MPCP: “Non-intrusive” Time Synchronization in PHY

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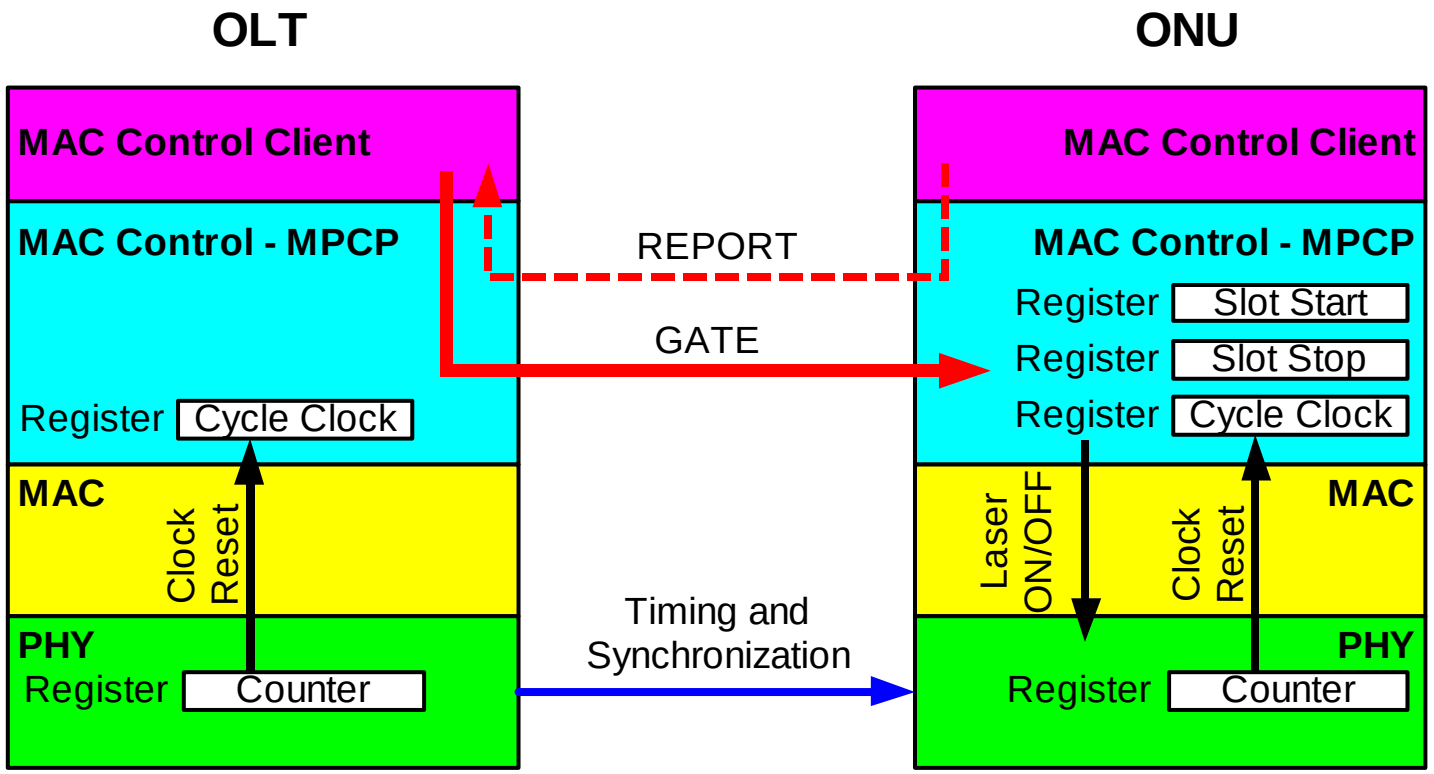
Overview

