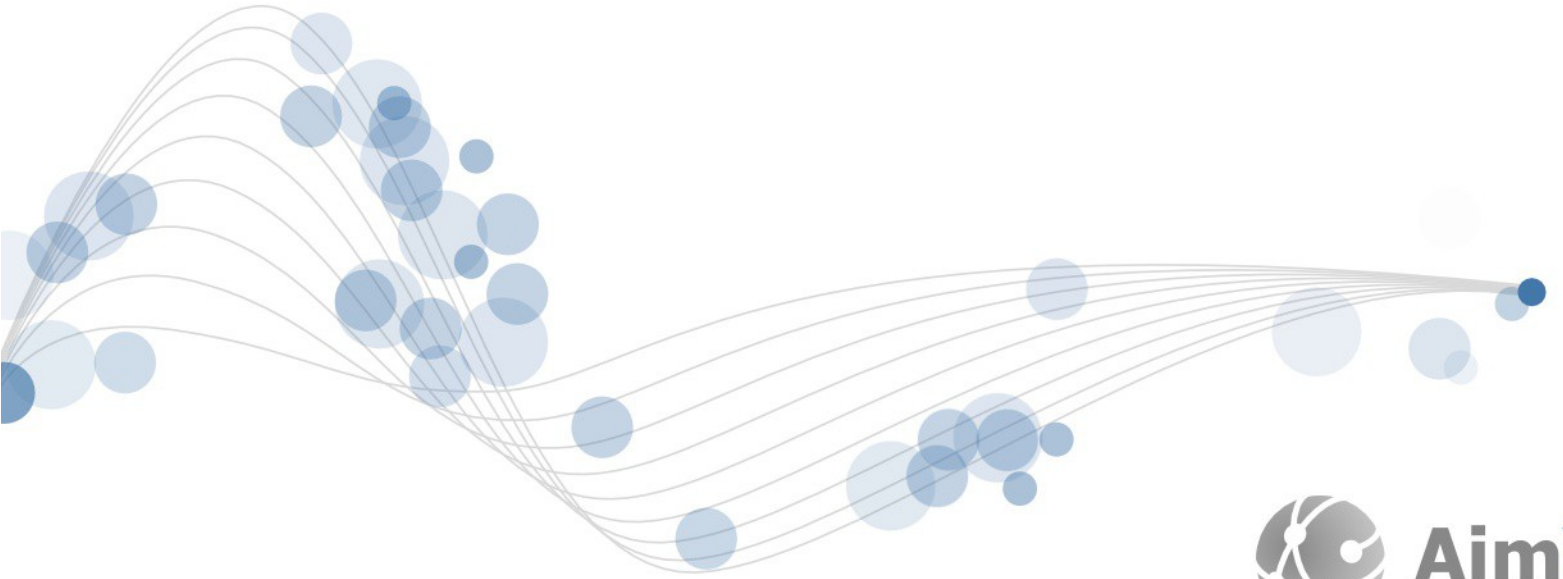
Add T-TC to Equipment and Verify behavior with PDV test-cases

Willem van den Bosch



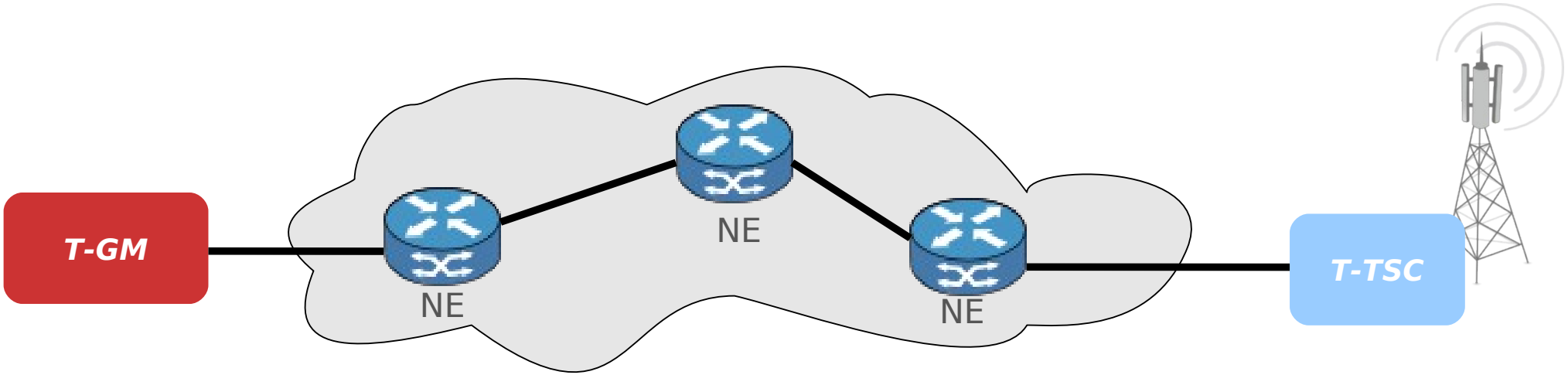
AimValley

Agenda

- ToD distribution through the Network
- IEEE1588 Transparent Clock characteristics
- Differences between TC and BC
- Transparent Clock measurement setup G.8261 test cases
- Transparent Clock measurement results G.8261 test cases
- Transparent Clock measurement over Microwave link (A1 Telekom)
- Conclusion

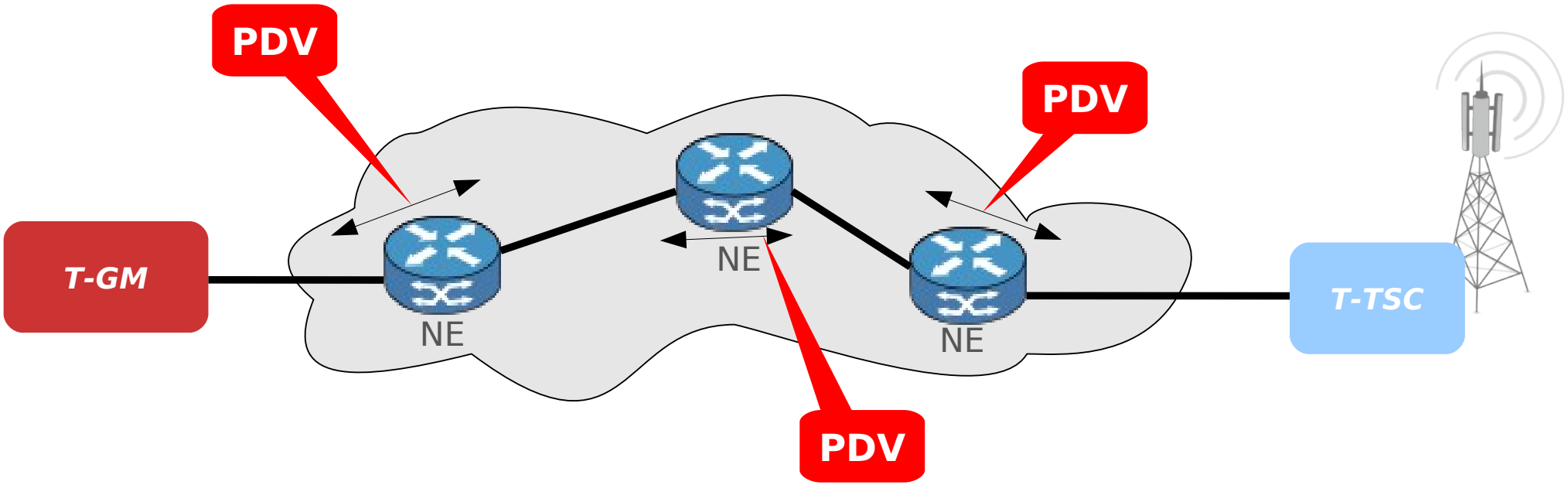
ToD distribution through the Network – 1

- Network with IEEE1588 unaware Network Elements (NE's)



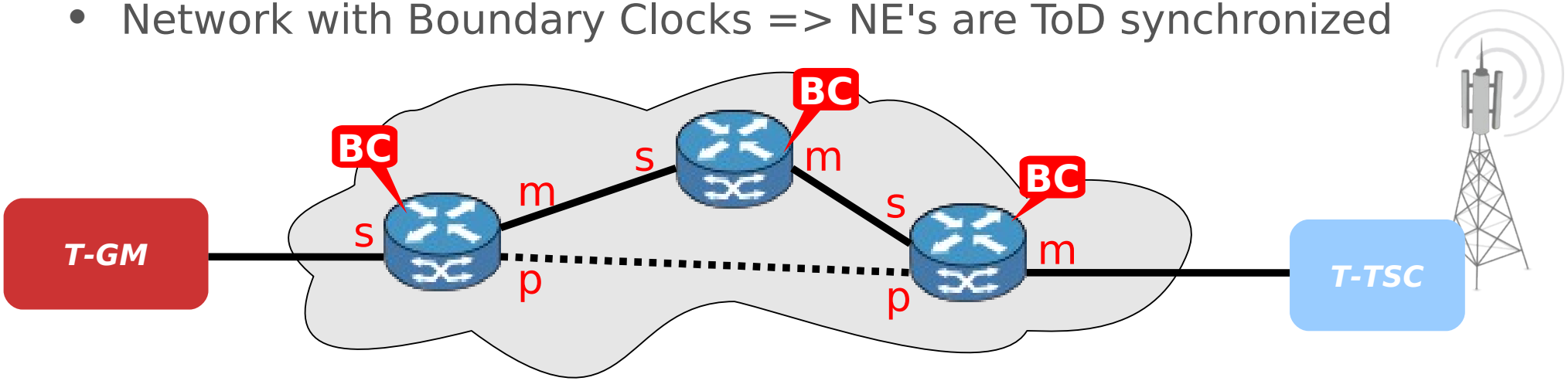
ToD distribution through the Network – 2

- Network with IEEE1588 unaware Network Elements (NE's)
- The Packet Delay Variation in each NE prohibids proper Time of Day synchronization between T-GM and T-TSC

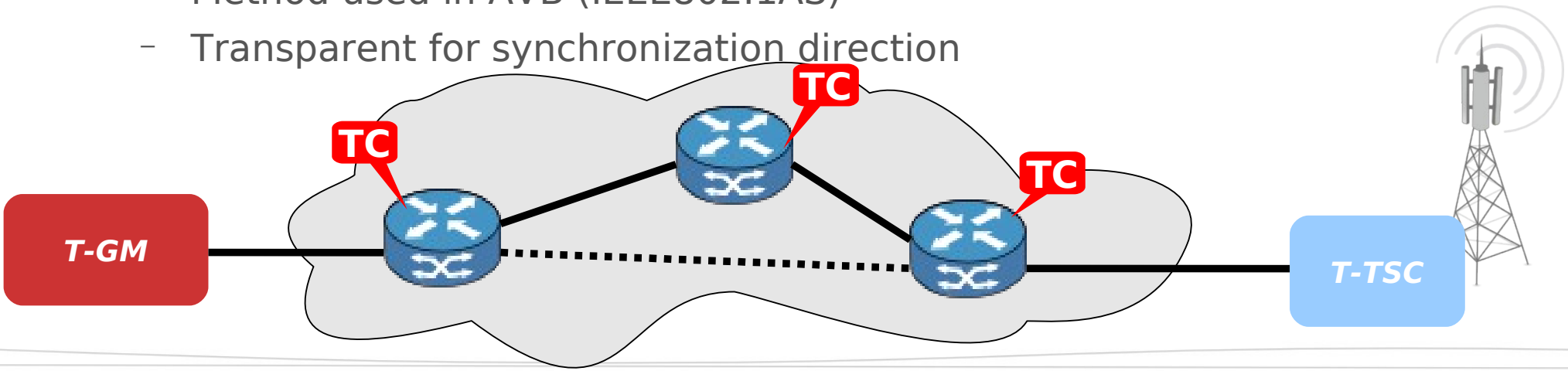


ToD distribution through the Network – 3

- Network with Boundary Clocks => NE's are ToD synchronized

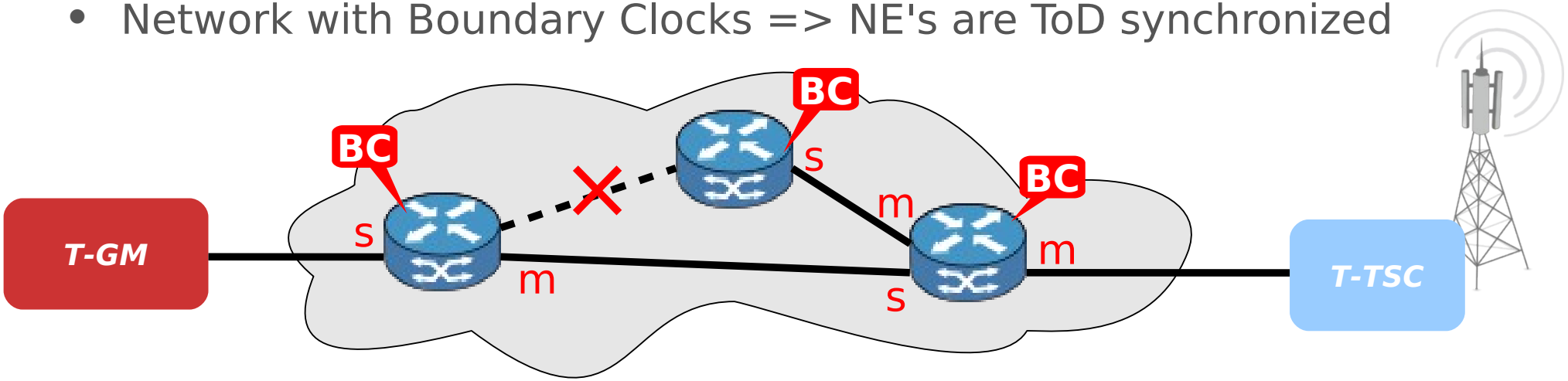


- Network with Transparent Clocks => NE's are not synchronized
  - Method used in AVB (IEEE802.1AS)
  - Transparent for synchronization direction

