

The Application of precision time protocol on EAST timing system

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Abstract The timing system focuses on synchronizing and coordinating each subsystem according to the trigger signals. The former timing system was based on commercial off-the-shelf devices and a set of synchronized optical network which was made up of several pairs of multi-mode fibers. The expensive PXI devices and inconvenient extension methods compel maintainers to upgrade the timing system to meet the ever increasing demands of the experiments. A new prototype timing slave node based on precision time protocol has been developed using ARM STM32 platform. The proposed slave timing module is tested and experimental results show that the synchronization accuracy between slave nodes is in sub-microsecond range. This paper will introduce the features of the precision time protocol and the details about the system architecture, slave timing module platform and test results will be described in this manuscript.

Motivation

Main Goals of Timing system

- To provide the timing reference clocks
- To provide the trigger sequence signals

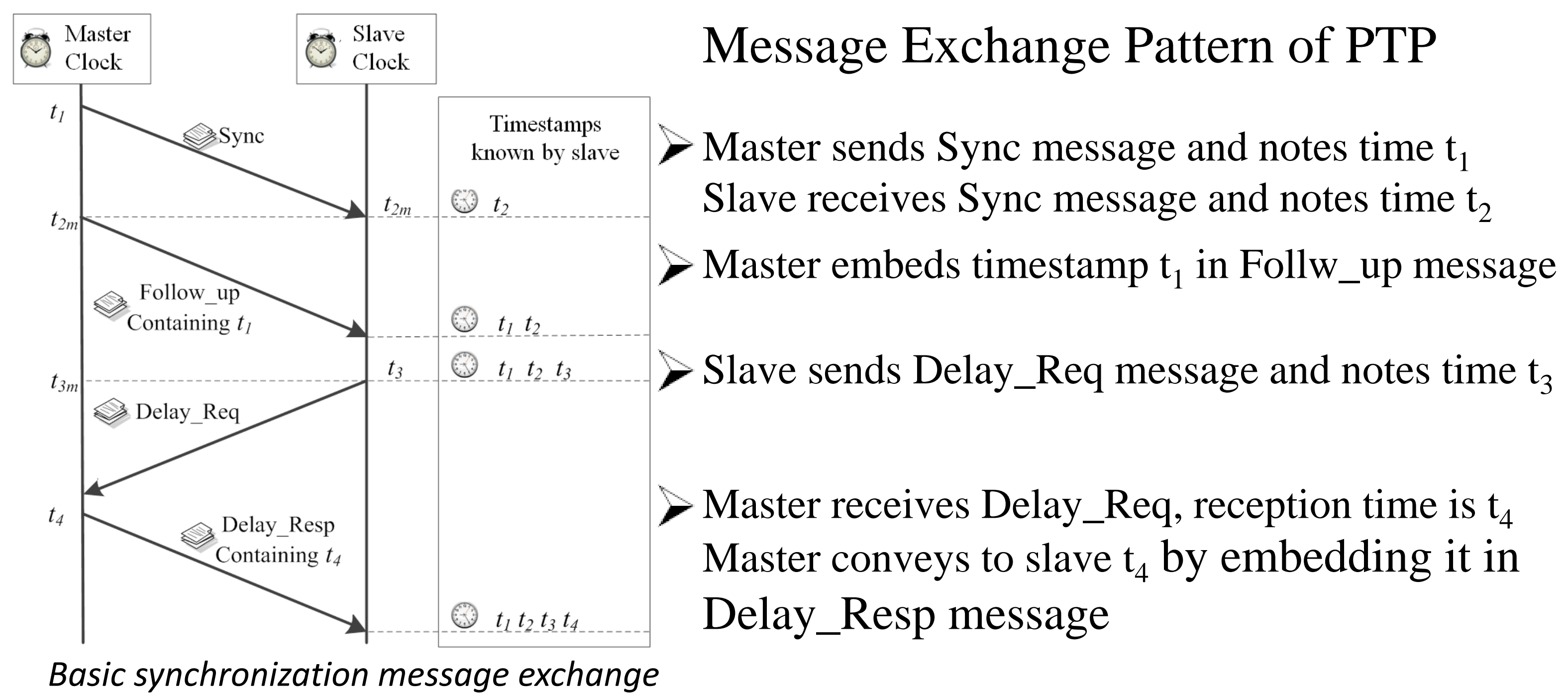
Previous system

Commercial off-the-shelf devices → HIGH COST

Pairs of equal length fibers → Be plagued with expansion

Stable, Easy expansion, First step for custom devices

Background



$$\text{offset} = \frac{t_2 - t_1 - t_4 + t_3}{2} = \frac{(t_2 + t_3) - (t_4 + t_1)}{2} \quad \text{MS_Delay} = \frac{t_2 - t_1 + t_4 - t_3}{2} = \frac{(t_2 + t_4) - (t_1 + t_3)}{2}$$

System Components

◆ Database Server Linux MySQL

◆ Synchronized Network

Control Network, PTP Network, Optical Fan-out Network

◆ Isolation & Drive Fan-out Module

- Remove ground loops among different subsystems
- Provides high voltage isolation

