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Performance Evaluation of Quality of Service Parameters for Scheduling Algorithms in Wireless Mesh Networks

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Abstract: There is a great popularity achieved by Wireless Mesh Networks in the recent years due to their last mile Internet access, low deployment cost and self-configuring features. It is considered to be an effective solution to support multimedia services in last miles due to their automatic configuration and low cost deployment. The main feature of WMNs is multi-hop communications which may result in increased coverage, better robustness and more capacity. Implemented on limited radio range wireless media, WMNs bring about many challenges such as effective media access control, efficient routing, quality of service provisioning, call admission control and scheduling. The various performance measurements based on reported result analysis use various optimal metrics for energy efficient wireless communication system. The energy efficient wireless communication protocols that are being used in the current work includes viz. data transfer rate, packet size, protocol used, energy efficiency, number of nodes, square topology area, distance between nodes and base station. The parameters achieved during simulation for prototype design of energy efficient network initiated with 300 nodes, clustered into 30 each forming such 10 major clusters, distance between clusters is maintained up to 200m, with 50 iterations/rounds the data packets received is up to 16kbps within the clusters, with square topology area of 1250mx1250m and, power consumption of up to24dB.

Key Words*:* Scheduling, Multi-hop network, Wireless Mesh Networks, Cluster Head election, energy delay tradeoff.

1. Introduction

Wireless Mesh Networking has emerged as an interesting and challenging area of research and it is attracting significant interest in order to support wireless and broadband access using commodity low-cost networking platforms [1]. WMNs are dynamically self-organized and self-configured, with the nodes in the network establishing an ad hoc network and maintaining the mesh connectivity. WMNs as a kind of wireless multi-hop network, have received increasing attention due to their attractive advantages, e.g. low cost, ease of deployment and wide range of application scenarios, and providing a promising solution to provide wireless broadband access.

A wireless multi-hop network can be viewed as a set of nodes able to communicate with each other directly or beyond their transmission range by using nodes as relay points acting as routers. Multi-hop communication has many advantages: interference reduction, spectrum reuse increase, radio-coverage extension, traffic load balancing, and energy consumption reduction [2]-[4].

The layout of the paper is as follows. Section 2 describes about literature review, Section 3 states about the Methodology, Section 4 describes about the Wireless Architecture, Section 5 shows the simulation results and Section 6 states the Conclusion of the paper.

2. Literature Review

The whole literature review is focused on the following literary works being done by an array of scholars and researchers from the field of energy efficient wireless communication systems.

Vijay Gabale, Bhaskaran Raman, Partha Dutta and Shivkumar Kalyanraman has discussed in "A Classification Framework for Scheduling Algorithms in Wireless Mesh Networks" that the scheduling transmission in multi-hop wireless networks is an active and stimulating area of research [1].

Table I Simulation parameters used

Transmission power	10mW
Path loss exponent	4
Noise power spectral density	-90dBm
Communication threshold	20dB
Interference threshold	10dB

V. Lakshmi Praba and A. Mercy Rani has discussed in "A Review on Load and Energy Based Routing in Wireless Mesh Network" that the research contributes above suggested various routing metrics, algorithms and protocols for the route construction process of WMN. The Routing process was mainly carried out based on energy or queue length to balance load, energy consumption, reduce end-end delay and throughput, etc. The paper focuses on route construction process in WMN based both on energy and queue length factors for the route construction in WMN [2].

Ankit Thakkar and Ketan Kotecha has discussed in "Cluster Head Election for Energy and Delay Constraint Application of Wireless Sensor Network" that analyze energy-delay trade-off by doing extensive simulation by deriving EDIT protocol. It has also been demonstrated the effect of two types of distances to be used to elect the cluster heads using EDIT protocol and their effect on delay and energy [5].

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3. Wireless Mesh Architecture

3.1 Wireless Mesh Network

The communication network of WMN is made up of radio nodes arranged in mesh topology. A mesh topology is the one in which every node has a connect ion to every other node in a network coverage area. Wireless Mesh Networks consists of mesh clients, mesh routers and gateways. Mesh clients are end-user devices such as laptops, PDAs, smart phones, etc, that can be used for accessing the applications like email, game, location, detection, etc. through the network. These devices are mobile and have limited power and routing capability and it may or may not be connected to the network. WMN has a more planned configuration and may be deployed to provide dynamic and cost effective connectivity over a certain geographic area. The mesh routers are static in nature and it forwards the network traffic between mesh clients and gateways. Transmission power consumption is low for multi-hop communication network [2].

