Time Synchronization and 802 models

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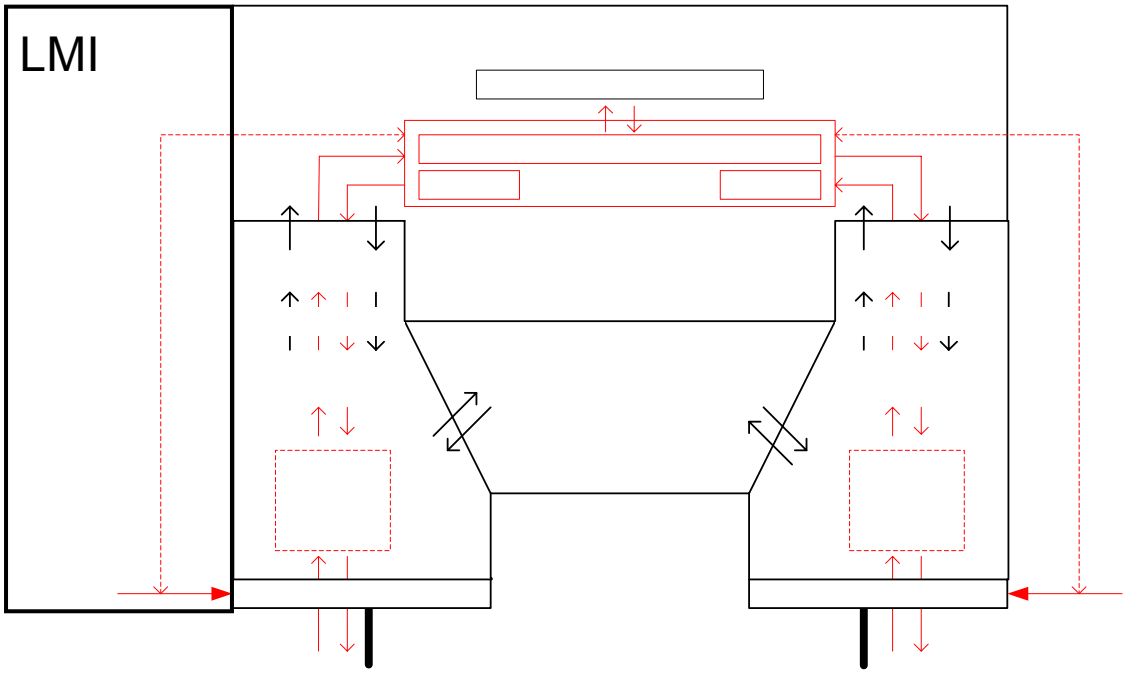
Goals of this effort

- Define downward-facing 802.1AS interface
  - For 802.3 MAC
  - For 802.11 MAC
- Specify MAC compliance for timestamp measurements and ensure:
  - Consistency with existing MAC models
  - Consistency with current TS implementations
  - Accuracy of PTP-derived clock
- Ultimately, initiate development of MAC-specific PAR/5C to realize any MAC-specific changes

