

Plain Old PTP
Better than you think?

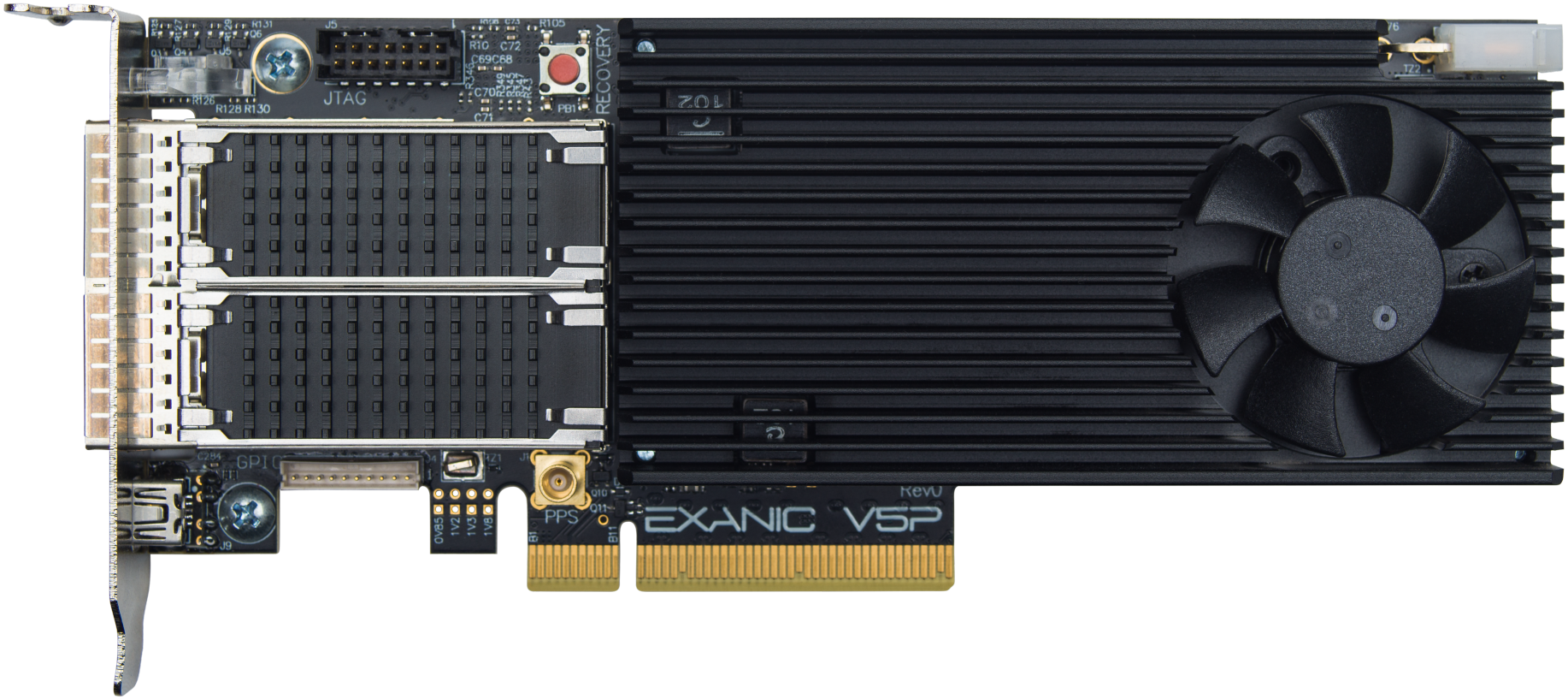
Matthew Grosvenor

STAC Summit London, Autumn 2018

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Disclaimer:
Not STAC measurements

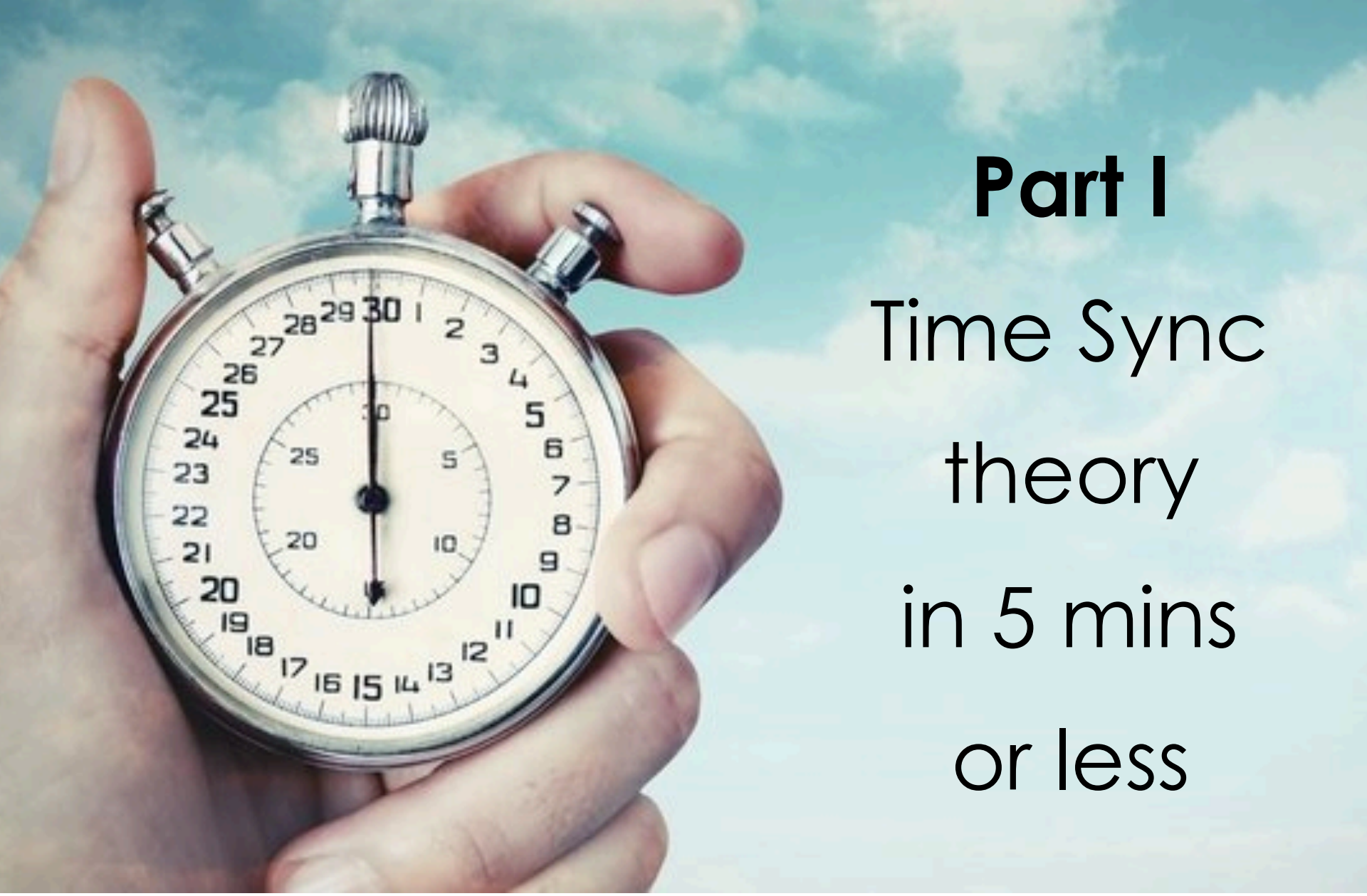
Trading in nanoseconds



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“PTP isn’t good enough for a nanosecond world ”

- someone in this room (probably)

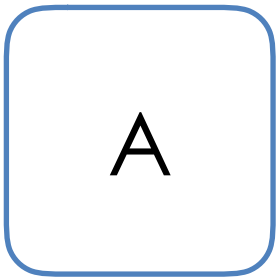


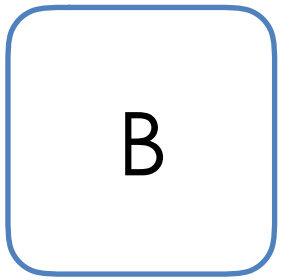
Part I

Time Sync theory in 5 mins or less

1 Pulse Per Second (1PPS)

1 Pulse Per Second (1PPS)





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1 Pulse Per Second (1PPS)



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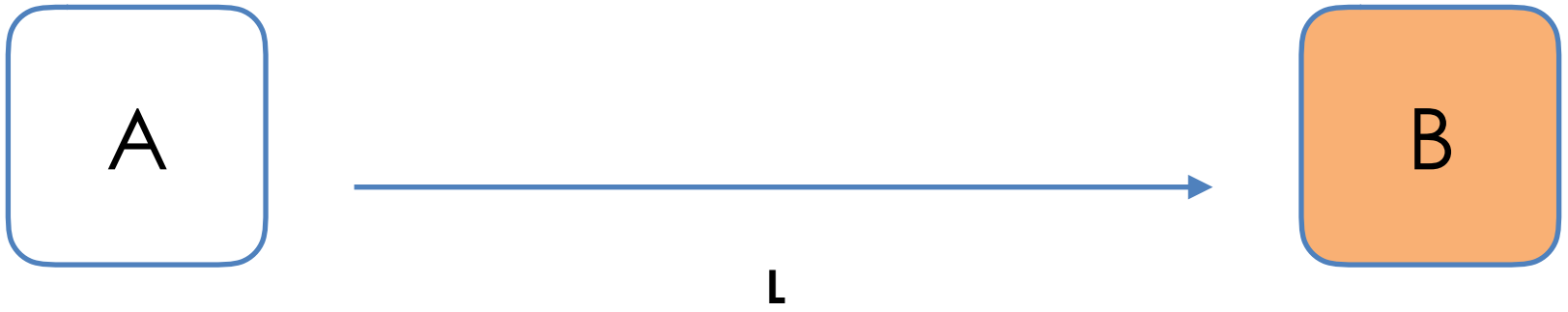
1 Pulse Per Second (1PPS)



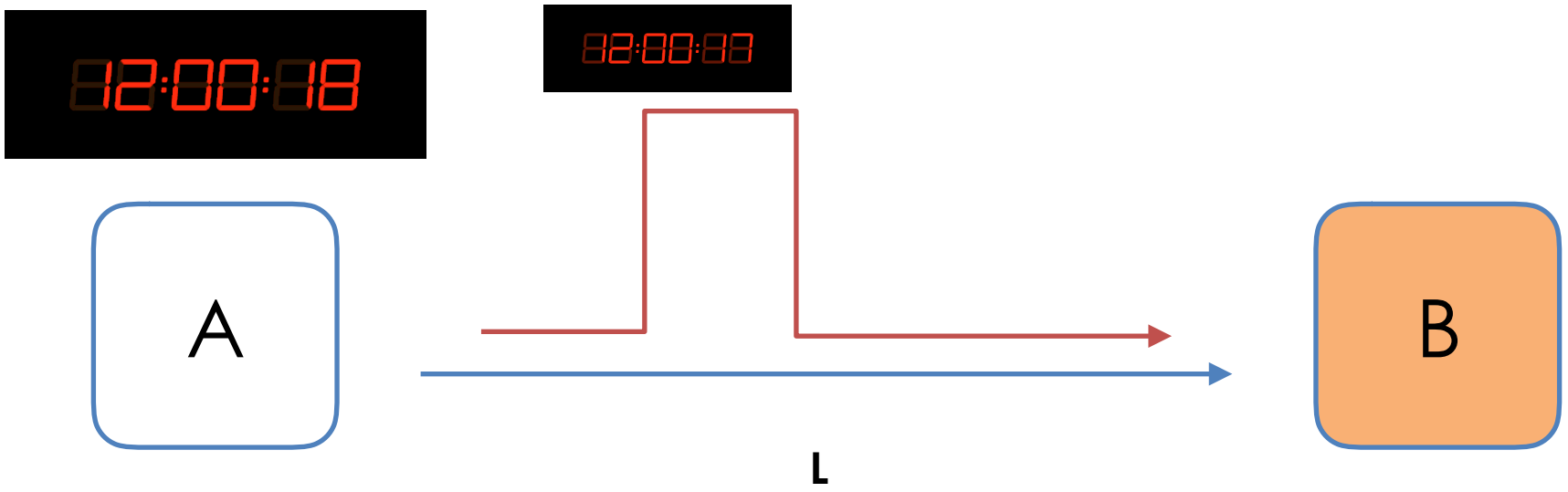
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1 Pulse Per Second (1PPS)

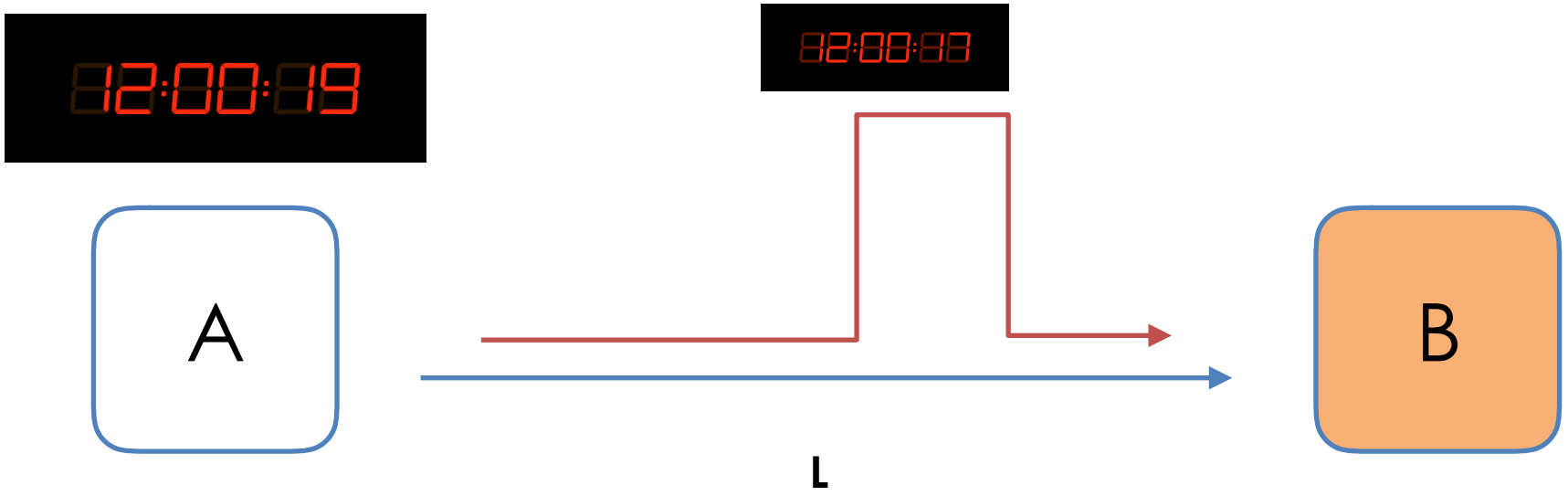




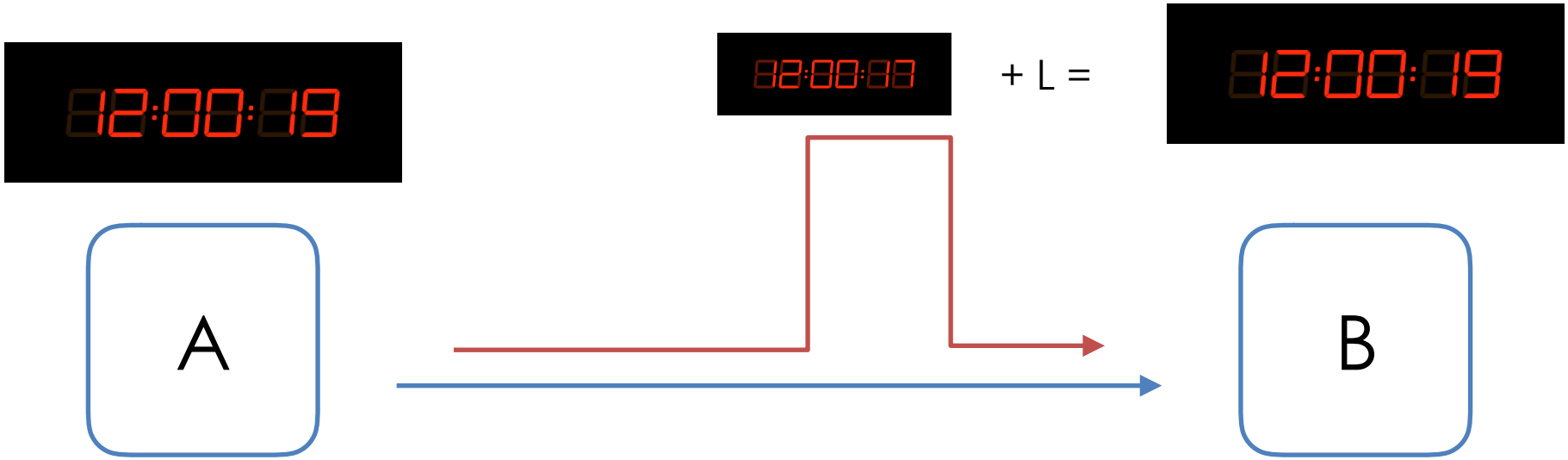
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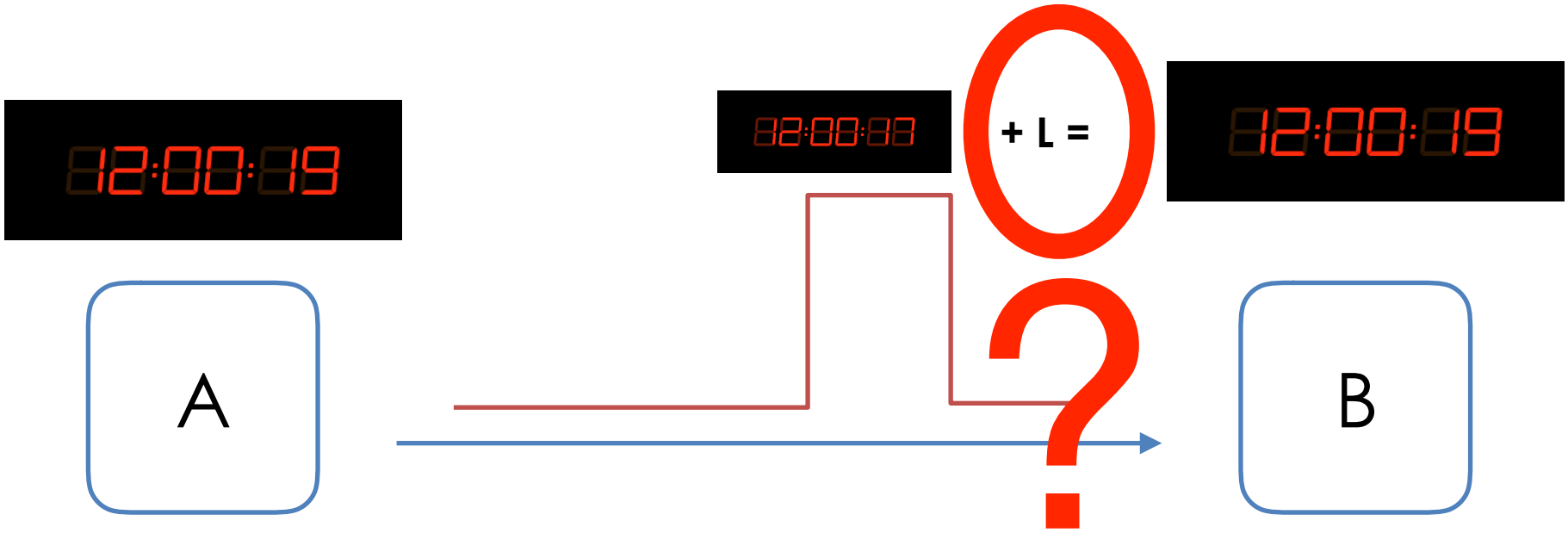
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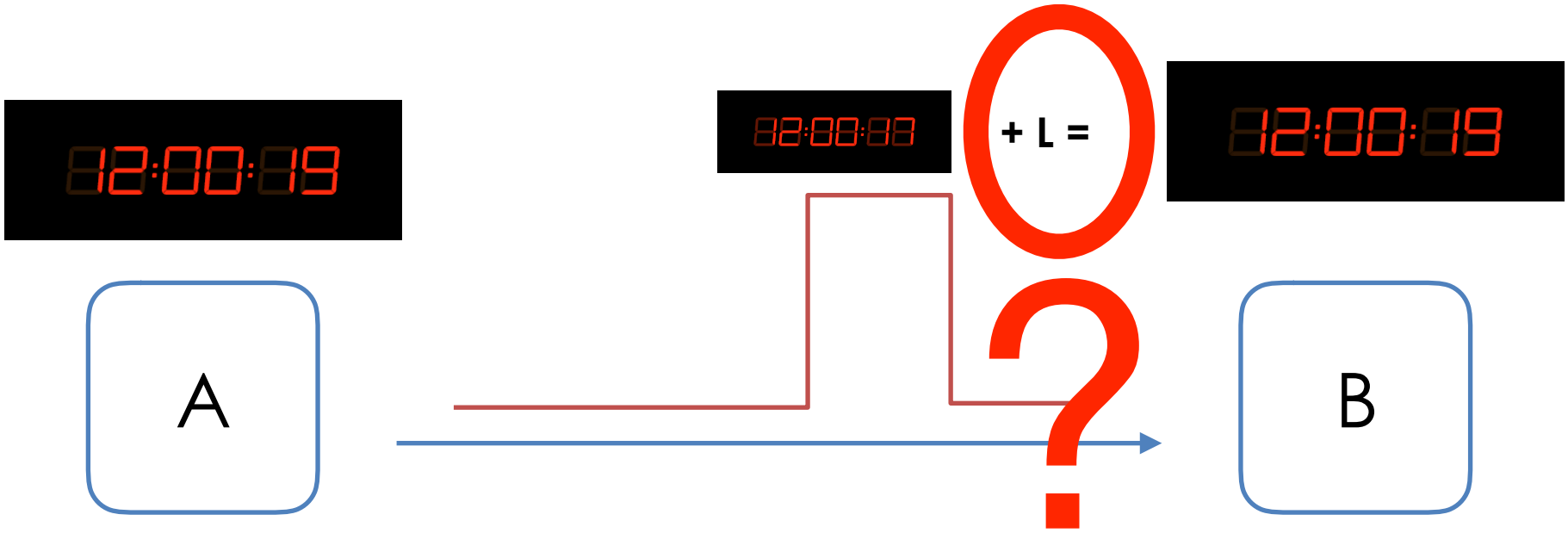
1 Pulse Per Second (1PPS)



Problem 1 - what is L_t?

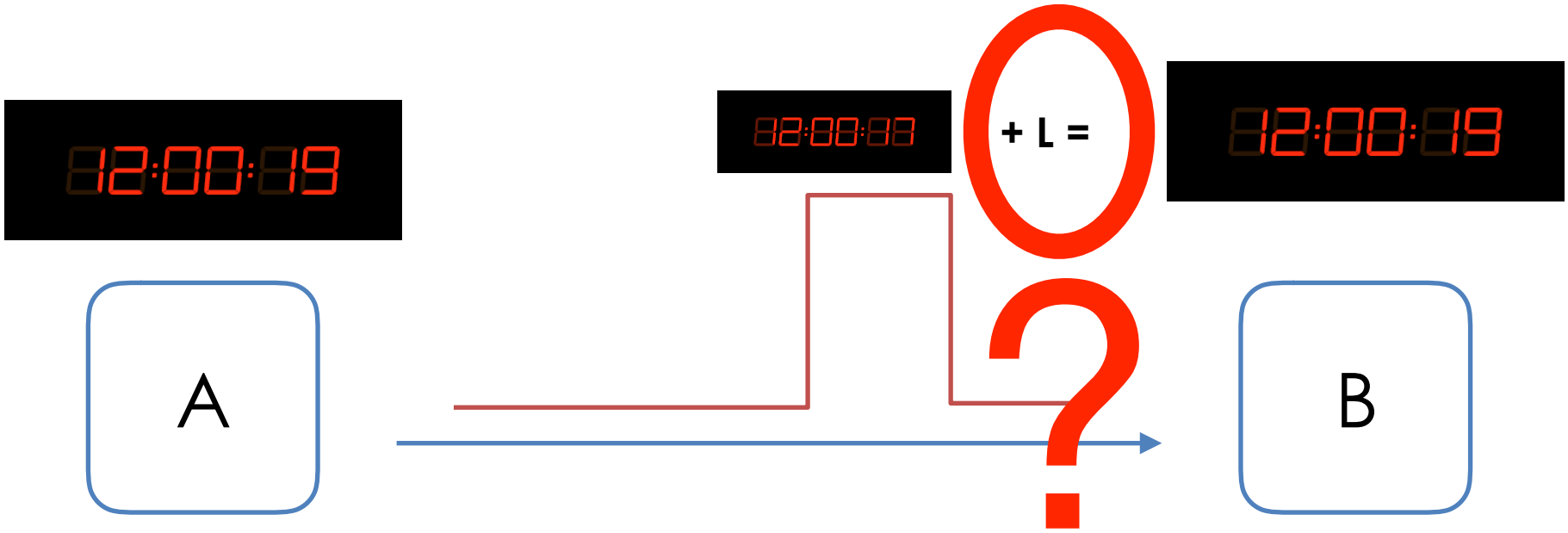


Problem 1 - what is L_t?



Solution: assume V_{prop} = 5ns/m

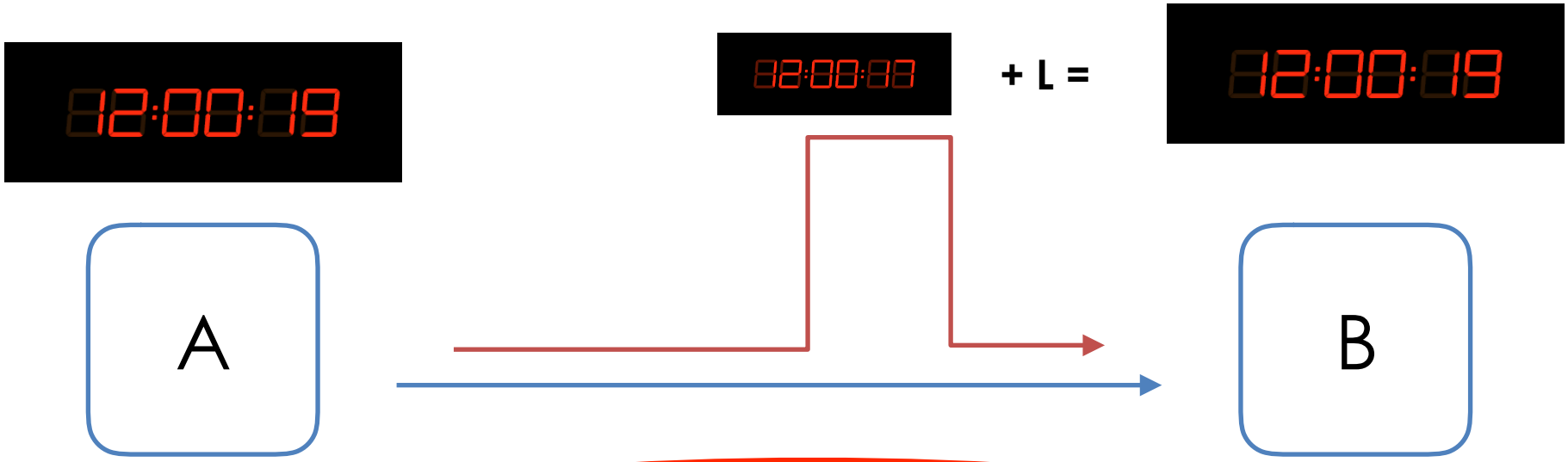
Problem 1 - what is L_t?



Solution: assume V_{prop} = 5ns/m

$L_t = V_{prop} \times L$

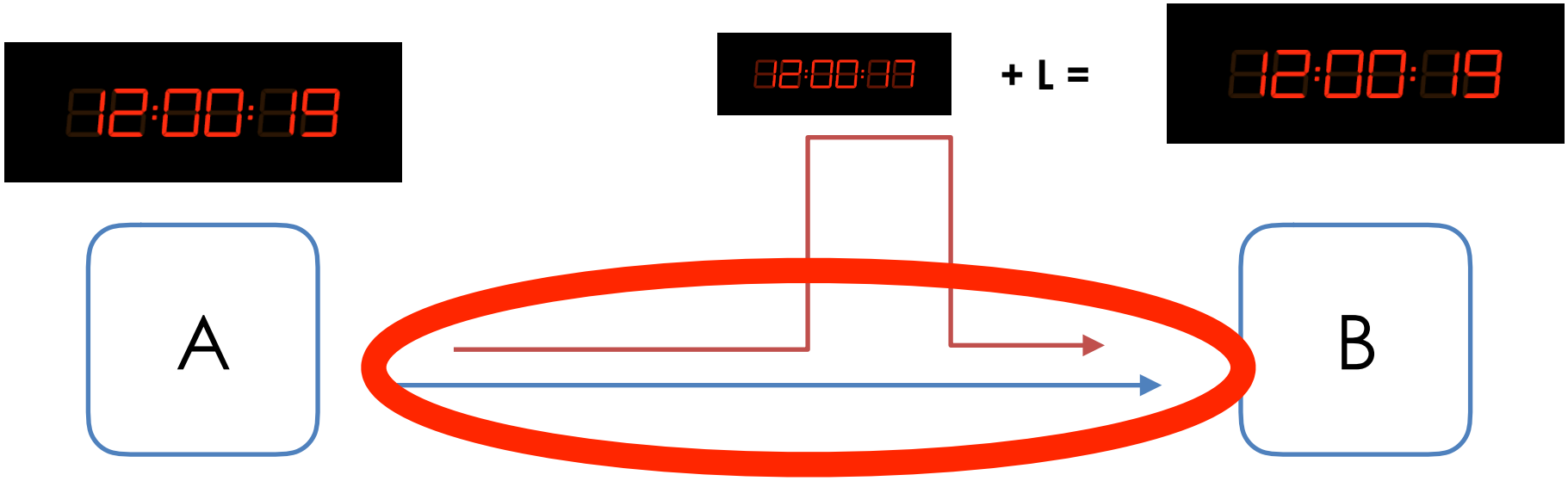
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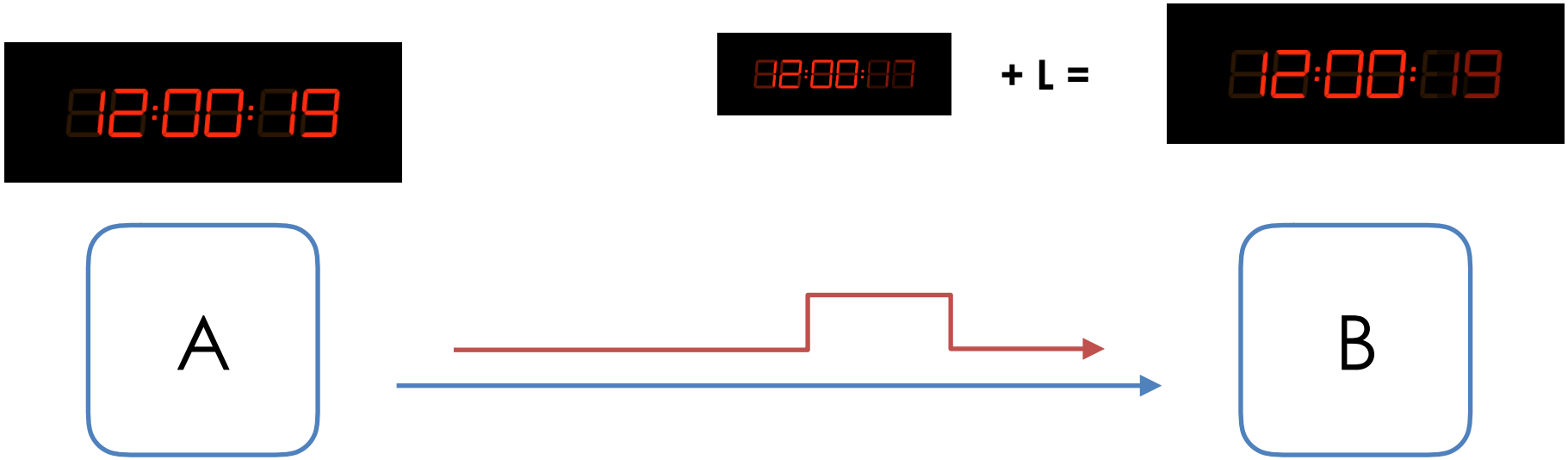
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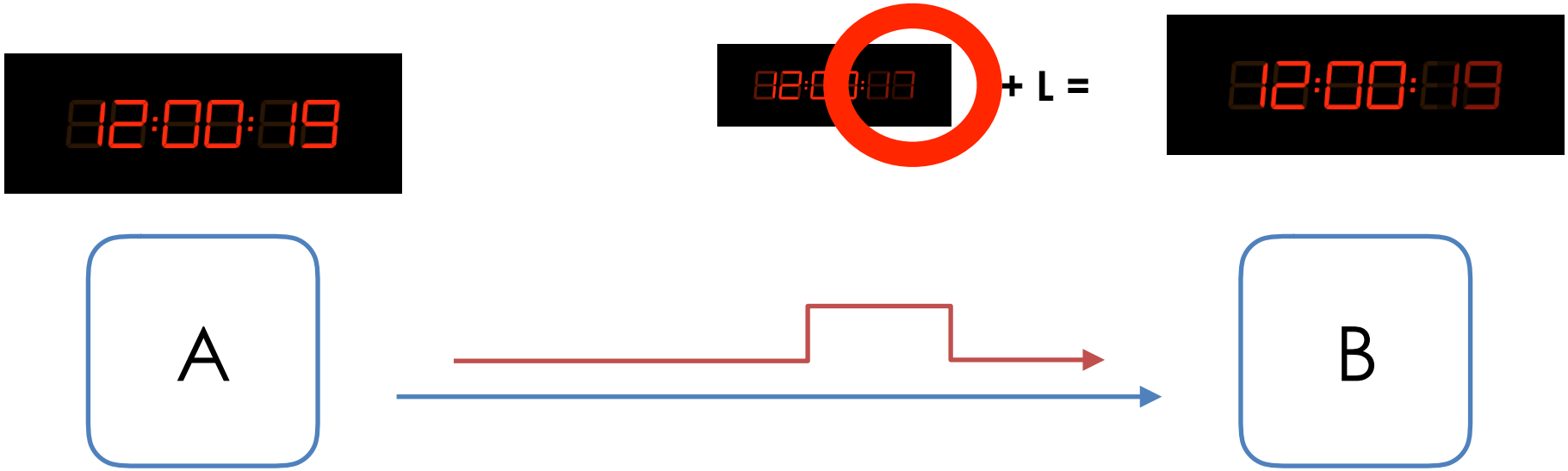
Problem 2 - what if D is long?



