ITU-T Q13/15activity and its relation with the leap second

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Calnex solutions

Q13/15
Network synchronization and time distribution performance

Q13 has already studied network synchronization issues related to PDH and SDH from 1988 until 2000, and to OTN in 2001-2004 and 2008-2012 Study Periods.
This question has also started studying the network synchronization issues related to packet networks with focus on mobile network needs from 2004 until 2012.

Continuing effort needs to be put into the study of synchronization issues in packet based networks.

Need for synchronization

In the 1970's digital switches had to be synchronized (syntonized in fact) to prevent slips. PDH links 2.048 and 1544 Mbits could transport timing between switches

In the 1990's SDH &SONET networks provided a new synchronization network.
In the 1990s, NTP was condisered accurate enough for the existing applications

The OTN (Optical Transport Network) specified at the begining of the 2000's was not defined to be a new synchronization network, but simply to be transparent to the existing SDH one.

Need for synchronization

In the 1990's the emerging mobile networks were specified to operate within a 50 ppb frequency accuracy
-the reference timing was transported with the data via synchronized 2Mbits signals

The evolution of telecom networks toward packet networks has generated a new need to transport a reference frequency through packet networks for FDD networks requiring 50ppb accuracy

-The evolution of mobile networks toward TDD techniques added a new requirement for the transport of time with an accuracy of 1.5 µs

Q13 milestones

Until 2003 transport of frequency over

-PDH, SDH, OTN

2003-2013 transport of frequency over packet networks via

-CES

- synchronous Ethernet

- IEEE 1588 V2

2011-2013 transport of phase and time over packet networks via IEEE 1588 V2

-work still ongoing

synchronous Ethernet

-based on SDH clocks and network architecture

-totally compatible with SDH

*SyncE links and SDH links can be chained

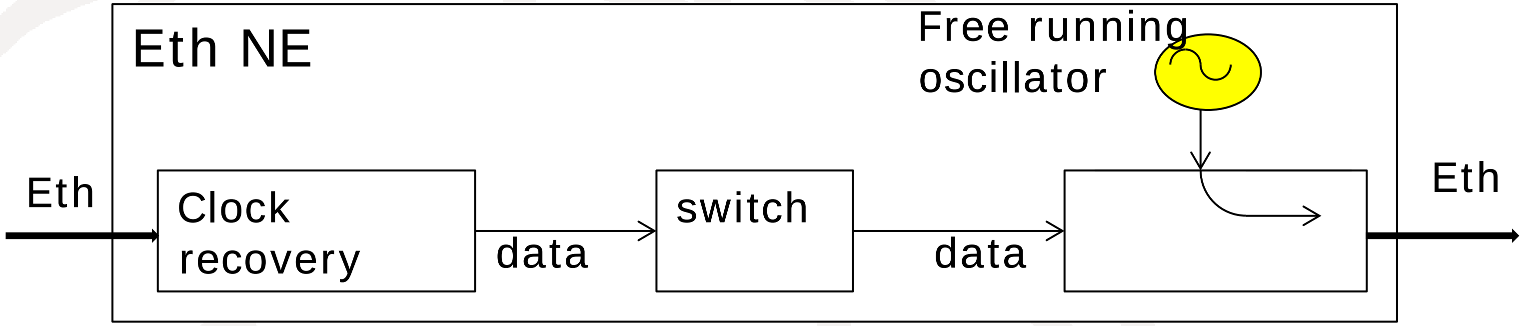
*a synchronization network may have both SDH and SyncE network elements

-But it does not transfer time

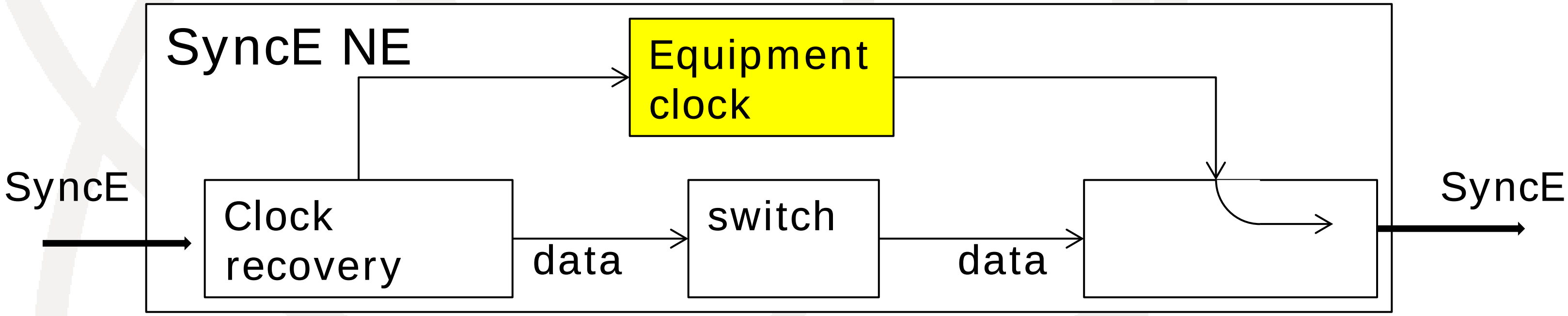
* could be done using packets with SSM

*but it was preferred to use the new IEEE 1588

SyncE equipment



Ethernet equipment



Synchronous ethernet equipment

TDM and SyncE standards

	TDM	SyncE
Definitions	G.810	G.810
Architecture	G.803	G.8261
Performance	G.823/4/5	G.8261
Functional model	G.781/783	G.8264* G.781
Clock specification	G.811/2/3	G.8262
Test equipment	O.171/172	O.174

Packet networks and PDV

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- In packet networks switches/routers store packets in buffers as they arrive and transmit them when possible in the outgoing link
- The transfer delay through a switch/router highly depends on the traffic and the design of the switch/router implementation
- This packet delay variation, PDV, degrades the quality of timing.
- PDV may reach tens or hundreds of µs in a packet network, to be compared with 1.5µs accuracy requested for TDD mobile applications

