Synchronization Transport: Packet Based Method Overview

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Introduction

- **CBR over ATM**: need to carry timing over packets (AAL1)
  - "aynchronous" CBR clock recovery required when physical layer sync is not an option (e.g. multioperator)
  - ETSI TR 101 685 provides an overview on ATM timing aspects
- **IETF (PWE3 sync related Drafts and RFCs)**
- **ITU-T G.8261 has generalized the concepts**
  - wander budget for CES timing recovery
  - Use of dedicated timing packets (e.g. NTP, PTP) to carry network clock
- **Packets to carry time of day (or phase)**
  - NTP (IETF) and PTP (IEEE)

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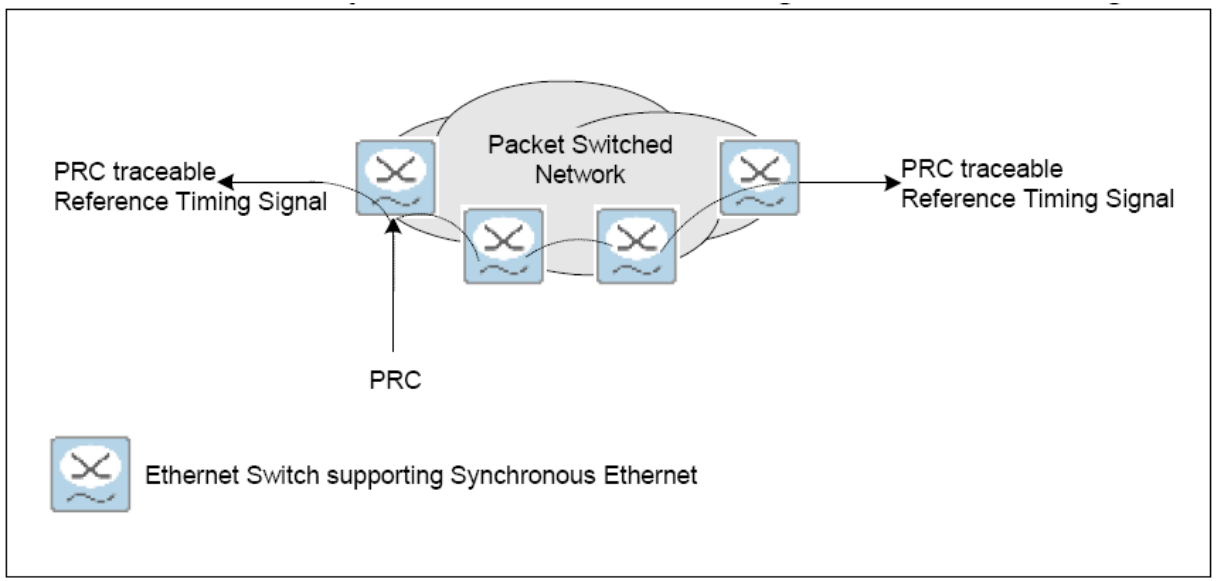
The “Traditional” Approach: Physical layer timing



From ITU-T G.8261

The physical layer is used to provide reference timing distribution:

- PDH (2048 Kbit/s – 1544 Kbit/s)
- SDH (STM-N)
- SyncE

May not always be feasible; Frequency only

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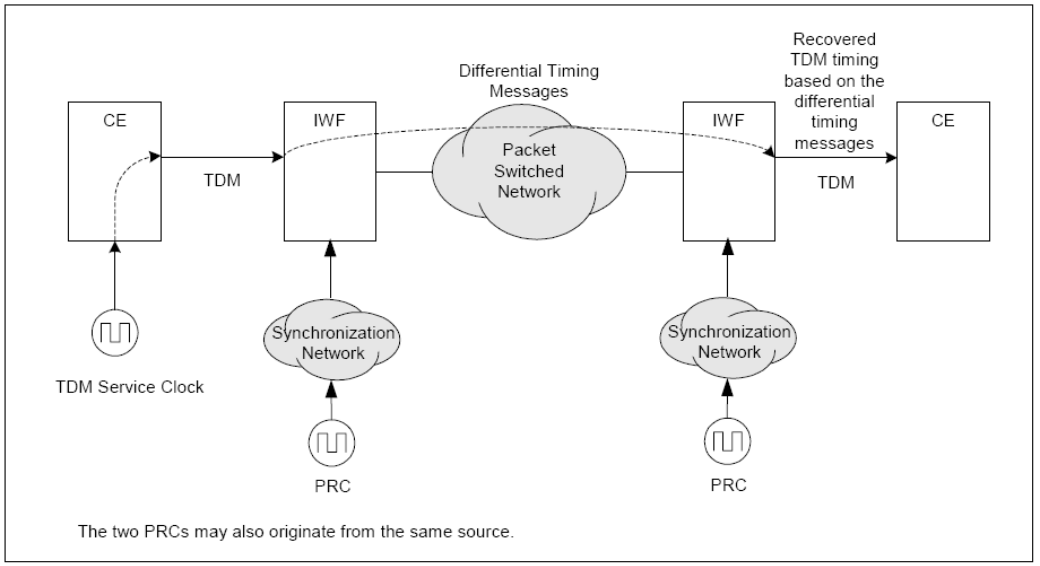
Differential Methods

