bi-connected static networks with aiming of minimizing the maximum transmitting power level for every node.

T Johansson et al. [7], 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.

KN Ramachandran et al. [8], 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 [9], briefly discussed 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.

IV. CONCLUSION

In this paper, we have identified the key challenges associated with VOIP against assigning channels to radio interfaces in a multi-radio multi-channel wireless mesh networks. 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.

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