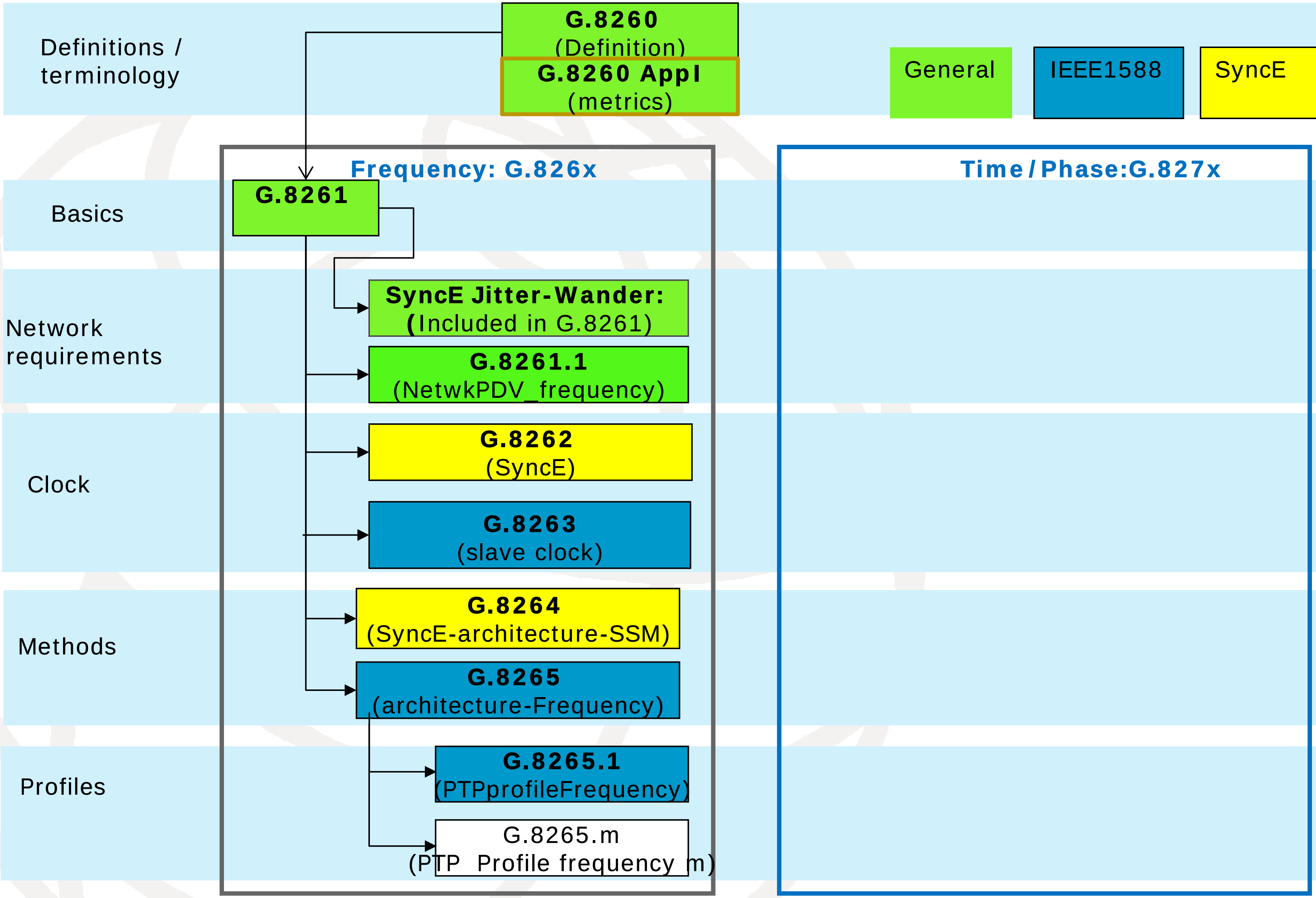
IEEE Std 1588™ - 2008

- IEEE 1588-2008 defines a Precision Time Protocol designed to synchronize clocks in a distributed system
- It is intended for Telecom networks, and other applications
- It defines several types of clocks, e.g BCs and TCs, with mechanisms reducing the amount of PDV
- It offers a lot of options; each application must select them in a « profile »
  - One way vs two way
  - Mapping, IP V4, V6, Eth etc
  - Rate and type of messages
  - etc

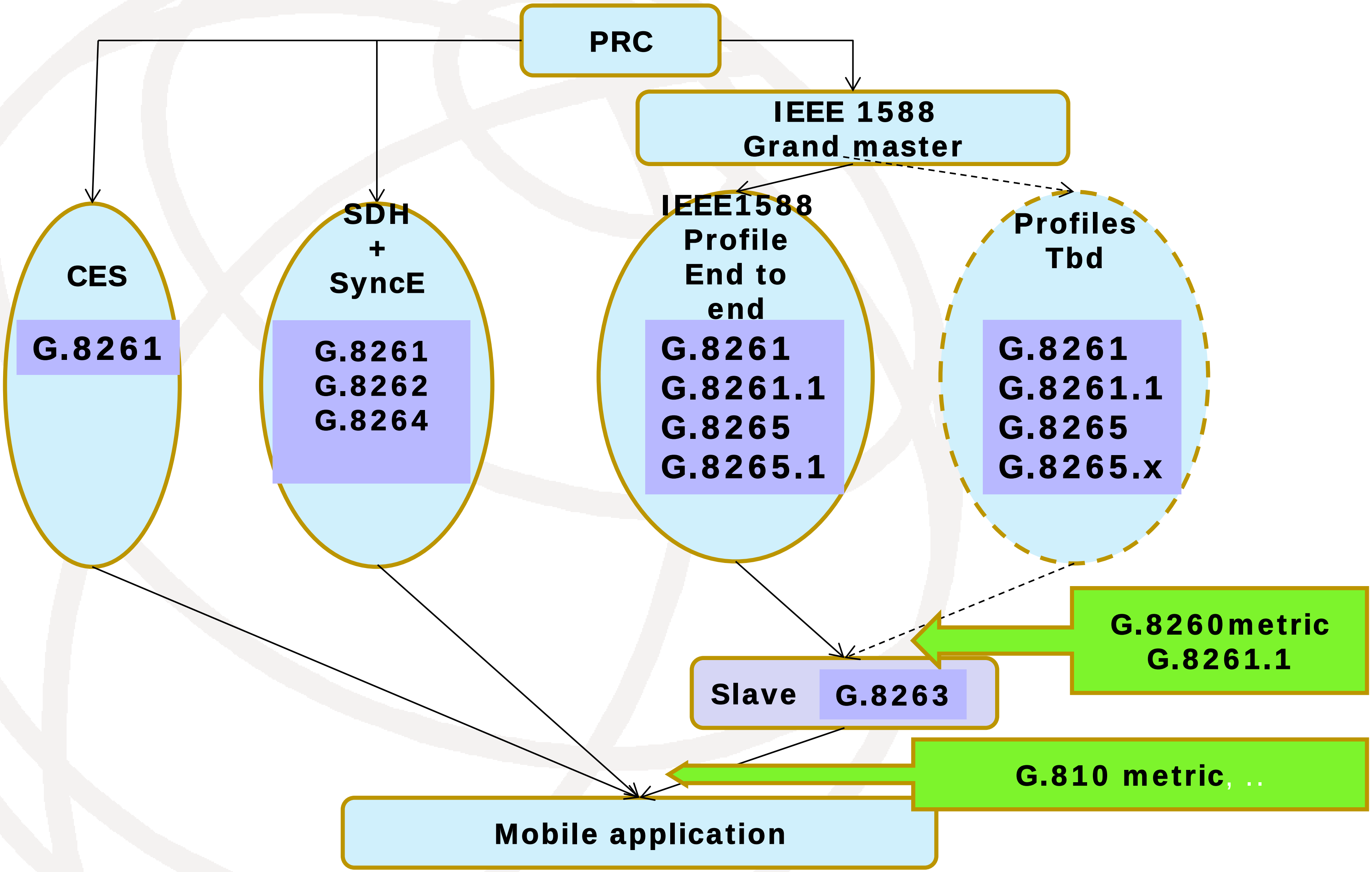
transport of frequency over packet networks using IEEE-1588

