IEEE-1588 Profiles

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Agenda

- IEEE-1588 Profiles
- IEEE Std 1588™-2008 Telecom profiles at ITU-T
- PTP Options and Configurable Attributes
- Best Master Clock Algorithm (BMCA)

IEEE-1588 Profiles

- IEEE-1588 defines profile as "The set of allowed Precision Time Protocol (PTP) features applicable to a device"
- "The purpose of a PTP profile is to allow organizations to specify specific selections of attribute values and optional features of PTP that, when using the same transport protocol, inter-work and achieve a performance that meets the requirements of a particular application."
- A PTP profile should define
  - Best master clock algorithm options
  - Configuration management options
  - Path delay mechanisms (peer delay or delay request-response)
  - The range and default values of all PTP configurable attributes and data set members
  - The transport mechanisms required, permitted, or prohibited
  - The node types required, permitted, or prohibited
  - The options required, permitted, or prohibited
- IEEE-1588 also specifies how a profile can extend the standard
  - By the use of the TLV mechanism
  - By specifying an optional best master clock algorithm
  - By specifying an optional management mechanism
  - By specifying a new transport mapping referenced by a profile
  - By allowing the use of a unicast model provided that the behavior of the protocol is preserved

IEEE Std 1588™-2008 Telecom profiles at ITU-T

- ITU-T Q13/15 is working on developing IEEE Std 1588™ -2008 Profiles to address Telecom applications

- Two profiles have been identified
  - Short term: PTP Profile for frequency delivery without support from network nodes (focus of this presentation)
  - Middle term: PTPv2 telecom profile for phase/time-oriented applications

- The on-going work at ITU-T includes both protocol interoperability and performance aspects
  - The definition of the PTP profile itself only consists of the protocol interoperability

- The performance aspects are addressed by ITU-T as part of a wider work item including PDV studies, PDV metrics, network PDV accumulation, etc…

- ITU-T G.8265.1, PTP Profile for frequency delivery without support from network nodes, is planned to be consented in June 2010
  - This profile was formerly ITU-T G.8264.1. During the last meeting it was decided to re-organize the different Recommendations and therefore it is now ITU-T G.8265.1

Packet-based frequency distribution architecture

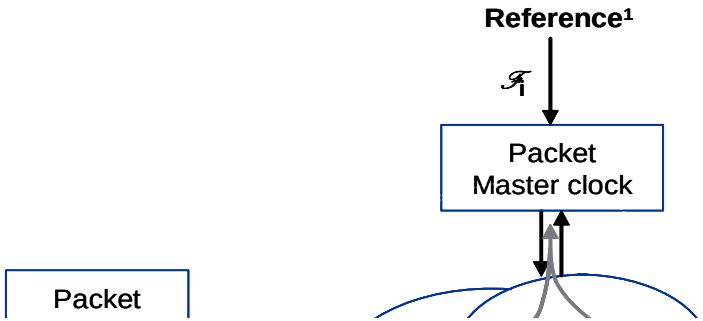


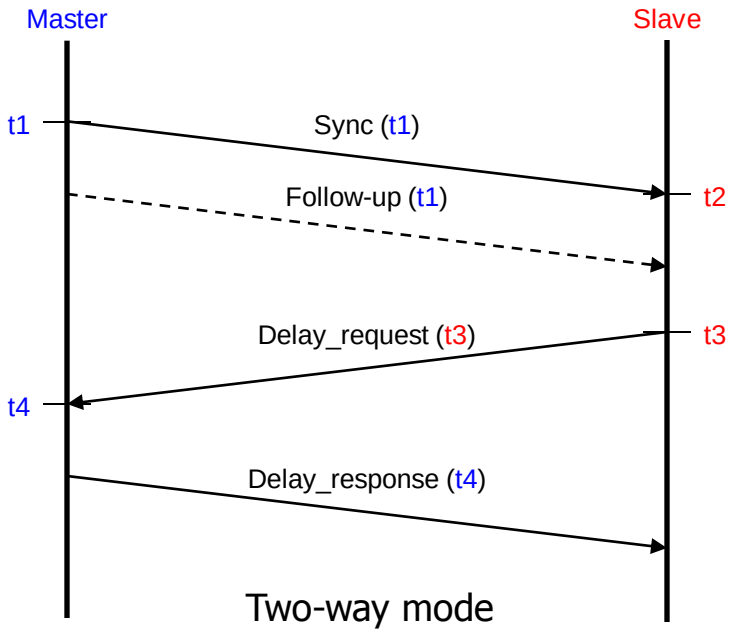
Figure 1/ITU-T G.8265.1: General packet network timing architecture