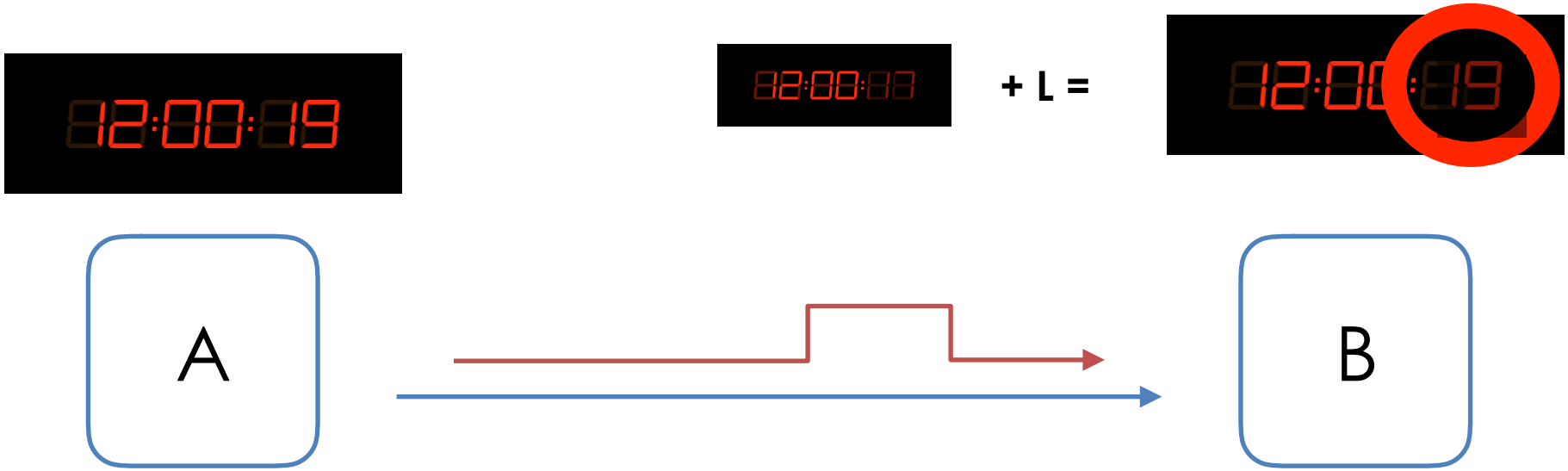
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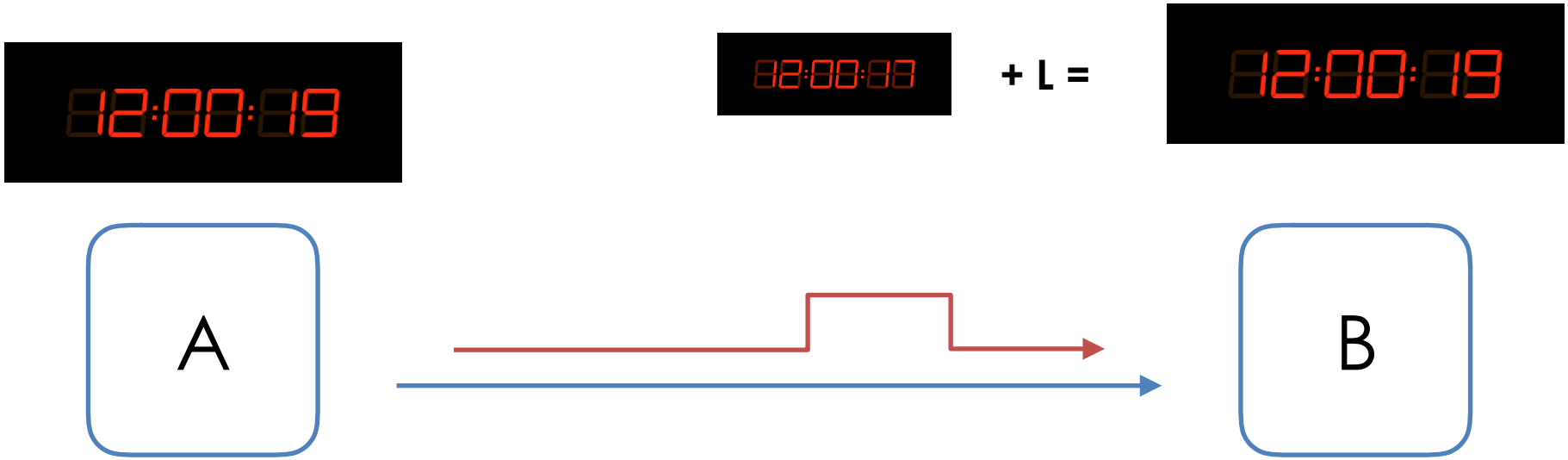
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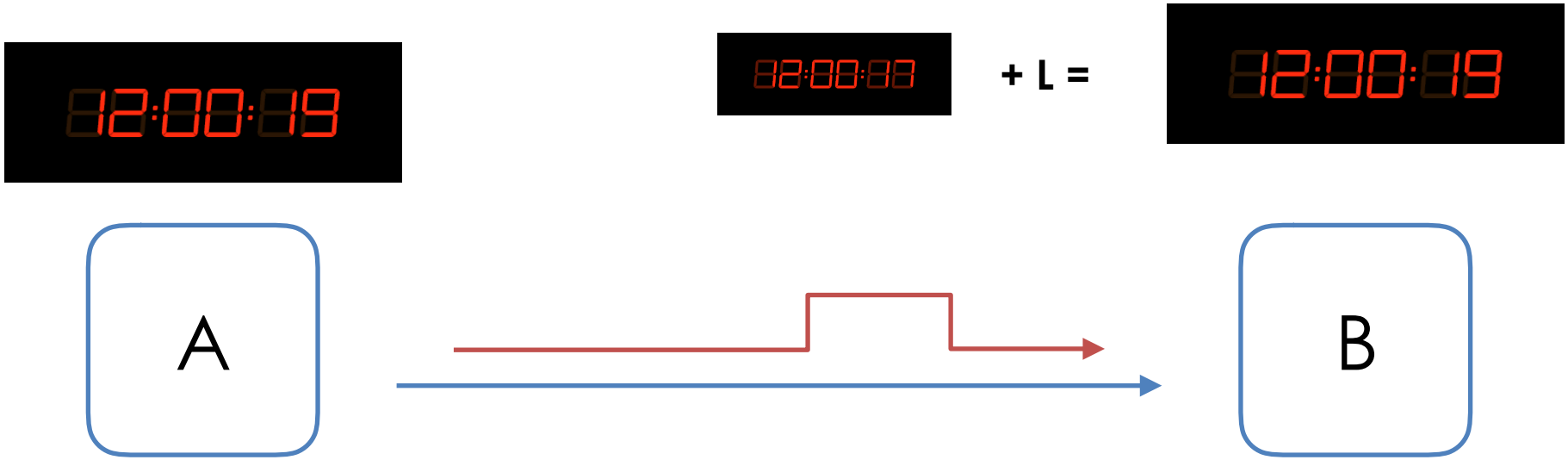


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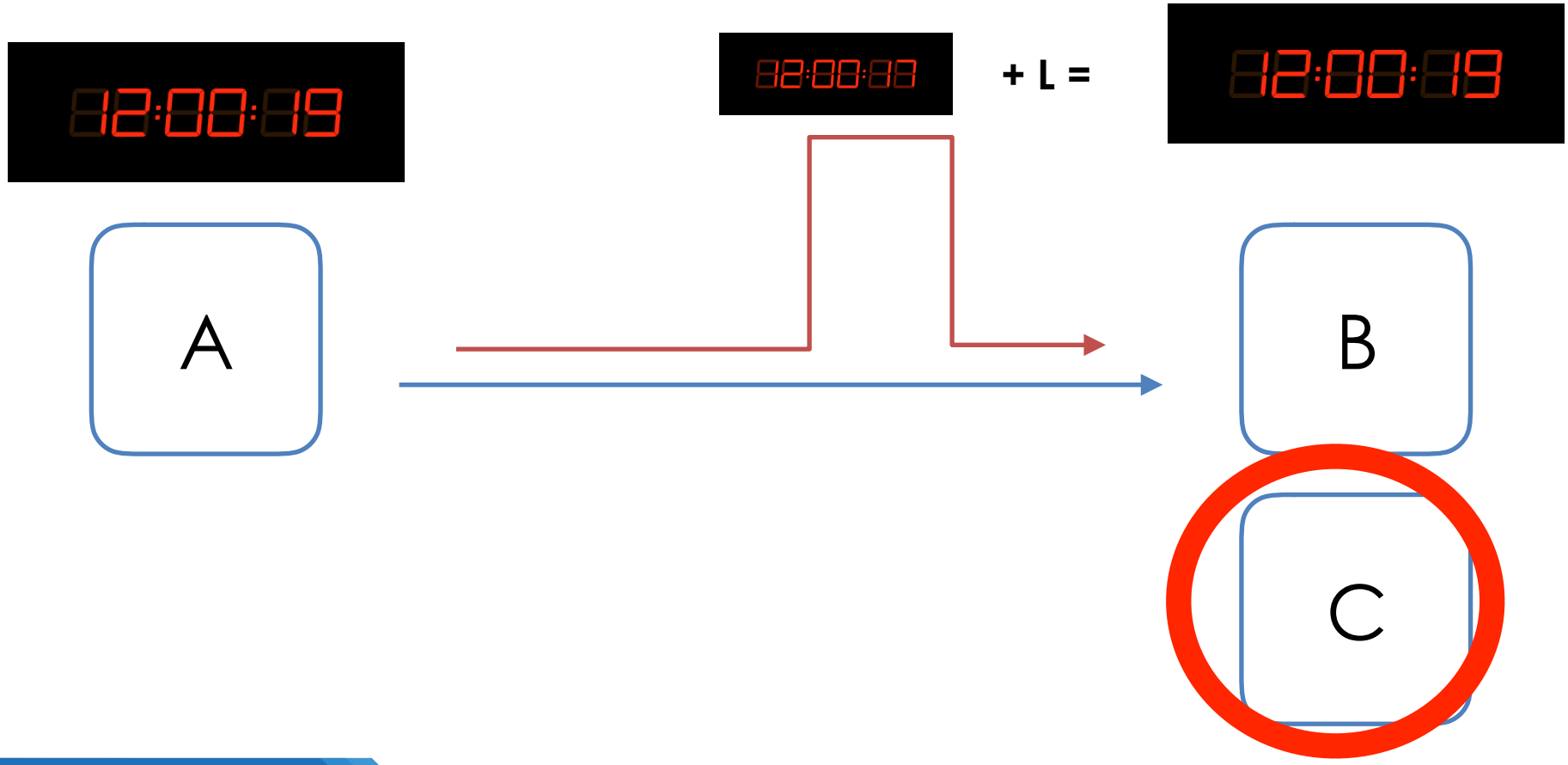
Solution: Amplifier ?

Problem 2 - what if D is long?

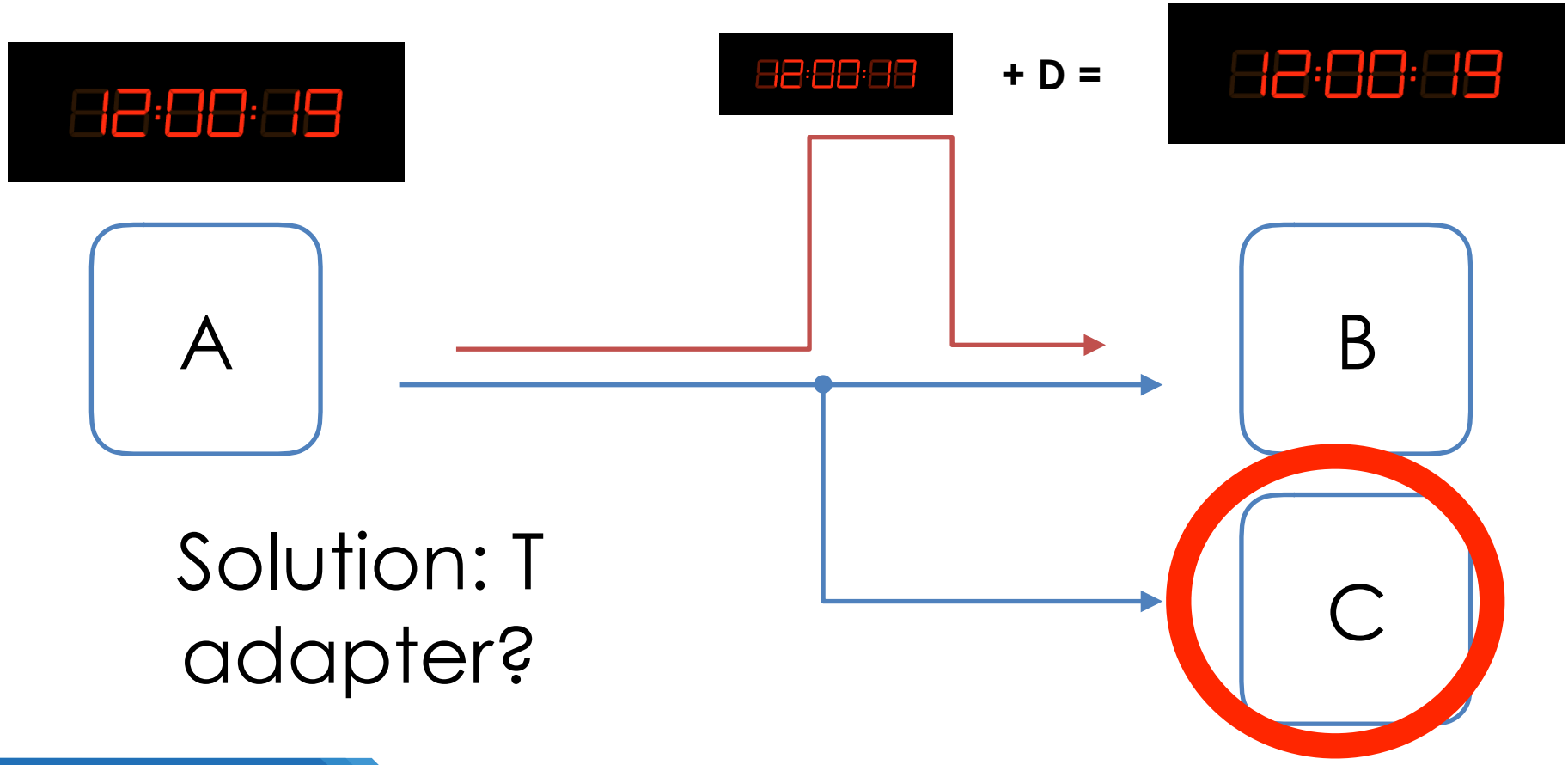


Solution: Amplifier ?

Problem 3 - multi-host?



Problem 3 - multi-host?



Solution: T adapter?

1PPS Conclusions:

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- Doesn't scale well

1PPS Conclusions:

- Doesn't scale well
- Unsuited distrib. time sync

What about PTP?

