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AN EFFICIENT AND SCALABLE DATA TRANSMISSION PROTOCOL FOR WIRELESS MESH NETWORKS

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ABSTRACT

Wireless Mesh Network is one of the most prominent network technology which is gaining impact in the recent decades. The impact is due to the advancement of the wireless communications and availability of the wide range of nodes and devices. But wireless mesh networks has numerous challenges to address the various issues in order to contribute effectively for any kind of applications. Some of the issues like – data transmission rate, scalability, energy efficiency and security. This paper focuses on the scalability and increase data transmission in the WMN using the clustering techniques. This paper also discuss the various architecture of the wireless mesh network and exiting work which has been carried out in this area. Some of the major classification of the MAC protocols with respect to the Wireless mesh network has been highlighted in this research work.

Key words: Wireless Mesh Network (WMN), Medium Access Control (MAC), Time Division Multiple Access (TDMA), Custeing, Scalability, Mobility**.**

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1. INTRODUCTION

Wireless Communication is gaining huge impact in the recent years with wide range of applications. This plays a major role in different categories like – Wireless Mobile Networks, Wireless Sensor Networks, Wireless Ad-hoc Networks, and Wireless Mesh Networks. While coming to the application wireless communication brings in huge impact in emerging pervasive platforms, civil and military surveillance applications, and ubiquitous

communication. The main idea behind all these is the transmission of the information from once source to another for processing and analysis of the information collected. The main source of information collection is the nodes which are used at the target location like sensors, devices or any nodes. [1, 2]

Wireless communication can be executed in the different types like – Centralized and Decentralized, Mobile and Stationary, Ad-hoc and With Base Station and many others. All these types wireless communication faces many challenges like – energy efficiency, security, delay, transmission of data, scalability and life time of the nodes used for collection of the data. The main reason for this is because of the presence of the wide range devices at each layer of the mesh network.

This paper further focuses on the Wireless Mesh Network. The sample architecture of the Wireless Mesh Network (WMN) is shown in figure-1[3]. This paper mainly focuses on the various aspects like how the transmission between the nodes can be made effective in various conditions.

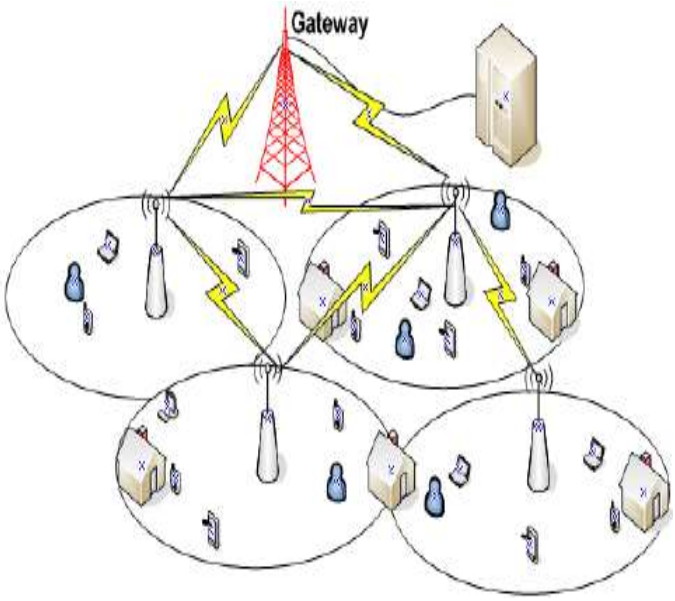

Figure 1 Architecture of the Wireless Mesh Network

The architecture shown in figure-1 consists of the wide range of devices like - sensors, mobile devices, laptops, gateways, routers, central base station and a computing unit. Each devices connected in this architecture have its own features, challenges and applications. As the main component of the network is Sensors which is responsible for data collection.

1.1. Some of the Current Applications of WMN are

WMNs play a vital role in military applications for communicating with the various devices during the mission critical applications and other field operations.

Automatic Energy Meter: Electric meters which are being installed on the residences location to get the readings and do the billings to the customers automatically [4].