Q13 decided to study a first « end to end » profile where:
-the transport of frequency is done via IEEE 1588 messages
-The IEEE 1588 Grand Master delivers the PTP
messages
-The slave clock extracts the timing from the PTP
messages and delivers the frequency
- Equipment located between the grand Master and the Slave clock are basic switches/routers , unaware of IEEE 1588, providing a solution for existing packet networks

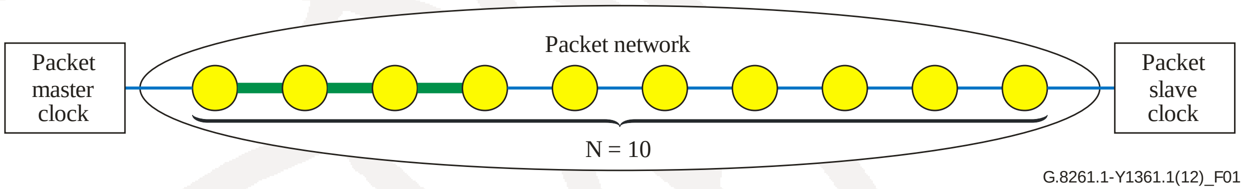
Recommendations for Frequency



Transport of frequency in packet networks



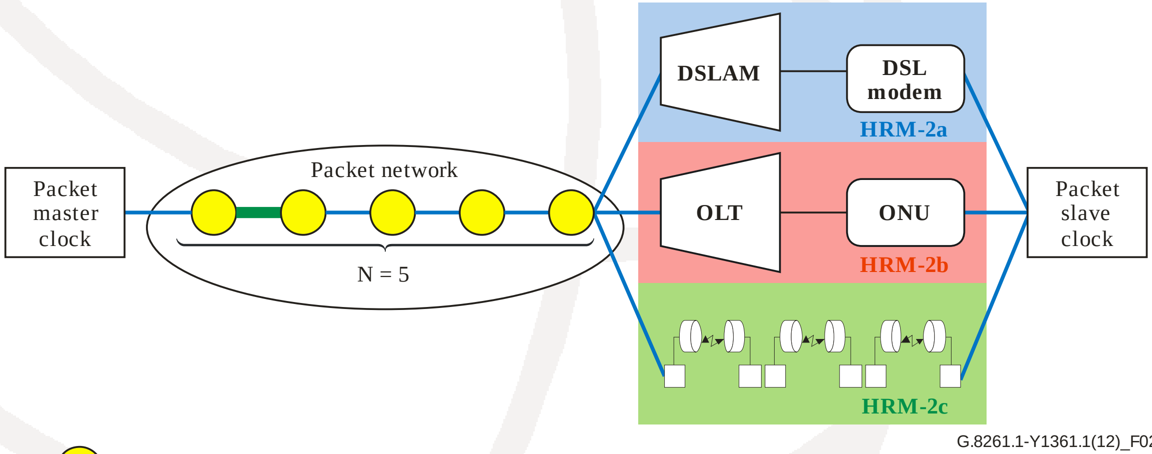
G.8261.1 defines 2 HRMs
(HRM= hypothetical reference model)



Packet node (e.g., ethernet switch, IP router, MPLS router)

10 Gbit/s fibre optical link

1 Gbit/s fibre optical link



Packet node (e.g., Ethernet switch, IP router, MPLS router)

