IPV6 Packet Transmission for High Speed Networks

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Abstract

IPV6 is a new technology that has been developing as a replacement for existing Internet protocol, IPV4. IPV6 was designed with same additional features to the IPV4. In order to meet the requirement of fast growing internet, we must switch from IPV4 to IPV6. IPV6 is a datagram protocol same as IPV4 having 128 bit addresses instead of 32 bit in IPV4. The Internet Protocol Version 6 (IPv6) becomes the next-generation Internet protocol, and was originally proposed due to the scarcity of the IPv4 address space. To transmit lage IPV6 packet on short time, we can use Gigabit Ethernet. The CRC calculation is a core part of the Ethernet processing. CRC is used to generate a checksum over the whole frame at transmission and to check that the frame is still correct at reception. Gigabit is a popular broadband technology for good reason. It can transfer large amounts of data through a large network at high speeds. It uses full duplex bidirectional links, each side of the link must be capable of computing two CRC checksums at the same time, one for the transmitted frame. Here the CRC processing time is very much reduced.

Keywords

CRC, Gigabit Ethernet, IPV6, Ethernet Frame.

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Introduction

Ethernet technology is currently the most deployed technology for high performance Recently, for Data Link layer, we have gigabit Ethernet technology that is able to transmit large IPv6 packets on short time while Physical layer, we have fiber optic that has very low bit error rate (BER)[1]. Hence, using gigabit Ethernet as Data Link layer protocol and fiber optic as transmission medium will produce very low error possibility. Gigabit Ethernet uses a common bus structure to transmit frames to the appropriate destination[2]. This structure allows Gigabit Ethernet to send frames to more than one recipient (multicast) or all recipient on the local networks (broadcast). Gigabit Ethernet uses variable length frames. Once the router receives an entire Gigabit frame, a frame check sequence value is calculated and compared to the value in the frame check sequence (FCS) field. If there value do not match, the frame is discarded. If the FCS is valid, the router strips away all information from the frame except for the data field. Typically, the data field of a Gigabit Ethernet frame will consist of an IP packet. 10 gigabit Ethernet has 10 times the performance over Gigabit Ethernet today. 10 Gigabit Ethernet meets several criteria for efficient and effective high-speed networks performance[3]. A customer's existing Ethernet infrastructure can be easily interoperable with 10 Gigabit Ethernet. This new technology provides lower ownership cost and flexibility in network designs. The 10 Gigabit Ethernet standard not only increases the speed of Ethernet to 10 Gbps, but also extends its interconnectivity and operating distance upto 40km. Like Gigabit Ethernet, the IEEE 802.3ae* supports both single mode and multimode fiber mediums. However, in 10 Gigabit, the distance for single mode fiber expanded from 5km to 40kms. The IEEE 802.3ae* standard provides a physical layer that supports specific link distance for fiber optic media. To meet the distance objectives, four physical media dependent devices (PMDs) are used- a 1310nm serial PMD to support single mode fiber a maximum distance of 10km, a 1550nm serial PMD to support single mode fiber a maximum distance of 40km, an 850nm serial PMD to support multimode fiber a maximum distance of 300m and a 1310nm wide-wave division multiplexing PMD to support a maximum distance of 10km on single-mode fiber, as well as a maximum distance of 300 meters on multimode fiber[4].

Nowadays, Internet has become a primary technology in the human daily life. The explosive growth of Internet users caused Internet address depletion problem. Current Internet Protocol known as Internet Protocol version 4 (IPv4) has 2^{32} address spaces To overcome the problem IETF has developed a new Internet Protocol called IPv6. Compare with the former, this new protocol comes with big advantages including larger address space that is 2^{128} address spaces, simpler header format and more extensibility. However, IPv6 packets transmission still uses the traditional TCP/IP protocol stack. So the cyclic redundancy check (CRC) is an error detection technique that is widely utilized. The CRC methodology requires that a CRC value be generated for a packet, and appended to the packet prior to propagation from the data source[5]. The CRC is propagated, together with the associated packet, from the source to the data destination and the CRC can be then utilized at the data destination to detect any corruption of the packet that may have occurred during transmission of the packet.

Gigabit Ethernet

Ethernet based network architecture is being and will continue to be the most widely used network due to its low implementation cost and reliability. As the demand for the ever faster network speed has increased high speed Ethernet, Gigabit Ethernet was designed. Gigabit Ethernet is 100 times faster than regular 10Mbps Ethernet and 10 times faster than 100Mbps fast Ethernet.