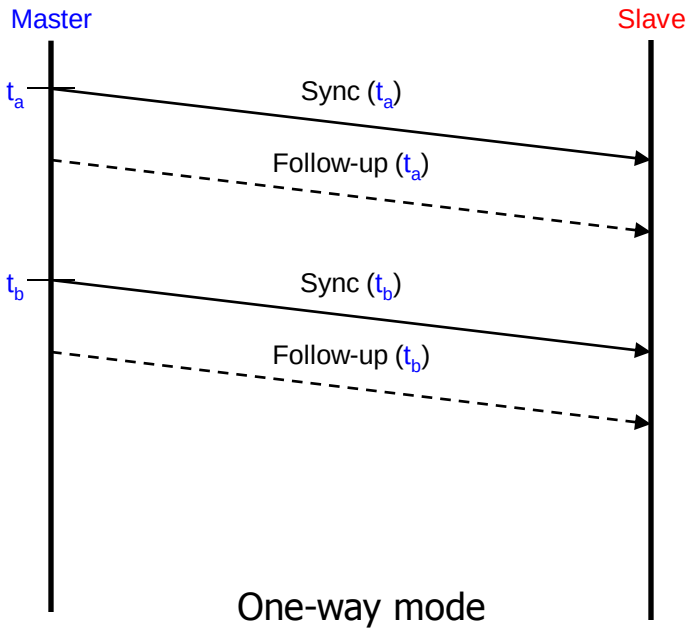
- The PTPv2 Telecom Profile for frequency synchronization under study in ITU-T assumes that there is no timing support from intervening transport nodes
  - No Boundary Clock, no Transparent Clock, and of course no Synchronous Ethernet links
- Packet Delay Variation (PDV) will therefore be generated by the intermediate equipments in this architecture
  - Need to filter the PDV by the PTPv2 slave (proprietary mechanisms)
  - But these performances aspects are outside the scope of the "PTP profile" itself, they will be covered in a different recommendation

PTP Options and Configurable Attributes

- One-way versus two-way mode
- One-step versus two-step clock mode
- Unicat versus Multicast mode
- Unicast Message negotiation
- PTP mapping
- PTP Message rates
- Best Master Clock (BMC) Algorithm