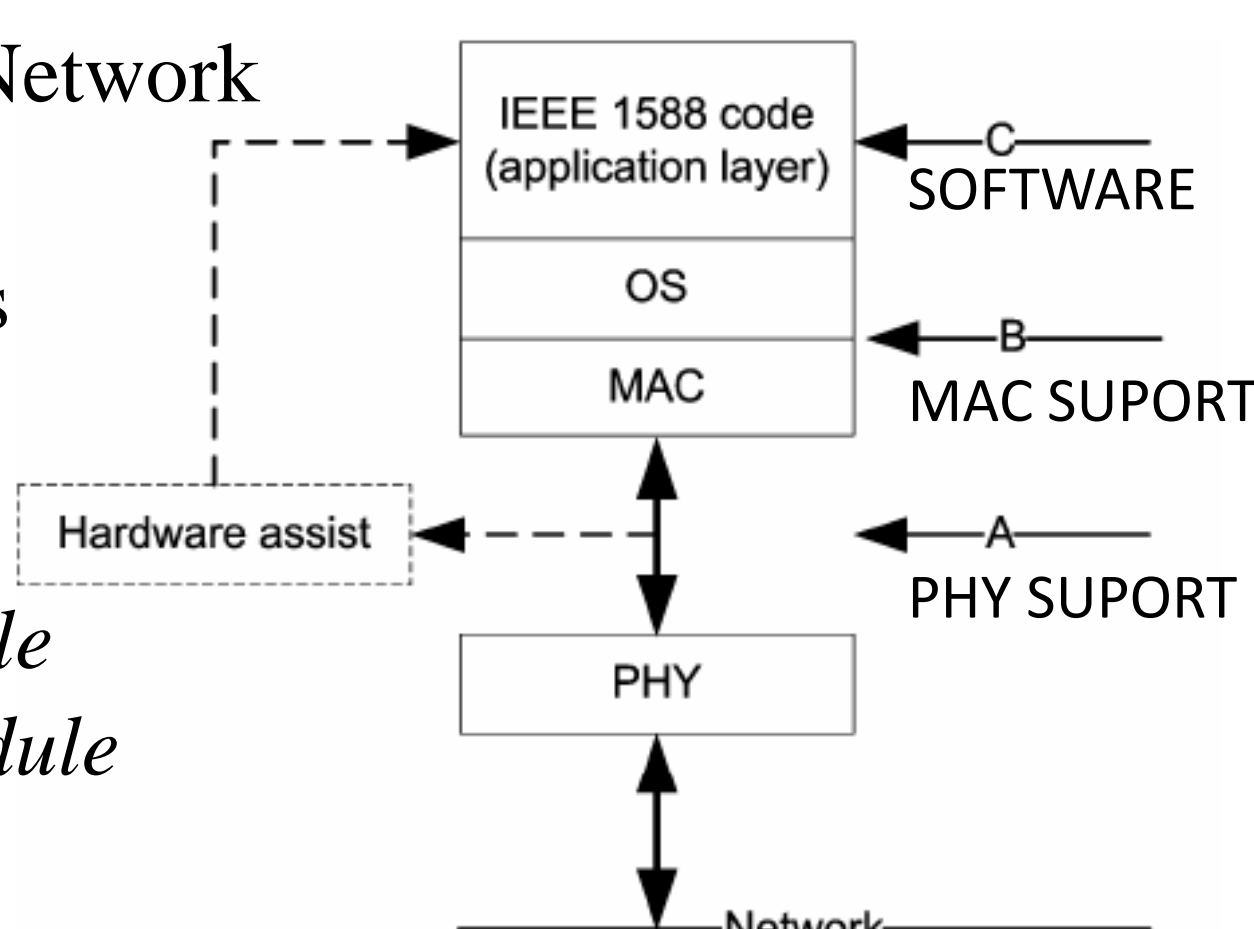
◆ Master Node -- PXI node -- GPS

PXI-6683 Timing and Synchronization Module

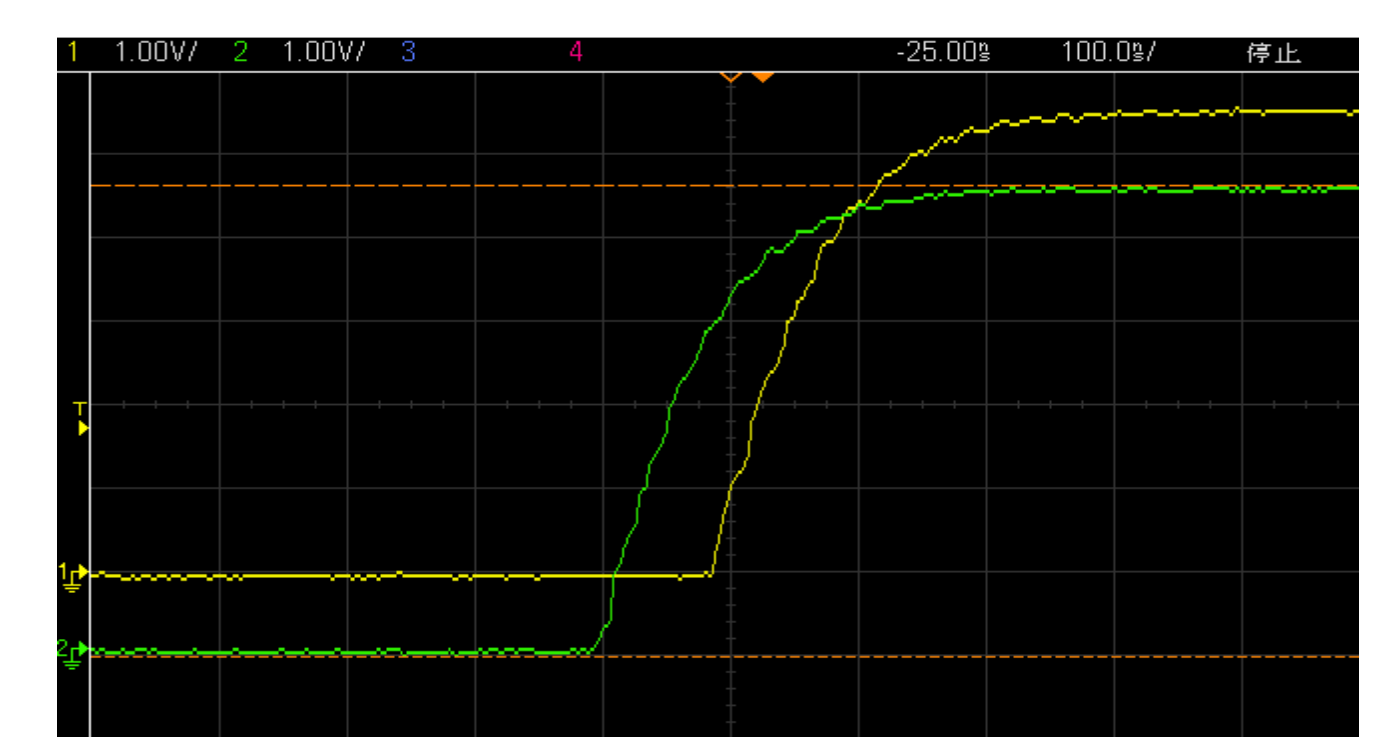
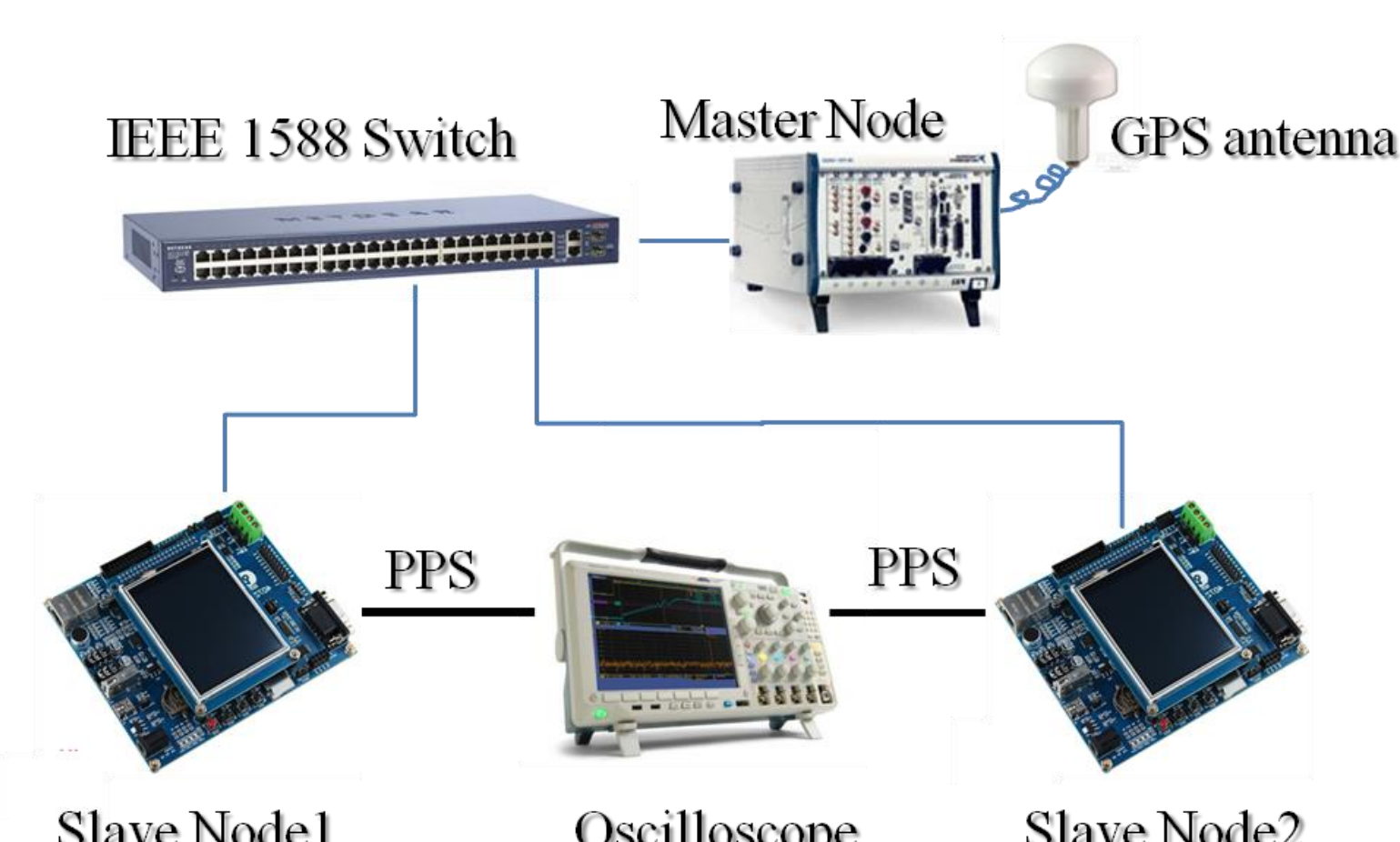