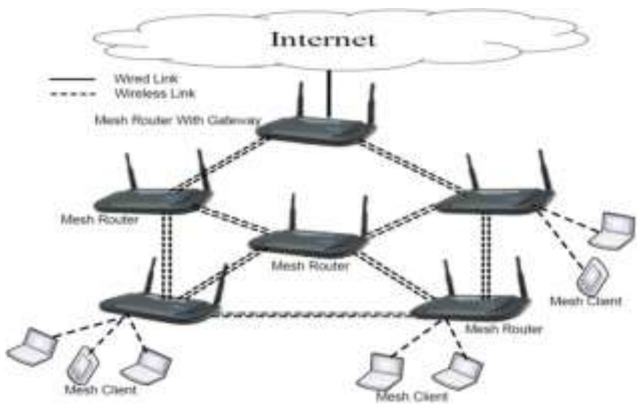

Fig. 3.1 Wireless Mesh Network

3.1.1 Features of WMN

Self-healing and Self-Configuring: There is a flexibility in WMNs in network architecture and are not dependent on the implementation and the protocols. Self-healing and the self-configuring is the main feature of WMNs, it enhances the performance of the network further. It is able to automatically find the fastest and reliable path when the nodes lose their connectivity and blocked in the network, due to the self -healing feature of WMN. The self-configuring feature is responsible for adding new nodes, remove or relocate existing nodes to or from the network without human intervention. Hence, because of these features, the end users demand can be fulfilled and the network set-up time and maintenance cost can be reduced [1]-[4].

Low Utilization cost: Mesh routers are wireless and static; they facility of providing services in multi-hop environments. The uses of wireless routers are cheaper in larger areas when compared to single hop router with wired connection. In general wired connections are more expensive to install and maintain. The deployment of WMN leads to low operation cost due to faster installation and maintenance [1]-[4].

Better Reliability: The packet transmission is from source to destination through multiple paths in WMN. The multiple paths are used as alternate paths in case of failure. To minimize the bottleneck in congested area of the network the alternate paths are preferred. Using multiple paths, the traffic load can be balanced in the network. Load balancing and minimizing the bottleneck through alternate path can considerably increase the network reliability in WMN [1]-[4].

Scalability: In traditional wireless networks the performance decreases when the number of nodes increases. However, in WMNs once the number of nodes increases, the performance also increases by providing alternate routes. The mesh network can handle hundreds or thousands of nodes, due to the feature of Scalability. By adding more routers, the network can get rid of the weak signals and dead zones [1]-[4].

Network capacity: WMN supports the feature of multiple channels and multiple interfaces. Multiple interfaces are provided by the routers in the mesh network which increases the throughput and capacity of the network considerably [1]-[4].

3.1.2 Architecture of WMN

Client Wireless Mesh Network

The peer-to-peer connection among the client devices is offered by the Client mesh networks. The devices usually have a single radio. An important aspect of this type of WMN is that the network consists of fully mobile devices without a wireless backbone. Thus, it forms a conventional ad-hoc network. The client nodes from the real network to perform routing and self-configuration functionalities [1]-[4].

Infrastructure Wireless Mesh Network

In infrastructure WMN, the mesh routers provide an end-to-end connectivity to mesh clients and form a high bandwidth wireless backbone. The different types of radio technologies in addition to IEEE 802.11 technologies is used to form this type of WMN. The conventional clients can directly communicate with the mesh routers if both have the same type of radio technology. Only through their base stations which have Ethernet connections, the clients can communicate with the mesh routers . The mesh routers with the gateway feature can be connected to the Internet. This approach incorporates the WMNs with existing wireless networks. The nature of mesh router is static that provides the features of self-healing and self-configuring functionality among the links themselves [1]-[4].