802 Baggy Pants Model



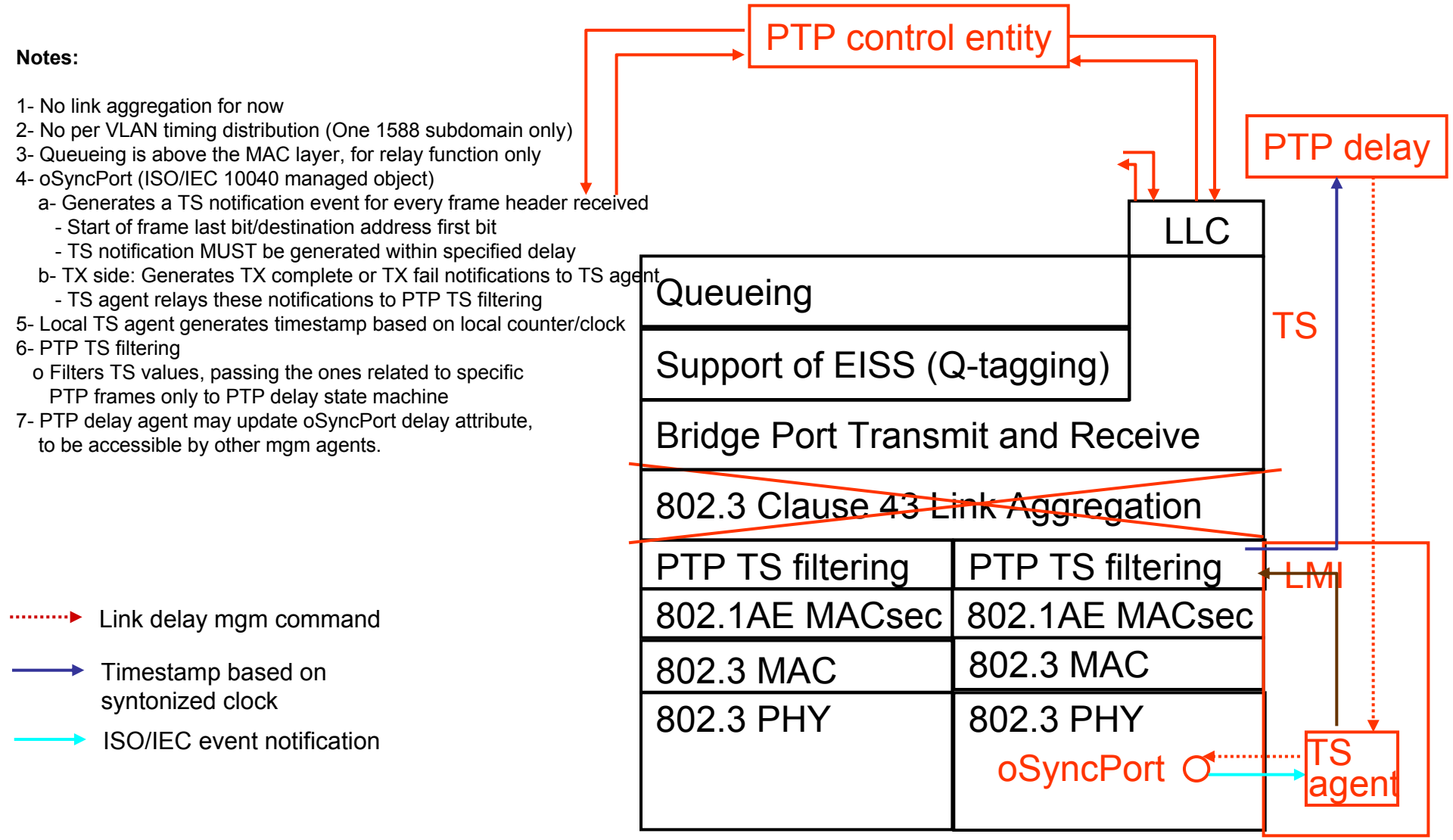
LMI TS support

-PHY generates TX_Event, RX_Event within X uSec accuracy
-PTP correlates LMI TS events with received frames
-PHY generates TX/RX events for every frame