Fundamentals of PTP



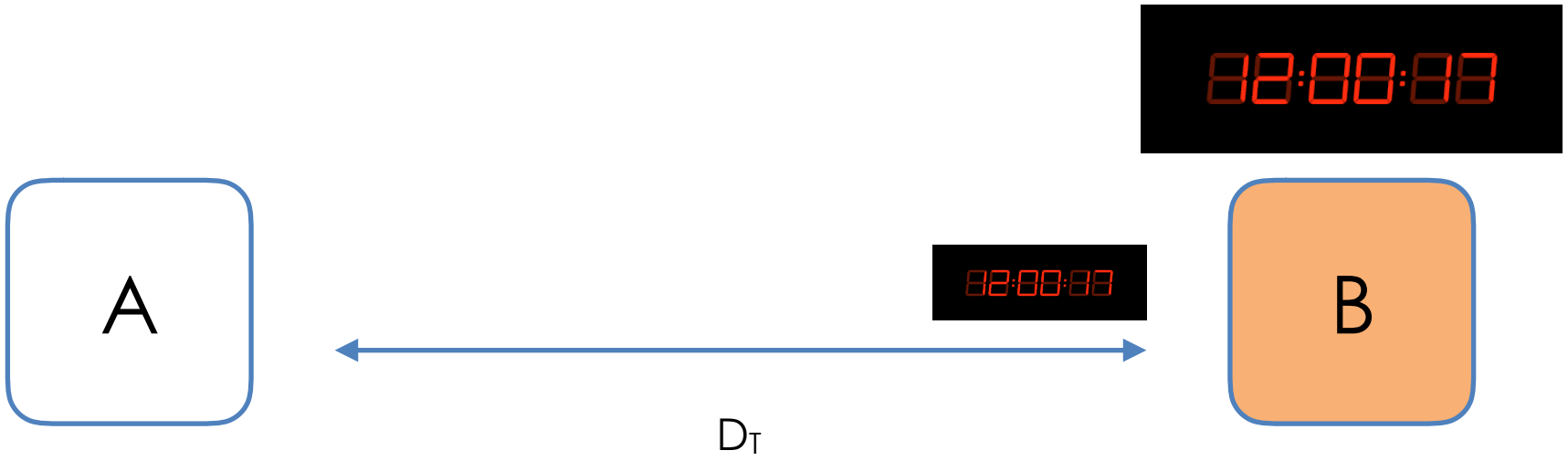
Fundamentals of PTP



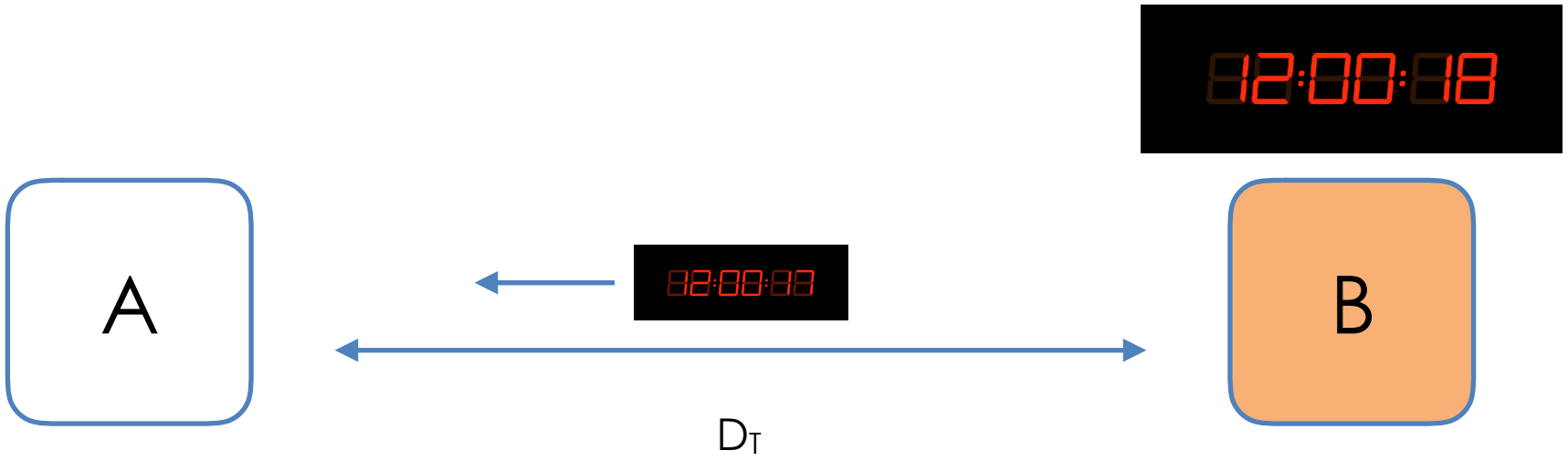
Fundamentals of PTP



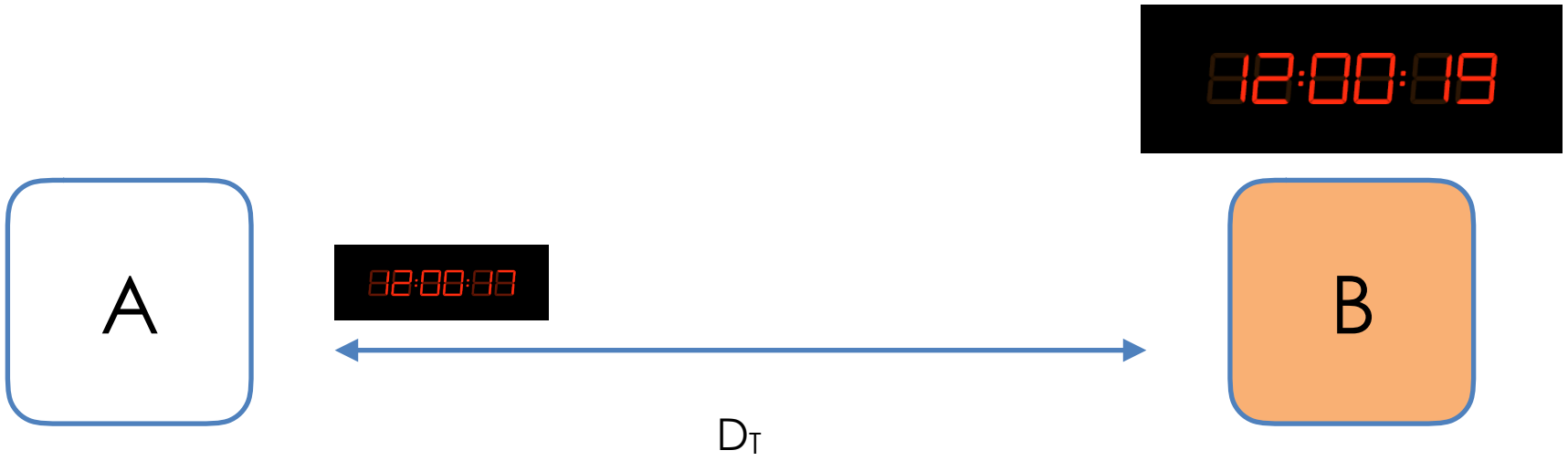
Fundamentals of PTP



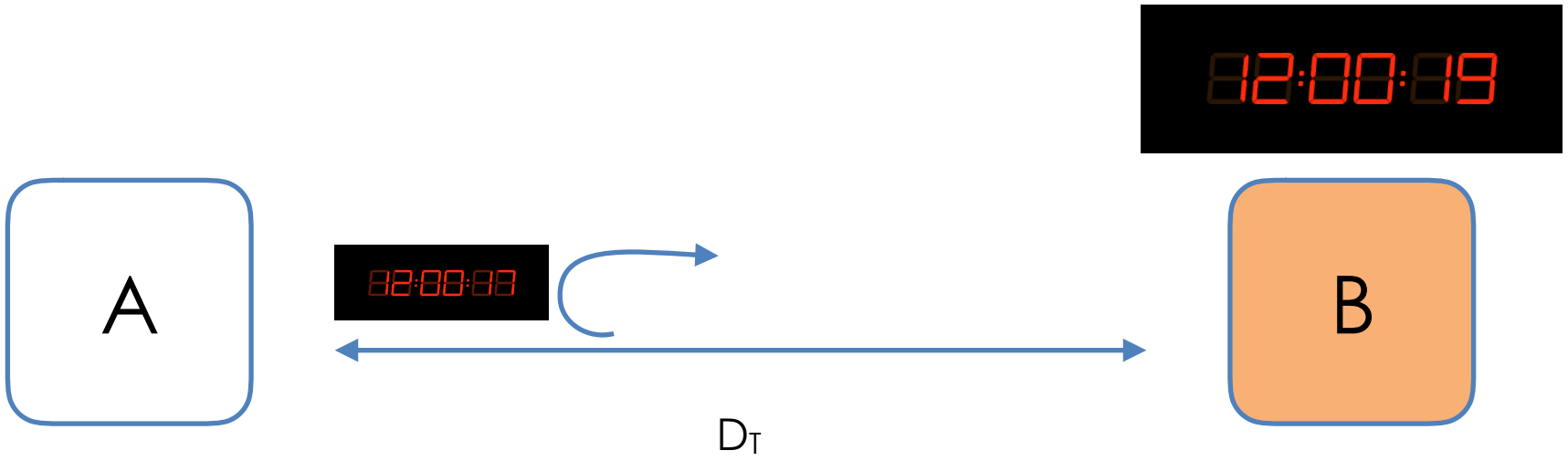
Fundamentals of PTP



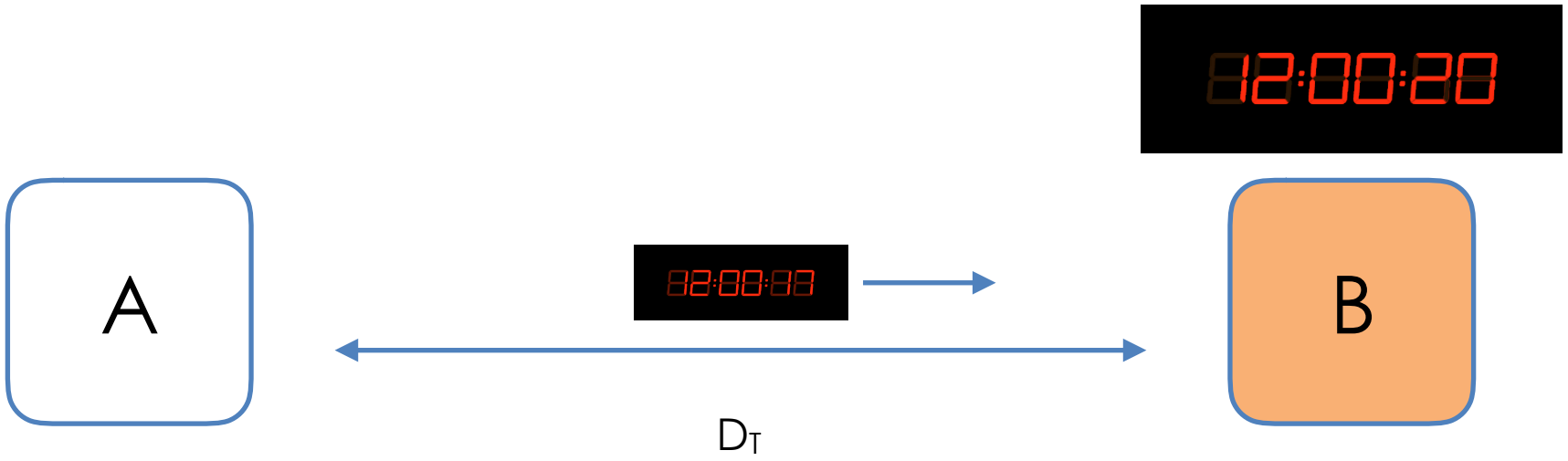
Fundamentals of PTP



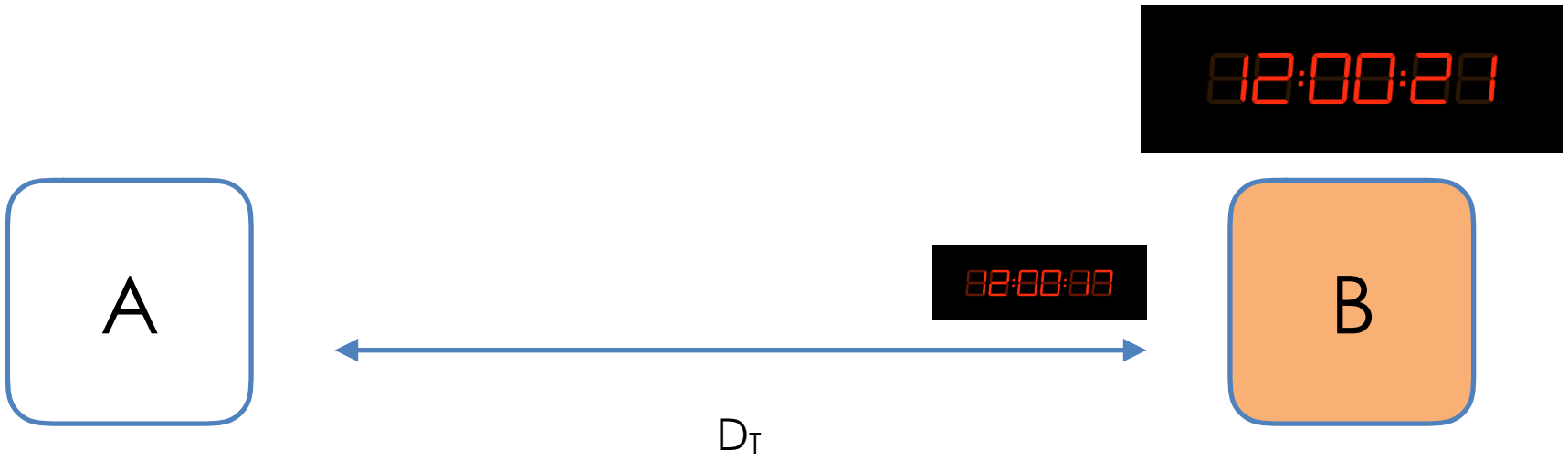
Fundamentals of PTP



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Fundamentals of PTP



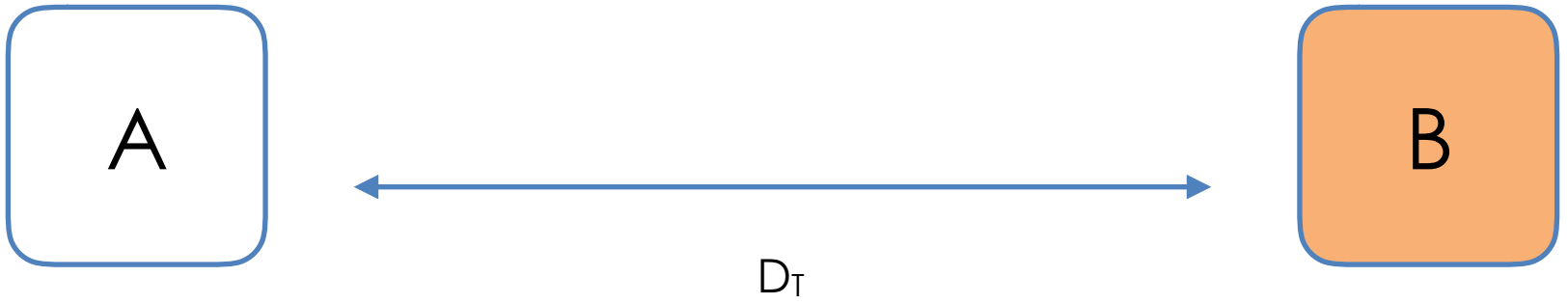
Fundamentals of PTP



-



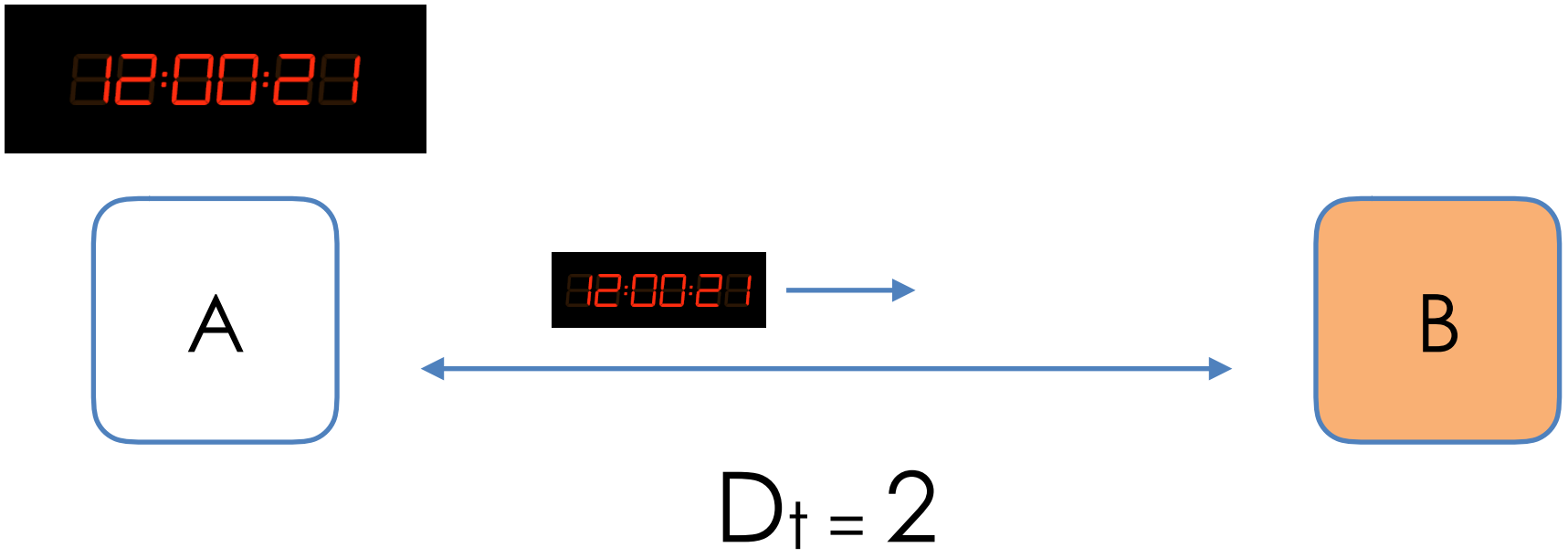
$= 2x\ D_t$



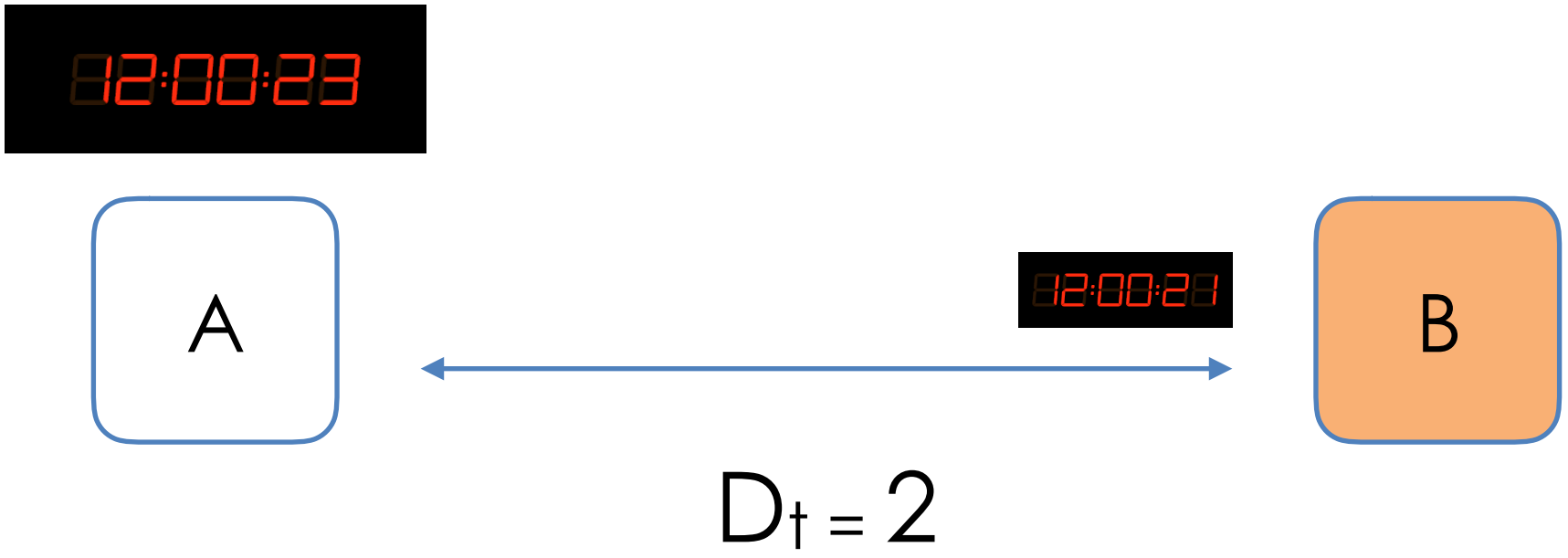
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PTP solves PPS estimation problem

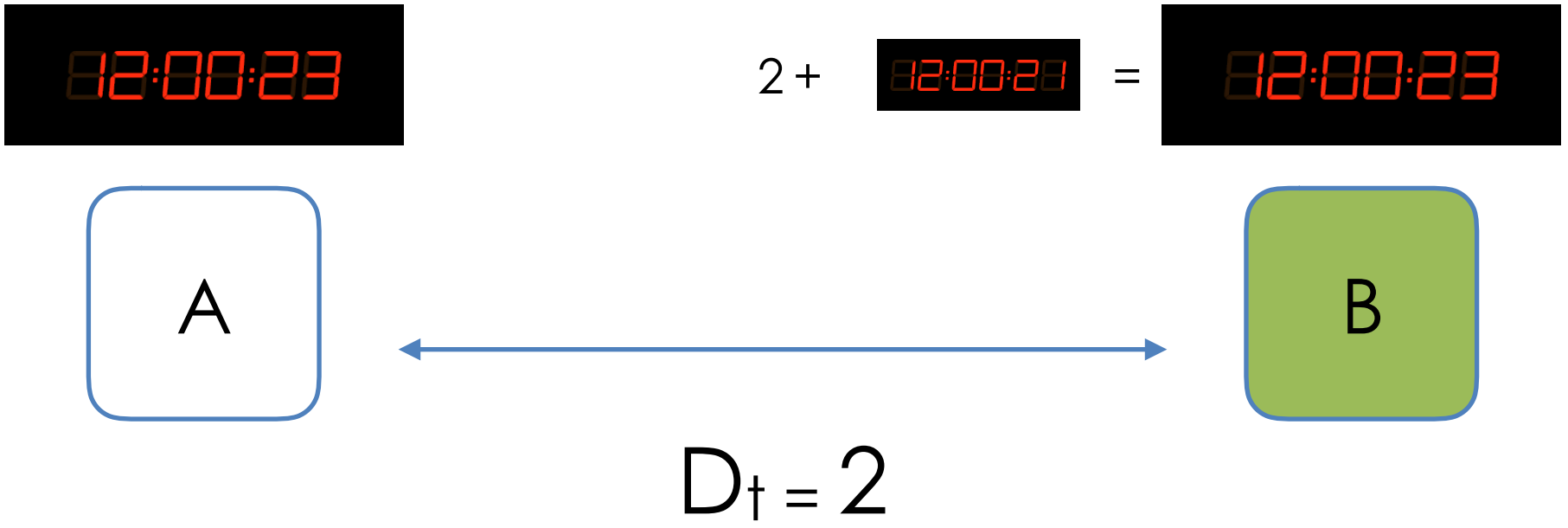
Fundamentals of PTP



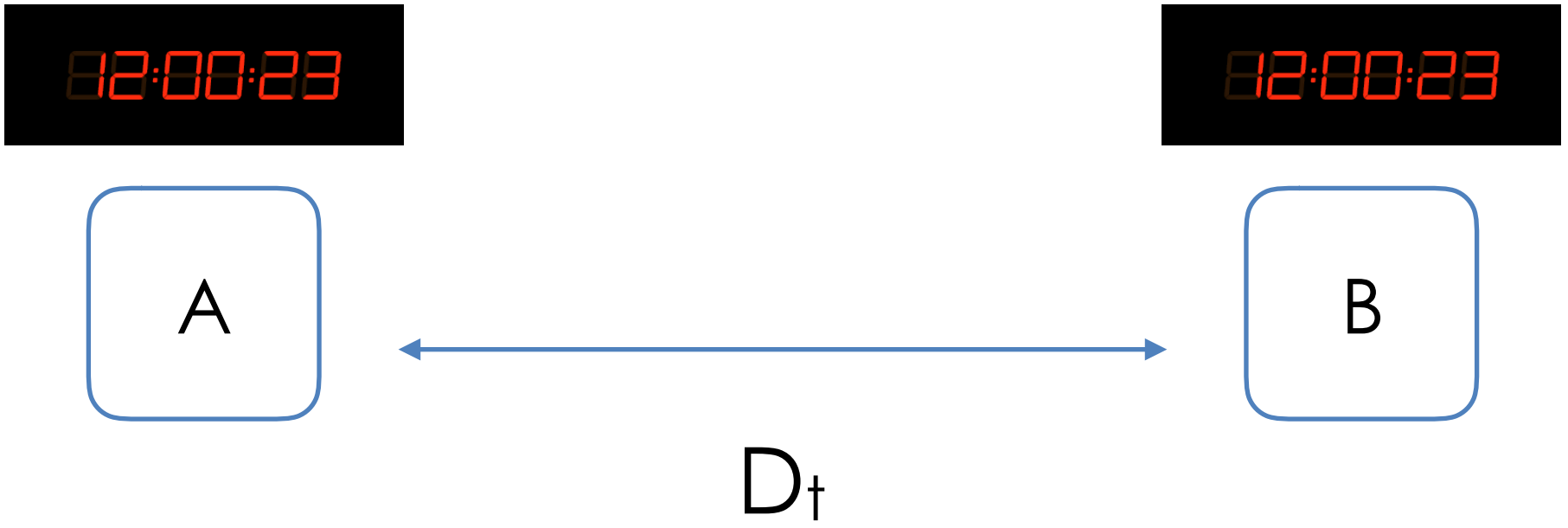
Fundamentals of PTP



Fundamentals of PTP



What if D is long?



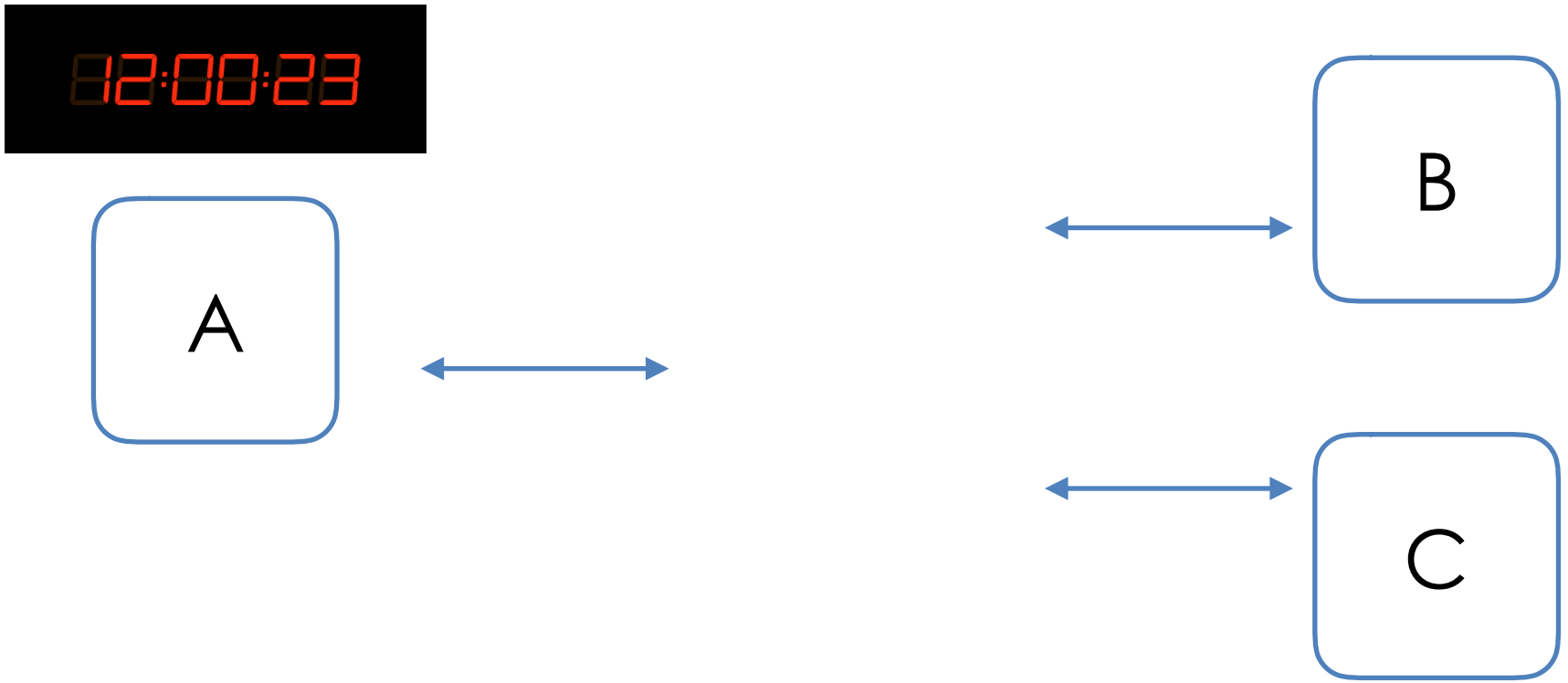
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What if D is long?



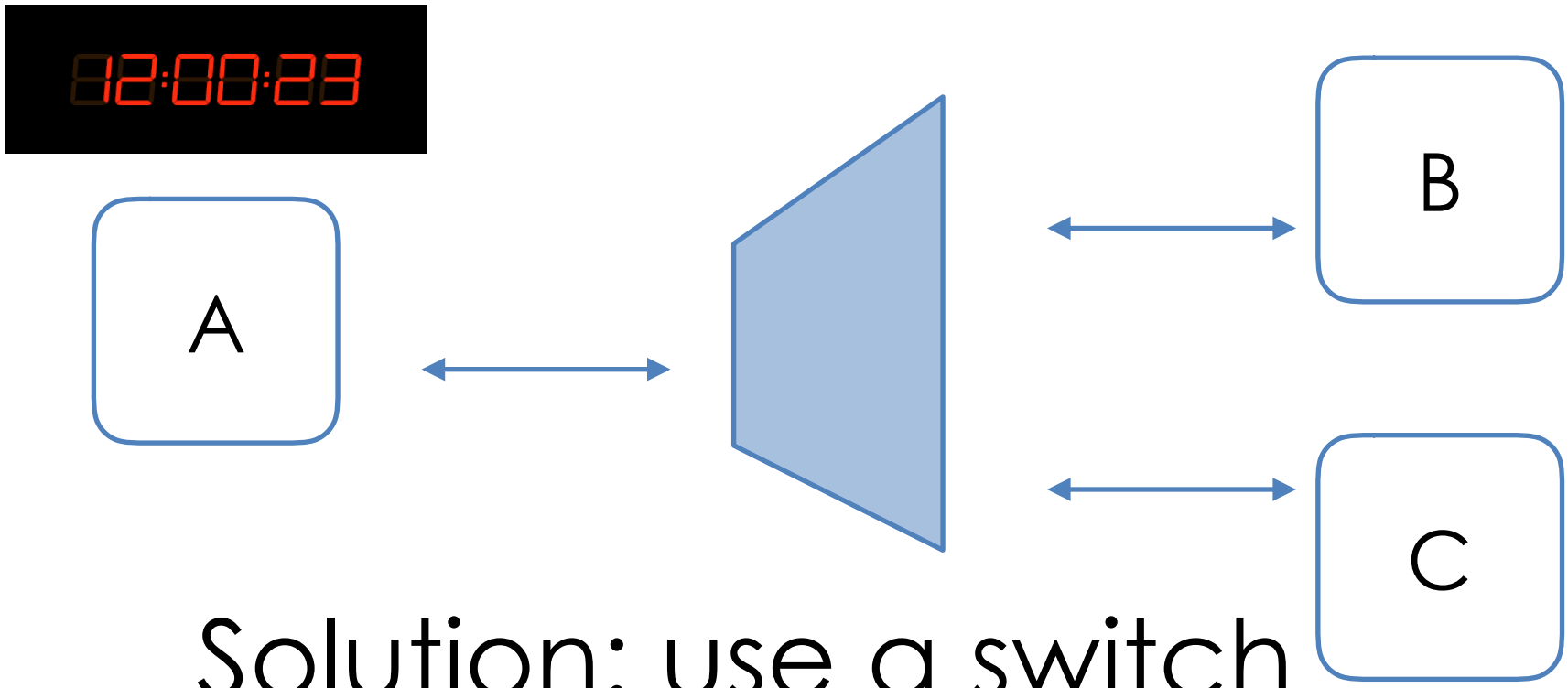
Solution: LR Transceivers

PTP - Multi-host?



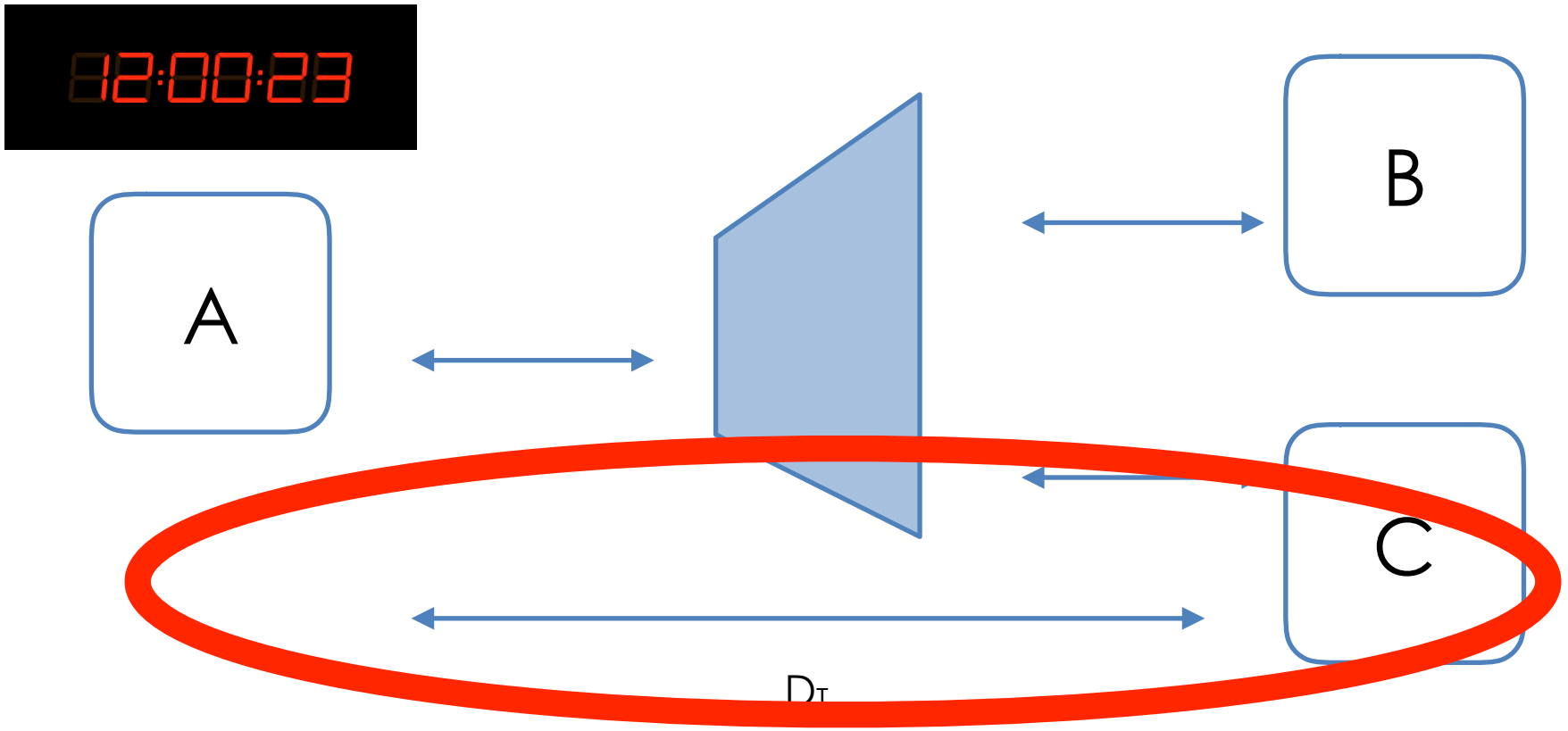
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PTP Problem - multi-host?

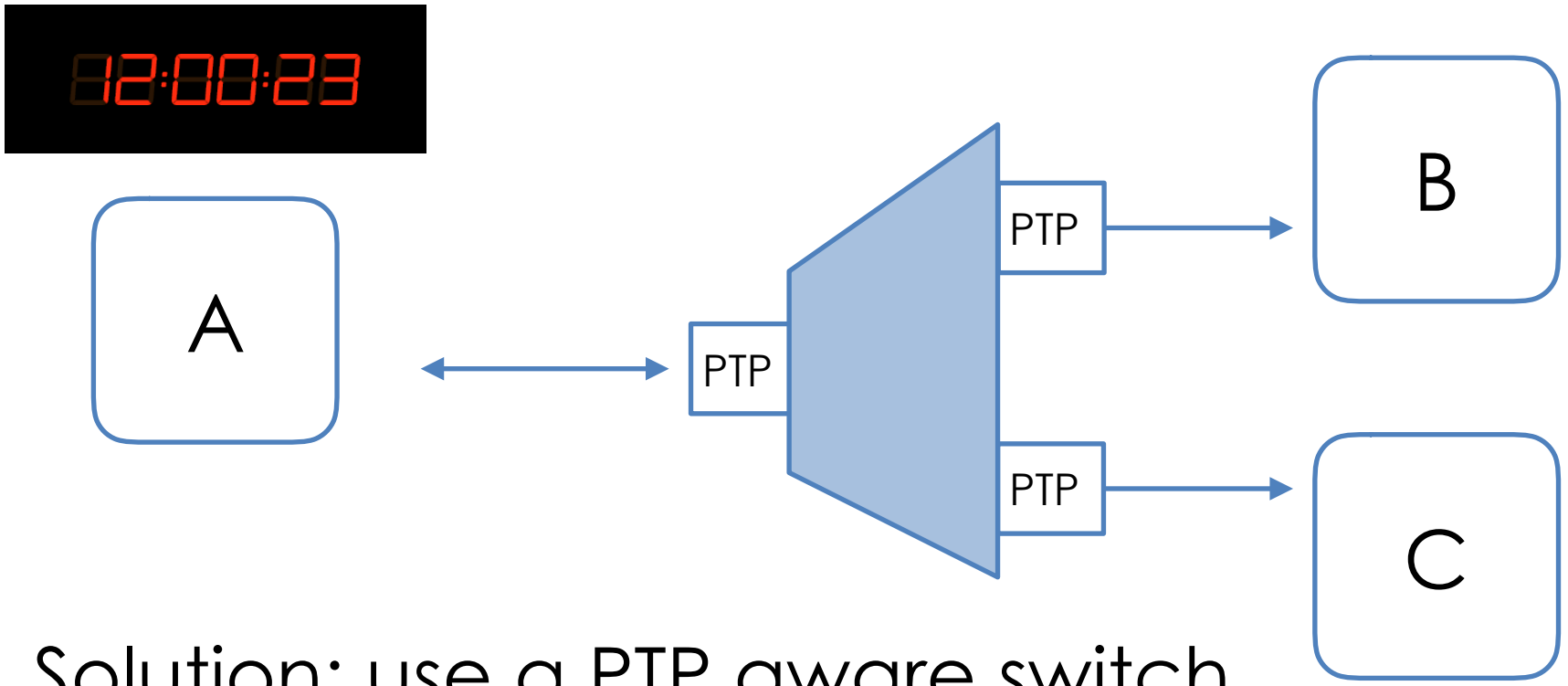


Solution: use a switch

PTP Problem - switch queuing?



PTP Problem - switch queuing?



Solution: use a PTP aware switch

PTP on paper:

PTP on paper:

- Better quality sync (D_t est.)

PTP on paper:

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- Scales longer distance

PTP on paper:

