Discussion of Multidrop Access Methods

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Purpose

- The purpose of this presentation is to:
  - Initiate discussion on multidrop access methods

Motivation

- IEEE P802.3cg may develop a multidrop option for cost sensitive applications
- A deterministic access method is required for control applications
  - Automotive
  - Industrial
  - Other

Relevant IEEE methods

- 802.3 MPCP (MultiPoint Control Protocol)
  - Defines scheduled transmission
  - Defines time synchronization used by scheduled transmission
- 802.1 TSN (Time Sensitive Networking)
  - 802.1Qbv defines scheduled transmission
    - Can avoid collisions
  - 802.1AS defines a time synchronization method usable by scheduled transmissions
  - Defined for a Coordinated Shared Network (CSN)

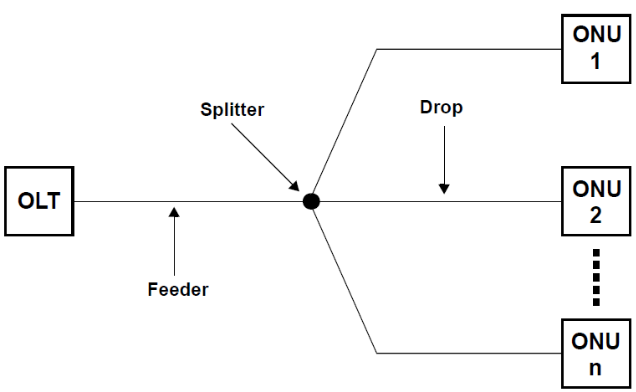
Observations

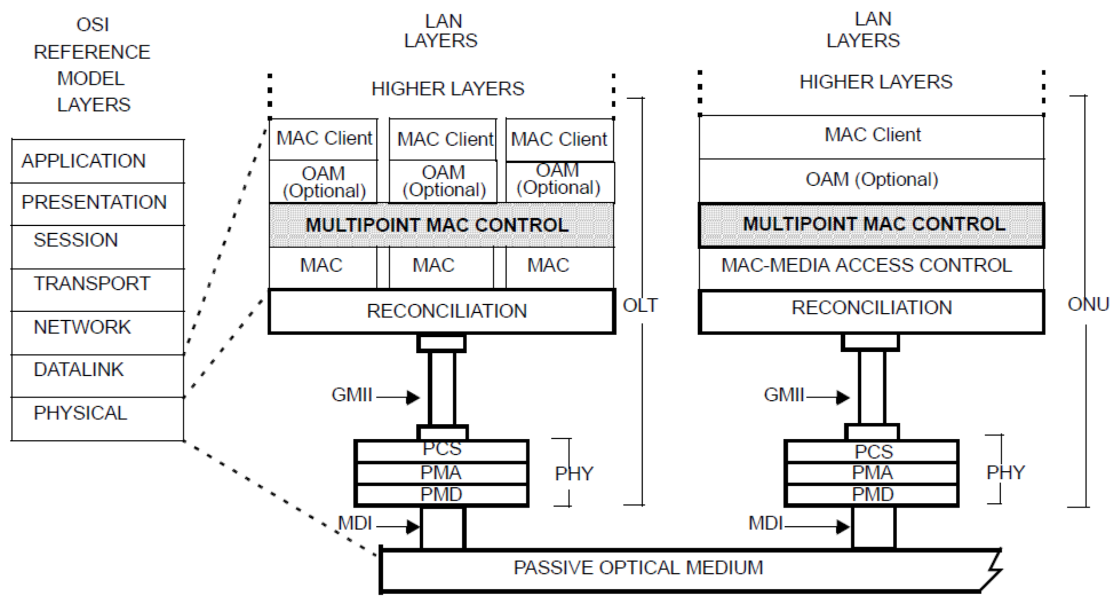
- TSN is on a path to becoming an expected option for deterministic Ethernet
- MPCP is likely to also require TSN

MULTIPOINT CONTROL PROTOCOL (MPCP)

Multipoint MAC Control (Clause 64)

