DAYNAMIC CHANNEL SELECTION FOR MESHED WIRELESS PERSONAL AREA NETWORK

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Abstract

Wireless Personal Area Network refers to the interconnection among devices within a limited range of meters. The need to extend the coverage area of the WPAN without increasing the transmission power and response to the suddenly user increase in the network is one of the primary motivations that lead researchers to investigate the required changes for topology and study performance parameters to support the meshed WPAN. Therefore, many prototypes have emerged as a draft candidate, but many problems have arisen. One of these problems is the restricted capacity of the meshed WPAN since they use TDMA scheme. This thesis focused on the meshed WPAN to investigate and determine the possibility of exploiting the available increasing in wireless nodes to enhance the performance and increase the capacity for meshed WPAN. A Dynamic Channel Selection Algorithm has been suggested. This algorithm uses the available channels, which are five channels in the WPAN, to enable simultaneous transmission of two or more channels to achieve a high packet delivery ratio and better performance of the network especially when it uses applications that needs high traffic. Furthermore, it gives the network the flexibility to increase the capacity when new devices want to join the network by allocating their location in the working topology. The new prototype of 46 wireless nodes was created by expanding an old prototype of 9 wireless nodes. The NS2 software tools function is used to implement the nodes in the network in order to examine the performance of the two prototypes network by making comparison.

Abstrak

Rangkaian Kawasan Peribadi Wayarles (WPAN) merujuk kepada sambungan antara peranti dalam julat yang meter terhad. Keperluan untuk memperluaskan kawasan liputan bagi WPAN tanpa meningkatkan kuasa penghantaran dan tindak balas kepada peningkatan mendadak pengguna dalam rangkaian adalah salah satu motivasi utama yang memimpin penyelidik untuk menyiasat perubahan yang diperlukan untuk topologi dan mengkaji parameter prestasi bagi menyokong jejaring WPAN. Oleh itu, banyak prototaip telah muncul sebagai calon draf, tetapi banyak masalah telah timbul. Salah satu daripada masalah ini adalah kapasiti terhad daripada jejaring WPAN kerana mereka menggunakan skema TDMA. Tesis ini memberi tumpuan kepada jejaring WPAN untuk menyiasat dan menentukan kemungkinan meningkat di nod wayarles bagi meningkatkan prestasi dan keupayaan jejaring WPAN. Algoritma Pemilihan Dinamik Saluran telah dicadangkan. Algoritma ini menggunakan saluran yang ada, iaitu lima saluran dalam WPAN, bagi membolehkan penghantaran serentak dua atau lebih banyak saluran untuk mencapai nisbah penghantaran paket yang tinggi dan prestasi yang lebih baik daripada rangkaian terutama apabila ia menggunakan aplikasi yang diperlukan pada trafik yang tinggi. Tambahan pula, ia memberikan rangkaian fleksibiliti untuk meningkatkan keupayaan apabila peranti baru ingin menyertai rangkaian dengan memperuntukkan lokasi mereka dalam topologi kerja. Prototaip baru 46 nod wayarles diwujudkan dengan mengembangkan sebuah prototaip lama 9 nod wayarles. Perisian NS2 digunakan untuk melaksanakan nod dalam rangkaian bagi mengkaji prestasi rangkaian dua prototaip dengan membuat perbandingan keputusan.

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LIST OF ABBREVIATION

PDA	Personal Devices Assistance
NIC	Network Interface Card
Wi-MAX	Worldwide Interoperability for Microwave Accessr
IEEE	Institute of Electrical and Electronics Engineers
MAC	Media Access Control
WEP	Wired Equipment privacy
LAN	Local Area Network
ACK	Acknowledgment
WMN	Wireless Mesh Network
DSL	Digital Subscriber Line
PAN	Personal Area Network
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network
WMAN	Wireless metropolitan area network
MPAN	Mesh Personal Area Network
PHY	Physical Layer
DCS	Dynamic Channel Selection
MDEVs	Mesh Devices
APs	Access Points
PNC	Piconet Coordinator
CCTV	Closed-circuit television
WMPAN	Wireless Mesh Personal Area Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless mesh network is the key technology for the present generation in wireless networking for providing fast and hassle free services to users. Nodes in wireless mesh networks comprise mesh routers and mesh clients. Each node operates not only as a host but also as a router, forwarding packets on behalf of other nodes that may not be in within direct wireless transmission range. Connectivity between nodes in wireless mesh networks is automatically established and maintained among the participating nodes.

This makes wireless mesh network a dynamic, self-organized, and self-configured wireless network. This feature brings many advantages such as low installation cost, low cost of maintenance, robust and reliable service coverage. The most commonly used technology in day to day life, such as desktops, laptops, PDA's, Pocket PC's, Phones etc. is based on conventional nodes equipped with Wireless Network Interface Cards (NIC's) which in turn can connect to wireless mesh routers [1,2].

Nodes without a wireless NIC can still access wireless mesh networks by connecting to wireless mesh routers through other technologies such as Ethernet. In addition, gateway or bridge functionalities in mesh networks enable integration of wireless mesh networks with various existing wireless networks such as Cellular networks, wireless sensors, wireless-fidelity (Wi-Fi) and worldwide inter-operability for microwave access (Wi-MAX). Wireless mesh networks can also be used in other applications such as broadband, networking, community and neighborhood networks, enterprise networking building automation [3].

Wireless mesh networks can be deployed one node at a time and they also have a capability of self-organization and self-configuring. Reliability and connectivity for the users of such networks increases significantly as more nodes are installed. As all the required components are already available in the form of Ad-hoc network routing protocols, IEEE 802.11 MAC protocol, wired equipment privacy (WEP) etc., deploying a wireless network is not difficult, so this feature also brings up several companies offering wireless mesh networking products [4].