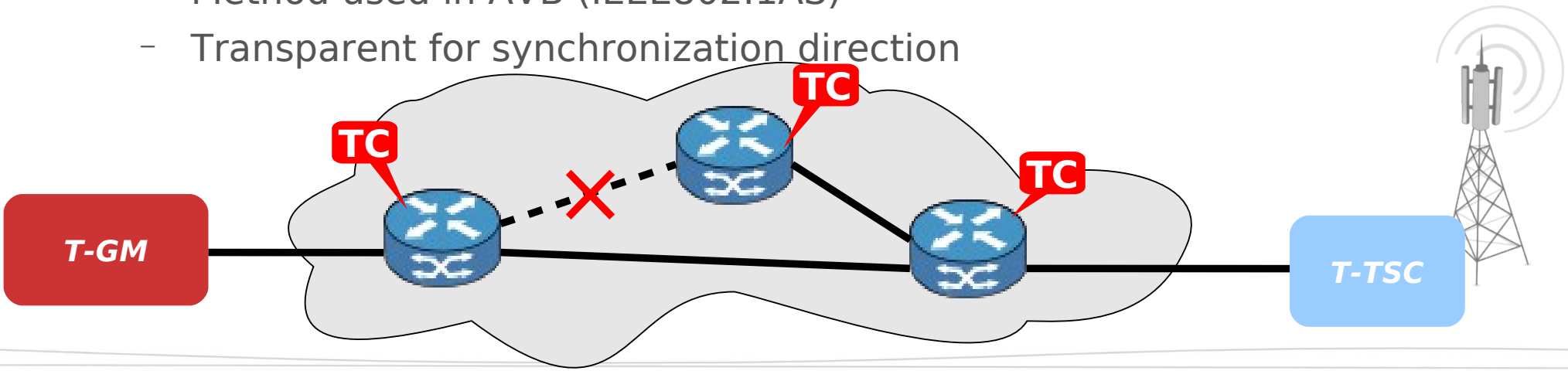


ToD distribution through the Network – 4

- Network with Boundary Clocks => NE's are ToD synchronized

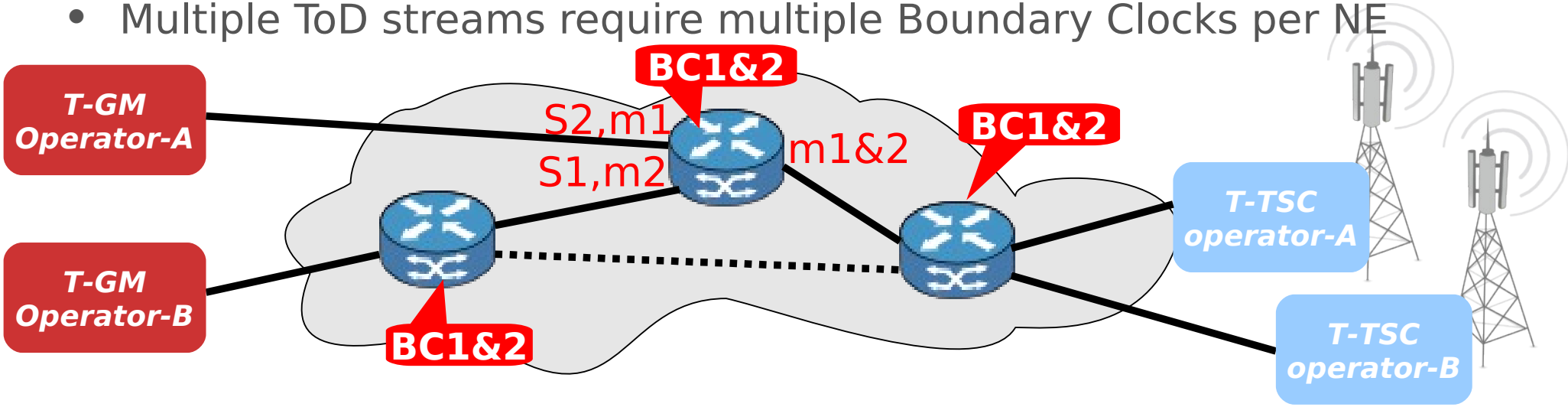


- Network with Transparent Clock => NE's are not synchronized
  - Method used in AVB (IEEE802.1AS)
  - Transparent for synchronization direction

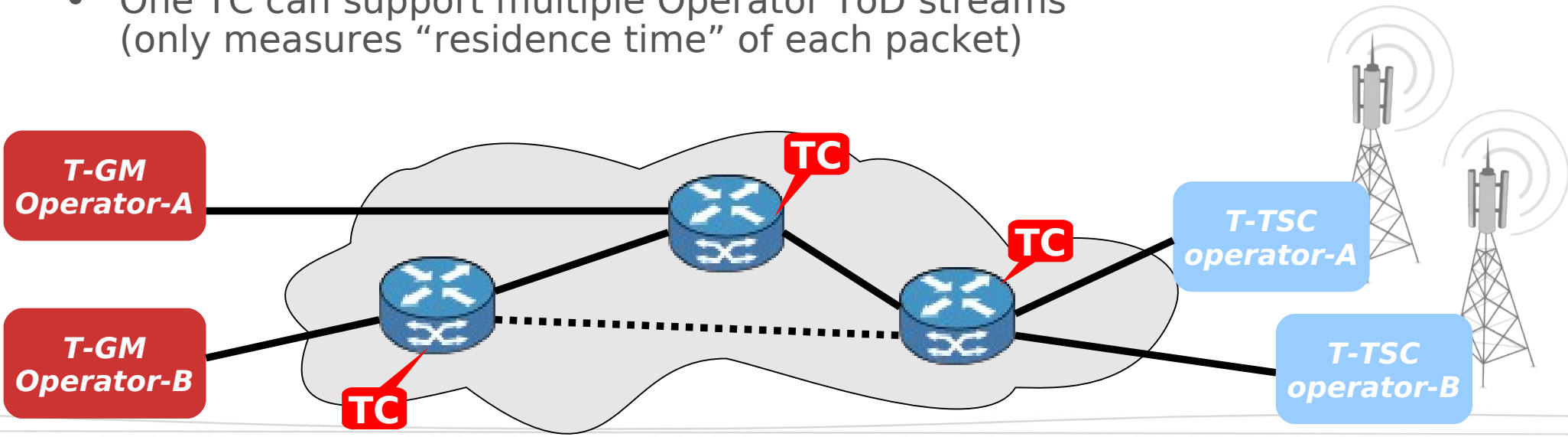


Multiple ToD streams through the Network

- Multiple ToD streams require multiple Boundary Clocks per NE

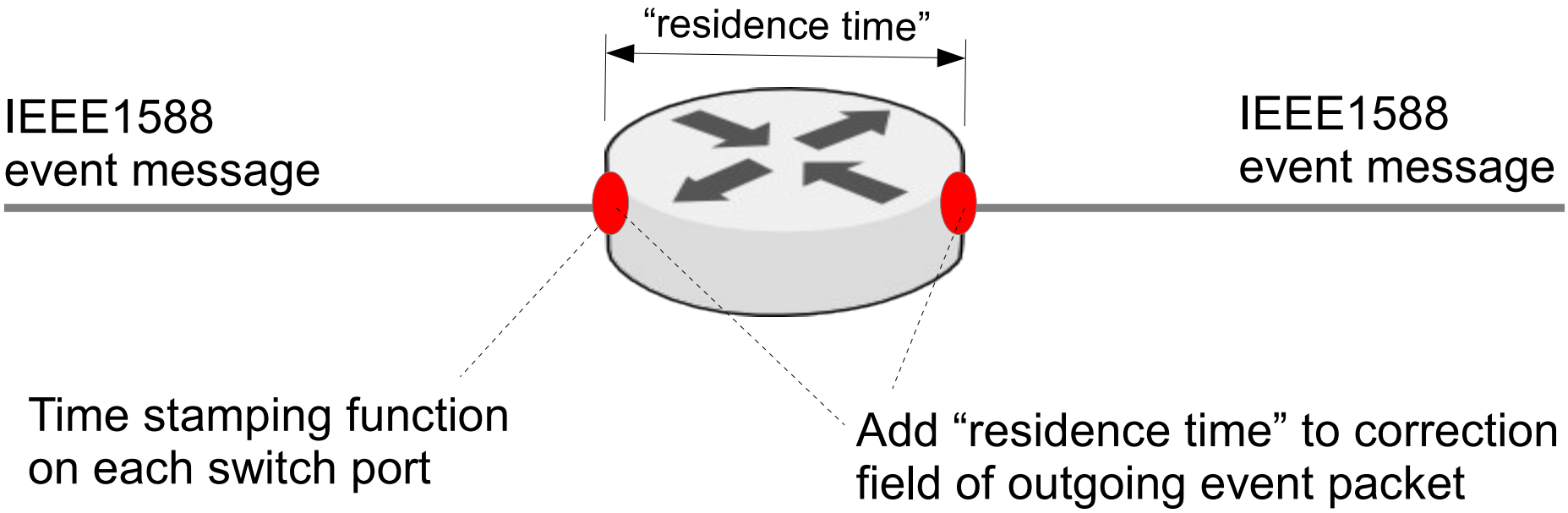


- One TC can support multiple Operator ToD streams (only measures “residence time” of each packet)



Transparent Clock Basic function

- Transparent Clock measures the time it takes for an 1588 event meassage to travel through a Router or Switch
- This is called “residence time” which can be different for each packet
- “Residence time” is added to the correction field of an event message
- Transparent for the direction of the Sync and Delay_Req messages

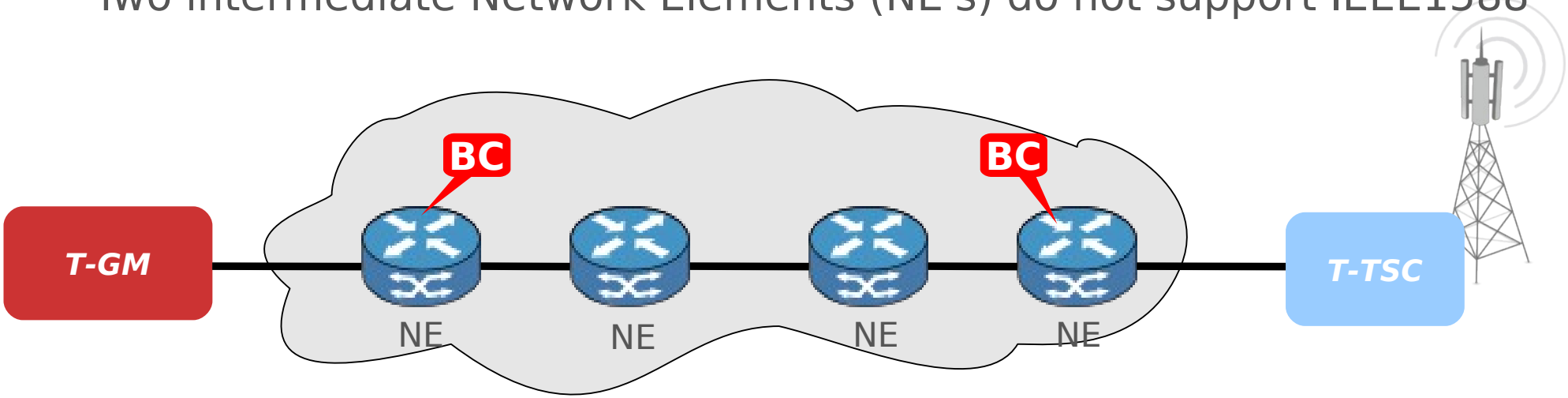


Differences between T-BC and T-TC

Boundary Clock	Transparent Clock
BC terminates and synchronizes to the PTP flow received at a slave port. BC generates a new PTP flow based on its own ToD towards all master ports.	Measures “residence time” of each Sync or Delay_Req packet (PTP event packets) and adds this value to the Correction-field of the same PTP message.
BC requires provisioning to determine the synchronization direction in the network (master, slave or passive port).	TC is “synchronization direction” independent, no provisioning required
Every impairment of the network topology can result in a different synchronization direction.	TC is “transparent” for network impairments which change the synchronization direction.
BC requires multiple HW instances to support more than 1 domain (multi operator ToD)	TC is “transparent” for domains and can support multiple operator ToD streams.
BC has filtering (PLL) function with associated lock-time and requires a very stable internal clock which relates to the low filtering bandwidth.	No PLL function, no lock time. Clock accuracy of ± 4.6 ppm is sufficient and gives a maximum error of 4.6ns over a measured millisecond “residence time”.

Network with “partial” IEEE1588 support

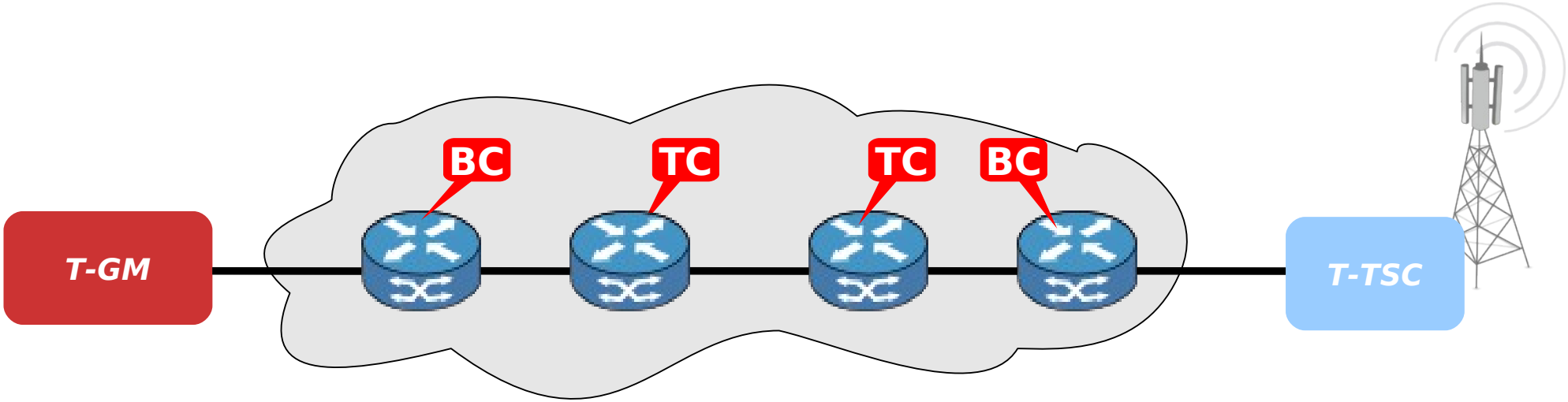
- Two intermediate Network Elements (NE's) do not support IEEE1588



- Proper Time of Day synchronization between T-GM and T-TSC can be established by “upgrading” the two intermediate notes with a BC or a TC function.