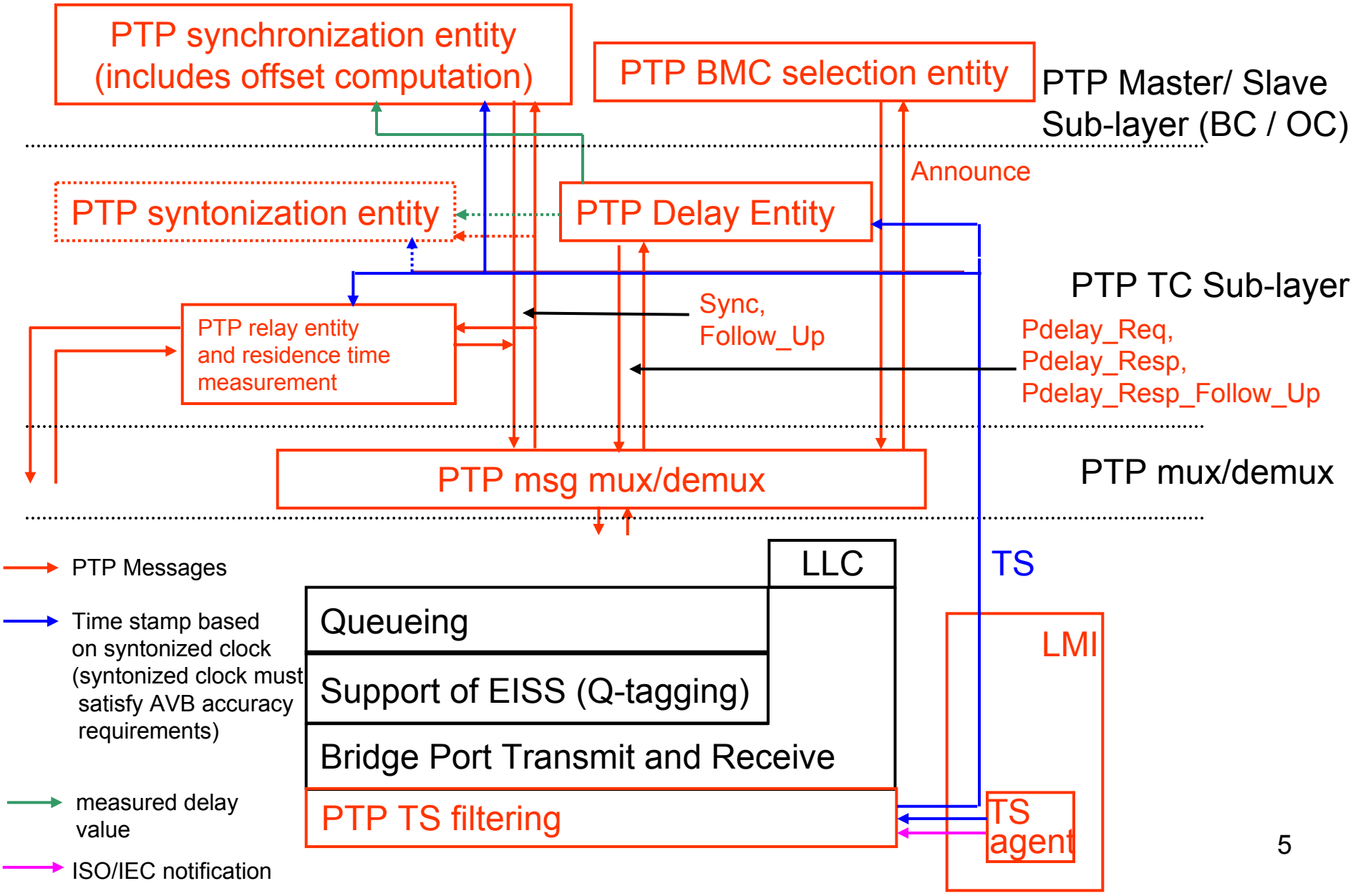
Current 802.1/3 Layering

Notes:

1- No link aggregation for now
2- No per VLAN timing distribution (One 1588 subdomain only)
3- Queueing is above the MAC layer, for relay function only
4- oSyncPort (ISO/IEC 10040 managed object)
  a- Generates a TS notification event for every frame header received
    - Start of frame last bit/destination address first bit
    - TS notification MUST be generated within specified delay
  b- TX side: Generates TX complete or TX fail notifications to TS agent
    - TS agent relays these notifications to PTP TS filtering
5- Local TS agent generates timestamp based on local counter/clock
6- PTP TS filtering
  o Filters TS values, passing the ones related to specific PTP frames only to PTP delay state machine
7- PTP delay agent may update oSyncPort delay attribute, to be accessible by other mgm agents.



