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

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)
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*:
- 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