IEEE 1588 and accurate Time Stamping Techniques

Chinmayi Avasarala

Indiana University - Purdue University Fort Wayne

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Abstract

Many real-time distributed systems require some shared notion of time. The IEEE 1588 standard defines a Precision Time Protocol to synchronize time in a distributed system over network to sub-microsecond range. The Protocol was developed to bridge the gap between the existing common methods of time synchronization, where NTP may not be accurate enough and GPS may be too expensive.

My research involves studying the various possible points of time-stamping in IEEE 1588, and focuses on improving the accuracy of the system by introducing hardware assist block.

Principle of operation

\[
\text{Delay (D)} = (t_1 - t_0) + (t_3 - t_2) \frac{1}{2}
\]

\[
\text{Offset (O)} = (t_1 - t_0) - (t_3 - t_2) \frac{1}{2}
\]

- Drift compensation
  - Frequency transfer
  - Consecutive time stamped Sync messages allow to determine and compensate the deviation
- Offset correction
  - Time transfer
  - Correction is based on the round trip time measurement

Architecture

The protocol operates on a hierarchical master-slave distribution where slave clocks synchronize their time to master clocks. A best master clock (BMC) algorithm is used to select the master clock.

There are two main approaches for the synchronization of distributed nodes. In the first method, each node keeps information about the relative offset with every other node. In the second, each node maintains synchronization with a reference clock. Time-stamped messages are generally employed in both approaches.

Hardware Assist Accuracy

The two primary problems that must be overcome in network timekeeping are oscillator drift and time transfer latency. Regardless of the protocol used, oscillator drift can be mitigated by using higher quality oscillators.

The time transfer latency problem is two-fold in nature:
- Latency associated with processing of time packets by the operating system
- Network latency created by the hubs and other hardware that exist between clocks.

The hardware assist block is an innovative way of reducing OS latency. It is placed between MAC and PHY. It issues a time stamp when the leading bits of a 1588 packet are identified, precisely marking the arrival or departure of 1588 time packets.

Conclusion

The IEEE 1588 with the hardware assist has the following advantages:
- Better precision and accuracy
- Enables synchronization and syntonization
- Less expensive when compared to GPS