IP Home Network Multimedia Application over IEEE 1394

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Abstract: To utilize the IEEE 1394 protocol features, a new multimedia home network is presented to facilitate the broadband network and multimedia applications. In this work, we design some experiments and use two kinds of operating systems to test the ability of IP packets over IEEE 1394. The performance of both IPv4 and IPv6 over IEEE 1394 are quite satisfactory.

Key-Words: IA, IP, IPv6, IEEE1394

1. Introduction

As IA (information appliance) products become more popular, multimedia applications play an important role in home network design. The trend is to have all IA products connected to the Internet with control through the Internet in or outside of the home. Thus, a network of low-cost, easy to use and manage plug-and-play devices with stable performance are needed. Traditionally, multimedia transmissions must be separated into video and audio segments transmitted using different transmission lines. With IEEE 1394 cable, both video and audio data can be combined into digital data streams for transmission and display together. The IEEE 1394 multimedia home network can connect all IA products to the Internet and utilize fast transmission speed to handle large multimedia data streams.

This paper is organized as follows: Section 2 presents the IEEE 1394 overview. Section 3 presents the IP over IEEE 1394 overview. Section 4 presents the implementation and performance analysis for the multimedia home network experiment based on IPv4 and IPv6 packets over IEEE 1394. Our conclusions and suggestions for future work are given in Section 5.

2. IEEE 1394 Overview

This chapter will briefly introduce the IEEE 1394 serial bus standard. In general, the IEEE 1394 defines high performance serial bus architecture supports data transfer rates up to 400Mbits/sec. The main benefits of the IEEE 1394 standard are listed below:

- Real-time audio and video streaming
- High-speeds of 100,200, and 400Mbit/sec and beyond
- Plug-and-play devices
- Peer-to-peer communication
- Small, durable, flexible cable and connectors
- Two kinds of topologies: Back-plane, Cable-plane
- Optional power-passing capability from an IEEE 1394 hub to various pieces of termination equipment

2.1 Network Architecture

The IEEE 1394 network architecture includes a Serial Bus Management process that connects to the lower three ISO protocol: Physical layer、Link Layer and Transaction Layer (shown in Figure 1). [1]

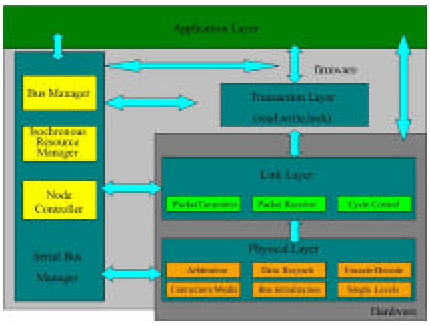


Figure 1 Network architecture

The Physical Layer provides the electrical and mechanical connections between the IEEE 1394 device and the IEEE 1394 cable. Besides the actual data transmission and reception tasks, the Physical Layer provides arbitration to insure that all devices have fair access to the bus.

The link layer provides acknowledge datagram service to the transaction layer. It provides: addressing, data checking and data framing. The link layer also provider data transfer services directly to the application. This includes cycle generation for synchronizing each 125μs.

The transaction layer plays the role of interface with the applications. It defines three services available for application (Read, Write and Lock). Note that the transaction layer does not define services for isochronous transfers.

The serial bus management defines all protocols, services and procedures used by one node exercising management level to control the bus operation.

2.2 IEEE 1394 Operation

To transmit data, an IEEE 1394 device first requests control of the physical layer. With asynchronous transport, the address of both the sender and the receiver are transmitted followed by the actual packer data. Once the receiver accepts the packet, a packet acknowledgement is returned to the original sender. To improve throughput, the sender may continue transmission until 64 transactions are outstanding. Should a negative acknowledgment be returned, an error recovery is initiated. Figure 2 shows how all channels are allocated to transmit isochronous packets to maintain the quality of real-time applications and use the others to transmit asynchronous packets.

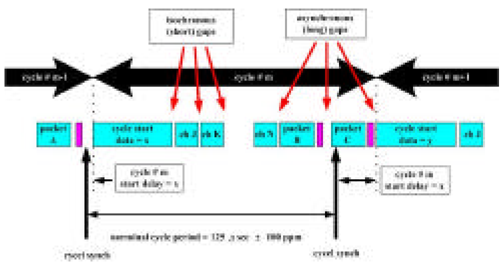


Figure 2 Cycle structure

3. IP over IEEE1394 overview

This chapter will introduce the mechanism that transports IP datagrams (including IPv4 and IPv6) over IEEE 1394. It defines the necessary methods, data structures and codes for RFC 2734 and RFC 3146. [2][3]

3.1 Link Encapsulation and Fragmentation

All IP datagrams (broadcast, unicast or multicast), 1394 ARP request/responses and MCAP advertisements/solicitation that are transferred via 1394 block write requests or stream packets are encapsulated within the packet's data payload.

This requires that the encapsulation format also permits 1394 link-level fragmentation and IP datagram reassembly.. IP-capable nodes may operate with an MTU size larger than the default value. Tests were made in our experimental environment about this point.

