

Research Article

Comparison of Local Area Network Technologies: Ethernet (IEEE 802.3), ATM and WLAN/WiFi (IEEE 802.11g)

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Abstract

A rigorous comparative study on Local Area Network technologies: Ethernet, ATM and WLAN with respect to the delay and throughput in each system is done in this work. These three technologies are prominent and used on a commercial scale in homes, campuses, offices, industries etc. However the data communication requirement and the working condition are not same in these places. The cost of these three technologies also is not the same. The paper compares the three technologies and can be helpful in selecting the LAN technology according to the requirements and place of deployment. The network simulator used in this work is OPNET 17.5 Academic Edition to calculate the delay and throughput of the three technologies under similar scenario conditions.

Keywords: Ethernet, ATM, WLAN

1. Introduction

The last mile delivery challenge is one of the major problems which is being faced by engineers and scientists today in data communication. No matter how good a wireless wide area network (e.g. GSM, WiMAX etc.) may be but users could be located anywhere. They may be in buildings, underground tunnel, terrace, campuses, roads etc. There location may be such that the signals of the WAN (Wide Area Network) becomes so weak in last mile due to absorption, scattering, multipath delay etc that the desired Quality of Service (QoS) required for the customer is not achieved. To meet the needs of the customer located at a random and remote location LAN technologies like Ethernet (IEEE 802.3 standard), ATM (Asynchronous Transfer Mode) and WLAN (IEEE 802.11 Standard or WiFi) is used. Ethernet local area network operation is specified for selected speeds of operation from 1 Mb/s to 100 Gb/s using a common media access control (MAC) specification and management information base (MIB). The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) MAC protocol specifies shared medium (half duplex) operation, as well as full duplex operation. Speed specific Media Independent Interfaces (MIIs) allow use of selected Physical Layer devices (PHY) for operation over coaxial, twisted-pair or fibre optic cables. System considerations for multi segment shared access networks describe the use of Repeaters that are defined for operational speeds up to 1000

Mb/s. Local Area Network (LAN) operation is supported at all speeds. Other specified capabilities include various PHY types for access networks, PHYs suitable for metropolitan area network applications, and the provision of power over selected twisted-pair PHY types (IEEE 802.3 Section 1, 2012).

In ATM the station doesn't wait for its time slot to transmit, instead station can transmit asynchronously. In ATM the connection is identified by a connection identifier, which is carried along with the data. I.e. two stations are connected via a connection identifier known as VPI/VCI included in the transmitted packet instead of by a time slot as in STM networks. Connection identifier gives the flexibility to statistically multiplex several connections over the same link based on their traffic characteristics. For example if a large number of connections are burst then they can be assigned to same link hoping that statistically they won't burst at the same time. And even if some of them burst at the same time, then there are enough buffers to hold them.

This kind of multiplexing is also known as Statistical Multiplexing (Broadband Forum). The 802.11g subcommittee was tasked to extend the 2.4-GHz unlicensed spectrum to data rates faster than 20 Mbps. The resulting 802.11g standard was ratified in June 2003. The 802.11g standard provides optional data rates of up to 54 Mbps, and requires backward compatibility with 802.11b devices to protect the substantial investments in today's WLAN installations. The 802.11g standard includes mandatory and

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optional components. It specifies OFDM (the same technology used in 802.11a) and CCK as the mandatory modulation schemes with 24 Mbps as the maximum mandatory data rate, but it also provides for optional higher data rates of 36, 48, and 54 Mbps (IEEE 802.11g, White Paper, Broadcom). In this work a study on these 3 technologies under heavy traffic is done to understand that where to deploy these technologies in accordance with the requirement and location of the customer.

2. Related Work

IEEE 802.3 standard is assigned with the development and enhancement of Ethernet technology. ATM forum earlier was involved in the development of this LAN technology but now it has merged with Broadband forum and continues its development. IEEE 802.11 standard is assigned with the development and enhancement of Wireless LAN technology.