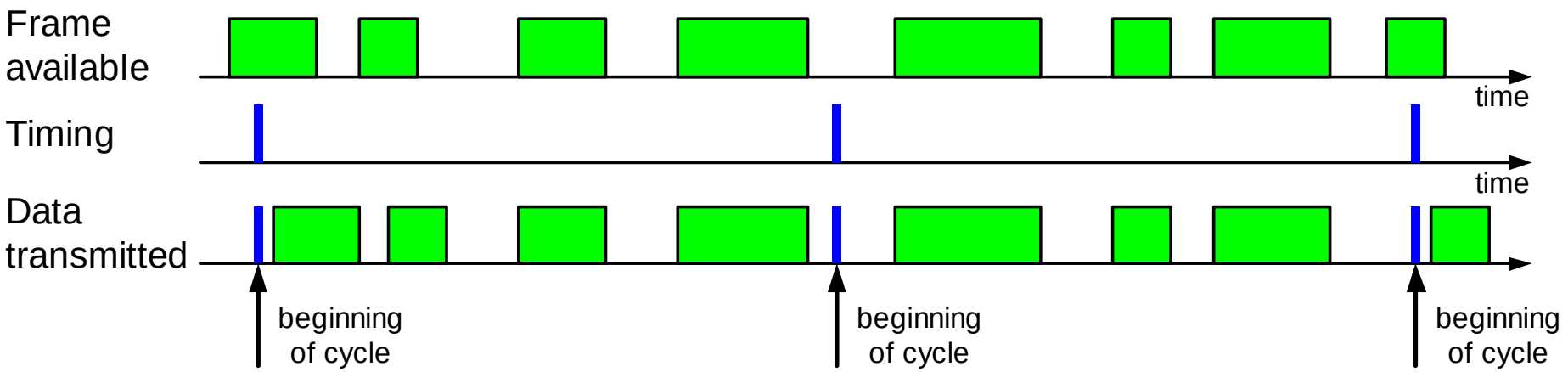
- Node synchronization is important in P2MP environment.
- Aperiodic traffic consisting of variable length frames does not carry implicit timing and synchronization information.
- Byte synchronization can be achieved by using Rx clock.
- 4 methods of delivering cycle synchronization information without affecting data traffic are presented.

Layer diagram



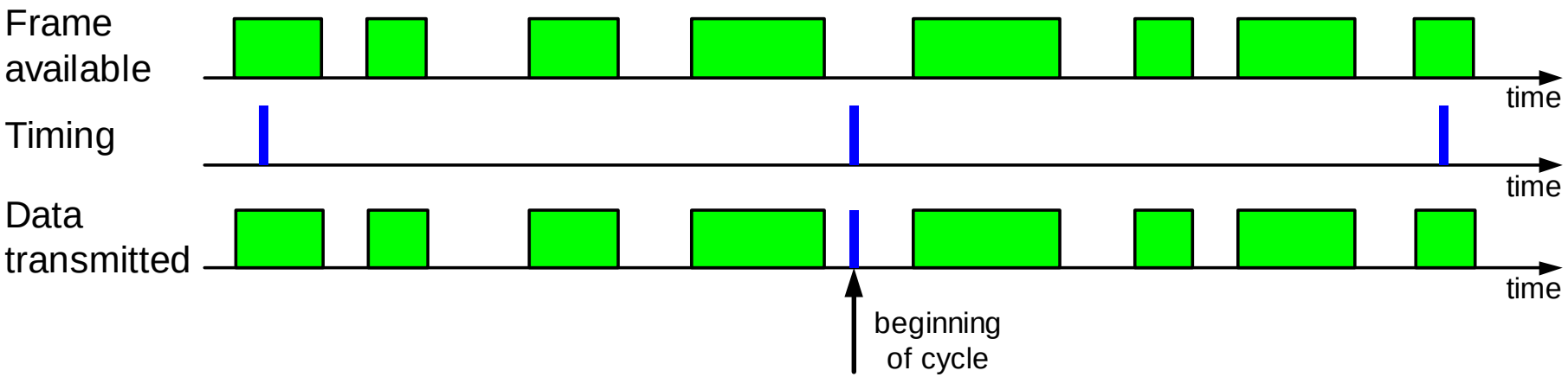
- Counter runs at 125 MHz
- Cycle clock may run at lower frequency than Counter
- GATE transmission time and processing is not time sensitive

Method 1: “weakly-intrusive”



