ELECOMP CAPSTONE SYMPOSIUM
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THE UNIVERSITY OF RHODE ISLAND

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# Network Control Signaling - Precise Timing Control via Ethernet

FARSOUNDER

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## Project Motivation

FarSounder's sonar has a transmit system that must be synchronized with the receiver's data collection system. The receiver system electronics are stored in the in-water portion of the system (the Transducer Module). Transmit system electronics are stored in the on-board portion of the system (the Power Module). A custom bundled cable with ethernet, transmit signal, power supply, and DIO conductors connects the power module and transducer module. The cable currently being used by FarSounder is clunky, large, and heavy, making it difficult to install and more costly to ship. The cable also requires many potentially unnecessary parts which increases the price of the cable. For our project, we hope to reduce the size of the cable by removing the potentially unnecessary DIO conductors (**Fig. 1, in red**), and to use the existing ethernet cable connection to transmit the necessary data. Reducing the size of the cable and the number of conductors within it will allow for a cheaper and easier to use product.

## Anticipated Best Outcome

By April, it is necessary to have successfully produced the sample source code for the development boards that meets FarSounder's requirements, and can be used as a reference design by FarSounder for implementation in their electronics. This solution will be an entirely ethernet-based method to synchronize the transducer module and the power module. By implementing this method, FarSounder should be able to remove the 4 DIO conductors from their custom bundled cable. Overall, we hope that our solution can be used in the future in order to create a cheaper and more efficient product.

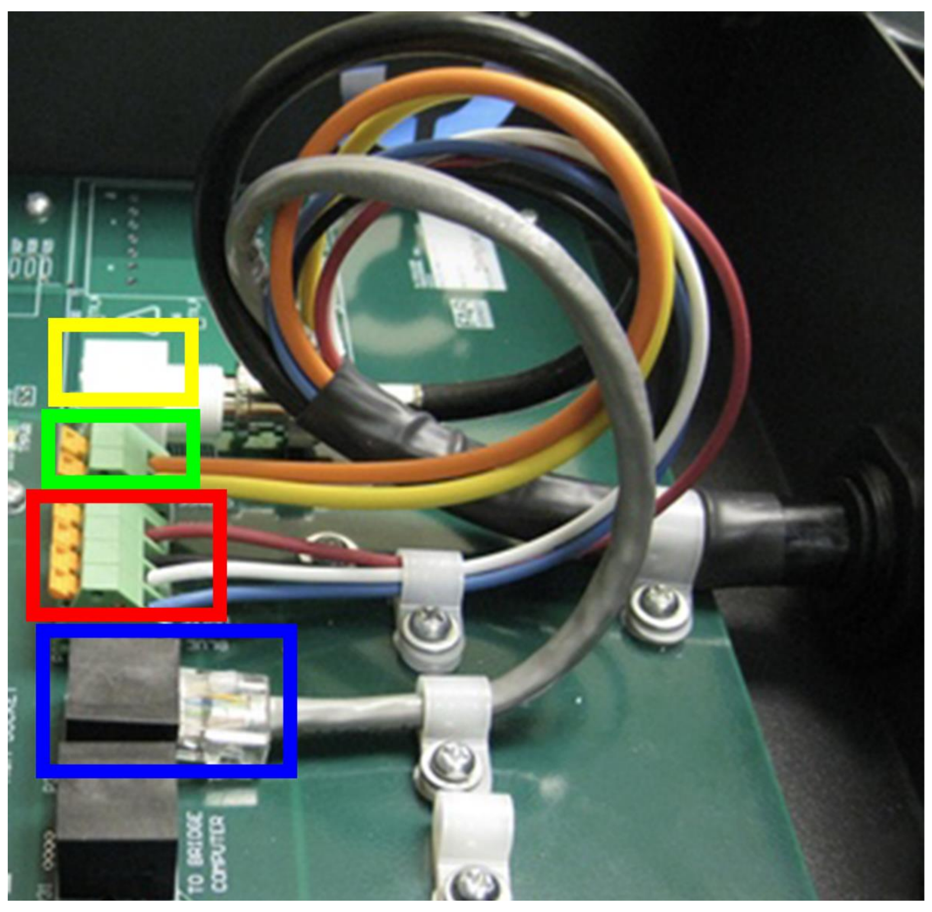
## Key Accomplishments

**Communication Method Selection:** An ethernet-based network protocol was selected that meets our timing requirements in terms of accuracy. This protocol was identified to be the Precise Timing Protocol (PTP). It offers the capability for a master-slave style clock synchronization that can be within 10µs of accuracy **(Fig. 4)**. It was also necessary to identify some peripheral communication methods for interfacing with other devices in the sonar system. PTP will be used to modify FarSounder's time synchronization system from the current DIO method **(Fig. 2)** to the ethernet based method **(Fig. 3)**.

**Microcontroller Selection:** A microcontroller evaluation kit was selected that allows for prototyping an ethernet-based clock synchronization implementation and has capabilities to interface with other devices in the sonar system. The device is NXP's MIMXRT1060-EVK. This board features an ARM-based MCU, 100mbps Ethernet with support for the Precise Timing Protocol (PTP), multiple USB ports, and much more. Development for this platform is done with the MCUXpresso IDE.