However, considerable research efforts are still going in the case of MAC and routing protocols applied to wireless mesh networks which do not have enough scalability. The throughput drops significantly as the number of hops or nodes in a wireless mesh network increases. Consequently, all existing protocols in the protocol stack need to be adapted or modified in order to handle these conditions. Many research groups focus on protocol design of existing wireless networks such as IEEE 802.11 network, ad-hoc networks and wireless sensor networks [5].

Industrial standards groups are also actively working on new specifications for the wireless mesh networking. Despite significant advances in physical layer technologies, today's wireless LAN still cannot offer the same level of sustained bandwidth as their wired brethren. The advertised 54 Mbps bandwidth for IEEE 802.11a/g wireless LAN interface is the peak link-layer data rate. When all the overheads-MAC contention, 802.11 headers, 802.11 ACK, packet errors Are accounted for, the actual good put available to applications is almost halved. In addition, the maximum link layer data rate falls quickly with increasing distance between the transmitter and the receiver. The bandwidth problem is further aggravated for multi-hop ad hoc networks due to interference from adjacent hops on the same path as well as from neighboring paths [1, 2]. Fortunately, the IEEE 802.11b/g standards and IEEE

802.11a standard provide 3 and 12 non-overlapped frequency channels, respectively, which could be used simultaneously within a neighborhood.

Ability to utilize multiple channels substantially increases the effective bandwidth available to wireless network nodes. Such bandwidth aggregation is routinely used in 802.11-based wireless LANs that operate in infrastructure mode, where traffic to and from wireless nodes is distributed among multiple interfaces of an access point or among multiple access points. However, bandwidth aggregation is rarely applied to 802.11-based LANs that operate in the ad hoc mode. As a result, most ad hoc network implementations use only a single frequency channel, wasting the rest of the spectrum [6].

1.2 Problem Statement

The main problem with wireless networks is repeating the enlargement process for many times. Understanding this area is also considered as it improves the performance of the whole network. Familiarity with the behavior and the performance of the meshed wireless network and interacts with the cases of expansion and the influence of many factors while adding new users or subscriber join the network. Comparing the performance of 9-node network with 46-node network and understanding the behavior of these networks. Last, but not least, a discussion about possible future works as well as specifying a system that will help to improve the performance.

1.3 Objectives

The main aim of this project is to get better performance, scalability on a wireless mesh network. This is comparatively a new area in the networking field and therefore the aim has been decided to find new methods that could help using this technology more effectively. This was done by providing a study of what is suitable and providing some measures for what needs to be done by making a comparison with a chosen related work.

The objectives of this project are as follows:

I. To exploit multiple NIC cards in wireless nodes, most of them were based on hardware and software installed.
II. To work and manipulate directly with the unknown and unexpected expansion of the network, which requires only systems topology modification.

1.3 Project Scopes

This project describes and evaluates a novel multi-channel WPAN architecture that is built on 802.11-based on wireless WMN hardware and is specifically tailored to multi-hop wireless access network applications. Although the multi-NIC approach has been mentioned in the past, Believed that this work represents a more comprehensive study of this approach in the context of a wireless access network. In particular, this project makes the following research contributions:

I. A fully distributed channel assignment algorithm that can adapt to traffic loads dynamically.
II. A load-balancing routing algorithm that can adapt to traffic load changes as well as network failures automatically.
III. A comprehensive performance study that shows significant packets delivery ratio improvements over multi-NIC WPANs, which are validated through empirical measurements on a fully working prototype.
IV. Implementation metric types and choose the best.
V. NS2 software simulation environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Wireless mesh networks have been adopted to be the key technology for the next generation wireless networking. They have provided great advantages in different fields and applications in recent years; that make wireless mesh networks issues first priorities for researchers in many networking categories such as WLAN, WMAN, and WPAN which has led to a rapid development in mesh networking technologies. However, in terms of wireless Meshed Personal Area Networks (MPAN) standards, IEEE 802.15 Task Group 5 and many researchers are still working to determine and provide the necessary mechanisms that should be supported in PHY and MAC layers for both high data rate and low data rate WPAN to enable mesh networking capabilities [7].

Dynamic channel selection (DCS) is one of the mechanisms that could be used to increase the network capacity or reduce the interference resulting from the increment of the number of mesh devices (MDEVs) in the same network or the interference from other networks operate on the same channel [8]. In 2000 a Dynamic Channel Selection (DCS) scheme was proposed for IEEE 802.11 [9], which takes into account the interference by the other neighbouring access points (APs) or devices (DEVs).

The access point of the BSS will determine the best channel for all the stations within its BSS and initiate channel switching for all its stations to the new channel. This mechanism has succeeded in being implemented-independent as it does not require any change of the PHY layer specification of IEEE 802.11. Another Dynamic channel selection mechanism is given in [10], in which the necessity of DCS is demonstrated as well as the lack of the present mechanism in IEEE 802.15.X, that the PNC listening range is limited for one hop only. Therefore, it cannot detect the interference outside its pickets and its transmission range. Furthermore PNC cannot know when and which node is the one that should inquire the channel status. With the new proposed mechanism the nodes decide to do interference detection by themselves periodically. In this way the detection result is reported to PCN which will make an analysis and determine whether to change the operating channel: this gives faster channel change.

Another approach has been adopted in [10]; scheduling algorithm is presented to allow simultaneous utilization of the available multiple channels, thereby enabling the sharing of the channels among the nodes. Therefore, each device is made to be able to transmit and receive on any channel. This mechanism uses distributed dynamic channel allocation algorithm so that each piconet will determine the set of channels depending on the local information. This algorithm shows an increase in the throughput of the piconet and reduces the average packet delay, but the scheduling efficiency drops when the number of channels used by the piconet increase.

The suggested dynamic switching of the channels in such a way that neighbors meet periodically common channel for communicating [11]. This approach is proposed to be compatible with IEEE 802.11 and it can be done in software. Therefore, one of the main advantages is that it does not need any change in the MAC protocol specifications. Furthermore, it achieves significant improvement in the capacity of ad hoc wireless networks. The proposed a MAC protocol, so that the nodes dynamically negotiate who sends in specific times and on which channel. It uses the idea of dividing time into fixed time intervals using beacons and each interval have small a window used to determine the traffic and channels during that interval. This protocol successfully exploits multiple channels and shows significant enhancement for throughput over the total network.

