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Performance Analysis of NICs and Its Interactivity with Internet Services

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Abstract

This paper analyses the problem of slow data or video streaming on the World Wide Web internet through the network interface cards (NICs). The service of the entire network and internet connectivity largely rest on the installed Network Interface Cards (NICs). The performance of the various NICs such as 10Mbps, 100Mbps, 1,000Mbps and 10,000Mbps were examined using different message data sizes on the network. Also, the paper extensively discusses the performance of 10Gbps Ethernet card such as: data transmission time and throughput. The fact remained that the major backbone of the Internet network is the transmission control protocol (TCP) which is designed for reliable sending of data over the internet. The TCP as the protocol of the NIC is used for browsing web and downloading or uploading files. Additionally, the paper also examines the TCP feedback mechanism that is able to detect loss packets and retransmit them. Also, the TCP is able to dynamically adapt its packet sending rate to the network conditions in order to achieve the highest possible throughput. However, this paper proposes the use of the 10Gbps Ethernet card for the Internet Servers and Workstations for effective and fast internet access in all public networks.

Keywords: Ethernet Card, Transmission Control Protocol, Data transmission time, throughput.

1. Introduction

A network interface card sometimes called a network adapter or network card or simply NIC, is the physical interface between a computer, or other device and a local area network, practically, a network interface card connects your computer to the LAN cabling. NICs come in various forms: some are built in to the computer's motherboard: others are in the form of an expansion card that plays into your computer's motherboard: some are PC cards; and still others can attach to the computer's USB port. Additional hardware specifications define whether a NIC will be used with co-axial cable twisted pair, fiber optic or even wireless. Also, these cards are available at a designated data transmission rate such as 10Mbps, 16Mbps, 100Mbps, and 1Gbps and so on. The network interface card is a physical connectivity and assembles it into an acceptable format from transmission across a network medium. Likewise, the NIC accepts information from the network medium and "translates" that information into a format the computer can understand. Many data applications over asymmetric networks such as web browsing or file transfer are built on TCP/IP, the widely used Internet data transfer protocol (Wright, 1995) When sending data such as file from a computer to another computer through a LAN, it is fairly simple process. If you are using e-mail, you click on send. If you are accessing a file transfer protocol (FTP) or hypertext transfer protocol (HTTP) server, you click upload. If you simply want to save a file on another computer such as a server on the LAN, you click File save, and then specify a filename and location on the other system (Ogletree, 2006)

However, there is a lot technology going on within the computer to help you convert your file medium. The data must exit the computer through the network interface card, but before it can do so, the NIC segments your data transmission into chunks called FRAMES, that the physical network can manage. In other words, an entire file would be broken into hundreds or thousands of smaller pieces and transmitted as frames as the file is being sent from your computer to another location across the LAN.

Each frame includes not only a portion of the data being sent, but also the address information of both the sending and the receiving network cards. Each frame needs to have this source and destination address information so that the data can find its intended destination as well as known were it originated. This address information is sometimes called the physical address of the network interface card, or simply the hardware address, because it is encrypted into a chip on the NIC. But this address is associated with the data link layer of the OSI model discussed in Section 3, so we call the address of each network interface card a data link layer address. Every NIC has a unique, 48-bit address known as a media access control, (MAC) address. The MAC-address is comprised of a 24-bit Organizationally Unique Identifier (OUI) that is always assigned by the IEEC for a fee to the manufacturer, plus a manufacturer generated 24-bit code that is concatenated or appended to the OUI. The address is represented as a series of six, eight-bit represented such as AF: 00: CE: 3A:8B:0C.