PTP MAC Client



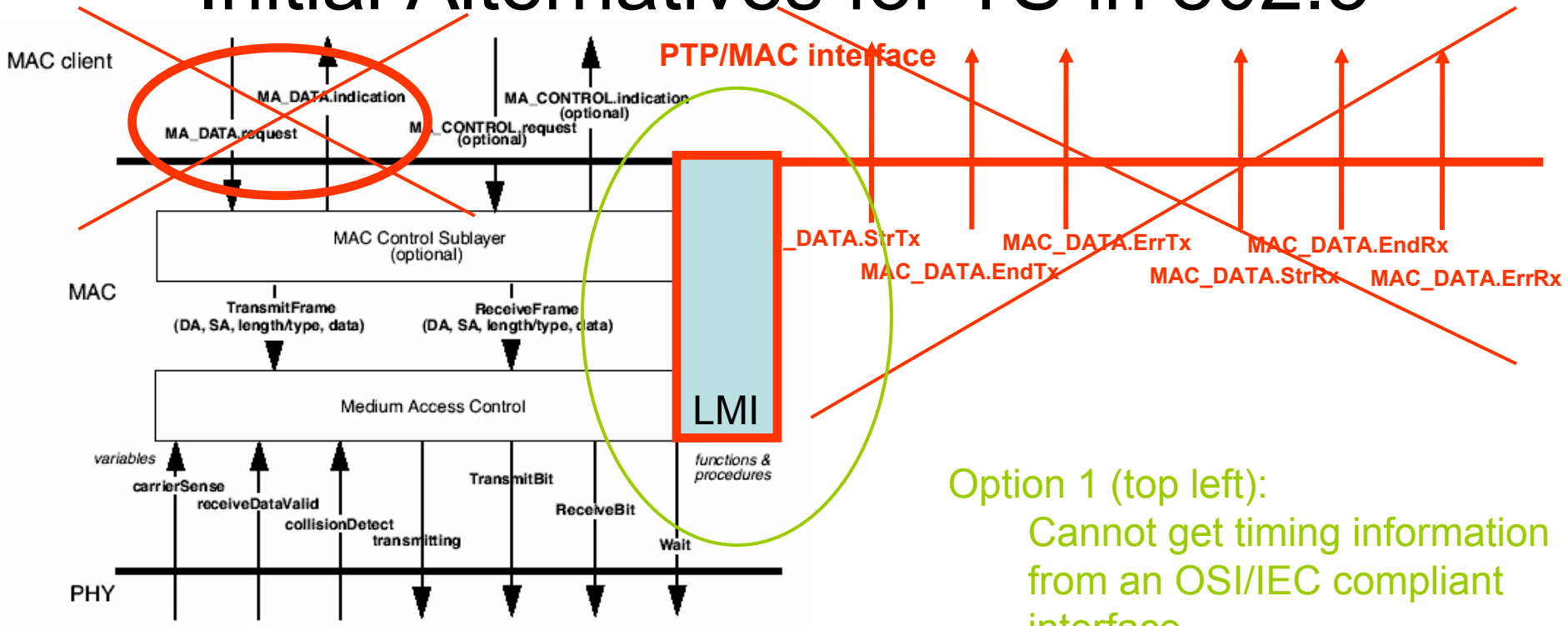
Notes for Previous Slide

- **PTP synchronization entity** measures phase offset relative to GM and creates synchronized clock (possibly with endpoint filtering)
- **PTP syntonization entity** measures frequency offset relative to GM and creates syntonized clock
- **PTP delay entity** measures propagation delay on upstream link
- **PTP BMC selection entity** executes BMC algorithm to determine best master
- **PTP relay entity** measures receive and transmit times of Sync messages relative to syntonized clock, computes residence times, updates correction fields of Sync and Follow_Up messages, and transmits Sync and Follow_Up messages to downstream nodes
- **PTP msg mux/demux** recognizes each message and sends it to the appropriate higher layer function

Log of model evolution

BackUp Slides

Initial Alternatives for TS in 802.3



PTP requirements to MAC layer:
1- Signal events for start of frame TX/RX
2- Signal events for end of TX/RX or error.

Definitions needed within MAC layer:
1- Definition of frame position where those events should be reported
2- Definition on where within PHY the start of TX/RX should be detected
3- Delay bounds on these events, relative to the definitions of clauses 1 and 2.

July 2006 Plenary output:
1- LMI interface is preferable
2- MAC client should not rely on MA_DATA.request return parameters of 802.3, since this defies ISO/IEC service primitive layering specifications.

