Performance of IEEE 802.1AS for Automotive System using Hardware Timestamp

Yong Ju Kim, Jin Ho Kim, Bo Mu Cheon, Young Seo Lee, Jae Wook Jeon
Department of Electrical and Computer Engineering
Sungkyunkwan University
Suwon, Republic of Korea
dragonju@skku.edu, besteng83@gmail.com, cheonbomu@naver.com, lys673@naver.com, jwjeon@yurim.skku.ac.kr

Abstract— This paper presents the time synchronization performance of the IEEE 802.1AS standard using a hardware-assisted time stamp. The IEEE 802.1AS standard describes a time synchronization protocol that is part of Ethernet audio/video bridge (AVB) that is expected to be implemented in a wide variety of multimedia and infotainment applications of automotive systems.

Keywords—Ethernet AVB, IEEE 1588, IEEE 802.1AS, Time synchronization

I. INTRODUCTION

Recently, the bandwidth required for in-vehicle networks has exponentially increased as a result of the requirements for interconnecting a variety of consumer electronic devices, infotainment terminals and multimedia applications. The Multimedia Oriented System Transport (MOST), which had been developed for automotive multimedia and infotainment applications, cannot provide sufficient bandwidth since the data throughput of new devices has exceeded the bandwidth limit of its specification. Therefore, the automotive industry presently considers Ethernet to be the next standard for in-vehicle networks.

BroadR-Reach makes it possible to have full-duplex communications using a single twisted pair cable as long as it satisfies the electromagnetic compatibility (EMC) requirements for automotive systems. As a result, Ethernet is expected to be the dominant in-vehicle network protocol [1], and Ethernet AVB will then be used for multimedia and infotainment applications.

Ethernet AVB includes a time synchronization protocol, IEEE 802.1AS, in order to provide synchronous streaming services. The performance of the time synchronization subsystem is very important to properly synchronize each audio and video stream.

Even though 802.1AS is expected to extensively used, current studies analyzing the performance of 802.1AS in automotive systems are insufficient. Lim et al. [2] discussed the synchronization performance of IEEE802.1AS, Xueqiao, Li, et al. [3] presented a performance analysis of the IEEE 1588 hardware and software timestamps, but the analysis within the context of usage in a vehicle was not done.

This paper presents the measured performance of the IEEE 802.1AS standard using hardware-assisted time stamp. For this, IEEE 802.1AS was implemented using the MPC5604 based embedded system.

II. BACKGROUND

A. IEEE 1588

IEEE 1588 is a standard that uses the Precision Time Protocol (PTP) for time synchronization. It transmits a PTP message through the packet network to allow time synchronization, and it supports microsecond accuracy. In 2008, IEEE 1588 Version 2 was introduced [4]. IEEE 1588 Version 2 improves the accuracy and precision of the standard. IEEE 1588 can be implemented via software-only or hardware-assisted time stamping. Software-only time stamping results in long delays and jitter. On the other hand, hardware-assisted timestamp method provides a more precise capability.

B. IEEE 802.1AS

The IEEE 802.1AS protocol is an improved standard for audio/video bridge network. It implements a time synchronization procedure between the devices in the AVB network [5]. In order to synchronize time, IEEE 802.1AS basically uses the IEEE 1588 Version 2 synchronization method. IEEE 802.1AS is compatible with the IEEE 1588 and includes IEEE 1588 profile [6]. In addition, it has characteristics that specialized implementation in the 802.3(Ethernet) and 802.11(Wi-Fi) standards [7].

C. Audio Video Bridge

Audio/video Bridging (AVB) is a technology that transmits audio and video data in real-time. It is also available for real-time transmission of messages through Ethernet cables and devices connected to an in-vehicle network can be controlled and managed.

AVB consists of a comprehensive set of specifications that provides precise time streaming application over 802.3 (Ethernet), such as audio and video data [8].

III. CONSTRUCTION OF THE ENVIRONMENT

The MPC5604E board (time slave) is connected to a personal computer (PC, time master) using TRACE32 (debug device) through a switch. First, the master and slave clocks are set individually, and then the slave clock can be synchronized to the master clock by exchanging the time-information (PTP) message [9]. The Trace32 PowerView for PowerPC program draws a graph of offset values between the master time and the slave time over time.

A. MPC 5604E (Slave)

Freescale`s MPC5604E board was used in the experiment. It has an Ethernet module, and it supports precision timestamps (IEEE 1588). When the PTP message arrives, it is possible to record the hardware timestamp through the media independent interface (MII).

B. Extreme network switch

The Extreme Networks x440 switch is used in this experiment. It supports IEEE 802.1AS to enable reliable real-time audio and video transmissions.