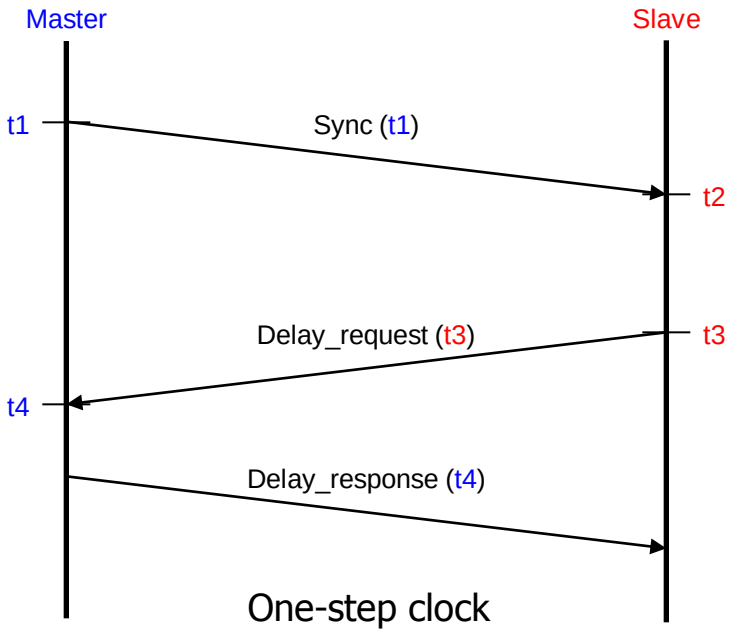
One-way vs two-way

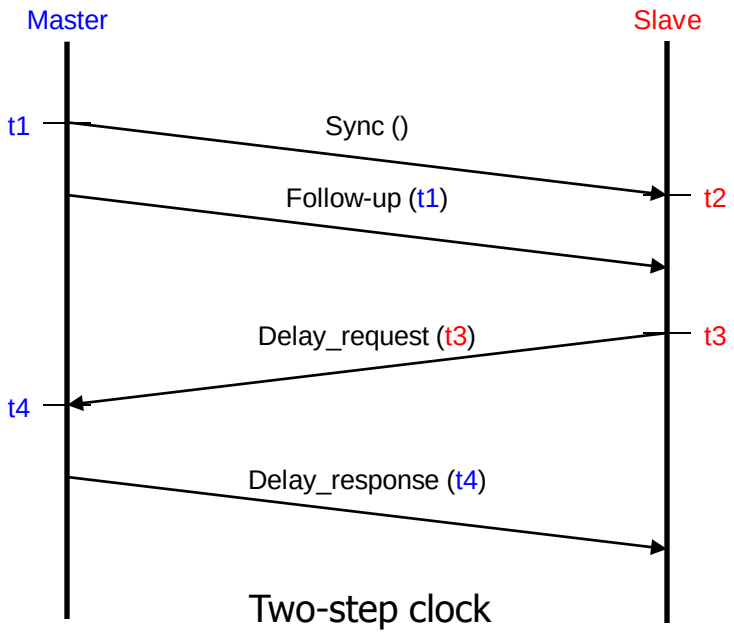




- Both one-way and two-way modes are allowed in the PTPv2 Telecom profile
- The mode used depends on the slave implementation

