Performance Analysis of Wired and Wireless LAN Using Soft Computing Techniques- A Review

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***Abstract*-The wired Computer Networks provide a secure and faster means of connectivity but the need of mobility i.e. anywhere, anytime and anyone access is tilting the network users towards wireless technology. In this paper, an overview of the current research literature, in the field of Wired and wireless networks, has been presented. The network simulators provide an ease in predicting and estimating the performance of networks. Among the various network simulators available, OPNET gains an edge in analysing the performance of the networks through simulations. The metrics like throughput, delay and retransmission attempts have been overviewed for performance analysis of the wireless and wired computer networks using soft computing techniques like simulation through OPNET.**

Keywords—IEEE 802.11, RTS/CTS, OPNET, Wired LAN, Wireless LAN.

I. INTRODUCTION

Networks have grown like weed over the past few decades providing a pace to the means of accessing network resources. For example, the use of Internet is gaining importance with the adoption of network technologies for purposes like education, business, banking and defence. These interconnected set of computer system permits interactive resource sharing between connected pair of systems. Rapid advances have taken place in the field of Wired and Wireless Networks. Several network models have been modelled by various researchers, using network simulators, to find out the most feasible ones. Investigations of these network models have been performed using the simulation techniques that reduce the cost of prediction, estimation and implementation of the network models. Among the various network simulators available like NetSim, NS-2, GloMoSim etc., OPNET provides the industry's leading environment for network modelling and simulation. It allows to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It provides object oriented modelling approach and graphical editors that mirror the structure of actual networks and network components. It provides support for modelling both the wired and wireless LANs.

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Though the wired networks have provided the high speed connectivity but due to the drawbacks like extensive cabling and immobility etc., the WLAN gained momentum. The computer networks today are not only wired but wireless too, depending on the type of circumstances like need of mobility, rough terrains, or secure networks.
Open system interconnection (OSI) reference model divides the Data Link Control (DLC) layer into Logical Link Control (LLC) and Medium Access Control (MAC) sub layers. The LLC layer is independently specified for all 802 LANs, wireless or wired. Like IEEE 802.3 (Ethernet), IEEE 802.5 (Token Ring), IEEE 802.11 (WLANs) standard also focuses on the above mentioned two layers [1]. Our study has focused on performance analysis of IEEE 802.3 (Ethernet) based Wired LANs and IEEE 802.11b based Wireless LANs using soft computing techniques like network simulators. This paper has been organised as follows: Part I deals with Introduction, Part II deals with the Literature Overview, Part III and IV deals with the brief description of IEEE 802.11 and IEEE 802.3, Part V deals with the performance metrics being focused upon and in the last section the paper has been concluded.

II. LITERATURE REVIEW

A wireless communication is flexible data communication system implemented as an extension to or as an alternative for a wired communication. It has overshadowed the wired technology over a span of time and is a rapidly growing segment of the communications industry, with a potential to provide high-speed, high quality information exchange between the portable devices located anywhere in the world. Wireless Local Area Networks (WLANs) have been developed to provide users in a limited geographical area with high bandwidth and similar services supported by the wired Local Area Network (LAN). Unlike wired networks, WLANs,uses IEEE 802.11 standards, to transmit and receive radio waves through the air medium between a wireless client and an Access Point (AP), as well as among two or more wireless clients within a certain range of each other. A WLAN basically consists of one or more wireless devices connected to each other in a peer-to-peer manner or through APs, which in turn are connected to the backbone network providing wireless connectivity to the covered area. In [8], the authors worked on improving the performance of WLANs using Access points.They investigated and estimated the traffic load on an access point, which can help determine the number of access point to be employed in a network. The effect of enabling Point Coordination Function (PCF) on network stations and also the number of PCF stations that can be deployed per access point was also investigated. Correctly setting the number of PCF stations will help tune the performance of these nodes as well as the overall network performance. In [20], also the author introduced a wireless LAN design framework for optimal placements of access points at suitable locations to satisfy the coverage and capacity requirements of the users. Optimal planning of WLANs can result in improved Quality of Services, efficient use of resources, minimizing interference and reduced deployment cost. The performance of WLANs depends on the RF conditions in which they operate. Randomized optimization algorithms were used, to solve the AP placement and channel allocation problems like coverage, traffic, Redundancy, channel interference and wiring cost. Then the output of this algorithm was validated using OPNET.