MAC addresses are encoded, into one of the integrated circuits on each NIC so that every computing device on a LAN can be uniquely identified. When devices generated requests or send information the LAN, the MAC address of both the sending and destination computers is added to each packet of information that is placed on the network media. Computing devices on the LAN read the destination MAC address on the DATA PACKETS and determine whether to receive or ignore these packets. For example, if you are using a computer installed with Windows 2000 or Windows XP Professional, you can open a command prompt and enter the command “IPCONFIG/ALL”. This command will display a MAC address in the format: 00-03-47-8F-FF-8E along with other pieces of information and information about various LAN services that support configuration such as Domain Name Services (DNS) and Dynamic Host Configuration Protocol (DHCP) (Miller, 2006). This paper is organized as follows: Section 2 describes the truncated binary exponential back-off algorithm (TBEBA) of the NICs. In Section 3, the operation of the Ethernet frame is extensively discussed. Section 4 clearly explained the features of the IEEE 803.2 Ethernet standards. Section 5 analyses the data transmission of the various model of the Ethernet card on the Internet network of public institution. Finally, we conclude this paper in Section 6.

1. Truncated Binary Exponential Back-off Algorithm

Without a back-off algorithm, the device that detects a collision will stop and then try once again to transmit its data onto the network. If a collision occurs because two stations are trying to transmit at about the same time, they might continue to cause collision because both will pause and then start transmitting at the same time again. This will occur unless a back-off algorithm is used.

The back-off algorithm is an essential component of CSMA/CD. Instead of waiting for a set amount of time when a device backs off and stops transmitting, a random value is calculated and is used to set the amount of time for which the device delay transmission.

The calculation used to determine this time value is called the Truncated Binary Exponential Back-off Algorithm. Each time a collision occur for an attempted transmission for a particular frame, the device pauses for an amount of time that increases with each collision. The device tries up to 16 times to transmit the data, if it finds that it cannot put the information onto the network medium after 16 attempts, it drop the frame and notifies a higher- level component in the protocol stack, which is responsible for either retrying the transmission or reporting an error to the user or application (Ogletree, 2006).

3. The Ethernet Frames

When referring to the data that is transmitted through the network, it is a common practice to call the bundles of data “packets”. However, the actual terminology for the container of data exchanged between systems on a network varies, depending on which level of the OSI seven-layer reference model we are referring to the diagram in Fig 1 below. For example, at the Network layer, a unit of data is called a “packet” or “datagram”. The term datagram usually refers to a connectionless service, whereas packet usually indicates a connection-oriented service. We find that both terms are used in the literature when discussing the internet protocol (IP). At the data link layer, these datagrams are usually referred to as FRAMES. Each frame contains information required for it to he transmitted successfully across the network media, as well as the data that is being exchanged. At the physical level, the frame is transmitted as the series of bits, depending on the particular technology used for encoding on the network medium (Ogletree, 2006).

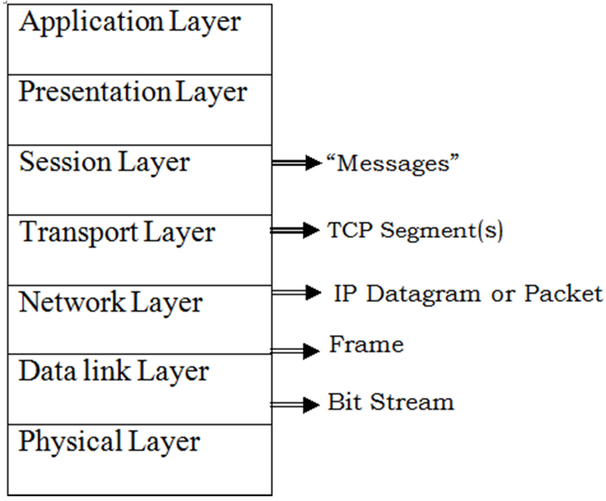


Fig 1: How Information unit changes as it passes up or down the OSI reference model stack (Ogletree, 2006)

The data portion of the frame usually consists of bytes of information that were packaged by a high-level protocol and then delivered to the Data Link layer for transmission inside an Ethernet frame. For example, the IP protocol specifies the header information used by that protocol as well as the data that is being carried by the IP datagram. When the IP datagram passes down to the data link layer, however, all this information is contained in the data portion of the Ethernet frame. The composition of the frame depends on the type of network. The original Ethernet frame format and Ethernet II format differ only a little from the IEE 802.3 frame format and the IEEE 802.5 (Token-Ring) standard defines a frame that is far different from these two. This is because Ethernet and Token–ring have different methods for granting access to the network media and for exchanging data between network nodes (Miller, 2006).