The principal benefits of Gigabit Ethernet are

- Increased bandwidth for higher
- Performance
- Full duplex capacity
- Low cost of acquisition and ownership
- Transferring large amount of data across a network quickly

In the development of Gigabit Ethernet, some changes were made to the MAC standards to support high-speed shared networks. With shared 10 and 100Mbps Ethernet, the minimum frame size is equal to the slot time. In other words, the minimum frame size = slot time = 512 bits. Using this rule with shared Gigabit Ethernet the minimum frame is maintained at 512 bits (64 bytes), but the slot time is defined as 4096 bit times (512 bytes). Frames that are shorter than the slot time are artificially extended by appending a carrier-extension field so that the frames are exactly one slot time in length. By increasing the minimum time a station sends, the standard can support a larger maximum network topology.

Ethernet Frame

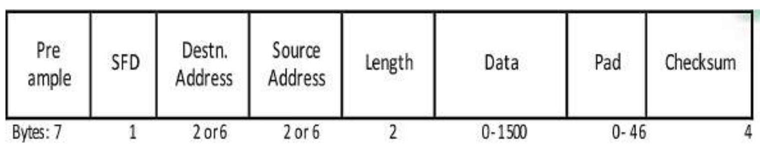

Figure 1. Ethernet II Frame structure

An Ethernet frame starts with the 64 bit pre ample (P). The end of an Ethernet frame is a four-byte frame check sequence (FCS). An Ethernet frame has a 14 byte header with the following fields

- Designation Address (DST): The first six bytes (48bits) identify the hardware address of the Ethernet interface to which the frame is destined. DST, also known as Physical or MAC addresses are assigned by the manufacturer of the interface.
- Source Address (SRC): The source address is the 6 byte (48bit) hardware address of the interface that generated the Ethernet frame.
- Ether Type (ET) or length (LEN): The Ether Type specifics the type of protocol being carried in the frame. If the value of this 2 byte field is between 0x0000 and 0x05DC, then the two bytes are an 802.3 length field. The length field indicates the number of bytes of data contained within the data portion of the frame. The maximum possible is 1500. An Ethernet II frame uses a 2 byte Ether Type field in place of the length field. The Internet Protocol (IP) usually uses an Ethernet Version II frame. The Ether Type for IPV4 is 0x0800 and for IPV6 is 0x86DD.

The minimum size of an Ethernet frame as shown in figure 1 is 64 bytes, counting the 14 byte header and 4-byte FCS, but not counting the preamble, which is used for clock synchronization. A frame that is less than 64 bytes is illegal and is called a runt. The maximum frame size for Ethernet is 1518 bytes, counting the header and FCS, but not the preamble.

10 Gigabit Ethernet Standard

As the demand for ever faster networks speeds has increased, Ethernet has been adapted to handle higher speeds. 10 Gigabit Ethernet in the new evolution of Ethernet in speed and distance, while relating the same Ethernet properties, such as the packet format. BUt 10 Gigabit Ethernet standard in different in some respect from Ethernet standards is that it will function only over optical fiber and operates only in full duplex mode. Since it work on full duplex mode there is no need for CSMA/CD protocol, which is used in other Ethernet technologies. The 10 Gigabit Ethernet standard provides a significant increase in bandwidth while retaining the existing principles of network operation and management.

Fig shows the architecture of 10 Gigabit Ethernet standard (802.3ae*std). At the lower layer (physical layer), an Ethernet device connects the optical or copper media to the MAC layer through a connectivity. The IEEE 802.3ae* standard define two PHY types: the LAN PHY and the WAN PHY. They provide the same functionality expect the WAN PHY has an extended feature that enables us to connect with other networks like SONET.

Media Selection

Deploying Gigabit Ethernet have a choice of media selection. Cat-5 cable is the most common medium for horizontal cabling in ceilings and floors. Also fiber cable is the most common choice for connecting buildings. Fiber is typically reserved for situations that require cabling distances greater than the 100m, which is the limit of Cat-5 copper cable. Copper cable is susceptible to electromagnetic interference, which can corrupt files, while fiber optic cable is not. Fiber cable is more secure than Cat-5 copper cable.

i. Gigabit Ethernet over copper

Gigabit Ethernet was first standardized only for fiber, so deploying Gigabit becomes expensive since to upgrade the infrastructure to fiber cable. The situation changed when IEEE standardized Gigabit over Cat-5 copper cabling, which makes Gigabit Ethernet a widespread deployment at less expense over the existing copper infrastructure. The IEEE standardized IEEE 802.3ab Gigabit Ethernet over copper as 1000 BASE-T, allowing Gigabit speeds to be transmitted over Cat-5 cable. The copper standard covers cabling distances of upto 100 meters, or networks with a diameter of 200 meters. 1000 BASE-T provides 1 Gbps Ethernet signal transmission over four pairs of Cat-5 UTP cable.

ii. Gigabit Ethernet over optical

It is essential for the Gigabit Ethernet to transport at all types of network, otherwise the format conversion is needed. The operation is based on physical layer signaling standard of Gigabit Ethernet.

