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TRANSFORMING HOW CARS OF THE FUTURE ARE BUILT

IEEE802.1DG – GPTP | 2020-09-23

IEEE contribution

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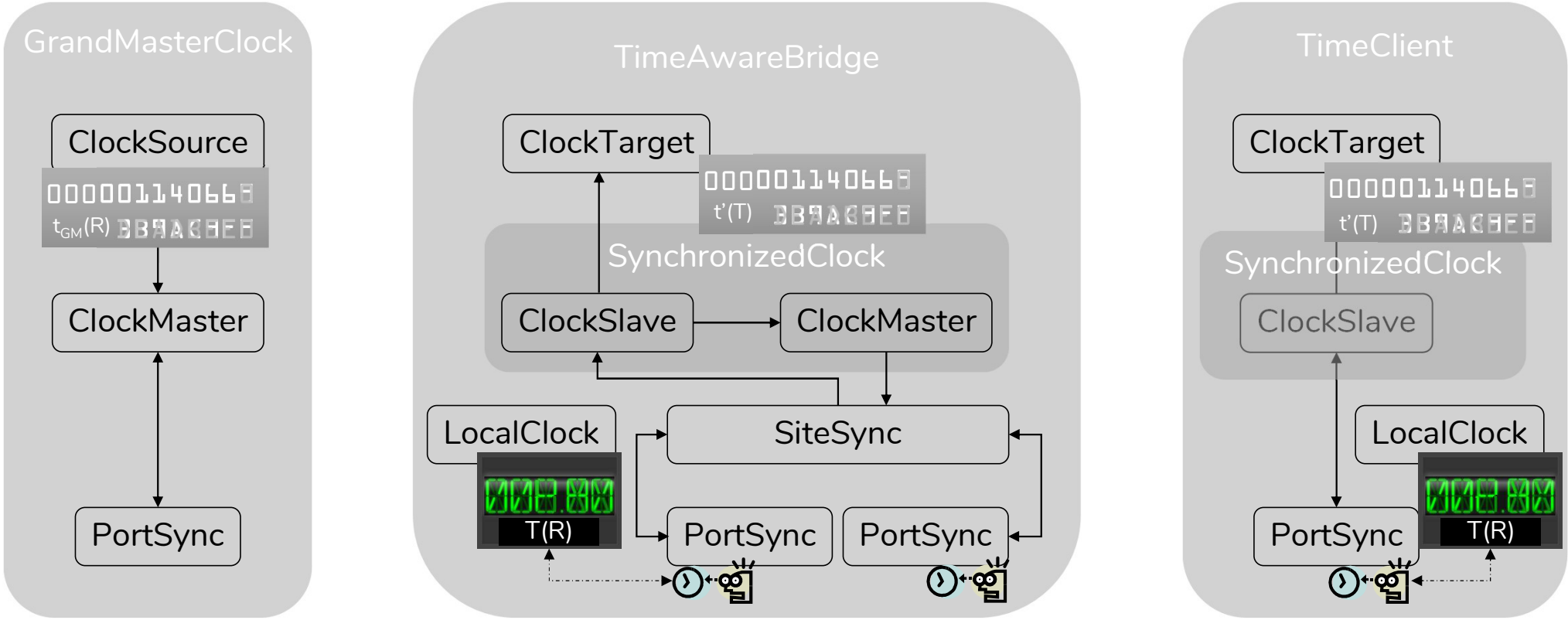
Symbols and Nomenclature



T ... LocalClock (free running)

t' ... SynchronizedClock (syntonous with GM)