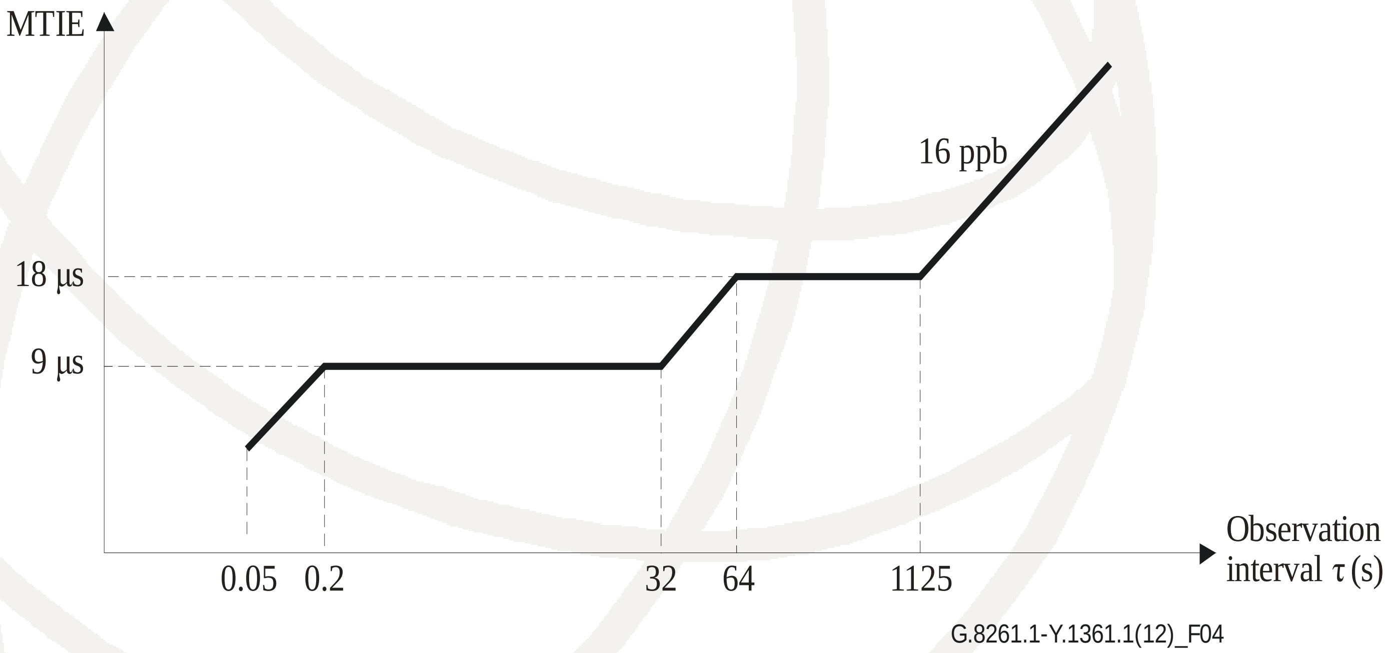
10 Gbit/s fibre optical link

1 Gbit/s fibre optical link

Microwave link

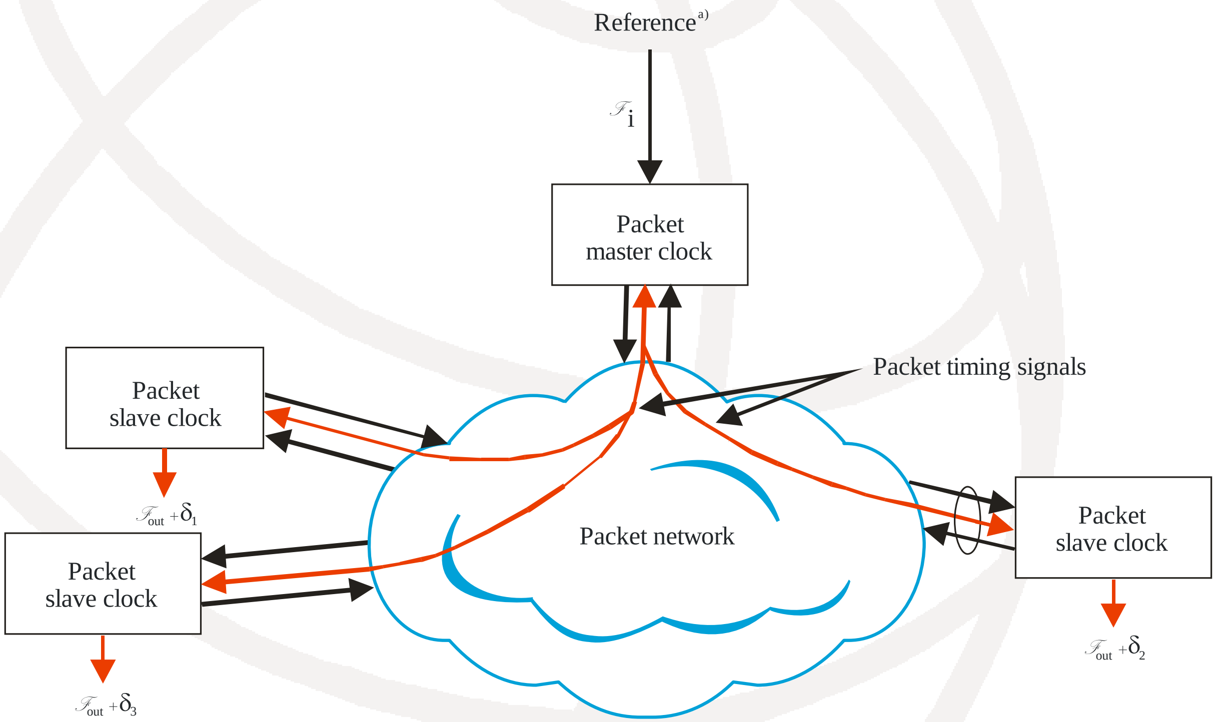
G.8261.1 defines the performance of the transport for mobile application

For short obervation time it follows the 2 Mbits mask defined for traffic interfaces.
For longer observation times it must comply with the requirement of the end user.



G.8265

G.8265 specifies the network architecture and addresses the protection aspects



[a)] The reference may be from a PRC directly, from a GNSS or via a synchronization network

G.8265/Y.1365(10)_F01

G.8265.1

G.8265.1 specifies the profile for frequency distribution without timing support from the network (PTP messages not processed in equipments between master and slave)

Mapping: IP
Mode: one-way or two-way
Unicast mode
Message rates
Protection: definition of an alternate BMCA
(Best Master Clock Algorithm)

G.SUPP

Extensive simulations were done to validate the specifications done for the transport of frequency using IEEE 1588.
A supplement called G.SUPPxx <u>will</u> present the simulation results.

transport of phase and time over packet networks using IEEE-1588

Transport of time implies a two-way mode to take into account the transport delay between the the master clock and the slave clock.