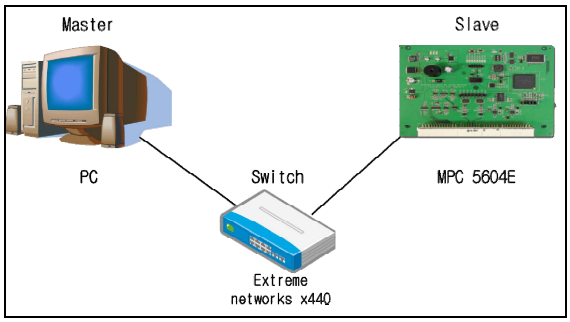

Fig. 1. Experimenal setting of the IEEE 802.1AS hardware module with a switch.

IV. EXPERIMENT RESULTS

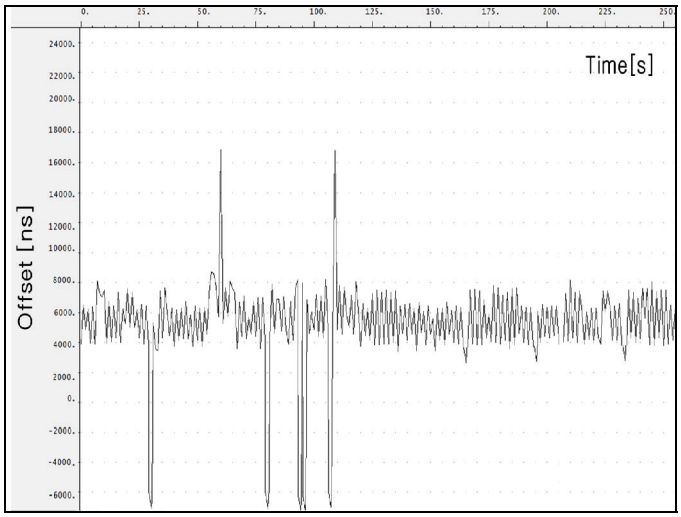

Fig. 2. Experimenal results of the IEEE 802.1AS time synchronization using hardware timestamp module.

The experimental results of performance of the IEEE 802.1AS time synchronization method using a hardware timestamp are presented. The graph figures show the offset between the master time and the slave time. Prior to approximately 110 seconds, the offset value is measured to be between about -6.5μs to 16μs. After that, the offset value is measured to be between about 3μs to 8μs. As a result, the performance of IEEE 802.1AS time synchronization using a hardware timestamp module presents an average about 5μs offset value between the master and slave time.

V. CONCLUSION

In various areas, the IEEE 1588 time synchronization standard has been studied, but research of its use as an Ethernet AVB time synchronization protocol, such as in IEEE 802.1AS, is insufficient. Research on the performance of IEEE 802.AS hardware time stamp was not previously carried out completely. Using a hardware timestamp module, IEEE 802.1AS time synchronization was measured, and the average of the offset measured was 5μs after a period of time. Thus, among the devices connected to the network, those that require high-precision within 5μs can be implemented using an IEEE 802.1AS hardware module.

ACKNOWLEDGMENT

This research was supported by the MSIP(Ministry of Science, ICT & Future Planning), Korea, under IT/SW Creative research program supervised by the NIPA(National IT Industry Promotion Agency)" (NIPA-2013-(H0502-13-1054)).

REFERENCES

[1] S. Tuohy, M. Glavin, E. Jones, M. Trivedi and L. Kilmartin. "Next generation wired intra-vehicle networks, a review."*Intelligent Vehicles Symposium (IV), 2013 IEEE*. IEEE, 2013

[2] H.T.Lee, D.Herrscher, L.Volker and M.J.Waltl. "IEEE 802.1 AS time synchronization in a switched Ethernet based in-car network." Vehicular Networking Conference (VNC), 2011 IEEE. IEEE, 2011.

[3] L.Xueqiao, C.Yuan, L.Shuang and D.Yaxing. "Implementation and research of hardware time stamping techniques based on IEEE1588." Communication Software and Networks (ICCSN), 2011 IEEE 3rd International Conference on. IEEE, 2011.

[4] "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems," *IEEE std 1588-2008 (Revision of IEEE Std 1588-2002)*, pp. c1-269,2008.

[5] IEEE, "IEEE Standard for Local and Metropolitan Area Networks − Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks," IEEE Std. 802.1AS-2011, Mar. 2011.

[6] IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, IEEE Std 1588TM–2008,24 July 2008.

[7] D.Michael, J.Teener and M.Garner. "Overview and timing performance of IEEE 802.1 AS." Precision Clock Synchronization for Measurement, Control and Communication, 2008. ISPCS 2008. IEEE International Symposium on. IEEE, 2008.

[8] Imtiaz, Jahanzaib, Jürgen Jasperneite, and Lixue Han. "A performance study of Ethernet Audio Video Bridging (AVB) for Industrial real-time communication."*Proceedings of the 14th IEEE international conference on Emerging technologies & factory automation*. IEEE Press, 2009.

[9] Y.K.Lee, S.H.Yang, T.Y.Kwon and C.B.Lee. "Evaluation of synchronization performance with PTP."*Precision Electromagnetic Measurements (CPEM), 2012 Conference on*. IEEE, 2012.