ISSN: 0975-766X
CODEN: IJPTFI
Available Online through
Research Article
www.ijptonline.com

PERFORMANCE ANALYSIS FOR WIRELESS MESH NETWORK CONSIDERING DIFFERENT CLIENT DISTRIBUTION PATTERNS

S.Dhivya[#1], G.Merlin Sheeba[#2]
PG Scholar[#1], Assistant Professor[#2], Dept. of ETCE,
Faculty of Electrical and Electronics Engineering
Sathyabama University, Chennai-119.
Email: dhivyashanmugham77@yahoo.com[#1], merlinsheeba.etc@sathyabamauniversity.ac.in[#2]

Received on 10-02-2016 *Accepted on 20-03-2016*

Abstract:

Wireless Mesh Networks (WMN) is widely preferred broad band internet access technology which provides minimal upfront investment as the technology installed can be incremented. Mesh structure ensures that the each node has the ability to provide available multiple path for communication. WMN with more number of nodes provides more reliability and coverage as the nodes can act both as clients and routers. In this paper, the clients are distributed using four different distributions patterns namely Normal, Uniform, Exponential and Weibull distribution and their corresponding performance metrics such as throughput, end to end delay and packet delivery ratioare calculated. Our main objective is to evaluate the performance of each client distribution. The simulation results shows that the Weibull client distribution provides overall better QOS performance of about 35% than the other distributions.

Keywords: Wireless Mesh Network, Mesh router, Client distribution, Packet Delivery Ratio.

1. Introduction:

Wireless Mesh Network is an emerging technology which can effectively cover specific area and provides high bandwidth and cost effective system. The traditional network connects user through Wired Access Point (AP) or Wireless hotspot. WMN can connect hundreds of nodes and can share the network across a large area [1]. WMN consists of mesh clients, mesh routers and gateway. They are buildup of peer radio devices which need not to be cabled to wire port as in Wireless Local Area Network (WLAN) AP [2, 9].

The mesh infrastructure carries port over large distance through series of short hops where the intermediate nodes forwards packets based on their knowledge of network, that is, the node can act as routers. WMN has stable topology except for occasional failure or addition of nodes. Another advantage of WMN is their self-healing and self-form properties [3, 10]. They communicate through rest of the nodes in case of failure. WMN uses dynamic routing algorithm in which each device communicates their routing information to other devices. The routing algorithms ensure that the nodes choose the most appropriate or fastest route to its destination [4]. The structure of the paper is organized as follows: Section 2 gives information about routing protocol. Section 3 explains about the recent work. Section 4 gives detailed information about proposed work. Section 5 and 6 gives simulation outputs and conclusion.

2. Overview of HWMP routing protocol and 802.11s:

Hybrid Wireless Mesh Protocol is the wireless mesh networks basic routing protocol defined in 802.11s. It is a tree based routing protocol. They depend on peer link management protocol so each mesh node search and track its neighbor node. They provide both reactive and proactive routing algorithm. Reactive routing algorithm discover route when source sends the packet which has to be send to the destination. Proactive algorithm provides routes by building its own routing table based on the information exchanged within each router. As they have both routing algorithm they provide optimal and effective path selection.

IEEE 802.11s is a working group within IEEE 802.11 standard which is used to standardize the Extended Service Rate (ESS). They define MAC and physical layer of mesh network. To support IEEE 802.11 ESS mesh, they define architecture and protocol based on IEEE 802.11 MAC to support both broadcast and unicast delivery at MAC layer.

3. Related work:

WMN is a reliable source of wireless connectivity for wide variety of applications such as large enterprises, campus wireless network, municipal area network, etc. The nodes can be distributed in various forms of distributions. C.Sanches[5] et al. have proposed three types of clients distribution namely subway, boulevard and stadium model. The subway model distributes the nodes in the horizontal strip. Subway distribution is a realistic form of distribution as they are based on the characters of humans behaving in the Subway Street or station. Boulevard distribution distributes the nodes on two horizontal stripes, that is, on the both sides of the boulevard. Stadium model as the name indicates the nodes are distributed on a circle pattern. They have concluded that the subway distribution of clients performs better than the other two distributions. J. Wu [6] have proposed a routing protocol which is based on connected dominating set, that is, they assign the node as gateway if it has at least two unconnected neighbor. M. Kas [7] et al. has proposed social network analysis metrics to detect critical nodes in WMN. They provide high priority to nodes which have high closeness centrality values and the simulation results shows that there is improvement in the throughput and but with considerable amount of delay. C Gomas [8] have proposed column generation method to optimize the routing problem. Their main objective is to balance the router load and reduce the communication time required.