3. General Simulation Parameters

Table 1 Table of parameters common in all the 3 Scenarios

Parameter Name	Parameter Value/Nature
Terrain Size	100m X 100m
Simulation Time	1 Hour
Database Access	Heavy
Database Access	Light
Email	Heavy
Email	Light
File Transfer	Heavy
File Transfer	Light
Web Browsing	Heavy
Web Browsing	Light
All applications running	Simultaneously

In this work three scenarios are created under the same project. These three scenarios are for: Ethernet (IEEE 802.3), ATM (Asynchronous Transfer Mode) and WLAN (IEEE 802.11g). Office level (100*100) scenario is used in each of the three cases. Similar physical conditions are applied for each case like star topology, 8 periphery nodes and 1 central node, distance between a periphery node and central node is 30m and same application profile is used for each case. In OPNET 17.5 Academic Edition Network Simulator a default application profile has 24 different applications. In this work out of those 24 applications only 8 general (which are usually used in all places be it home, office, industry, business, research etc) applications are chosen a given in Table 1. All these applications run simultaneously up to the end of simulation in this work.

4. Scenario

A. Ethernet

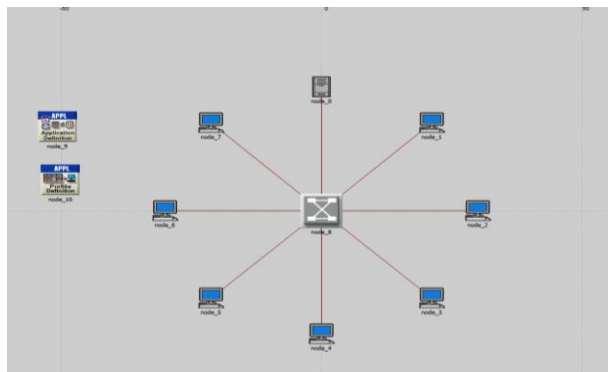


Fig. 1 Scenario of Ethernet System

1Gbps cable is used in this Ethernet system with 7 Ethernet workstations and one Ethernet server connected in star topology with central node as Ethernet switch connected to an Ethernet server. Each Ethernet cable is 30m in length. The 1000BaseX duplex link represents an Ethernet connection operating at 1 Gbps (or 1000 Mbps.) It can connect any combination of the following nodes (except Hub-to-Hub, which cannot be connected): Station, Hub, Bridge, Switch, LAN nodes. The Ethernet workstation node model represents a workstation with client-server applications running over TCP/IP and UDP/IP. The workstation supports one underlying Ethernet connection at 10 Mbps, 100 Mbps, or 1000 Mbps. This workstation requires a fixed amount of time to route each packet, as determined by the "IP Forwarding Rate" attribute of the node. Packets are routed on a first-come-first-serve basis and may encounter queuing at the lower protocol layers, depending on the transmission rates of the corresponding output interfaces. The ethernet16_switch node model represents a switch supporting up to 16 Ethernet interfaces. The switch implements the Spanning Tree algorithm in order to ensure a loop free network topology. Switches communicate with each other by sending Bridge Protocol Data Units (BPDU's). Packets are received and processed by the switch based on the current configuration of the spanning tree. The ethernet_server model represents a server node with server applications running over TCP/IP and UDP/IP. This node supports one underlying Ethernet connection at 10 Mbps, 100 Mbps, or 1 Gbps. The operational speed is determined by the connected link's data rate. The Ethernet MAC in this node can be made to operate either in full-duplex or half-duplex mode. Note that when connected to a Hub, it should always be set to "Half Duplex". A fixed amount of time is required to route each packet, as determined by the "IP Forwarding Rate" attribute of the node. Packets are routed on a FCFS basis and may encounter queuing at the lower protocol layers, depending on the transmission rates of the corresponding output interface.