Option 1 (top left):
- Cannot get timing information from an OSI/IEC compliant interface

Option 2 (middle):
- This is the recommended method, see future slides

Option 3 (right):
- Seen as too intrusive, requires excessive specificity in MAC layering

Receive side

Comments:

1- PTP layer receives RX_start event, to produce an accurate timestamp

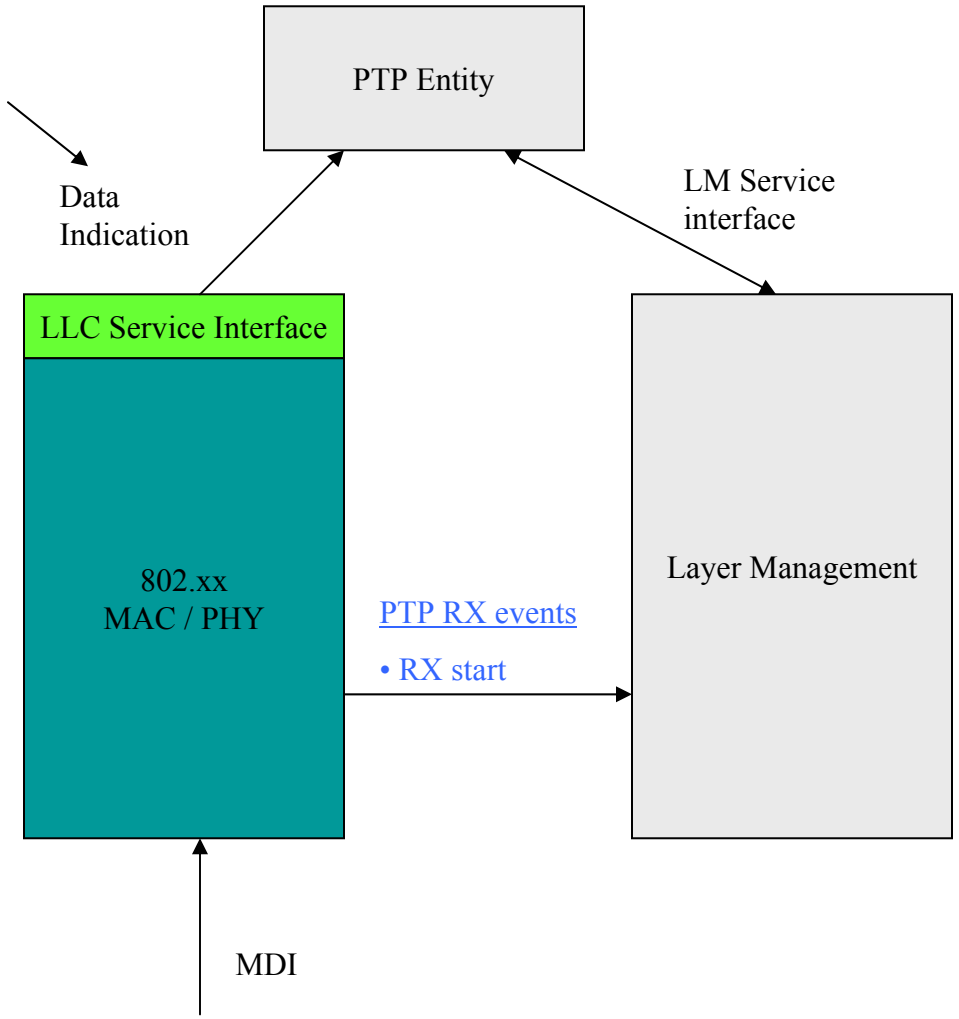
2- MA_DATA.indication validates TS produced by latest RX_Event only under the assumption that from RX_Event generation to MA_DATA.indication no other RX_Event is generated. There could be a problem if PTP frames are generated too fast.

From 802.3-2005 section 2.3.2.1

MA_DATA.indication	(destination_address, source_address, mac_service_data_unit, frame_check_sequence, reception_status)

Discussion:

Frames are received into the 802.xx MAC / PHY, and at the start of the frame, an RX start is posted to indicate that the front of the frame has passed a predefined location in the stack. The PTP Entity collects the event, and associates a timestamp with it. If a Data Indication is presented later, the time information becomes associated with the frame. If there is another RX start before a Data Indication, previous time information is discarded by the PTP Entity. Location of where the RX start occurs in the 802.xx stack is TBD, but a maximum figure may be specified in 802.1AS.