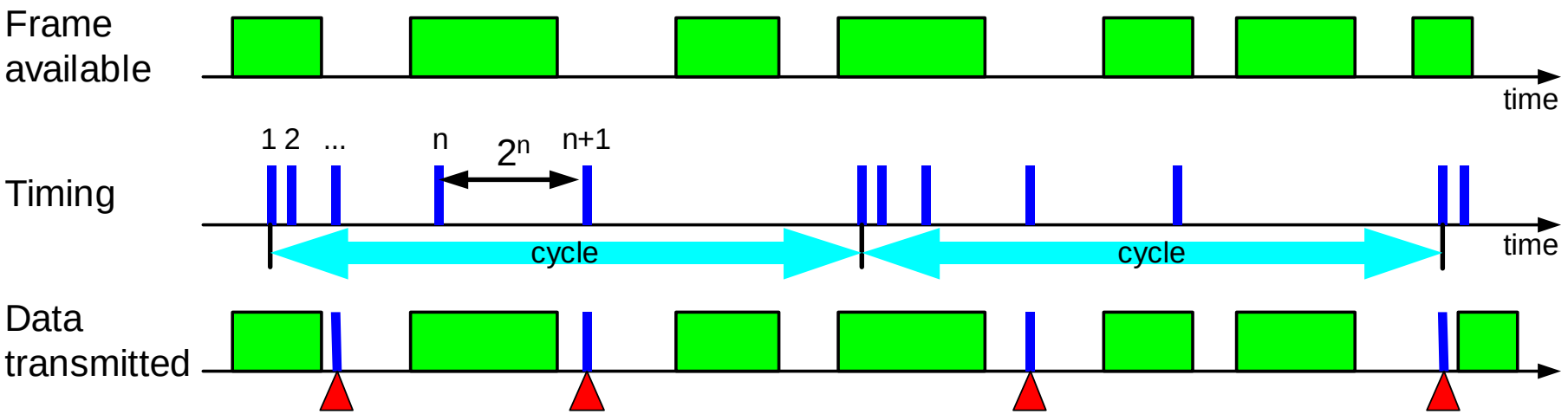
- MPCP guarantees that no frame is transmitted when cycle clock is 0.
- MPCP delays frame (by at most frame size) if necessary
- PHY inserts SYNC instead of IDLE when clock is 0
- Guaranteed SYNC in every cycle

Method 2: Opportunistic SYNC



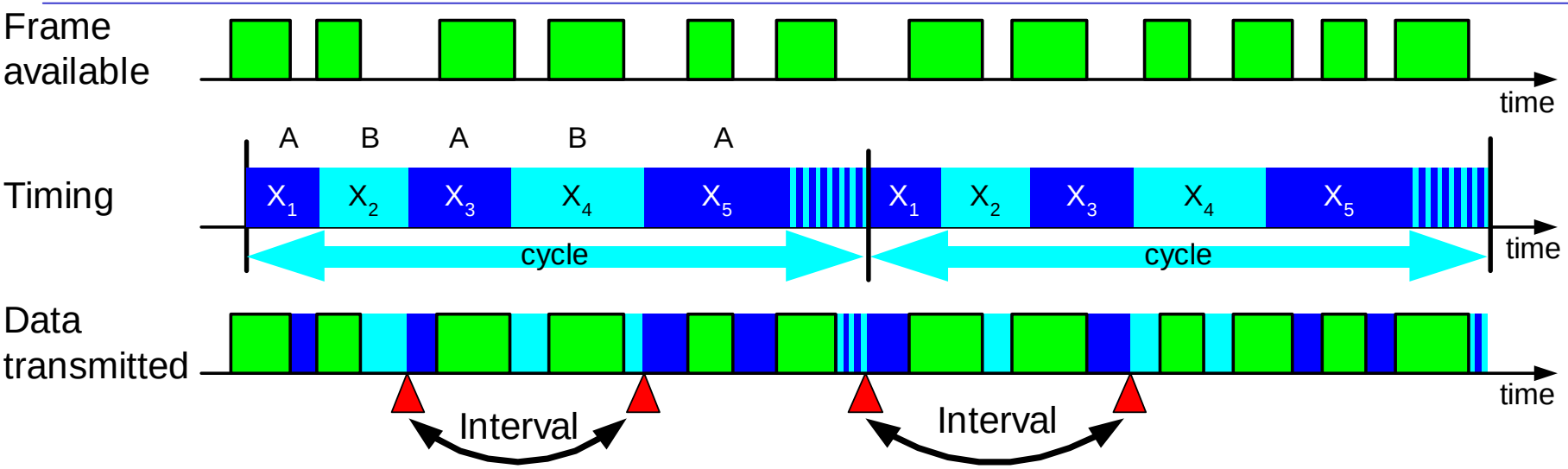
- PHY transmits SYNC only when cycle clock is 0 and IDLE is to be transmitted
- May not have SYNC in every cycle