4. Proposed system:

A WMN system with 36 routers and 48 clients are considered and the clients are distributed with four different distributions namely Normal, Uniform, Exponential and Weibull distribution and their corresponding performance metrics such as Packet Delivery Ratio (PDR), Throughput and End to End delay are calculated. They are simulated using Network Simulator-2. The mesh clients arranged using the four different distributions are explained below:

4.1. Uniform distribution:

In this type of distribution, the distribution of data is equally spread across the given range. They do not have any clear peak. In the other words, the probability of occurrence of all events has equal chance. They are also called rectangular distribution.

Probability density function:

$$f(x)=\frac{1}{b-a};a\le x\le b \quad (1)$$

Cumulative distribution function:

$$F(x)=\frac{x-a}{b-a};a\le x\le b \quad (2)$$

Where a and b are the minimum and maximum intervals.

4.2. Normal distribution:

They are also called bell curve as they create bell shaped curve. In this distribution, they have a central peak which is symmetrical to either sides of the curve. They have same mean, median and mode.

Probability density function:

$$f(x)=\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(x-\mu)^2}{2\sigma^2}} \quad (3)$$

Where μ = mean or expectation and σ^2 = variance.

4.3. Exponential distribution:

Exponential distribution is a process where the occurrence of events is continuous and independent at constant average rate. They are used to model Poisson process. They are one of the widely used continuous distributions.

Probability density function:

$$f(x) = \lambda e^{-\lambda x} ; x \geq 0 \qquad (4)$$

Cumulative distribution function:

$$F(x) = 1 - e^{-\lambda x} H(x) \qquad (5)$$

Where $\lambda > 0$ is called the rate parameter and *H(x)* is called Heaviside step function.

4.4. Weibull distribution:

They are named after its inventor Waloddi weibull. They can model wide variety of data sets. They have the ability to take the characteristics from other type of distribution. So they are popular among engineers.

Probability density function:

$$f(x) = \frac{k}{\lambda} \frac{x}{\lambda}^{(k-1)} e^{(x/\lambda)^k} ; x \geq 0 \qquad (6)$$

Where k = shape parameter and λ = scale parameter (k and λ is greater than 0).

4.5. Performance Metrics:

The performance metrics considered are Packet Delivery Ratio (PDR), throughput and end to end delay.

4.5.1. Packet Delivery Ratio:

PDR can be defined as the ratio of number of packets received to the number of packets sent. The PDR contribute for the successful transmission of data.

$$\text{PDR} = \frac{\sum number\ of\ packets\ received}{\sum number\ of\ packets\ sent} \qquad (7)$$

The higher value of PDR denotes the better performance of the system.

4.5.2. Throughput: The throughput is the amount of data successfully sent within the given time. They are usually measured in Bits per Second (Bps), Mega Bits per Second (Mbps) or Giga-Bits per second (Gbps). The throughput should be in higher range for better performance of the network.

4.5.3. End-to-End Delay:

The end-to-end delay is the total amount of time taken by the packet to reach its destination from the source.

$$\text{End-to-end Delay}=\frac{\sum(\text{Arrival time}-\text{send time})}{\sum \text{number of connection}} \qquad (8)$$

They also represent the time taken to discover the route and the queuing time for data transmission. The packets that are successfully sent to the destination are only considered. The delay should be lesser for efficient performance of the system.

5. Result and Discussion:

Wireless mesh network is simulated using Network Simulator-2 with an area dimension of about 2000x 2000 and 36 numbers of router and 48 clients are considered. The clients are distributed using four different distributions and a packet of size 1000 bytes are sent within the simulation time of 100 seconds which is given in the Table 1. Then their corresponding performance metrics such as PDR, throughput and end to end delay are calculated.