TC and BC in the same Network

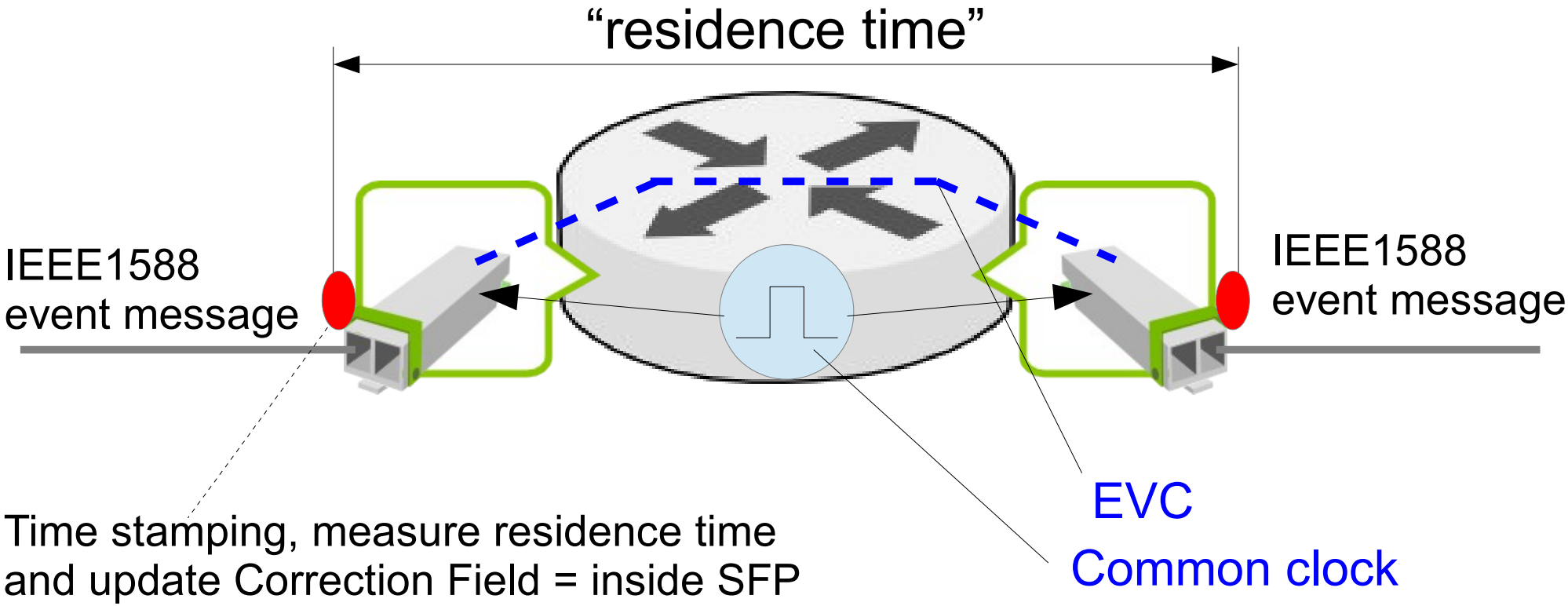
- BC and TC can be combined in the same network
- TC is a good option to improve “partial support of the network”



- With ideal TC's => connection in between BC's behaves like a wire.
- If SyncE is used in the network a TC can measure the residence time of event messages very accurately with the frequency of the T-GM.

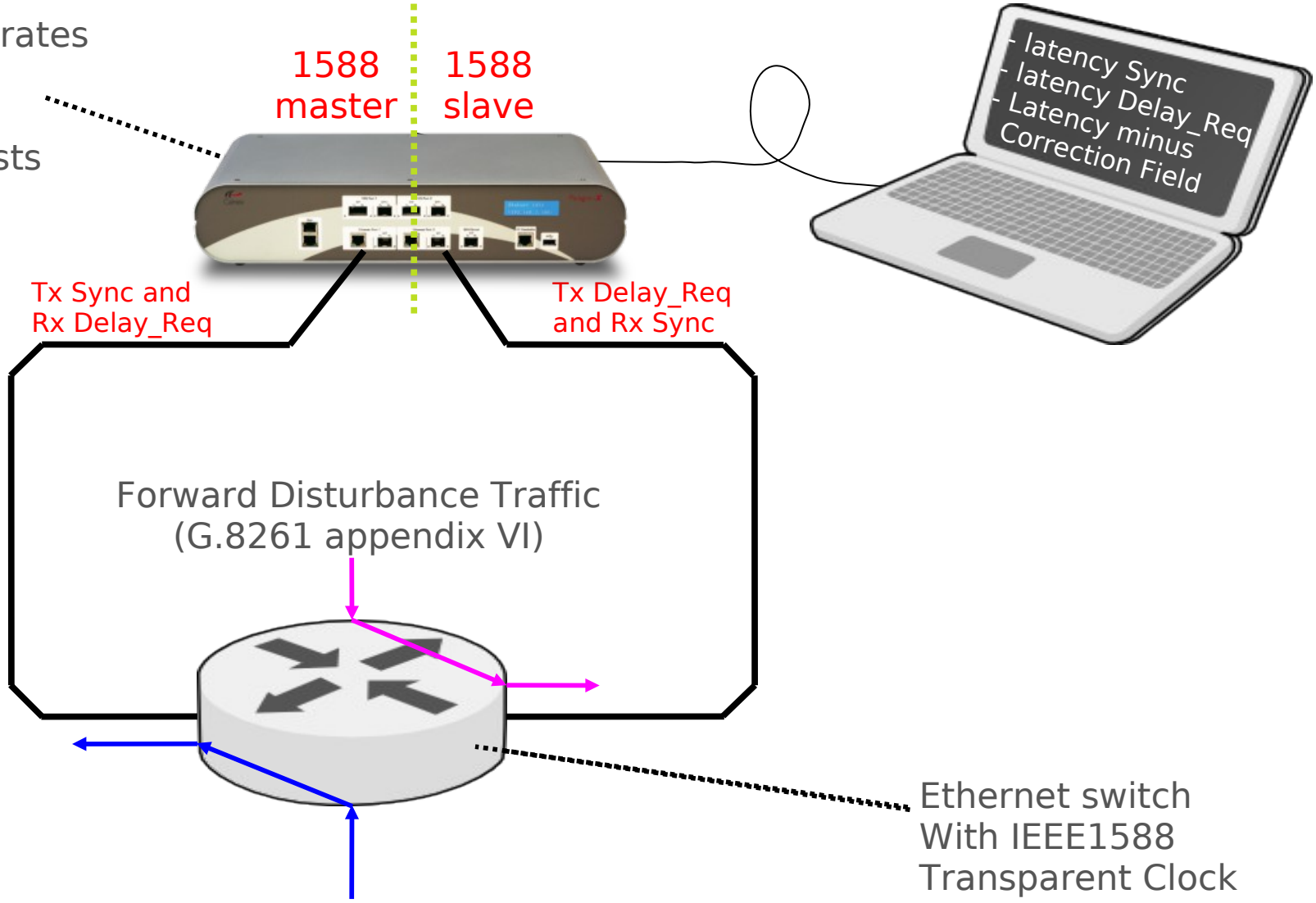
Add Transparent Clock to a NE via Smart SFPs

- Network Element must provide:
  1. Common frequency towards all Ethernet output ports
  2. Ethernet Virtual Connection (EVC) through NE to allow SFP communication



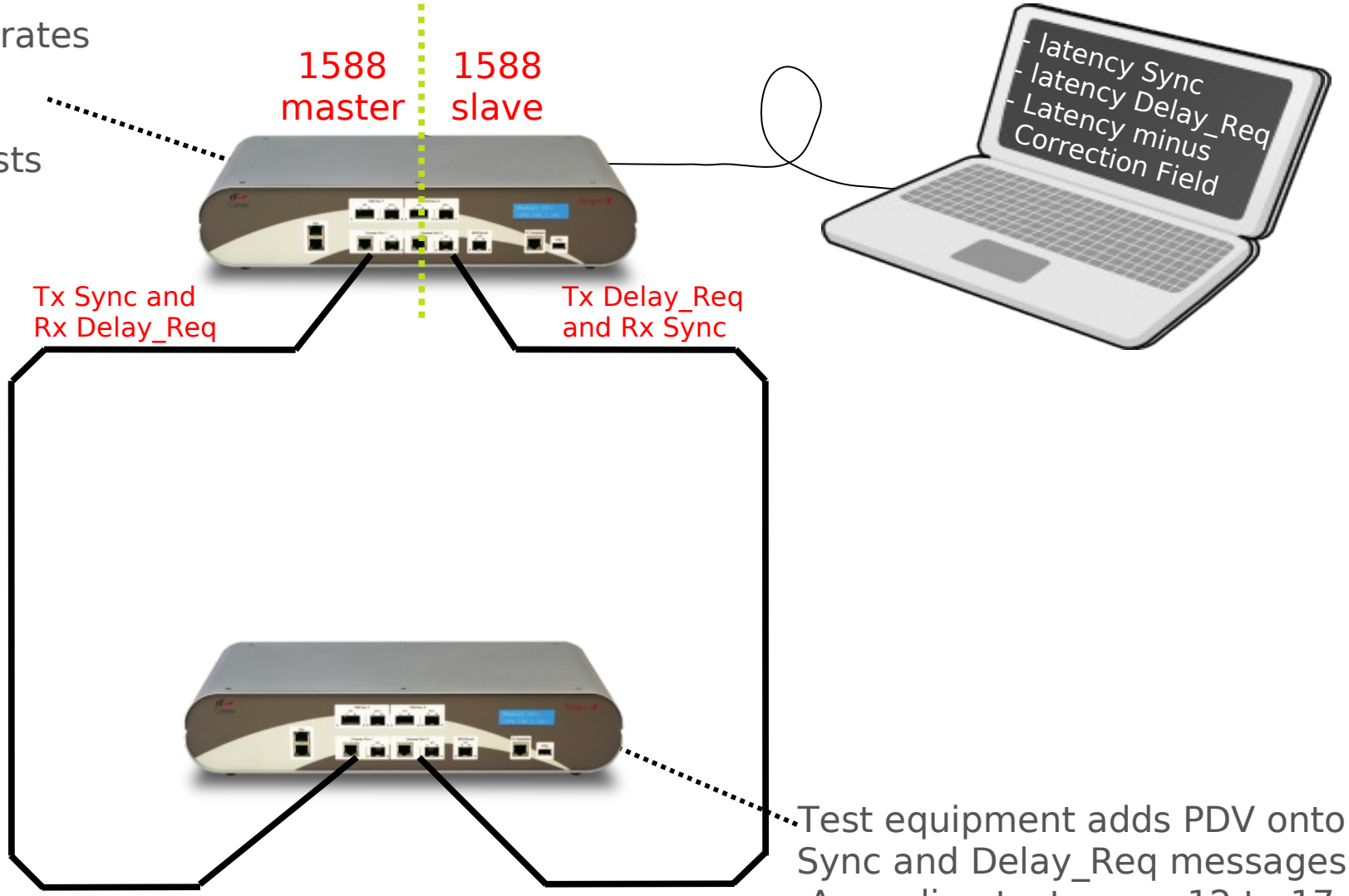
Transparent Clock Test Setup (1)

Test equipment generates Sync and Delay_Req messages to perform Transparent Clock tests



Transparent Clock Test Setup (2)

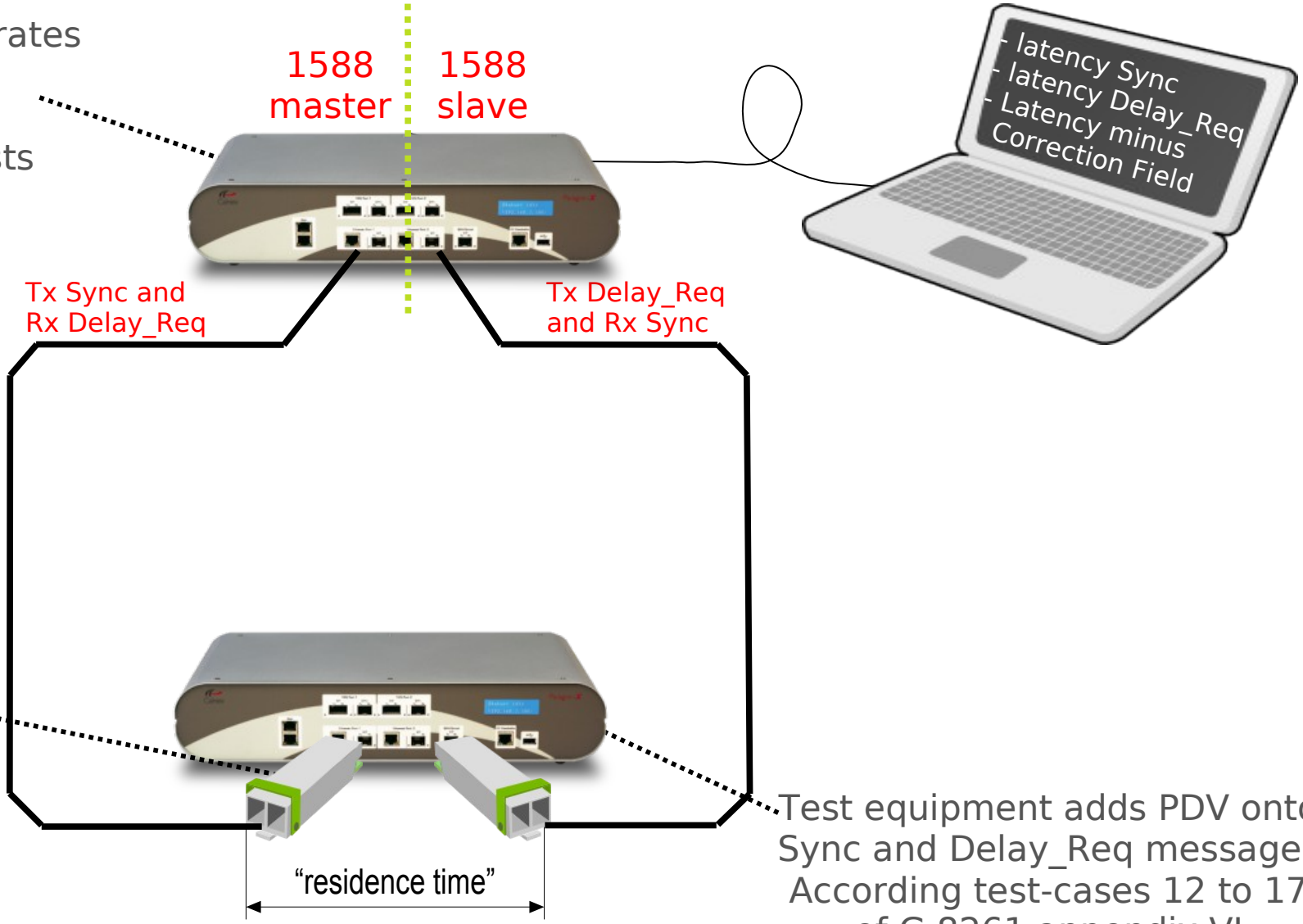
Test equipment generates Sync and Delay_Req messages to perform Transparent Clock tests



Test equipment adds PDV onto Sync and Delay_Req messages According test-cases 12 to 17 of G.8261 appendix VI

Transparent Clock Test Setup (3)