Method 3: Distributed SYNC



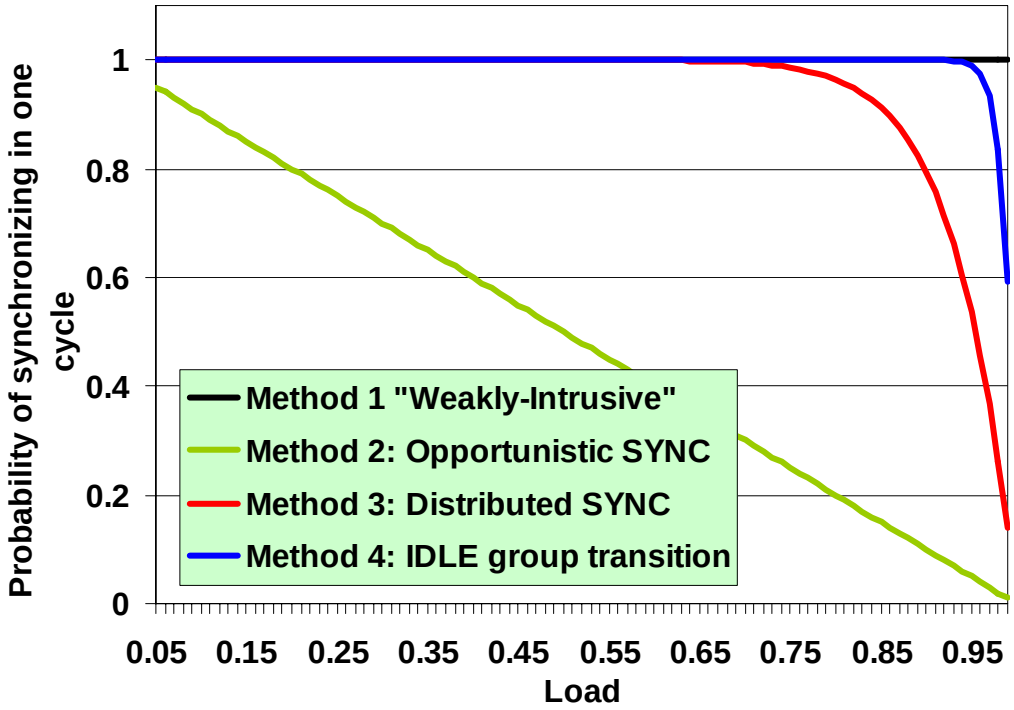
- Generate *k* SYNCs in a cycle, s.t., octet distance between *n* and *n+1* is 2^n
- PHY transmits SYNC when it has opportunity (instead of IDLE)
- ONU measures time (octet count) elapsed between any two SYNCs (ignore if measured interval >= cycle time)
- Interval between any 2 SYNCs uniquely identifies offset from beginning of cycle

Method 4: IDLE Group Transition



- 2 IDLE codes: A & B
- Generate alternating intervals of As and Bs
- Interval size increases linearly (min. interval > max. frame)
- Last interval consist of ABABABA…
- Find any two IDLE transitions (A->B or B->A) s.t. last interval is not between them.
- Interval between transitions uniquely identifies offset from beginning of the cycle

Performance comparison



Parameters:

Method 3:

- **Cycle time 2 ms**
- **Min. SYNC interval – 16 octets (128 ns)**
- **Interval increases exponentially**

Method 4:

- **Cycle time 2 ms**
- **Min. SYNC interval: 2000 octets (16 μs)**
- **Interval increases linearly with increment: 16 octets (128 ns)**

Conclusion

- Synchronization is a PHY function
- PHY layer can reliably synchronize on Rx data stream
- Timing and synchronization info can be transmitted without affecting data traffic
- High resolution timing – lower guard bands possible
- PHY level synchronization allows “out-of-range” detection even if ONU sends no data, only IDLEs.