



Impact of Cable Quality on Data Transfer Rate and Packet Loss

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Abstract

This paper examines how Ethernet cable quality affects performance of a network, particularly the key performance indicators (KPI) which include data transfer speed, throughput, delay as well as packet loss. The study presents a comparison of four popular cable types, such as, Cat5e, Cat6, Cat6a and Cat7. An emulation-based approach was adopted whereby a simulation approach based on the OPNET Modeler was used to simulate a Local Area Network (LAN) in controlled conditions. Different scenarios had been constructed in which all types of cables were tested separately with the rest of the network parameters such as the type of traffic, the size of the packets and the number of nodes constant. Measures of performance were gathered and calculated and the efficiency of each type of cable was determined. The findings reveal that there is a great difference in the performance of the network based on the quality of cables. Better cables that were of higher grade such as Cat6a and Cat7 cables showed better performance in throughput, lower delay and decreased packet loss. On the contrary, the older cable models like the Cat5e were found to limit in high-speed and high-load situations. The results accentuate that one should choose relevant cabling infrastructure to provide a reliable and efficient network functioning. The research offers valuable knowledge to network designers and engineers in streamlining the performance according to the need of the application and network size.

Keywords: data transfer speed, computer network, Cat5e, Cat6, or Cat6a, Cat7, Ethernet cables.

1. Introduction

Computer networks are very crucial in the operations of contemporary organizations where they support everyday operations and exchange of information. To have a smooth operation and avoid delays or/and technical disruption, it is necessary to achieve reliable network performance. Although servers and software systems can be the main focal point, the physical structure of the network especially the quality of the cables also play a major role on the overall performance of the network during the interface on the basis that cables are the main channel through which data are transmitted. As the assortment of types of network cables is rather vast, and the technical parameters of cables can vary significantly, it has grown quite essential to consider the effect that cable quality might have on the speed of the data transfer and the emergence of other issues (such as packet loss that can be a problem in most network environments). This research, therefore, explores how the kind of network cable employed and the performance of the network are connected based



on actual experiments and a comparison of the cable of choice on the efficiency of a network.

2. Research Problem

Some computer networks suffer from slow performance and sudden connection interruptions. Moreover, various rates of packet loss can be observed, decreasing the efficiency and reliability of the network. One of the main reasons for these problems may be the use of low-quality or unsuitable network cables. The research problem is whether data transmission speed and packet loss dependence on the quality of network cables. This research paper will analyze how the quality of cable affects the performance of the network and what can be done to enhance the efficiency of the network.

3. Research Hypothesis

The hypothesis is that the data transmission speed and the loss of packets are directly proportional to the quality of network cables. Quality cables enhance the performance of networks since high quality cables are capable of transferring data faster and minimize the loss of packets as opposed to low quality cables that are capable of low performance cables.

4. Significance of the Research

1. The aim of the study is to improve network performance in organizations.
2. Providing scientific guidance to engineers and technicians in selecting appropriate cables for networks.

5. Scope of the Research

This study focuses on testing the quality of network cables: Cat5e, Cat6, Cat6a, and Cat7. The evaluation is done using OPNET simulation software to examine factors such as delay, packet loss, and data transmission rate. The research is carried out in a virtual environment without using real networks, relying only on simulation results and not on field measurements. The study covers the period set for preparing the research during the academic year.

6. Research Limitations

1. The research is based only on simulations and no real network tests are conducted.
2. OPNET considers all the devices and networks as the ideal based on default settings.

7. Related Work

Many papers and scientific works were devoted to the issue of measuring network cable performance and its influence on the quality of data transmission and the comparison of



the different types of Ethernet cables in terms of speed, interference and transmission efficiency. According to a study conducted by IEEE [1], Cat6 and Cat6a cables are superior to Cat5e when it comes to support higher speed and lower the electromagnetic interference, particularly with traditional networks in which the support of high speed of data transmission is necessary. One study by Elsevier [3] to assess the performance of high rated cables like Cat7 was done. These results indicated that this type offers a high shielding level and minimizes noise and thereby enhances stability of the network in an industrial setting. Other simulation tools like OPNET [4] have also been utilized in several studies to study the network performance using various measures like throughput, delay and packet loss. The outcome was that the type of cable has a direct influence on these parameters. Generally, the literature supports the argument that due to the development of cable types (cat6a and Cat7), network activity has greatly improved especially in where speed and reliable transfers of the data high speed are important.