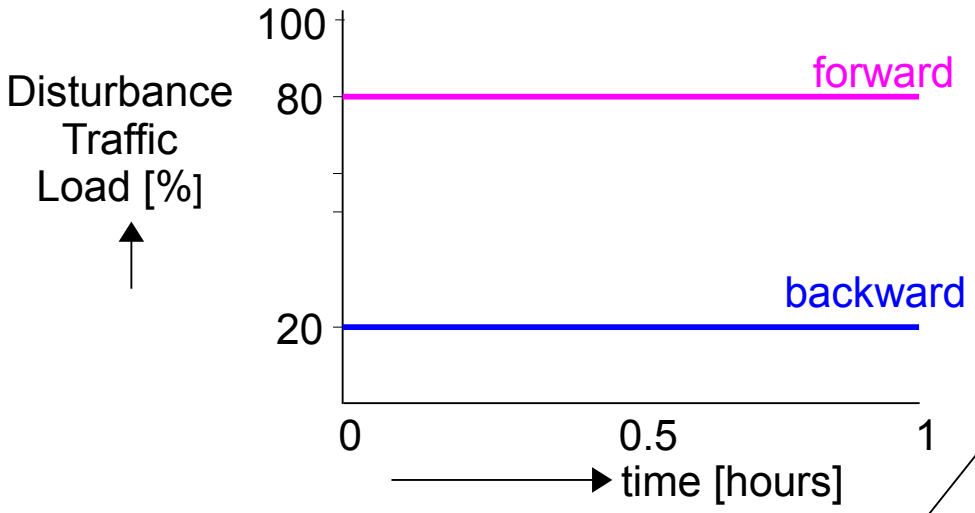
Test equipment generates Sync and Delay_Req messages to perform Transparent Clock tests

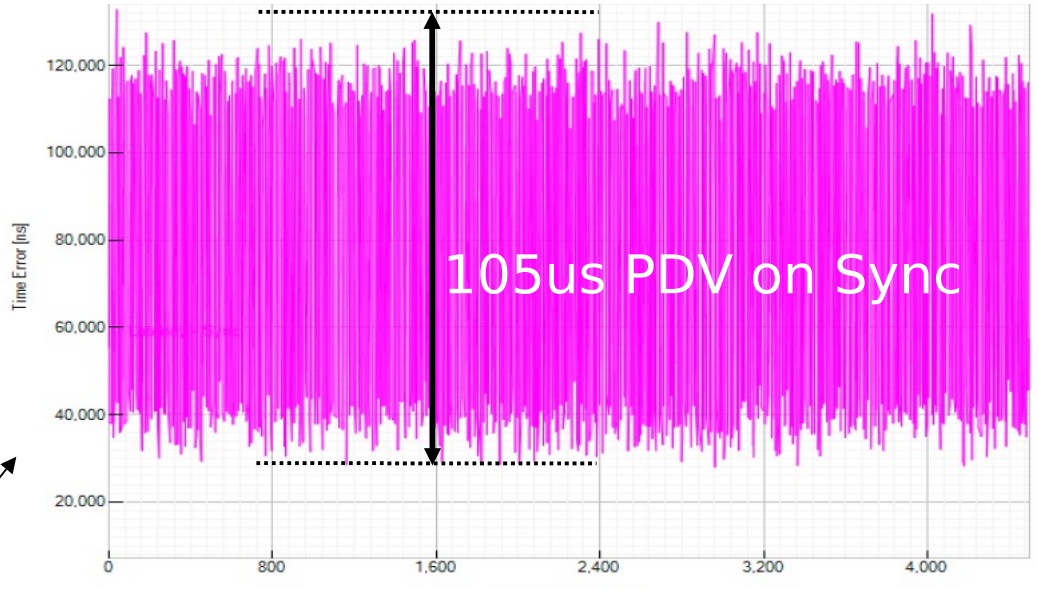


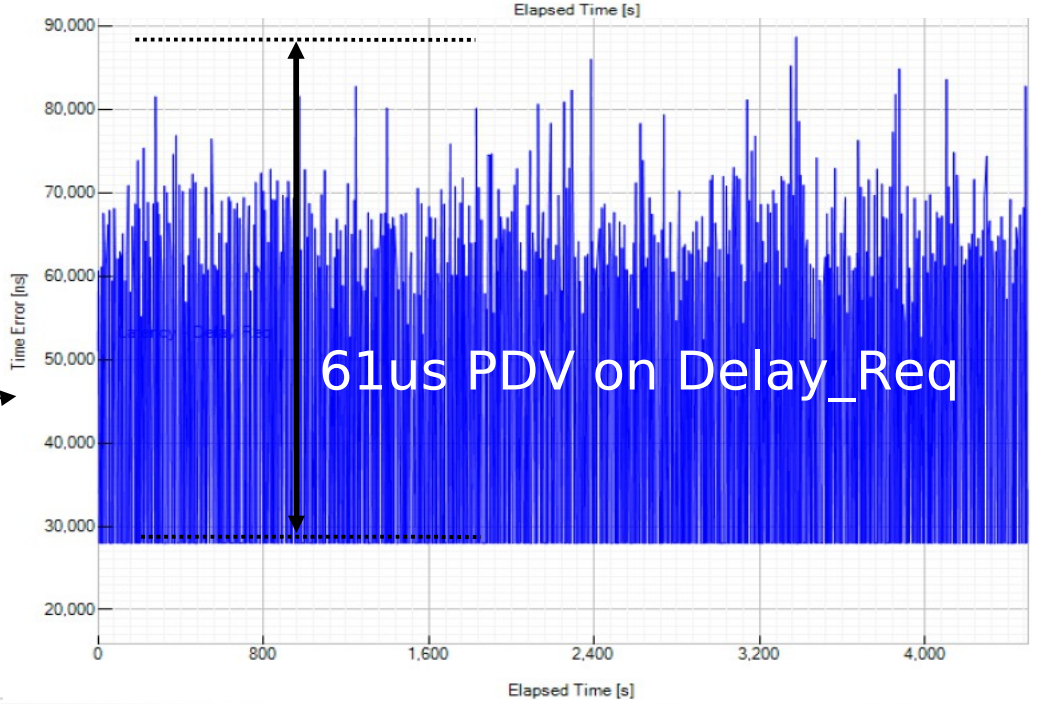
Smart SFP's "add" Transparent Clock function to Test equipment

Test equipment adds PDV onto Sync and Delay_Req messages According test-cases 12 to 17 of G.8261 appendix VI

G.8261 - testcase 12 – measured PDV ***BEFORE***







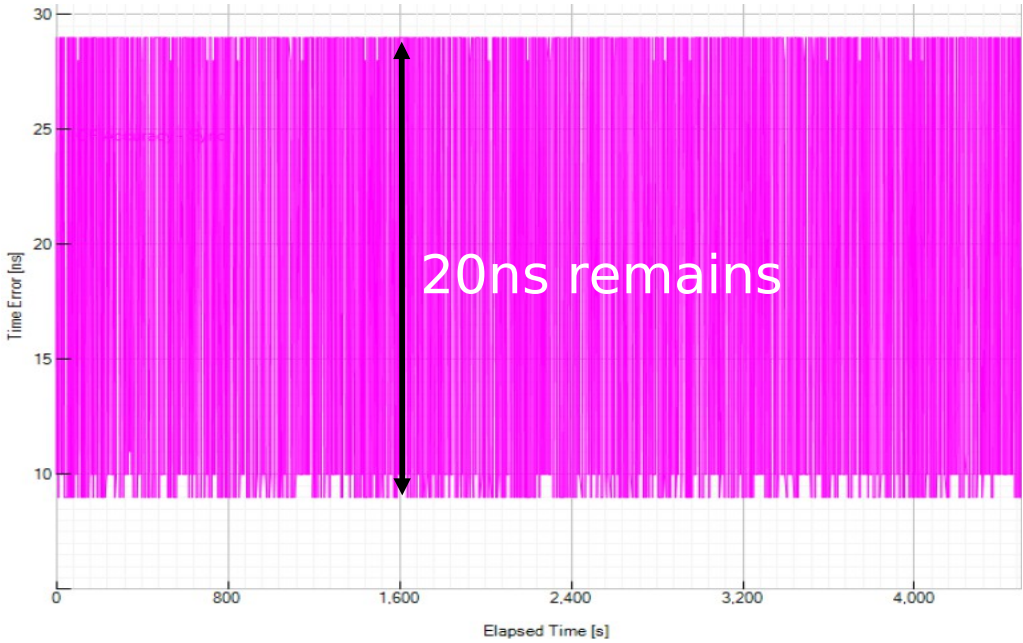
Measured 105us forward PDV
on Sync packets – 32packets/sec

Measured 61us backward PDV
on Delay_Req packets – 32packets/sec

G.8261 – testcase 12 – PDV after correction

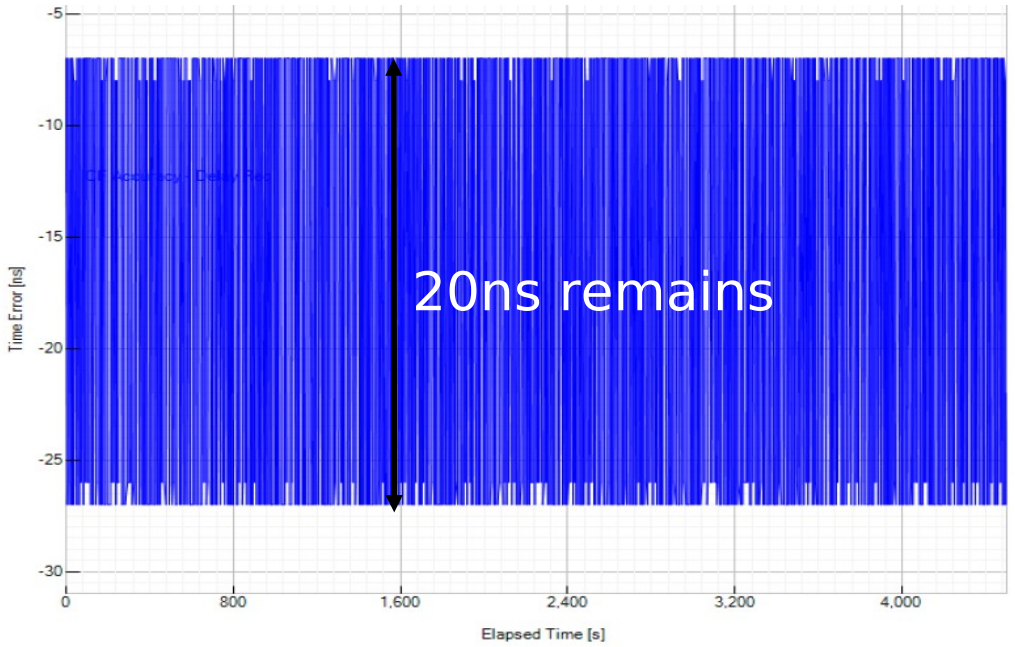
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

105 us --> 20 ns !

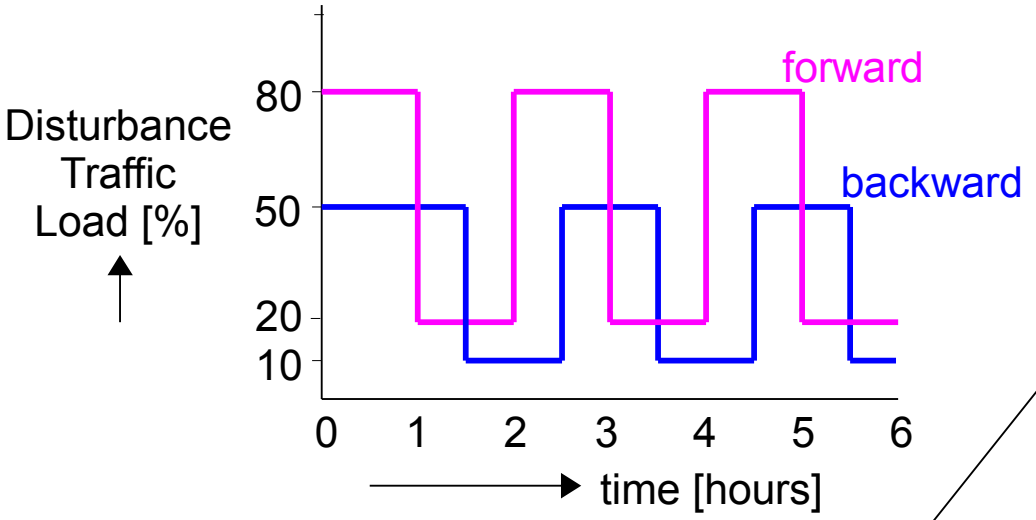


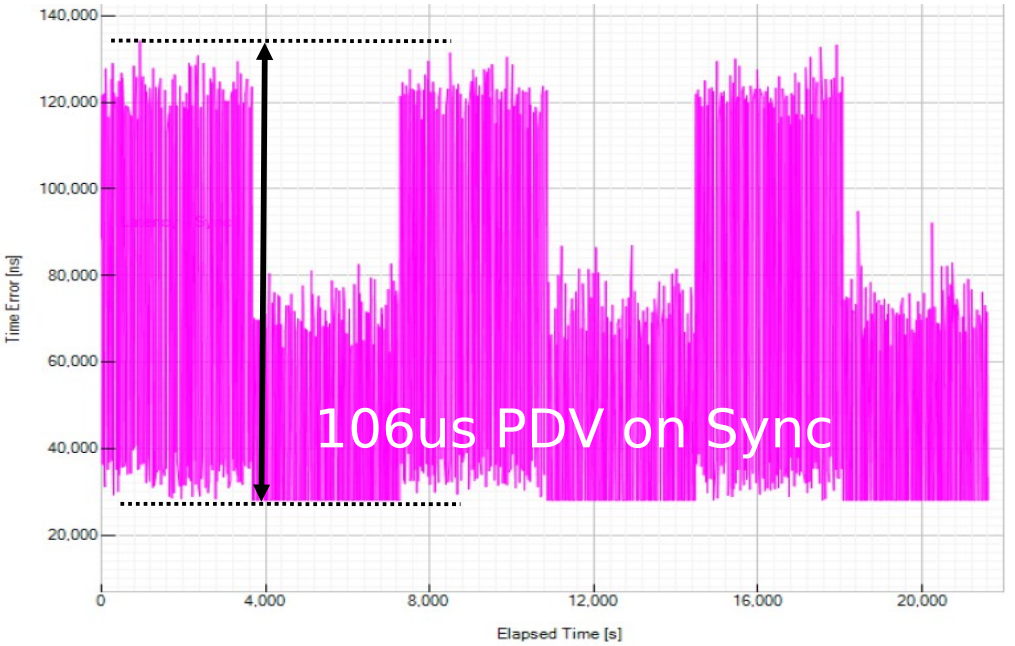
For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

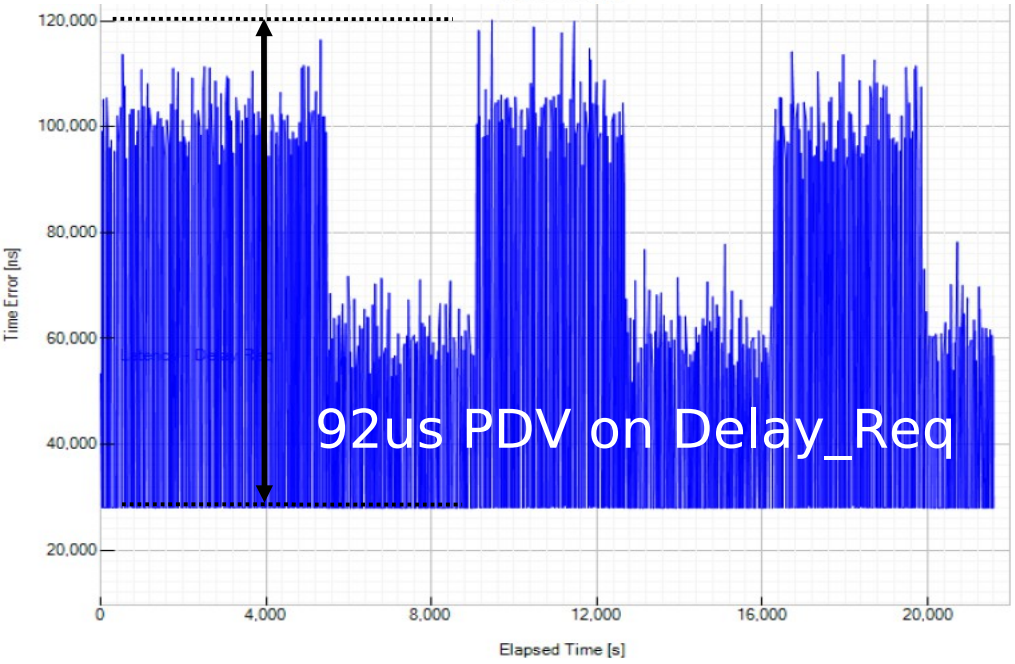
61 us --> 20 ns !