Another important issue is the Bandwidth of wireless networks. The bandwidth of wireless local area networks is limited as compared to that of wired local area networks which provide a large bandwidth. This limitation is due to the error prone physical medium (air). The methods like tuning the physical layer related parameters [6], tuning the IEEE 802.11 parameters and using enhanced link layer (media access control) protocol were used to improve the performance of WLANs.

The IEEE 802.11 standard operates far from theoretical throughput limit depending on the network configuration [7]. An analytical model was proposed to achieve maximum protocol capacity (theoretical throughput limit), by tuning the window size of the IEEE 802.11 back-off algorithms. The main reason why the capacity of the standard protocol is often far from theoretical limit is that during the overload conditions, a station experiences a large number of collisions before its window has a size which gives a low collision probability. It was cited that proper tuning of the back-off algorithm can derive the IEEE 802.11 protocol close to the theoretical throughput limit.

The identification time is another critical indicator for the performance enhancement of RIFD in wireless systems. In [12], the authors proposed a Rician fading channel model to highlight the fading effect in Radio frequency Identification (RIFD) System, using the statistics of Bit Error Rate (BER) and Signal-to-noise Ratio (SNR). This model was employed in addition to the existing RIFD system and was used to calculate the identification time to reflect the influence of channel situation on tag identification. The simulation showed that the Fading channel effect increased the Identification time as BER varies. It was also analyzed that the wireless channel has strong effect on the identification time.

The throughput performance of WLANs is affected by the mobility of the users [19]. The wireless data connections have high bit error rates, low bandwidth and long delays. The physical and MAC layer were fine tuned to improve the performance of WLAN. The performance metrics like slot time, short Inter-frame spacing (SIFS), minimum contention window (CW_{min}), Fragmentation Threshold (FTS) and Request to send (RTS) thresholds were focused upon to reduce collisions and media access delay. Hence an increase in throughput and channel utilization occurs, which can improve the performance of Wireless networks under heavy load conditions (high BER values). The effectiveness of optional RTS/CTS handshake mechanism on the performance of IEEE 802.11 based wireless local area networks (WLANs) using OPNET was also evaluated in [21]. The impact of parameters like throughput, packet loss rate, round trip time (RTT) for packets, retransmission rate and collision count on the performance metrics like retransmissions, throughput, media access delay was presented. It was cited that handshake mechanism is useful where hidden node problem exists, but the unnecessary use of RTS/CTS mechanism increases the overhead of RTS/CTS packets. The parameters like RTS/CTS threshold, fragmentation threshold and data rate impact the performance of wireless LAN. In [3], also the authors proposed the wireless network performance optimization using OPNET Modeler. The model was simulated and the results indicated that fine tuning of these parameters can help to improve the performance of WLANs.

The impact of load, number of nodes, RTS/CTS, FTS and data rate on performance metrics like end-to end throughput and average delay was analyzed by means of simulation. The simulation study of IEEE 802.11b wireless LAN using OPNET IT Guru Academic Edition 9.1 for improvement in the throughput by fine tuning the attributes like fragmentation threshold and RTS threshold [1].In the literature, discussed above the performance analysis of wireless LANs has been surveyed but the use of wireless technology doesn't mean an end to the wired technology. The following literature survey provides scope of improvement in the wired technology too.

In order to deal with burst data transmission the 100Mbps Ethernet is preferable to ensure communication performance [18]. The features of conventional protection system, including current differential protection and distance protection were analysed by the author. The disadvantages of complex power systems were pointed out. The comparative investigation of three wide area protection System (WAPS) architectures, i.e. centralized, distributed and networked using OPNET, revealed that networked structure is considered to be best due to its fast response time in terms of lesser delay or transfer time. The architecture and communication network of WAPS was investigated to utilize global information instead of local information to achieve better performance.