4. The IEEE 802.3 Ethernet Standard

When the IEEE 802 project defined a frame format, it kept most of the features found in the original Ethernet II frame. There are some important differences, however. In Fig.2 below, we can see the layout of the 802.3 Ethernet frame.

7 bytes	1 bytes	6 bytes	6 bytes	2 bytes	46 – 15000 bytes	4 bytes
Preamble	Start of frame delimiter (SFD)	Destination MAC address	Source MAC address	Length of data field	Data field	Frame check sequence (FCS) (CRC)
Minimum of 54 Bytes, maximum of 1518 Bytes						

Fig 2: The IEEE 802.3 Ethernet frame format (Ogletree, 2006)

The major changes included the replacement of the type field with a new field. These 2 bytes were now used to specify the length of the data field that was to follow it. When the value in this field is 1,500 Bytes or less, we can tell it is being used as la length field. If the value of 1,536 Bytes or larger, the frame is being used to define a protocol type Additionally, the preamble was reduced from 8 Bytes to 7 Bytes, and following it now is a 1 – Bytes start of frame delimiter (SFD). The SFD is composed of a bit configuration of 10101011 (the last byte of the earlier preamble has 10 for the last 2 bits).The last part of the frame is a 4-Byte frame check sequence (FCS) is used to store a cyclic redundancy check (CRC) value that is calculated on the frame. The transmitting station calculates this value based on the other bits in the frame. The receiving station calculates the CRC based on the frame's bits and compares it to this value. If they are not identical, the frame must have suffered some damage in transit and must be retransmitted (Ogletree, 2006).

5. Ethernet Data Transmission Analysis

The Ethernet data transmission analysis is needed in order to sufficiently support reasons for the Enterprise WAN NIC upgrade. The analysis is basically carried out using the maximum or highest Round Trip Time (RTT) of the TCP/IP on the Ethernet Cards and the maximum period of data acknowledgement (Tack) in (Kurose, 2000) and (Ramakrishna, 1999).

For better analysis, considering a message size of 1MB to be transmitted having a one-way delay round trip time (RTT) of 1ms in order to receive an acknowledgement in 1ms with the TCP/IP on the Internet (Lakshman, 1994), (Shenker, 1990), (Zhang, 1989) and (Zhang, 1991). In this scenario, we determine the empirical data transmission time and throughput of the Ethernet

i. If the link has a capacity of 10Mbps
ii If the link has a capacity of 100Mbps
iii. If the link has a capacity of 1.000Mbps
iv. If the link has a capacity of 10,000Mbps