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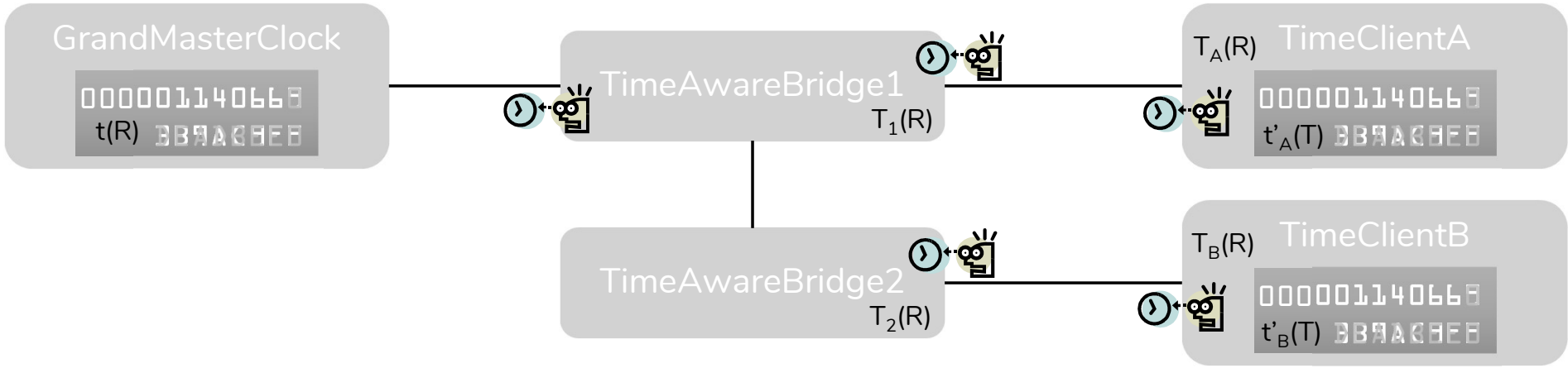
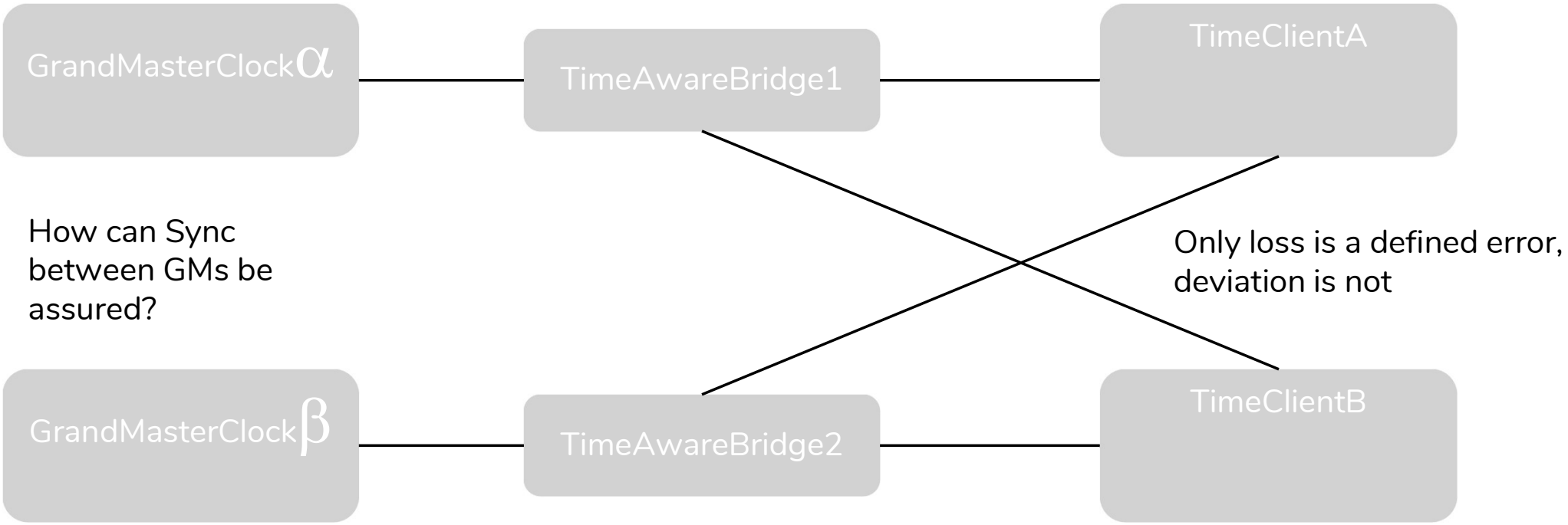
Problem Description



- gPTP-Sync-Messages (t') sent from GM to the Bridges/Clients
- pDelay-Messages based on Local-Clock (T) information
- How can we ensure – in safety terms – at any one point in Real-Time (R), the GM and all (relevant) clients have synchronized to the same clock-counter value, within an accepted accuracy?
  $t(R) \approx t'_A(R) \approx t'_B(R)$

Redundant GM/Client Connections



How can Sync between GMs be assured?