G.8261 - testcase 13 – measured PDV ***BEFORE***







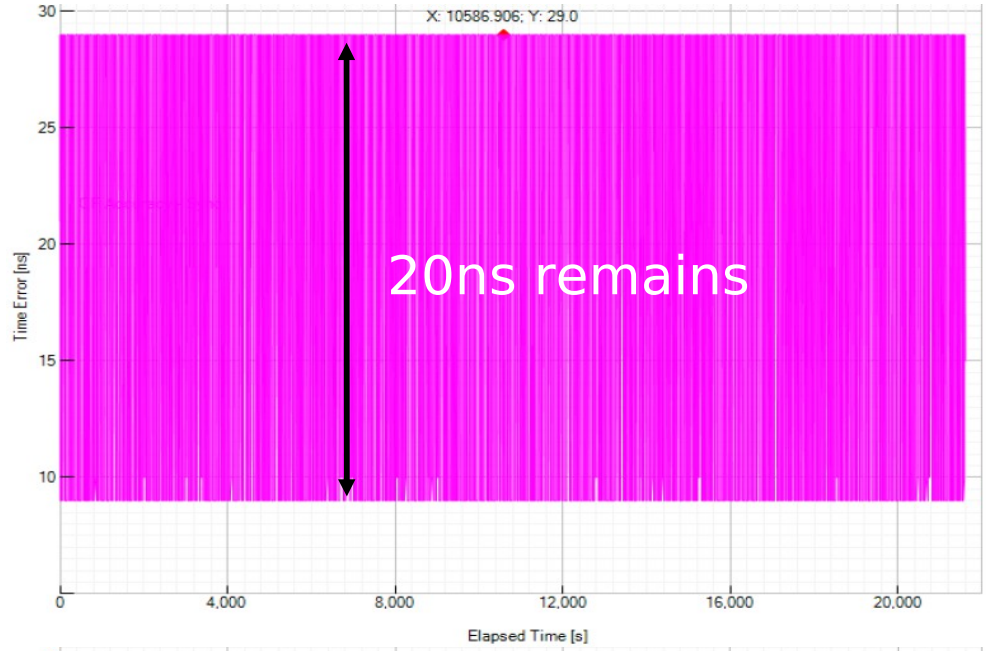
Measured 106us forward PDV
on Sync packets – 32packets/sec

Measured 92us backward PDV
on Delay_Req packets – 32packets/sec

G.8261 – testcase 13 – PDV after correction

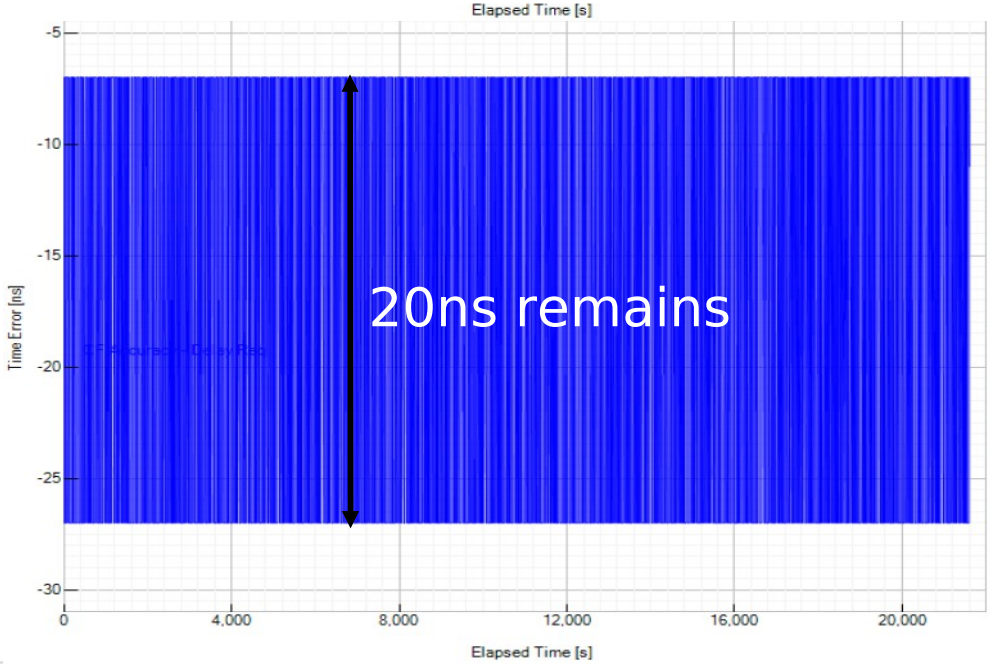
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

106 us --> 20 ns !

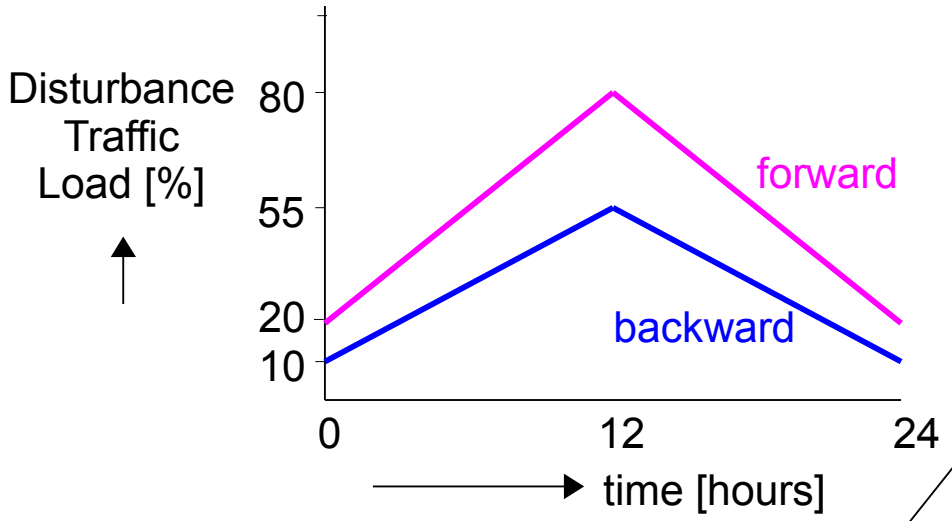


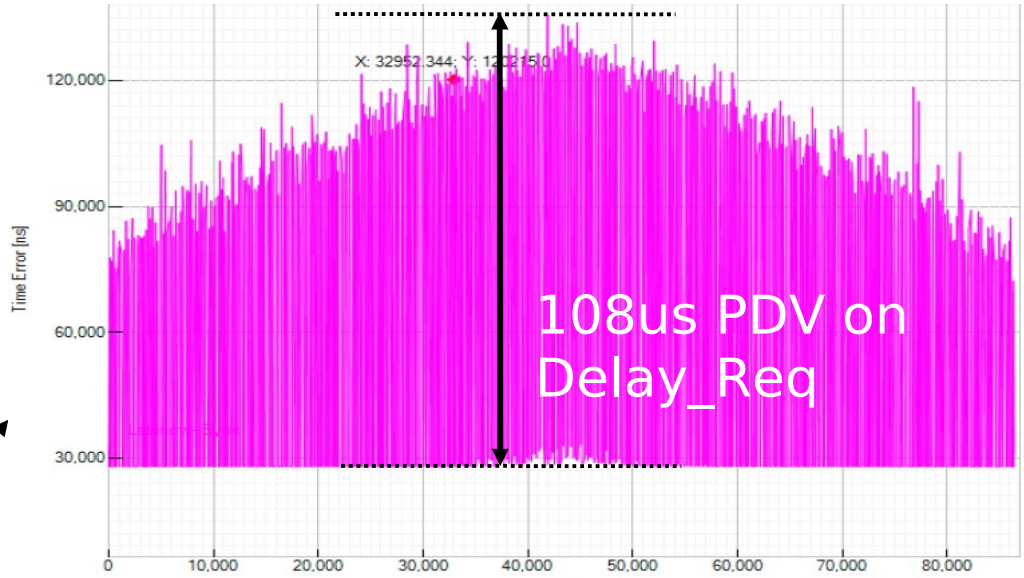
For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

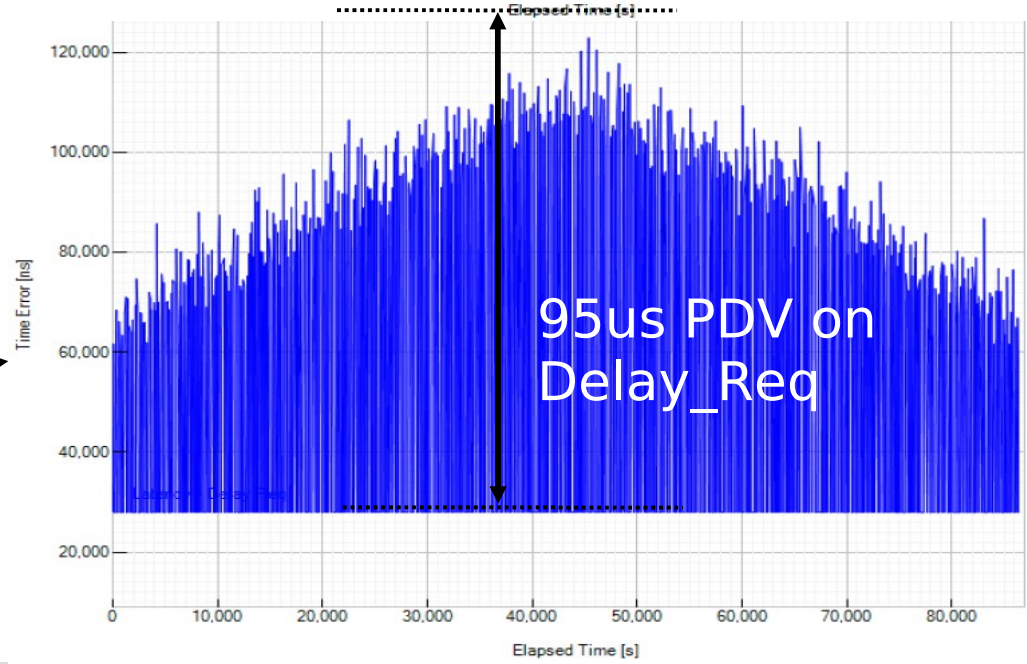
92 us --> 20 ns !



G.8261 - testcase 14 – measured PDV ***BEFORE***







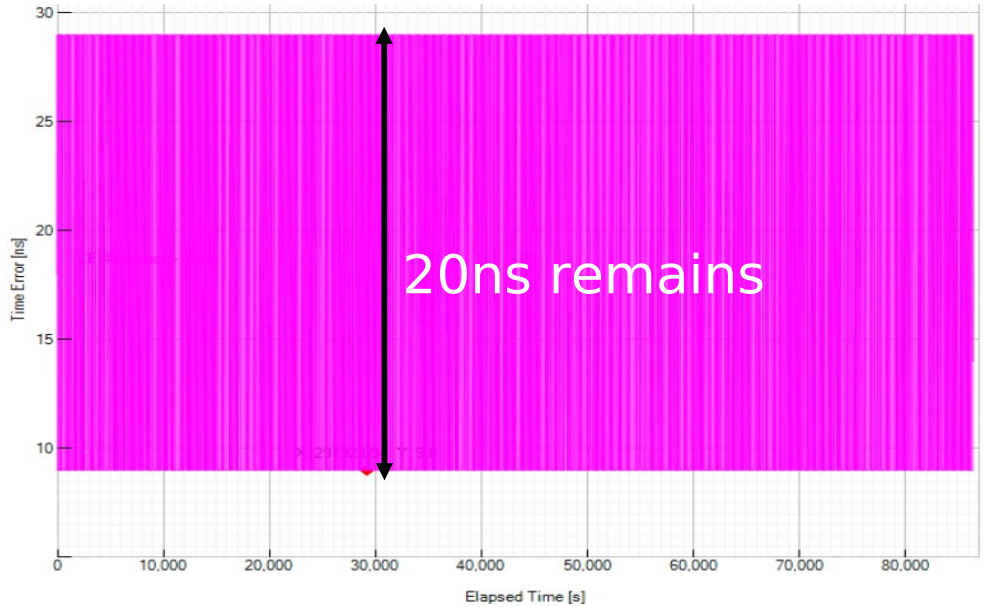
Measured 108us forward PDV
on Sync packets – 32packets/sec

Measured 95us backward PDV
on Delay_Req packets – 32packets/sec

G.8261 – testcase 14 – PDV after correction

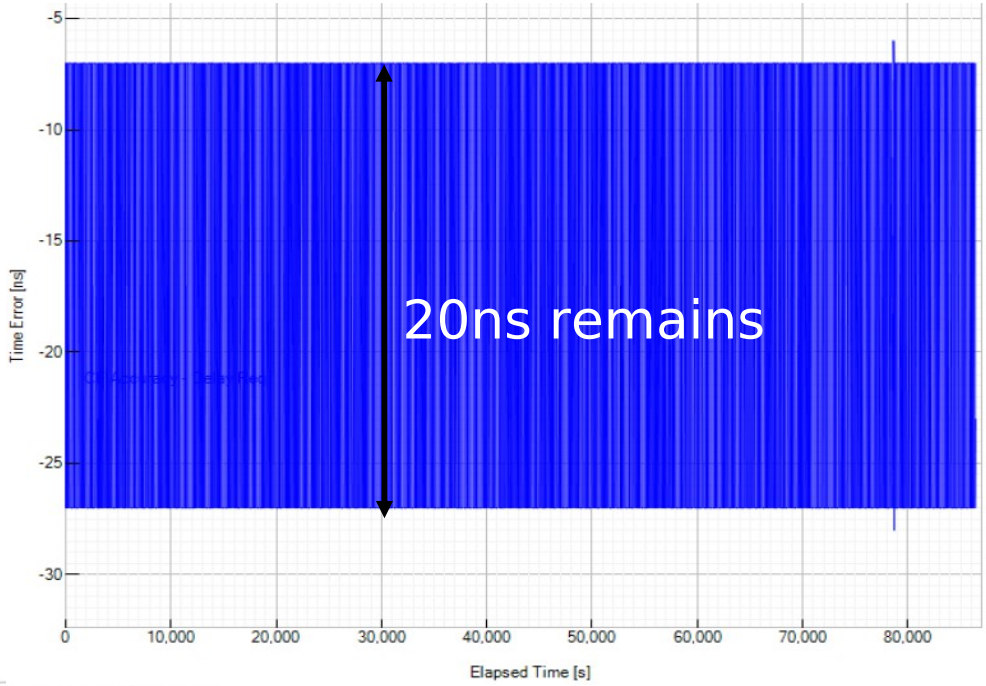
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

108 us --> 20 ns !

