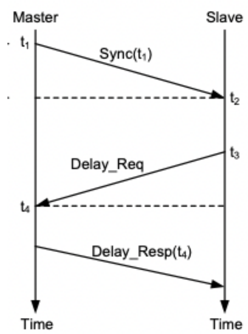
Proposal for PTP simulation Research Internship

Motivation

It is common that electronic devices synchronise their time clock. Usually, this is done by a wildly used protocol called Network Time Protocol (NTP), this protocol is able to maintain the accuracy to the millisecond time level, which meets most everyday requirements. However, many industrial applications, like machine controlling signal or stock market trading, require the error of the time syntonisation less than one microsecond. The Precision Time Protocol (PTP) is used for those application, which achieves the time sync accuracy to sub-microsecond. In this case, the message delay variation, network topology and device itself become important to ensure the accuracy. To determine the effect of these factors on accuracy, analytical models and simulations are required. This project will focus on how message delay variation affects the PTP synchronisation.

Basic of PTP

The original PTP protocol is published in 2002, with 2 updated versions released in 2008 and 2019 and profiles for different applications. Generally, there are many types of devices in actual PTP [1]: ordinary clocks, boundary clocks, end-to-end or peer-to-peer transparent clocks, etc. Here will focus on a simplified situation, which only a master clock and a slave clock exists. The basic operations of PTP are exchanging the timestamped messages: *Sync, Follow_Up* (not showed in the figure), *Pdelay_Req,* and *Delay_Resp.* The path delay is calculated by



$$path\_delay = \frac{(t_4 - t_3) + (t_2 - t_1)}{2}$$

The offset of slave clock is given by

$$offset = (t_2 - t_1)$$

For the Synchronization Performance of PTP, the message delay variation is one of the major factors. The congestion and jitter can both cause the variation of delay. [2] gives analytical model and simulation of effect from clock's frequency drift and jitter on absolute error. The figures of [2] show that the error is additive in the cascade system and master or slave drifting cause different errors.

Major Task

This project aims to implement a simulation of PTP and find out the effect of delay variation. Considering that the process of PTP, the simulation will be built based on OMNet++. A project on GitHub named ptp-sim [3] is used as an reference during implementation.

The main object is to assign different delay for the PTP messages, which means the link delay can be set arbitrarily or following a certain distribution during the simulation. For each simulation, the timestamp of master clock and ordinary clock is given to calculate the error of synchronisation. Based on the delay distribution parameter and synchronisation error, the effect of delay variation on PTP can be concluded.

Reference

1. Watt, S.T., et al. *Understanding and applying precision time protocol*. IEEE.
2. Scheiterer, R.L., et al., *Synchronization Performance of the Precision Time Protocol in Industrial Automation Networks.* IEEE Transactions on Instrumentation and Measurement, 2009. **58**(6): p. 1849-1857.
3. *Simulation of PTP (IEEE 1588)*. Available from: https://ptp-sim.github.io/.