



# POTENTIAL FIRMWARE FOR PRECISION TIME PROTOCOL

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# PRECISION TIME PROTOCOL (PTP)

- IEEE standard to synchronize time.

First **sync** message & follow-up message from master to slave clock.

Offset = Send time at master –  
Receipt time at slave

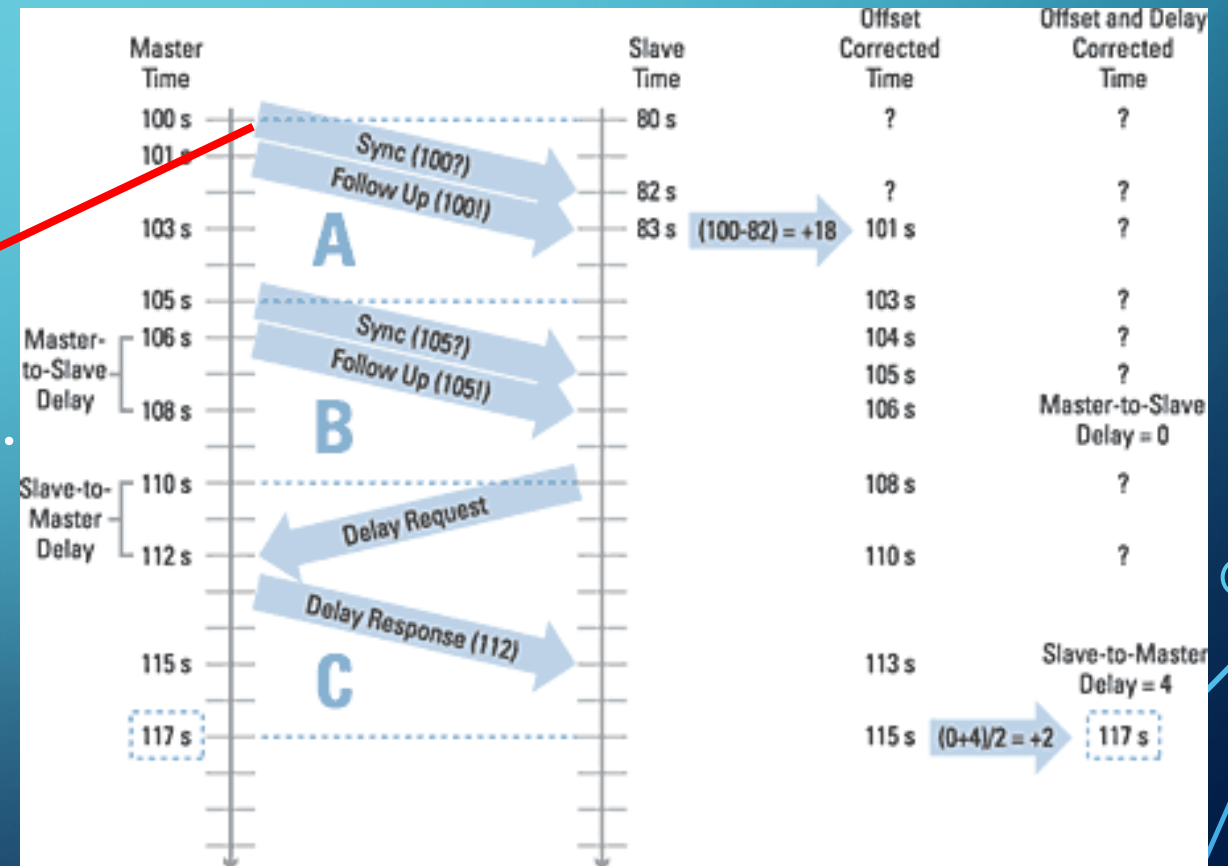
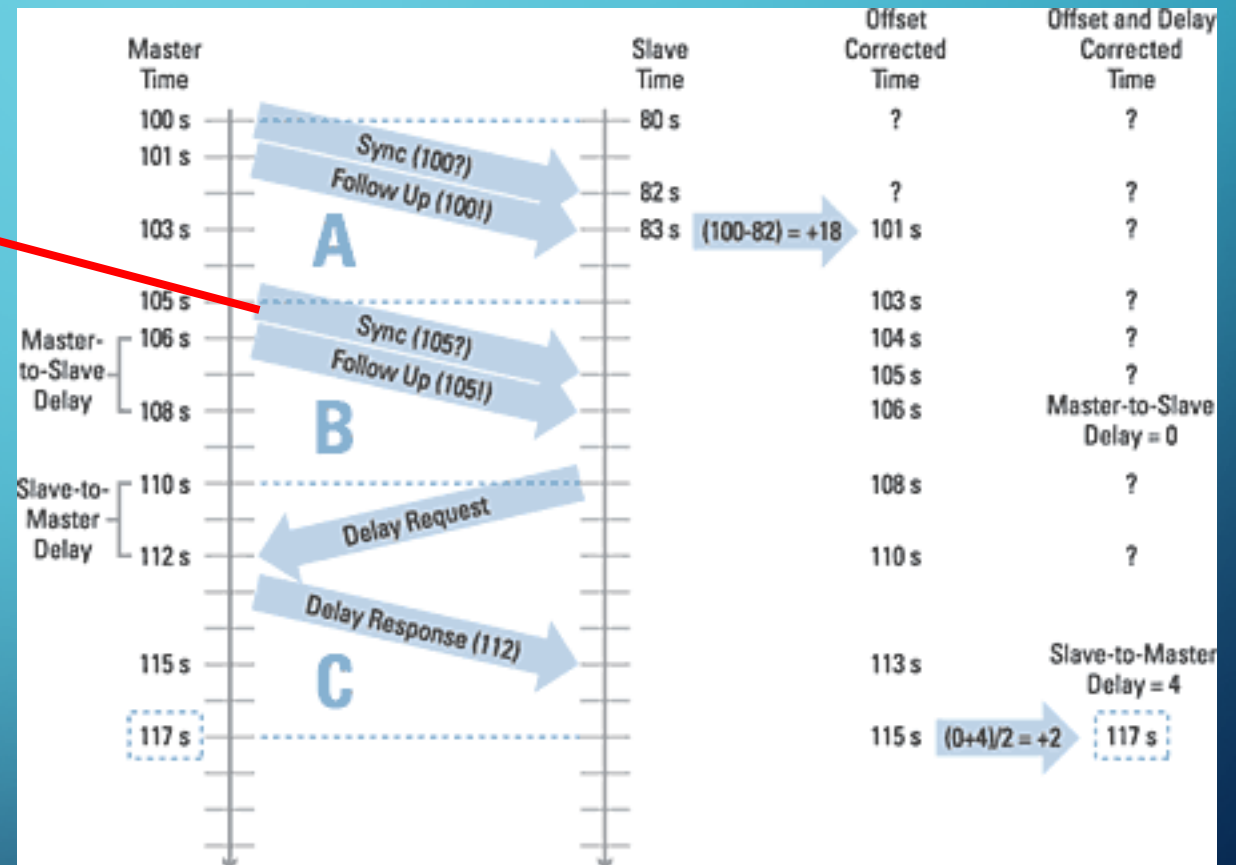