Some IP datagrams, and 1394 ARP requests and responses, may be transported via asynchronous stream packets. When asynchronous stream packers are used, their format should conform to the global asynchronous stream packet (GASP) format specified by IEEE P1394a. The GASP format illustrated below (shows in Figure 3) is informative and reproduced for ease of reference, only.

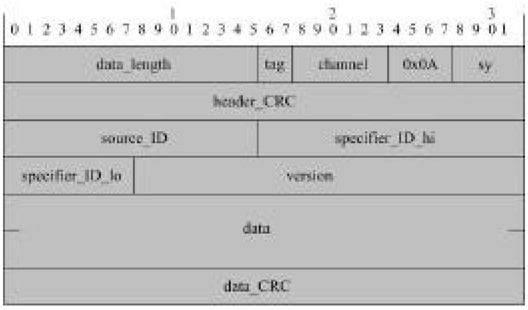


Figure 3 GASP format

All IP datagrams transported over IEEE 1394 are prefixed by an encapsulation header with one of the formats illustrated below.

Figure 4 Unfragmented encapsulation header

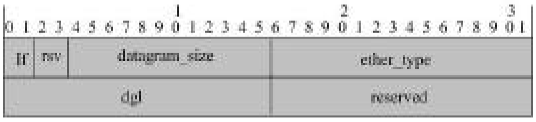


Figure 5 First fragment encapsulation header

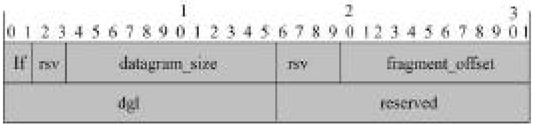


Figure 6 Subsequent fragment encapsulation header

3.2 Serial Bus Address Resolution Protocol

The purposes to determine the hardware address of a device from its corresponding IP address. Both are inextricably tied to the transport medium utilized by the device. We use 1394 ARP (1394 Address Resolution Protocol) to define the address mapping in IPv4 and neighbor discovery to define the address mapping in IPv6.

3.3 IP Multicast

Now we will describe the multicast channel allocation protocol (MCAP) employed by both IP multicast sources and recipients whenever a channel number other than the default is used. MCAP is a cooperative protocol; the participants exchange messages over the broadcast channel used by all IP-capable nodes on a particular serial bus.

We use MCAP to advertise messages and solicit messages to allocate the channel mapping. If multicast data is to be transmitted, first, whether or not another multicast source has already allocated a channel number for the group address must be determined. MCAP is transmitted to advertise the request and solicit channel allocation. The intended multicast source may transmit an MCAP solicitation request with one or more group address descriptors and refresh the channel mapping. The multicast source then begins data transmission according to the new channel mapping.

4. Multimedia Home Network Architecture

The proposed multimedia home network is introduced, implemented and analyzed, as shown in Figure 7

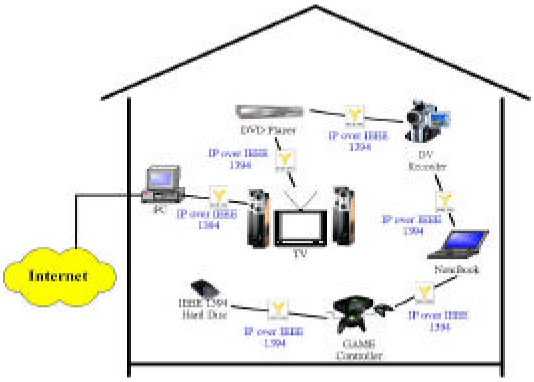


Figure 7 Multimedia home network

Since many IA devices are not yet supported by the IEEE 1394 protocol, we cannot directly test the proposed architecture. Instead we used a DV recorder and PC to design an experimental environment to closely model this multimedia home network. We used three PCs with two kinds of operating systems, Microsoft windows XP and Linux RedHat7.3, to implement our architecture.

4.1 Microsoft Windows XP System

In this section, the experiment is arranged into six scenarios. Each scenario uses the same PCs to maintain an identical environment. The architecture includes a digital video recorder, as shown in Figure .8. The first scenario result is shown in Figure 9.

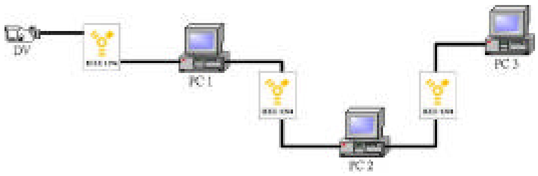


Figure 8 Scenario 1

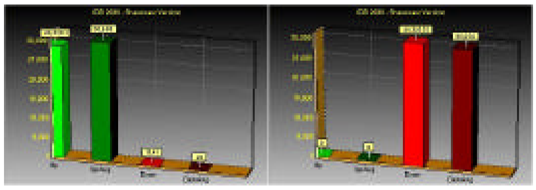


Figure 9 Throughput of scenario 1

All the following scenarios the connection medium between the PCs are changed. The results are tabulated in Table .1.