8. References Glossary / Terms

1. Computer network: A system that connects multiple devices to exchange data.
2. Ethernet cable: A means of transferring data between devices on local networks.
3. Cat5e: A type of Ethernet cable that supports transmission speeds up to 1 Gbps and is suitable for small and medium-sized networks.
4. Cat6: A faster and more interference-resistant version of Cat5e, used in faster and more demanding networks.
5. Cat6a: A Cat6 development that supports higher speeds and greater bandwidth.
6. Cat7: One of the latest types of Ethernet cables, characterized by very high speeds and a high ability to resist interference.
7. Bandwidth: The amount of data that can be transferred via the cable in a given time.
8. Data transfer speed: Data transmission and reception rate via cable.
9. EMI protection: The cable's ability to prevent surrounding electrical devices from affecting transmission quality.
10. Cable length: The maximum length the cable can reach without losing signal quality.

9. Methodology

The study adopts a simulation-based methodology to evaluate the performance of different Ethernet cable types. A virtual Local Area Network (LAN) was designed using OPNET Modeler. The network topology is 20 nodes connected by various types of cables (Cat5e, Cat6, Cat6a and Cat7). The simulations were carried out in the same conditions in order to compare them.

The parameters of simulation are:



- Number of nodes: 20
- Traffic type: FTP
- Packet size: 1024 bytes
- Simulation time: 10 minutes

The metrics were used to evaluate the performance: End-to-end delay, Throughput and Packet loss.

10. Research Tools

1. OPNET Modeler Network Simulation and performance analysis software.
2. TCP/IP protocol of transmitting data between network nodes.
3. A virtual networked environment which is a combination of multiple connected devices.

11. Simulation Model and Cable Types

The simulation model consists of four most popular cable types: Cat5e, Cat6, Cat6a, and Cat7.

12. Simulation Procedure

The first step in OPNET Modeler's simulation process is establishing a Virtual Local Area Network (LAN). For this purpose, numerous nodes, which symbolize network elements, were introduced. Cables of different Ethernet types were used to interconnect various node clusters. Communication was further refined by configuring the TCP/IP protocol. For the purpose of uniformity, simulation parameters were adjusted. As a result, the simulation was able to gather performance metrics, such as delay, throughput, and packet loss.

13. Performance Metrics

13.1 Delay

Delay is the time required for a data packet to travel from the source to the destination across a network.

$$\text{Delay} = \frac{\text{Total time}}{\text{Number of packets}}$$

13.2 Packet Loss

Packet loss is the percentage of packets that are lost during transmission.



$$\text{Packet Loss} = \left(\frac{\text{Packets sent} - \text{Packets received}}{\text{Packets sent}} \right) \times 100$$

13.3 Throughput

Throughput is the amount of data successfully transmitted over the network per unit time.

$$\text{Throughput} = \frac{\text{Total data received}}{\text{Time}}$$

14. Theoretical Framework

14.1 Network Definition

A network is a system that connects multiple devices to exchange data and information [1][2].

14.2 Network Components

1. Nodes: Such as computers and printers.
2. Transmission media: Cables of different types.
3. Protocols: Rules governing data communication [3][4].

14.3 Types of Cables Used in Networks

- Cat5e: Up to 1 Gbps, suitable for small to medium networks.
- Cat6: Up to 10 Gbps over short distances.
- Cat6a: Up to 10 Gbps over longer distances.
- Cat7: Very high speeds, excellent shielding [5][6].

14.4 Signal Loss, Delay, Throughput, and Packet Loss

Signal loss occurs when the signal weakens while traveling through a cable, affecting data speed and efficiency. Higher-quality cables reduce signal loss [7][8]. Delay (latency) is the time for data to travel from source to destination. A smaller delay is better than performance [1]. The measure of successful data transmission over a period of time is throughput, which is favorable when it is higher [2]. Packet loss is when packets do not reach their final destination and when loss is high the reliability is unsatisfactorily reduced [3].

14.5 Importance of Simulation

The prediction of network performance is aided by simulation tools such as OPNET to ensure that a network is predicted to operate before being implemented [4][8].

15. Results and Discussion



The simulation results indicate that different kind of Ethernet cable act differently as follows. Table 1 shows that Cat7 is the best in terms of maximum throughput and minimum delay and packet loss.