- “Multipoint MAC Control sublayer” replaces the “MAC Control sublayer” to support multiple clients and additional MAC control functionality
- Multiple MAC entities use a single Physical Layer (and PHY)



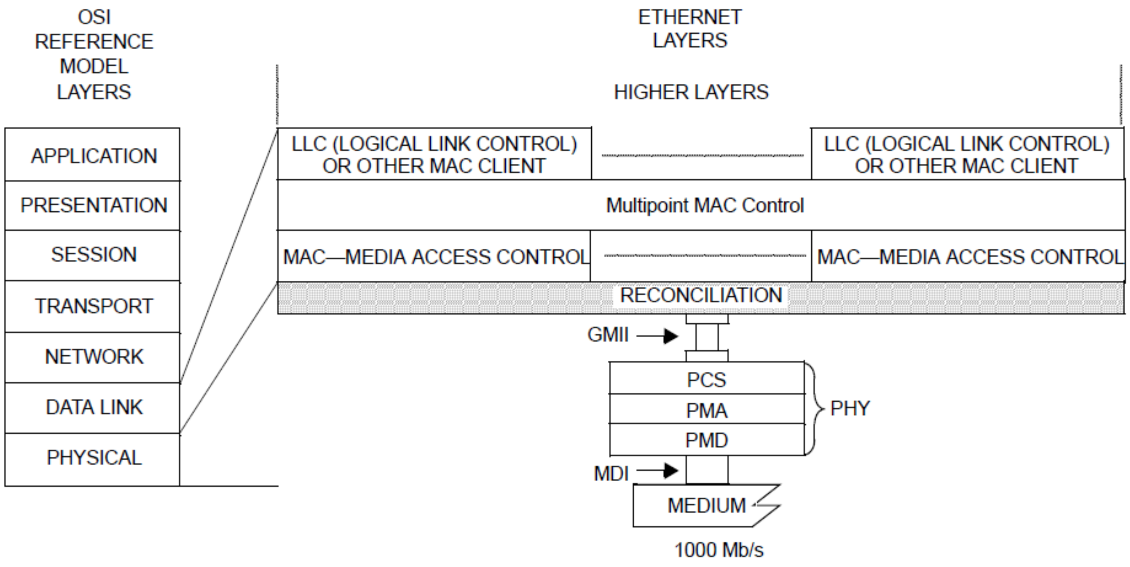


Multipoint MAC Control (Clause 64)

- Time synchronization
  - Local time is kept by a 32-bit counter that increments every 16 ns (62.5 MHz)
  - OLT distributes time
  - OLT initiates Round Trip Time (RTT) measurement and informs ONUs
    - Can be used for ranging
  - Must guarantee a constant delay through the MAC and PHY in order to maintain the correctness of the timestamping mechanism
    - Maximum delay variation of 16 bit times through the MAC
- Scheduling
  - OLT sends "GATE messages" with time grants to organize the transmission schedule
  - No specific algorithm

Extensions of the Reconciliation Sublayer… (Clause 65)

- RS handles multiple MACs
  - Each identified by a Logical Link Identifier (LLID)
- Modified preamble carries the LLID so that RS can choose a MAC



Changes are required

- Not GMII
- Probably 62.5 MHz clock is too fast
- Consideration of linkage to TSN
- Consideration of default schedule for simple applications

CSMA/CD

Motivation for CSMA/CD usage

- CSMA/CD is a well-known technique
- Already available in:
  - Existing 10M MACs
  - Low-end MCUs
- All that is required for many applications is access and congestion control
  - Client/server and infrequent updates

TSN Coordinated Shared Network

- TDMA (scheduled access) creates a CSN
- TSN provides scheduling
- TSN scheduling depends on time synchronization

- Does (or can) time synchronization be made to work on top of CSMA/CD?