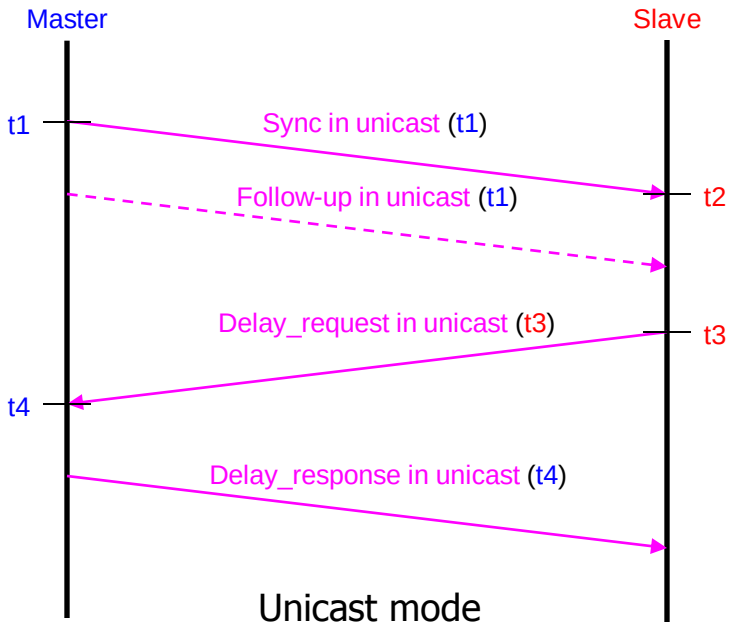
One-step clock vs two-step clock



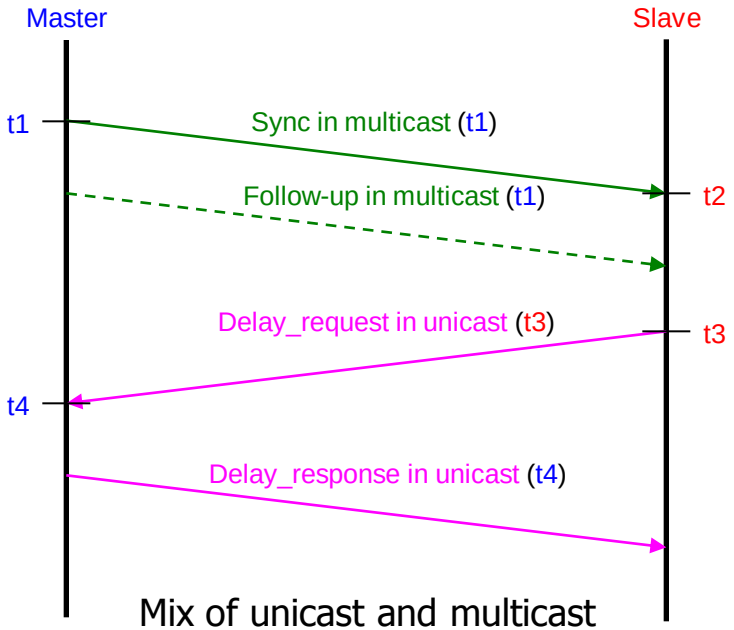


- Both one-step clock and two-step clock are allowed in the PTPv2 Telecom profile
- One-step clock is *a priori* the preferred option (significant reduction of the number of messages sent by the master)
- However, some features (e.g. security) may require the use of the two-step clock