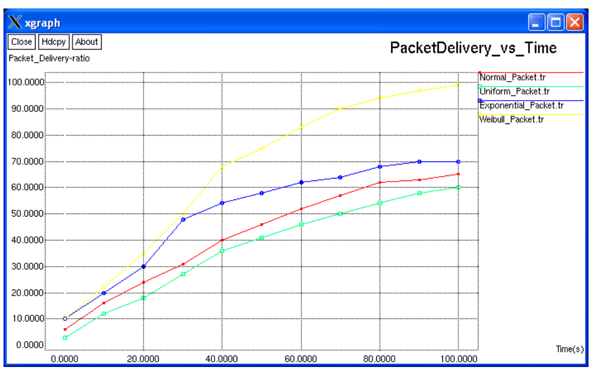

Figure 1: Mean Packet Delivery Ratio

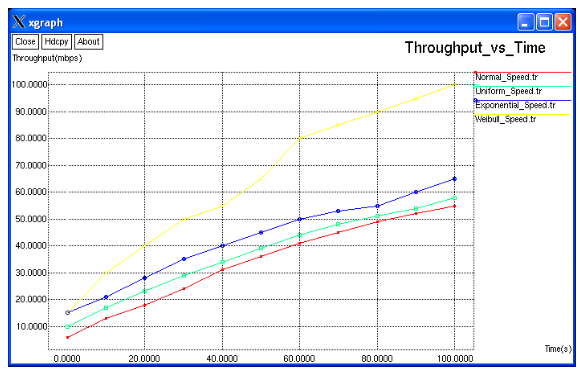

Figure 2:Mean Throughput

Table1: Simulation Settings

Area size	2000x2000
MAC	802.11s
Routing protocol	HWMP
Number of mesh routers	36
Number of mesh clients	48
Transport protocol	UDP
Application Type	Constant Bit Rate (CBR)
Packet size	1000 bytes
Packet rate	800 packets per second
Simulation time	100 sec

The comparative result shown in Fig.1 indicates that the packet delivery ratio is high when clients are distributed using Weibull pattern. The Weibull client distribution shows an overall 35% increase in PDR than the other distributions.

The simulation results from Fig.2 shows that the throughput is high for weibull client distribution and the remaining distributions provide almost same throughput values. The throughput value is higher of about 35-41% for Weibull client distribution.

The end-to-end delay results shown in the Fig.3 depicts that the delay decreases as the time increases. The observed delay for the packet transmission from source to destination is veryless in Weibull client distribution compared to other distributions.

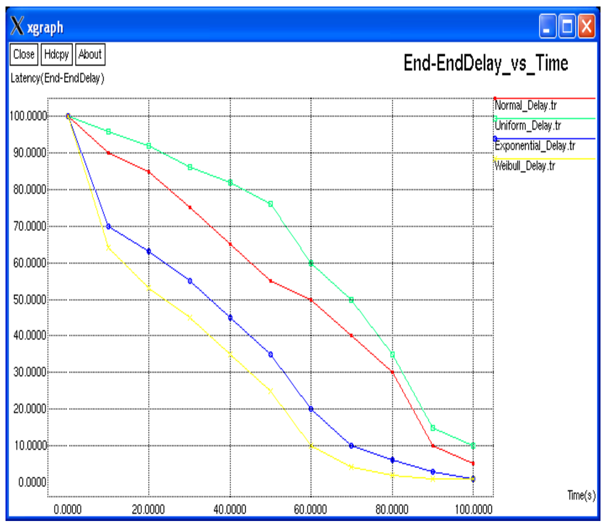

Figure 3: Mean End to End Delay.

5. Conclusion:

WMN is highly preferred for its low cost and high bandwidth nature over a specific coverage area. The clients are distributed using four distributions and their performances are calculated. From the simulation results, Weibull client distribution provides better performance than the other distributions. The work can further be extended using heuristic method to have a optimum distribution of node.

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Corresponding Author:
S. Dhivya*,
Email: *dhivyashanmugham77@yahoo.com*