- Better quality sync (D_t est.)
- Scales longer distance
- Scales to more hosts



Part II - PTP in practice

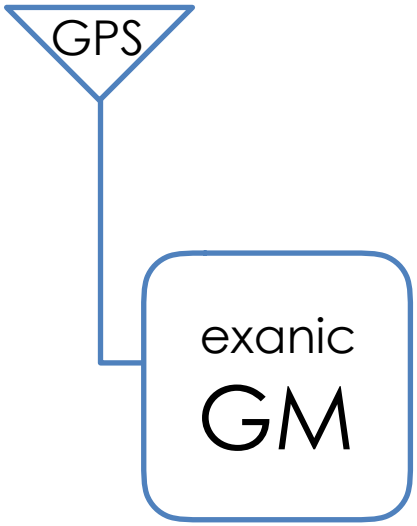
PTP in Practice



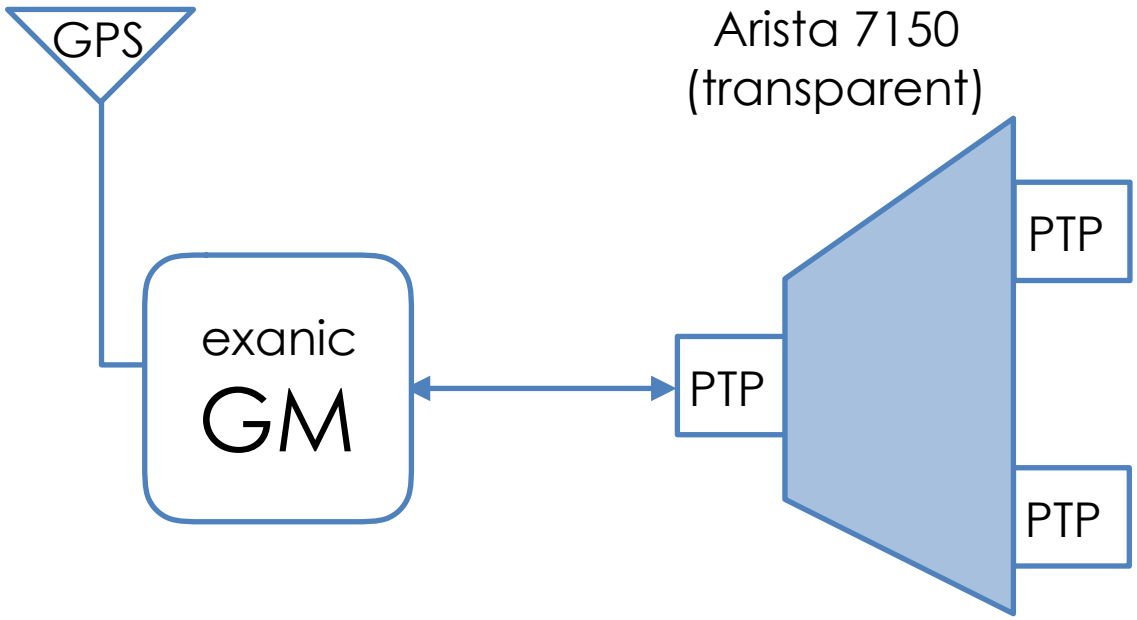
PTP in Practice



PTP in Practice

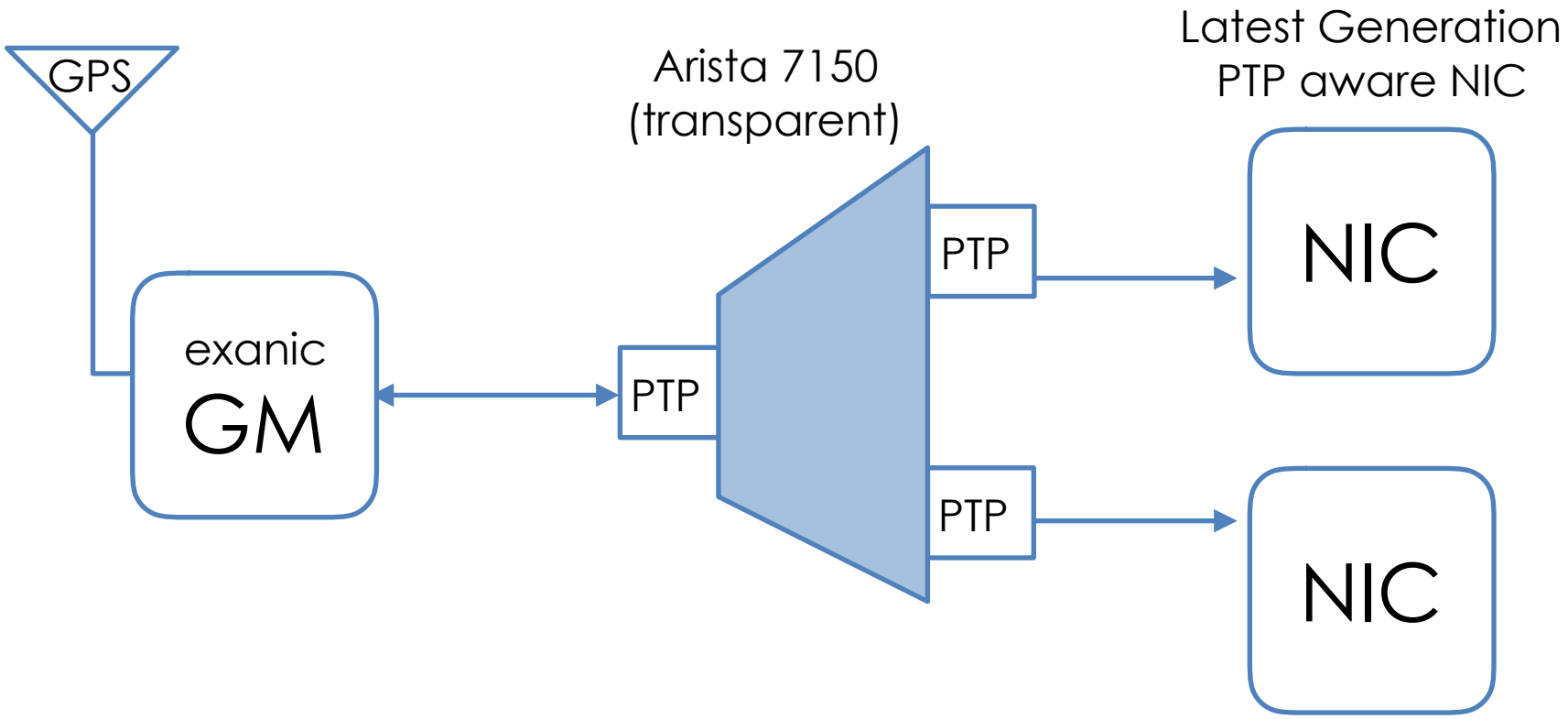


PTP in Practice

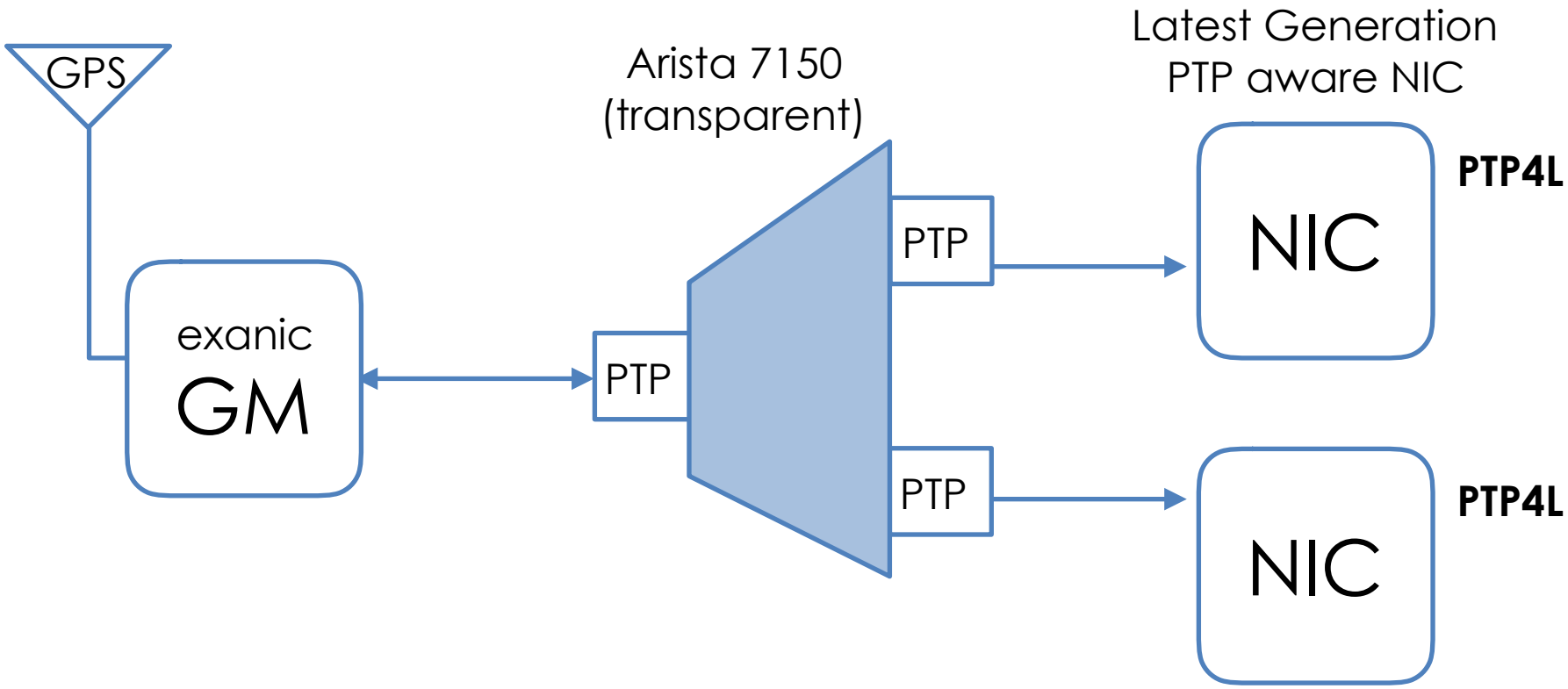


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PTP in Practice



PTP in Practice



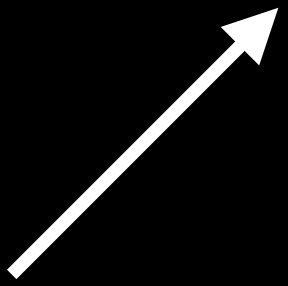
PTP4L Configuration

PTP4L Configuration

```
$ ptp4l -i enp101n1 -m
```

PTP4L Configuration

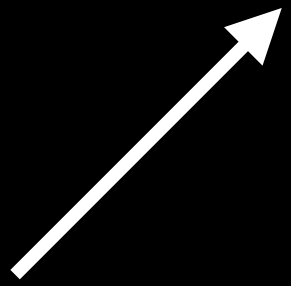
```
$ ptp4l -i enp101n1 -m
```



network interface

PTP4L Configuration

```
$ ptp4l -i enp101n1 -m
```



log to stdout

How do you measure PTP Sync Quality?

PTP4L Logs

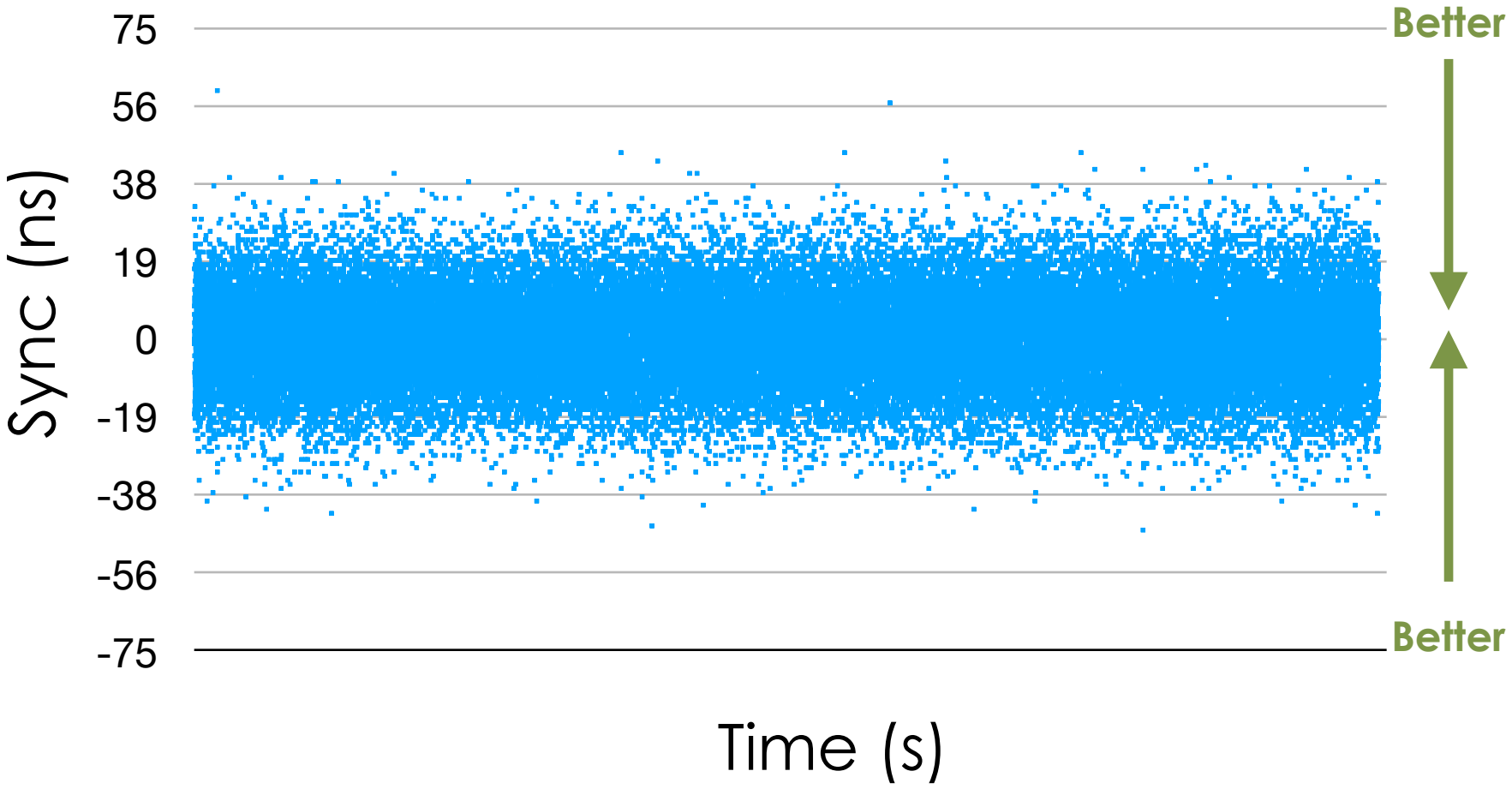
```
ptp4l[336539.407]: selected /dev/ptp2 as PTP clock
ptp4l[336539.408]: port 1: INITIALIZING to LISTENING on INIT_COMPLETE
ptp4l[336539.408]: port 0: INITIALIZING to LISTENING on INIT_COMPLETE
ptp4l[336539.703]: port 1: new foreign master 643f5f.fffe.01347e-1
ptp4l[336539.780]: port 1: peer detected, switch to P2P
ptp4l[336541.703]: selected best master clock 643f5f.fffe.01347e
ptp4l[336541.703]: port 1: LISTENING to UNCALIBRATED on RS_SLAVE
ptp4l[336542.703]: master offset        -76 s0 freq    -246 path delay        63
ptp4l[336543.703]: master offset        -75 s2 freq    -245 path delay        57
ptp4l[336543.704]: port 1: UNCALIBRATED to SLAVE on MASTER_CLOCK_SELECTED
ptp4l[336544.703]: master offset        -76 s2 freq    -321 path delay        57
ptp4l[336545.703]: master offset        -18 s2 freq    -286 path delay        57
ptp4l[336546.703]: master offset          6 s2 freq    -267 path delay        57
ptp4l[336547.703]: master offset         17 s2 freq    -254 path delay        57
ptp4l[336548.703]: master offset         29 s2 freq    -237 path delay        57
ptp4l[336549.703]: master offset         17 s2 freq    -241 path delay        57
ptp4l[336550.703]: master offset         -2 s2 freq    -255 path delay        57
ptp4l[336551.703]: master offset          2 s2 freq    -251 path delay        57
ptp4l[336552.703]: master offset        -16 s2 freq    -269 path delay        57
```

PTP4L Logs

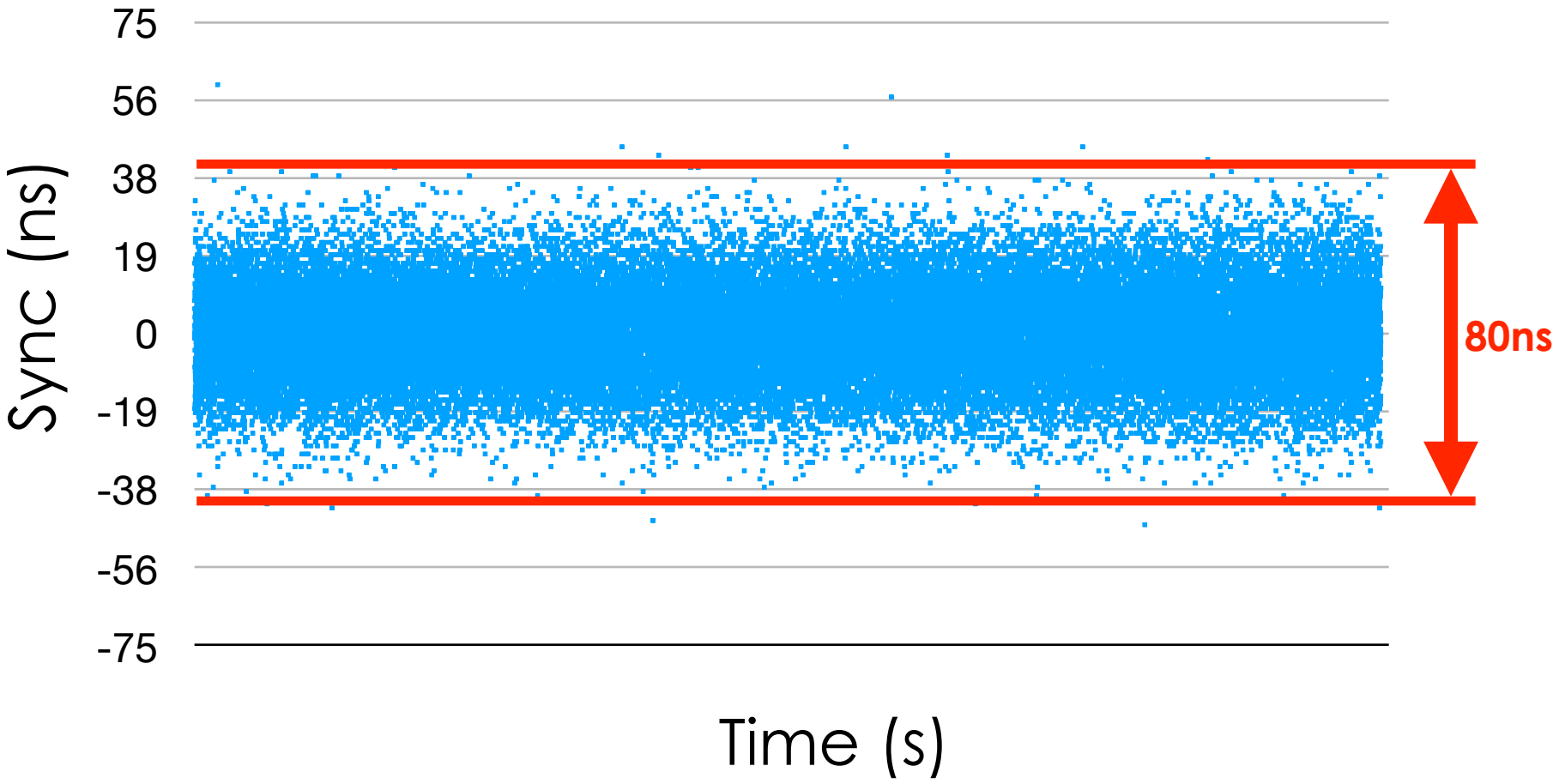
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ptp4l[336550.703]: master offset         -2 s2 freq    -255 path delay        57
ptp4l[336551.703]: master offset          2 s2 freq    -251 path delay        57
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```

Perceived Sync

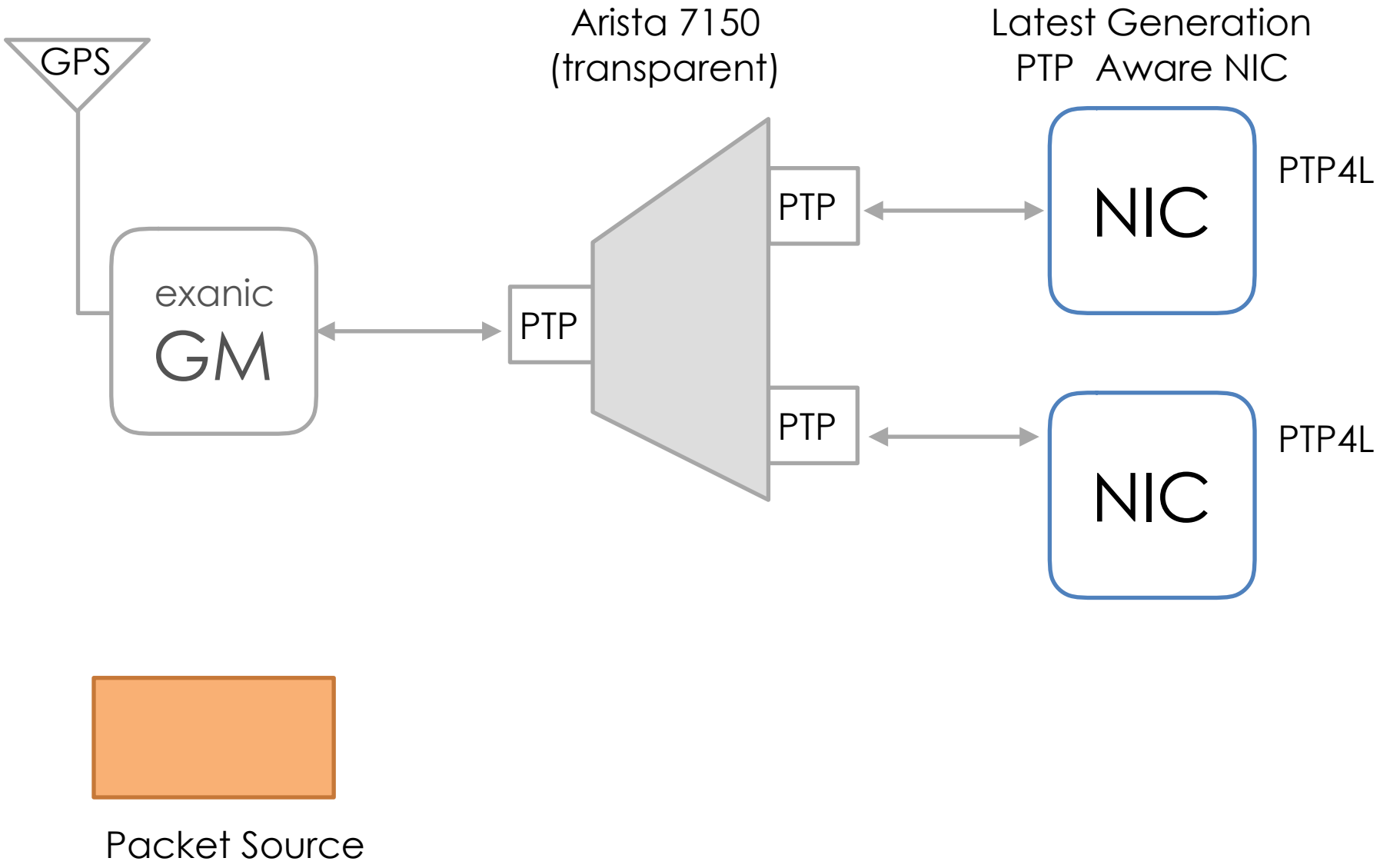
PTP4L Perceived Sync

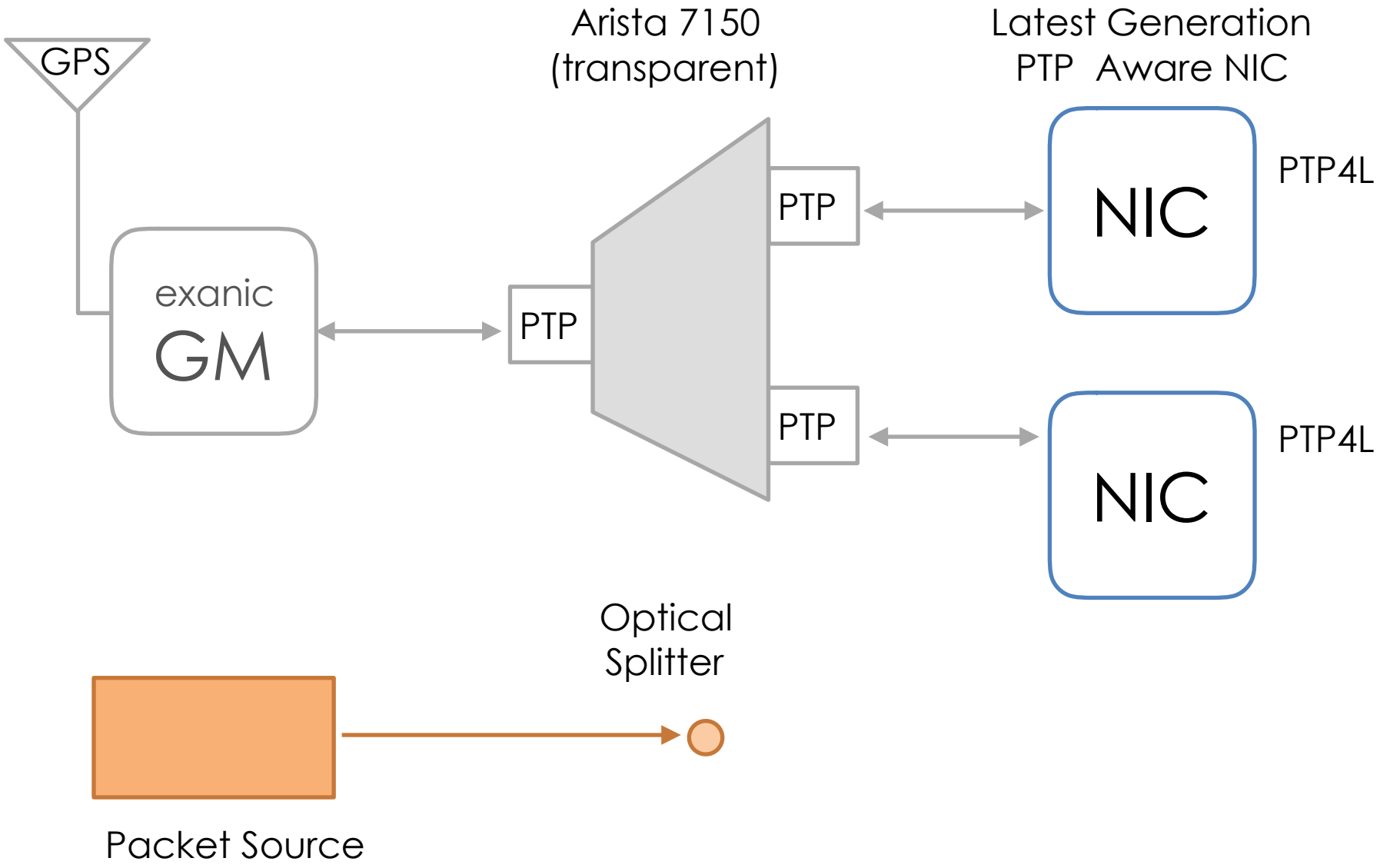


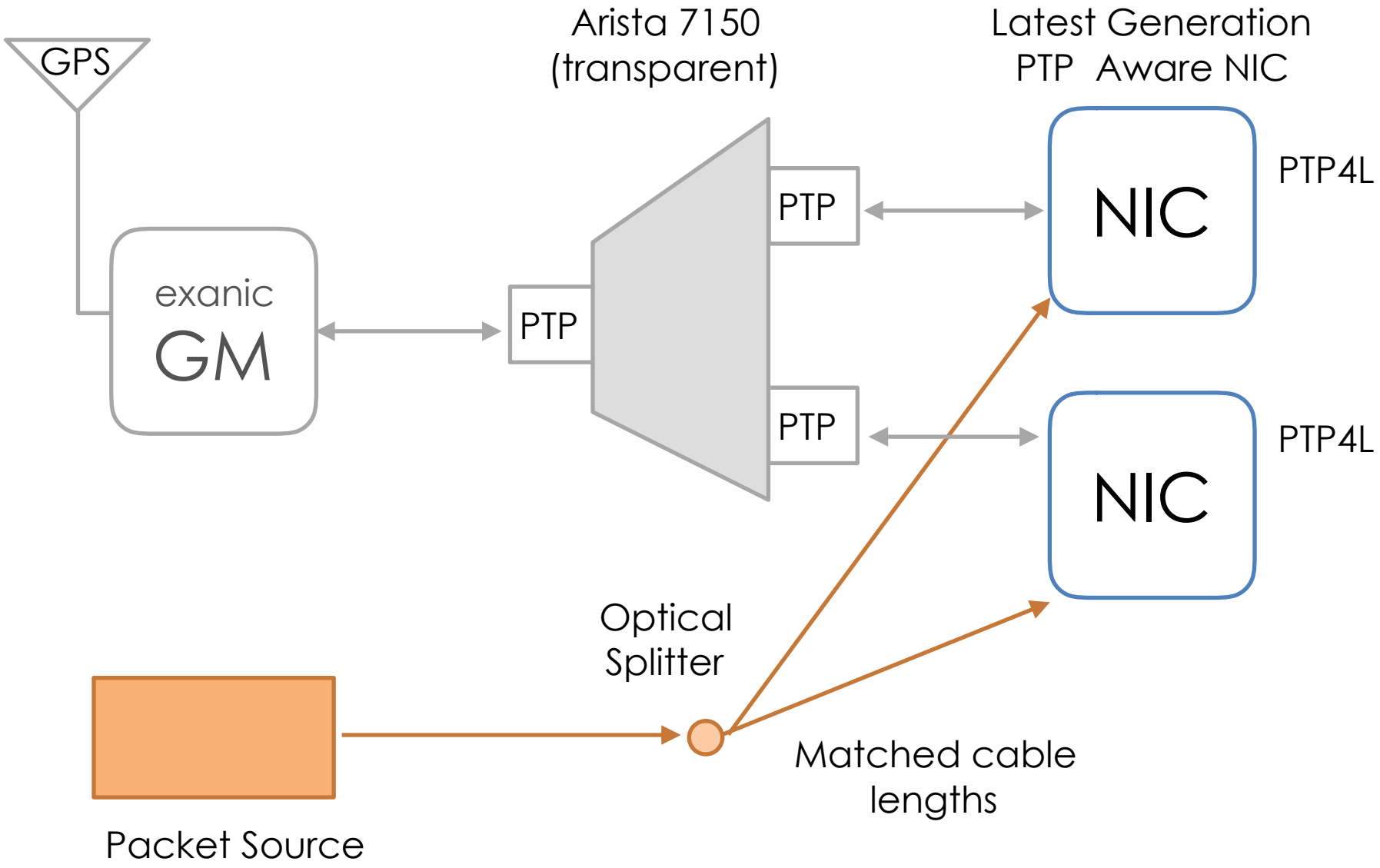
PTP4L Perceived Sync

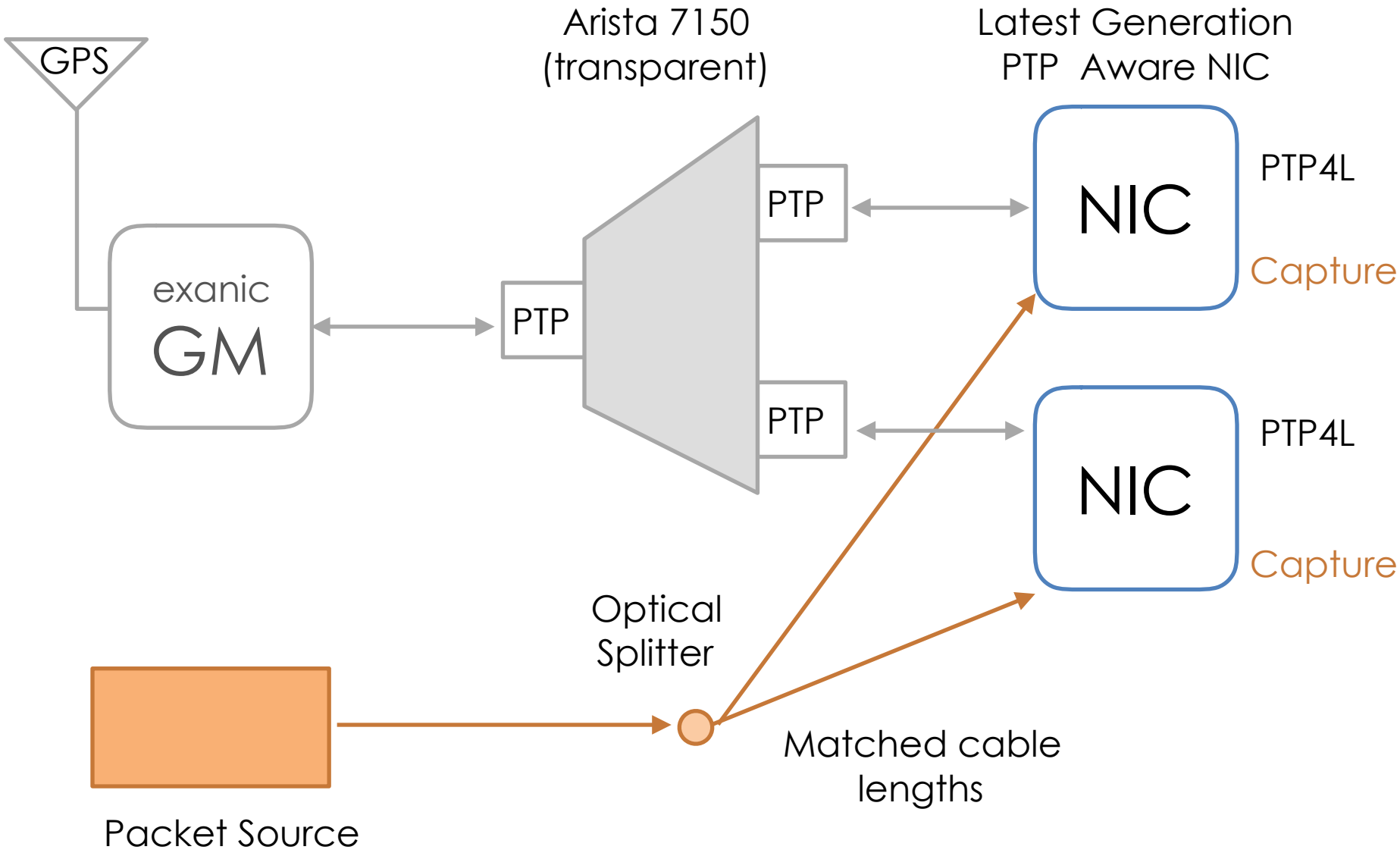


Another way to measure PTP Sync Quality?