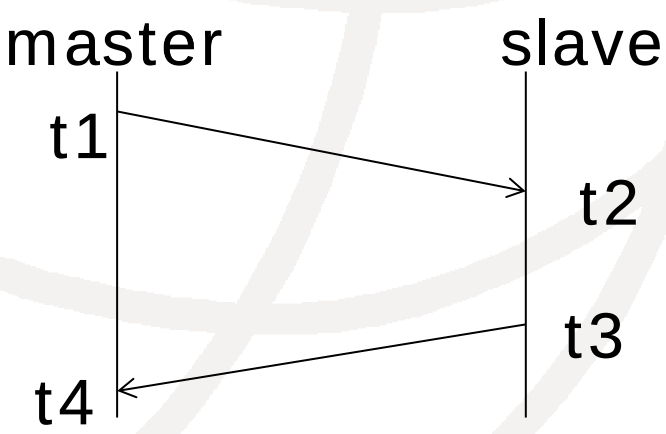
IEEE 1588 is based on TAI time but it also provides an information to get UTC, called the « currentUtcOffset »

IEEE 1588 propagation delay

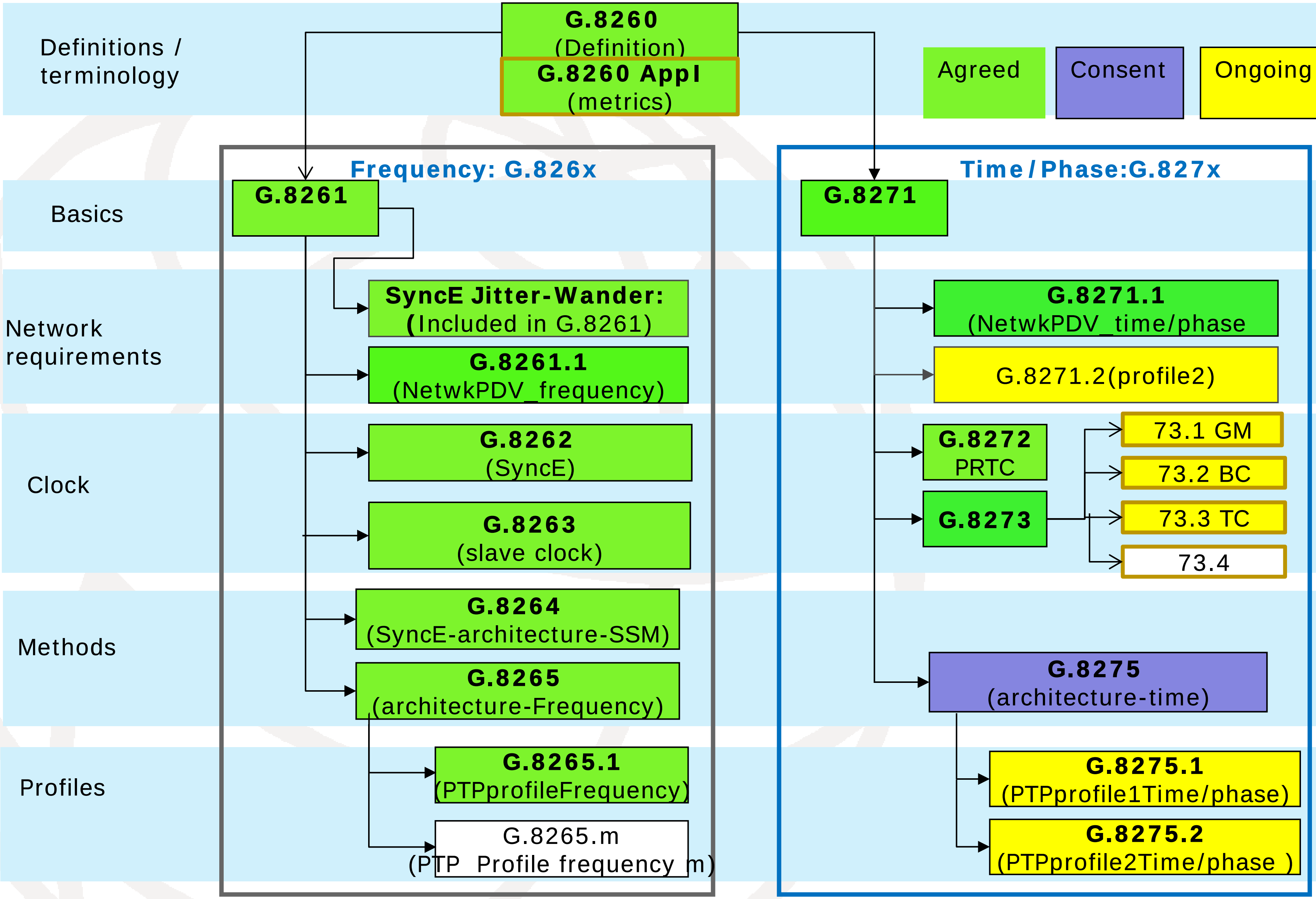
The delay in the propagation of time between two Clock is calculated with the time stamps of messages in the master and the slave as half of the roundtrip delay