The load on the network server increases with increase in the user activity. An increased number of users increase the network load and degrades the performance. An effort was made to improve the performance by load balancing. Various probabilistic methods to study network performance [2] had been proposed during the research. The significance of using discrete-event simulation, as a methodology to confront network design and fine-tuning its parameters was also highlighted.

Another major problem exists in the form of network congestion. To overcome the problem of congestion, Fiber Distributed Data Interface and Asynchronous Transfer Mode type high-performance networks along with the bucket congestion control mechanism were modeled and simulated [4]. The effect of variation in attributes like traffic load on the performance metrics like end-to-end delay and throughput was analyzed.

The increase in traffic load effects the network performance In [5], a network model with switched Ethernet subnets and Gigabit Ethernet backbone under typical load conditions and also for time-sensitive applications such as voice over IP was modeled and simulated. The simulations were carried out to study the impact of increase in traffic load on the performance metrics like delay.

The type of routing technique used in the network is an important consideration to study the network performance. Three technologies – Internet protocol (IP), Asynchronous Transfer Mode (ATM) and Multiprotocol Label Switching (MPLS) were compared in terms of their routing capability [9]. Different performance metrics like end-to-end Delay, throughput, Channel Utilization, FTP download response time and normalized delivered traffic were analyzed using OPNET simulator. The results indicated that ATM and MPLS outperform IP (without modification) in terms of delay and response time to the exposed data. Another comparison of the performance of Gigabit Ethernet and ATM network technologies using modeling and simulation was done. Real-time voice and video conferencing type traffic were used to compare the network technologies in terms of response times and packet end-to-end delays. While ATM is a 53-byte frame connection-oriented technology, Gigabit Ethernet is a 512-byte frame (minimum) connectionless technology. The performance analysis indicated that the performance of ATM network is still very good [14]. But it does not keep up with the Gigabit Ethernets small delay time. Hence Gigabit Ethernet provides better performance than ATM as a backbone network, even in networks that require the transmission of delay sensitive traffic such as video and voice.

A new operational model called "AMP model" and an improved ack-regulation scheme called SAD to explain and improve the performance of TCP/IP over wireless networks was presented. The use of link –sharing schedulers with just two queues (ack and packet queues, with SAD implemented on ack queues) to support bidirectional traffic was also proposed. In [10], the authors analyzed TCP performance in asymmetric networks, where throughput significantly depends on the reverse direction and packet loss.

The queuing disciplines are implemented for resource allocation mechanisms. The queuing disciplines used are First-in-first out (FIFO) queuing, priority Queuing (PQ) and weighted Fair Queuing (WFQ). A comparison of different queuing disciplines for different scenarios using simulation was presented for performance evaluation [11]. By varying the queuing disciplines the parameters like End-to-End Delay and Traffic received for live streaming video were presented.The use of network connecting devices plays an important role in the network design. Various network scenarios were designed by changing the network devices like Hub, Switch and Ethernet cables using the network simulation software – OPNET. The performance of the network was analysed using various performance metrics like Delay and collision count, Traffic sink, Traffic source and packet size. It was observed that the throughput improved and collisions decreased when the packet size is reduced [13].

The choice of network simulator is very important for accurate simulation analysis. A comparative study of two network simulators: OPNET Modeler and NS-2 for packet level analysis was presented in [15]. Both discrete events and analytical simulation methods were combined to check the performance of simulator in terms of speed while maintaining the accuracy. For performance testing of the network, different types of traffic like CBR (constant Bit Rate) and an FTP (File transfer protocol) were generated and simulated. Though both the simulators provide similar results, the "freeware" version of NS-2 makes it more attractive to a researcher but OPNET Modeler modules gain an edge by providing more features. So, OPNET can be of use in academia i.e. advanced networking education [16]. Various scenarios like VoIP, WLAN or video Streaming were designed, simulated and also analysed analytically to check accuracy. This illustrated the broader insight the OPNET software can offer in the networking technologies, simulation techniques and its impact of applications on the network performance.