	PC1 to PC2	PC2 to PC3	Purpose	Result
Scenario 1	IEEE 1394 cable	IEEE 1394 cable	Pure IEEE 1394 network	well
Scenario 2	Ethernet line	Ethernet line	Pure Ethernet network	well
Scenario 3	Ethernet line	IEEE 1394 cable	Transmitting Packets from Ethernet line to IEEE 1394 cable	well
Scenario 4	IEEE 1394 cable	Ethernet line	Transmitting Packets from IEEE 1394 to Ethernet line	well
Scenario 5	IEEE 1394 cable	IEEE 1394 cable	IEEE network to real internet	well
Scenario 6	Ethernet line	Ethernet line	Ethernet network to real internet	Unstable

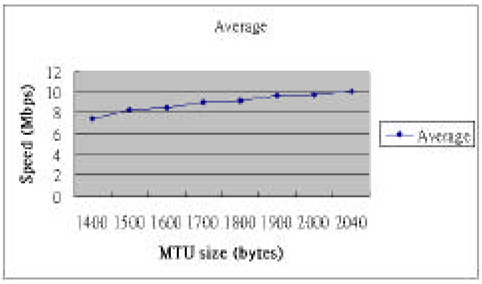
Table .1 Conclusion of the scenarios

4.2 Linux RedHat7.3 system

In this section, the Microsoft Windows XP operating system was change to Linux RedHat7.3. The MTU (maximum transmission unit) size was changed to evaluate the performance.

The first file was transmitted over the IEEE 1394 network using MTU size 1400 octets which is the Ethernet standard. This MTU size enables us to transmit packets over the IEEE

1394 network without changing the MTU path. We gradually shifted the MTU size from 1400 octets to 2040 octets and transmitted a 240.12



MB file from PC1 to PC2. The result is shown in Figure 10. [4]

Figure 10 FTP testing at different MTU sizes

We can see from Figure10 that the larger MTU size facilitates an increase in speed. The maximum MTU size, 2048 bytes, is defined in the IEEE 1394 standard. Since it supports the 400 Mbps speed in IEEE 1394a, we have no problem using this size to transmit packets.

4.3 IPv6 testing

The first step in the IPv6 testing is to add IPv6 address to the IEEE 1394 port in the Linux system, as shown in Figure 11.

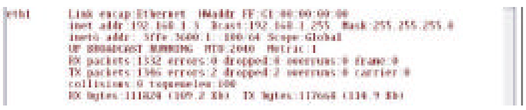
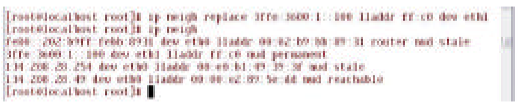


Figure 11 Add IPv6 address

We then used the "ip neigh" command to make a mapping table between the link-layer address and IP-layer address, as shown in Figure



12.

Figure 12 "ip neigh" command

We then used some applications to test this IEEE 1394 network using PC1 and PC2. The results are shown in Figures 13 and 14.

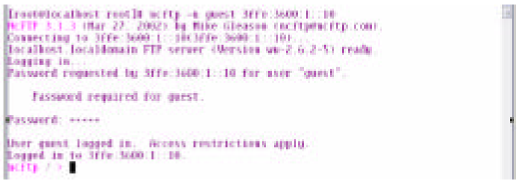


Figure 13 FTP testing

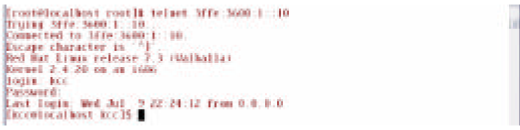


Figure 14 Telnet testing

The FTP is used to test the network performance similar to the IPv4 test. The results are shown in Figure 15.

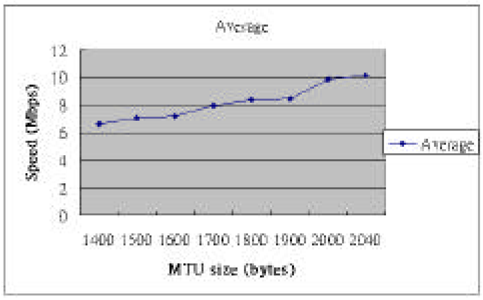


Figure 15 FTP testing in different MTU size

The performance is the same as the IEEE 1394 network performance in IPv4.

IPv6 can be used over the IEEE 1394 network to transmit DV stream with stable display quality.

5. Conclusion and Future work

An IP test over the IEEE 1394 network was performed using two kinds of operating systems, Windows XP and Linux 7.3. The experimental results were encouraging and the test results were valid and stable. If IA products have IEEE 1394 ports, a fast and convenient All-IP multimedia home network can be implemented. As more companies (like Apple, Sony, TI etc.) become interested in IEEE 1394, we anticipate that there will be more such products entering the market in the near future.

To overcome the difficulty of distributing limited IP addresses as more IA products connect to the Internet, IPv6 over IEEE 1394 network will stand as the future network architecture because of its huge addressing ability. In this work, we successfully tested the IPv6 functions over IEEE 1394. The performance results proves that it will work well in an All-IP network in the future.

6. References

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