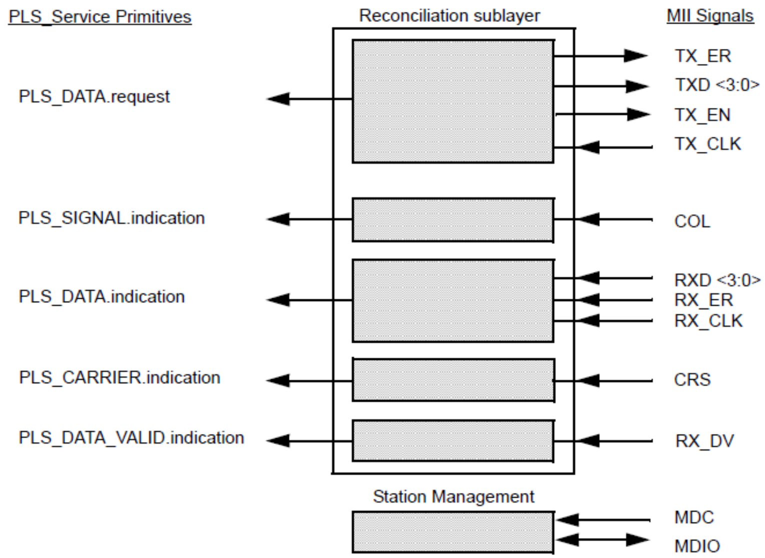
TIMESYNC OVERVIEW

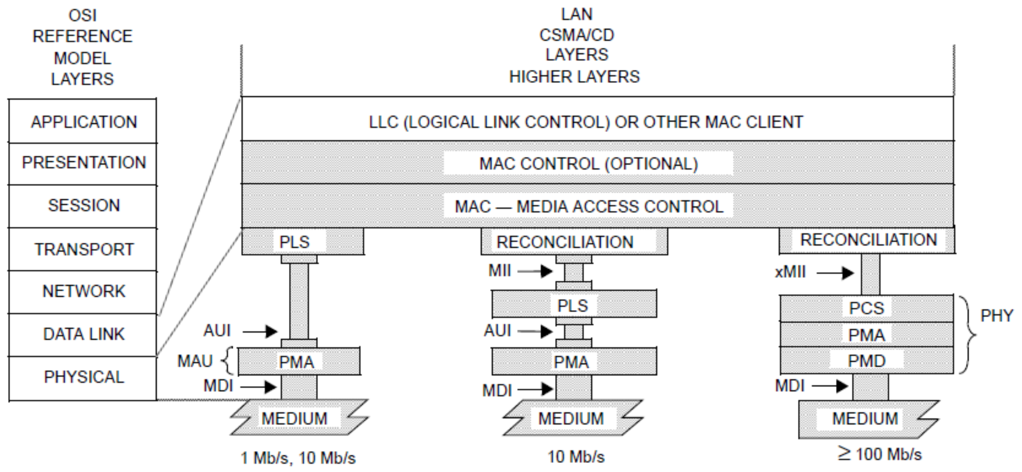
IEEE P802.3bf

- http://www.ieee802.org/3/bf/public/1007/3bf_1007_carlson_1.pdf

Reconciliation Sublayer (Clause 22)

- Mapping function between the MAC and PHY
  - Creates optional interface to a physical layer device
    - "simple, inexpensive, and easy-to-implement"
  - Puts part of the OSI physical layer (the RS) into another device (sometimes an MCU)