III. IEEE 802.11

An 802.11 LAN is based on a cellular architecture where the system is subdivided into cells. Each cell called Basic Service Set is controlled by a Base Station called Access Point. Although a wireless LAN may be formed by a single cell, with or without a single Access Point, most installations will be formed by several cells, where the Access Points are connected through some kind of backbone called Distribution System. This backbone is typically Ethernet and, in some cases, is wireless itself as shown in Figure 1. The whole interconnected Wireless LAN, including the different cells, their respective Access Points and the Distribution System, is seen as a single 802 network to the upper layers of the OSI model and is known in the Standard as Extended Service Set. As any 802.x protocol, the 802.11 protocol covers the MAC and Physical Layer.

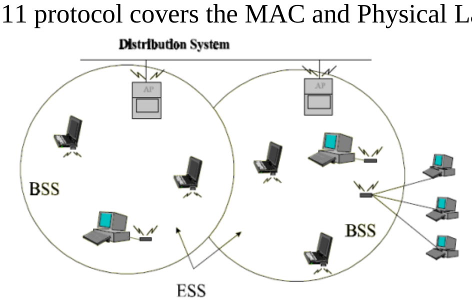

Figure 1: IEEE 802.11 LAN

The Standard currently defines a single MAC which interacts with three PHYs (running at 1 and 2Mbit/s) as Frequency Hopping Spread Spectrum (in 2.4 GHz Band), Direct Sequence Spread Spectrum (in 2.4 GHz Band), and Infrared. The MAC Layer defines two different access methods, the Distributed Coordination Function and the Point Coordination Function. The IEEE 802.11b DCF mode is based on a "listen before-talk" mechanism i.e. it may be CSMA/CA protocol – a basic two way handshaking mechanism or Virtual Carrier Sense mechanism – four way handshaking mechanisms.

IV. IEEE 802.3

Wired Local Area Networking includes several technologies such as Ethernet, token Ring, Token bus, FDDI and ATM LAN. Some of these technologies survived for a while, but Ethernet is by far the dominant technology. Evolution from a 10Mbps Standard Ethernet to bridged Ethernet and then to a switched Ethernet paved a way for faster Ethernet. IEEE 802.3 Standard specifies CSMA/CD as the access method for first-generation 10-Mbps Ethernet, a protocol that helps devices share the bandwidth evenly without having the two devices transmit at the same time on the network medium. This CSMA/CD protocol was created to overcome the problem of collisions that occur when the packets are transmitted simultaneously from different nodes.

Performance metrics

Some of the Performance metrics focused on, in the literature review, regarding wired and wireless LAN are:

Collision count: Total number of collisions encountered by this station during packet transmissions.

Data Dropped: Total number of bits that are sent by wireless node but never received by another node.

Delay: This statistic represents the end to end delay of all packets received by all the stations and forwarded to the higher layer.

Load: Total number of bits received from the higher layer. Packets arriving from the higher layer are stored in the higher layer queue. It may be measured in bits/sec or packets/sec.

Media access delay: Total time (in Seconds) that the packet is in the higher layer queue, from the arrival to the point when it is removed from the queue for transmission.

Queue Size: Represents the total number packets in MAC's transmission queue(s) (in 802.11e capable MACs, there will be a separate transmission queue for each access category).

Throughput: Total number of bits sent to the higher layer from the MAC layer. The data packets received at the physical layer are sent to the higher layer if they are destined for this destination.

Though Wireless networks, in contrary to wired networks, are relatively a new field of research, there exist some simulators to develop and test the effect of change in the input/other attributes parameters on various performance metrics.

V. CONCLUSIONS

The aim of the paper is to highlight the research going on in the field of Wireless and wired Computer Networks. Various simulation studies were done using different types of network simulators, to study their performance comparison. An extensive literature review on wireless and wired networks using simulation has been investigated for their performance comparison by varying the attributes of network objects such as traffic load, file size, RTS/CTS, customizing the physical characteristics to vary BER, slot time, SIFS time or the contention window, to determine their impact on throughput & delay.

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