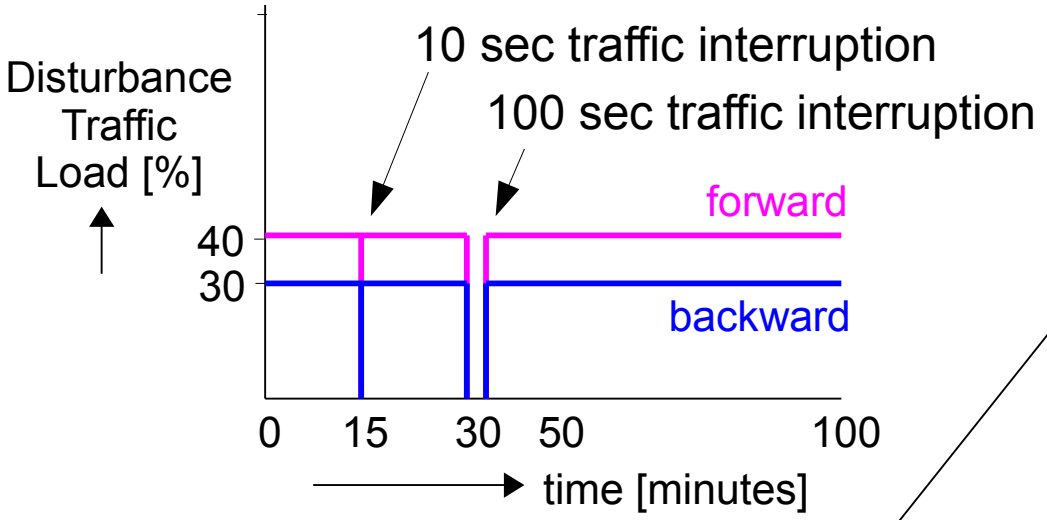


For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

95 us --> 20 ns !

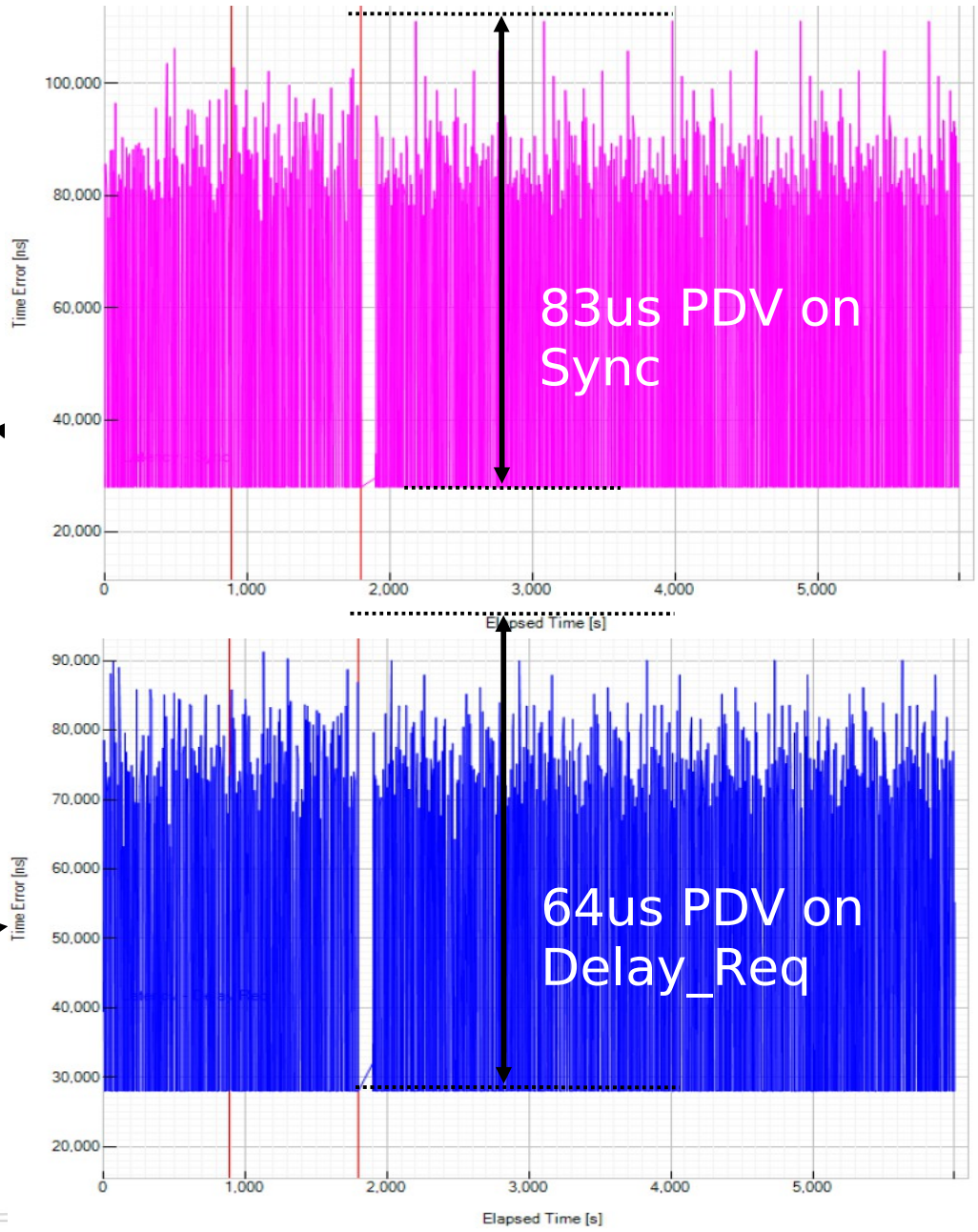


G.8261 - testcase 15 – measured PDV ***BEFORE***



Measured 83us forward PDV
on Sync packets – 32packets/sec

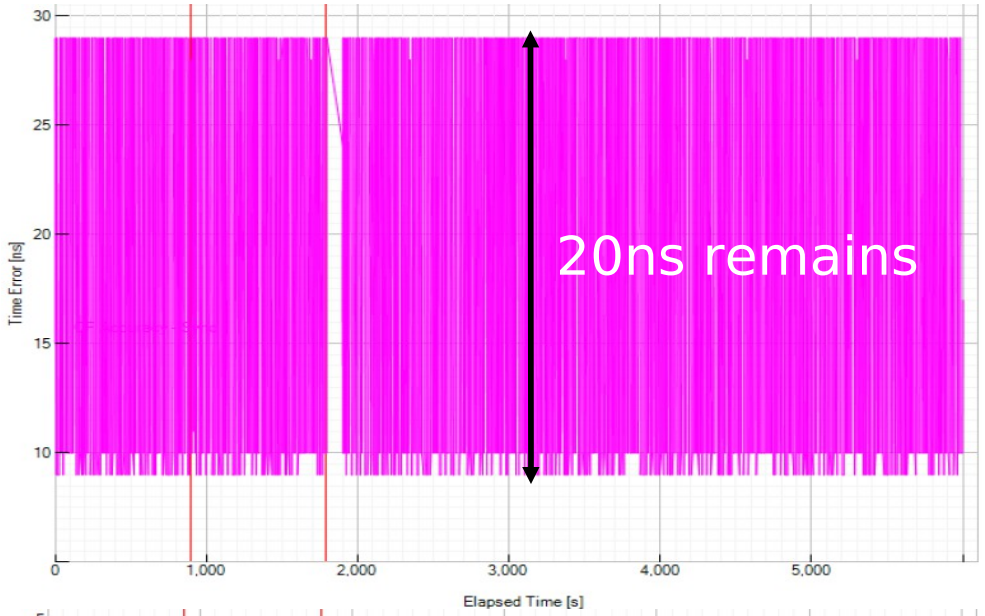
Measured 64us backward PDV
on Delay_Req packets – 32packets/sec



G.8261 – testcase 15 – PDV after correction

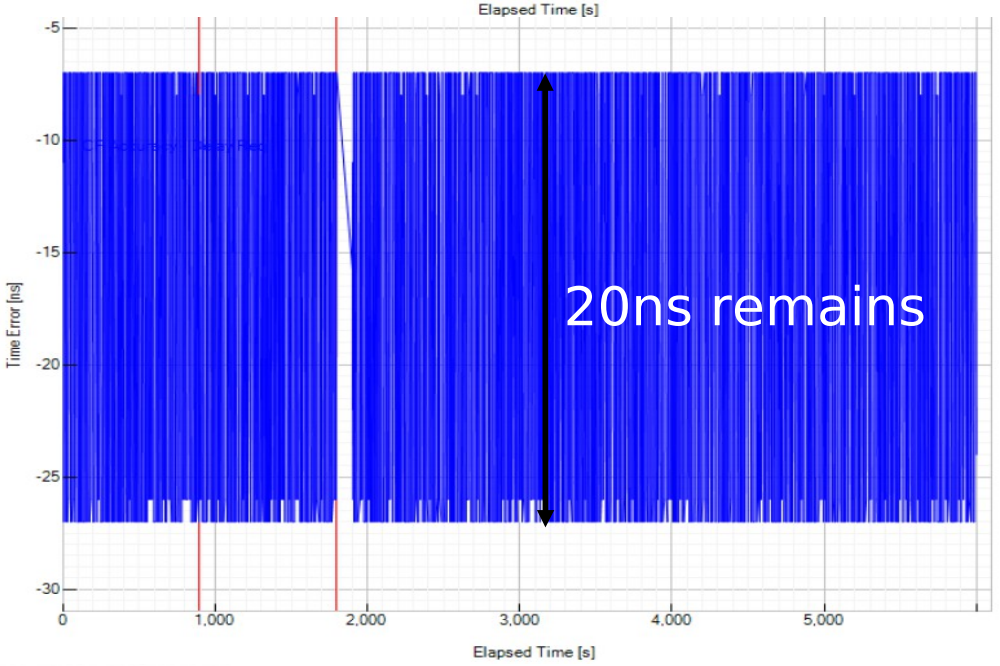
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

83 us --> 20 ns !

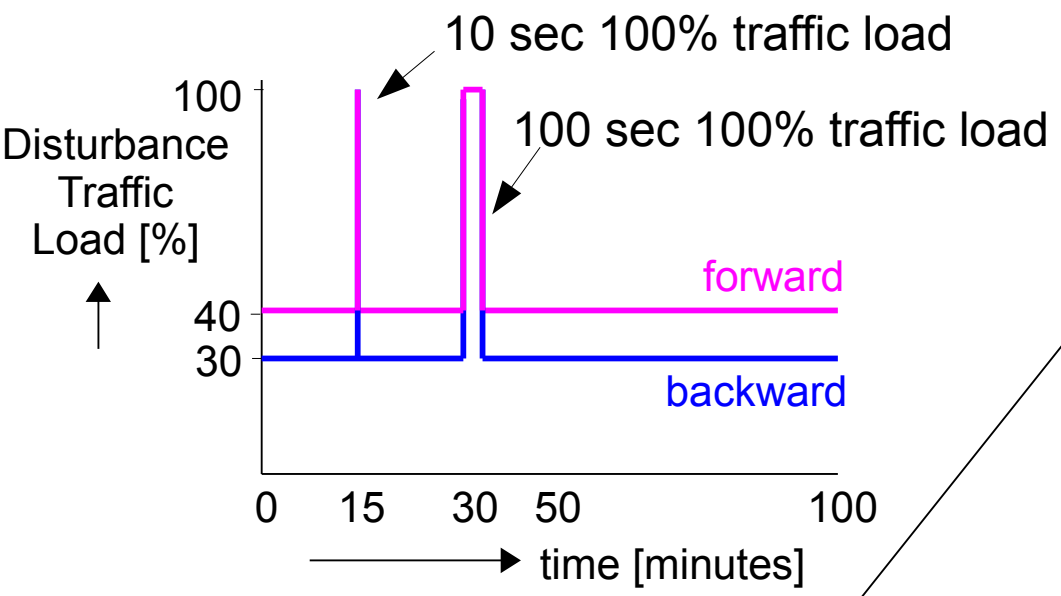


For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

64 us --> 20 ns !