B. ATM

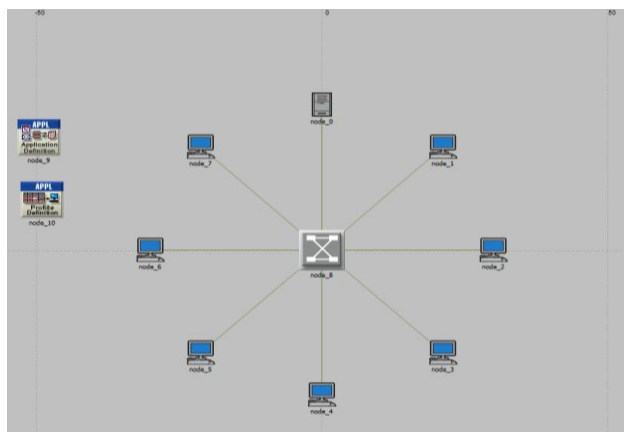


Fig. 2 Scenario of ATM System

SONET fibre OC 24 which has a bandwidth approximately 1Gbps is used with 7 ATM workstations and one ATM server connected in star topology with central node as ATM switch connected to an ATM server. Each SONET cable is 30m in length. The ATM_SONET_OC24 link connects ATM switches, gateways, and station nodes at selectable data rates. The ATM workstation node model represents an ATM node with client-server applications running over TCP/UDP. The Routing Information protocol (RIP) or Open Shortest Path First (OSPF) is used to dynamically and automatically create the gateway's routing tables and select routes in an adaptive manner. The atm8_crossconn node represents an ATM switch which implements VP and VC switching capabilities in an ATM network. It is capable of switching VCCs among eight VP links. The atm_server node model represents an ATM node with client-server applications running over TCP/UDP. The Routing Information protocol (RIP) or the Open Shortest Path First (OSPF) may be used to dynamically and automatically create the gateway's routing tables and select routes in an adaptive manner.

C. WLAN

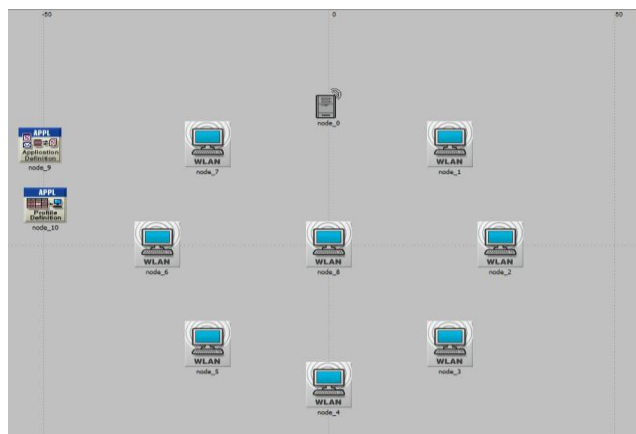


Fig. 3 Scenario of WiFi/WLAN System

5 WLAN workstations connected in star topology with central node as access point. Each workstation and the server are 30m away from the access point at centre. The WLAN workstation node model represents a workstation with client-server applications running over TCP/IP and UDP/IP. The workstation supports one underlying WLAN connection at 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps. This workstation requires a fixed amount of time to route each packet, as determined by the "IP Forwarding Rate" attribute of the node. Packets are routed on a first-come-first-serve basis and may encounter queuing at the lower protocol layers, depending on the transmission rates of the corresponding output interfaces. The WLAN server model represents a server node with server applications running over TCP/IP and UDP/IP. This node supports one underlying IEEE 802.11 connection at 1 Mbps or 2 Mbps. The operational speed is determined by the connected link's data rate. In this work WLAN is operated at the data rate of 54 Mbps.

5. Result

A. Delay

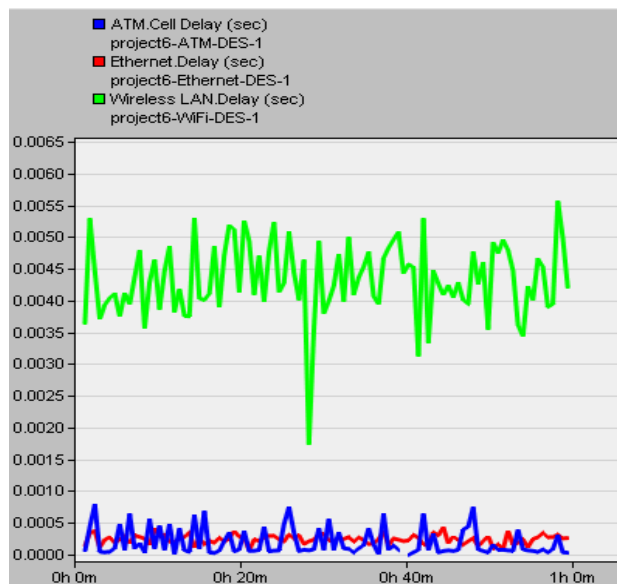


Fig. 4 Delay (s)