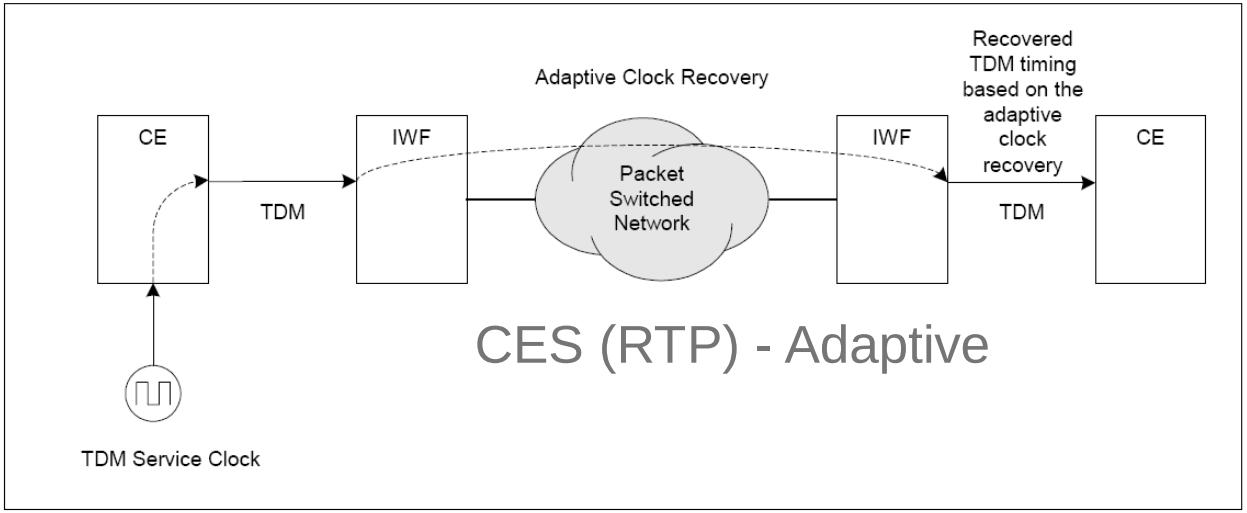
•The difference between the *service clock* and the *reference clock* is encoded and transmitted across the packet network .
• The service clock is recovered on the far end of the packet network making use of a common reference clock.
•The Synchronous Residual Time Stamp (SRTS) method is an example of this family of methods.



From ITU-T G.8261

Network Clock (PRC traceable) required at both ends

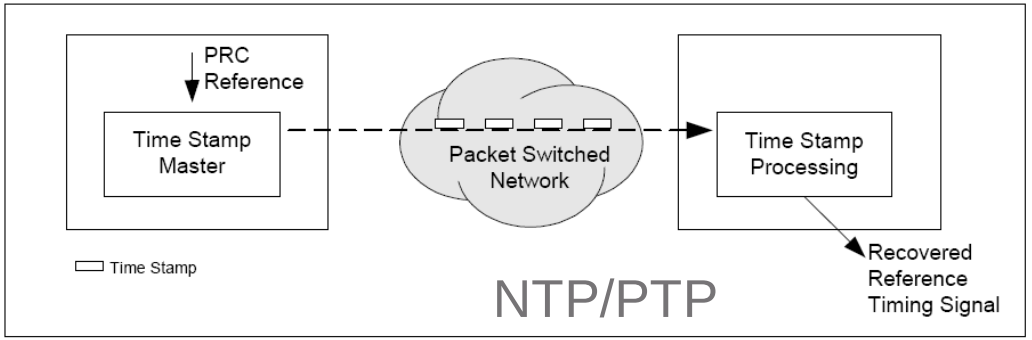
Adaptive Methods



CES (RTP) - Adaptive

From ITU-T G.8261

- Timing recovery process based on the (inter-)arrival time of the packets
- The information (timestamp) carried by the packets could be used to support this operation
- Two-way or one-way protocols