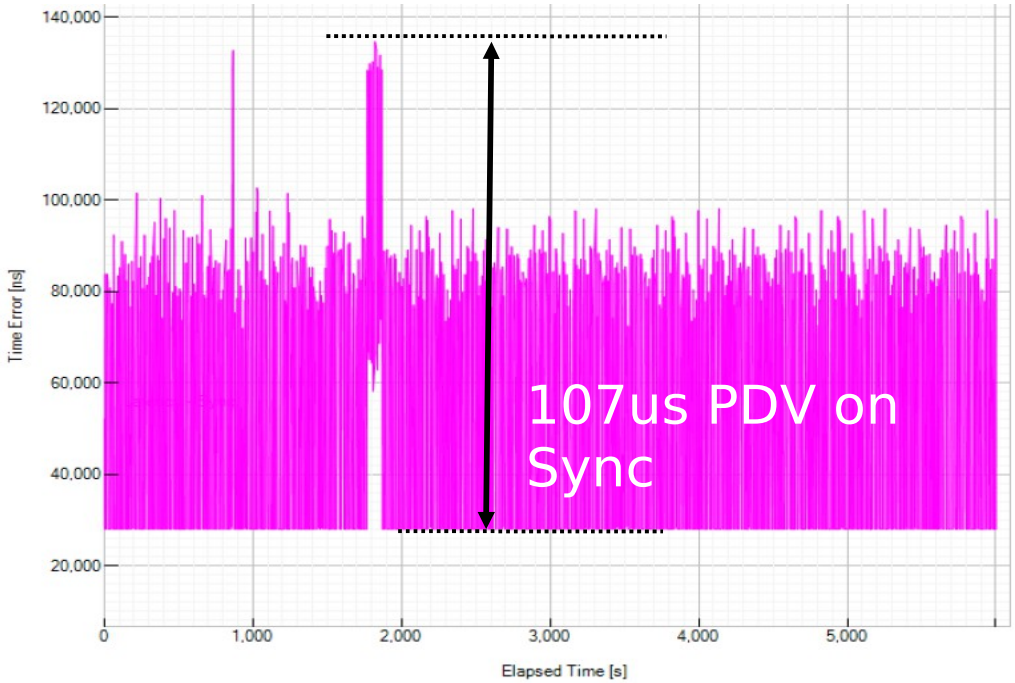


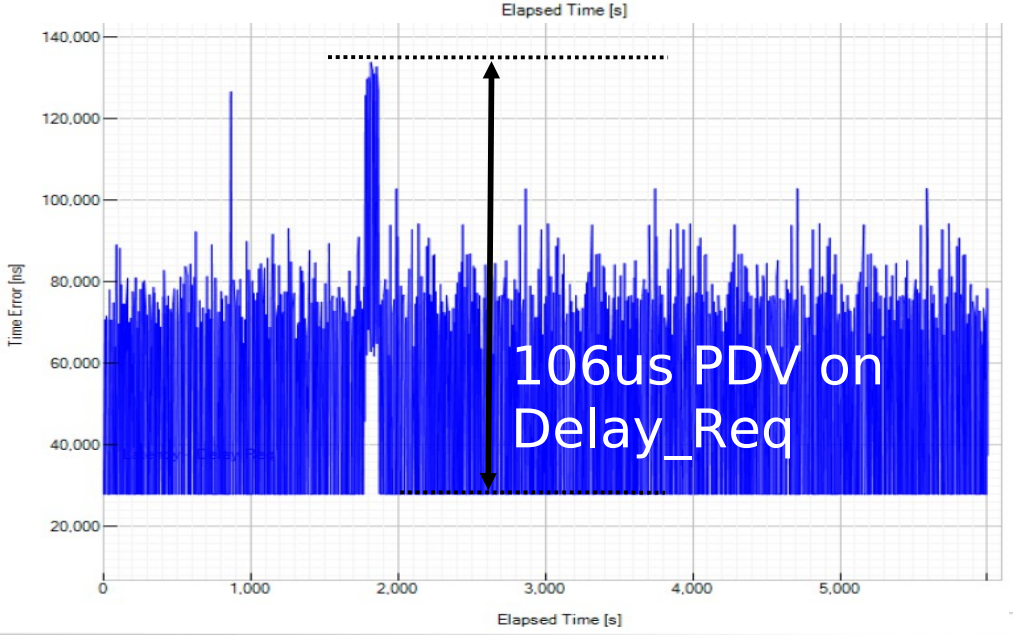
G.8261 - testcase 16 – measured PDV ***BEFORE***



Measured 107us forward PDV
on Sync packets – 32packets/sec

Measured 106us backward PDV
on Delay_Req packets – 32packets/sec

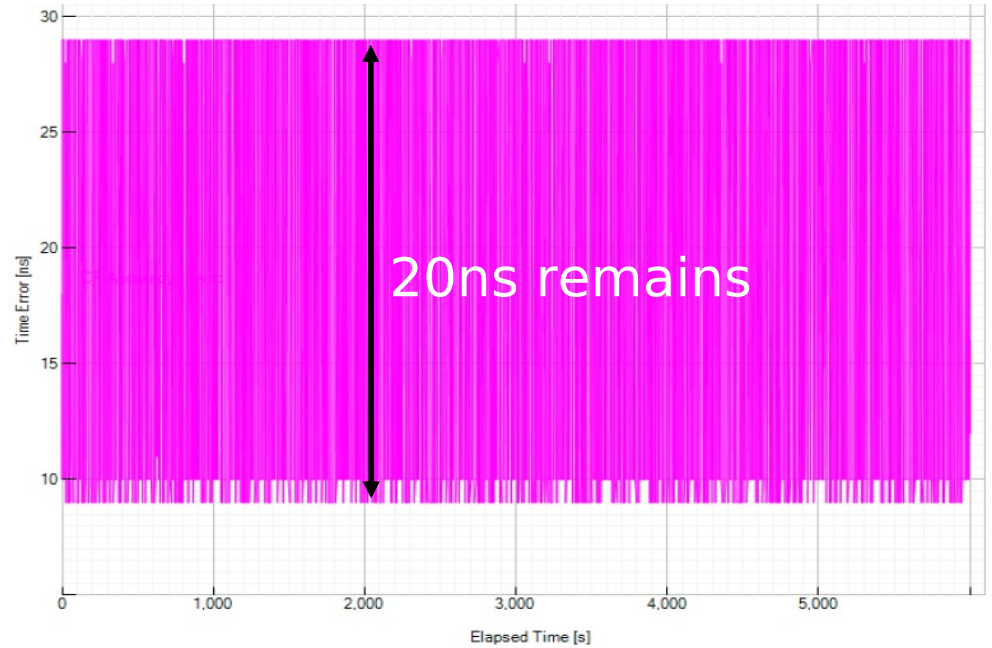




G.8261 – testcase 16 – PDV after correction

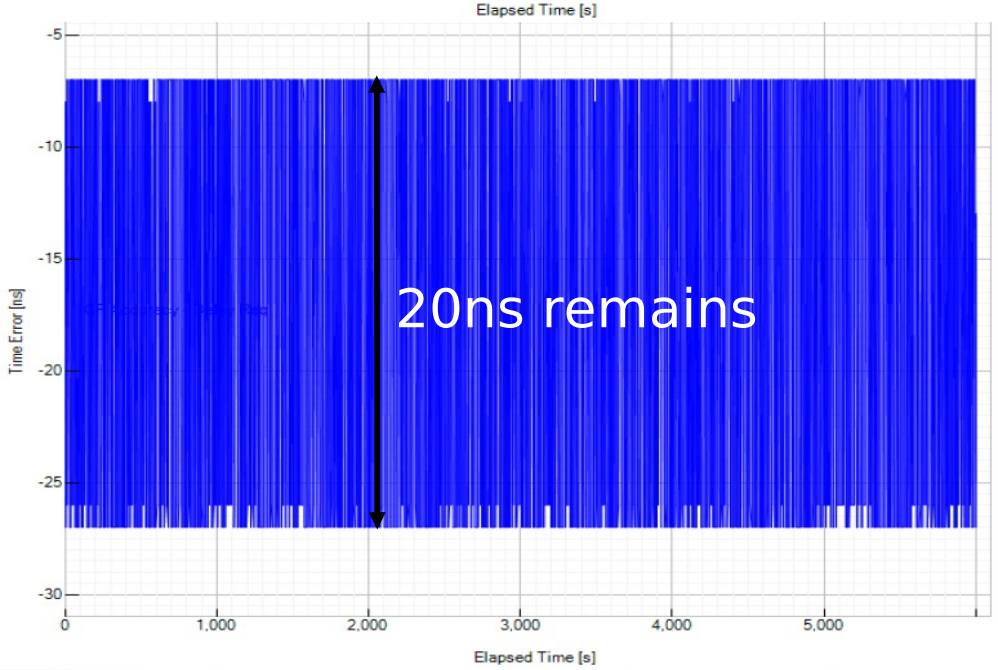
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

107 us --> 20 ns !

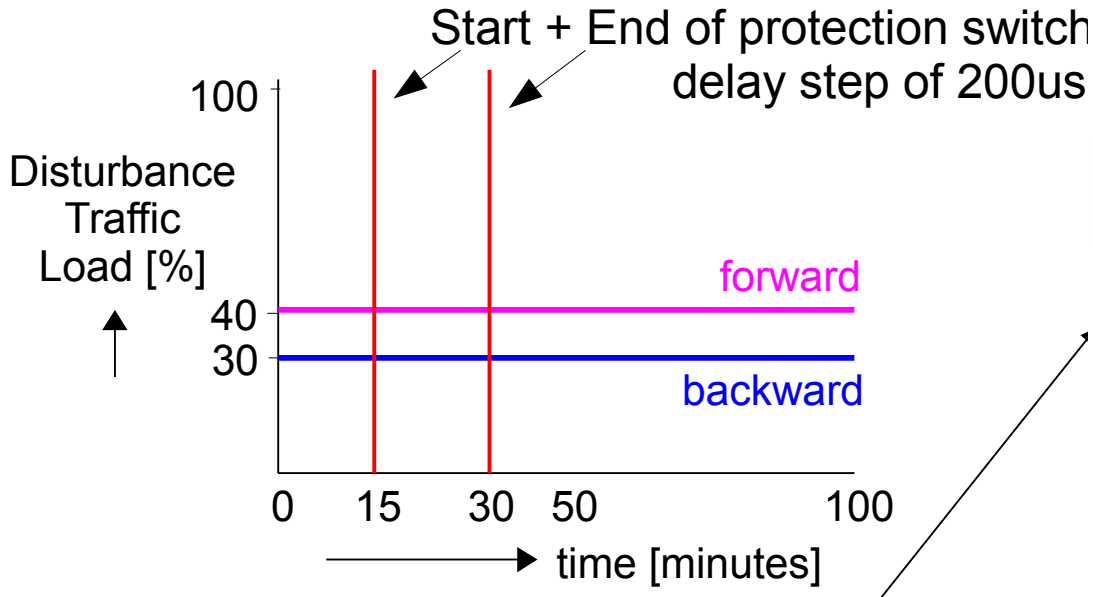


For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

106 us --> 20 ns !

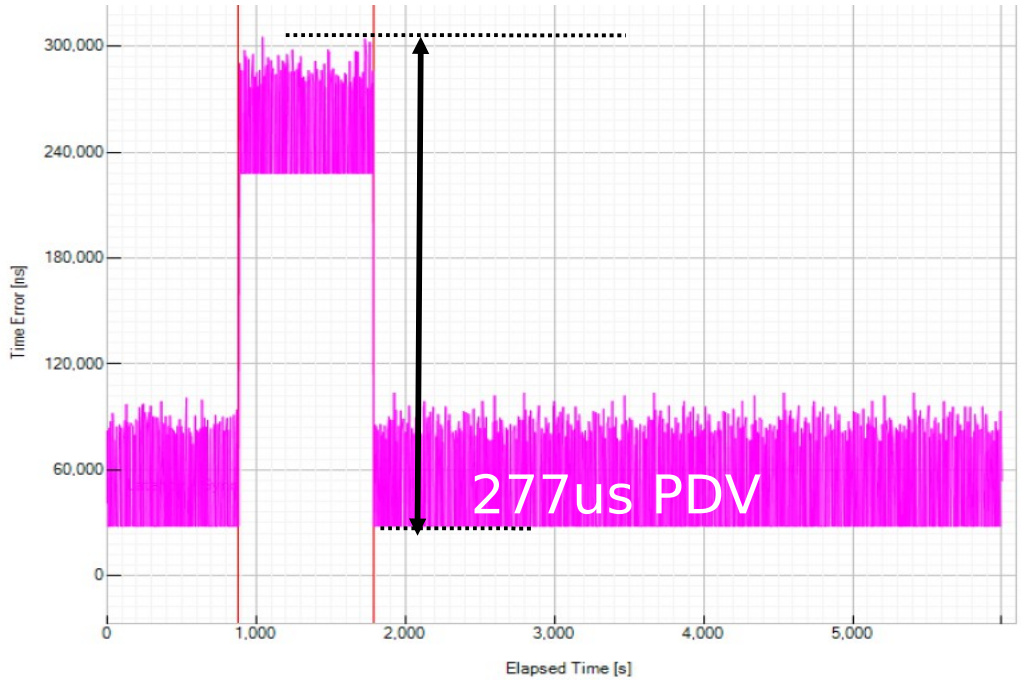


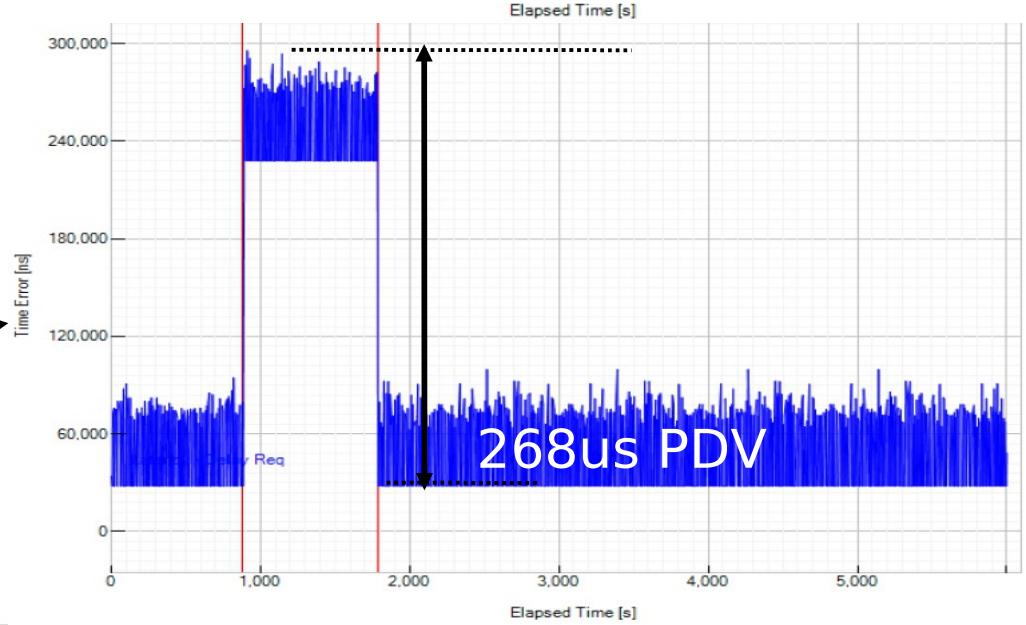
G.8261 - testcase 17 – measured PDV ***BEFORE***



