PTP based clock synchronization for delay measurement in Autonomous Vehicles

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PTP 기반 클록 동기화를 통한 지연 측정용

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Abstract

The real-time operation of Autonomous Vehicles (AVs) is paramount for ensuring passenger safety and optimizing road efficiency in dynamic and unpredictable environments. To achieve millisecond-level real-time performance a robust delay measurement tool is could be employed, capturing timestamps from multiple hardware units. However, the accurate timestamping is critical, particularly in scenarios involving multiple units where precise synchronization is essential. This paper focuses on the pivotal role of hardware clock synchronization, specifically employing the Precision Time Protocol (PTP) as a state-of-the-art protocol introduced in the IEEE 1588 standard.

I. Introduction

The real time operation of Autonomous Vehicles (AVs) is of utmost significance given the challenging nature of their dynamic environment. Navigating through unpredictable scenarios requires swift decision-making to prioritize passenger safety and optimize road efficiency. The immediate processing of sensor data empowers AVs to respond promptly to unforeseen obstacles, evolving traffic conditions, and emergencies, enabling precise maneuvers. Essential safety features, like collision avoidance, rely on AV services attaining real-time performance at the millisecond level and accuracy down to centimeters [1].

Ensuring real-time performance can be done using delay measurement tool, which will capture the timestamps from multiple hardware units. Accurate timestamping is a crucial aspect of various applications, particularly in scenarios involving multiple units where precise synchronization is paramount. In the realm of delay measurement, hardware clock synchronization plays a pivotal role in ensuring temporal alignment across different units. The synchronization of clocks across these units is essential for obtaining accurate and reliable timestamps, minimizing discrepancies and enhancing the overall precision of delay measurements [2].

When multiple units are involved, each equipped with its own clock, disparities in their internal clocks can lead to inaccuracies in timestamping. This misalignment, even if minimal, can significantly impact the reliability of delay measurements. Hardware clock synchronization addresses this challenge by harmonizing the clocks of various units, ensuring they tick in unison.

There are different ways to create hardware clock synchronization for delay measurement, However, one of the most prominent ways is to use Precision Time Protocol (PTP), which is a state-of-the-art CS protocol introduced in the IEEE 1588 standard [3].

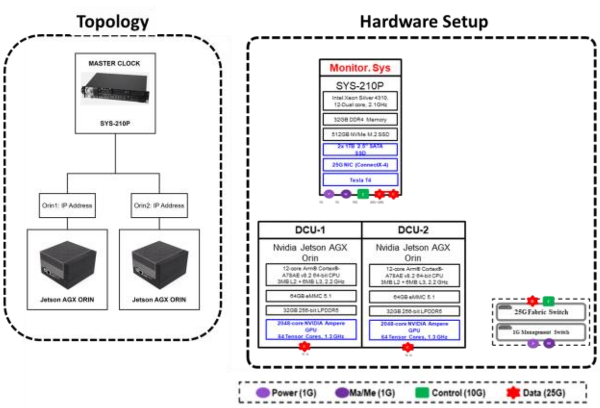

Figure 1: Testing Environment Topology and Hardware Setup

Ⅱ. Method

In order to perform this task, we had to create the testing environment with multiple computing units that can be reached from one single hardware unit. As shown in Figure 1, we utilize single Supermicro SYS-210P and two Jetson AGX Orin Kit. The SYS-210P has been used as a monitoring system. All three hardware units are interconnected using a switch with a bandwidth of up to 25 Gbps. All of the hardware units are set up with phc2sys, which is a utility software that is used in conjunction with the Precision Time Protocol (PTP). The phc2sys software works by reading the hardware clock on the device and comparing it to the PTP reference clock. It then makes adjustments to the system clock to ensure that it is synchronized to the reference clock, which can be critical in applications where precise timing is required. One of the key benefits of phc2sys is its ability to work with a variety of different PTP reference clock sources, including GPS receivers, IEEE 1588 PTP grandmasters, and NTP servers. This makes it a versatile tool that can be used in a wide range of applications. Overall, phc2sys is an important tool for maintaining accurate and synchronized timekeeping in PTP-based systems. By ensuring that the system clock is precisely synchronized to a reference clock, phc2sys can help to prevent errors and improve system performance in critical applications. Precision Time Protocol (PTP) is a protocol used to synchronize the clocks of different devices on a network. PTP is especially useful in systems where precise timekeeping is critical, such as in industrial automation, power distribution, and financial trading. Hardware clock synchronization using PTP works by designating one device on the network as the" master" clock, and all other devices synchronize their clocks to it. The master clock periodically broadcasts synchronization messages to all the devices on the network, which adjust their clocks accordingly. In our case, we have to maintain synchronization across the machine units in order to be able to correctly monitor the delay measurement of all the Orin Kits. Overall, hardware clock synchronization using PTP is an important tool for ensuring accurate and precise timekeeping in critical systems. By ensuring that all devices on a network are synchronized to the same precise time reference, PTP can help to prevent errors, reduce downtime, and improve overall system performance. In our scenario, the monitoring system's hardware clock is set as a master clock. And other hardware units are taking the roles of the" slaves", thus their hardware clocks are synchronized with the monitoring system.

Ⅲ. Conclusion

We currently working on the delay measurement tool for monitoring hardware units in our testing environment. Hardware clock synchronization is essential requirement for successful delay measurement tool, since it is instrumental in achieving the temporal harmony necessary for accurate delay measurement in scenarios involving multiple units. By mitigating clock discrepancies and ensuring precise timestamping, this synchronization enhances the overall reliability and effectiveness of various applications.

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