The problem of the previous two approaches is they assume that all nodes are synchronized [12].

Another proposal by Po-Jen C. [1] Has been proposed in 2010 uses the idea of Dynamic Channel Selection to balance traffic in mesh networks. It records the information on the history of channel utilization in each node by adding a counter to each end of a channel to record the frequency of packet routing. Based on these records the node will determine the channels to work on and divert the traffic from the current load distribution through the less trafficked channels. This gives balance traffic load of the network. The backdraw of this approach is it assumes a specific scenario and each node has four channels to communicate with neighbors.

Some past works have been done to dynamically select channels some of them use load-aware dynamic channel assignment algorithm. The proposed mechanism needs the traffic loads to be known before channel selection take place. The other algorithm is based on the knowledge of interference in the mesh networks, but all these proposals use multiple radios whereby the node has two or more channels to use simultaneously [1].

In IEEE 802.15.3 standard, dynamic channel selection is defined in such a manner that the PNC initiates the dynamic channel selection if it determines that the current channels are poor and that one or more of the other channels operate with better conditions, but the algorithm needed to utilize the channel status information when deciding whether to change channels is not defined [13]. Furthermore, IEEE 802.15.5 is still a draft candidate and to the best of our knowledge not much work has been done for dynamic channel selection in meshed WPAN.

In this project a new algorithm has been proposed to dynamically select channels and we have focused on this algorithm’s ability to increase the capacity of the mesh network. This algorithm is implementation-independent, as it does not need changes in the current standard and can be implemented using software. With the increase of needs for mobility and the expansion of the coverage area, wireless networking became the dominant communication technology to serve all over the world.

Wireless networks provide great advantage of mobility and offer cheap solutions, thereby increasingly replace the wired communications. But like any technology, wireless networks are not free of challenges such as data transfer speed, reliability and security, which leads the mesh networks to be the key technology among the other wireless networks evolving into the next generation because it contributes to solve most of those problems.

It is believed to be a highly promising to offer enhancements to the performance of the existing standards in terms of cost, providing reliable service coverage, robustness, easy configuration, and extend the coverage area. Unlike the centralized wireless systems such as the cellular networks and wireless local area networks, it gives the divergence of features for all those networks which it is involved in. Furthermore, WMNs are different from the other networks that even if more than one node are failed, the network will remain working and keeping the ability to relay data between nodes, in this way they will not affect their performance.

2.2 Mesh Networking

When somebody speaks about the mesh network, it means the network has many-to-many connections that capable of dynamically optimizing and updating these connections, because the dynamic self-organization, self-configuration and self-healing represent the most important features of wireless mesh network. This may be a mobile network in which some or all the nodes of the network are mobile units that change position over time.

A mesh networks employ to be one of two types, full mesh topology or partial mesh topology. In the full mesh topology, each node is connected directly to every other node in the network. This connecting is very expensive to be built, but it gives the most reliable performance so in case when one of those nodes fails, the others can direct traffic to each other so that it is usually used for backbone networks figure 2.1 [13].

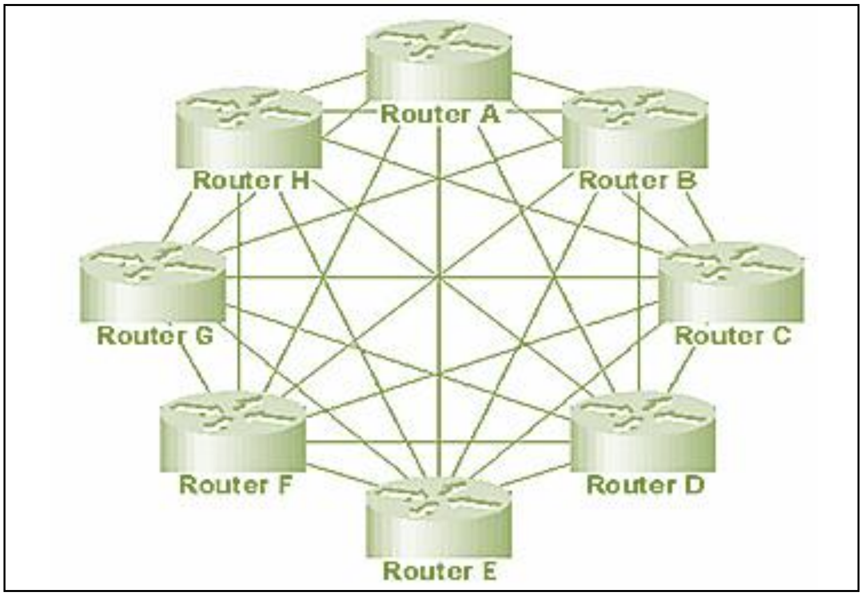

Figure 2.1: Full mesh networking [14].

In the partial mesh topology, some nodes are connected to all the others, but some of the nodes are connected only to those other nodes with which they exchange the most data [14].