NTP/PTP

Applicable to CES-RTP or PTP/NTP

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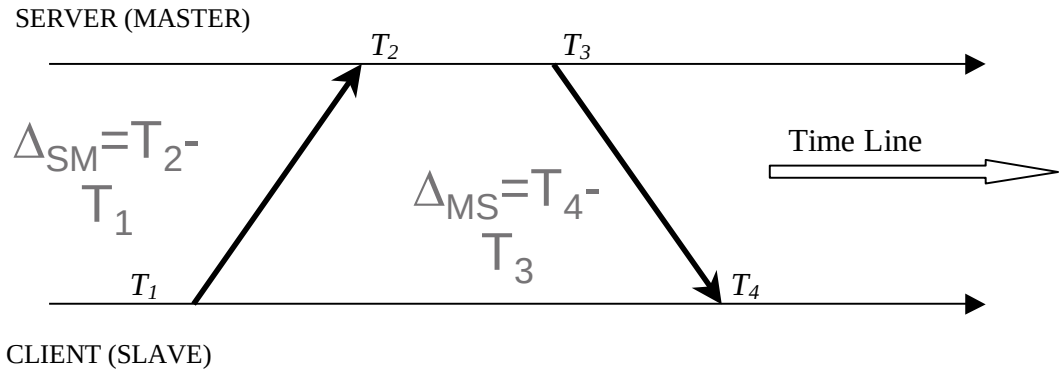
Time Synchronization using Packets

- The distribution of time via packets is based on the exchange of 4 time stamps between master and slave.
- Two main protocols: PTP (IEEE1588) and NTP/SNTP
- Time offset between master and slave (NTP is considered in this example):



$$\text{Offset} = (\Delta_{MS}-\Delta_{SM})/2$$

- To obtain an unbiased offset estimate, the forward and reverse path delays must either be known or assumed symmetric

Requirement: Symmetric Networks

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Performance Aspects

- Differential method is generally immune to packet delay variation,
  - but requires PRC traceable references at both ends
- Adaptive clock recovery methods are impacted by packet delay variation
  - slow changes in the traffic load are among the main issues
- Requirements in terms of max PDV (e.g. PDV of 99% of packets < 10 ms) generally not sufficient
  - statistics of the PDV should also be considered, especially to achieve the most stringent requirements
- Asymmetry in the network is a key aspect when accurate time is to be distributed
  - Especially critical in some transport technologies inherently asymmetric (e.g. ADSL)
- Similar performance irrespectively of the protocol
  - NTP (SNTP) and PTP provide the same performance
  - Assumptions: same algorithm, same clock, same network conditions
    Note: HW timestamping is also applicable to NTP (SNTP) packets