$$\text{Delay} = ((t2 - t1) + (t4 - t3)) / 2$$

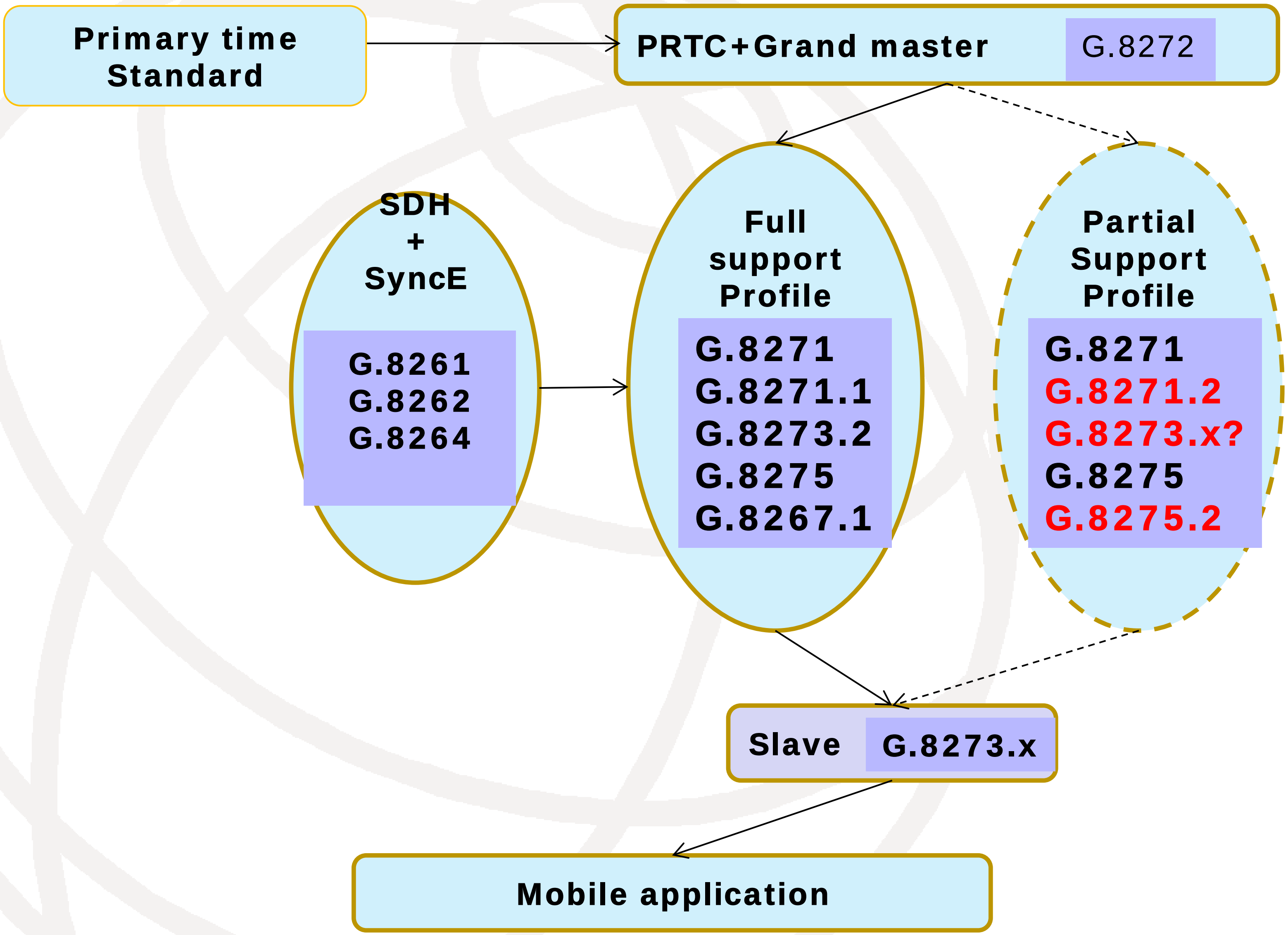
The asymmetry in the two direction delays is one of the main source of inacurracy



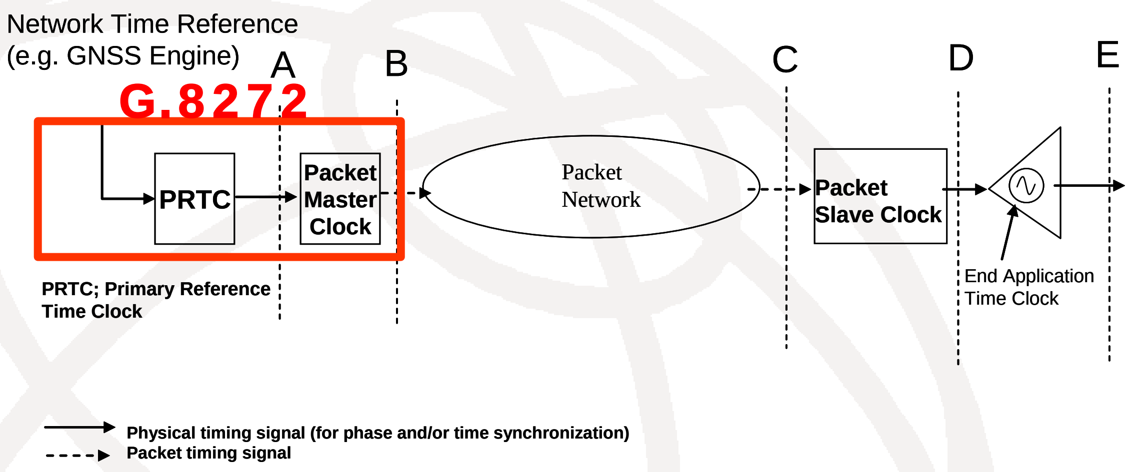
Recommendations for F and T



Transport of time and phase in packet networks



G.8271: network model

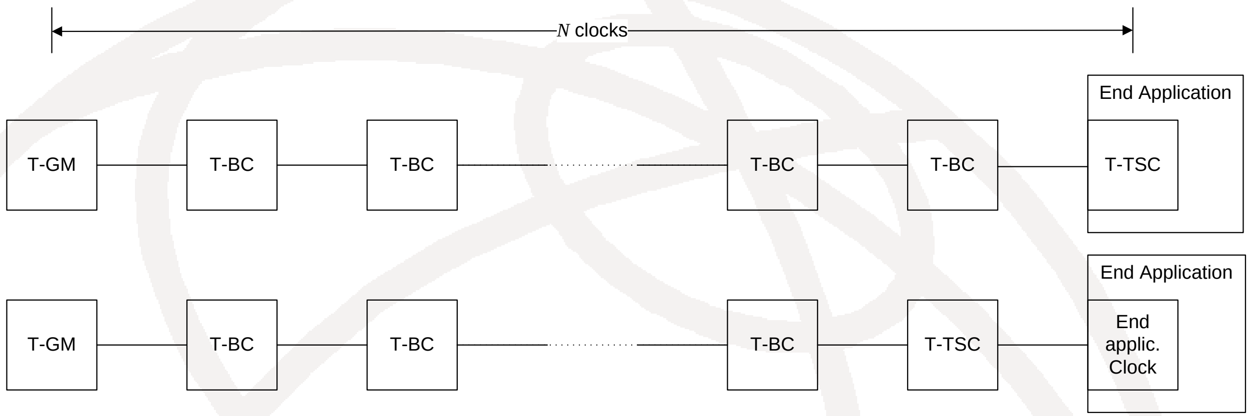


A: PRTC Network Limits
B: Packet Master Clock Network Limits
C: Packet Slave Clock input Network Limits
D: Packet Slave Clock output Network Limits (if applicable)
E: End Application requirements (e.g. Phase accuracy)