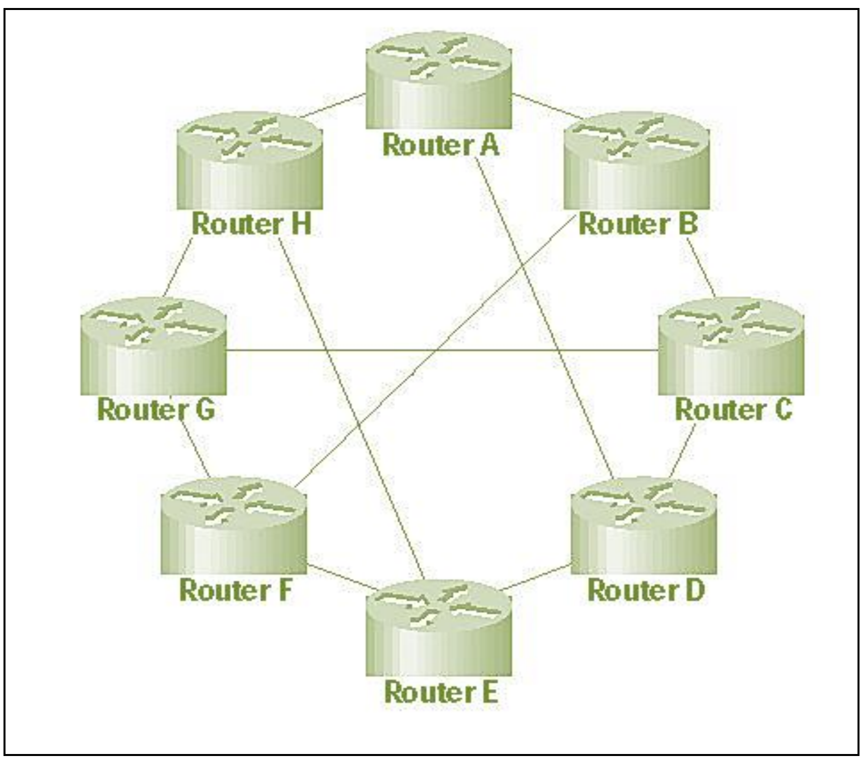

Figure 2.2: Partial Mesh Networking [14].

WMPANs consist of two types of nodes: mesh routers and mesh clients. In addition to the routing capability for gateway/bridge functions as in a traditional wireless router, additional routing functions are contained in the mesh router to support mesh networking. Through multi-hop communications, the same coverage can be achieved by a mesh router with much lower transmission power. A mesh router is usually equipped with multiple radios for further improvement to the flexibility of the mesh networking, and it is built on either the same or different wireless access technologies.

In spite of all these differences, mesh and conventional wireless routers are usually built based on a similar hardware platform. Mesh routers have minimal mobility therefore they form the mesh backbone for mesh clients. Thus, although mesh clients can also work as a router for mesh networking, the hardware platform and software for them can be much simpler than those for mesh routers. For example, communication protocols for mesh clients can be light-weight but the gateway or bridge functions do not exist in them, and only a single wireless interface is needed in a mesh client.

2.3 Wireless Mesh Network Architecture

Based on the functionality of the WMNs' node, they can be classified into three types. Those types are:

2.3.1 Client WMNs

In this type of architecture, peer-to-peer networks are provided by connecting client devices to form a mesh network. Clients act as hosts and routers to perform routing and configuration functionality as well as delivering end-user applications to customers. Here all the nodes are at the same level with each other so that it is the simplest case among the three WMN architectures. Clients WMN are usually provided by single radios on devices and the packets are forwarded by hoping through multiple nodes to reach its destination as shown in figure 2.3. It is similar to ad hoc networks in term of simplicity and this feature is the primary advantage for such architecture, but the scalability is one of the disadvantages as well as routing, addressing scheme, and service discovery schemes [15].

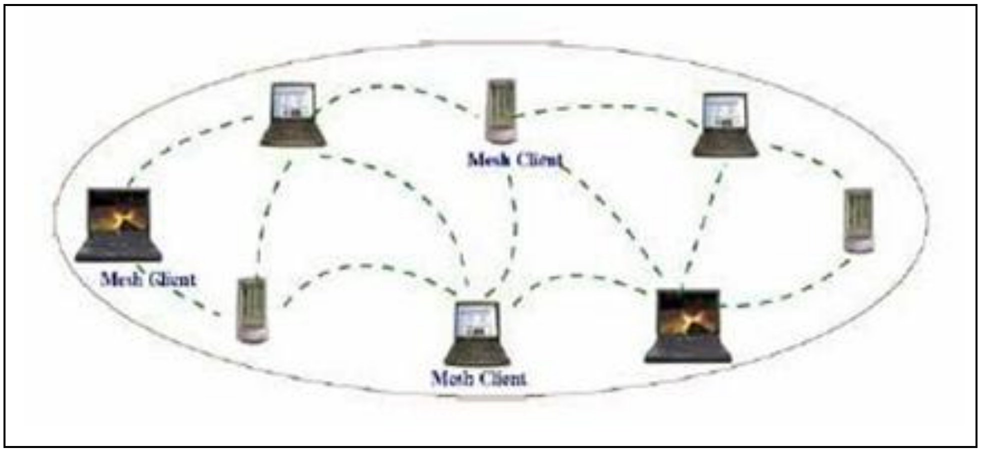

Figure 2.3: Client WMNs [16].

2.3.2 Infrastructure/Backbone WMNs

Two levels are there in this architecture, the first one is the routers that form the backbone of the WMN and the other one is the clients that are connecting to them. The mesh routers are responsible to self-organize and maintain the backbone network. That's why in most of the times the router nodes may not originate or terminate data like the client devices. This backbone can be provided with different types of radio technologies in addition to the most used IEEE 802.11 technologies. Sometimes mesh routers are connected to the internet using external interface with gateway/bridge functionality to provide connectivity with the existing wireless networks [16]. As shown in figure 2.4.