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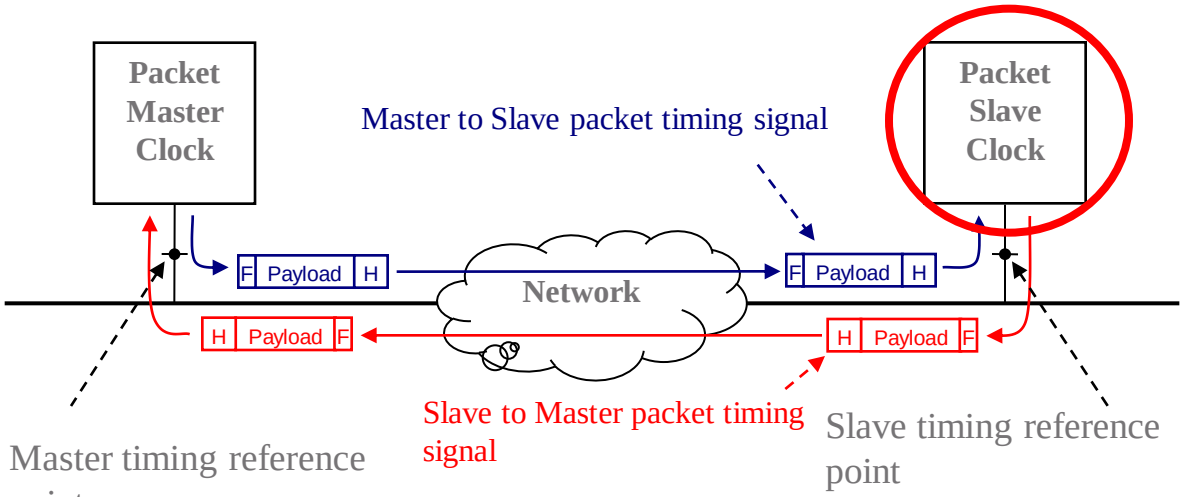
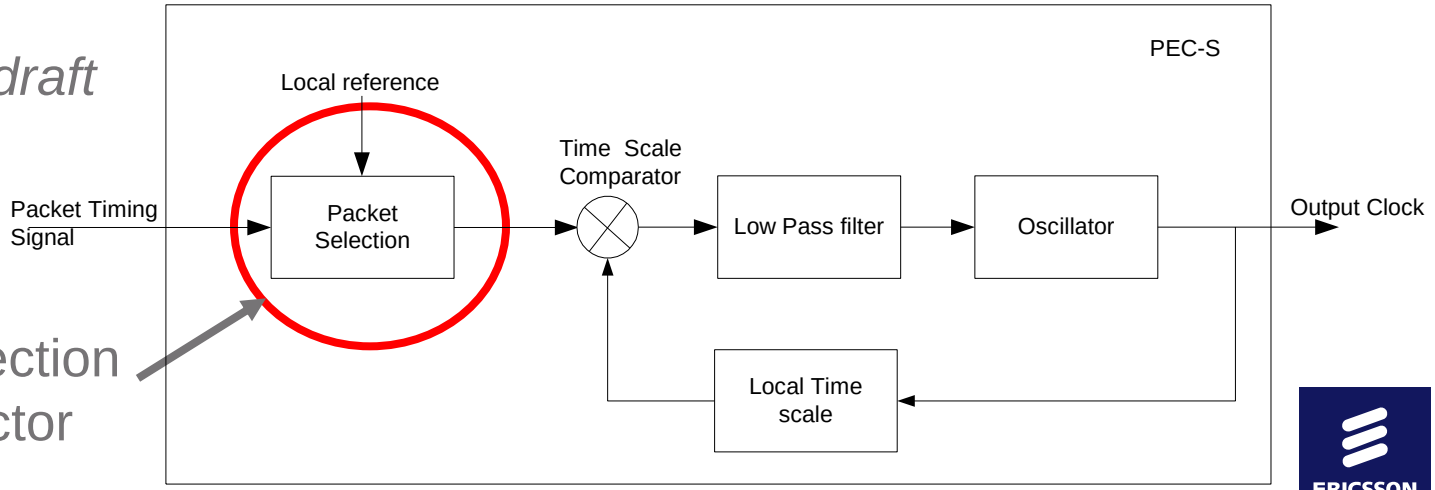
Packet Based Equipment Clocks

Clock Types	*Examples*
PEC-S	PTP Slave NTP Client
PEC-M	PTP Master NTP Server
PEC-B	PTP Boundary Clock NTP Stratum n Server (n>1)



PEC: Packet based Equipment Clock

From G.8263 draft



Packet Selection is key factor

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Dealing with Performance

- Packet Selection
  - The impact of PDV can be mitigated by means of a suitable selection of packets
- Oscillator characteristics in the slave is a key aspect
  - OCXO oscillator allows for higher tolerance to PDV
- Increasing the packet rate can provide better statistics
  - Optimum rate depending on oscillator characteristics
  - Higher rate than 100 packet per seconds may not help
- Under discussion the use of external frequency reference source
  - E.g. to improve Time Sync holdover
- Solutions to reduce the PDV:
  - Controlling PDV in the network (Network Engineering, QoS)
  - HW timestamping
  - Timing Support from the transport Network