Fig. A simplified diagram of Precision Time Protocol  
(<http://www.ni.com/newsletter/50130/en/>)

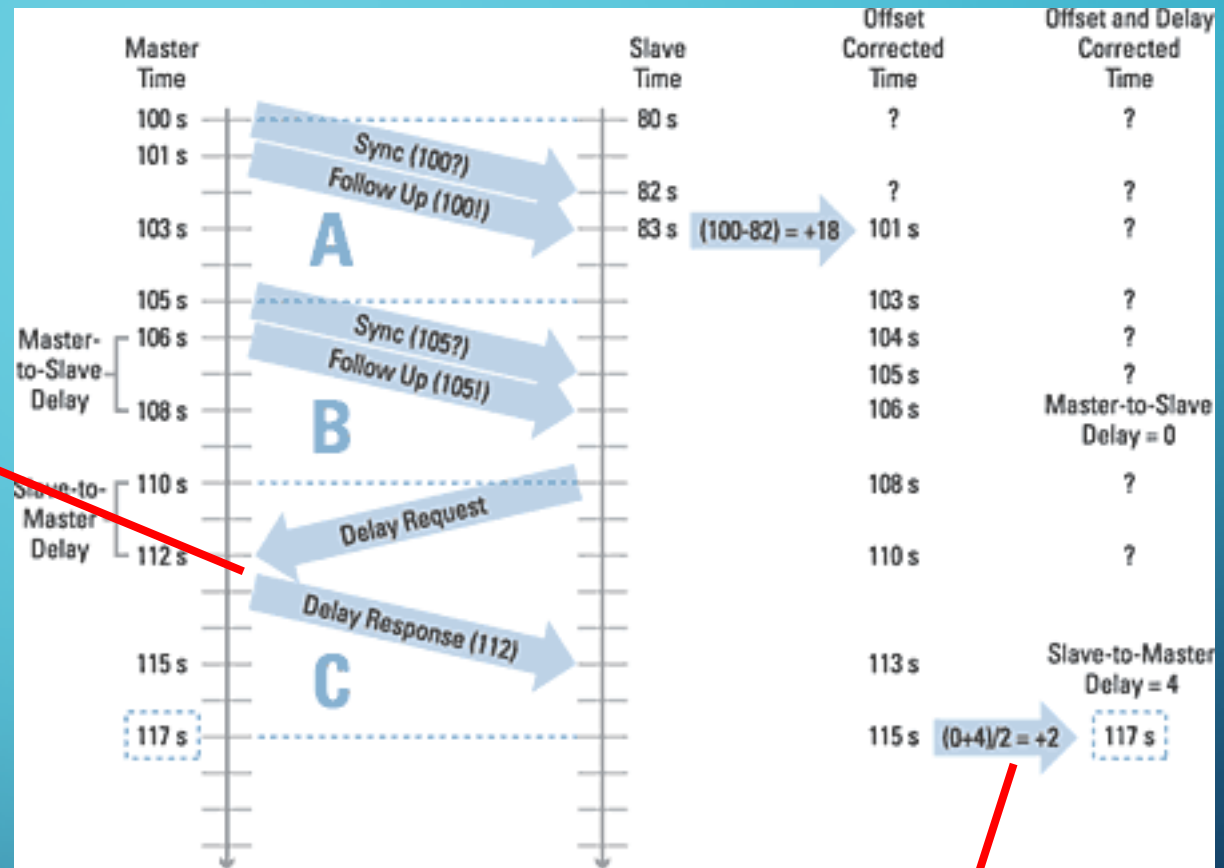
Second **sync** message and follow-up calculates the master-to-slave delay.

Master-to-slave delay =  
Send time at master –  
Receipt time at slave clock



Delay request and delay response messages calculate the slave-to-master delay.

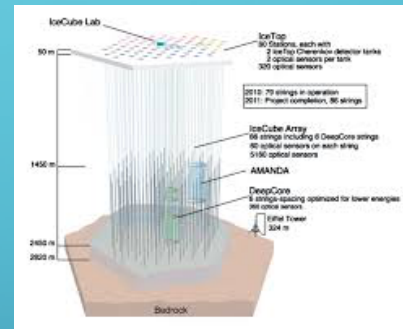
Slave-to-master delay =  
Send time at slave clock –  
Receipt time at master clock



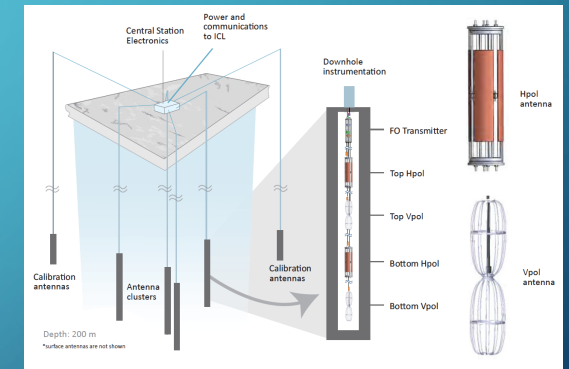
One way delay = (Master-to-slave delay + Slave-to-master delay)/2

# IMPLICATIONS FOR THE USE OF PRECISION TIME PROTOCOL IN UHE EXPERIMENTS

- Potential to synchronize clocks of ARA and IceCube up to a few nanoseconds.
- Synchronization → Noise reduction.
- Also achieve synchronization between stations.