Transmit side

Comments:
1- PTP exclusive parameter may violate GENERIC MAC service interface
2- PTP receives TX_Start to generate accurate timestamp

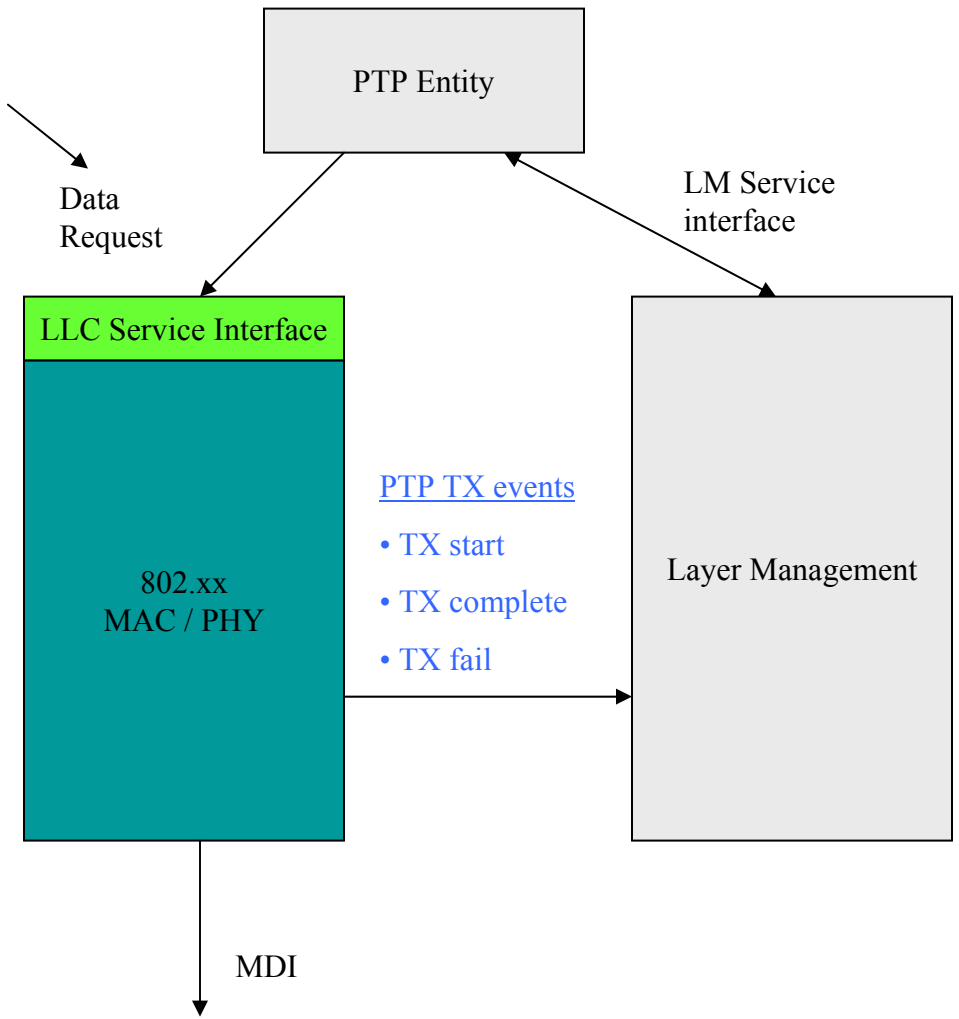
From 802.3-2005 section 2.3.1.2 (modified to include event request)

MA_DATA.request (
destination_address,
source_address,
mac_service_data_unit,
frame_check_sequence,
~~Post PTP TX Events~~
)

Discussion:

Data Requests are received at the LLC Service Interface for frame transmission. When needed, the PTP Entity requests posting of PTP TX Events that occur lower in the 802.xx stack. Such events are specific to the PTP Entity in order to differentiate from other requestors. The TX start event is posted at the beginning of the frame, and TX complete / fail serve to indicate completion status. Location of where the TX start occurs in the 802.xx stack is TBD, but a maximum figure may be specified in 802.1AS.