Table 1: Simulated Performance Comparison of Ethernet Cables

Cable Type	Delay (ms)	Throughput (Mbps)	Packet Loss (%)
Cat5e	20	850	5
Cat6	15	940	3
Cat6a	10	980	2
Cat7	5	995	1

Table 2: Speed and Signal Attenuation Comparison

Cable Type	Max Speed (Gbps)	Signal Attenuation	Ideal Distance	Additional Notes
Cat5e	1	Relatively high	Short	Suitable for small networks
Cat6	10	Medium	Medium	Suitable for medium networks
Cat6a	10	Low	Long	Reduces electromagnetic interference
Cat7	10+	Very low	Long	Best for large networks/data centers

Table 3: Cable Performance Comparison

Cable Type	EMI Resistance	Insulation Thickness	Optimal Use
Cat5e	Medium	Thin	Home networks, small offices
Cat6	Better	Medium	Medium office networks
Cat6a	High	Thick	Large networks, data centers
Cat7	Very high (shielded)	Very thick with shielding	High-performance networks

Table 4: Protocol Support Across Cable Types

Cable Type	TCP/IP	UDP	HTTP/HTTPS	FTP	VoIP
Cat5e	Supported	Supported	Supported	Supported	Supported
Cat6	Supported	Supported	Supported	Supported	Supported
Cat6a	Supported	Supported	Supported	Supported	Supported
Cat7	Supported	Supported	Supported	Supported	Supported



The findings show that every category of Ethernet cables tested supports common networking protocols, such as TCP/IP, UDP, HTTP/ HTTPS, FTP and VoIP protocols in their entirety. Thus, variations seen in throughput, wait time and lost packets are caused by the physical properties of the cables including bandwidth capacity, shielding level, and vulnerability to electromagnetic interference as opposed to protocol constraints.

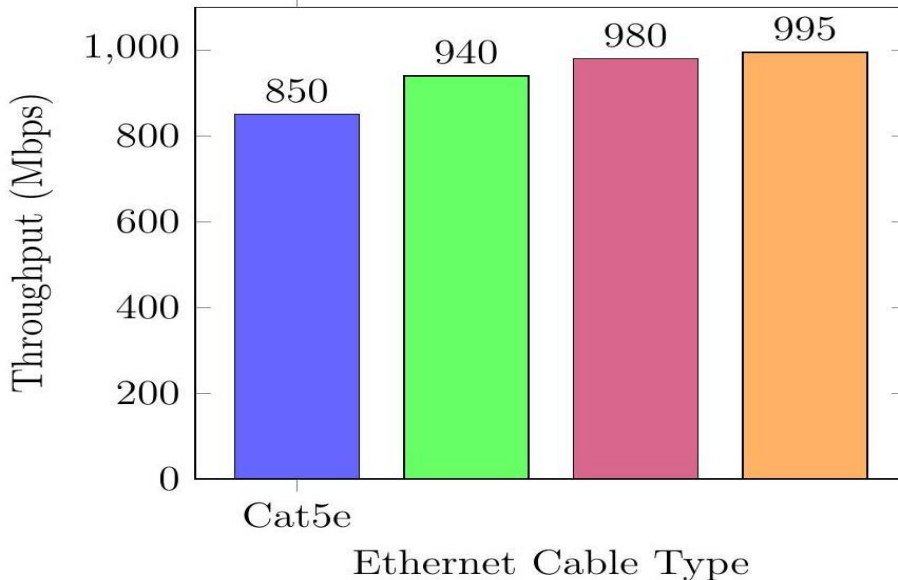


Figure 1: Throughput comparison of Ethernet cables (Mbps). Higher throughput indicates better performance.

In Figure 1, data transfer rate (throughput) of the chosen types of Ethernet cables is compared. Cat7 had the highest data transfer rate (995 Mbps), then Cat6a (980 Mbps), then Cat6 (940 Mbps) and Cat5e had the lowest data transfer rate (850 Mbps). This means that better quality cables have better and increased efficiency in transfer of data.