Unicast vs multicast



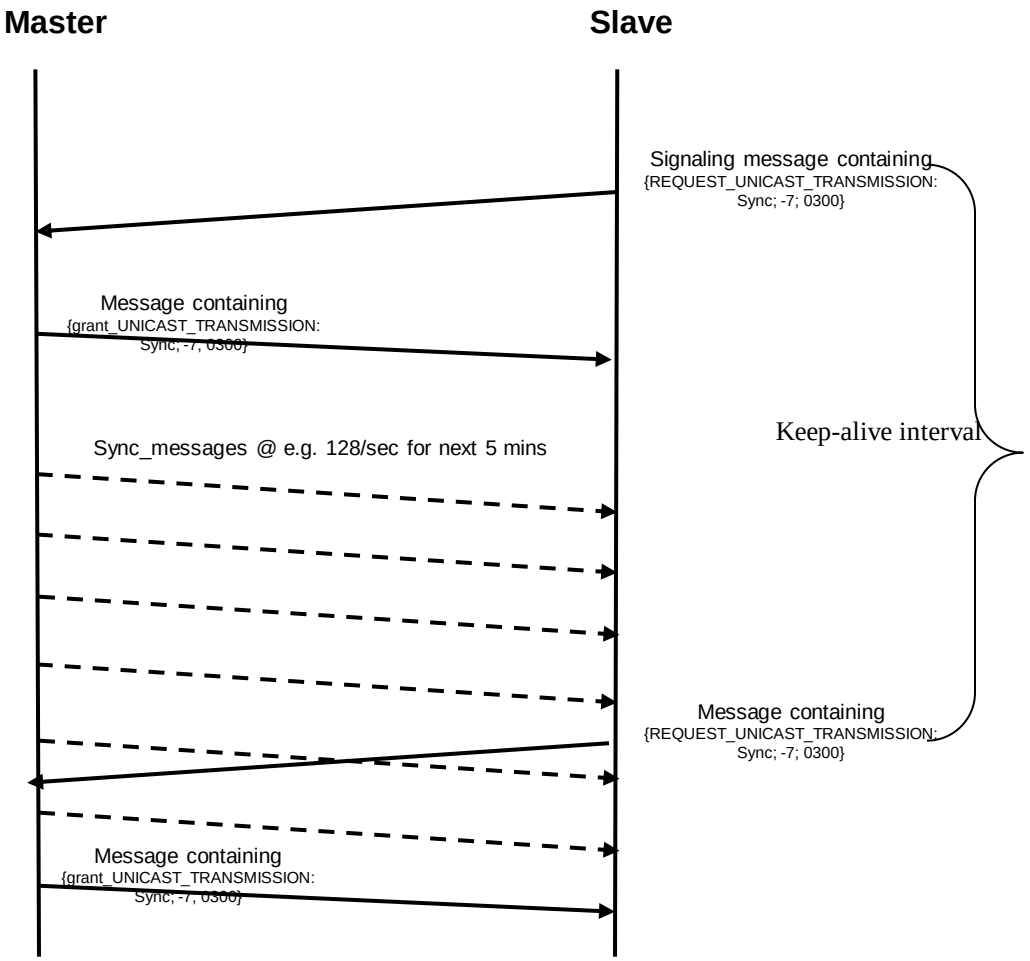
Unicast mode



Mix of unicast and multicast modes

- Both unicast and multicast modes are allowed for Sync and Follow-up messages in the PTPv2 Telecom profile
- Only unicast mode is allowed for Delay_Request and Delay_Response messages in the PTPv2 Telecom profile
- The mode used depends on the architecture over which PTPv2 is used (support for multicast or not, bandwidth consumption, etc…)
- The unicast mode is the default mode for the profile, some aspects of the mixed multicast/unicast mode will be for further study in the first version of the profile

Unicast request mechanism



- In unicast mode, PTPv2 slaves request synchronization service by sending a PTPv2 Signalling message in unicast using the "unicast message negotiation"
- It allows unicast sessions between two nodes with agreed packet rates for Sync, Announce, and Delay_Req messages.
- The mechnism enables to define a "keep-alive" period, in order to detect the inactive slaves
- It is part of the PTPv2 Telecom profile

PTP Mapping and Message Rates

- PTP mapping: IEEE1588-2008 annex D - Transport of PTP over User Datagram Protocol over Internet Protocol Version 4

- Unicast Messages rates (as currently agreed in the latest draft)
  - Sync /Follow-up - min rate: 1 pkt / 16 sec, max rate: 128 pkt / sec
  - Delay_Request/Delay_Response - min rate: 1 pkt / 16 sec, max rate: 128 pkt / sec
  - Announce - min rate: 1 pkt / 16 sec, max rate: 8 pkt / sec, default: 1 pkt / 2 sec

- Multicast Message rates are for further study

BEST MASTER CLOCK ALGORITHM (BMCA)

Best Master Clock Algorithm (BMCA)

- PTP allows the following options for the BMCA
  - The default BMCA specified in the IEEE-1588 standards
  - An alternate best master clock algorithm specified in a profile
- PTP specifies the requirements for an alternate best master clock algorithm
  - Provision must be made to provide the states required for operation of the PTP state machines and state decision events
  - The alternate best master clock algorithm may be dynamic or static
  - A static algorithm will simply configure the recommended state values on the ports of the node on which it is running.
  - The state decision codes for use in updating the data sets must be provided

IEEE-1588 Default BMCA

- All the clocks that are part of the same domain will organize themselves into a master-slave hierarchy based on the BMCA
- Announce messages are exchanged among potential grandmasters
- BMCA is run locally on each port
  - It compares its own data set with the data set that is received by Announce messages to determine which one is the better clock
- Two separate algorithms are part of the BMCA
  - Data set comparison algorithm
  - State decision algorithm