Note: An addition to the Data Request unit would be required to operate event actions associated with the request.



802.3 architecture and timestamps

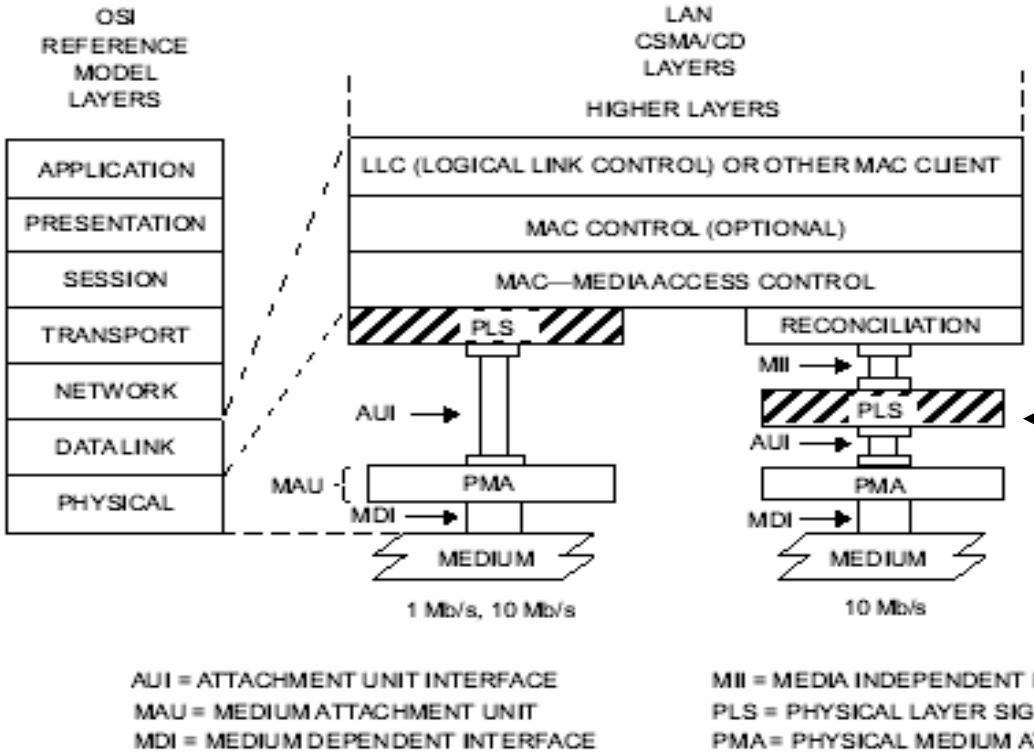


Figure 6–1—PLS service specification relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 CSMA/CD LAN model

Clause 6 – Physical Signalling Service

Defined for 10Mb/s speeds

Clauses 22, 35, and 46 define mappings To Clause 6 for 100Mb/s, 1Gb/s, and 10Gb/s, respectively

Delay tolerance
802.3-2005
Table 35-5 GMII
(48bits from TX_EN)

MAC delays

Clause 21.8 – Table 21-2 specifies for 100BASE-T between MAC-MII for exposed MII
4 bits BT for TX; 8 bits BT for RX

Clause 23 – I didn't find info on MII-MDI delays for 100BASE-T!

Clause 24.6 – Table 24-2 specifies for 100BASE-X between MII-MDI for exposed MII
Half duplex - 14 bits BT for TX; 24 bits BT for RX(MDI input to COL de-assert)
Full-duplex – 14 bits BT for TX; 32 bits BT for RX(MDI input to RX_DV de-assert)

Clause 40.11 specifies for 1000BASE-T half duplex between GMII-MDI
Table 40-13 half duplex : 84 bits BT for TX; 244 bits TU for RX(MDI input to COL de-assert)
Table 40-14 full-duplex – 84 bits BT for TX; 244 bits TU for RX(MDI input to RX_DV de-assert)

Clause 46.1 specifies for XGMII 8192 bits BT for round-trip (TX + RX) of MAC, RS, and MAC control
Clause 48.5 specifies for 10GBASE-X 2048 BT for round-trip PCS