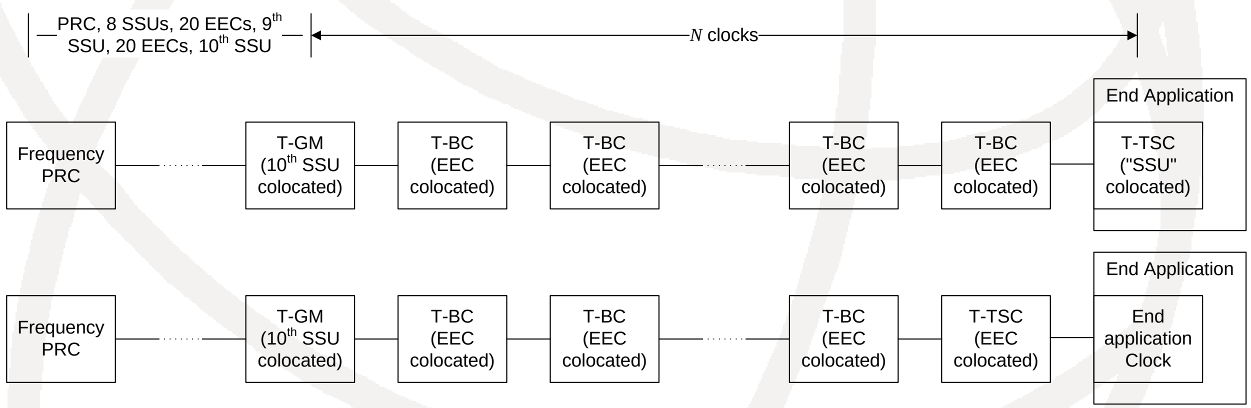
Note that:
-G.8272 specifies the global specification of PRTC and packet master clock (processing IEEE 1588), although PRTC might also remain a stand alone equipment
-packet slave clock might be colocated with the end application Time clock

G.8271.1 HRMs

Hypothetic reference Models



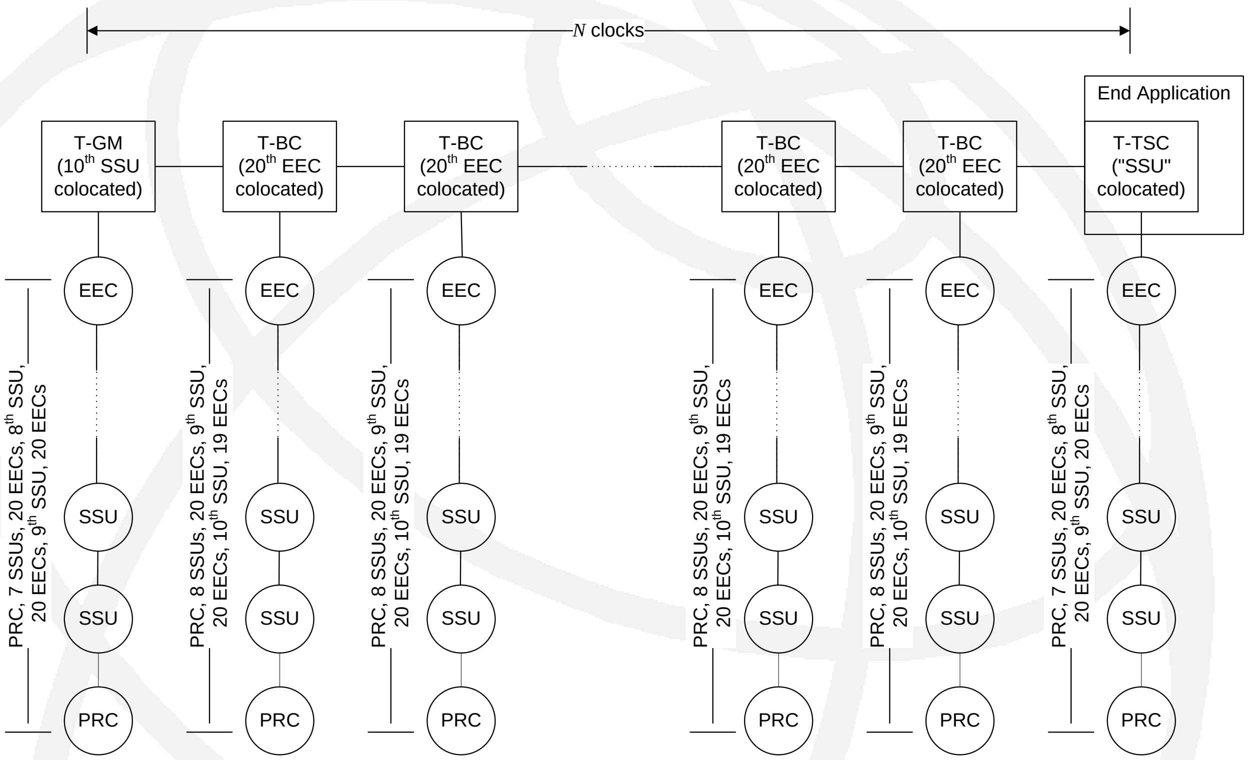
HRM1 without physical layer frequency support



HRM-2 with physical layer frequency support – congruent scenario

G.8271.1 HRMs

Hypothetic reference Models



HRM-3 with physical layer frequency support – non congruent scenario

G.8271.1: Noise budget

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Based on extensive simulations

BC noise : 50ns
(another BC with lower noise should also be specifed)

Budget Component	Failure scenario a) (change of PRTC)	Failure scenario b)	Long Holdover periods (e.g. 1 day)
PRTC (ce_{ref})	100 ns	100 ns	100 ns
Holdover and Rearrangements in the network (TE_{HO})	NA	**400 ns**	**2400 ns**
Random and error due to synchronous Ethernet rearrangements (dTE')	200 ns	200 ns	200 ns
Node Constant including intrasite (ce_{ptp_clock}) (Note1)	550 ns	550 ns	550 ns
Link Asymmetries (ce_{link_asym})	250 ns	100 ns	100 ns
Rearrangements and short Holdover in the End Application (TE_{REA})	250 ns	**NA**	NA
End application (TE_{EA})	150 ns	150 ns	**150 ns**
Total (TE_D)	**1500 ns**	**1500 ns**	**3500 ns (Note3)**