Measured 277us forward PDV
on Sync packets – 32packets/sec

Measured 268us backward PDV
on Delay_Req packets – 32packets/sec

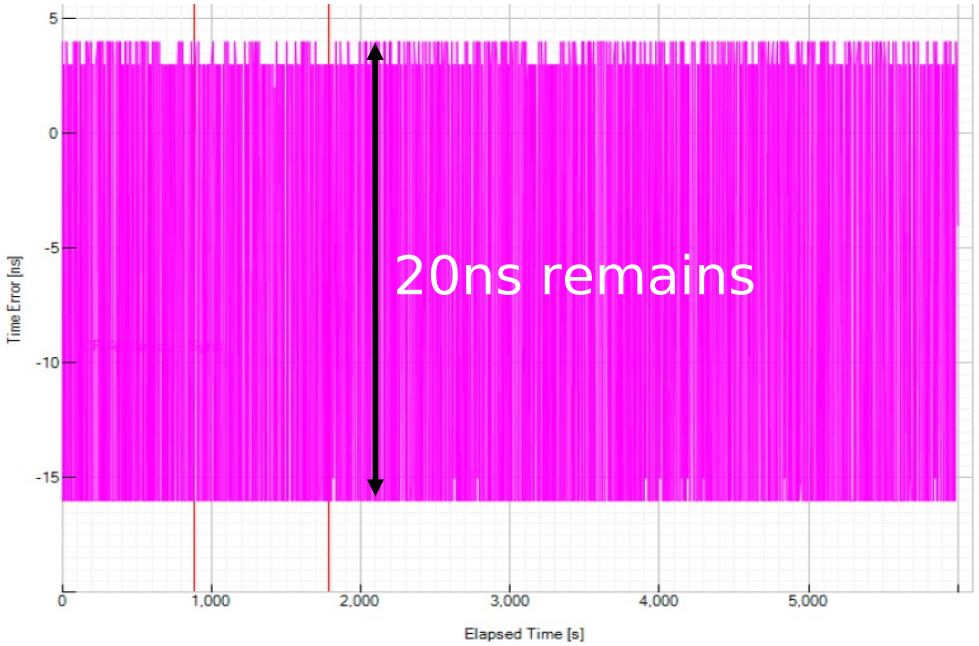




G.8261 – testcase 17 – PDV after correction

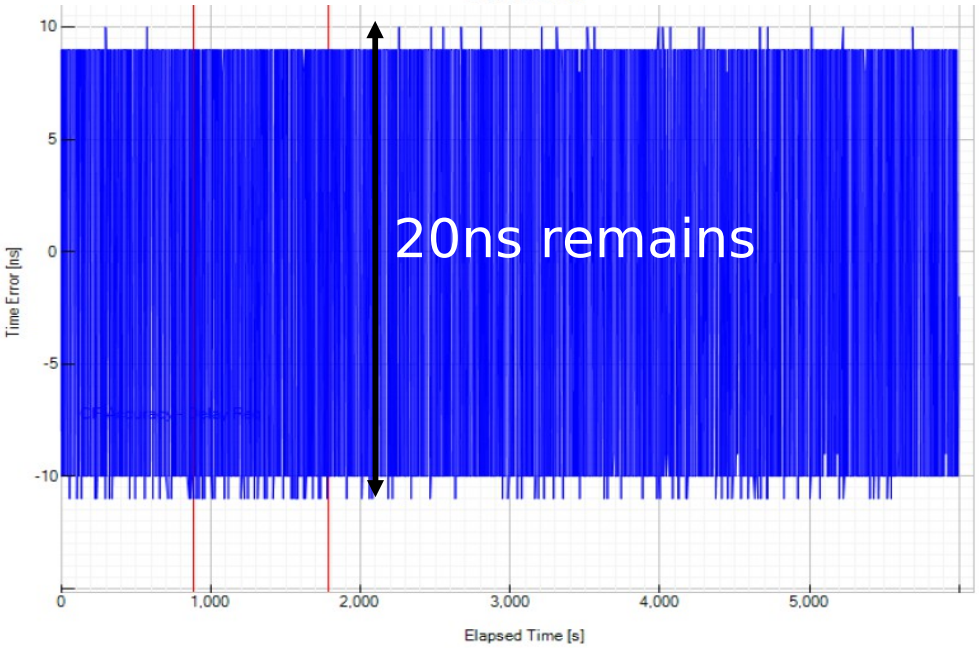
For each Sync message the
PDV after correction is:
“measured PDV”- “residence time”

277 us --> 20 ns !



For each Delay_Req message the
PDV after correction is:
“measured PDV”- “residence time”

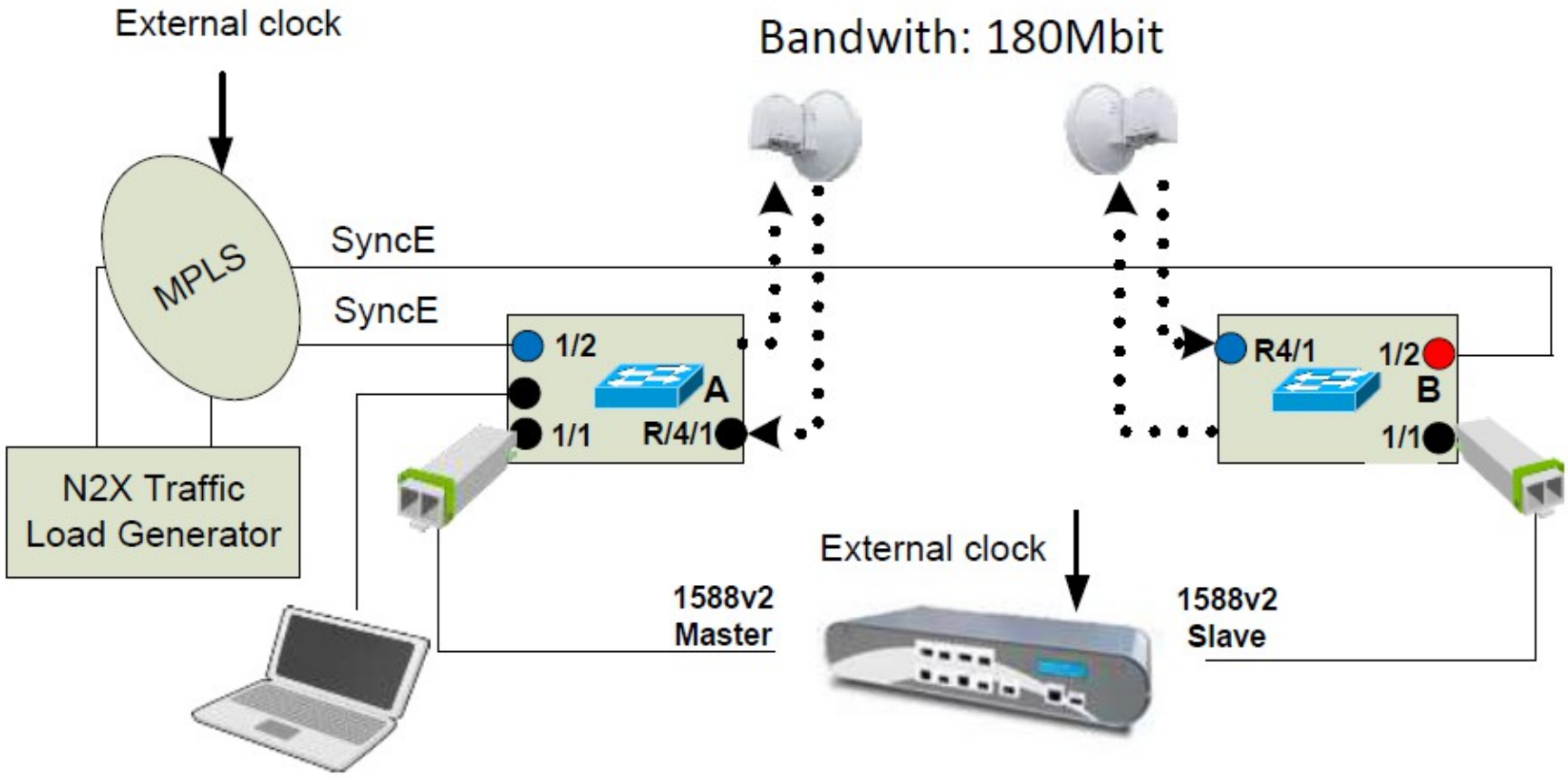
268 us --> 20 ns !



Microwave test setup – A1 Telekom Austria

- Slides presented at ITSF by Joachim Atzwanger, A1 Telekom Austria.
- For test details contact joachim.atzwanger@a1telekom.at

Test Setup in Lab:



Microwave test loads – A1 Telekom Austria

Traffic Loads:

Microwave system: Capacity: 180Mbit symmetrical

N2X: Framesizes: 66 – 1518 Bytes both directions, P = Priority, Capacity in Mbit;

Upload 170Mbit, Download capacity see table.

	P	Mbit	MBit	P	Mbit	Mbit
Vlan 900	4	80	140	4	80	80 - 140
Vlan 910	5	90	90	5	90	90
Vlan 1500 PTP Traffic	6			6		
Vlan 1588 Communication between SFP1 and 2	4			6		
Microwave overload		no	yes		no	yes
TC clock accuracy		OK	NOK		OK	OK
PDV Results Figure Nr		1	2		3	4

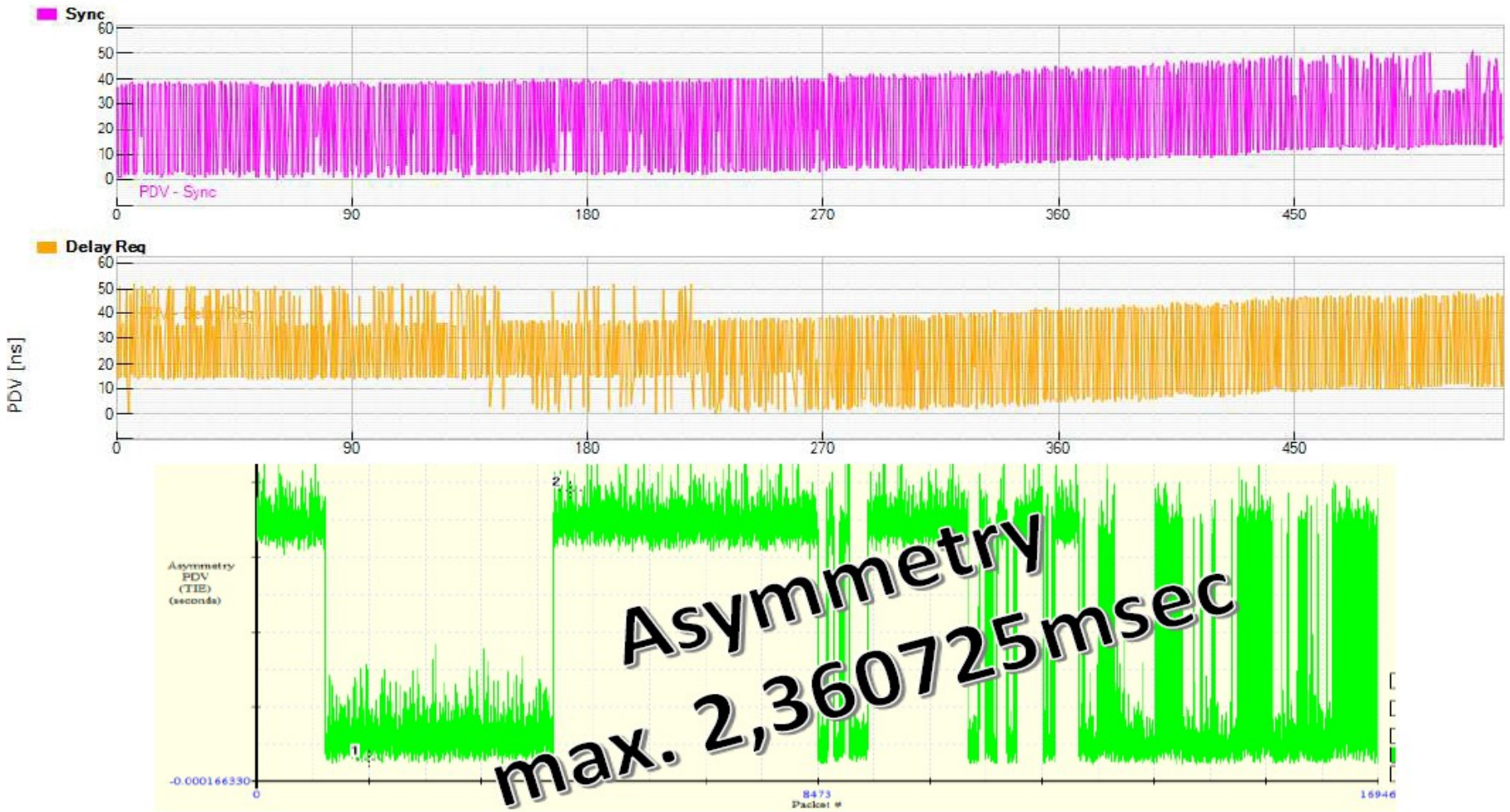
Microwave test figure4 – A1 Telekom Austria

Figure 4: PDV without CF; Overload 80–40Mbit in Priority 4

TC SFP Communication and Traffic in different priority classes.

Microwave test figure4 – A1 Telekom Austria

Figure 4: PDV with CF Overload 80–140Mbit with P 4



TC SFP Communication and Traffic in different priority classes.

Microwave test conclusion – A1 Telekom Austria

TC SFP Results

- ✓ Synchronisation is robust between the TC SFP´s.
  if corresponding Vlan TC SFP‘ are in a most significant priority class (6)
- ✓ Overload in priority class 4 does not distroy the synchronisation between the SFP´s
- ✓ Transparent clock accuracy OK
- ✓ Compensation of asymmetry OK

The TC SFP is an interesting and useful development

Conclusion / take aways

- IEEE1588 Transparent Clock measurements show a PDV error ≤ 20ns which equals the performance of a Boundary Clock.
- Transparent Clock is “transparent” for the synchronization direction and does not require changes upon a network protection switch.
- T-TC function can support multi-operator ToD distribution streams.
- T-TC function can be added to already deployed Routers and switches by means of a Smart SFP.

Thank you

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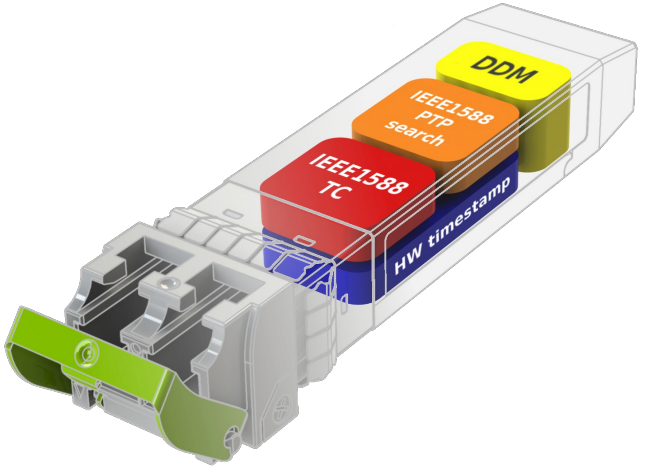

AimValley