Hybrid Wireless Mesh Network

Hybrid Wireless Mesh Network is an elegant version of WMN. As the name indicates it is a blend of Infrastructure and Client WMN and its architecture. The Mesh Router form a Mesh backbone infrastructure while the mesh clients involve in the routing and forwarding packets. The mesh clients can access the network through mesh routers and they can directly communicate with other networks such as Wi-Fi, WiMAX, cellular and sensor networks. The routing facility of clients offer enhanced connectivity and coverage within WMNs [1]-[4].

3.2 Multi-hop network

A wireless multi-hop network can be viewed as a set of nodes able to communicate with each other directly or beyond their transmission range by using nodes as relay points acting as routers. Multi-hop communication has several advantages such as: interference reduction, spectrum reuse increase, radio coverage extension, traffic load balancing, and energy consumption reduction. These advantages make multi-hop communication more popular, and several kinds of networks are based on it such as Mobile Ad hoc Networks (MANETs), Vehicular Ad hoc Networks (VANETs), Wireless Sensor Networks (WSN), Wireless Mesh Networks (WMNs), and so on. Their application range varies from civilian use to disaster recovery and military use. Recently, this technology has become a promising solution for the next generation wireless communication systems. It is considered in the standardization process of next-generation mobile broadband communication systems such as 3GPP LTE-Advanced, IEEE 802.16j (mobile Wi-Max), and IEEE 802.16m [1]-[7].

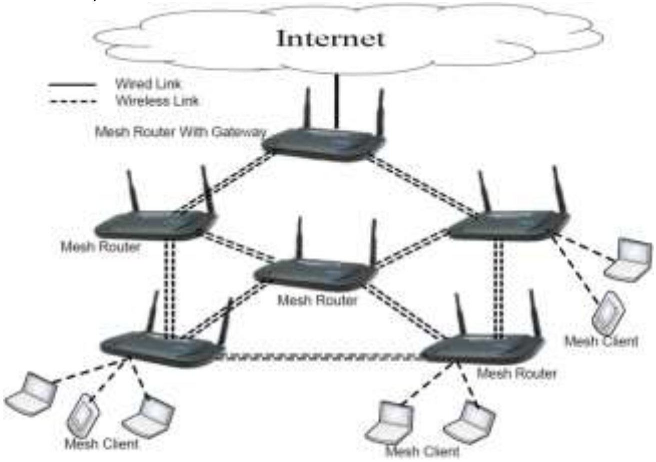

Fig. 3.2.Multi-hop Network

4. Methodology

The various energy efficient wireless networks are discussed in literature survey so far in the research work, the existing system has been studied and the optimal metrics which are suitable for the performance measurement are discussed below.

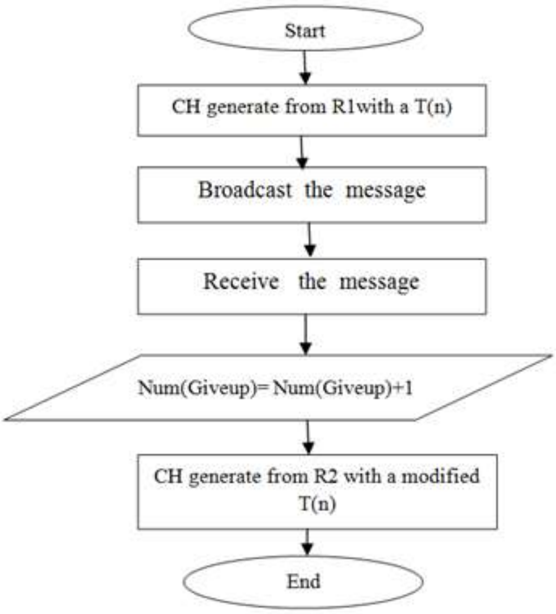

Fig. 4.1 Flowchart of the proposed system

4.1 Proposed Methodology

4.1.1. To design a network with the number of nodes comprising of 300 nodes with around 10 servers and the topology used is chain topology to achieve shortest path to reach all nodes.

4.1.2. To achieve Packet delivery ratio up to 100% with bandwidth of each channel with data rate of around 100 Mbps where packet delay should be maintained for load balancing constants in few tens of milliseconds.

4.1.3.The wireless mesh network to contain a minimum transmission delay power of 5mw with propagation delay of 0.1ms. The transmission time and throughput should be around 200ms and 70% respectively.