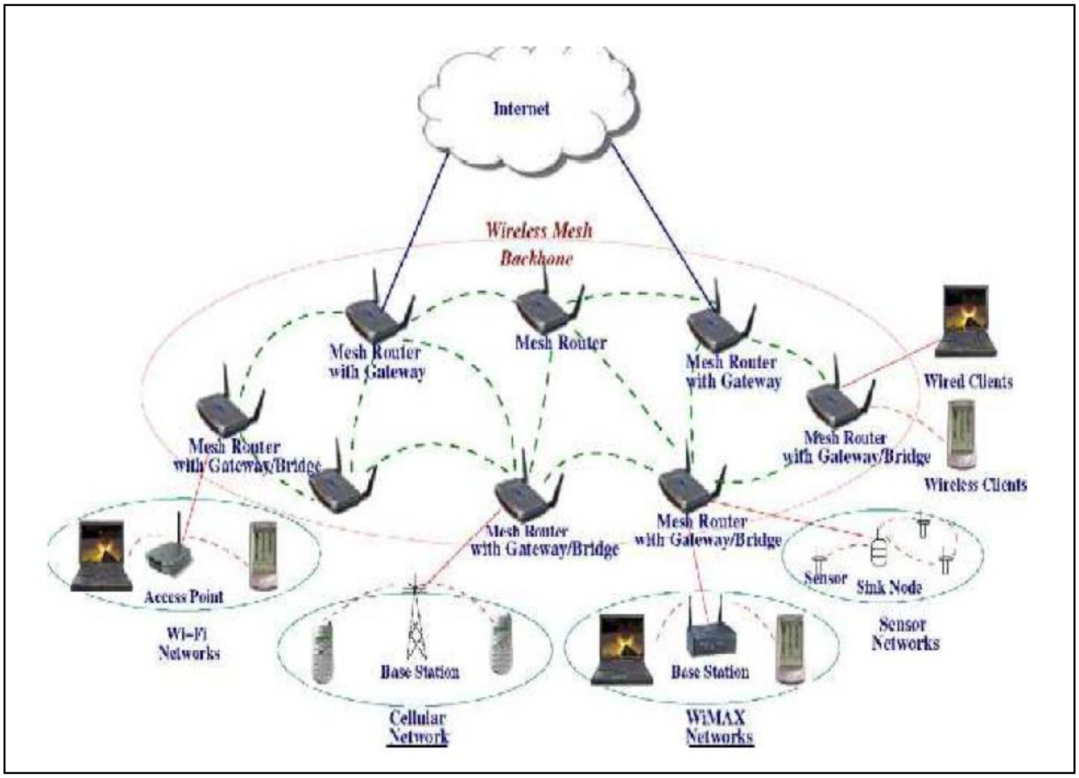

Figure 2.4: Infrastructure/Backbone WMNs [16]

2.3.3 Hybrid WMNs

In this architecture, both infrastructure and client meshing are forming this type of networks and through routers the clients can access the network as well as directly meshing with the other mesh clients. Furthermore, because of the routing clients' capabilities, high connectivity improvement and coverage inside the WMN can be provided while the network connecting to the other networks like internet, WiFi, WiMAX, cellular, and sensor networks [16]. Figure 2.5 shown.

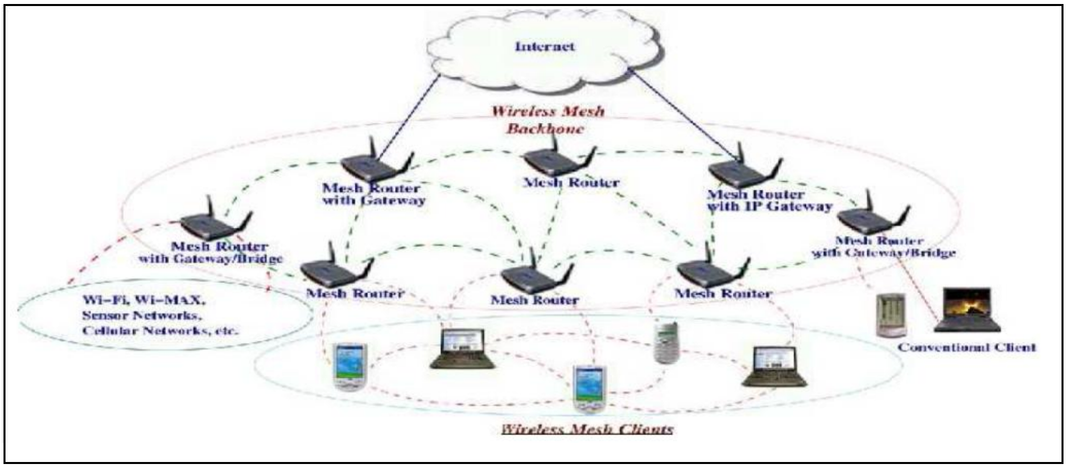

Figure 2.5: Hybrid WMNs [16].

2.4 Advantage and disadvantage of Mesh networking [17]:

2.4.1 Advantage

- **Scalability & Extensibility**: It is able to increase capacity, expand coverage area, add new applications, and maximizing performance throughout the mesh.

- **Security**: the security provided in wireless networks should protect and ensure the privacy and integrity of all user traffic by using a mix of user authentication, access controls and packet encryption. They use advanced encryption standard (AES) based on the IEEE 802.1x encryption standard, which is considered to be the most robust user authentication (at least 128 bits).

- **Reliability**: The self-tuning and self-healing features mark mesh networks to be more reliable than other systems; thus, any node fails, mesh systems can route around those failures to ensure that it does not affect the users. Also, mesh networks load balancing turn themselves to work on the optimal performance without human intervention taking the advantage of this basic configuration to maximize overall performance.

- **Performance**: Both high throughput and robust traffic management capabilities are required to provide acceptable levels of performance to support multi-use voice, video surveillance and data applications. Full control over throughput and quality of service (QoS) requires, at least: network segmentation, traffic filtering, rate limiting, and traffic prioritization. These capabilities are needed to ensure the voice and video traffic get handled at a higher priority to minimize latency and jitter. Mesh networks provide performances compared to standard networks, only with a much more flexible.

- **Ease of deployment and operation**: In an urban environment full of tall metal and/or concrete structures, the ability to overcome “line of sight” obstacles to RF transmission and a means to mitigate the inevitable RF interference.

- **Low cost**: This is the most important section; so many people can use this technology.

2.4.2 Disadvantage

- **Security:** As mentioned in advantage part security can be also issued in mesh disadvantages as everyone working on mesh realizes that security is an important issue, because nodes when they function as routers relaying packets to other nodes. More nodes that mean more people can view your data.

- **Overhead:** Increase in mesh network because nodes must learn their neighbors as well as paths to other nodes they must record and maintain routing tables.