For Ethernet this statistic represents the end to end delay of all packets received by all the stations. For ATM this statistic represents the end to end delay of ATM cells received by all ATM layers in the network. Measured from the time an ATM cell is sent from the source ATM layer to the time it is received by the ATM layer in the destination node. For WLAN this statistic represents the end to end delay of all the packets received by the wireless LAN MACs of all WLAN nodes in the network and forwarded to the higher layer. This delay includes medium access delay at the source MAC, reception of all the fragments individually, and transfer of the frames via AP (Access Point), if access point functionality is enabled. From the above comparative

graph we observe that Ethernet and ATM has far less delay as compared to WLAN and this observation is quite obvious and trivial due to the wired medium nature of Ethernet and ATM as compared to the wireless medium nature of WLAN. On comparing Ethernet and ATM it could be seen that Ethernet has very stable delay due to less variation whereas there is much variation of delay in ATM as compared to Ethernet. Hence, overall Ethernet proves to be superior as compared to ATM and WLAN for delay.

B. Throughput

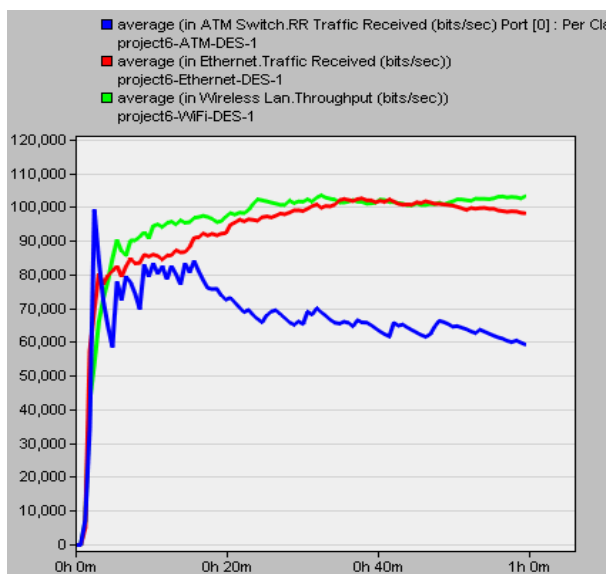


Fig. 5 Throughput (bits/s)

For Ethernet system, throughput (in bits/sec) of the data forwarded by the Ethernet layer to the higher layers in the Ethernet server. For ATM, traffic received (in bits/sec) by each queue of the port of ATM server. For WLAN, total data traffic in bits/sec successfully received and forwarded to the higher layer by the WLAN MAC of WLAN server. This statistic does not include the data frames that are: unicast frames addressed to another MAC, duplicates of previously received frames and incomplete, meaning that not all the fragments of the frame were received within a certain time, so that the received fragments had to be discarded without fully reassembling the higher layer packet.

On comparing the throughput of Ethernet, ATM and WLAN (IEEE 802.11g) it could be seen that Ethernet and WLAN has almost the same throughput while that of ATM degrades with time.

Conclusions

The result clearly shows that in least delay Ethernet is clearly winner. However Ethernet has some disadvantages like lack of mobility. For mobility WLAN or WiFi (IEEE 802.11g in this study) is winner. ATM uses SONET (Synchronous Optical Network) which uses optical fibre which has several advantages over Ethernet copper wires. To decrease delay in ATM higher quality SONET fibres like OC 48 could be used. In throughput WLAN (IEEE 802.11 g) when used at 54 Mbps mode proves to be the winner.

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