IceCube



ARA

Clock synchronization  
using PTP

# FIRMWARE FOR PRECISION TIME PROTOCOL

- Microcontroller on the ARA DAQ needs to be programmed to recognize PTP packets and forward them on to the output pin.
- Precision Time Protocol daemon (PTPd): open source, software-only implementation of PTP.

TIVA TM4C1294  
MICROCONTROLLER

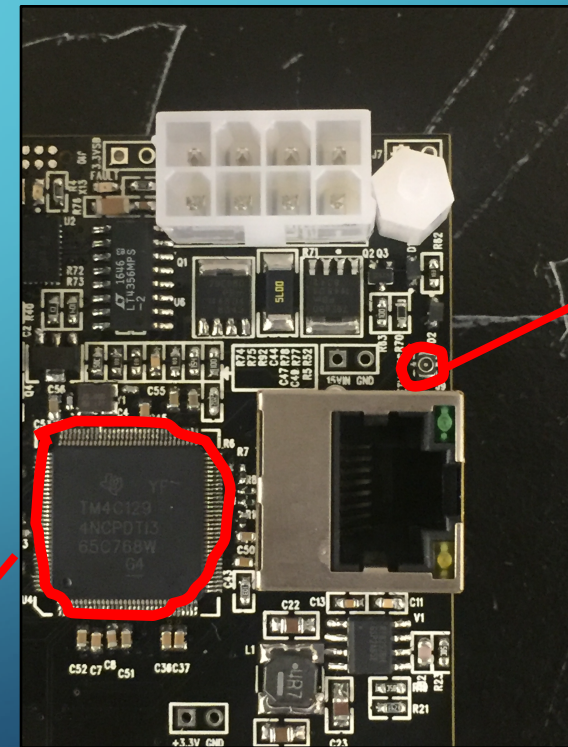


Fig. Hardware for PTP on the ARA  
Smart Power Data Acquisition  
board.

# DESIGN

- Clock Servo
  - Data path from protocol to to clock.
  - Calculates & filters offset, delay and inputs them to the Proportional-Integral (PI) Controller.
  - The PI controller disciplines the clock.