2.5 Mesh Network Application

Various applications in many fields of the real life are simplified and became much easier using mesh networks. Here are the main applications of the mesh networks:

1. Building monitoring and control: it can produce huge energy savings by the monitor and control lights, air conditions, heaters, and other functions in large buildings such as hotels and hospitals. That is difficult and too expensive to be achieved using wired networks while with mesh is simple to implement [18].
2. Military application: The reliability of mesh networks makes them the perfect way to handle soldier-to-soldier communication with longer range. Also, it helps to manage the battlefields by controlling and monitoring many weapons and systems [18].
3. Automotive: Recently, vehicles are included with electronic control systems for the purposes of either tracking or services or both and these systems need to be communicated through flexible and reliable networks, thus meshes are helping with the largest part of that by eliminating wiring and provides an improved way to monitor and control the hundreds of functions in vehicles [18].
4. Broadband wireless access: A mesh network using Wi-Fi can be created to provide high-speed Internet connections as well as other broadband services in areas where cable TV or DSL lines aren't available [18].
5. Security control: Mesh sensor networks provide an efficient security control systems, such as CCTV systems.

2.6 Related Work

2.6.1 Multi-channel MAC

To modify a MAC layer some proposals [19, 20] are considered to support multi-channel networks. To find a better channel for a single packet transmission, the method touched through the greatest of this form of this research, fundamentally evading of intervention and allowing several parallel transmissions in a neighborhood. In contrast to all these prior proposals, while ours architecture does not carry out the channel switching within a packet-by-packet foundation; our channel project takes for a longest, like a some minutes or hours, thus, not require re-synchronization to communicating network cards within various channels for each packet. This assets product in practical way to complete our architecture with using goods 802.11 hardware.

2.6.2 Multi-radio discuss

Had discussed the approach to multi-NIC in some previous work [21, 22], Nevertheless, no have been proposed algorithm channel distributed task which can be really recognize the exact potential of the performance of this structure [23]. The redoubled 802.11 NICs per node in ad hoc network through on the assumption an appropriate channel task of whole nodes, NIC-1 in particular channel-1, NIC-2 to channel-2, and upwards. The present method could only factor of 2 development using 2 NIC cards yield, contrast with 6 to 7 improvement possible factors with our task channel scheme. [23].

The use of several radios has been discussed along with directional antennas in [22]. The present clarifications using this method, the node each demand MAC adjustment into the backup radiation formulation [24], or demand a dissociate radio to connect with any of its neighbors [22]. On the other hand, the architecture can be given a big performance improvements through using a radios small number within any node. A multiple NICs per node has been used, and characterization how to contribute the enactment possibility of this method by using central channel task and routing algorithms [22].

A many reasons has been presented of traffic load-unaware channel task algorithm failure to do it. The existing project, suggest a collection of task distribution routing and channels and that load-aware possible achievement of raw efficiency of multi-NIC framework within the situation of networks and access of wireless for multi-hop algorithms. Comparison to previous type of this multi-channel WMN framework, this type perfectly removes require of several control interfaces, includes preferred channel task to simulate a reasonable fat tree framework, and quick supporting fails to retrieve them.

2.6.3. Ad hoc Network Routing Load-balancing

The vast quantity of class research capabilities in a single channel multi-hop routing in ad hoc networks, In the proposed algorithm specifically to load balancing and wireless connections balancing of the gate node connecting the arrival of a wireless network to the wired network. In this algorithm, the node gate coordinates all nodes traffic through the tree to achieve load balancing. In disparity, the algorithm does not require direct load-balancing we have such coordination or a central calculation. Different metrics to measure individual link-load has been proposed. In a wireless network, which is using a number of packages or the number of tracks that pass by a specific node and the intervention [25].

Similarly, The traffic has been measured which that passes by every node and the calculation of obtainable bandwidth within the path various links in addition to the gateway node to detection a path load balancing. The neighborhoods various links can work within various channels, dissociate of every load channel, then used toward calculating the remaining available bandwidth for every link. Lastly, the load balancing problem towards various nodes sits with cramped sector, while proposition algorithm joins two strategies avarice. Forward ever packet to less loaded node and forward any packet to further node [26].