i/ In the first case,

The total Round Trip Time is given as $RTT_{total} = RTT + Tack$

:. $RTT_{total} = 1ms + 1ms = 2ms = 0.002$ second

The Transmission Time is given as

$$T_{tx} = \frac{Message\ Size}{Ethernet\ Bandwidth}$$

$$= \frac{1 \text{ x } 8 \text{ x } 10^6}{10 \text{ x } 10^6}$$

:. $T_{tx} = 0.8$ second

The total time delay is given as

$T_{total} = RTT_{total} + T_{tx}$

$= 0.002 + l0.8$

:. $T_{total} = 0.802$ second

The throughput is given as

Throughput = $\dfrac{Message\ \ size}{Total\ Time\ delay}$

$$= \frac{1 \times 8 \times 10^6}{0.802} = 9.97 \times 10^6$$

$\therefore$ Throughput = 9.97Mbps

ii/ In the second case,
The Ethernet bandwidth = 100Mbps

Transmission Time, $T_{tx} = \dfrac{Message\ \ Size}{Ethernet\ \ Bandwidth}$

$$= \frac{1 \times 8 \times 10^6}{100 \times 10^6}$$

$\therefore\ T_{tx} = 0.08\sec ond$

The total time delay is given as

$T_{total} = RTT_{total} + T_{tx}$

= 0.002 + 0.08

$\therefore\ T_{total} = 0.082\sec ond$

The throughput is given as

Throughput = $\dfrac{Message\ \ size}{Total\ Time\ delay}$

$$= \frac{1 \times 8 \times 10^6}{0.082}$$

$$= 97.56 \times 10^6$$

:. Throughput = 97.56 Mbps

iii/ In the third case,
The Ethernet bandwidth = 1,000Mbps

Transmission Time, $T_{tx} = \dfrac{Message\ \ Size}{Ethernet\ \ Bandwidth}$

$$= \frac{1 \times 8 \times 10^6}{1{,}000 \times 10^6}$$

$\therefore T_{tx} = 0.008\sec ond$

The total time delay is given as

$T_{total} = RTT_{total} + T_{tx}$

$= 0.002 + 0.008$

$\therefore T_{total} = 0.01\sec ond$

The throughput is given as

Throughput = $\dfrac{Message\ Size}{Total\ Time\ Delay}$

$$= \frac{1 \times 8 \times 10^6}{0.01}$$

$$= 800 \times 10^6$$

$\therefore Throughput = 800 Mbps$

iv/ In the fourth case,

The Ethernet bandwidth = 10,000Mbps

Transmission Time, $T_{tx} = \dfrac{Message\ Size}{Ethernet\ Bandwidth}$

$$= \frac{1 \times 8 \times 10^6}{10{,}000 \times 10^6}$$

$$\therefore T_{tx} = 0.0008\,\sec ond$$

The total time delay is given as

$$T_{total} = RTT_{total} + T_{tx}$$

$$= 0.002 + 0.0008$$

$$\therefore T_{total} = 0.0028\,\sec ond$$

The throughput is given as

Throughput = $\dfrac{Message\ \ size}{Total\ Time\ delay}$

$$= \frac{1 \times 8 \times 10^6}{0.0028}$$

$$= 2{,}857.14 \times 10^6$$

:. Throughput = $2{,}857.14$ Mbps

When the above analysis was carried out using different message sizes of 5MB, 10MB, 15MB and 20MB, the empirical results are tabulated in Table 1, 2, 3 and 4 below.

Table 1: The performance of 10Mbps Ethernet Card

MESSAGE SIZE (MB)	DATA TRANSMISSION TIME (S)	THROUGHPUT (Mbps)
1.0	0.8000	9.97
5.0	4.0000	9.99
10.0	8.0000	9.99
15.0	12.0000	9.99
20.0	16.0000	9.99

Table 2: The performance of 100Mbps Ethernet Card

MESSAGE SIZE (MB)	DATA TRANSMISSION TIME (S)	THROUGHPUT (Mbps)
1.0	0.0800	97.56
5.0	0.4000	99.50
10.0	0.8000	99.75
15.0	1.2000	99.80
20.0	1.6000	99.87

Table 3: The performance of 1,000Mbps Ethernet card

MESSAGE SIZE (MB)	DATA TRANSMISSION TIME (S)	THROUGHPUT (Mbps)
1.0	0.0080	800.00
5.0	0.0400	952.38
10.0	0.0800	975.60
15.0	0.1200	983.60
20.0	0.1600	987.65

Table 4: The performance of 10,000Mbps Ethernet card

MESSAGE SIZE (MB)	DATA TRANSMISSION TIME (S)	THROUGHPUT (Mbps)
1.0	0.0008	2,857.14
5.0	0.0040	6,666.67
10.0	0.0080	8,000.00
15.0	0.0120	8,571.42
20.0	0.0160	8,888.89

The graphs of the performances of the various Ethernet cards are shown below.