WMN for the satellite communication needs – Nearly 66 satellite Iridium constellation operates as a mesh network and communicates with other nodes like other satellites, satellite phones and others by making the communication distance very shorter with lesser delay.

The further section of this papers focuses on the state of art of existing work which has been carried out in the field of Wireless Mesh Networks and a brief aspects of Sensor since it is the major component in collecting the data and aggregating the data.

Section II presents the related work done in the field of WMNs security. Section III presents proposed protocol focusing on the scalability and transmission issues in the WMNs. Section IV gives the results and discussions of the proposed protocols and the last section presents the conclusion of the proposed research work.

2. RELATED WORK

This section presents the analysis of the work carried out by the other researchers in the field of WMNs. This section also discusses the various WMNs architectures and some of the protocols that exits for the WMNs

2.1. A Multi-Objective Optimization of Broadband WMN: Energy Network Model [5]

The research work proposed in this referred paper focused on the optimization techniques of the Wireless Mesh Networks. In this paper the author considered a fixed architecture of the WMN by considering it as a directed graph. This also focused in the discussing the issues related to the Network capacity. The various factors with respect to the base station and gateway have been discussed along with the total network traffic. A link conflict model and energy model is given with respect to the wireless mobile networks. Some of the parameters considered in this referred work are:

- Thermal noise factors with SINR threshold, Function for calculation of Attenuation,
- Energy dissipation functions for the transmission energy consumption calculation.
- Energy dissipation functions for the receiver energy consumption calculation.
- Energy dissipation functions for the nodes during idle state
- Modulation and Coding Scheme based on the OFDM concepts

2.2. Wireless Mesh Network Architectures [6] : The paper referred in this Section Discuss the various Architectures as follows:

Mesh architecture for infrastructure-based network – this infrastructure based architecture equipped with wide range of networking devices like routers, firewall and gateways thereby provides a secure communication between the communicating devices

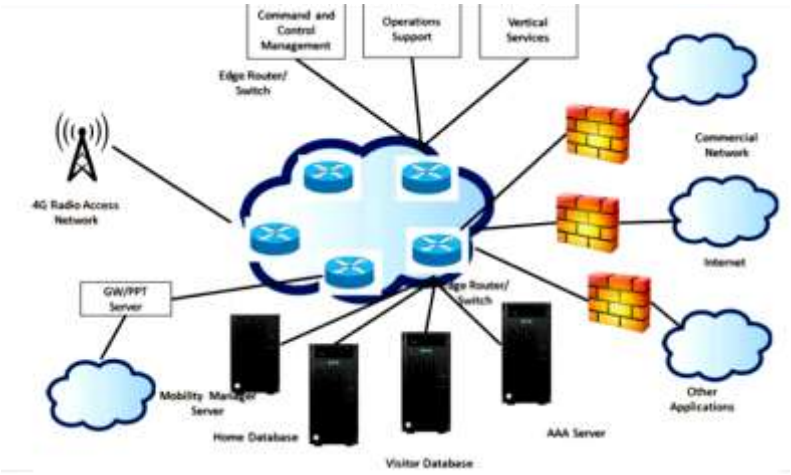

Figure 2 Infrastructure Based

Mesh architecture based on clients: This architecture is based on the client requirements like how the clients of WMN can be benefited by using WMN and how it can be viewed at the client side using their Personal Computers or laptops or any other handheld devices