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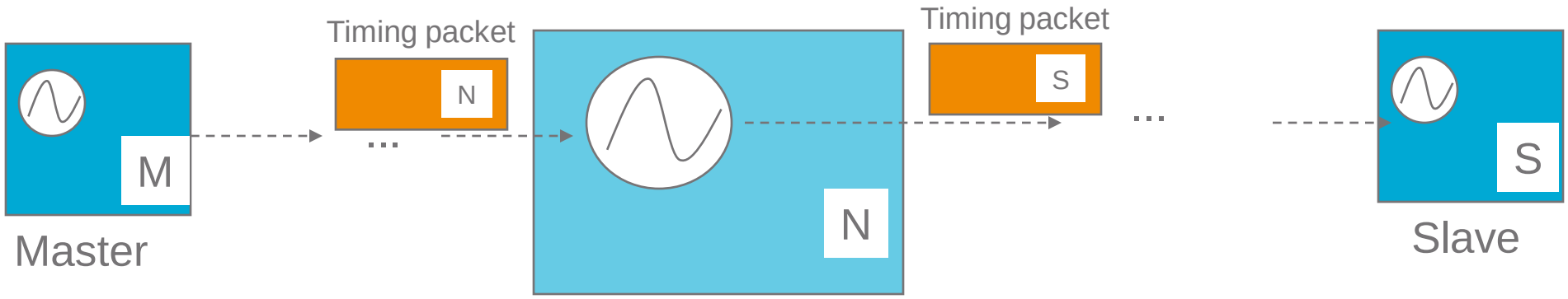
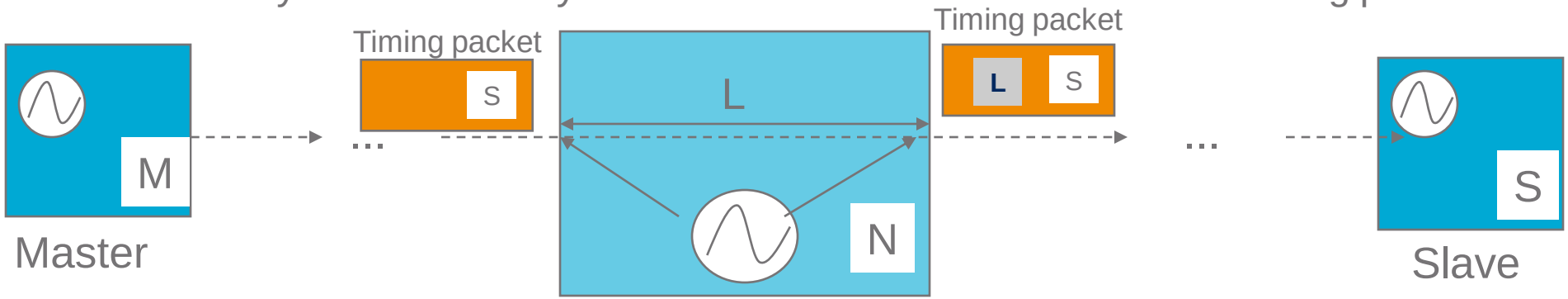
Timing Support: Examples

Timing packets are terminated and regenerated by N



e.g. IEEE1588 Boundary Clock, NTP Stratum Clock

Latency is calculated by N and the information is added in the timing packet



e.g. IEEE1588 Transparent Clock

Typical Applications

- **CES (Differential):**
  - TDM service clock recovery (PRC traceable reference available at the edges of the packet network)
  - Wireless applications (only frequency, e.g. WCDMA FDD, LTE FDD)
- **Packet Based with support from the network nodes**:
  - Wireless applications that requires accurate phase sync (LTE TDD, eMBMS, etc.); Transport network requirements (additional functions in the network nodes)
- **Packet Based method (incl. CES Adaptive)**:
  - Wireless applications (only frequency, e.g. WCDMA FDD, LTE FDD); Oscillator in the Base Station is a key aspect
  - TDM service clock recovery; Wander requirements (G.823, G.8261) met in a *controlled environment*
- **Controlled Environment?**
  - Not yet a standardized concept (PDV Metrics and PDV Limits under discussion)
  - Network Engineering (QoS, Traffic load below a certain treshold, Limited number of hops, suitable Physical layer)

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Conclusions

- **Packet Based Methods (CES or PTP/NTP) are a key technology in the next generation network**
  - Independence from the transport network
  - To handle migration scenarios
  - Timing across operator boundaries
  - Time and phase distribution as an alternative to GNSS solutions in the future
- **PDV and asymmetries in the network must be handled**
  - Understanding of these phenomena is a key point
  - Means to reduce PDV
  - Timing support from the network might be required in some scenario/application
  - Standardization of PDV Metrics and PDV Limits to be completed
- **Different levels of Synchronization Requirements apply**
  - Understanding of when these technologies are applicable
- **Similar performance irrespectively of the protocol**
  - E.g. NTP/SNTP and PTP (IEEE1588) provide the same performance under the same conditions

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THANK YOU

QUESTIONS ?