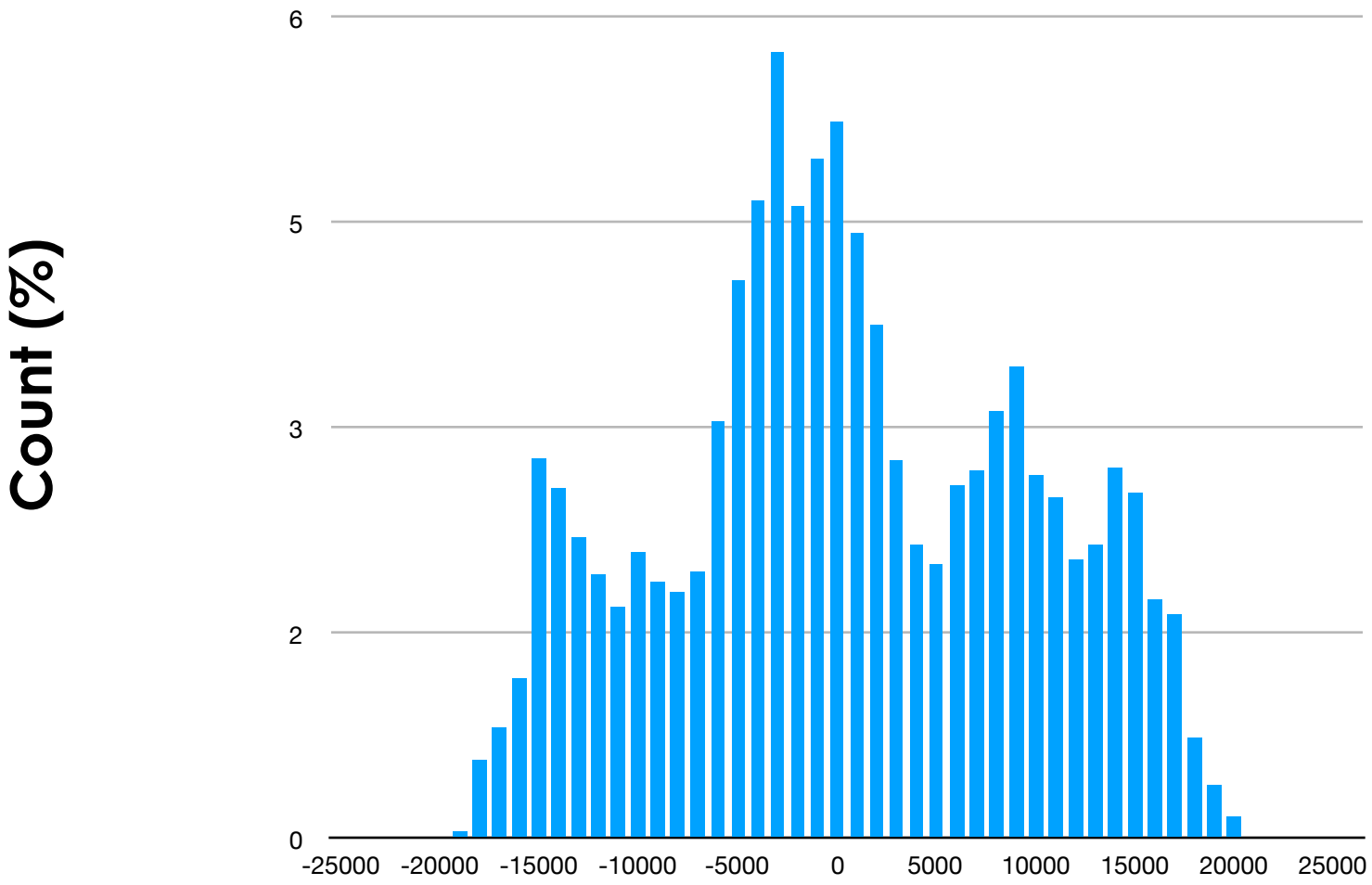

GPS
exanic
GM
Arista 7150
(transparent)
PTP
PTP
PTP
Latest Generation
PTP Aware NIC
NIC
NIC
PTP4L
PTP4L
Packet Source


Arista 7150
(transparent)
Latest Generation
PTP Aware NIC
GPS
exanic
GM
PTP
PTP
PTP
NIC
PTP4L
NIC
PTP4L
Optical
Splitter
Packet Source


GPS
exanic
GM
Arista 7150
(transparent)
PTP
PTP
PTP
Latest Generation
PTP Aware NIC
NIC
PTP4L
NIC
PTP4L
Optical
Splitter
Matched cable
lengths
Packet Source

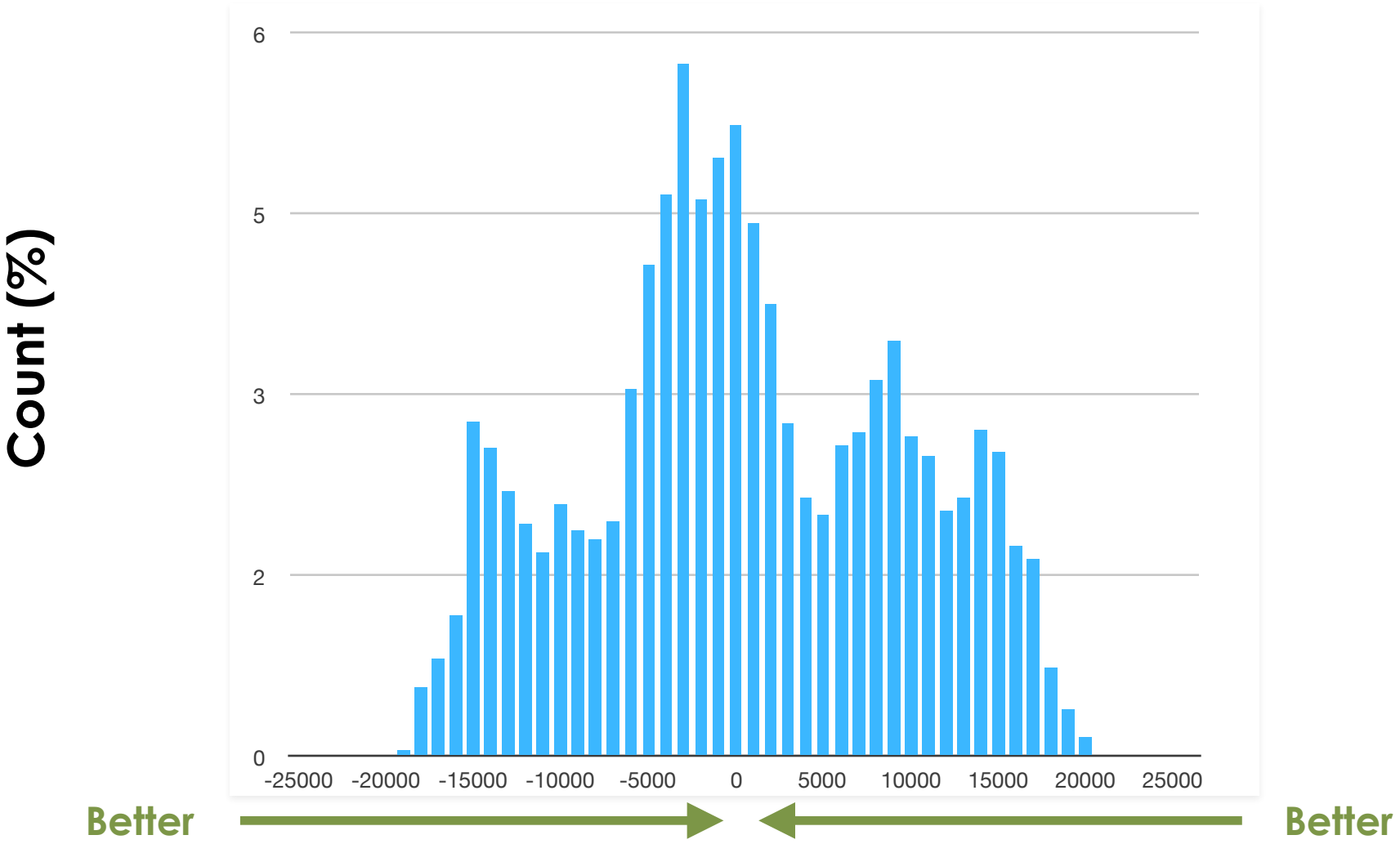

GPS
exanic
GM
Arista 7150
(transparent)
PTP
PTP
PTP
Latest Generation
PTP Aware NIC
NIC
PTP4L
Capture
NIC
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Measured Sync

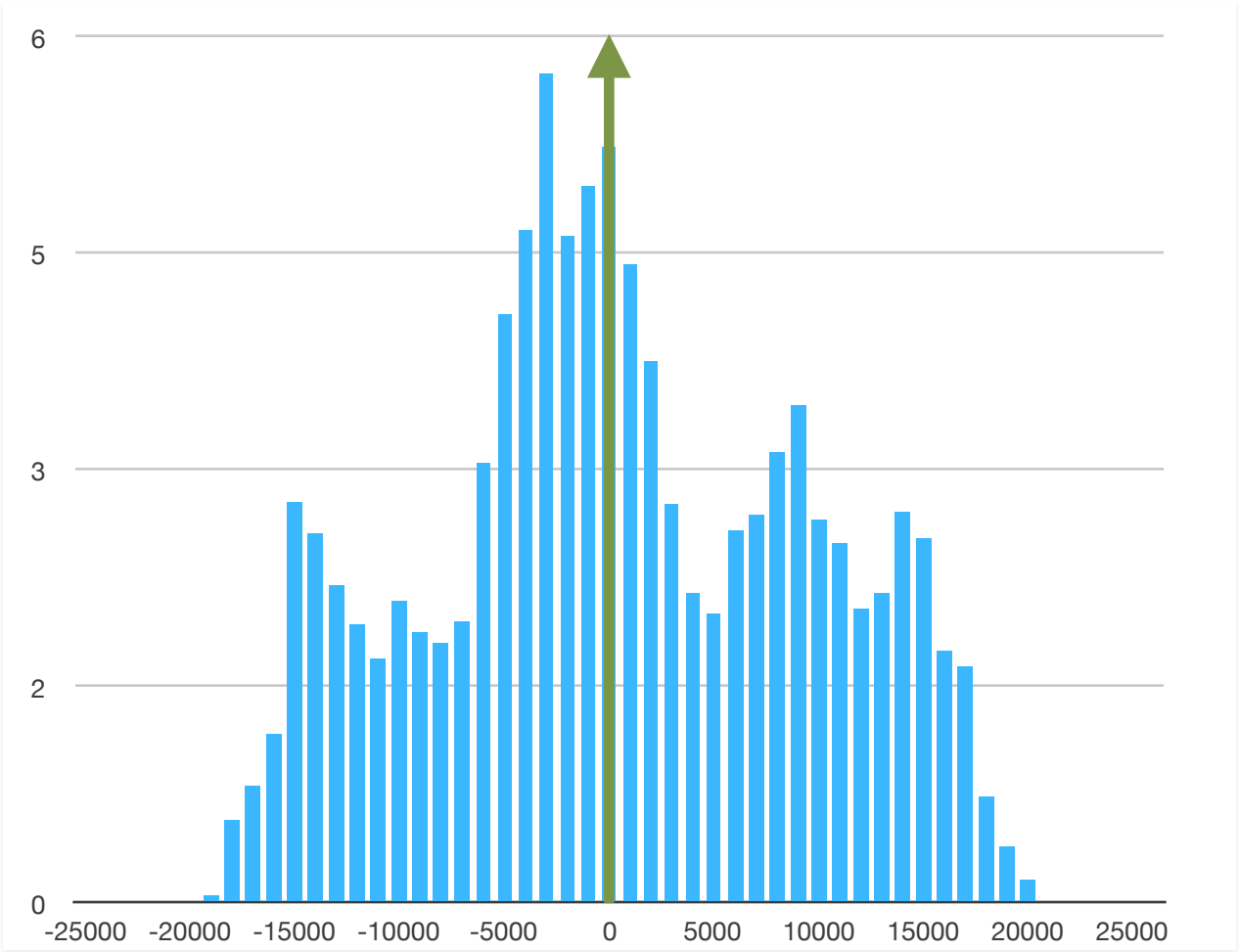


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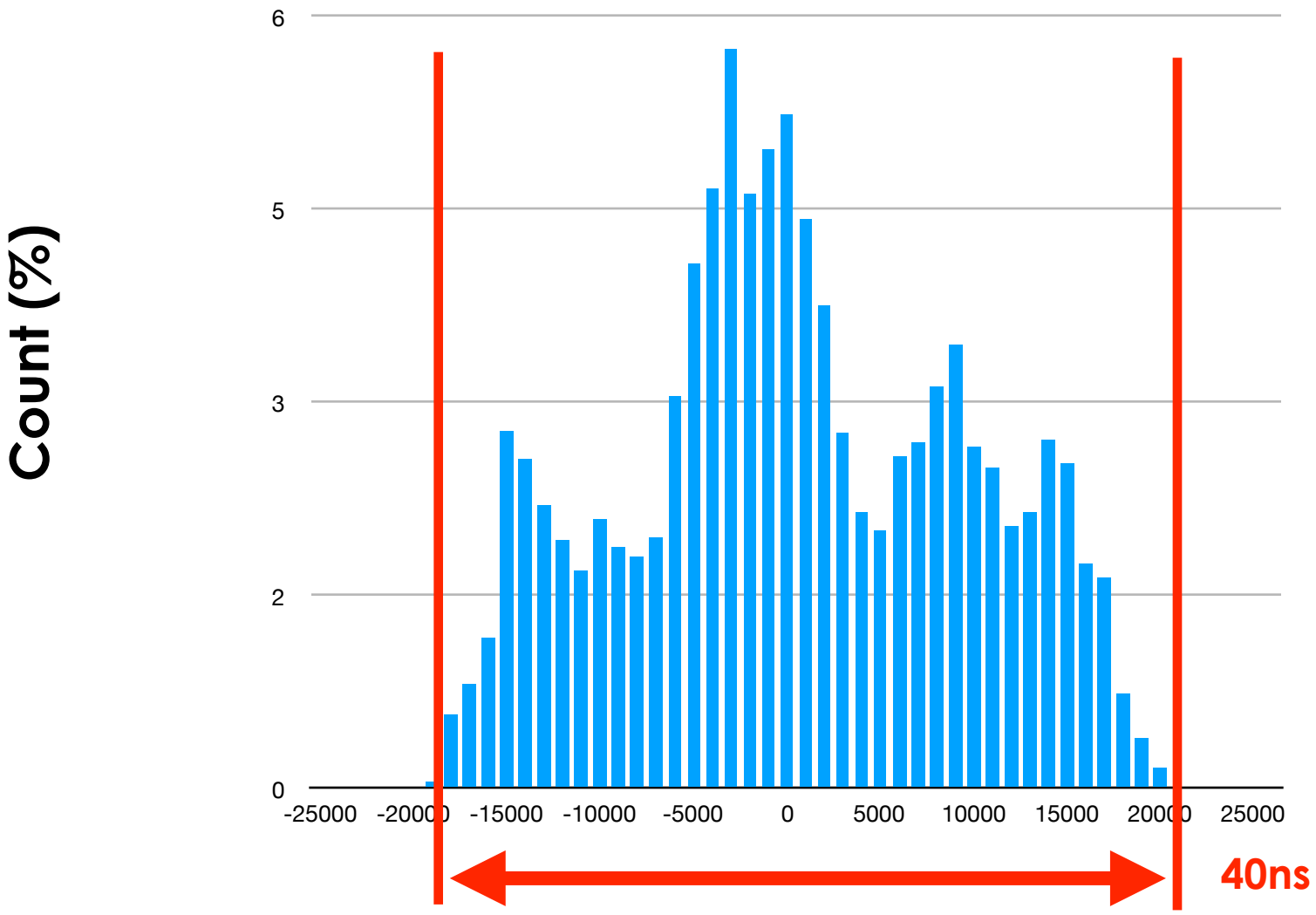
PTP4L Measured Sync



PTP4L Measured Sync



PTP4L Measured Sync



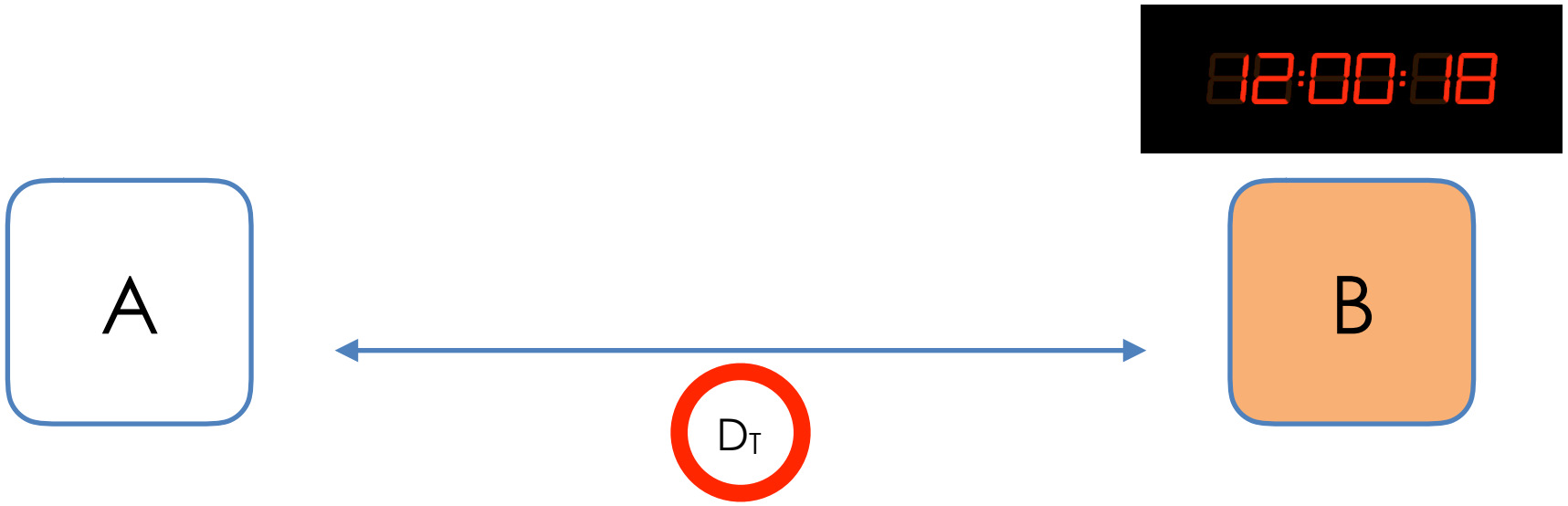
PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns

“PTP isn’t good enough for a nanosecond world ”

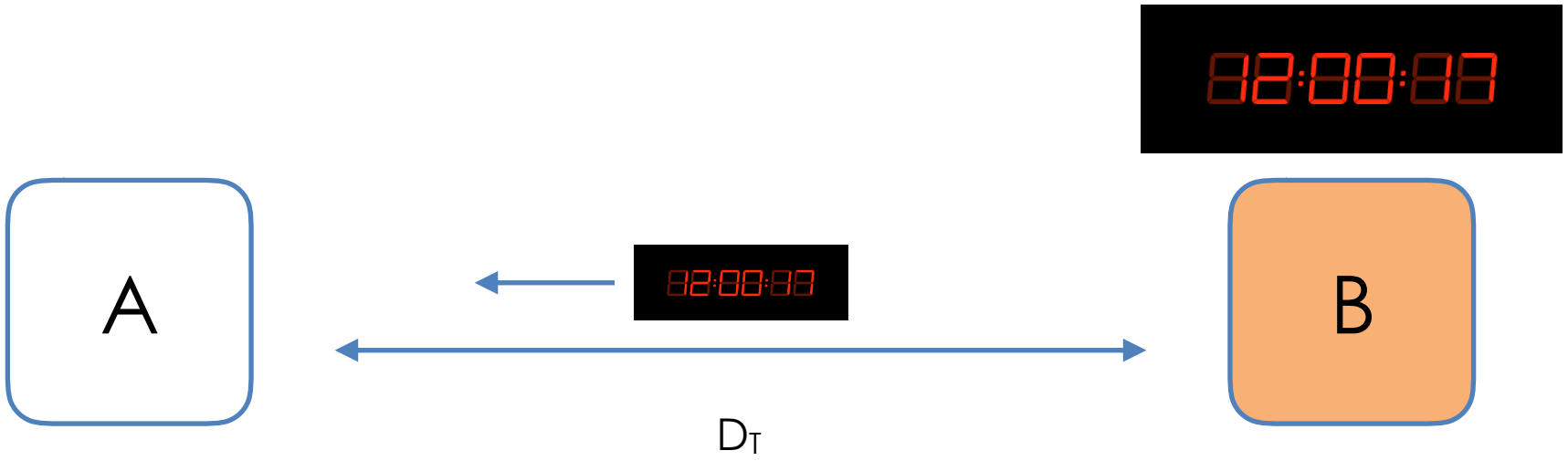
- someone in this room (probably)

Fundamentals of PTP

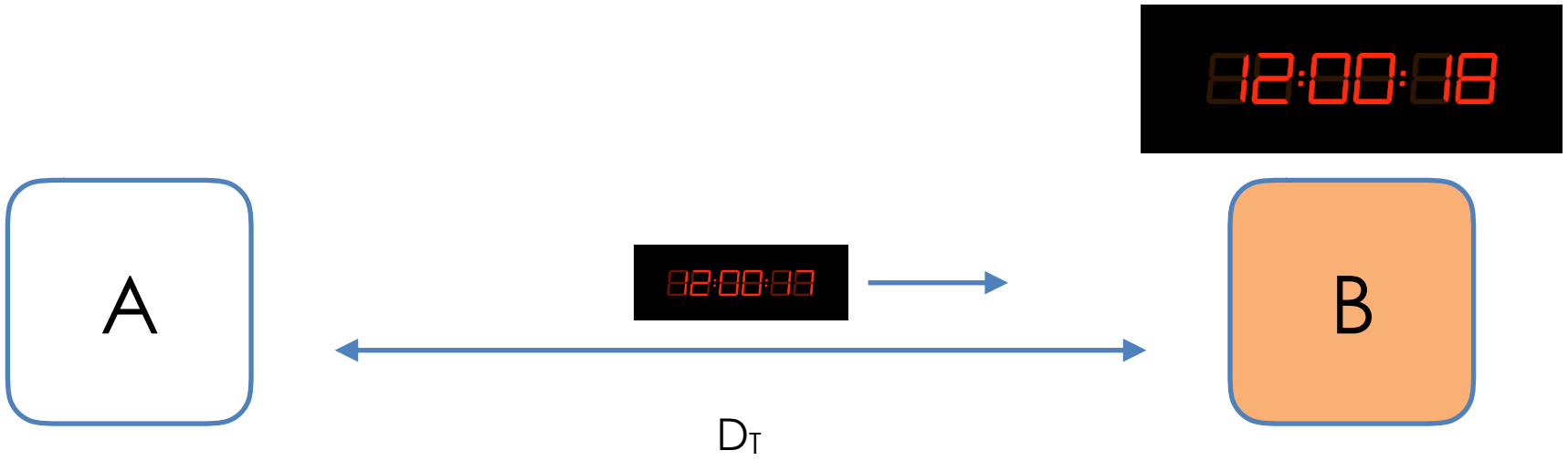


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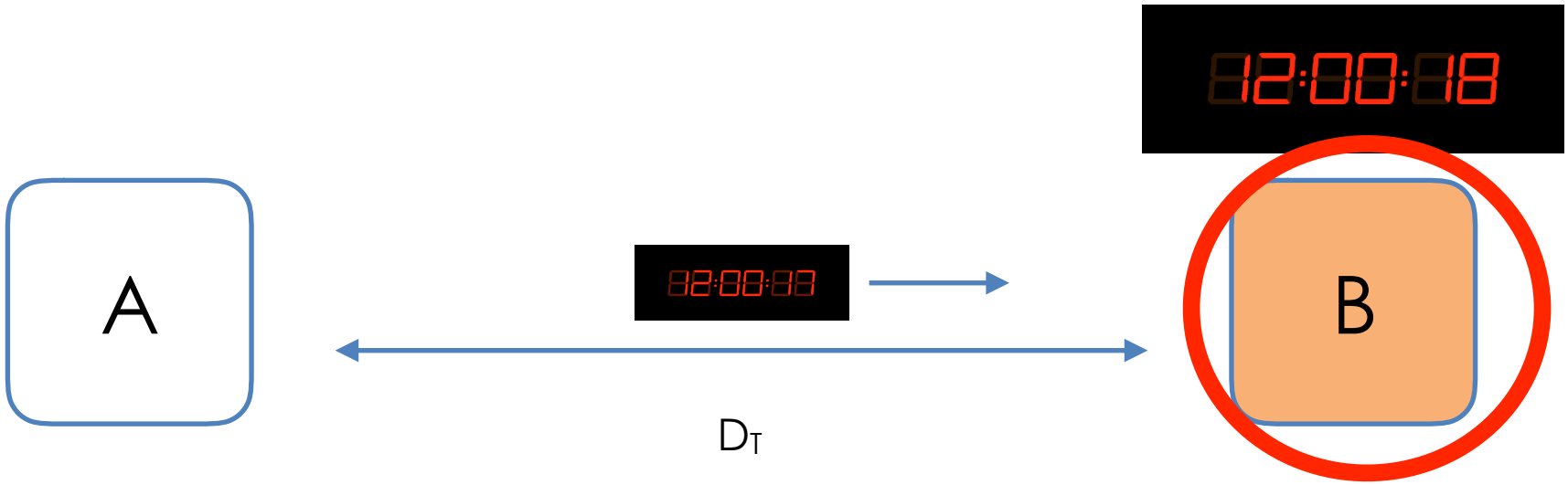
Fundamentals of PTP