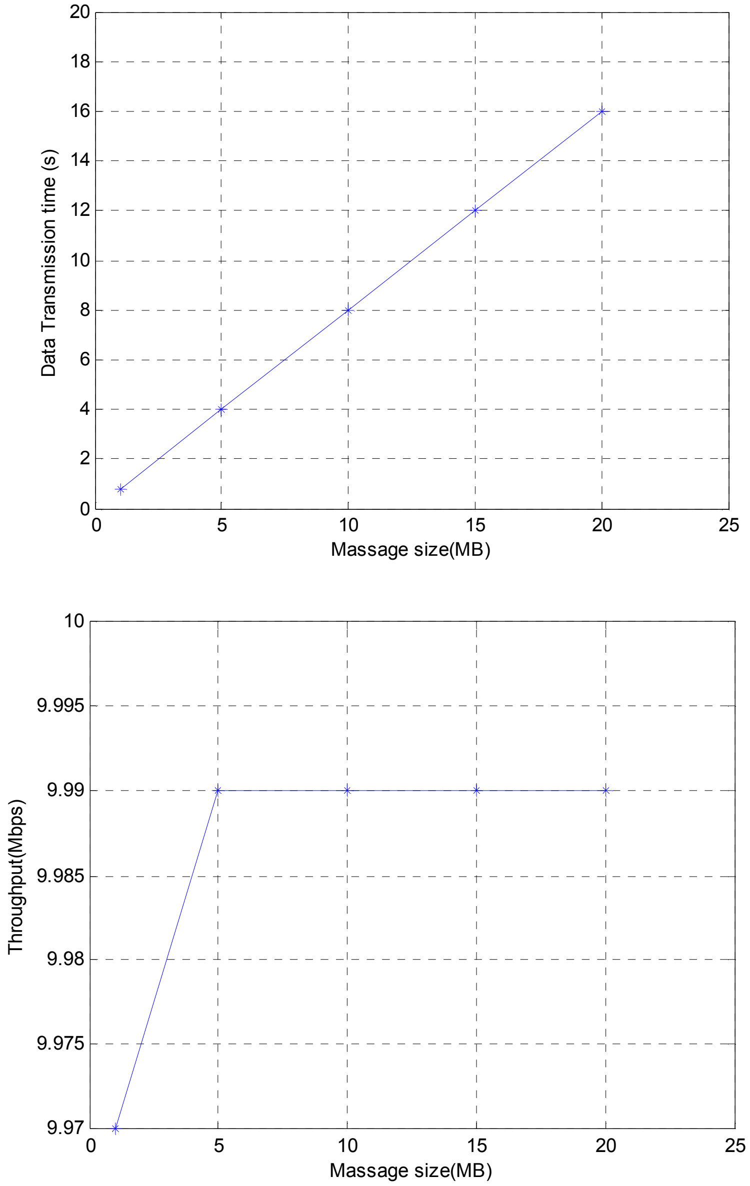
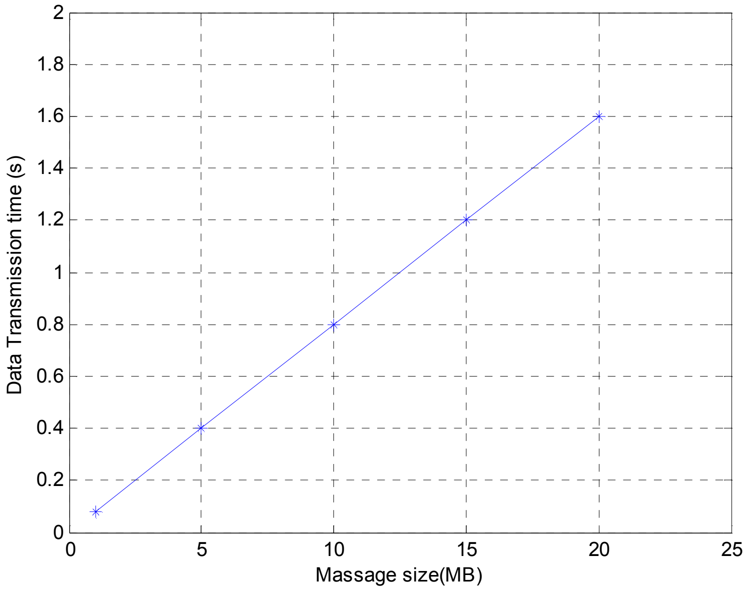