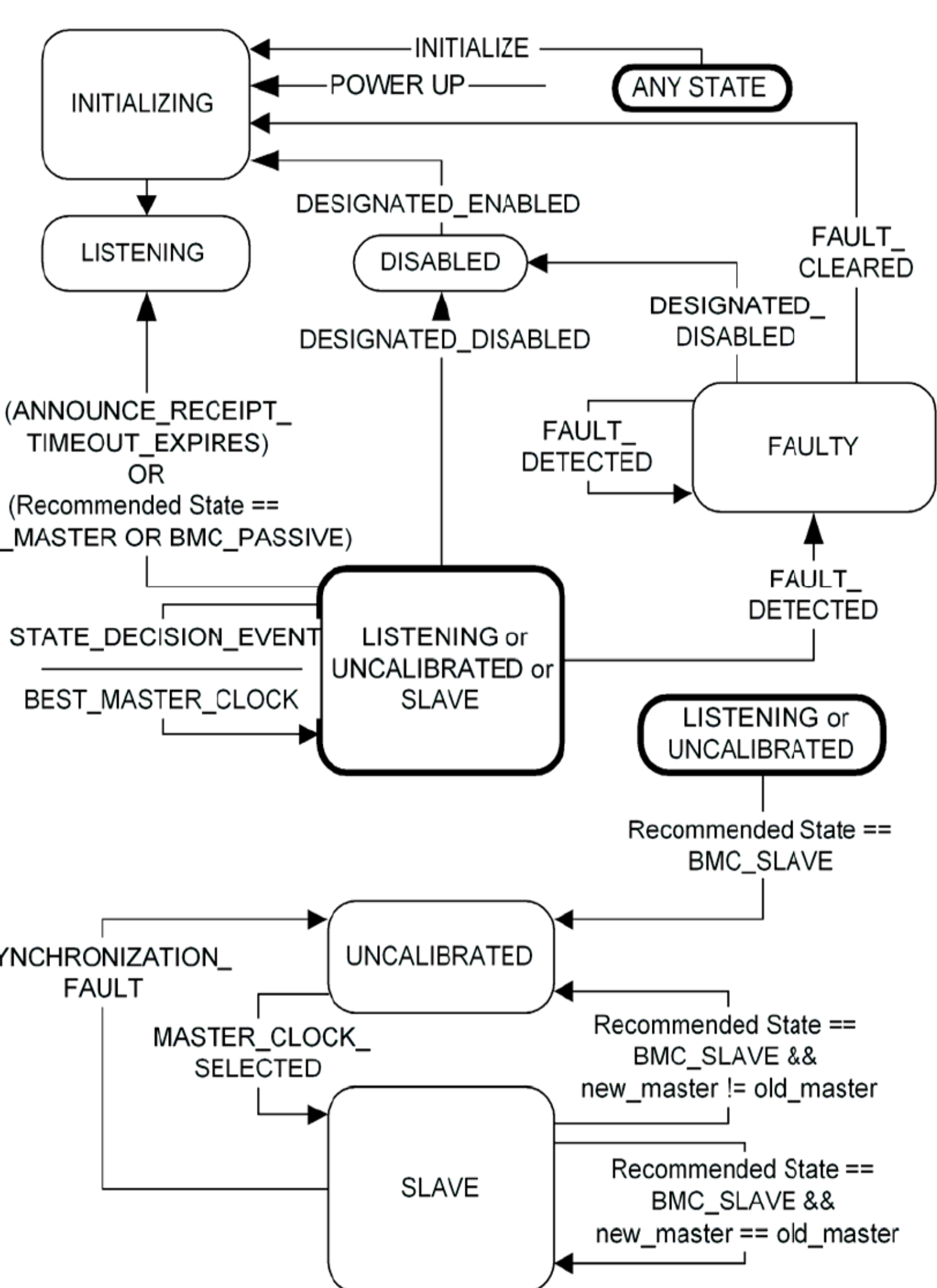
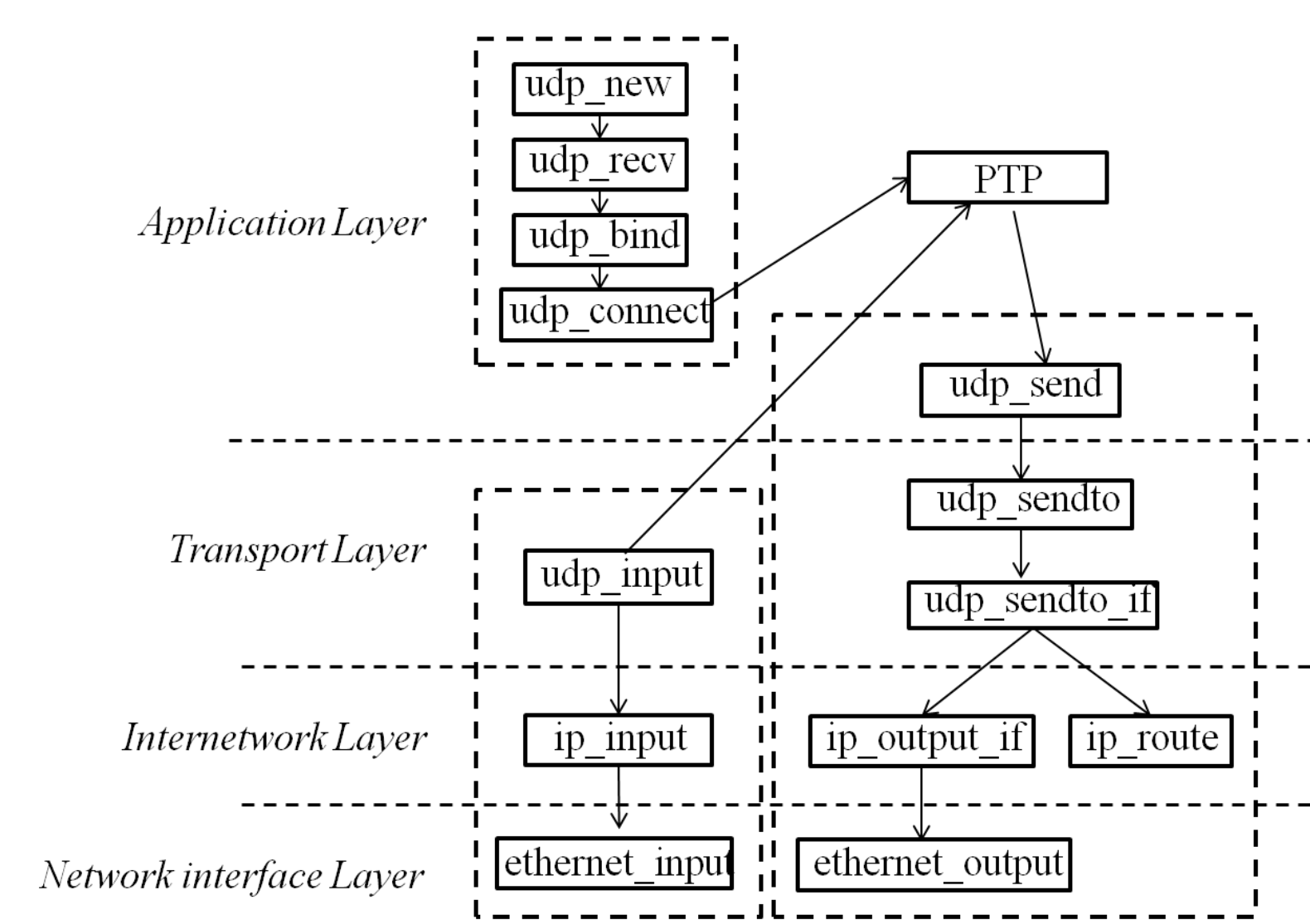
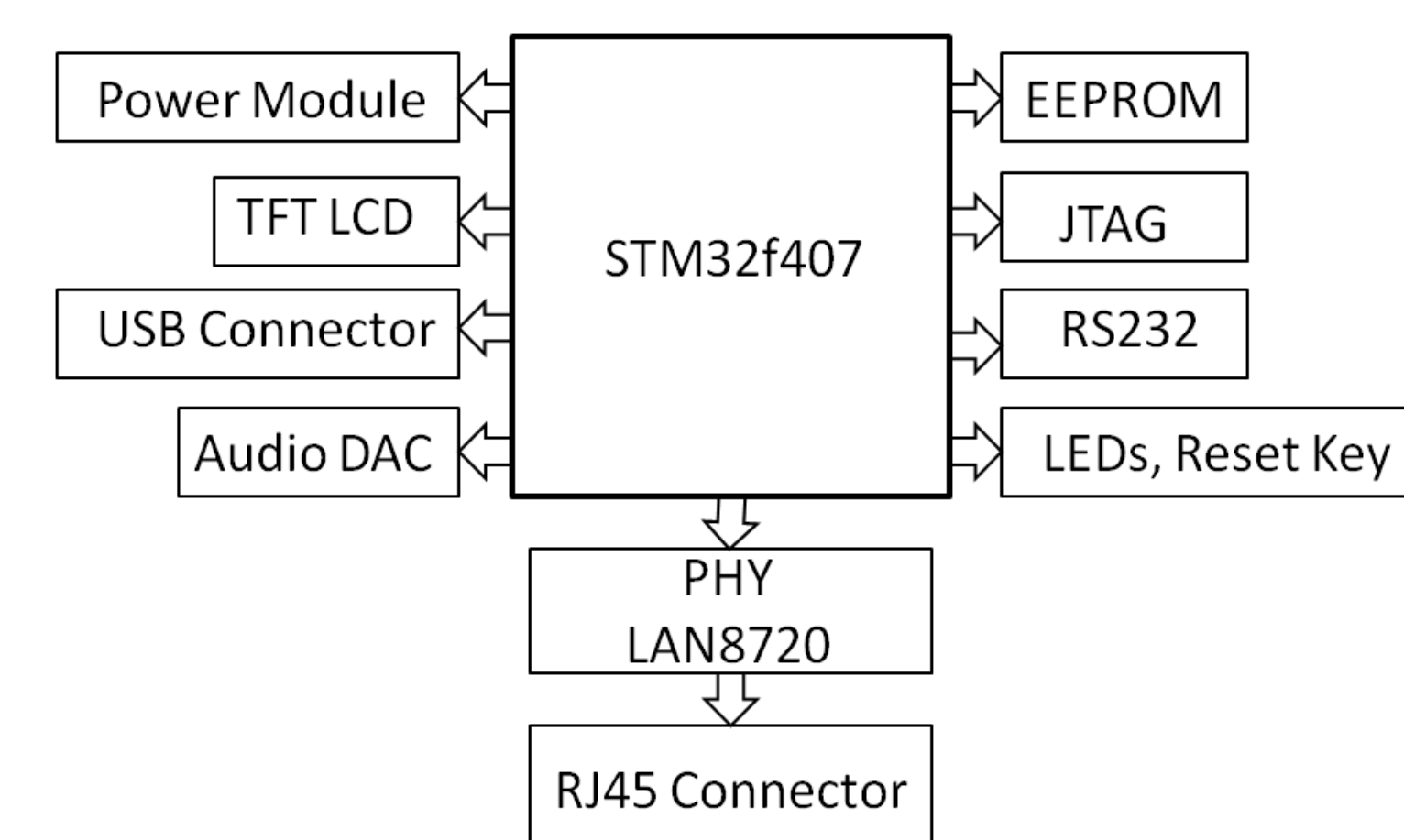
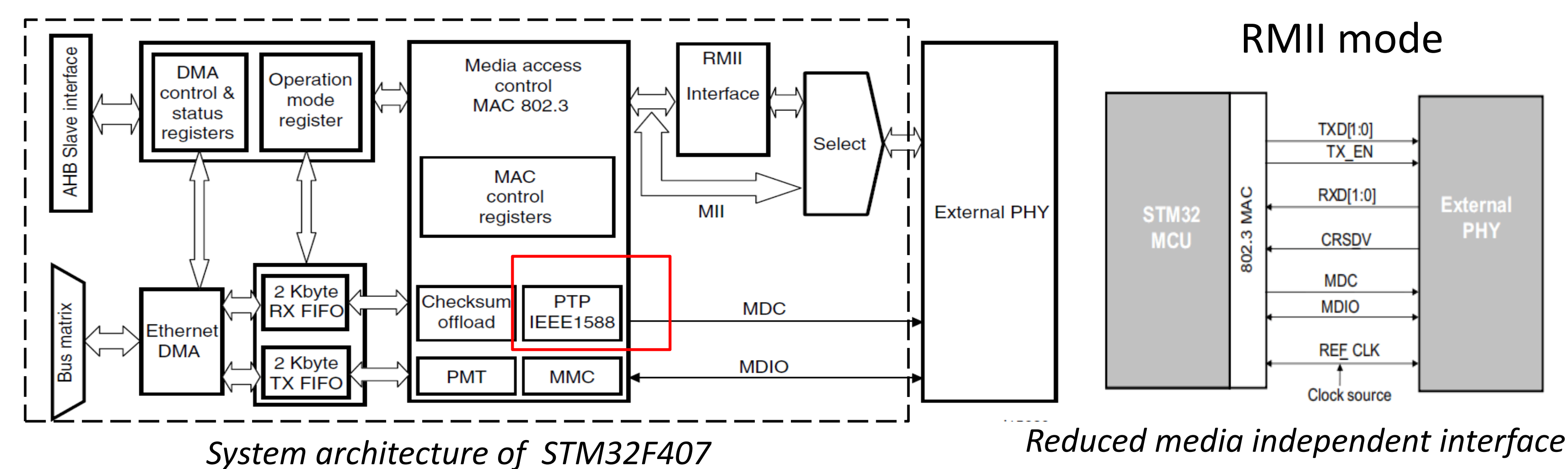
PXI-6608 High-Precision Counter/Timer Module

◆ Slave Node -- STM32+LWIP

- STM32F407
- 168 MHz CPU/210 DMIPS, up to 1 M of Flash memory adding Ethernet MAC
- Support IEEE 1588 protocol
- LWIP
- Protocols: IP, IPv6, ICMP, ND, MLD, UDP, TCP, IGMP, ARP, PPPoS, PPPoE
- DHCP client, DNS client, AutoIP/APIPA (Zeroconf), SNMP
- APIs: RAW APIs, NETCONN APIs, Berkeley-like socket API



Slave node architecture



Summary

The precision time protocol (PTP) IEEE 1588 standard is adopted by the EAST CODAC (Control, Data Access and Communication) system to implement the upgraded prototype timing node. All the nodes with PTP in different places have access to the timing network by normal Ethernet cable, and the timing node is synchronized with other IEEE 1588 devices on the network. The results between slave nodes show that the precision trigger with a high synchronization is realized, which can fulfill synchronization requirements of the subsystem.