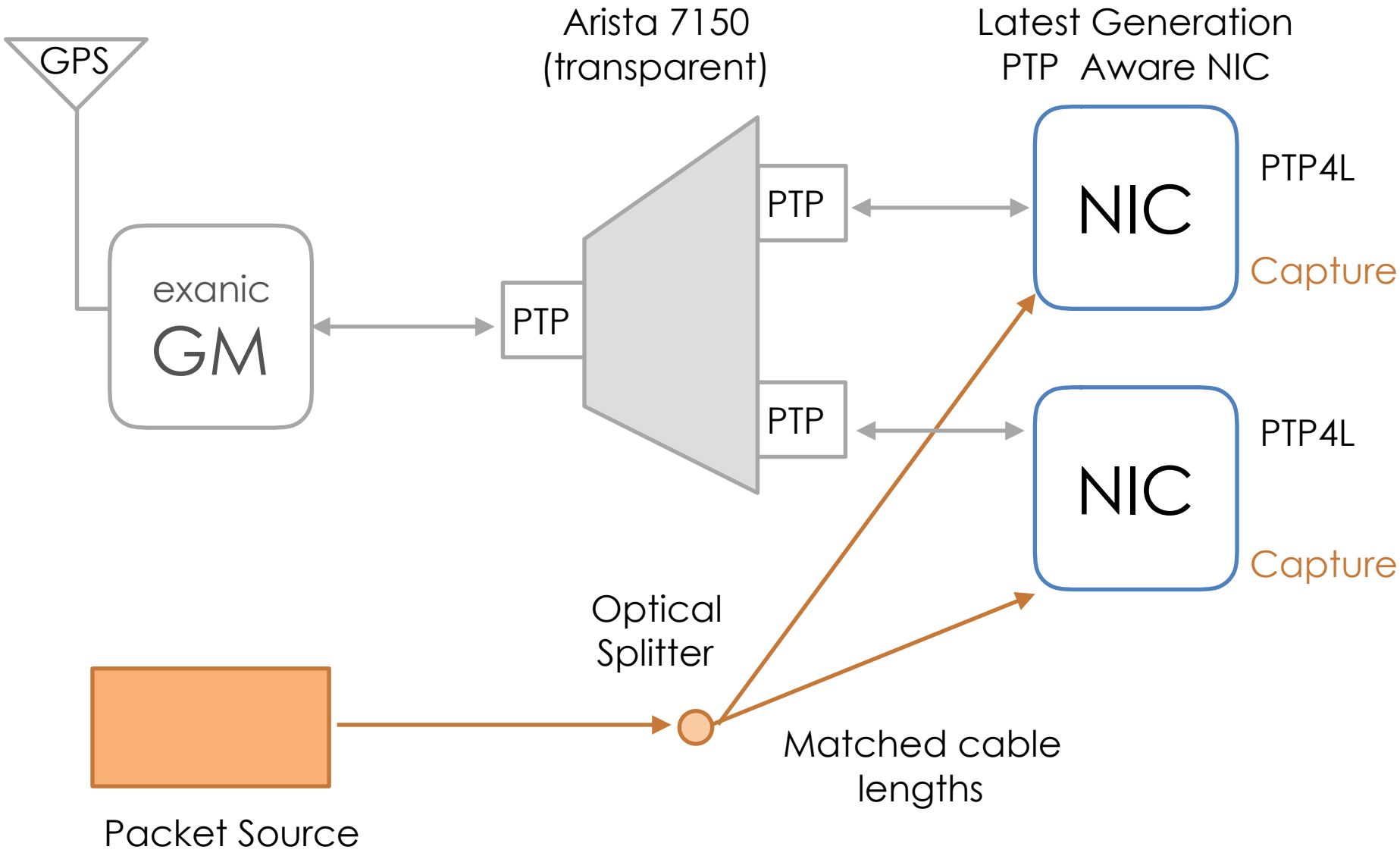


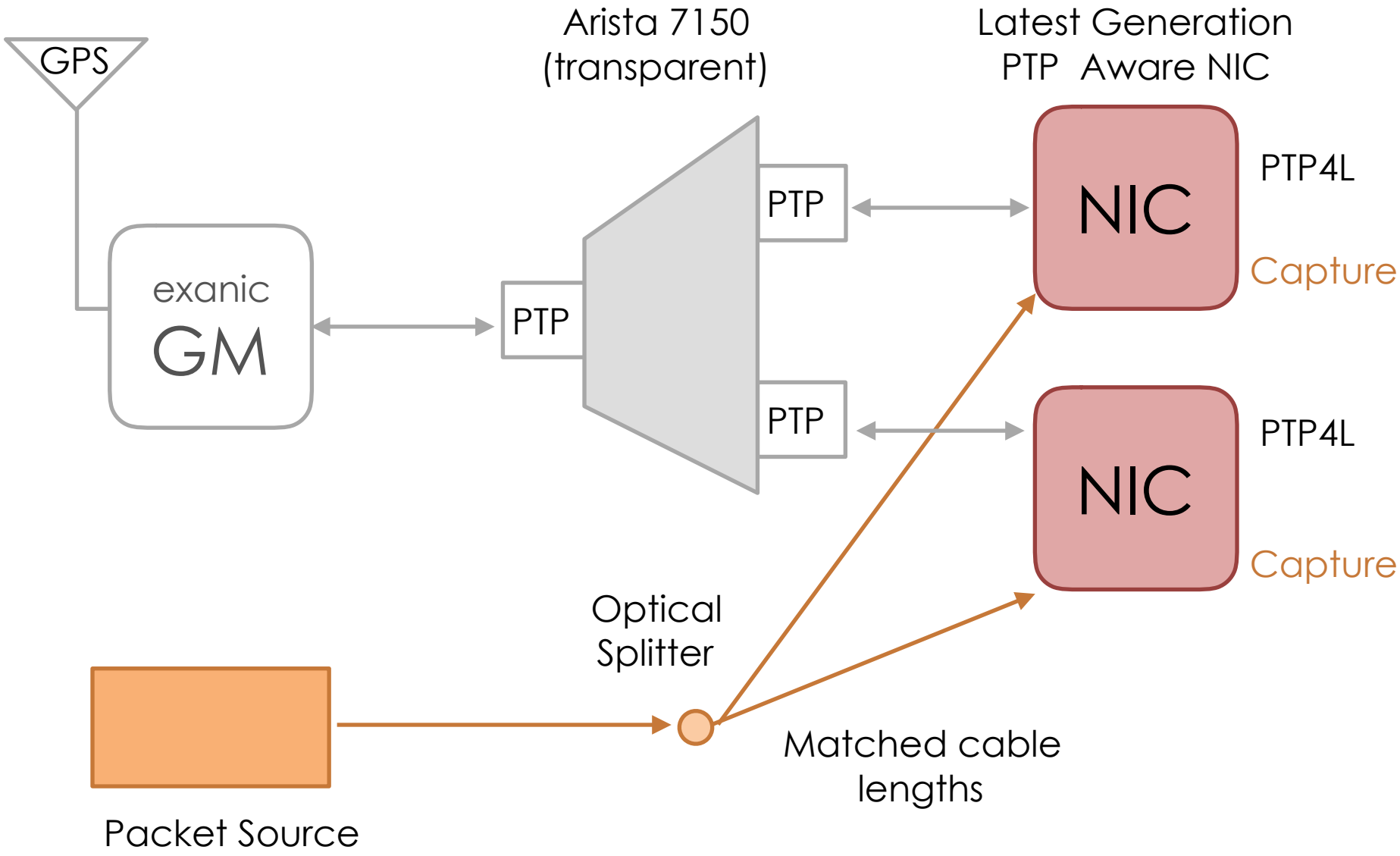
Fundamentals of PTP

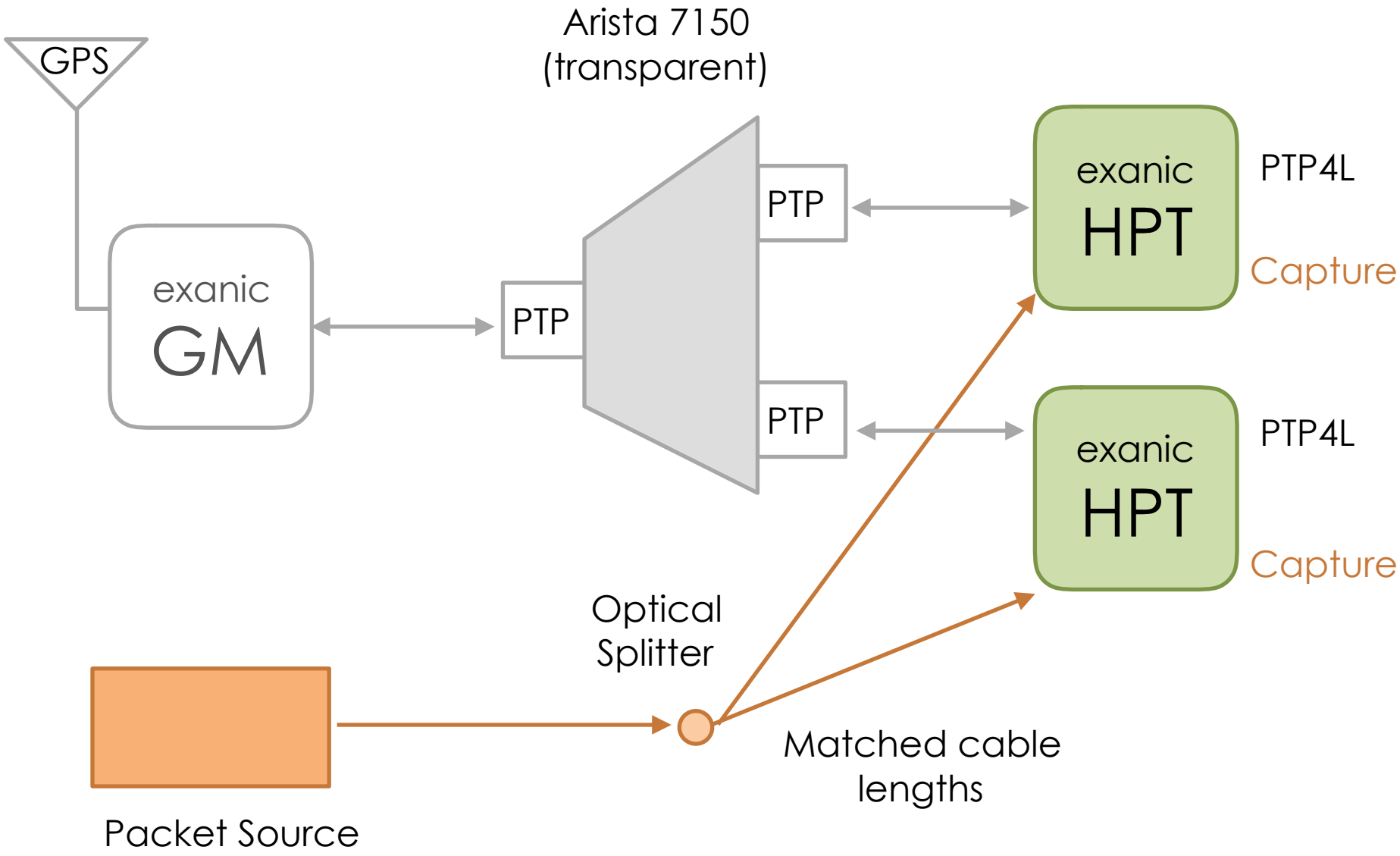


Fundamentals of PTP

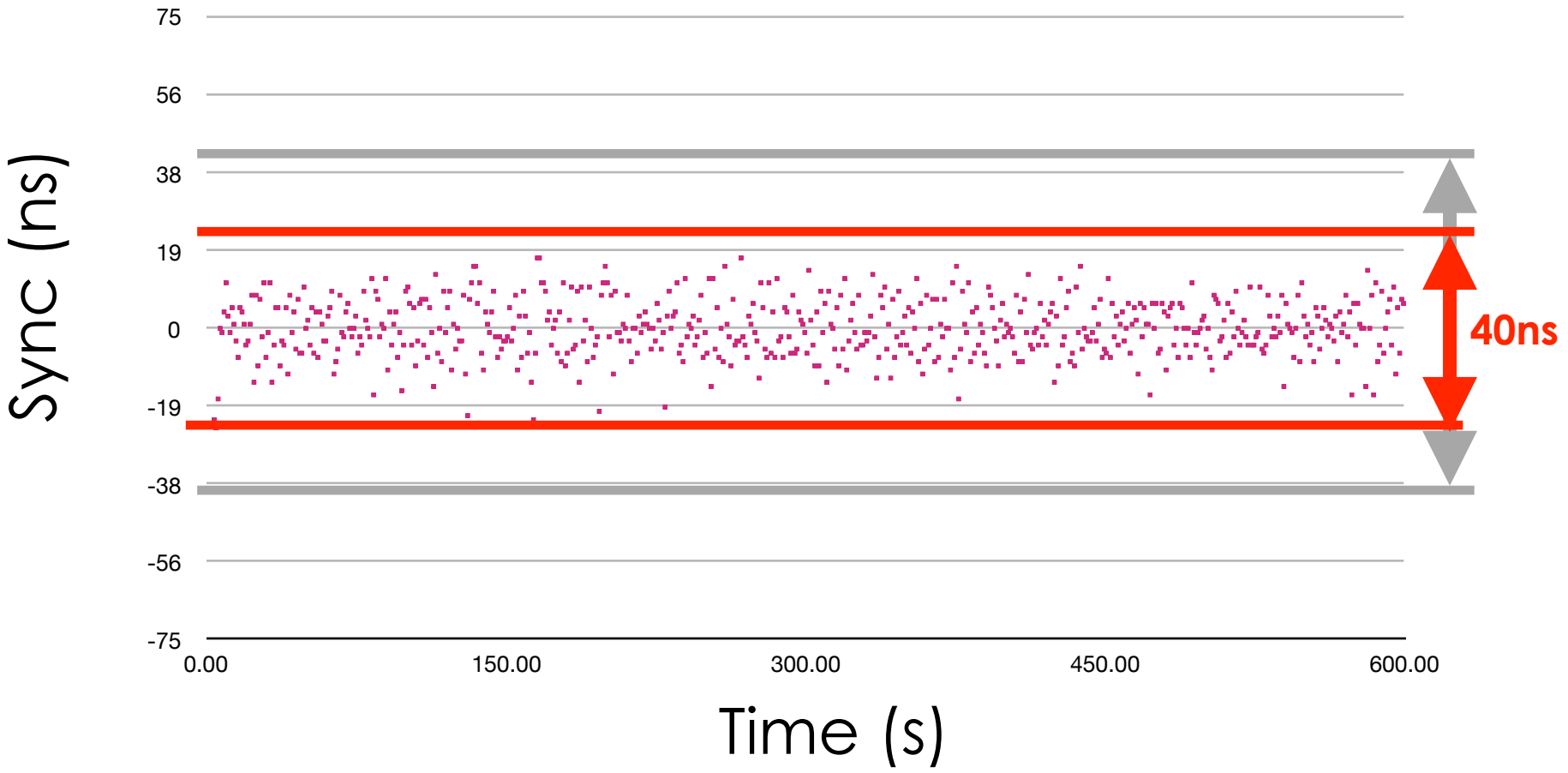



GPS
exanic
GM
Arista 7150
(transparent)
PTP
PTP
PTP
Latest Generation
PTP Aware NIC
NIC
PTP4L
Capture
NIC
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

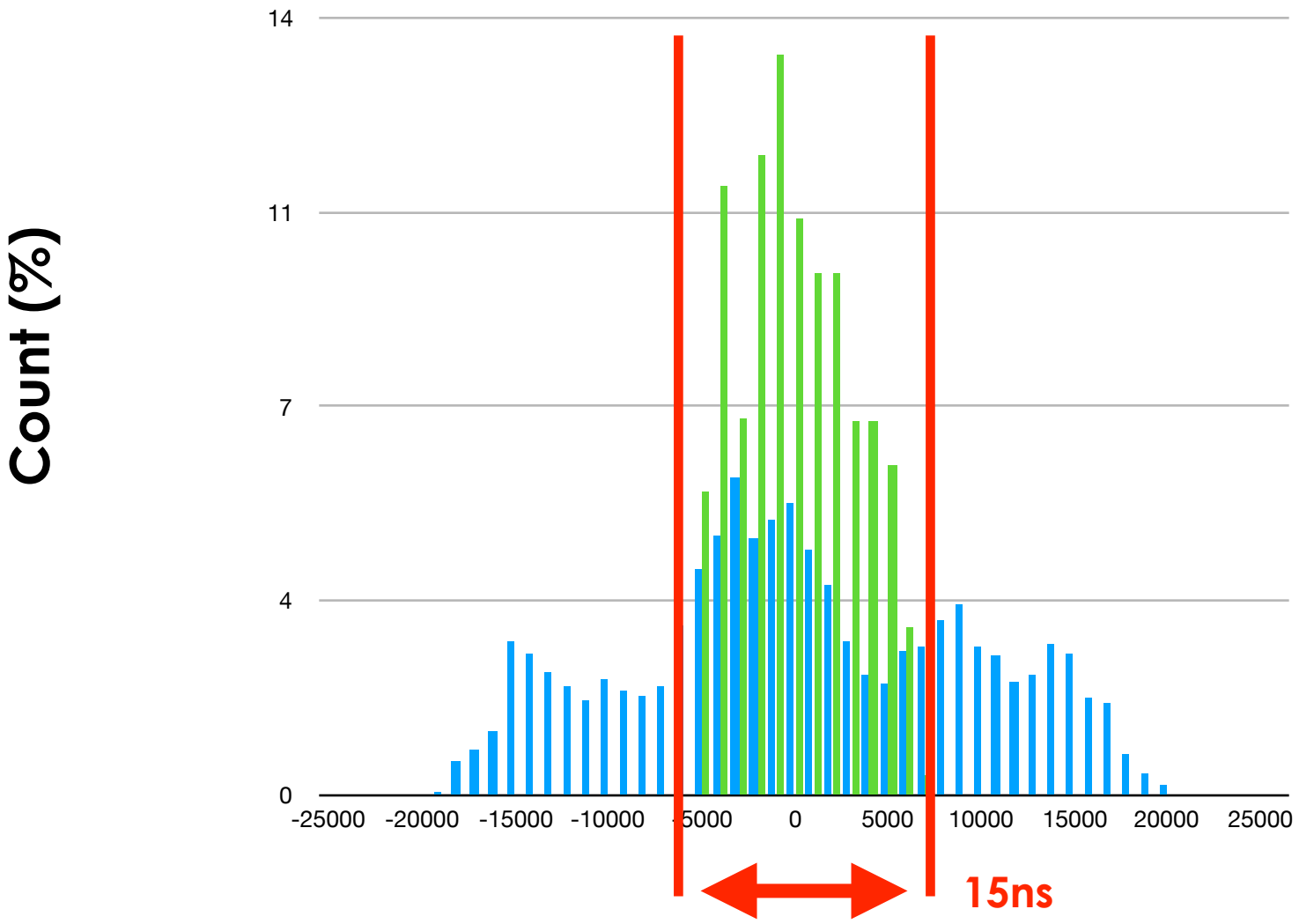

GPS
exanic
GM
Arista 7150
(transparent)
PTP
PTP
PTP
Latest Generation
PTP Aware NIC
NIC
PTP4L
Capture
NIC
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


Arista 7150
(transparent)
GPS
exanic
GM
PTP
PTP
PTP
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Perceived Sync



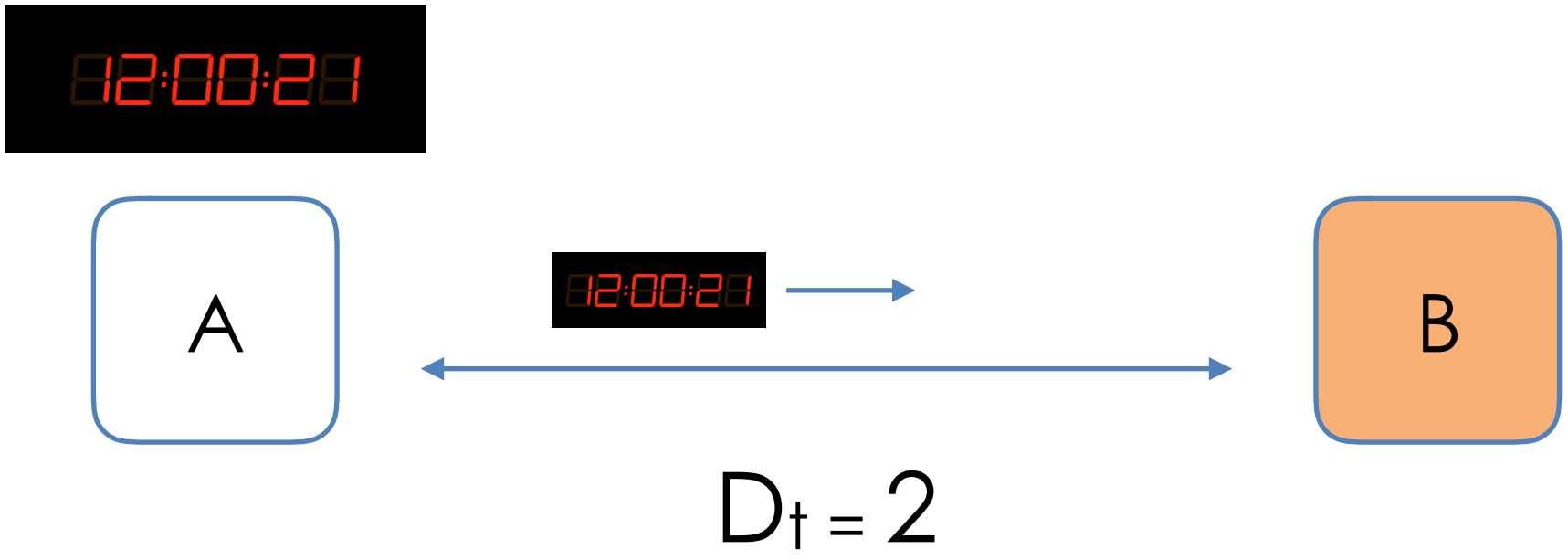
PTP4L Measured Sync

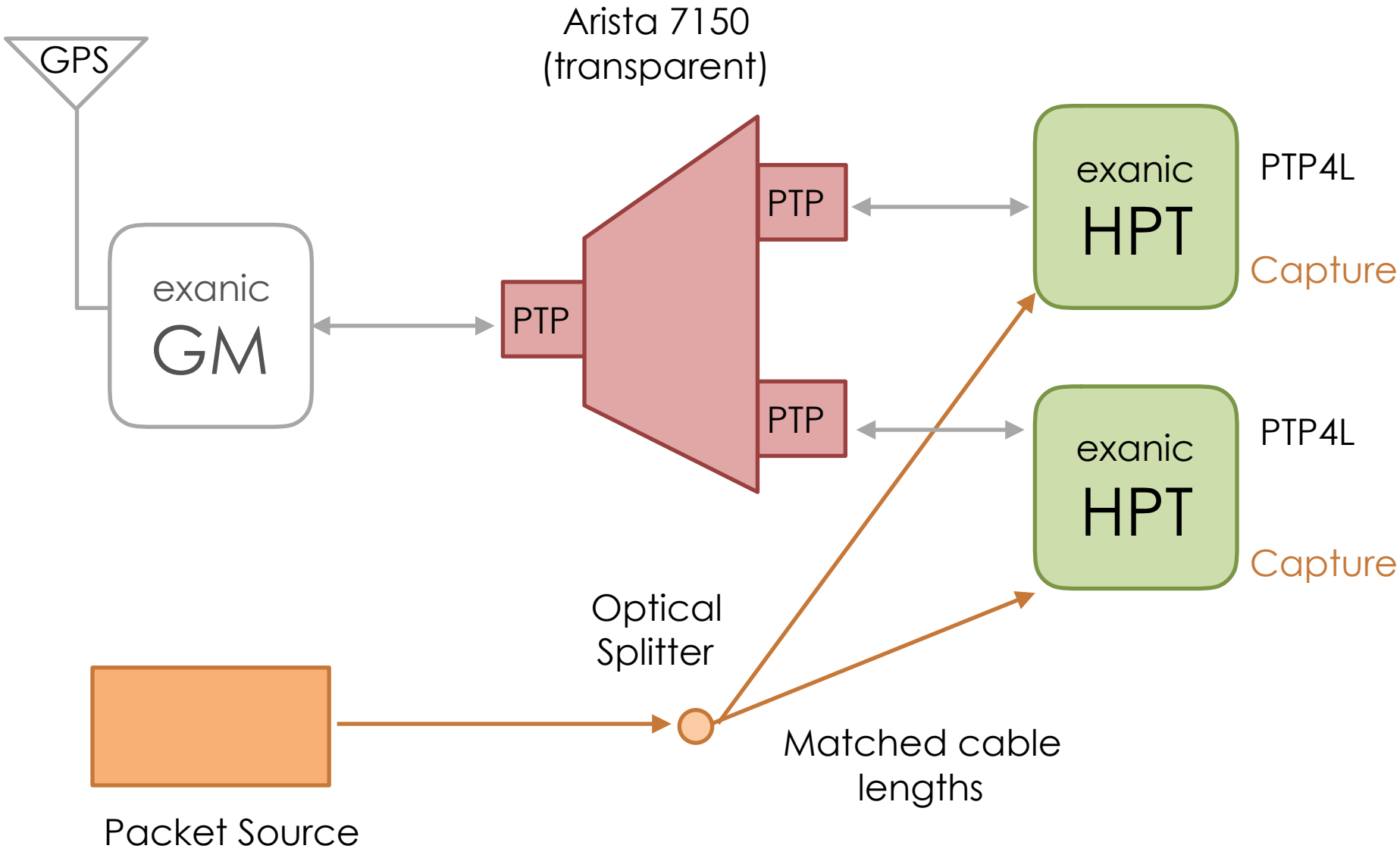


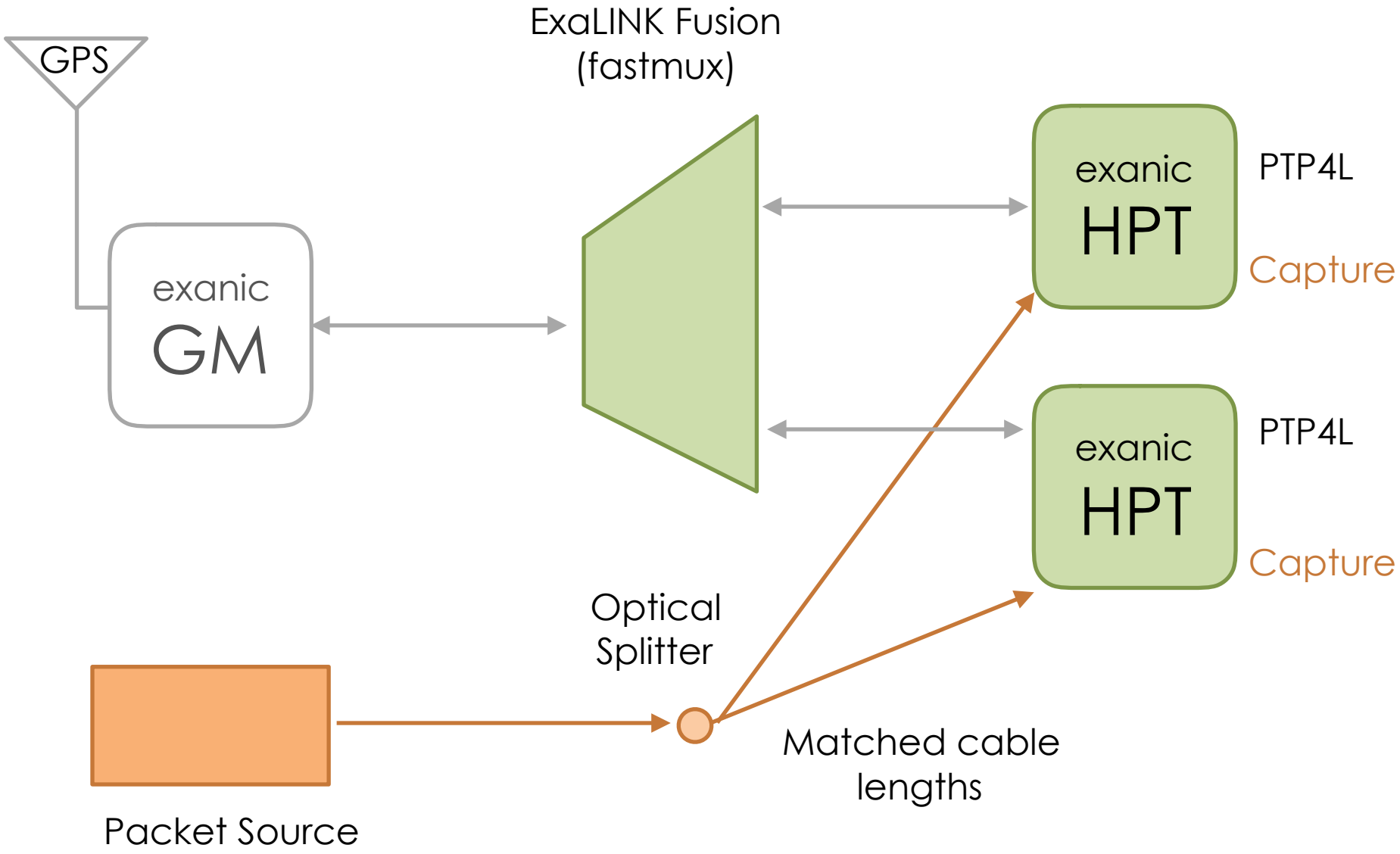
PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 20ns	+/- 7.5ns

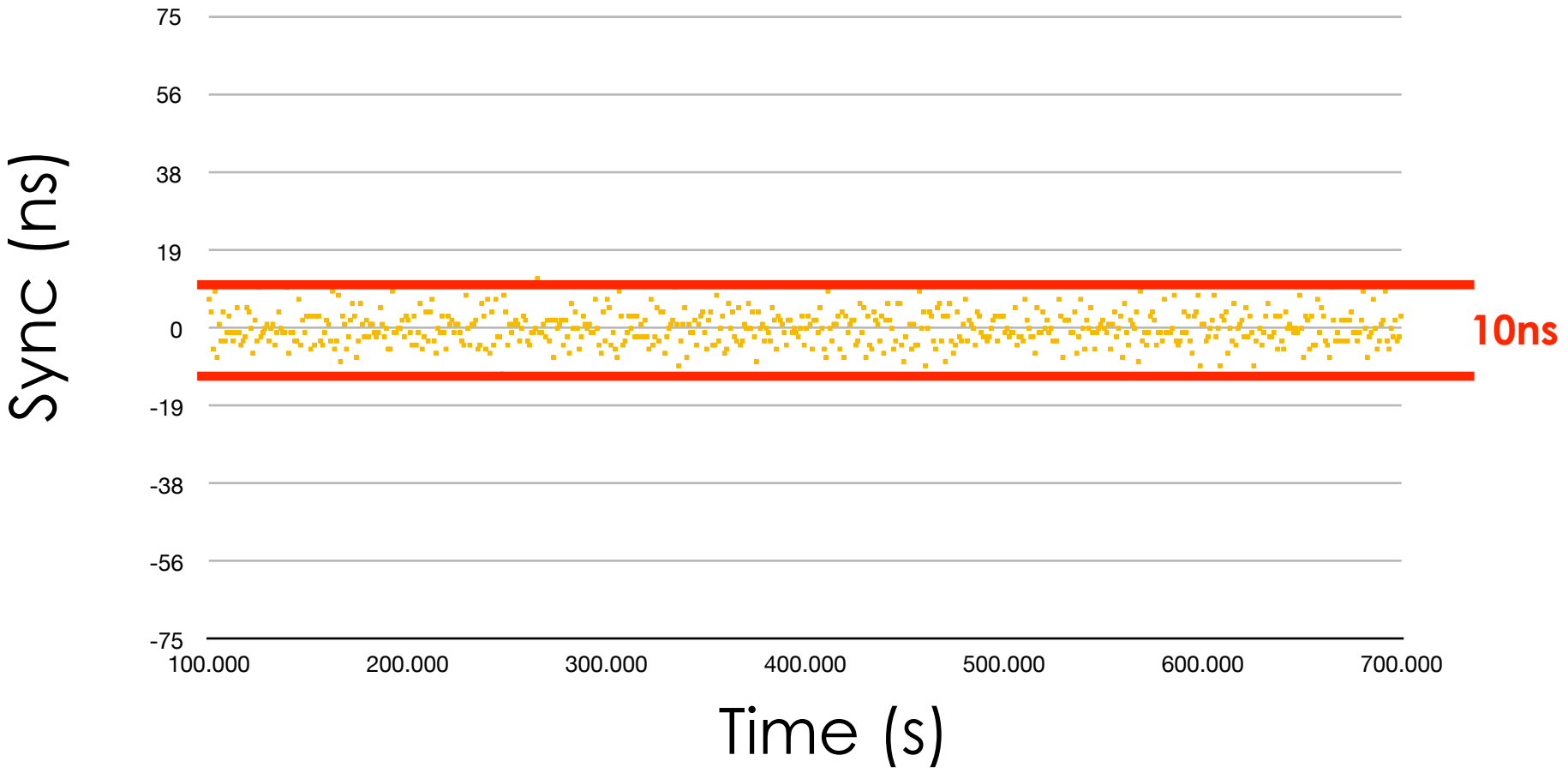
Fundamentals of PTP



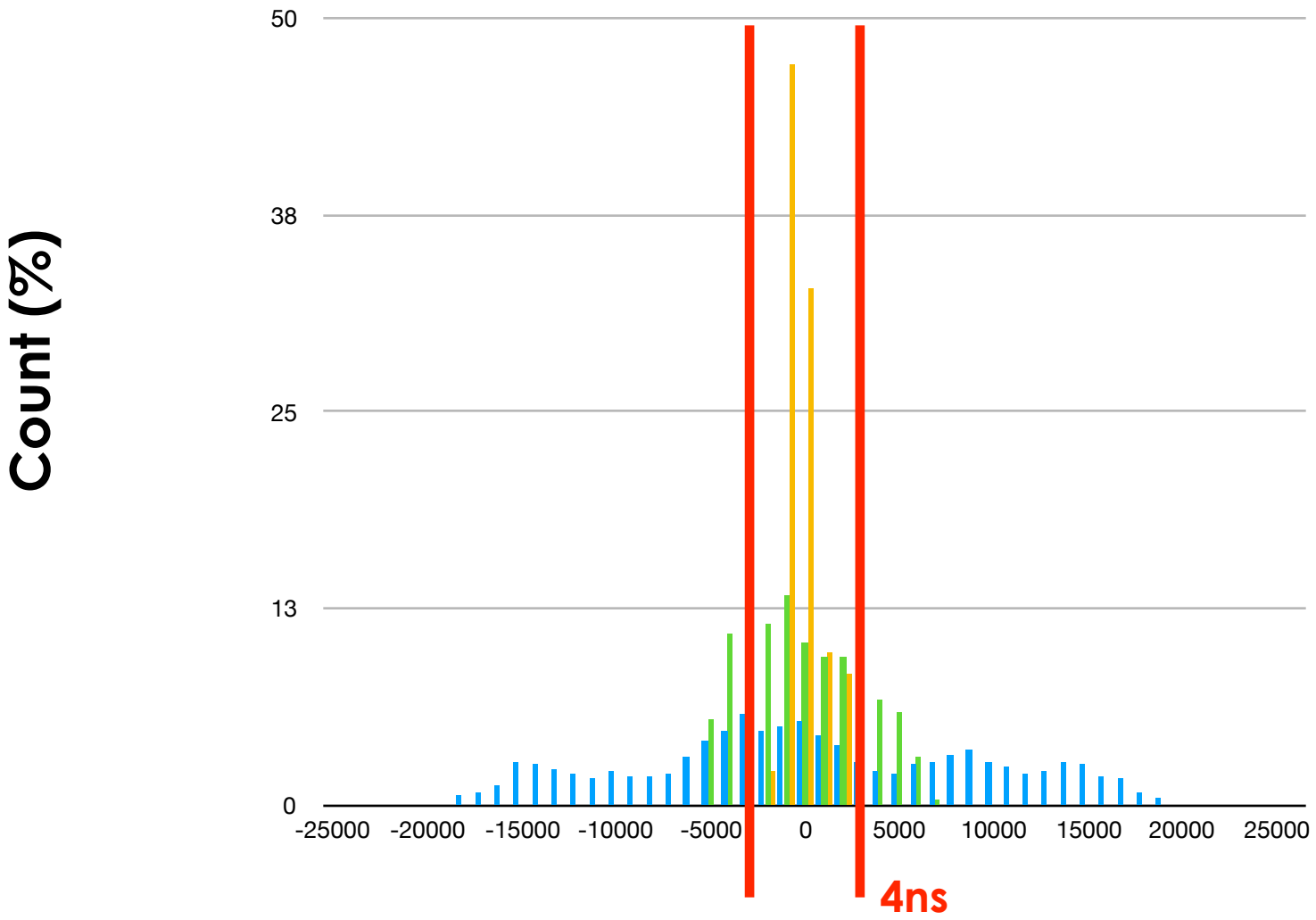

GPS
Arista 7150
(transparent)
exanic
GM
PTP
PTP
PTP
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


GPS
ExaLINK Fusion
(fastmux)
exanic
GM
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Perceived Sync

