Maintenance Channel message format for precise peer-to-peer Time Synchronization

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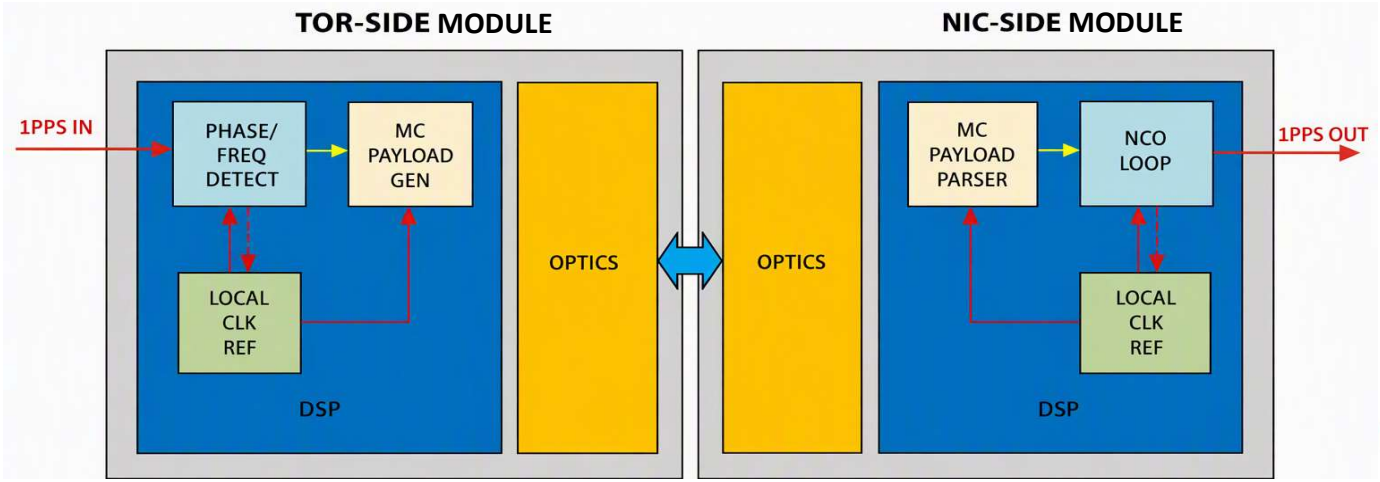
Introduction

- **An in-band maintenance channel (MC) has been defined for the purpose of link monitoring and maintenance for Ethernet links**
- **This presentation provides system requirements and data format for transmitting timestamps for a 1PPS clock synchronization protocol within the MC**
- **The scheme addresses the “end user” requirement of TOR to NIC synchronization via a 1PPS clock transfer mechanism**
- **Disclaimer : The scheme presented herein follows similar principles of operation as IEEE 1588 aka PTP. It is just better tailored to the strict timing accuracy and jitter targets of the end user.**

High Level Outline

- **The central idea is to convey a precision time-base from TOR-side module (aka TimeTransmitter) to NIC-side module (aka TimeReceiver), utilizing the MC capacity**
- **The TimeTransmitter generates timing info off a "virtual 1PPS clock", embedding it within the MC using time-stamps**
- **The TimeReceiver adjusts its local time-base using timing info in the MC**
  - A standard phase offset detector and loop filter can be applied
- **Precision of the time-stamps, and their frequency are specified here**
- **The accuracy and precision of the transferred clock also depend on –**
  - Latency and jitter of circuits parsing and processing the time-stamps at TimeReceiver
  - Structure and dynamics of the clock synchronization loop at the TimeReceiver
- **Fine details of implementation of these portions is out of scope**

Clock Transport and Synchronization Scheme



In-band clock forwarding

< 10 ns clock accuracy

Pinout for 1 PPS in and 1 PPS out

Calibrated latency: TP1 → TP4 and TP2 → TP4

Multiple optical 1 PPS/DSP: Support sending 1 PPS on each breakout and select which one is routed to 1 PPS out

PPS loopback, host & line side

- Calibrated loopback delay compensation vs. TP1–TP4 - Only needed at bring-up

- **Time-stamps are generated by the TimeTransmitter (TOR-side), inserted into MC**
- **TimeReceiver (NIC-side) receives timestamps and updates local time-base, generating 1PPS signal off calibrated local clock**
- **TimeTransmitter also has a TimeReceiver function, for loopback delay calibrations**

Recap: Maintenance channel using AMs

- **The idea that link between two PMAs can use the AM bandwidth for an in-band maintenance channel (MC) was discussed in previous meetings**
  - https://www.ieee802.org/3/400GPL/public/2609/ran_400GPL_01_2609.pdf
- **The message format defined is as shown below.**



- **CRC16 is calculated on the preceding 30 bytes, then appended**
- **Serves as message integrity check, ensuring reliability of MC messages**
- **Generator polynomial 0x1021 ($x^{16} + x^{12} + x^5 + 1$) used to compute CRC**
- **Receiver checks CRC16 before acknowledging message in VCMT**
  - CRC failure indicates corruption of preceding message