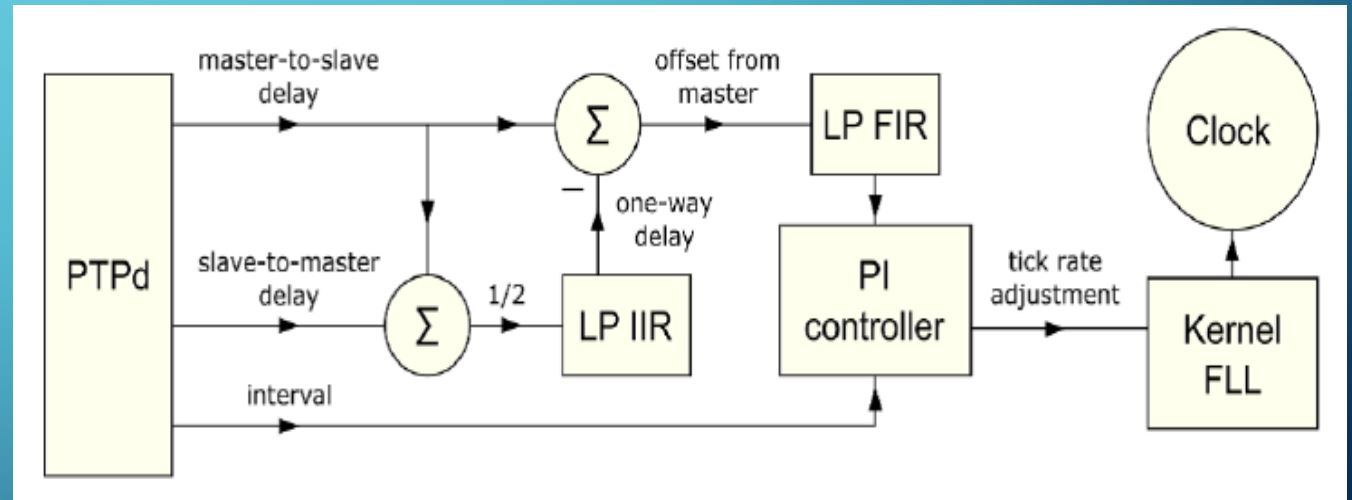
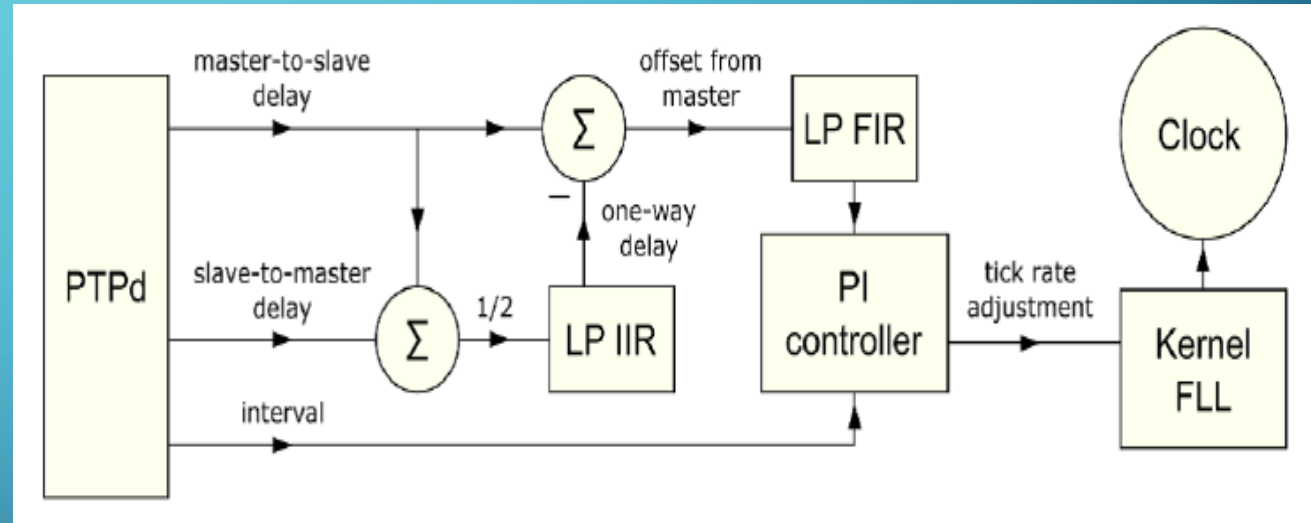


Fig. Diagram of the Clock Servo  
(Correll, Kendall, Nick Barendt and  
Michael Branicky's paper, 2005)

# DESIGN

- PI CONTROLLER
  - Corrects the local lock by correcting both the time error & rate error.
  - Time error: difference in times between master and slave.
  - Rate error: difference in tick rates between the clocks.



# CONSTRAINTS FOR USING PTP DAEMON

- Relies on Linux environment.
- Software-only implementation.
- Lesser coordination on medium time scales due to jitter in offset estimation as seen in the Allan variance plots.
- More suitable for stable network topologies or in other words, dynamic stiffness functionality is not present.

# SUMMARY

- Time synchronization b/w ARA and IceCube can help reduce thermal noise by allowing us to look at shorter time intervals.
- Microcontroller in ADAQ needs to be programmed to recognize and forward PTP signals.
- PTPd is a software-only implementation which could be used to program microcontroller.
- Several constraints with PTPd: lesser coordination on medium time scales and the need for stable network topology.

# REFERENCES

- Correll, Kendall, Nick Barendt, and Michael Branicky. "Design considerations for software only implementations of the IEEE 1588 precision time protocol." *Conference on IEEE*. Vol. 1588. 2005.