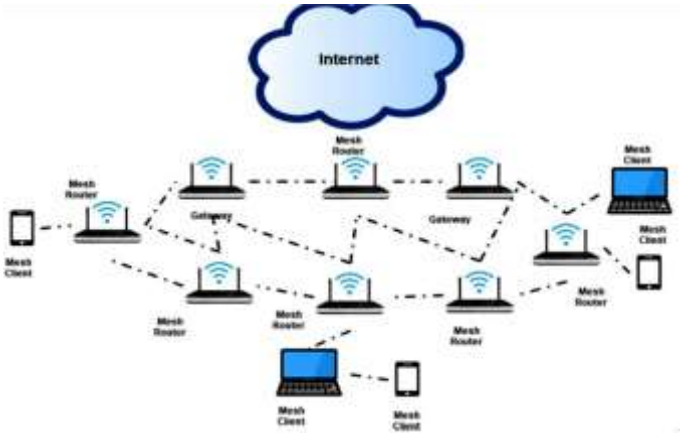

Figure 3 Client Based

Hybrid Mesh Architecture: this architectures provides the flexibility of combining more wide range of connected devices along with the fundamentals networking devices. All these types of WMN comes with a features of Dynamic self-configuration and self-organization, Adaptation, Fault tolerance and robustness, Low-cost and Integration and interoperability services in wireless communications

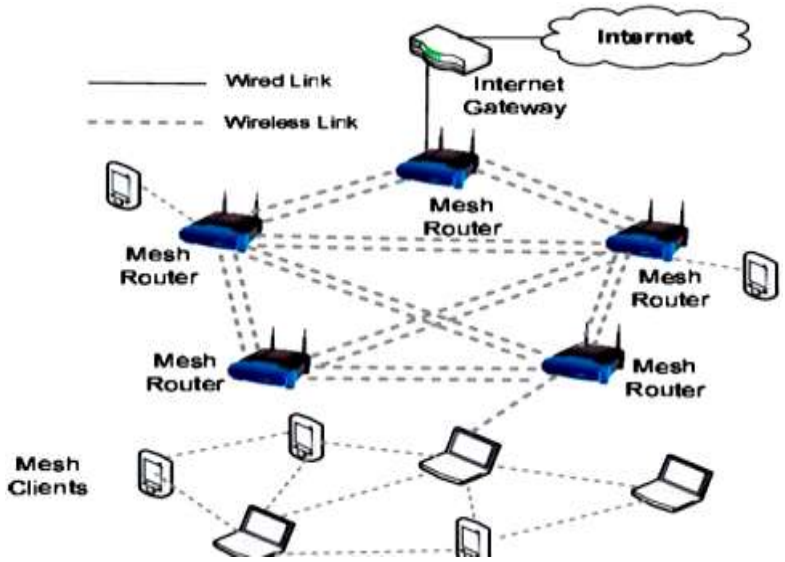

Figure 4 Hybrid Mesh Architecture

2.3. Wireless Mesh Network with Hierarchical Cluster [7]

Heterogeneity based hierarchical clustering protocol implemented in this clustering work. The clustering topology is shown in figure-5 where the group of nodes has been made into cluster for the efficient communication in the WMN. Since clustering provides a many advantages in communication resulting in the efficient resource utilization and other advantages This work also focused in the various protocols likes Mesh Point, Mesh Portal Point and

Mesh Access Point (MAP)

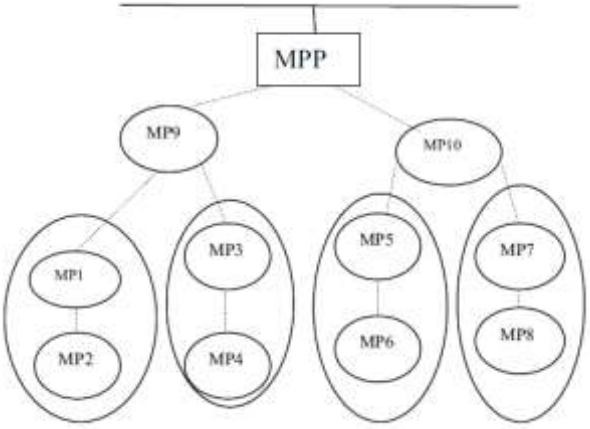

Figure 5 Hierarchical Clustering in WMNs

MAC Protocols: WMN can be very efficient by using the MAC protocols figure -6 presents the major classification of MAC protocols used in WMN. These classifications provide a fundamentals layer for all other protocols in WMN. Based n this numerous WMN protocols have been implemented as listed below [8-13]:

Ad hoc On Demand Distance Vector

- Distance vector
- Dynamic Vector
- Destination Sequenced Distance Vector
- Dynamic Source
- Hybrid WMN Protocol
- Infrastructure WMN Protocol
- Optimized Link State Protocol
- Open Shortest Path First WMN Protocol

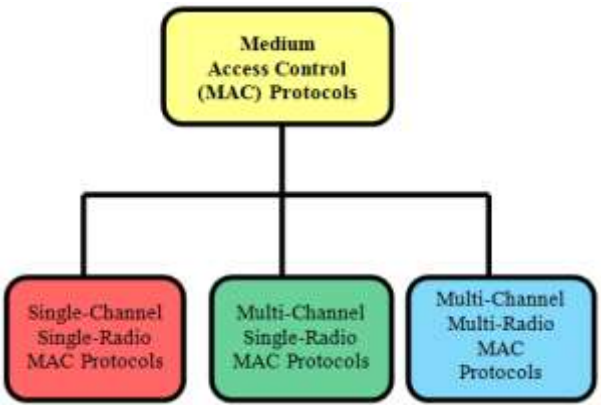

Figure 6 MAC Protocols Classification [14]

3. PROPOSED PROTOCOL

The main motivation for this proposed protocol is to contribute on the challenges in WMNs. The main challenges address in this research work are i) Scalability and ii) Increase transmission rate in the WMNs.

The proposed protocol works with the topology as depicted in the figure- 7. This topology is simulated considering the nodes in WMN and by implementing the clustering technology for the WMN for achieving the objectives of the proposed research work. The assumptions made in this proposed topology are – each mesh area is made into a cluster consisting of some nodes and with a cluster head for each cluster. All the nodes in the circle shapes are the normal nodes and the node in the filled circle ones are the cluster heads. Each mesh area is divided randomly and made to work on those area to collect and send the information to the gateway or base station which is located at the center of the network. The process of framing the clustering in WMN is explained in the algorithm which is explained in this section.

3.1. Mobility based Clustering Protocol in WMN

The topology given below is the deployment of 100 nodes over the network area of 100*100 and each of the node communication is done using a MAC Protocols at the cluster level.

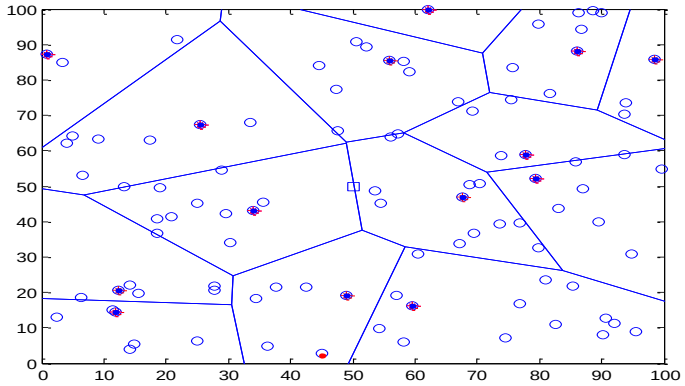

Figure 7 Proposed WMN Architecture

Figure 8, 9 and 10 shows the topology of the network with mobile nodes. The inclusion of the mobile nodes can ensure the scalability of the WMN and can collect more and more information. In this setup the nodes are made mobile which is set to move from one position to another in a linear direction. The speed and directions of the nodes can further altered using the variety of nodes in the WMN