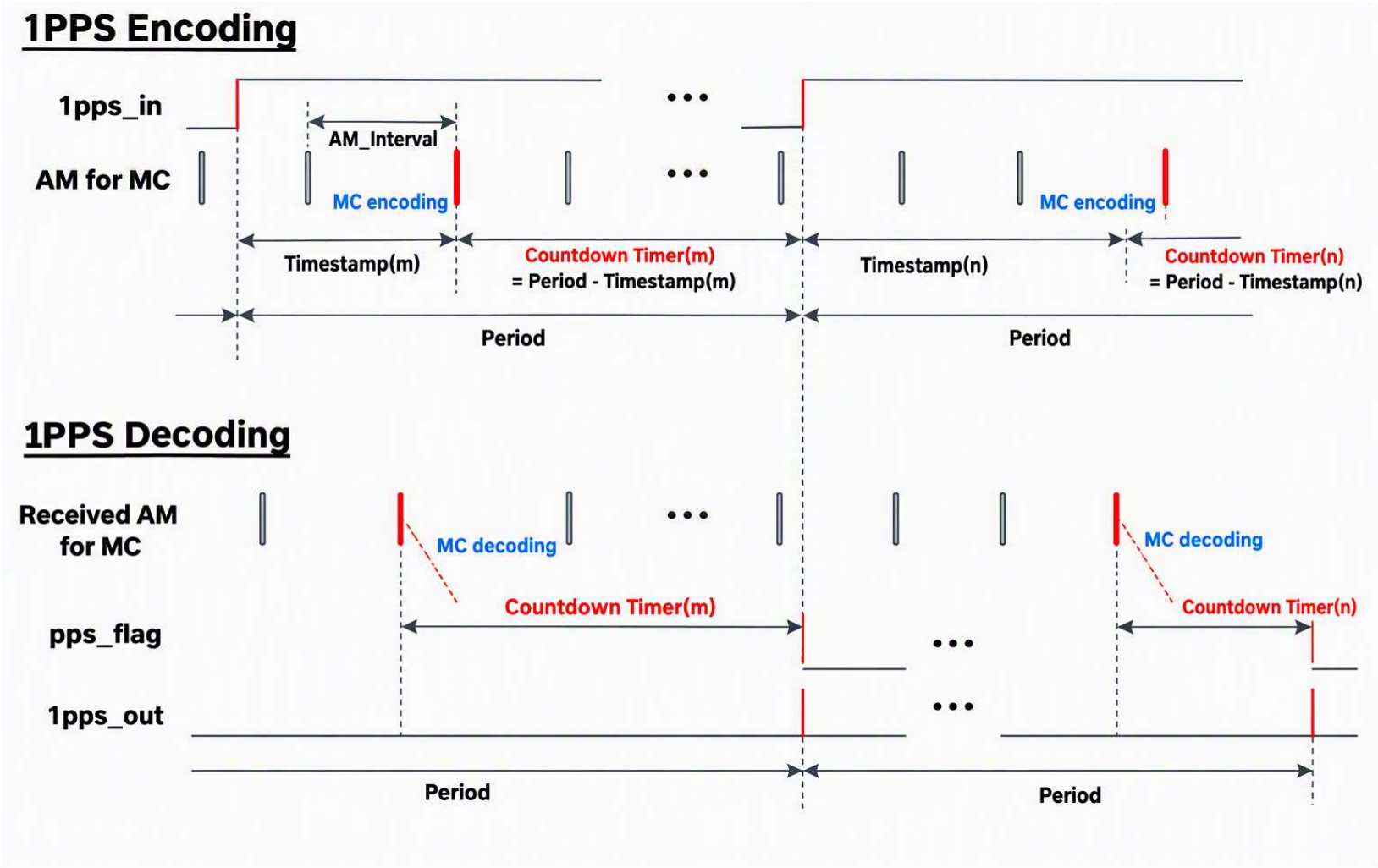
Proposed Timing Message format

Byte index	Content	Details	Encoding
2:0	Virtual clock + Message type (VCMT)	1 byte repeated 3 times Bit 7: outgoing message toggle Bit 6: incoming message toggle Bit 5: incoming message acknowledge Bits 4:0: outgoing message type	Type=0:null/idle Type=1: fixed-format message Type=2: CMIS payloads Type=3: Synchronization timestamps Type=4-31: reserved (ignore on receipt)
3	Message Length	1 byte	For Type 0 or 1: Transmit as 0, ignore on receipt
35:4	Message Body + CRC16	32 bytes, interpreted per message type	For type 0: Transmit as 0, ignore on receipt For type 1: based on Annex 178B E1 format • Coefficient select • Coefficient request • Coefficient select echo • Coefficient status

Timing Message format – cont'd

- **The 30-byte message is used as follows**
- **Format:**
  - Timer ID : 2 bytes. Counter, incrementing with new timer
  - Countdown Timer : 4 bytes. Denotes the time, in ns, from
    a) The transmission of the first PAM symbol of the AM containing this MC message at the egress interface, to
    b) The rising edge of the next nearest "virtual" 1pps pulse
  - Reserved : 24 bytes
- **Requirements –**
  - The accuracy of the Countdown Timer is +- 1ns
  - Timers shall be inserted in the messaging channel at least once per 0.5s, by which the MC receiver infers the 1pps clock period of relevance
- *Note: We refer to a "virtual" 1pps pulse to permit a host (TOR) that may or may not provide a physical 1PPS pulse. Other timing mechanisms may be supported.*

Timing transfer from TX to RX (Informative)



Summary

- **This proposal outlines a scheme for MC to carry timestamps**
- **The high degree of accuracy and precision of these timestamps enable the receiver to synthesize a 1pps precise local clock**
- **The transmitter and receiver are required to calibrate their internal transit latencies to sufficient precision and accuracy as well**