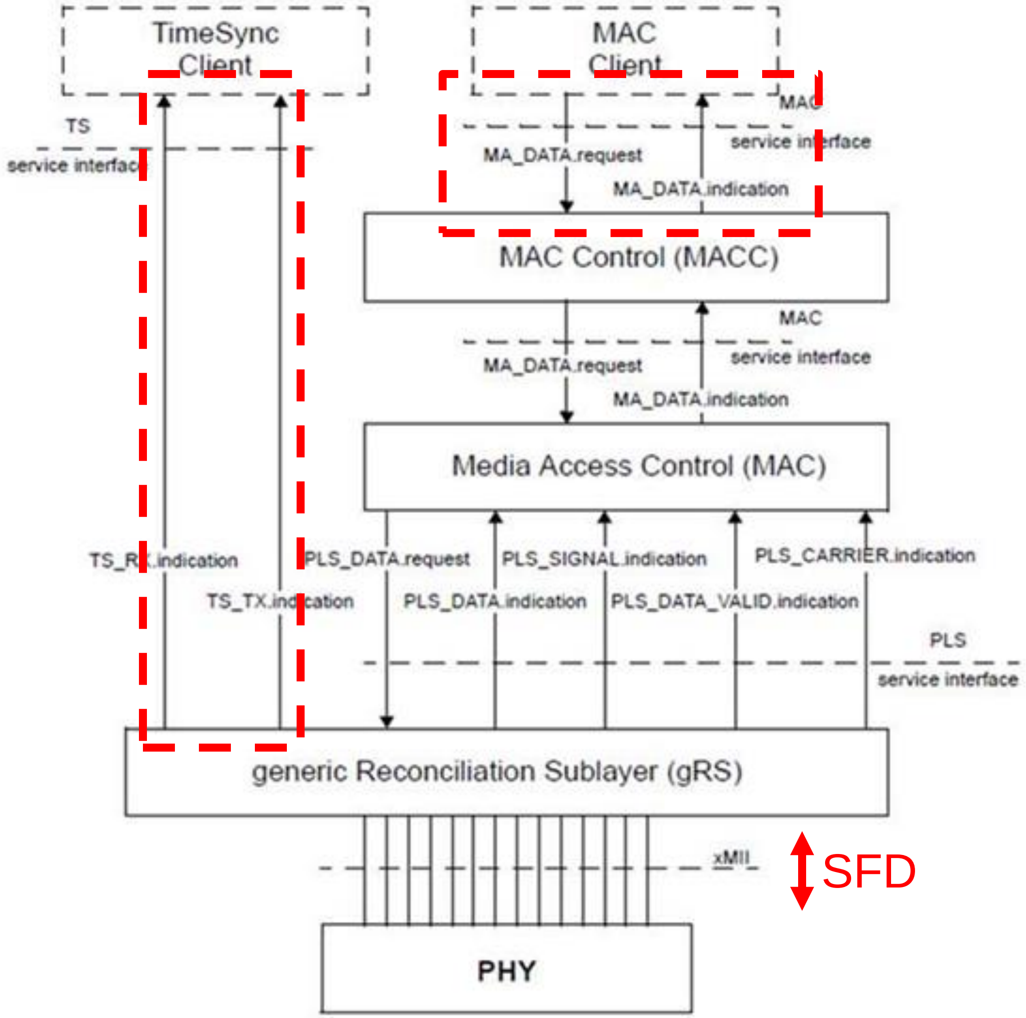


AUI = ATTACHMENT UNIT INTERFACE
GMII = GIGABIT MEDIA INDEPENDENT INTERFACE
MAU = MEDIUM ATTACHMENT UNIT
MDI = MEDIUM DEPENDENT INTERFACE
MII = MEDIA INDEPENDENT INTERFACE

PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PLS = PHYSICAL LAYER SIGNALING
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT

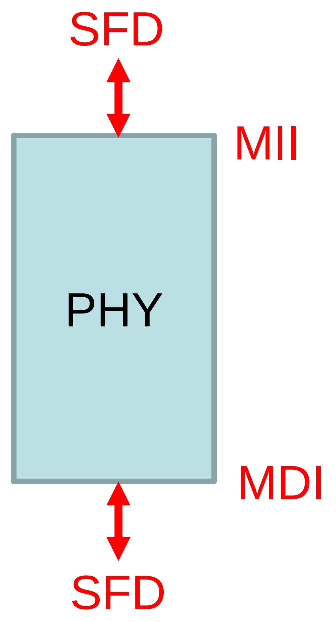
Time Synchronization Service Interface (TSSI) (Clause 90)

- gRS generates indications for transmit and receive based on detecting Start of Frame Delimiter (SFD) egress or ingress at the xMII interface
- Both data frames (MAC client frames) and control frames (MAC Control frames) generate TS indications
  - MAC can distinguish, but was not changed
  - TimeSync Client may act as MAC Client and note MA_DATA