Fig 2 shows the architecture of the multiplexer and demultiplexer used for transmission and reception of gigabit signal over optical fiber. Here eight Gigabit source are combined to one link using a multiplexer and transmitted through a 1300nm optical fiber. Multiplexer interface boards are used for providing interface to GbE signal both in the transmitting side and receiving side. Two interfaces are needed t provide full connectivity to the GbE sources. Clock synchronization and bit stream identification are the functions performed by the interface with the features of Gigabit Ethernet standard such as start and end of the frames. Similar operations are performed in the receiver direction also.

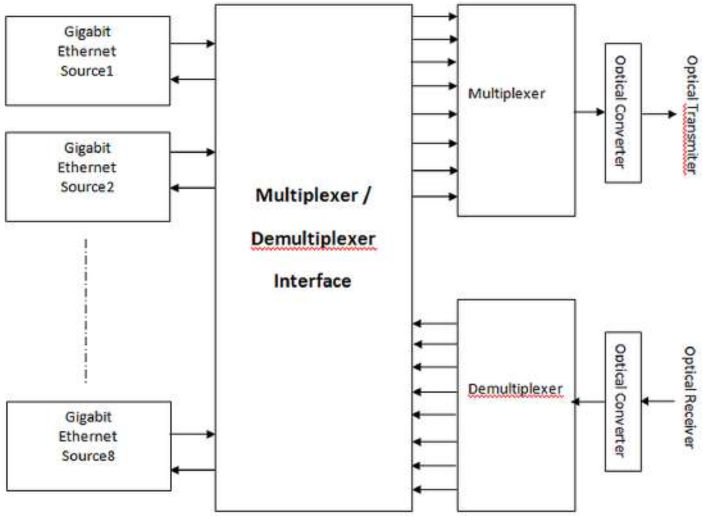

Figure 2. Architecture of GbE signal over optical fiber

Fiber in 10 Gigabit Ethernet

There are two types of optical fiber-multimode and single mode fiber. These two types are currently used in data networking. The 10 Gigabit Ethernet technology support both optical fiber types. Based on the type of the fiber and wavelength, the distance can be varied. In single-mode fiber applications, the IEEE 802.3ae standard supports 10km with 1310nm optical transmissions and 40km with 1550nm optical transmissions. With multimode optical fiber, the distance are not easily defined. In multimode fiber, the fiber information carrying capacity also determines the distance and bit rate at which a system can operate. As the transmission speed increases, the distance the signal can run decrease. When implementing multimode fiber for 10 Gigabit Ethernet, understanding of distance capability is a critical issue.

Features of IPV6

The main reason for designing a new protocol (IPV6) was the need to increase the number of address spaces. The IPV6 is a 128 bit address scheme instead of 32 bit scheme in IPV4. So the possible number of addresses. It's a datagram protocol same as IPV4. Here also data transmission is done as packets. Another feature is mobility that is each user is provided with two IP addresses, one permanent and one dynamic, used only in roaming. In IPV6, priority is also provided in IPV6 header, which is important in real-time applications.

i. IPV6 Packet

An IPV6 packet comprises of header and upper payload as shown is figure 2.

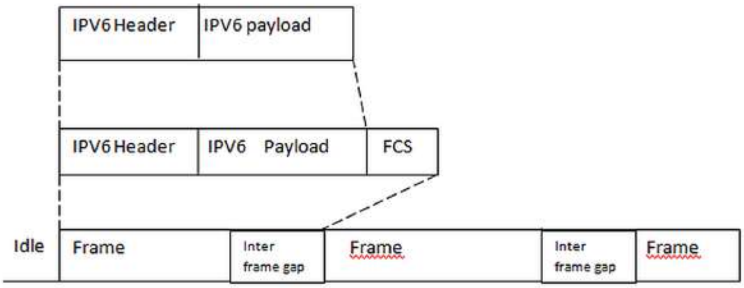

Figure 3. IPV6 Packet/Ethernet frame

Figure 3 shows how an ethernet frame is formed and transmitted through a network. First an IPV6 header is encapsulated to form an IPV6 packet. Then a frame check sequence (FCS) is added to form an IPV6 packet. This frame is encoded and mapped to the physical layer. The IPV6 header shown in figure 4 consists of main header having a fixed size of 40 bytes and as extension header with optional size.