4.1.4. The desired path loss exponent γ varying between 2 to 4 with interference threshold assumed to be node 0 and it is labeled red. The base station is fixed while other nodes are mobile in specific time interval. Fig -1 depicts a Base Station and remaining sensor nodes deployed in the network field.

5. Expected Results

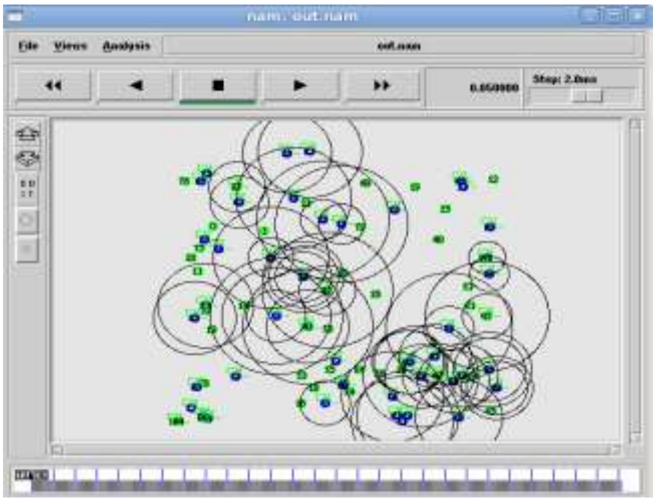

Fig. 5.1 Simulation of 300 nodes with Network Simulator 2

The research carried out with different metrics that are being used to measure energy efficiency the performance of energy efficient systems. To evaluate the performance of the Network system, a network with 250 - 300 nodes is simulated in Network Simulator 2. The communication between the various nodes is analyzed and the Throughput, Packet Acceptance Ratio and Packet Drop of the network is measured in the system. In the graphs calculated below, the green segment represents the data values of existing system and the red segment represents the data values of proposed system.

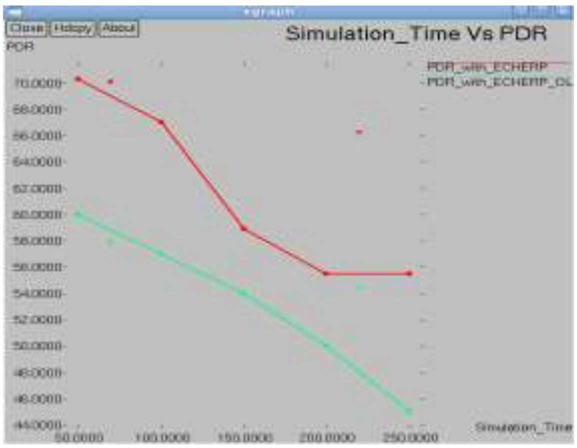

Fig. 5.2 Graph of Simulation time vs Packet Drop Ratio

In Fig.5.2, the graph of Simulation time vs Packet Acceptance Ratio of the network is shown. It can be seen from the graph that the packet acceptance ratio of proposed system is low when the calling starts at 50 sec but then it increases and remains constant at around 1 with increase in time.

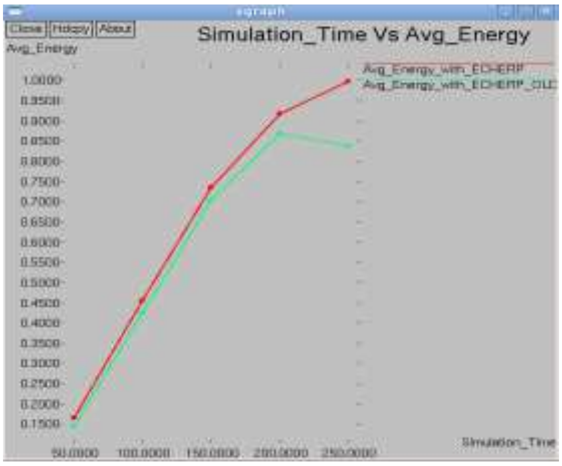

Fig. 5.3. Graph of Simulation time vs Average Energy

Fig 5.3 shows the graph of Simulation time vs Average Energy. The simulation starts from 40 seconds and the average energy is constant but it in the old system it is dropped and is not achieved completely. The proposed system gives out a constant result.