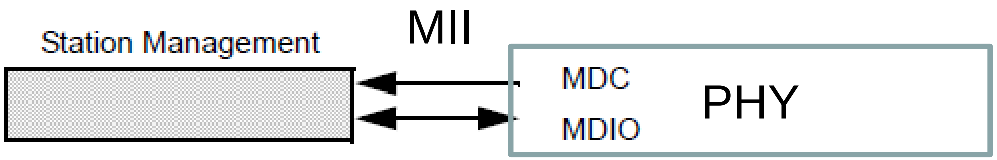
Data delay measurement (Clause 90.7)

- Transmit path data delay
  - Measured from the input of the beginning of the SFD at the xMII to its presentation by the PHY to the MDI
- Receive path data delay
  - Measured from the input of the beginning of the SFD at the MDI to its presentation by the PHY to the xMII



Management (Clause 30)

- TimeSync PHY-related management:
  - Aggregate value of the series of transmit path data delays
    - aTimeSyncDelayTXmax
    - aTimeSyncDelayTXmin
  - Aggregate value of the series of receive path data delays
    - aTimeSyncDelayRXmax
    - aTimeSyncDelayRXmin
- Values are derived from PHY Clause 45 MDC/MDIO registers
  - Not a *per frame* measurement
    - “minimum period for MDC shall be 400 ns” (2.5 MHz)



Limitation

- TSSI is defined for the full-duplex mode of operation only

HALF-DUPLEX TSSI?

RS modification seems plausible

- RS knows when collisions occur
  - COL from MII
- TS indications can be conditioned on whether a collision occurs
- In transmit, if there is a collision, no TS indication is sent, the MAC retries, on success a TS indication is sent
- In receive, a broken receive fragment may have a good SFD, but the collision is noted and the TS indication is not sent

- RS would have to wait until the slotTime of 512 bit times after the SFD before it was certain that there was no collision
  - Abnormal late collisions are left to upper layers
  - At 10 Mb/s, slotTime is 51.2 us, the minFrameSize of 64 octets
- TS client adjusts “delayed” indication by subtracting 51.2 us

Is RS modification in our Scope?

- RS is part of the OSI Physical Layer
- RS is not part of the IEEE PHY

- If we have to modify Clause 90, then it is still considered a "PHY project"?
- Implementation may be back in an MCU, with the end result is that we've changed the PHY specification, but a new PHY chip is not adequate, we need a new MCU
  - If both are together (like in a new SPI switch chip), then it doesn't matter

PHY signal method

- TI chose a PHY signal method to *improve accuracy*:
  - http://www.ti.com/product/DP83867CR/datasheet/detailed-description
  - http://www.ti.com/lit/an/snla242/snla242.pdf
- PHY generates an output when SFD crosses MDI interface
- MCU detects the PHY signal (an interrupt)
- No requirement for TS support in the RS

- MII interface could be extended, but not in legacy MCUs
- The same issue exists with collisions, but the PHY is what detects the collisions in the first place
  - A late signal could be sent and compensated by the TS client

TSN bootstrap (do nothing method)

- Time synchronization averaging methods have been used to operate over:
  - Unmanaged switches
  - Wireless
- Configuration messages can be sent over CSMA/CD links to configure scheduling
- Initial scheduling can operate with loose tolerances
- Messages (including time synchronization) messages flow in reserved slots without collisions
- Time synchronization accuracy improves
- Slot time is tightened

Comparison

Modified MPCP

- Requires a new project
- Not backward compatible with legacy MCUs
- Simplified PHY with no TimeSync or CD
- PHY must have a constant delay
- Headend requires multiple MACs
- Optional TSN
  - May replicate TSN functions
- Not usable in a simple random access system without some schedule

Modified CSMA/CD

- Project
  - Half-duplex RS+PHY TimeSync appears possible but requires a new project
  - PHY signal method potentially fits into current project
  - TSN bootstrap fits into current project
- May be backward compatible with legacy MCUs
- PHY requires TimeSync and CD
- Headend requires only a single MAC
- Optional TSN for determinism
- Usable in a simple random access system without scheduling

Conclusions

- Either of the two options appears workable
- The PHY signal method could give modified CSMA/CD an advantage
- CSMA/CD plus a TSN initialization method should be examined further