Fig. 3: The Performance of 10Mbps Ethernet Card



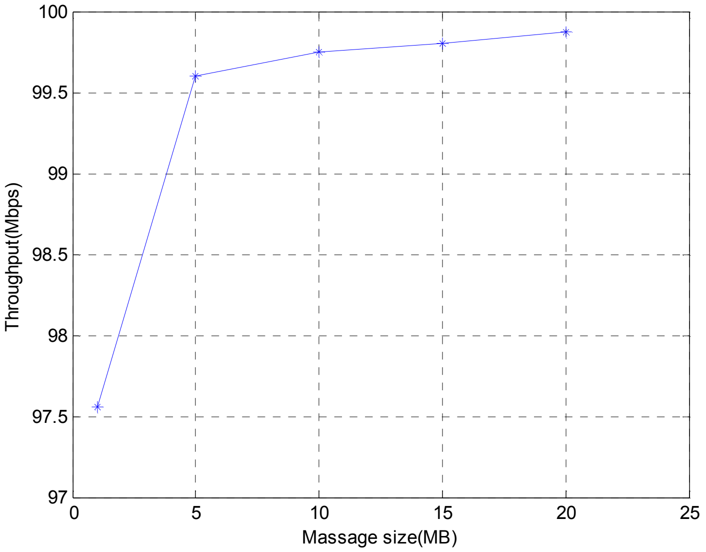
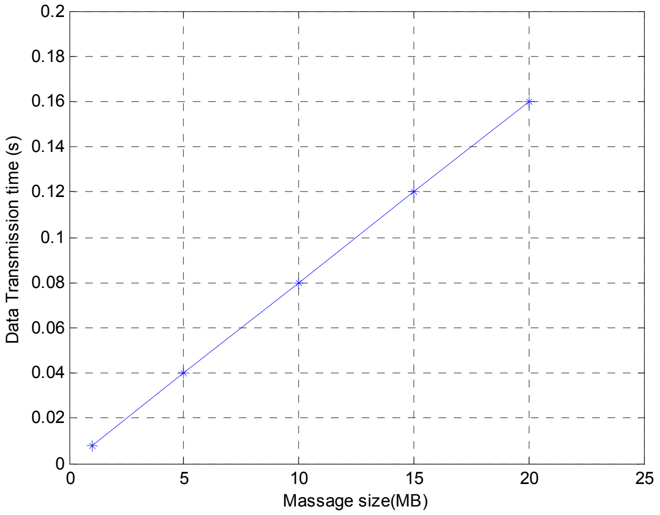