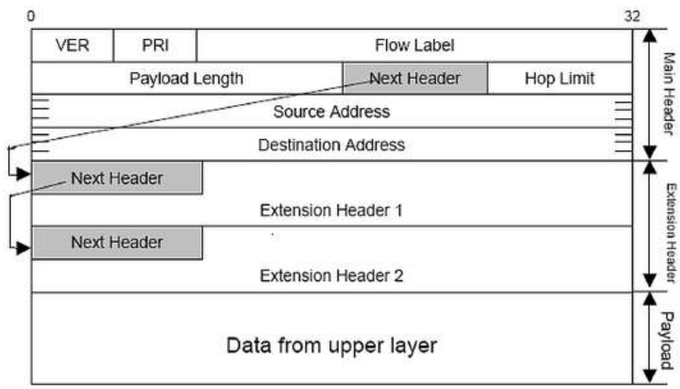

Figure 4. IPV6 new header

IPV6 packet transmission uses traditional TCP/IP.

IPV6 Packet Transmission

IPV6 packet transmitted through the internet has to pass through many routers along the network.

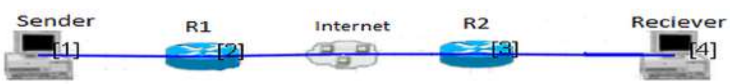

Figure 5. IPV6 packet transmission.

Figure 5 shows the process of transmitting data through different nodes (routers). First R1 receives the Ethernet frame from sender and an error check FCS is made using CRC. If no error is detected, then the IPV6 packet is forwarded by obtaining the destination address using routing table of R1. Then R1 encapsulate the IPv6 packet to form an Ethernet frame-consists of IPV6 payload and a CRC check field, is forwarded to the destination node which receives the frame first makes an FCS check and if no error detected it is forwarded to the destination.

Proposed System

An IPV6 packet transmitted through the internet has to pass through many routers along the network. When we look into the IP packet processing in an intermediate system, only few bits of the packets will change while being transmitted. Most of the field remains same In IPV4, 3 bytes are changing and in IPV6 only a single byte is changing, that is hop limit field which is decreasing by one after forwarding. In the existing systems, CRC is calculated over the whole rame. As only a small change in the IP header is accuring there is no need to check the overall packet. In the proposed system CRC computation is done only for the modified field of the frame. Thus overall CRC computation of an IPV6 frame is only 15 bytes. This technique is very effective to reduce the processing time of an IPV6 packet.

Experiment and Results

Here the error detection was simulated using two methods: existing and proposed method. First method calculates the CRC for whole frame and the second method only calculates the CRC for the modified bytes in the frame. In the above two methods, the sender generates the IPV6 packet as shown in figure 4. The packet is then encapsulated in data link layer by adding header and trailer. This an IPV6 frame is formed. Each intermediate node receives the packet, process it and compute CRC code to detect error. In the first method CRC code is calculated for the whole frame and in the second method its done only for the modified fields. Thus CRC computation in the second method is faster and also CRC processing time is reduced.

In this experiment we measure the overall processing time for an IPV6 packet and also the packet loss. Processing time is the time required to process an IPV6 packet. It the packet does not reach its destination in time, then it is considered as lost. The comparison of overall processing time for different packet size is listed in Table 1. The comparison shows that the lowest processing time is obtained in the second method, where the CRC is calculated only on the modified field (hop limit), which is the proposed method.

Table 1. Overall processing time

Packet Size (Bytes)	CRC calculated for whole frame Processing time in Milli sec	CRC done only for modified field Processing time in Milli sec
64	1.160	1.081
128	1.213	1.102
256	1.258	1.171
512	1.312	1.215
1024	1.470	1.321

Table 1 also shows that the processing time increases as the packet size increases. So the reduction in processing time by the proposed method is very much beneficial for IPV6 packet transmission through internet.

A packet is considered as lost when it does not reach the destination in time. If the processing time is high, the packets will not reach the destination in time. So that the packet X may be considered as a lost packet. Packet loss of IPV6 packets on the two methods in shown in Table 2.

Table 2. Packet loss during IPV6 transmission.

Packet size (bytes)	64	128	256	512	1024
Packet sent	142316	84346	44521	23804	12410
Packet Received	142313	84345	44521	23803	12410
Packet loss	3	1	0	1	0

Conclusion

Here error detection using CRC for an IPV6 packet is discussed when we look into an IP packet processing, we can see only a few bits of the packets transmitted will change Most of the field remains same. In an IPV6 packet, there is only a byte which is changing, that is hoplimit field, which is decreasing by one after forwarding. As only a small change in IP header occuring, so there is no need to check the overall packet. Thus CRC computation become faster and this technique is effective to reduce CRC time processing in a router. For the future, requiring faster network connections, Gigabit Ethernet is the natural evolution of IEEE 802.3* standard in speed and distance. This new Gigabit Ethernet technology provides lower ownership cost and flexibility in network designs.

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