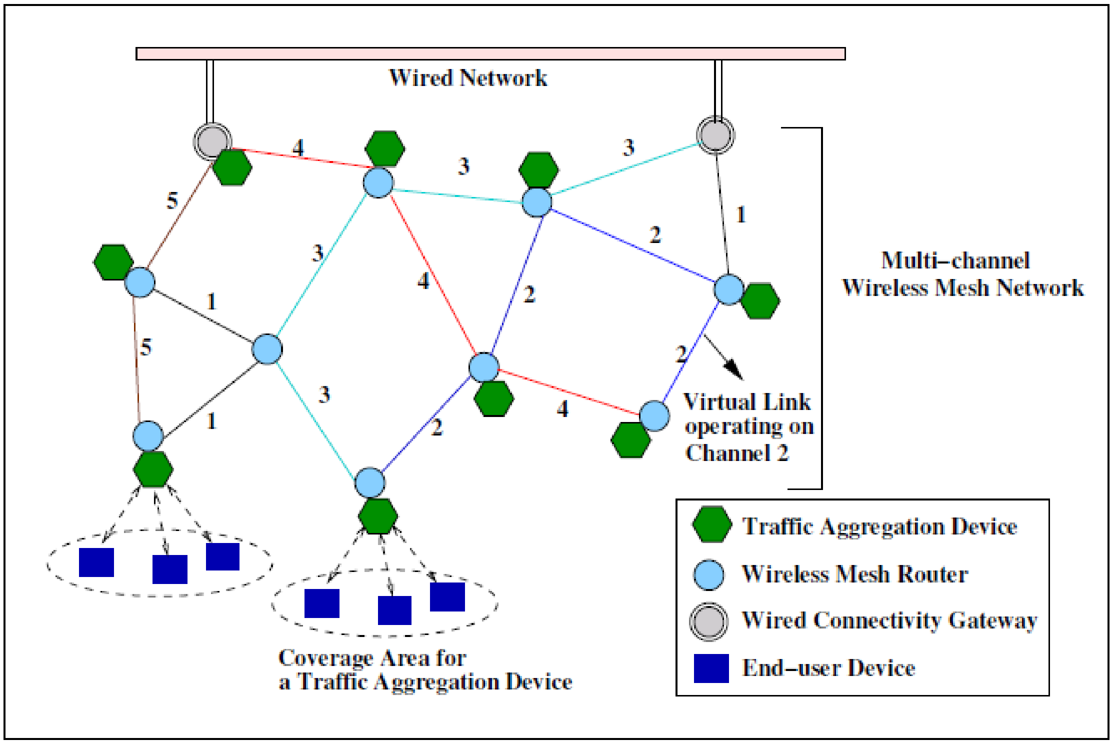

Figure 2.6: Multi-channel wireless mesh network (WMN) hyacinth structure consists [27].

Essence, while is approaching to a wired network providing the series of gates wired connection. WMN every node has multiple interfaces, of the every work in a featured radio channel. The WMN node is equipped with a traffic aggregation device (same with the arrival 802.11) while interact into different mobile station points. Data collected relays multi-channel mobile stations WMN "to or from the wired network. The links among nodes indicate is direct to communication with channels referred to the number of this link. In this model of any node processing toward 2 cards for wireless NIC, thus, the channel number used each node at one time while cannot be used more than two, and using the network as a 5 entire featured channels.

2.6.4 Traffic Profiling and Topology Discovery

The other side of each WMN is to discover the topology. Several have been proposed topology discovery algorithms in earlier [28]. Traffic information was discussing the application of the model mobile agent to discover the neighbor and the commutation. In a mesh network of these nodes using the same methods in order to determine the mesh neighboring network nodes in addition to detection the load into different channels for intervention area.

2.7 Problem Formulation

2.7.1 Architecture System

As shows in Figure 2.6, and is a wireless mesh network (WMN) structure to work consists of wireless routers constant, it was all of them equipped with an access point for the collection of traffic that provide network connectivity to mobile stations to the end- user within the attention area . In this regard, its wireless routers modality of the multi-hop ad hoc network between them to communicate traffic from and to mobile stations. Some WMN nodes act like gateways among WMN also the wire mesh. Of wholly resources infrastructures like servers of file web portals also the server's application, through wired network and can be accessed through some of the gateways. In more general conditions, it can be physical links among the gateways, wired network also wired connection, or the 802.11 and 802.16 wireless link from point to point.

Each processing node into the multi-channel WMN within several NIC 802.11 identical cards, of each is tuned to a present radio channel by comparatively long duration time, like few minutes or hours. The direct-dial, of two nodes require be during connecting domain on top of each other, then require to devoted channel to them common interfaces. A pair of nodes was used the similar channel toward intervention of several interferes to one another communications, until if they no way communicate directly.

Can node using various channels pairs transfer packet's at one time in the absence of any interference's. For instance, figure 2.6, shows were every node to two NIC cards processing. Realistic links among nodes shows depicting direction contact between them, while the channel used through a pair of nodes like the associated number in the link. This network is used, for example 5 completely separate channels. A privilege that the mobile nodes have one NIC, while the communication among the mobile device and contract assembly similar to the process of traffic infrastructure of the IEEE 802.11 criterion.

2.7.2 The Problem of Channel Task

Intuition, the target of the task channel in a multi-channel WMN to connect every network interface of radio channel like that, and the obtainable bandwidth to any realistic correlate commensurate with load, then wants to load. And bout the various problems is a task channel in cellular networks [29], That due to the neighboring stations linked to the cellular network through wired networks, while the adjacent nodes in WMN can only connect with each other through wireless connections.

Thus, if one simply employs at smallest channel used to interface WLAN, there is no underwriter that the outcome grid network and until linked. The Hyacinth node needs to take part of common channel with all its neighbors and communications term, which was interested in establishing a link or a virtual connection. Further, to minimize interference's node must decrease a neighbor's number who take part of common channel. Generally, further, one must break every area of the collision to the largest possible number of channels potential when preserves the desired link between adjacent node's.

Can in fact be divided channel assignment problem by two parts sub-problems: (1) Neighbors toward the interface binding (2) Interface for channel binding? Determine the neighbor-to interface connectivity through interaction using a node to link with all neighbors, who purpose to organize a realistic connection. Due to, the number of interfaces per node is limited, of every node usually uses a single interface to link at the complications neighbors. While the interface to guide defines the extent of the danger time restricted radio channel that must be used and the network interface. The main constraints that need algorithm assignment channel to meet that as following:

- Determined by the number of separate channels that can be particularized to a node WMN by the number of cards NIC has.
- Must two nodes that communicate with every another directly from participating in one common channel at least?
- Raw ability of radio channel within a limited area of intervention.
- Non-overlapped radio channels are a total number constant.

On the first glimmer, of the problem seems to be the graph coloring problem. Thus, the standard-coloring graph algorithms do not truly capture demands and restrictions. The formulation of a multi-node coloring failure [17] to capture the second constraint, where nodes communicate need to do is set the common color, the problem seems to be the graph coloring problem. But, the criterion coloring graph algorithms do not truly capture demands and limitations. The shape of a multi-node coloring fail [17] to captivate the second manacles, wherever nodes connect want to do is group the common color.

Formula-edge coloring failed to catch the first entry where no more than q (number of NIC cards per node) colors can be incident to a node. When the restricted edge coloring may be able to sample nearly the remaining restrictions, it is still able to meet the third constraint of limited channel capacity. In theory, should be given to the links that need to be greater traffic load support more bandwidth than others. This means that these links should be used radio channel that is shared among a smaller number of nodes. The load-aware ideal referral resource distribution channel between the radio links in a way that matches their expected traffic loads.