Scenario a) change of Grand master
Scenario b) Short interruption of the GNSS signal (e.g. 5 minutes)

G.8271.2 HRM for the partial support profile

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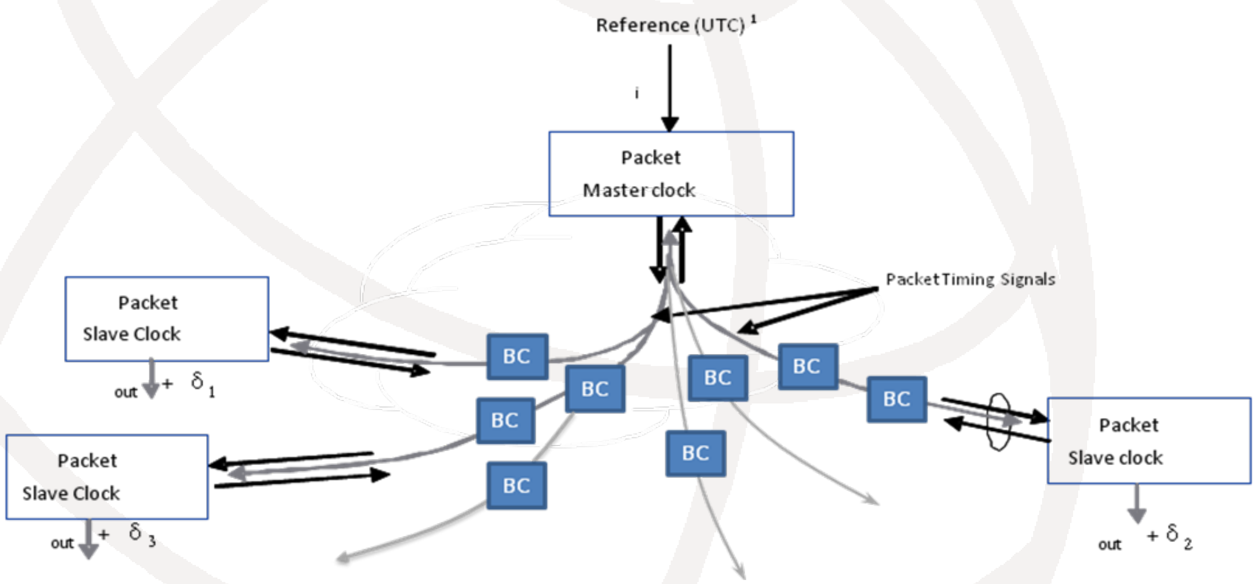
This HRM is under definition

The basic of this HRM is to have

- -1588 unaware equipments
- -Might have Boundary clocks to filter PDV generated by 1588 unaware Nes
- -numbers of NEs: to be defined

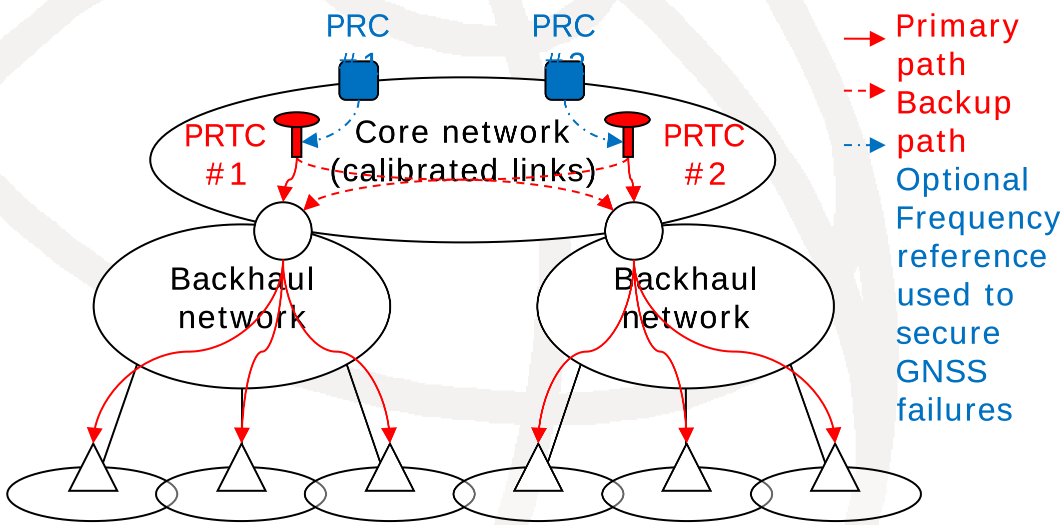
G.8275: network architecture

The current architecture deals with Boundary clocks (BC)
Transparent clocks will also been considered, after agreement with IEEE 802.1 on the issue of layer violation



G.8275 Protection

Several positions for PRC, PRTC have been listed to provide protection scenarios, inputs for simulations



Note: T-GM are connected to the PRTC in this architecture

Interest of Q13 in the leap second process

Q13 is responsible for the transport of time to end users, but is not involved in the applications which need time

Q13 does not need time information for operating the transport network

Q13 transports TAI from the PRTC to the end user via IEEE 1588

IEEE 1588 provides an information on the offset between TAI and UTC

G.8272 PRTC interface

example of information that could be transferred over the time interface

Name	Description
Time	International atomic time, TAI (seconds)
Leap seconds	Leap seconds (offset between TAI and UTC)
Leap second addition/subtraction flags	Provides advance notification of the occurrence of a leap second
Status	Provides an indication of whether the signal is locked, in holdover, or should not be used.

Conclusion

- All processes involved in the transport of time can deliver TAI and UTC, as they have implemented some software to handle leap seconds, i.e.

  -GPS receivers, PRTC

  -IEEE 1588 protocol

-Preservation or removal of leap seconds is not an issue <u>for Q13</u>

  - Current « Q13 network » is compatible with UTC

  - Divergence TAI vs UTC is no problem, <u>for Q13</u>

-But any modification in the leap second process will jeopardize the delivery of UTC at the end application, as it would require modification of equipments and protocols

Where to get the recommendations?

International Telecommunication Union

http://www.itu.int/ITU-T/recommendations/index.aspx?ser=G

A GIANT LEAP IN 1588V2 PTP MEASUREMENTS

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Thank You

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