IEEE-1588 Default BMCA cont'd

- The data set comparison algorithm uses the attributes contained in the Announce messages with the following priority
  - Priority1 (defines clock priority, it is a user configurable designation)
  - clockClass (defines clock traceability)
  - clockAccuracy (defines clock accuracy)
  - offsetScaledLogVariance (defines clock stability)
  - priority2 (defines finer grained clock priority, it is a user configurable designation)
  - clockIdentity (defines clock unique identifiers, serves as a tie-breaker)
- The state decision algorithm determines the state of the port based on the results of the data set comparison algorithm
  - The ports states can be MASTER, SLAVE, or PASSIVE

BMCA Telecom Requirements

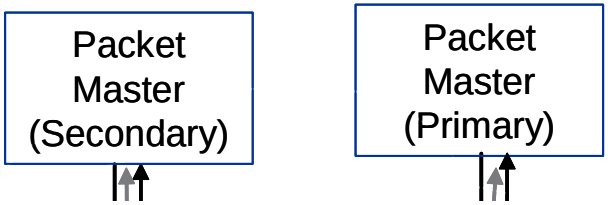
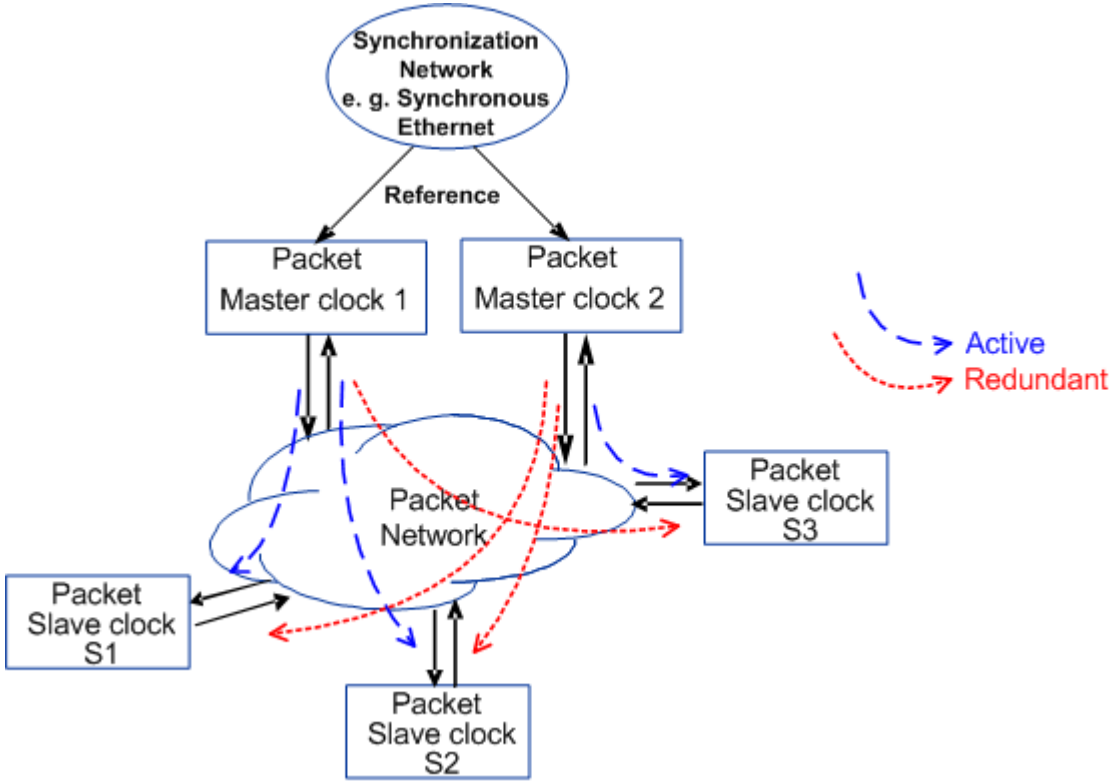


Figure 2/ITU-T G.8265.1: Packet network timing (frequency) protection

- Slaves should have the possibility to switch from one primary master to a backup master in case of failure
- It must be permitted by the Telecom Profile to have several masters delivering timing messages (e.g. Sync, Delay_resp) to slaves at the same time
- Different slaves must be able to select different masters
- The Master selection mechanism must be compatible with ITU-T Recommendation G.781 - Synchronization Layer Functions (SDH and Synchronous Ethernet)

