Interim Report - Investigation into the Precise Time Protocol

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Acronyms

CSMA/CD Carrier Sense Multiple Access with Collision Detection

GM Grandmaster

GPS Global Positioning System

IEEE Institute of Electrical and Electronic Engineers

NTP Network Time Protocol

PTP Precision Time Protocol

PTPd PTP Daemon

1 Executive Summary

2 Introduction

Synchronising time amongst a number of devices is very important in a wide range of applications, which include:

Automotive Industry
complete

Power Transmission
complete

Geoscience
complete

Telecommunications
complete

- Explain NTP, and how this was done traditionally
Traditionally timing was implemented on a seperate channel running alongside an existing telecommunications channel. With the design of PTP, existing Ethernet networks can be used instead. The problem with this however comes with how Ethernet works. When standard switches are used, it is indeterminant on the packet delay from Node A to Node B. This is bad for PTP as this packet delay must be taken into account when working out the clock offset. Specific timing switches (REFERENCE) can be used which will prioritise PTP packets, but these may not be available in existing networks. (LIST OTHER TYPES OF SWITCHES HERE TOO)

2.1 Project Description

As it can be seen from above, any industry where accurate timing would benefit from PTP, thus determining PTP performance across an network would be useful Therefore this project will investigate PTP performance across an existing ethernet network. The project specification has been left intentionally open so other work can be carried out time permitting. The university network will be used for this project.

2.2 Aims and Objectives

The project can be split into a number of sub goals and objectives. The following goals have been identified:

Learn about PTP and other work in relation to the protocol
This stage would occur at the beginning of the project to understand how PTP works. This is important so work can then be carried out to investigate PTP performance.

Collect PTP Data
In tandem with the above PTP data can be collected. This will be monitoring the performance of PTP across the network as well as how using multiple types of grandmaster/slaves affect the performance. Different clock locations in the network will also be considered.

Implement some packet metric scripts
To be able to understand the performance of the network, some packet metric scripts will be created. A suitable language will be chosen once this part of the project begins.

Determine packet performance using these scripts
Multiple window sizes and types of metric will be used to quantify network performance.

Test Chronos' equipment and provide feedback
As Chronos has provided this project with some equipment, this equipment will also be thoroughly tested and any information gathered can be passed to them once the project is completed.

- list the deliverables based on this - Gantt chart produced from these results

3 Literature Review

During the first week of the project a number of different Institute of Electrical and Electronic Engineers (IEEE) reports were read and summarised in the logbook. This section of the report will outline some of thedocuments that were used in order for work to begin. The reports were:

PTP Specification [] IEEE1558-2004 specification

Prevention of Packet Collisions [1] A journal article describing an algorithm that aims to prevent packet collisions in an Ethernet network.

Sub-nanosecond synchronisation [2] A conference paper describing a method of nanosecond accuracy synchonisation

Measurement of Egress and Ingress Delays [3]

3.1 PTP Specification

3.2 Prevention of Packet Collisions

The paper begins by explaining the drawbacks with Carrier Sense Multiple Access with Collision Detection (CSMA/CD) that is used in Ethernet and hence explains that time critical packets (mainly *Sync*, *Delay_resp* and *Delay_req*) would be effected if these packets collided. It then goes on to explain briefly how the author developed a token passing system between the slave clocks. Tokens are passed during every two-way session (*Delay_req* and *Delay_resp*).
Because the slave clocks don't require the two-session to be performed at regular interviews (only somewhere between 0 and some Tmax), the time being executions can be variable. Therefore the next slave could be designed by random. The sender would therefore need some registry of all of the other slave clocks. The author explains two ways in which this could be implemented: a centralised database or a local cache at each slave. The centralised database would create a single point of falure and it would also be a mutual exclusion problem. On the other hand having a local cache at each slave clock would be impractical to keep updating

when slaves join and leave the network. Therefore the journal authors decided on a compromise by maintain a neighbourhood of clocks which are a subset of the total population of slave clocks. The property of ”random walks” would still be maintained even though all of the clocks will not be in the list.
The authors also described a method in solving the issue if a particular slave clock (for example Clock Z) reached its maximum time between a two-way session. If the current slave clock proposes to past the token to Slave Y, and the master notices that Clock Z has not been updated since the max time, it will reroute the token to Clock Z instead. The current clock X will then update its neighbourhood with Y instead of Z.
This method will exclude any occurance of collisions as only one two-way session occurs at any one time. Also, at time t, the maximum number of slaves that are ”starved” (ie have reached their maximum time between sessions) is one. This is due to the maximum time between sessions being the same for all the clocks.

3.3 Sub-Nanosecond Synchronisation

3.4 Measurement of Egress and Ingress Delays

4 Work Carried out so Far

- outline all work that has been carried out to date. - Review this. how well has it gone

5 Challenges

6 Next Steps

7 Conclusion

References

[1] C. A, “Preventing the collision of requests from slave clocks in the precision time protocol (ptp),” May 2011.

[2] L. M. . W. T. . S. J. . A. P, “White rabbit: a ptp application for robust sub-nanosecond synchronization,” September 2011.

[3] R. C. . M. C. . R. M, “Measurement of egress and ingress delays of ptp clocks,” September 2013.