Clause 49.2.15 specifies for 10GBASE-R 3584 BT for TX and RX PCS

Clause 52.2 specifies for 10GBASE-S/L/E 512 BT for TX and RX PMA + PMD

Clause 53.2 specifies for 10GBASE-LX4 512 BT for TX and RX PMD

Clause 54.3 specifies for 10GBASE-CX4 512 BT for TX and RX PMD

OUR NUMBERS

100BASE-T – MAC-MDI delays: TX 4+?; RX 8 + ?
100BASE-X – MAC-MDI delays: half TX 4+14=18BT; RX 8 + 24=32BT
100BASE-X – MAC-MDI delays: full TX 4+14=18BT; RX 8 + 32=40BT
1000 BASE-T – MAC-MDI delays: half/full TX 8?+84=92BT; RX 8 + 244=232BT
XGMII 10GBASE-X – MAC-MDI delays: TX + RX = 8192 + 2048 = 10240BT

Time measurements at MII and 802.3

GMII Reconciliation sublayer (Std 802.3-2005 35.2.1)

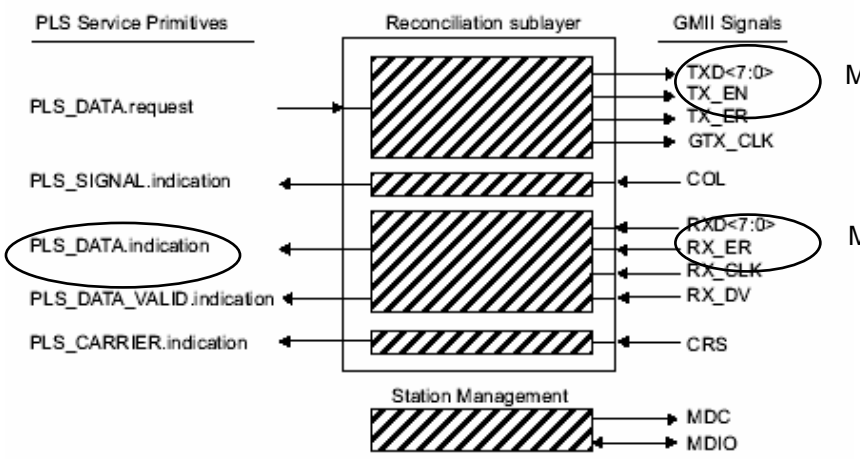


Figure 35–2—Reconciliation Sublayer (RS) inputs and outputs and STA connections to GMII

MII TXD<3,0>

MII RXD<3,0>

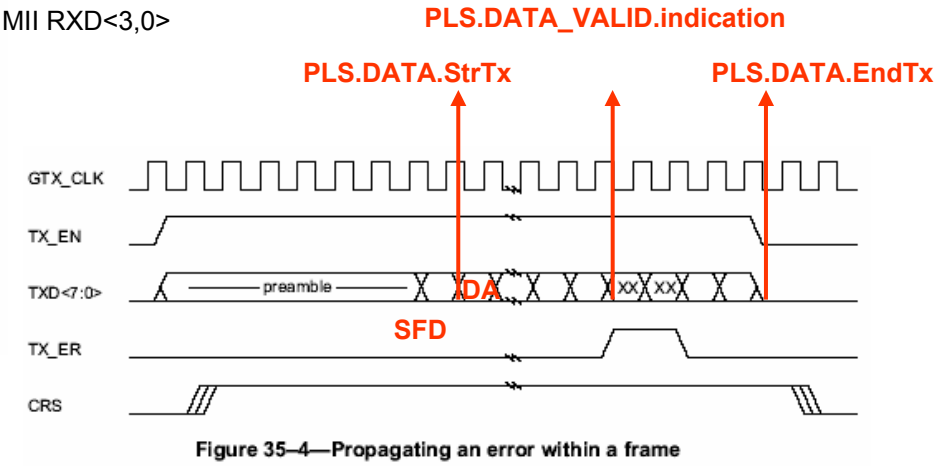


Figure 35–4—Propagating an error within a frame

Issue:

1- 1588 assumes timestamp epoch at MII

2- RS is not aware of byte semantics