Focus on the BMCA: multiple masters issue



- The default BMCA is designed to elect only one grandmaster as the unique active master in a PTP domain
- In the above example, if the default BMC is used then only 1 master will be sending timing messages and therefore there will be no protection mechanism available nor will there be any load balancing

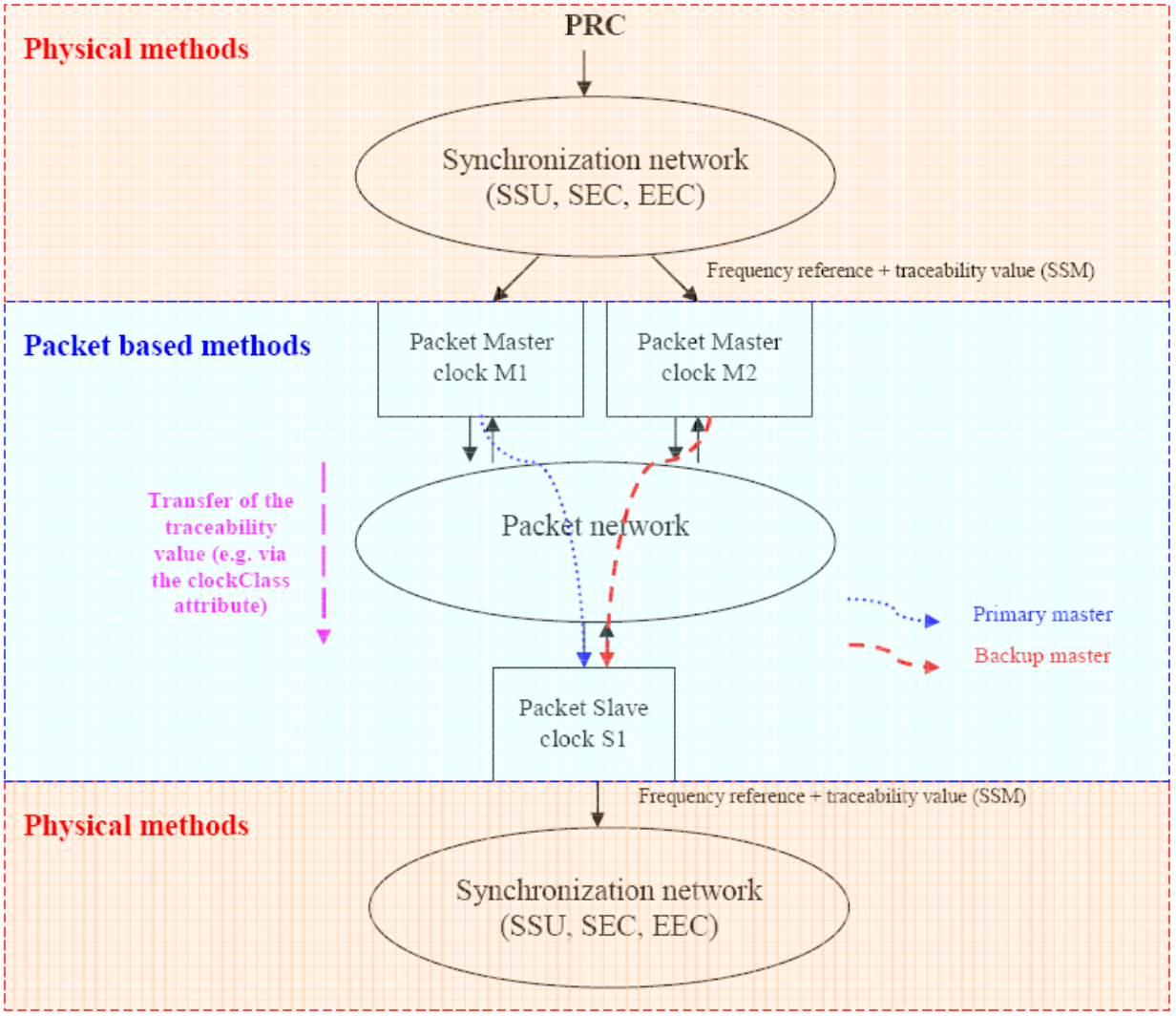
Focus on the BMCA: the solution

- ITU-T agreed to develop an Alternate BMCA in order to address telecom requirements
- Three approaches have been discussed to address this issue (but the choice has not yet been made)

1. Isolate the master so that it will never receive Announce messages from other masters, and therefore will always remain in the active state (agreed, but difficult to ensure the correct behavior in all the cases: e.g. miss configuration or malicious intentions) .
2. Have several Masters in active state at the same time. In this case, the master will remain in the active state even if it receives Announce messages from other masters.
3. Use the Alternate Master Flag to allow more than one Master in the network to send timing messages. In this case, the slaves are allowed to select and lock to a master in passive state with the Alternate Master Flag set to true.

Focus on the BMCA: SSM QL to clock class mapping

- G.781 specifies the clock Quality Level (QL) carried in Synchronization Status Messages (SSM)
- The need to carry a traceability information (corresponding to the SSM QL defined in ITU-T G.781) over PTP has been agreed
- It was agreed to use the Clock Class attribute in PTP to carry the SSM QL value
- Therefore, the SSM QL value will be transferred through the Clock Class attribute carried in the Announce messages
- The relevant codes to be used in the clock class attribute are still to be decided



Focus on the BMCA: G.781 oriented approach

- Several requirements defined in ITU-T G.781 have been discussed in the scope of PTPv2 profile
- This topic is not fully finalized, however the group is close to an agreement
  - PTP masters do not exchange unicast Announce messages with each other
  - PTP slaves will be defined as slaves only, therefore they do not send Announce messages