Fig. 4: The performance of 100Mbps Ethernet card



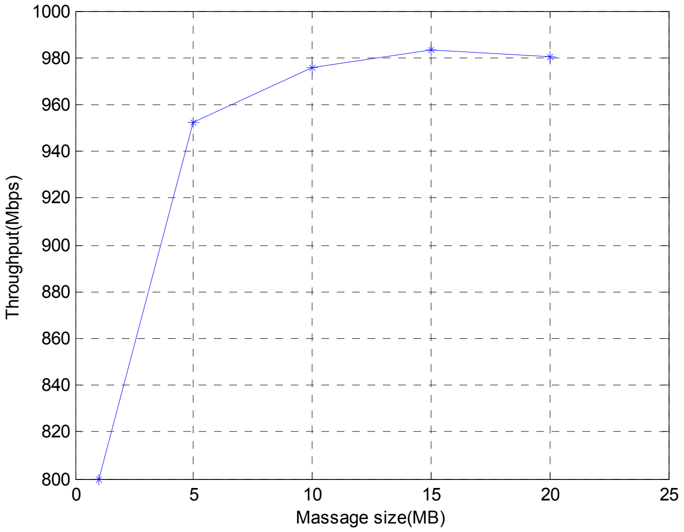


Fig 5: The Performance of 1,000Mbps Ethernet Card

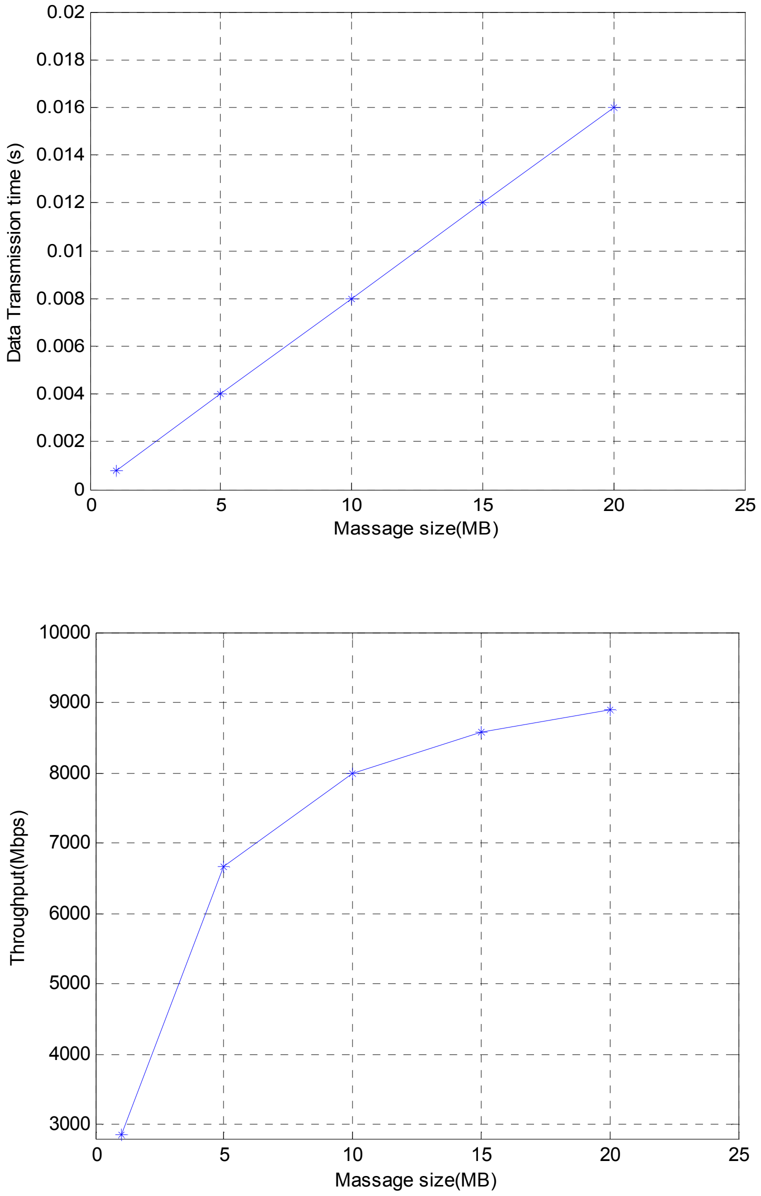


Fig 6: The performance of 10,000Mbps Ethernet Card

6. Conclusion

In this paper, the performances of the 10Mbps, 100Mbps, 1,000Mbps and 10,000Mbps Ethernet Interface cards were studied. From the graphical analysis, 10,000Mbps NIC proved to be the best in terms of its data transmission time and throughput. This card could achieve the fastest data transmission time and highest possible throughput while browsing the web and downloading or uploading files. It possesses an empirical throughput of 8,888.89Mbps and data transmission time of 0.016second while transmitting a data message size of 20MB on the Internet network (Shannon, 1948).

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