2.7.3. Problem of Load-Balancing Routing

The assignment of the channel depends on the load on each virtual link, while a turn relies on the guidance. Traffic distribution of WMN is a deviation. More than decades WMN communicate primarily with nodes on the wired network. This is the condition for most users concerned foremost with arrival to the Internet or scheme servers, together of which are probable to stay on the wired network [22].

The target of the routing algorithm is this to identify routes among every traffic, collecting device and the wired network with like that equipoise the load on the mesh network, inclusive the connect to the wired network. Load equipoise assistances sidestep narrow links, and boost the network resources employment performance.

2.7.4. Estimate Metric.

The definitive target of the assignment channel and algorithms of routing is to make as large of the thorough network good-put, or the bytes number it can transfer among the traffic collecting devices and the wired contact gateways on a unit time. To use in formal this target, was determine the cross-section good-put of a network as written equation in below [27]:

$$X = \sum_{a} \min\left(\sum_{i} C(a, g_i), B(a) \right) \quad (2.1)$$

Where $C(a, g_i)$ is the useful network bandwidth obtainable among the traffic gathering device *a* and a gateway node g_i. If the bandwidth requirement between a traffic aggregation device a and the wired network is B(a), then only up to B(a) of the bandwidth between node a and all the gateway nodes is considered useful. This criteria ensures that only the usable bandwidth of a network is counted towards its cross-section throughput, hence the term cross-section good-put. The goal of the channel assignment and routing algorithms is to maximize this cross-section good-put *X*.

2.7.5. Assignment Algorithm of Central Channel

Even though the idea of balancing simple and extensive network load theory, and is rarely used in the former load balancing routing algorithms because it is difficult to capture surprising quantified. Until with a full knowledge of the topology networks and matrix of traffic, and then the problem of an assignment channel is NP-hard. Evince its stiffness by decreasing the amount of multiple sub-problems to the problem of assignment channel. To create a baseline, we develop a centralized greedy algorithm to the problem of assignment channel / routing in multi-channel WMNS [23].

The algorithm doings through assessment the first load imposed on every realistic link by every traffic stream in the matrix confirm the movement, and thus the total foreseeable load on each realistic link. Algorithm of assignment channel then visit of all the links in the default arrangement decreased the in prospect loads. Onto visiting a present virtual link, the algorithm greedily assigns it a channel that leads to smallest interference and disagreement with neighboring nodes in the interference zone whose WLAN interfaces have already been assigned to specific channels.

2.7.6 Hyacinth Prototype Performance

This is discussed in an earlier work by [27], figure 2.7, shows the topology of the 9-node Hyacinth prototype which built. The nine nodes are placed in an area of size approximately 20m x 10m spanning two lab rooms with Node-1 and Node-9 connected to the department wired network. The transmit power on each node is reduced to 1 mW to limit interference zones of individual nodes.

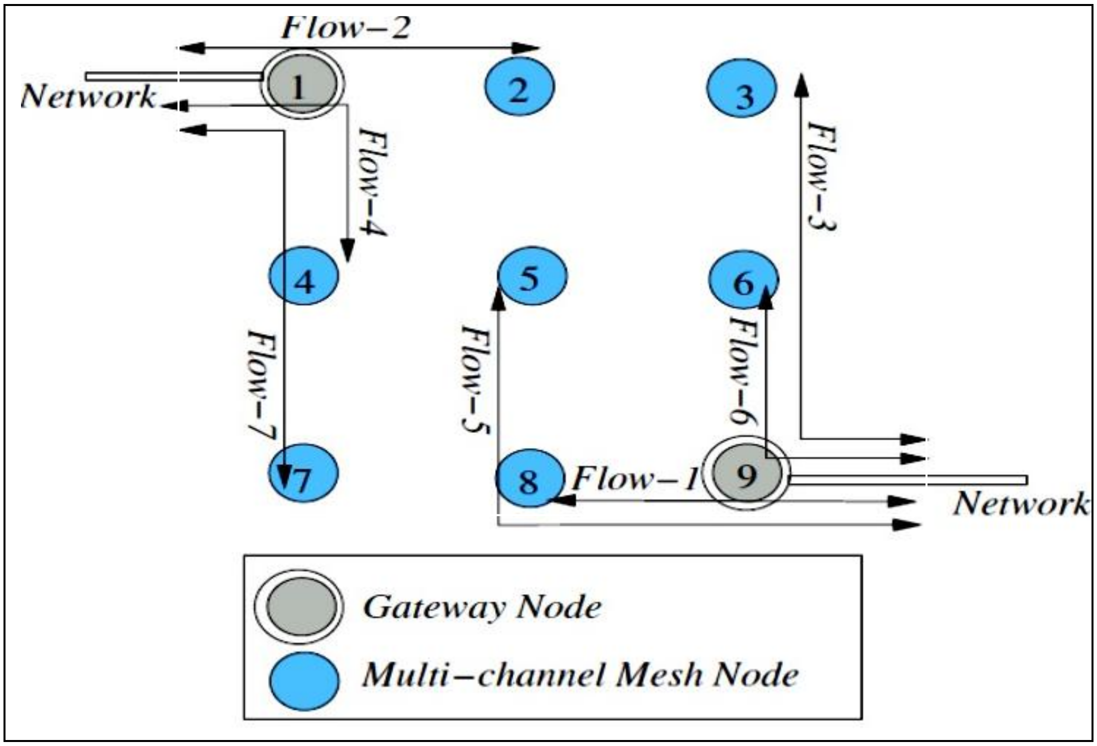

Figure 2.7: Physical topology of the 9-node Hyacinth prototype [27].

2.8 Summary

This chapter summarizes the important literature review and basic features and reliable information of WMNs. The chapter explains basic functionalities of WMNs, describes the system architectures of WMNs, characteristics of WMNs, MAC layer, and some other important layers of WMNs which already discussed according to previous studies. In addition, it explains application scenarios of WMNs, whereas, related work describe in several points.

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