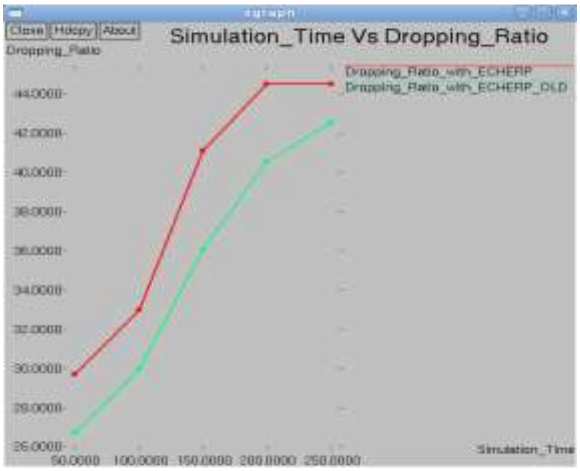

Fig 5.4 Graph of Simulation time vs Dropping Ratio

Fig. 5.4 shows the graph of Simulation time vs Dropping Ratio. The simulation starts from 50 seconds and in the old system the dropping ratio is not achieved completely. However in the proposed system there is no packet loss by giving out a constant result.

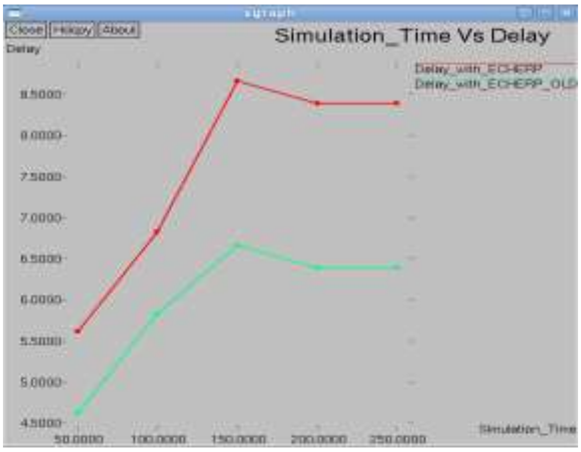

Fig. 5.3 Graph of Simulation vs Delay

Fig 5.3 shows the graph of Simulation vs Delay. Network delay is an important design and performance characteristic in computer networks. The delay of a network specifies how long it takes for a bit to travel across the network from one node or endpoint to another. As shown in the graph the packet delay stops at 150 seconds.

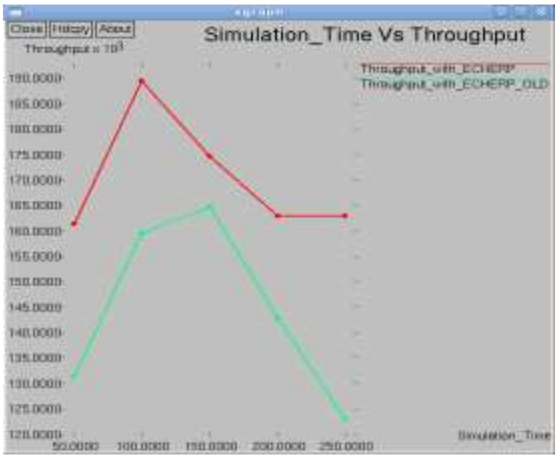

Fig 5.5 Simulation time vs Throughput

Fig 5.5 shows the Simulation time vs Throughput. Throughput is most likely the second most important parameter that affects QoS. It is the most important factor as it is responsible for moving data from one place to another without affecting the drop ratio. As seen in the graph the old system does not give the complete result. The proposed system achieves it by giving the constant throughput result at 200 second.

TABLE II RESULT SUMMARY

Parameter	**Results Reported**			**Results Achieved**			**Difference between Results Achieved & Results Reported**		
	Packet Acceptance Ratio (PAR)	**Packet Drop**	**Throughput**	**Packet Acceptance Ratio (PAR)**	**Packet Drop**	**Throughput**	**Packet Acceptance Ratio (PAR)**	**Packet Drop**	**Throughput**
Node Density	0.7	9	370	0.99	8	400	0.29	-1	30
Number of channels	0.25	2900	1200	0.3	2800	1350	0.05	-100	150
Locality	0.9	350	320	0.99	200	400	0.09	-150	80

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