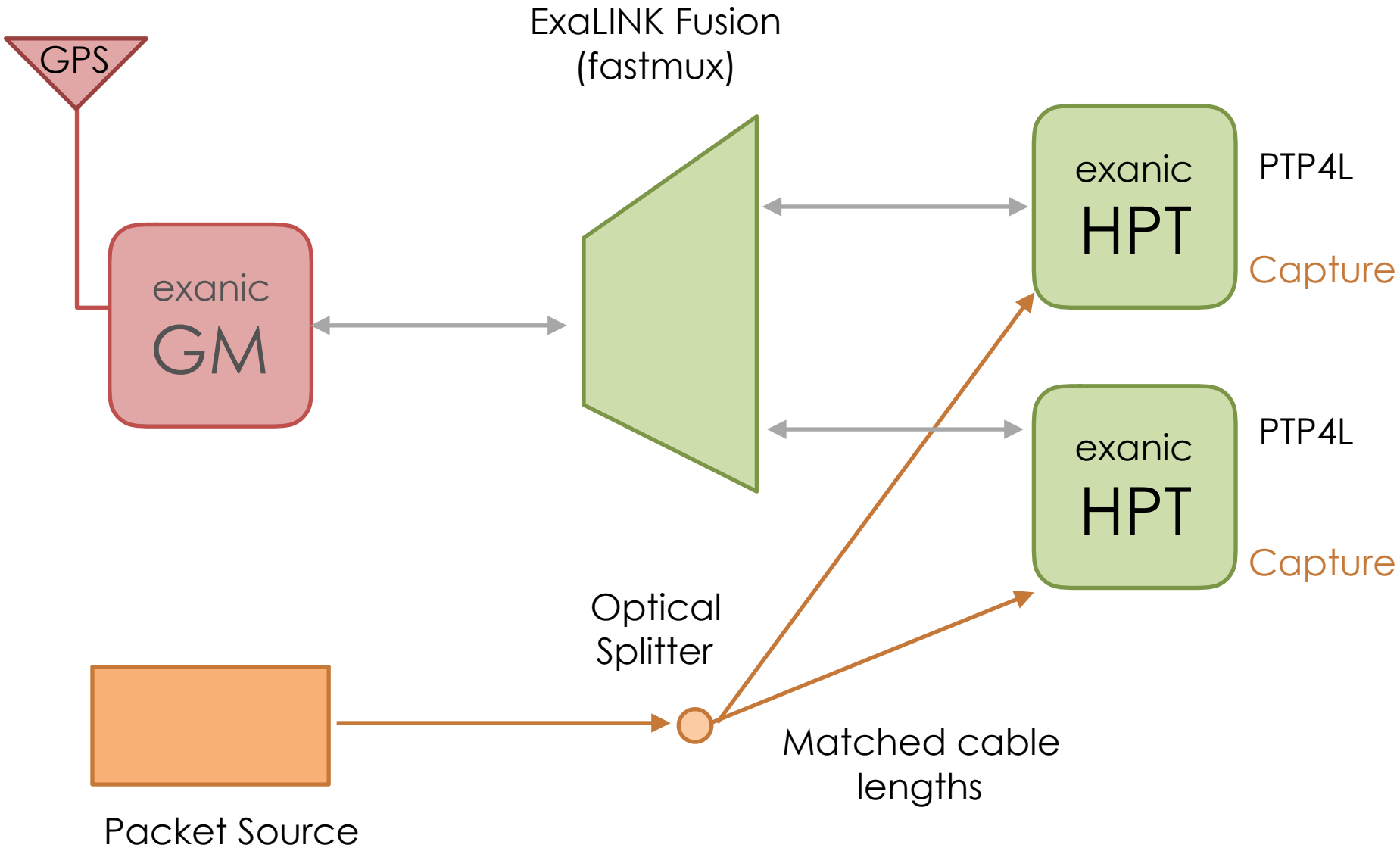


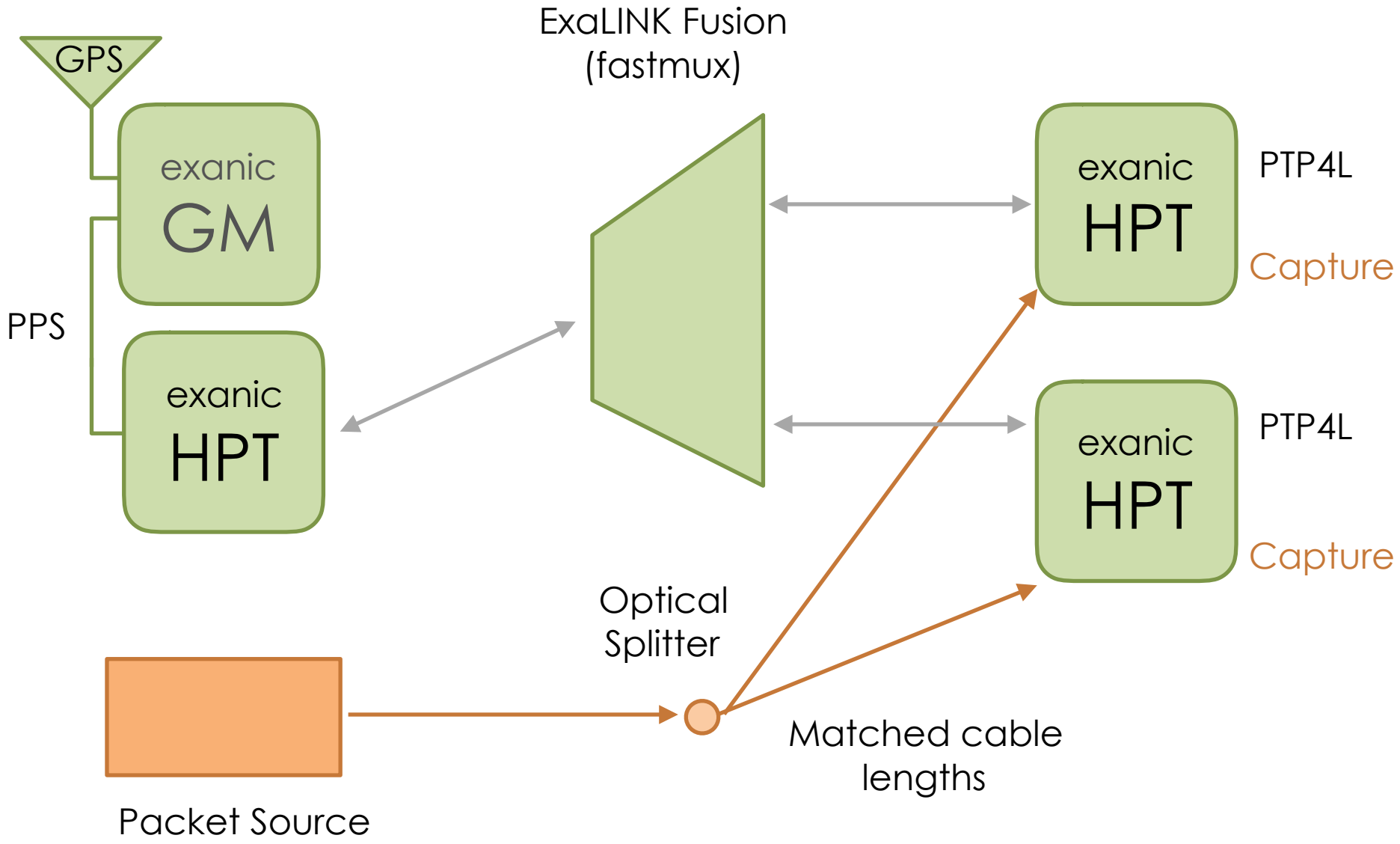
PTP4L Measured Sync



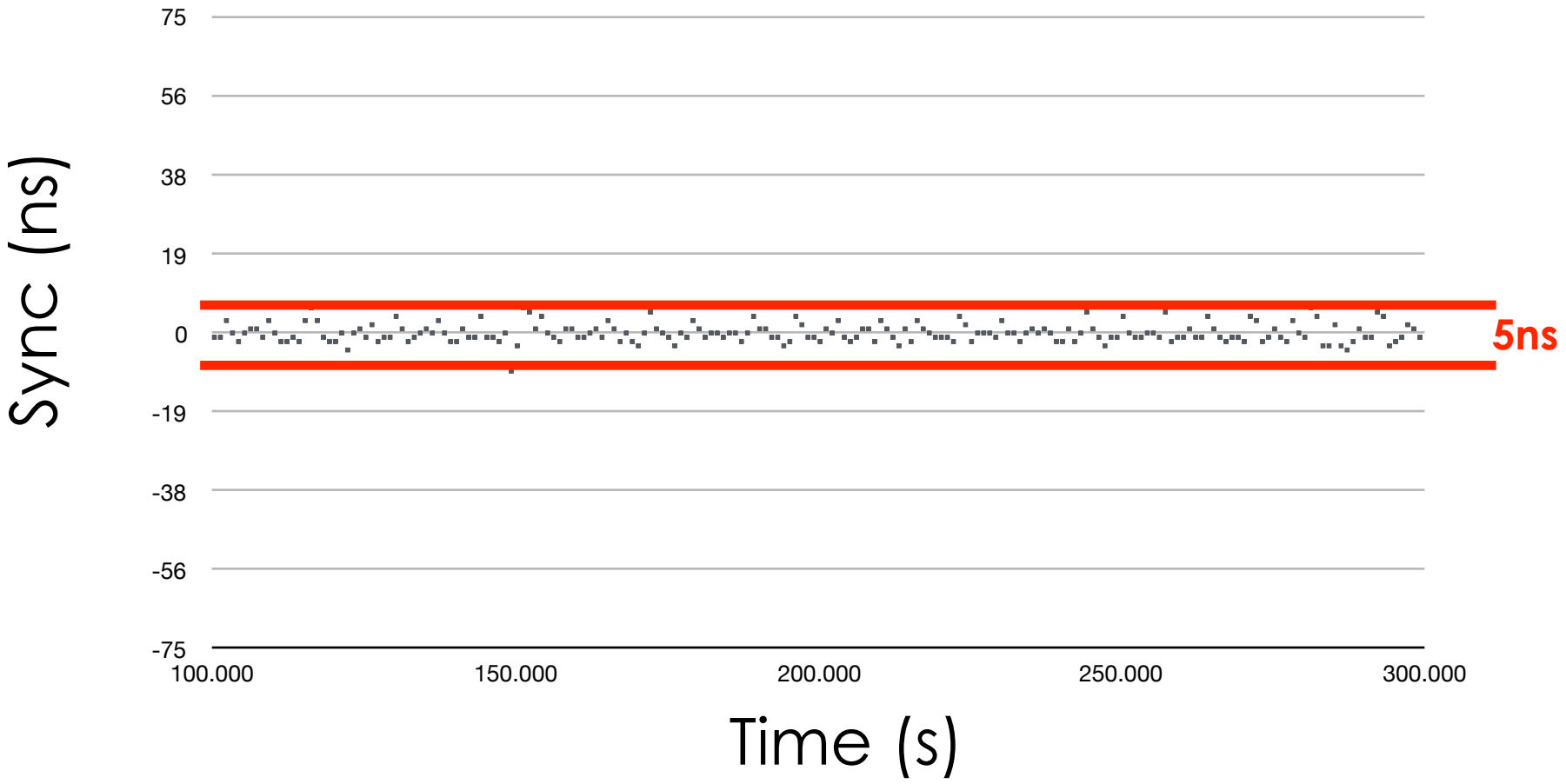
PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 20ns	+/- 7.5ns
ExaLINK Fusion	+/- 5ns	+/- 2ns

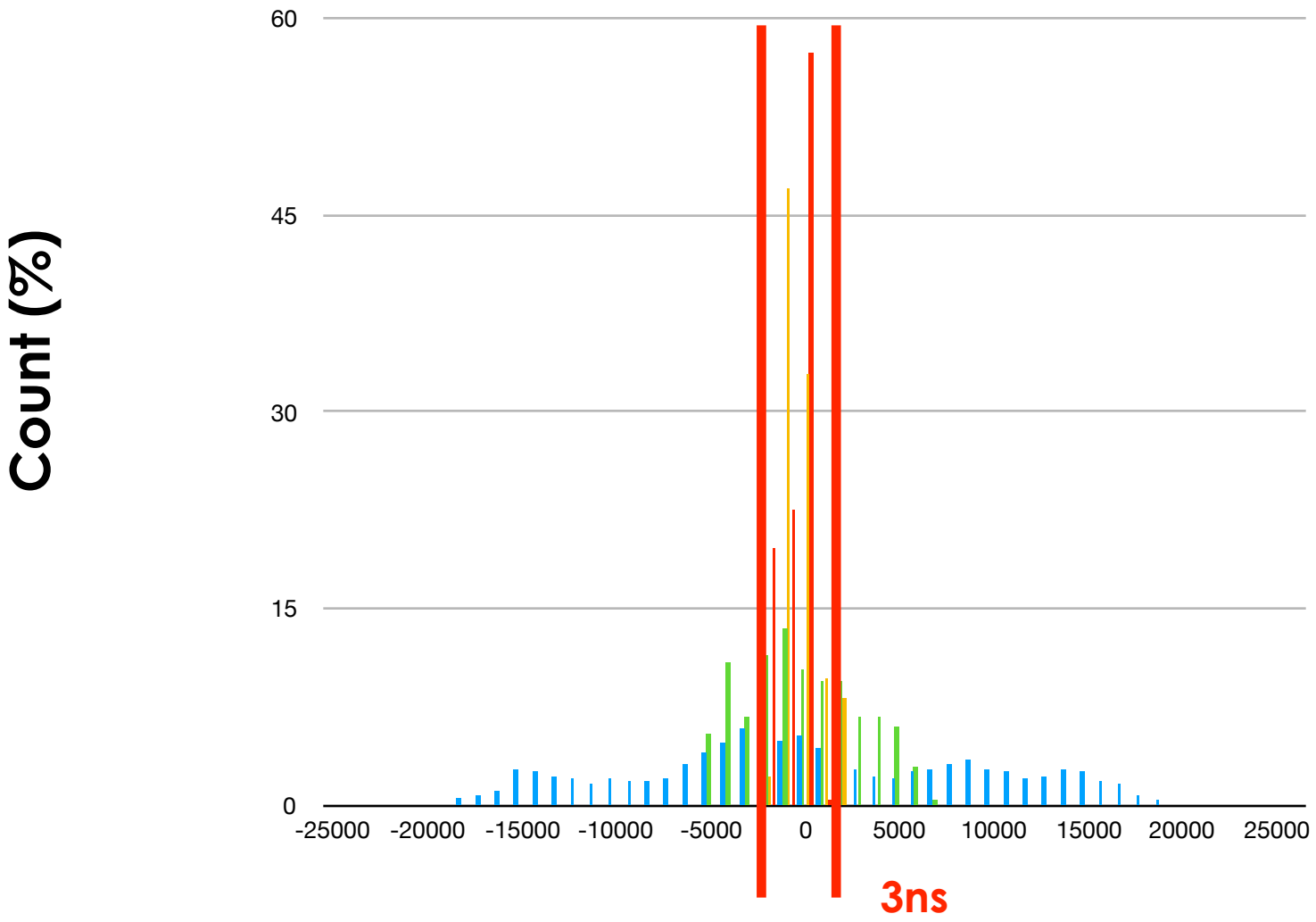

GPS
ExaLINK Fusion
(fastmux)
exanic
GM
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


ExaLINK Fusion
(fastmux)
GPS
exanic
GM
PPS
exanic
HPT
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Perceived Sync



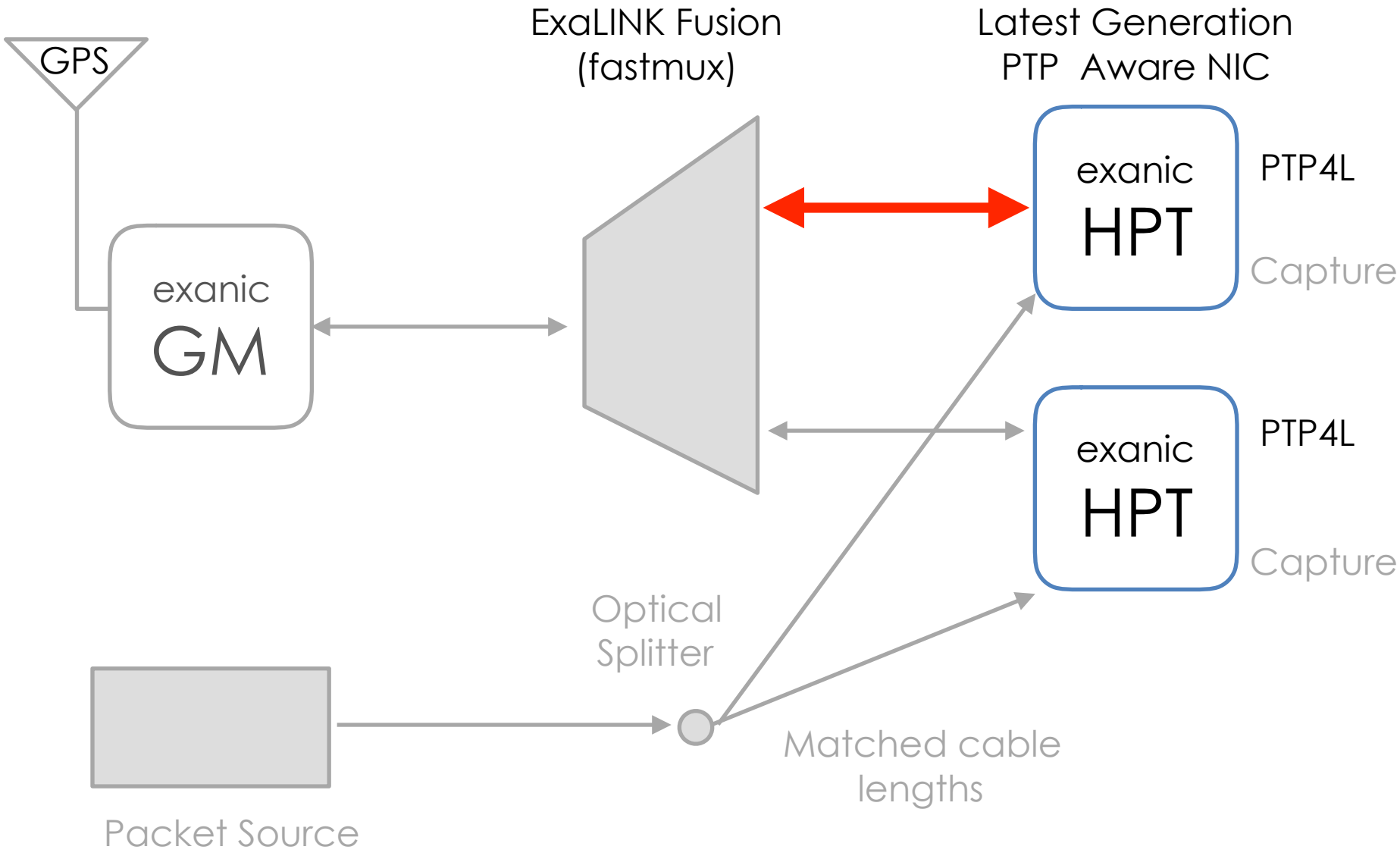
PTP4L Measured Sync

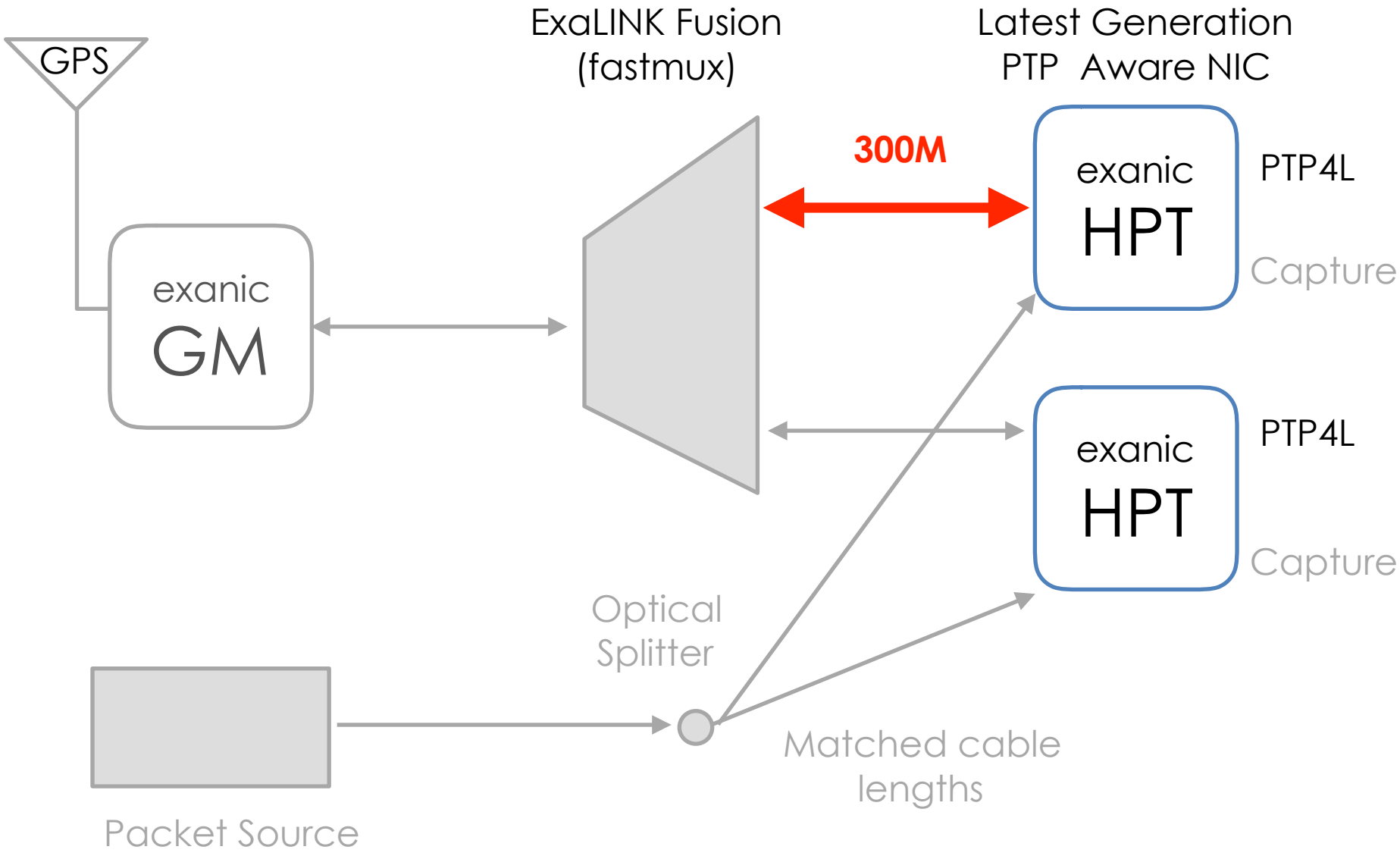


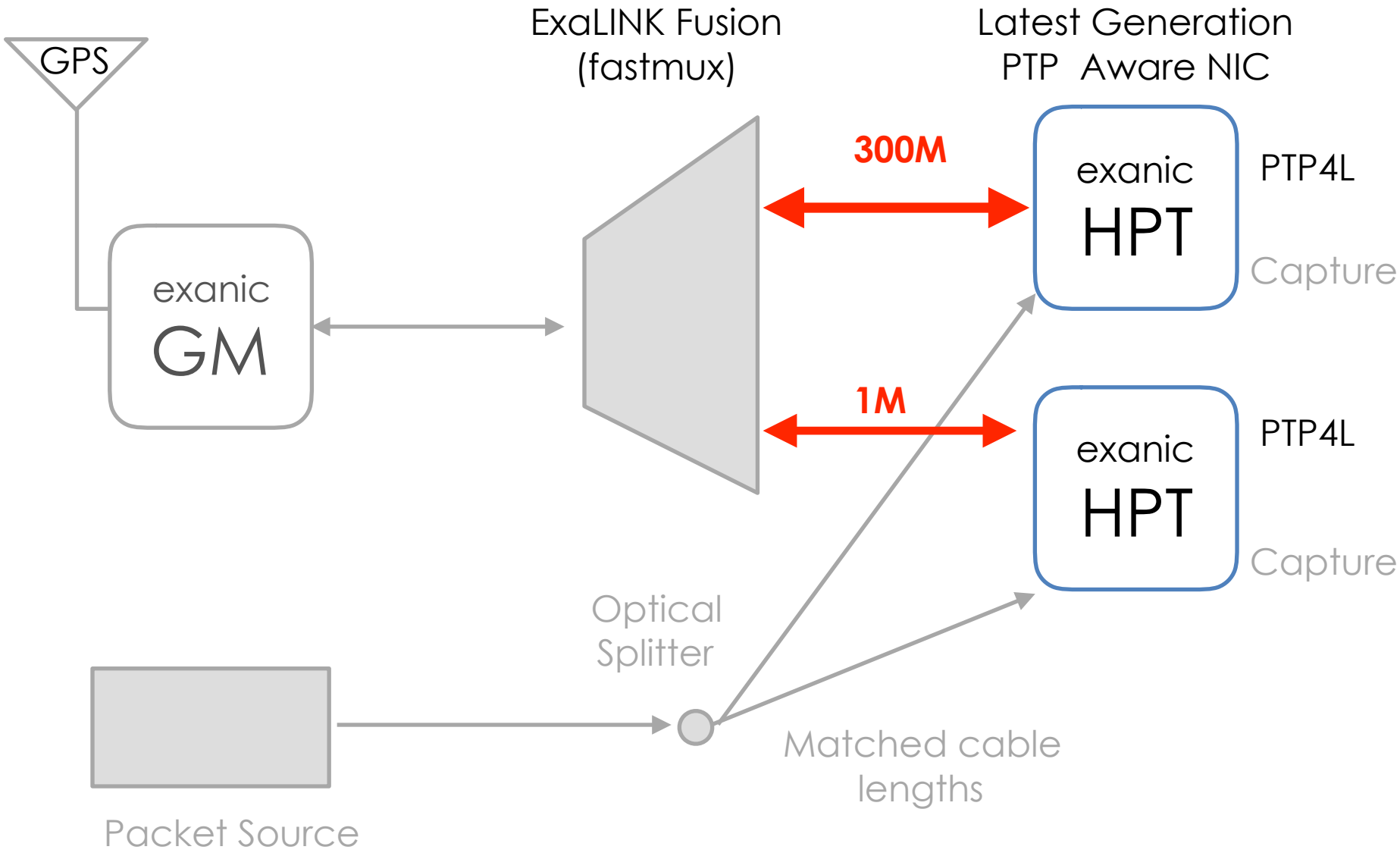
PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 20ns	+/- 7.5ns
ExaLINK Fusion	+/- 5ns	+/- 2ns
GM / HPT	+/- 2.5	+/- 1.5

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GPS
exanic
GM
ExaLINK Fusion
(fastmux)
Latest Generation
PTP Aware NIC
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


GPS
ExaLINK Fusion
(fastmux)
Latest Generation
PTP Aware NIC
300M
exanic
GM
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


GPS
ExaLINK Fusion
(fastmux)
Latest Generation
PTP Aware NIC
300M
exanic
HPT
PTP4L
Capture
exanic
GM
1M
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 10ns	+/- 7.5ns
ExaLINK Fusion	+/- 5ns	+/- 2ns
GM / HPT	+/- 2.5	+/- 1.5

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PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 10ns	+/- 7.5ns
ExaLINK Fusion	+/- 5ns	+/- 2ns
GM / HPT	+/- 2.5	+/- 1.5