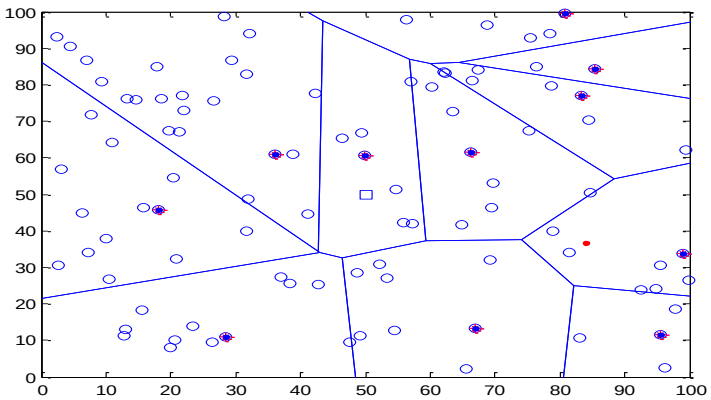

Figure 8 WMNs Topology at Initial Stage

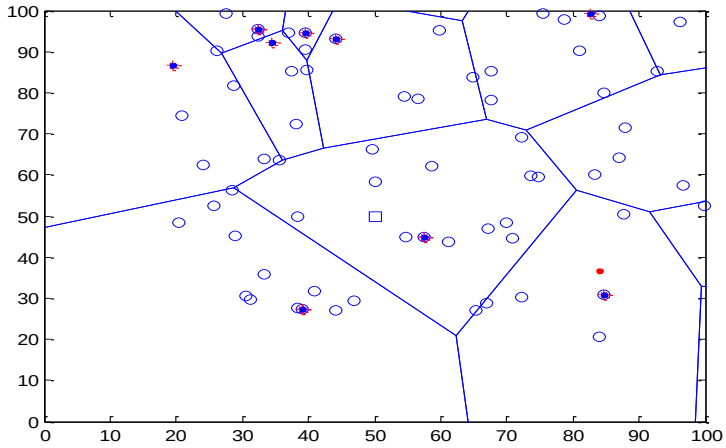

Figure 9 WMNs Topology at Final Stage with mobility and scalable network

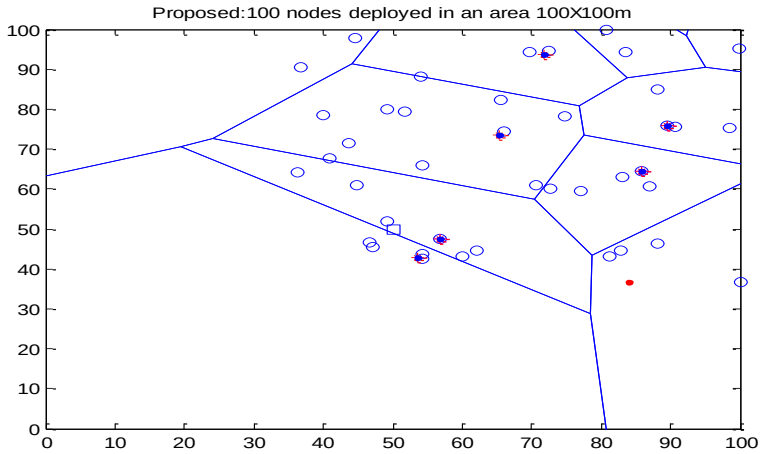

Figure 10 WMNs Topology at Final Stage with mobility and scalable network

The algorithm for setting up cluster is shown here explains the process of setting up the clusters. The notations used in this algorithm are listed below. Initially the algorithm selects a random node as a Cluster head and these cluster heads will advertize itself and ask the nearest nodes in the WMNs to join the clusters.

Notations:

- CH – Cluster Head
- G- Set of nodes which are not selected a CH till now
- id_{CH} – Cluster head identification number
- Distance $_{(a-b)}$ – Calculate the shortest neighbor using Euclidian distance formula

Algorithm Setup Phase for Clustering

1: $CH \Rightarrow G : id_{CH}, Adv(id_{CH}||position)$
2: $ni : Store(id_{CH}, min\{Distance_{(BS-ni)}, Distance_{(CH)}\})$
3: **if** $Distance_{(BS-ni)} > Distance_{(CH)}$ **then**
4: $ni \rightarrow CH : idn(member_{request}, id_{CH})$
5: **else**
6: $ni \rightarrow BS$
7: $CH \rightarrow ni(id_{CH}, TimeSlot)$