  - PTP attributes other than "clock class" in the Announce messages must not change the master selection
  - Each slave maintains a local ITU-T G.781 priority list of the masters

PTPv2 Telecom Profile (Frequency) Future Work

- PTP domain numbers
  - Agreed to define a default PTP domain number for the telecom profile different from the one per default in PTPv2 (i.e. different from 0), still needs to decide which one to use
  - There were discussions about using a range for the domain, but no agreements were reached
- Profile Identifier
  - The need to identify the PTP messages belonging to the Frequency telecom profile has been raised. This is an important issue in order to avoid any interaction with the messages belonging to the Phase/Time PTP profile and vice-versa. Both profiles will be running in the same network
- Finalize the Alternate BMCA
- Optional PTPv2 features to be used in the profile
  - Acceptable master table
  - Unicast discovery
  - Alternate master
- Finalize the Ordinary Clock attributes default values and ranges
- Security aspects (FFS for the first version of the Telecom Profile)
- Management aspects (FFS for the first version of the Telecom Profile)

PTPv2 Telecom profile phase/time oriented

- This work is still at an early stage
- The use of Boundary Clock (BC) or Transparent Clock (BC) in all the intermediate nodes to address PDV/asymmetry
  - Discussions about the use of BC vs TC is on-going at ITU-T
  - Several concerns were raised regarding the use of TCs
- Combination with Synchronous Ethernet is envisaged
- Preliminary tests results with BC+Synchronous Ethernet in all the network nodes were presented at the last ITU-T meeting in Geneva
  - The tests results were very promising
- Interaction between the PTPv2 telecom profile for phase/time and existing mechanisms to transport phase/time should be taken into account (e.g. PON, etc…)
- Need to standardized Time of Day (ToD) interface

References

- IEEE Std 1588™-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
- Michael Mayer, editor, ITU-T G.8265.1 (formerly G.8264.1) – Latest draft of Packet-based frequency distribution

QUESTIONS ???

THANK YOU!