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Fundamentals of PTP



-



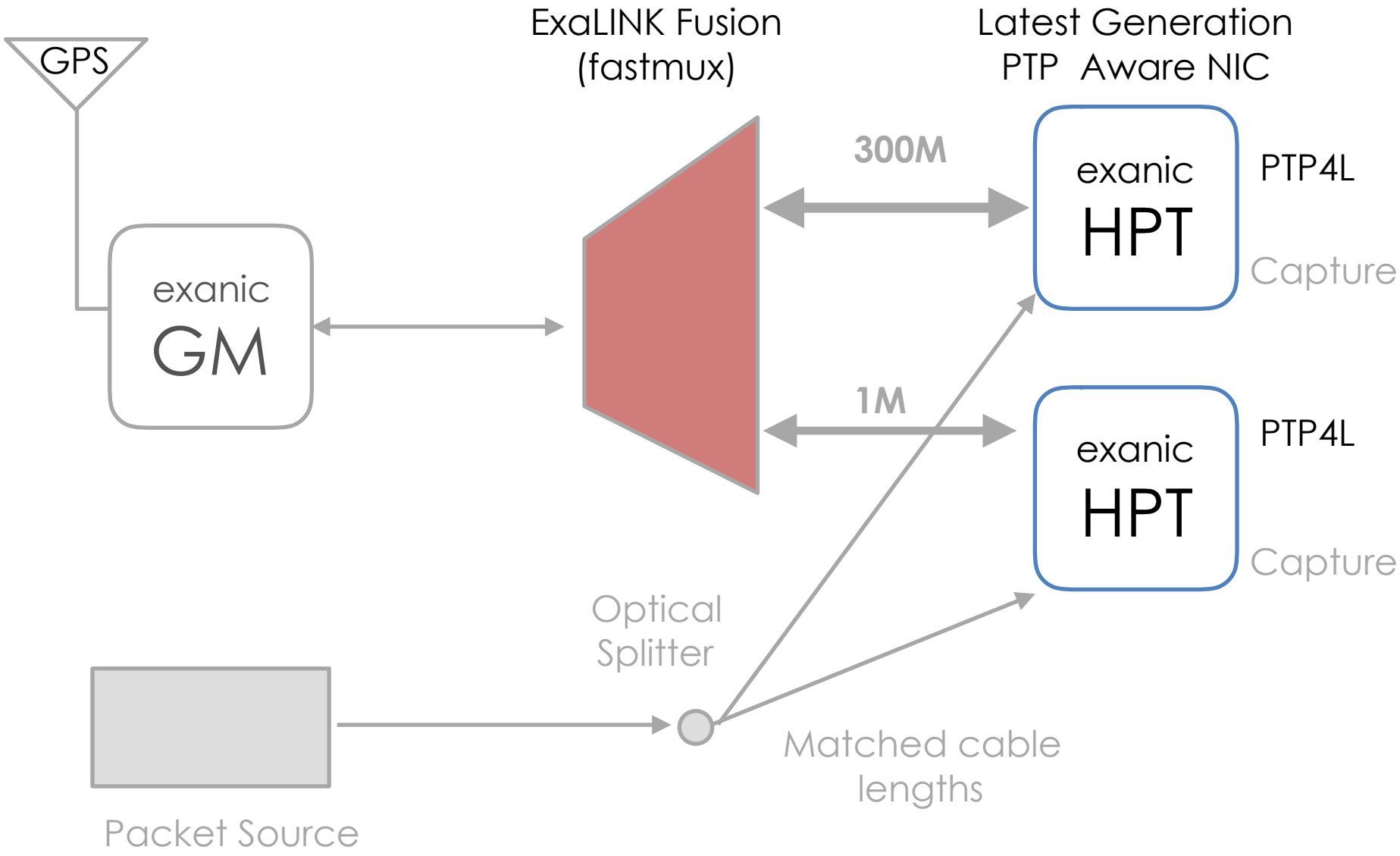
$= 2x\ D_t$

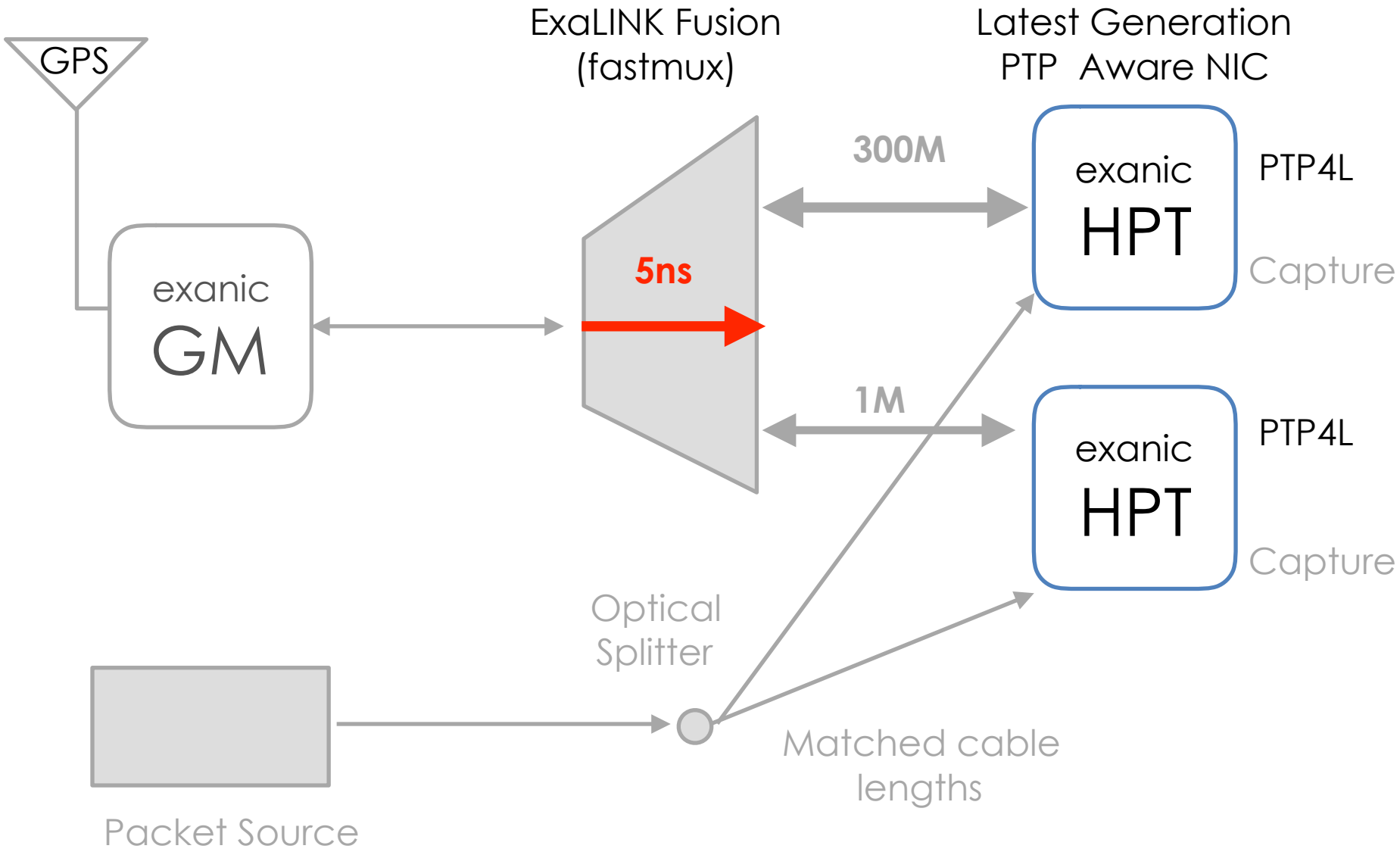


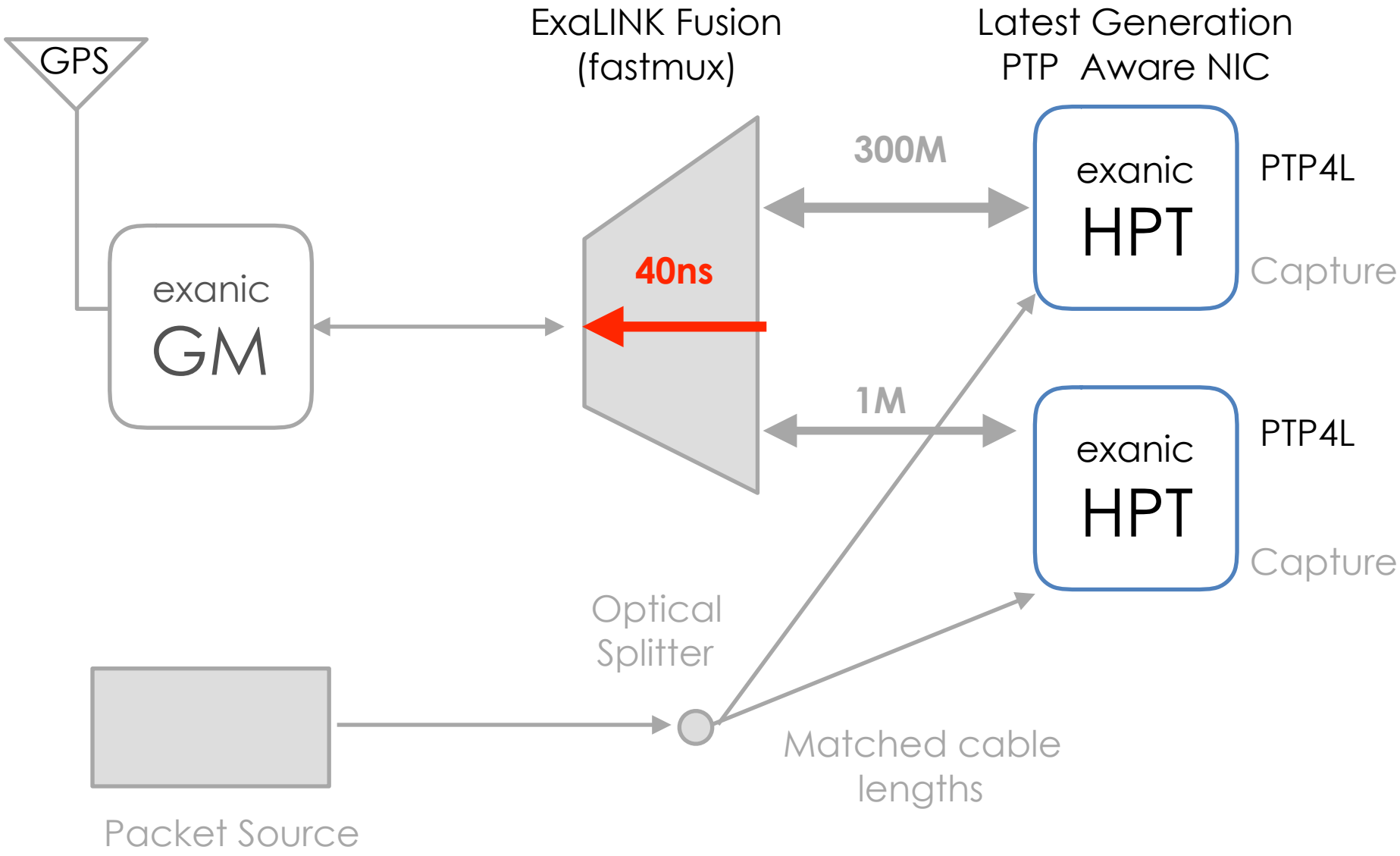
Fundamentals of PTP






GPS
exanic
GM
ExaLINK Fusion
(fastmux)
300M
1M
Latest Generation
PTP Aware NIC
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


ExaLINK Fusion
(fastmux)
Latest Generation
PTP Aware NIC
GPS
exanic
GM
5ns
300M
1M
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source


GPS
exanic
GM
ExaLINK Fusion
(fastmux)
40ns
300M
1M
Latest Generation
PTP Aware NIC
exanic
HPT
PTP4L
Capture
exanic
HPT
PTP4L
Capture
Optical
Splitter
Matched cable
lengths
Packet Source

PTP4L Configuration

```
$ ptp4l -i enp101n1 -m
```

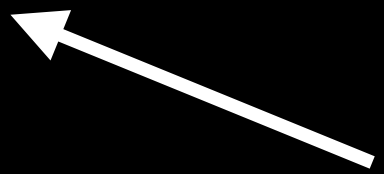
PTP4L Configuration

```
$ ptp4l -f enp101n1.conf
```

PTP4L Configuration

```
$ ptp4l -f enp101n1.conf
```

```
[global]
verbose          1
```



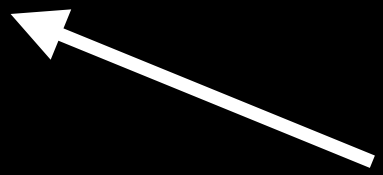
log to std-out

PTP4L Configuration

```
$ ptp4l -f enp101n1.conf
```

```
[global]
verbose             1

[enp101n1]
delayAsymmetry      -35
```



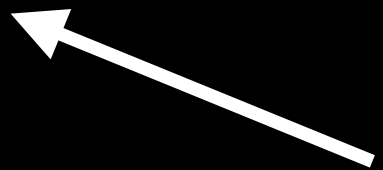
path asymmetry (ns)

PTP4L Configuration

```
$ ptp4l -f enp101n1.conf
```

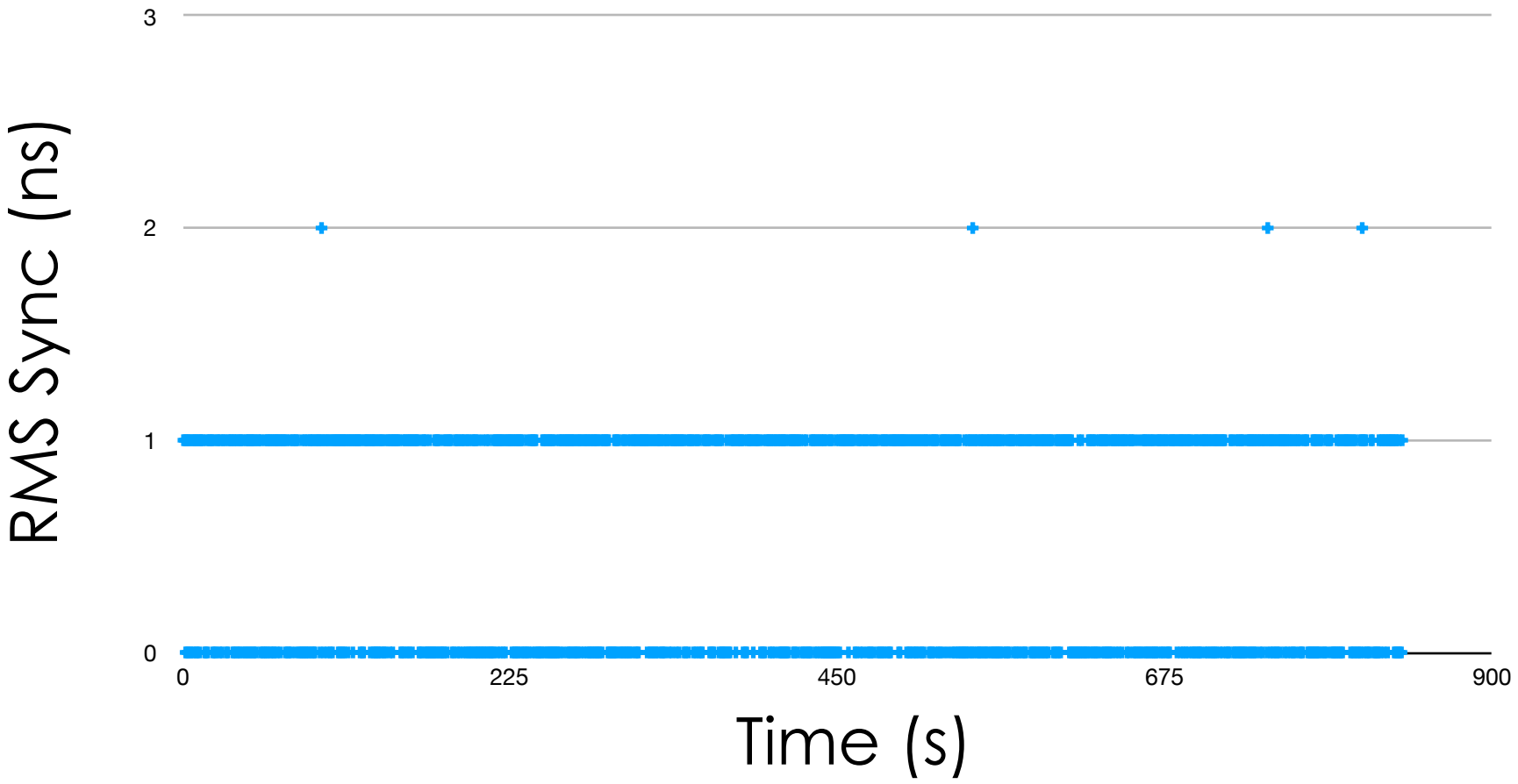
```
[global]
verbose             1

[enp101n1]
delayAsymmetry     -35
logSyncInterval    -4
```

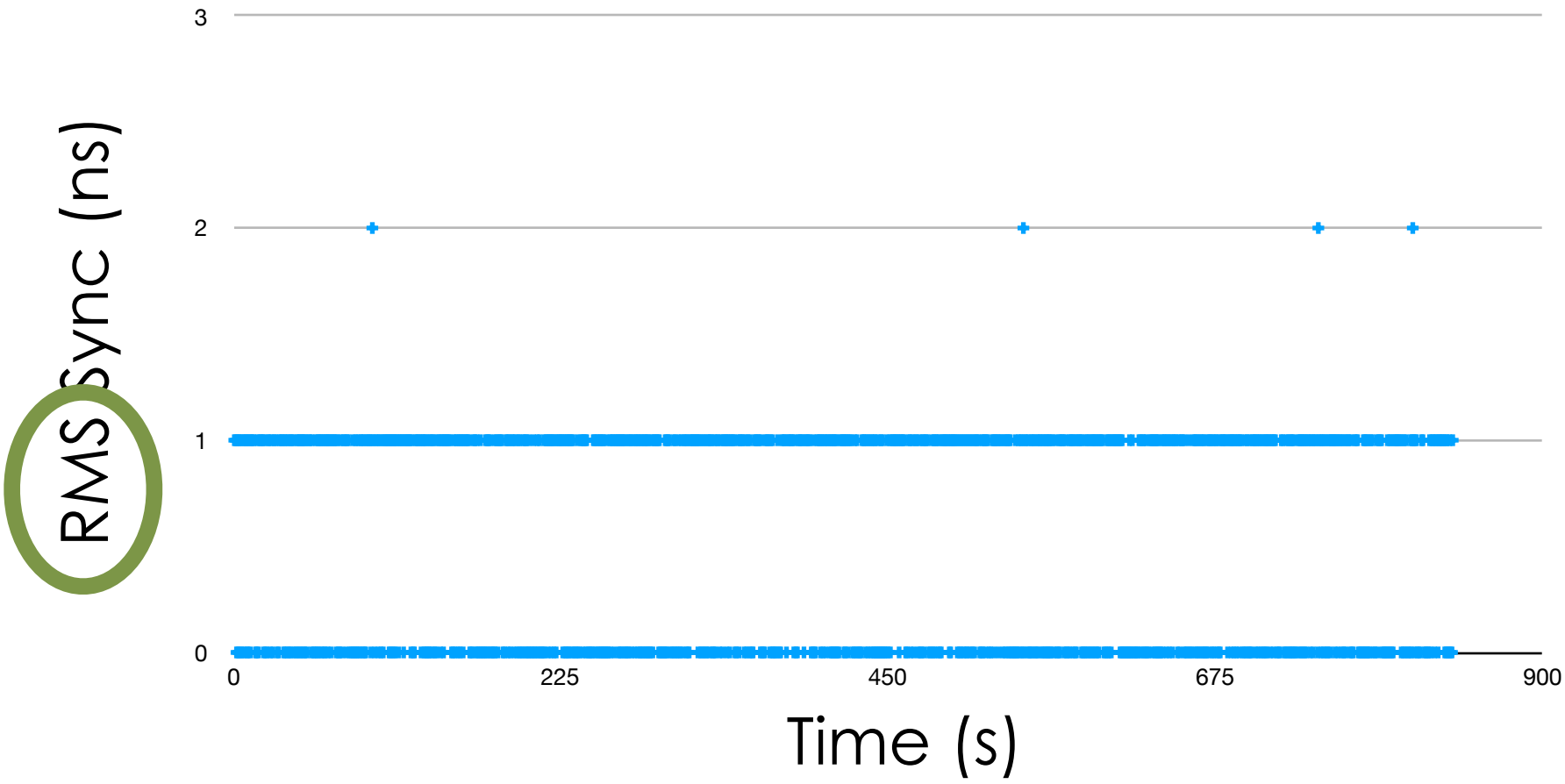


sync every 62.5ms

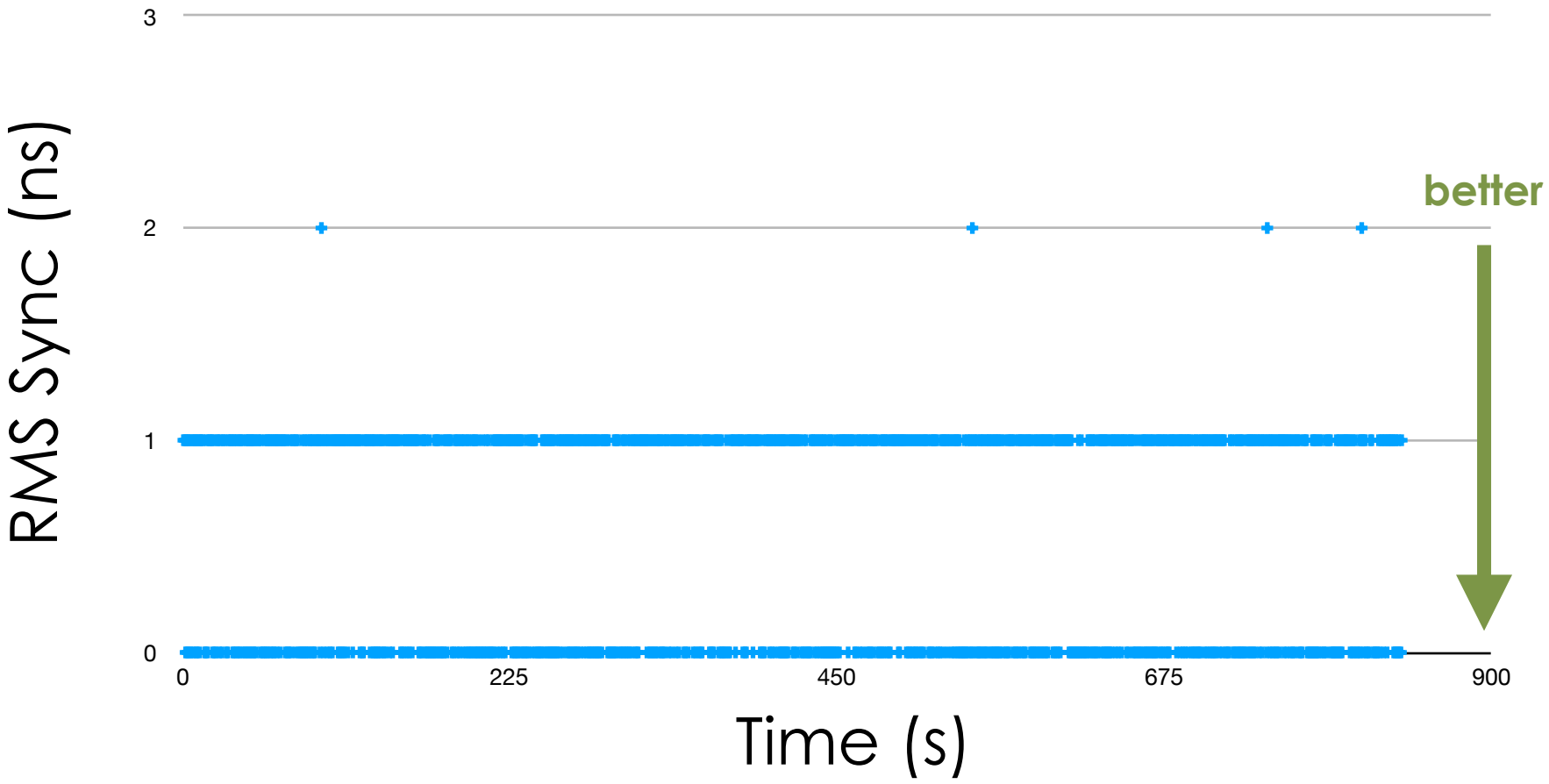
PTP4L Perceived Sync



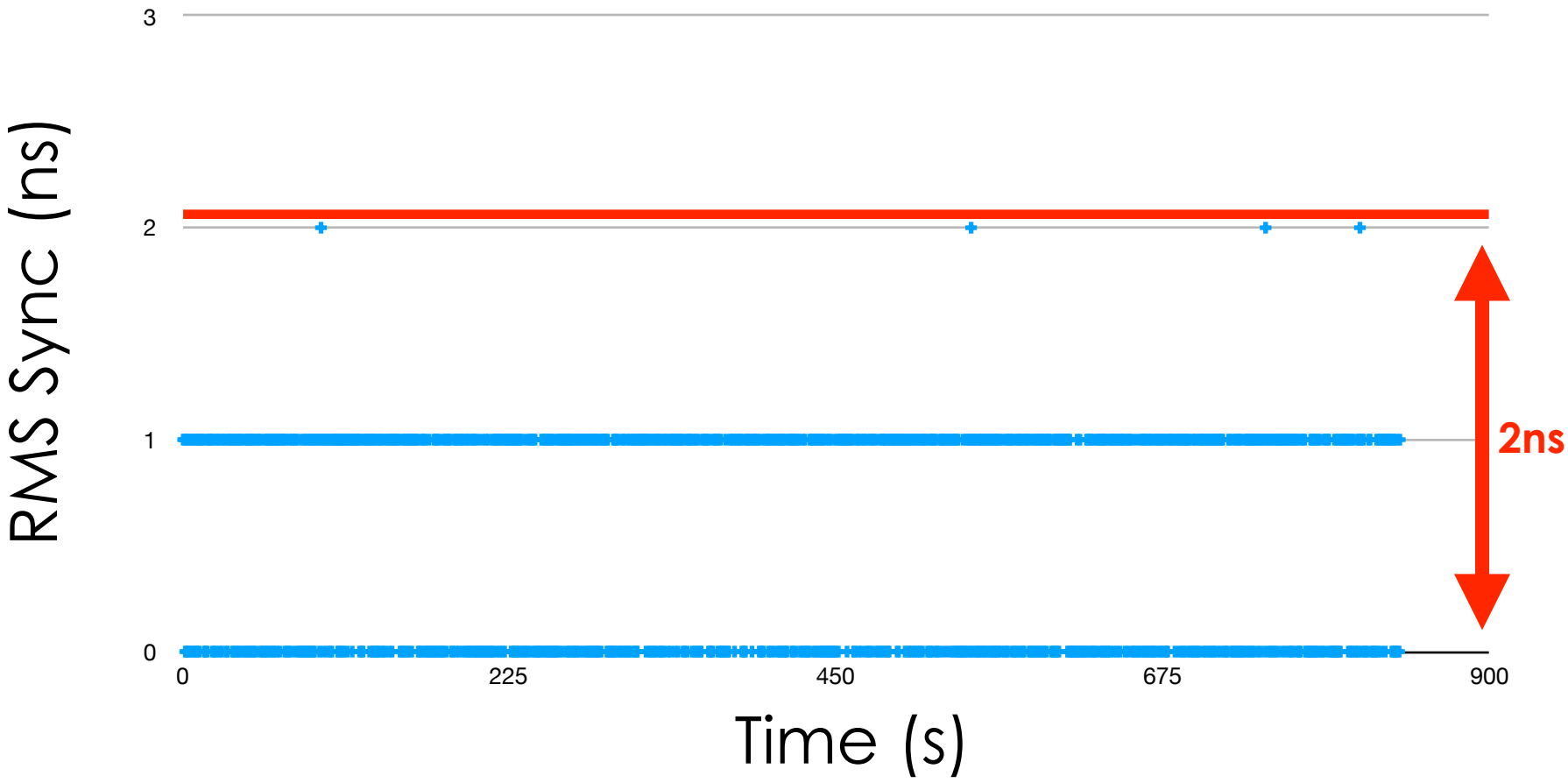
PTP4L Perceived Sync



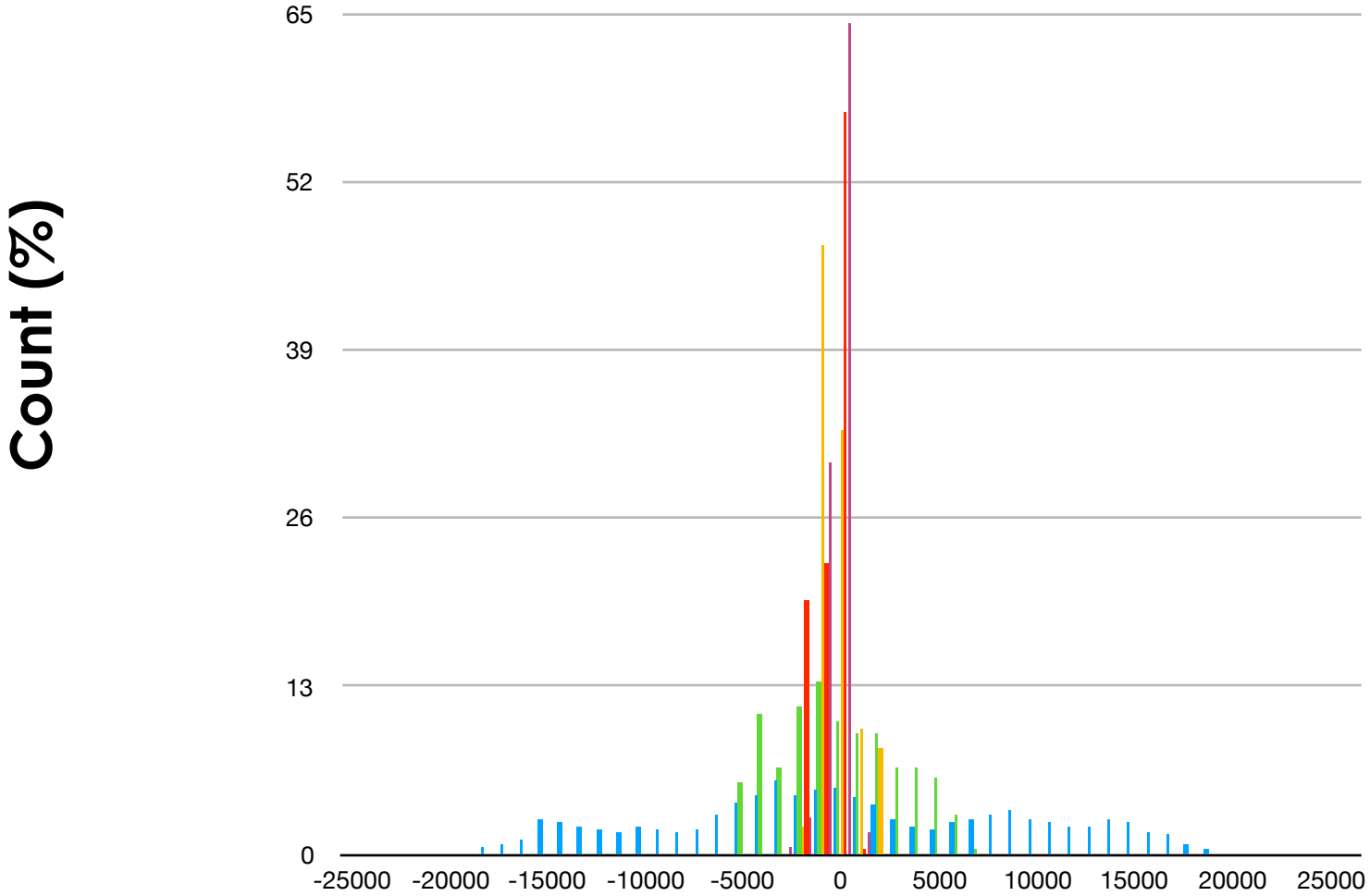
PTP4L Perceived Sync



PTP4L Perceived Sync

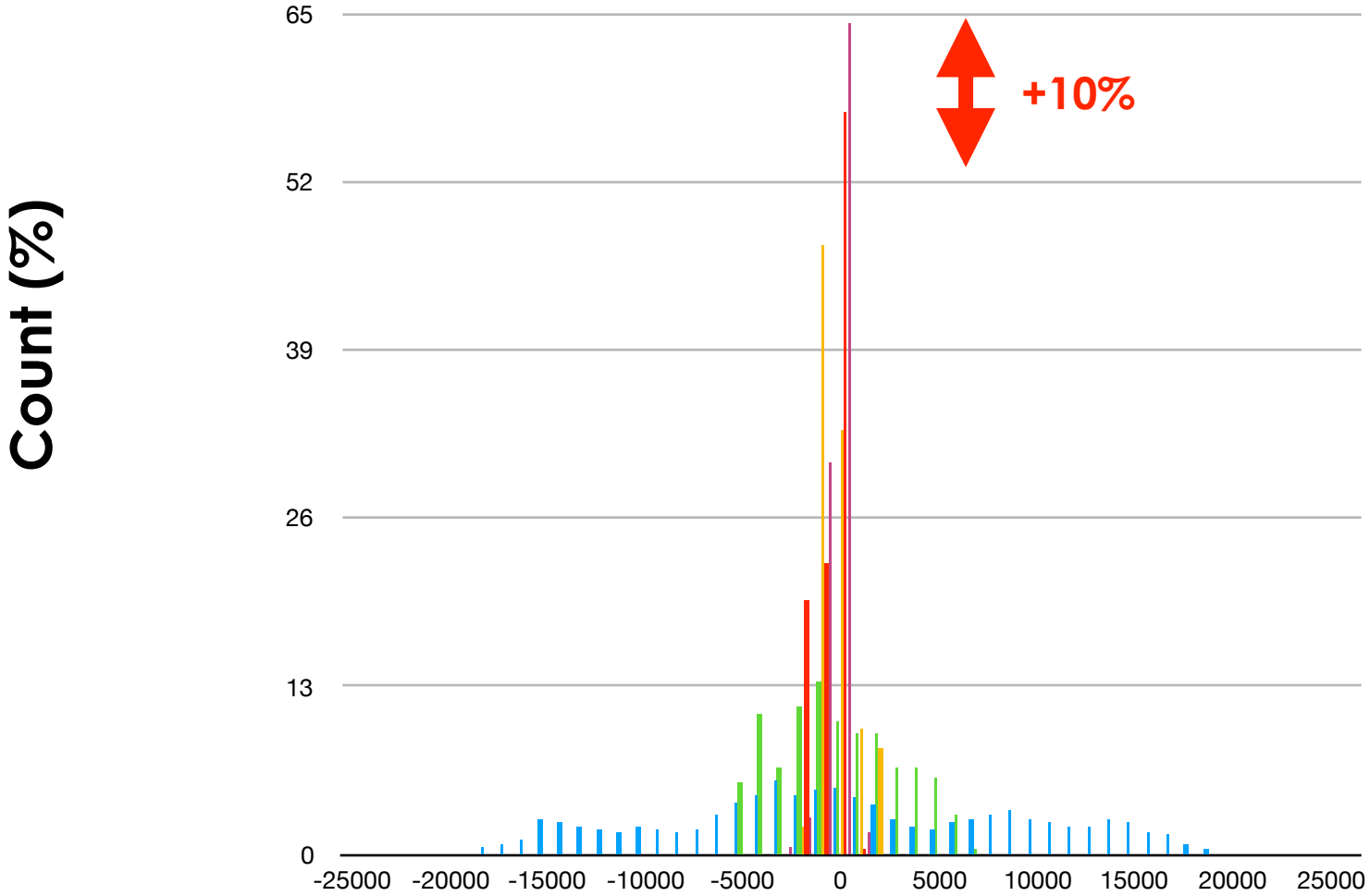


PTP4L Measured Sync



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PTP4L Measured Sync



PTP4L Sync Summary

Configuration	Perceived Sync	Measured Sync
Standard	+/- 40ns	+/- 20ns
ExaNIC HPT	+/- 10ns	+/- 7.5ns
ExaLINK Fusion	+/- 5ns	+/- 2ns
GM / HPT	+/- 2.5ns	+/- 1.5ns
GM / HPT / Config	+/- 1ns	+/- 1.5ns

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- Standard Ethernet network
- Open source software
- Familiar network hardware
- Scale distance and hosts

"PTP **is** good enough for a nanosecond world "

- people in this room (hopefully?)



Questions?



Tick the box for more info…