Where

$\Rightarrow$: Broadcast

$\rightarrow$: Unicast

n_i : sensor nodes

id_{CH} : ID of the CH

BS: Base Station

$Distance_{(BS-ni)}$: Distance from node to Base Station

$Distance_{(CH-ni)}$: Distance from nodes to Cluster Head

3.2. Result and Discussion

Figure 11 and 12 shows the result of the proposed clustering WMNs protocol which basically works over TDMA MAC protocols. The communication between the cluster members and CH will be based on the Time Slot given using MAC Protocols. Figure 11 shows the number of packets received by the BS from the Cluster during the simulation of 100 rounds. This graph shows that the proposed protocol has efficient packet transmission within the WMNs. Here x-axis represents the number of rounds for which the network is simulated for and y-axis represents the number of packets transmitted to the base station of WMN

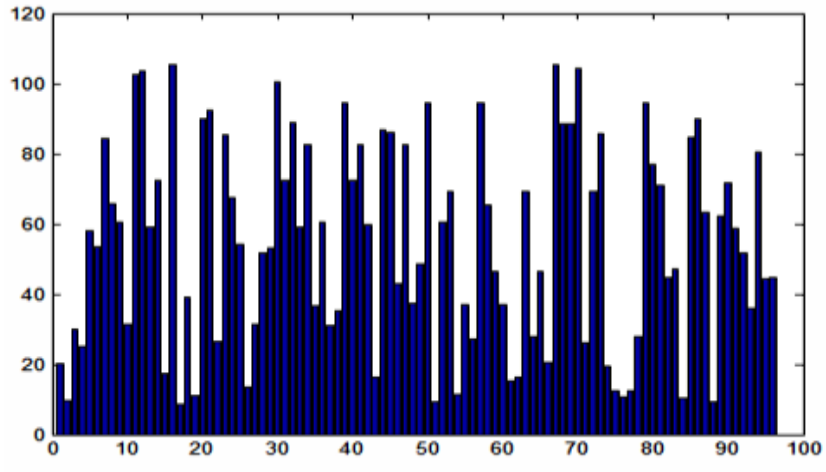

Figure 11 Packet Transmission to Base Station

Figure 12 represents the average number of nodes becoming the cluster head during the simulation of this protocol. Here x-axis represents the number of rounds and y axis represents the number of nodes becoming the cluster head during the simulation.

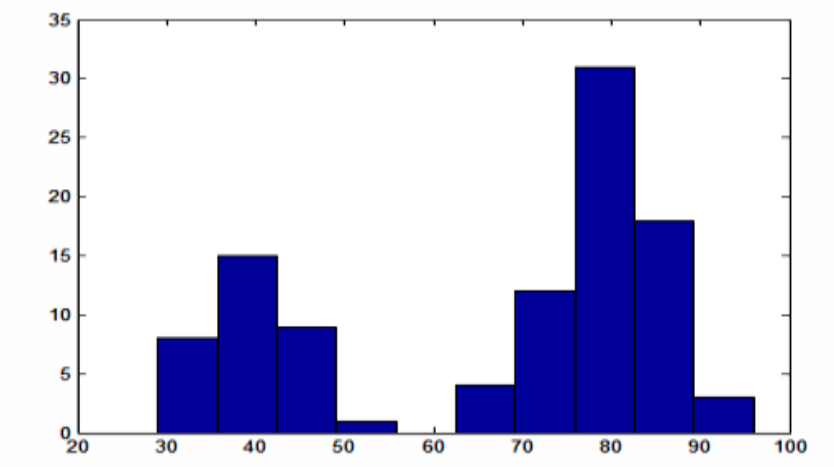

Figure 11 Average Number of Cluster Heads

4. CONCLUSION

The proposed efficient and scalable protocol concludes by addressing the two major challenges in the WMNs. The proposed research work initially highlighted some of the existing work in the domain of WMNs including the various architecture, protocols and some standard protocols. The proposed research work came with a clustering and mobility based data transmission protocol which majorly deals with making the WMN more scalable and efficient. The result and discussion section shows the effectiveness of the proposed protocol with the efficient data transmission in the Wireless Mesh Networks. Thus the proposed work in the protocols contributes significantly to the domain of Wireless Mesh Network.

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