Delay Comparison of Ethernet Cables

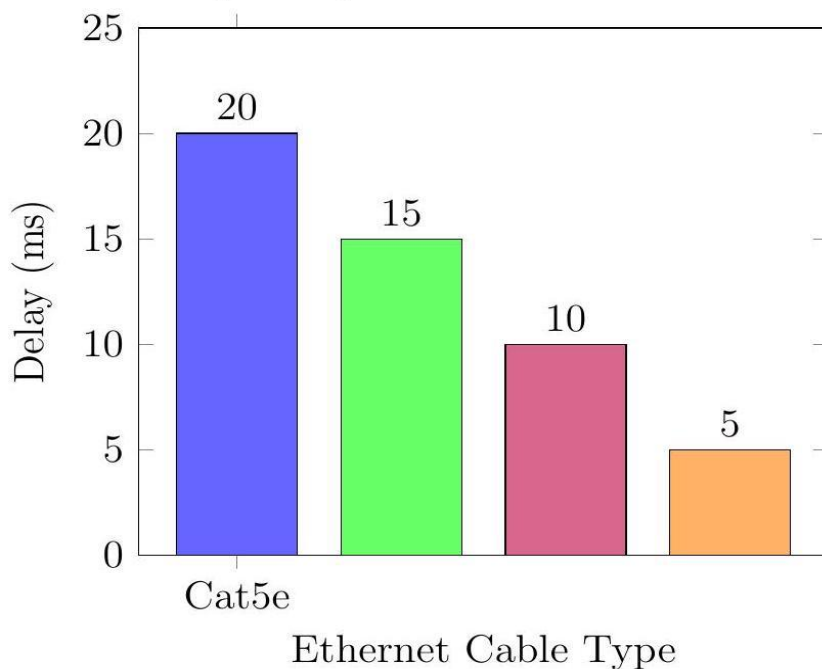




Figure 2: Delay comparison of Ethernet cables (ms). Lower delay indicates better performance.

Figure 2 shows the comparison of latency of the chosen types of cables. Reduced delay is an indicator of improved performance. Cat5e had the maximum delay (20 ms) and cat7 had the minimum delay (5 ms). This shows that higher-category cables will greatly lower the transmission delay.

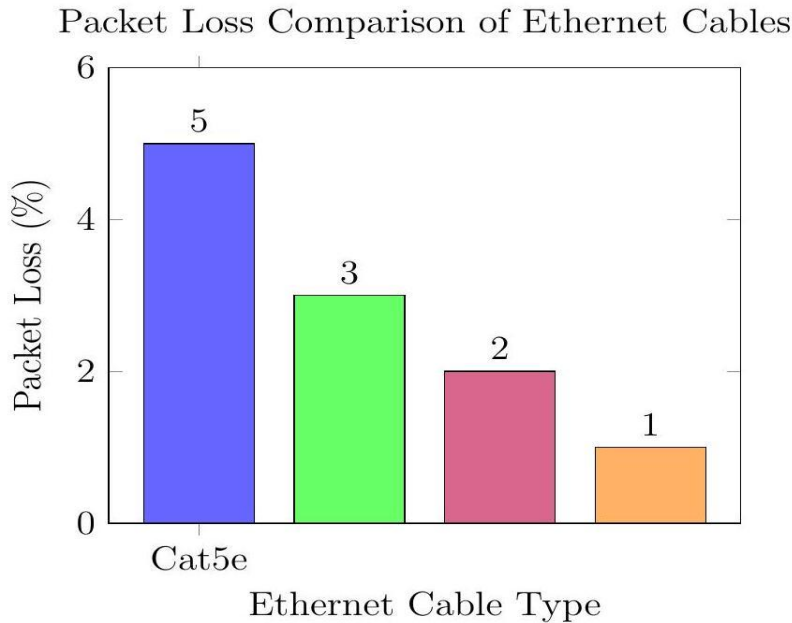


Figure 3: Packet loss comparison of Ethernet cables (%). Lower packet loss indicates better performance.

This figure shows that there is an inverse relationship between cable category and packet loss. Reduced loss of packets is a good performance indicator. Cat7 had the least packet loss (1%) and Cat5e had the highest (5%). The higher cable categories (up to Cat7) are more efficient with regard to data transmission with little packet loss.

Cable Performance Summary: Cat7 is the most generally good since it transmits data at an extremely high speed, maintains the signal at high power, and is also effective at high speeds; Cat6a follows right after it is equally fast and more effective than older cables in reducing interference. Cat6 is mediocre, as it is good at moderate usage networks and Cat5e is the lowest performing at high speed and ranges, but still takes care of small networks. Cat7 is the overall best. It transmits information at a high speed, maintains the signal and functions well even in high speeds.

16. Discussion of Results

The performance of the network, in general, is clearly correlated with cable technology. The enhanced quality of shielding and the increase of bandwidth have great advantages in throughput performance, delay and packet loss.



17. Conclusions

Based on our simulation what we can know from it:

1. Cable type has impact on network performance.
2. New generation cable (Cat7) adapts to higher speed and longer distance with correct performance.
3. Cat5e or Cat6 meets the performance of small network needs.
4. Simulation can transmit to performance well before actual implementation.

18. Recommendations

The study suggests the following:

1. Use modern cables on fast speed networks.
2. Make simulation before design with the real network.
3. Select the type of cable depending on the size of the network and number of users.
4. Study with real hardware implementation in the future.

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