**Learning how to develop for the platform we have chosen:** Through the use of many included demos and functions available for the MIMXRT1060, a strategy for development was put together. This included learning how to demonstrate program execution without a debug host controlling the execution. In other words, show the board booting from a power source and running a program of our choice without the intervention of a PC or IDE. Other tasks included learning to write values to GPIO, as it may be done to send signals to other parts of the sonar system.

**Demonstrating Network Activity:** A C library was identified that allows for the implementation of a full TCP/IP stack used for sending and receiving data: the Lightweight IP library (lwip). Using this library and its included functions, we can ping the development board from an ethernet-connected PC. It is also possible to transmit and receive ASCII messages using the board and lwip's implementation of Transfer Control Protocol functionality (TCP).



**Yellow: Transmit Signal**
**Green: Power Supply Conductors**
**Red: Digital I/O conductors**
**Blue: Ethernet**

**Fig. 1**: View of the conductors involved in the custom cable bundle.

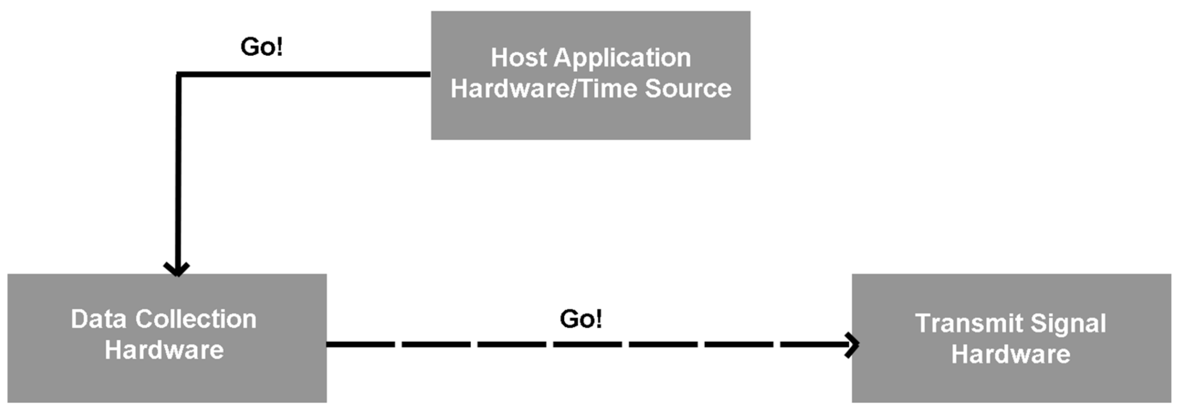



**Fig. 2**: Block Diagram of FarSounder's current time sync system

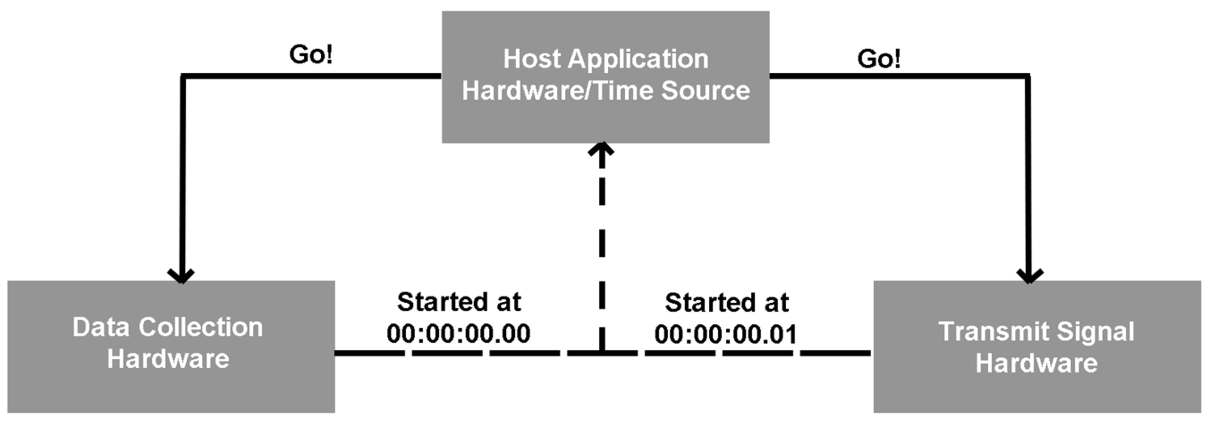



**Fig. 3**: Block Diagram of FarSounder's desired ethernet-based time sync system

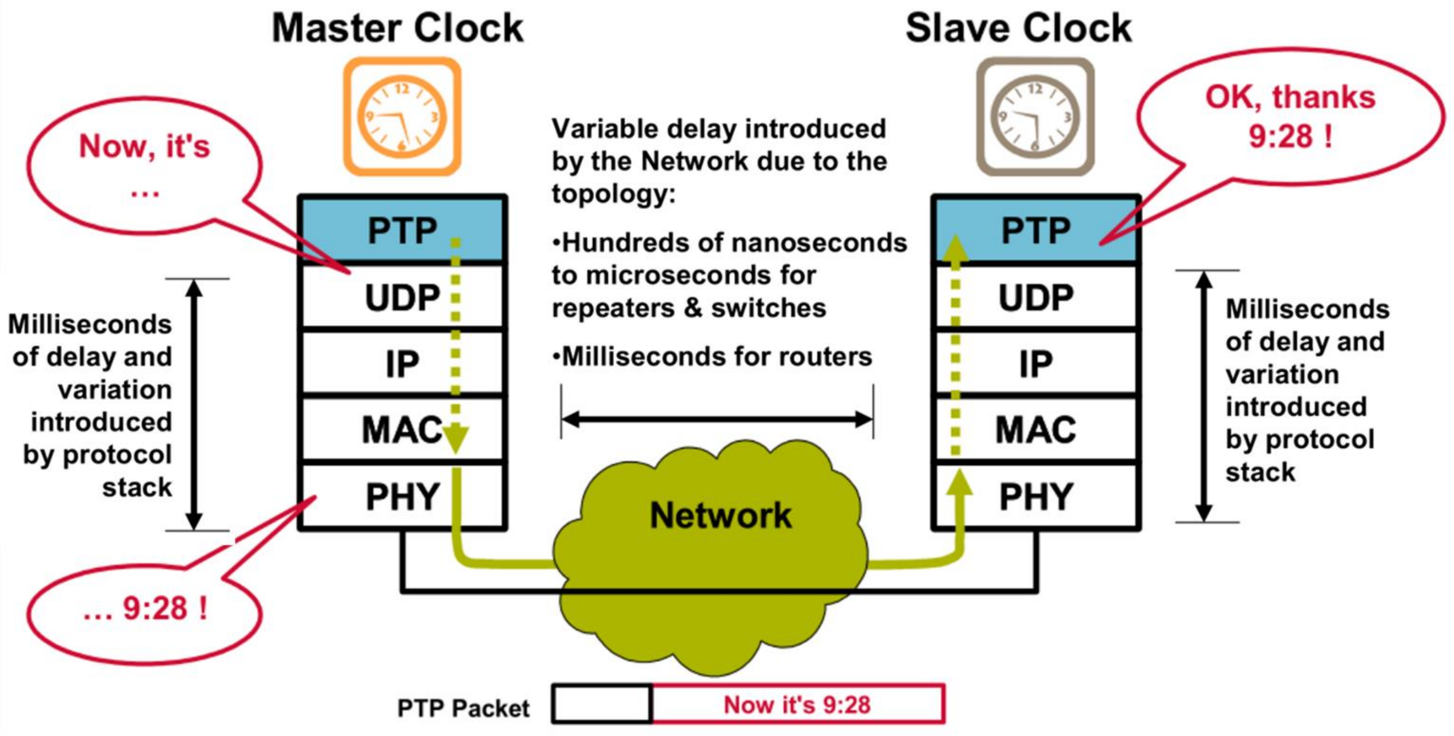



**Fig. 4**: Brief explanation of how PTP works on two microcontrollers connected via an ethernet network

## Remaining Technical Challenges

**Connection between two Microcontrollers:** In order to implement tPTP on the microcontroller pair, a master-slave connection between the two boards must first be established. In order to do this, a master-slave demo program must be implemented successfully using a wired connection between the external pins of both MIMXRT1060-EVK boards.

**Ethernet interaction between boards:** The two MIMXRT1060 boards must also be able to communicate using ethernet. A reliable method to allow for the boards to send information to each other using an ethernet cable must be determined. A first step in this process would be to find a way to send a simple message from one board to another using the local area network.

**IEEE 1588 PTP implementation:** After a master and slave connection between the two boards has been established and the boards have successfully communicated using ethernet, the PTP timing protocol must then be implemented. To do this, a PTP 1588 demo code must be modified to allow for PTP implementation between two boards over ethernet (Fig. 3), as most PTP 1588 demos establish a connection between one board and a PC.

**Verify Clock Accuracy:** It is one thing for the devices to notify if they are in sync or not, but to be able to prove this using some kind of measurement that is external to the board would be ideal so that we can be sure that the implementation of PTP is working properly.
Test Synchronization with more variables: It may be beneficial to test how well the clock synchronization method works with other nodes in the network. This could be done by adding a PTP-supporting switch in between two of the boards. In doing so, it may be possible to determine how other devices and traffic in the network affects the accuracy/reliability of the clock synchronization.

## Implications for Company & Economic Impact

Benefits for the production of each sonar unit include: a smaller cable diameter which means the cable will be lighter, easier to route, and have a smaller minimum bend radius (therefore making it easier to install). Another benefit is reduced cost of parts, due to having less conductors. The underwater connector could also cost less and require less precision when being mated. A rough estimate of the total savings per system is about $300 to $400 per unit. This process may also make it possible to switch to a more commonly used and accessible cable, helping to streamline the manufacturing process.

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