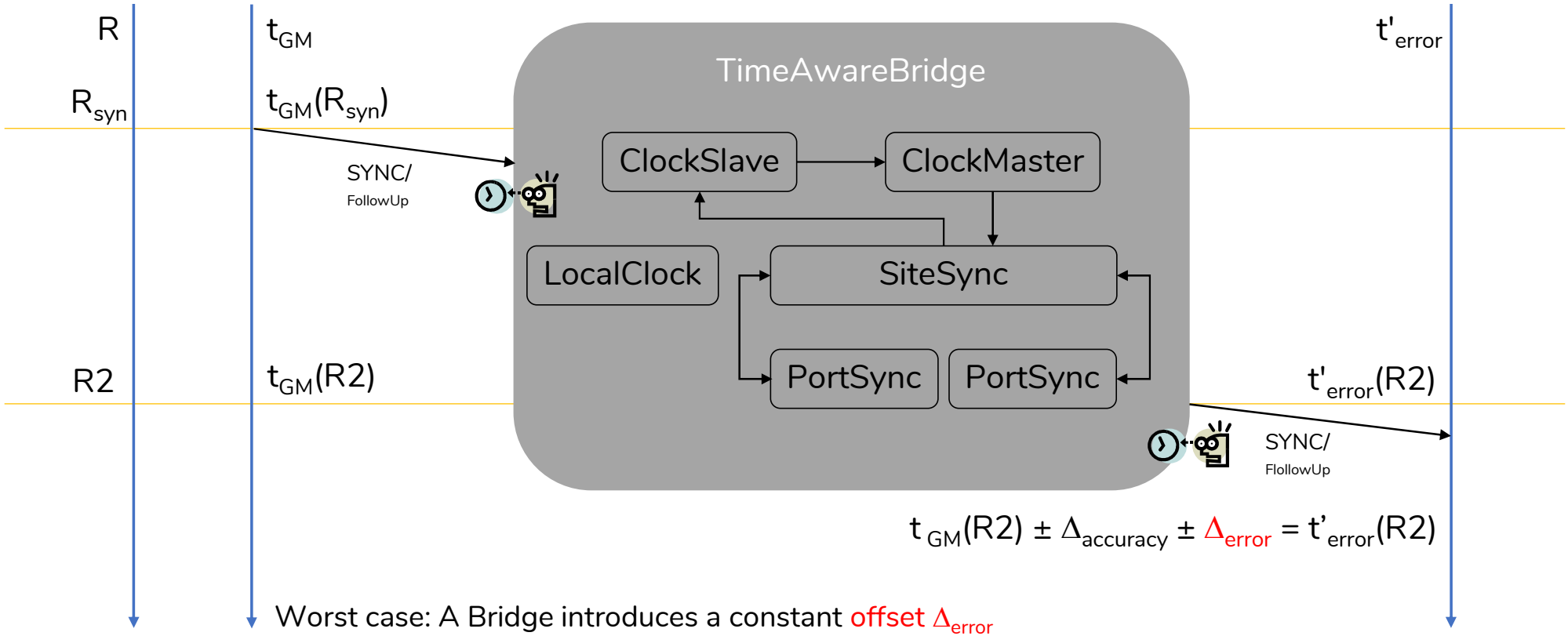
Only loss is a defined error, deviation is not

System can only start up, if <u>both</u> GMs are operational (and synchronized) -> reduced availability

Bridges can still introduce constant offset to one domain

Clients can compare domains locally but cannot compare each other

The “Byzantine” Bridge Error



Worst case: A Bridge introduces a constant offset Δ_{error} from the start-up (not a transient change)

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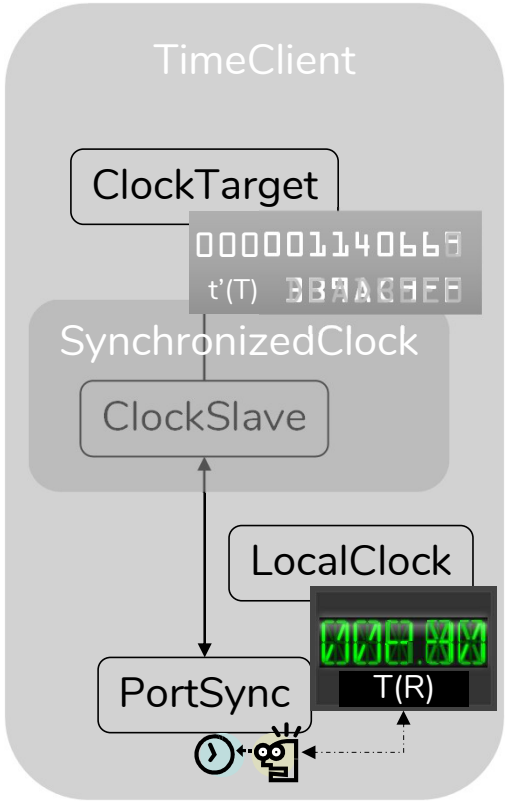
Delay within the Timing-Stack

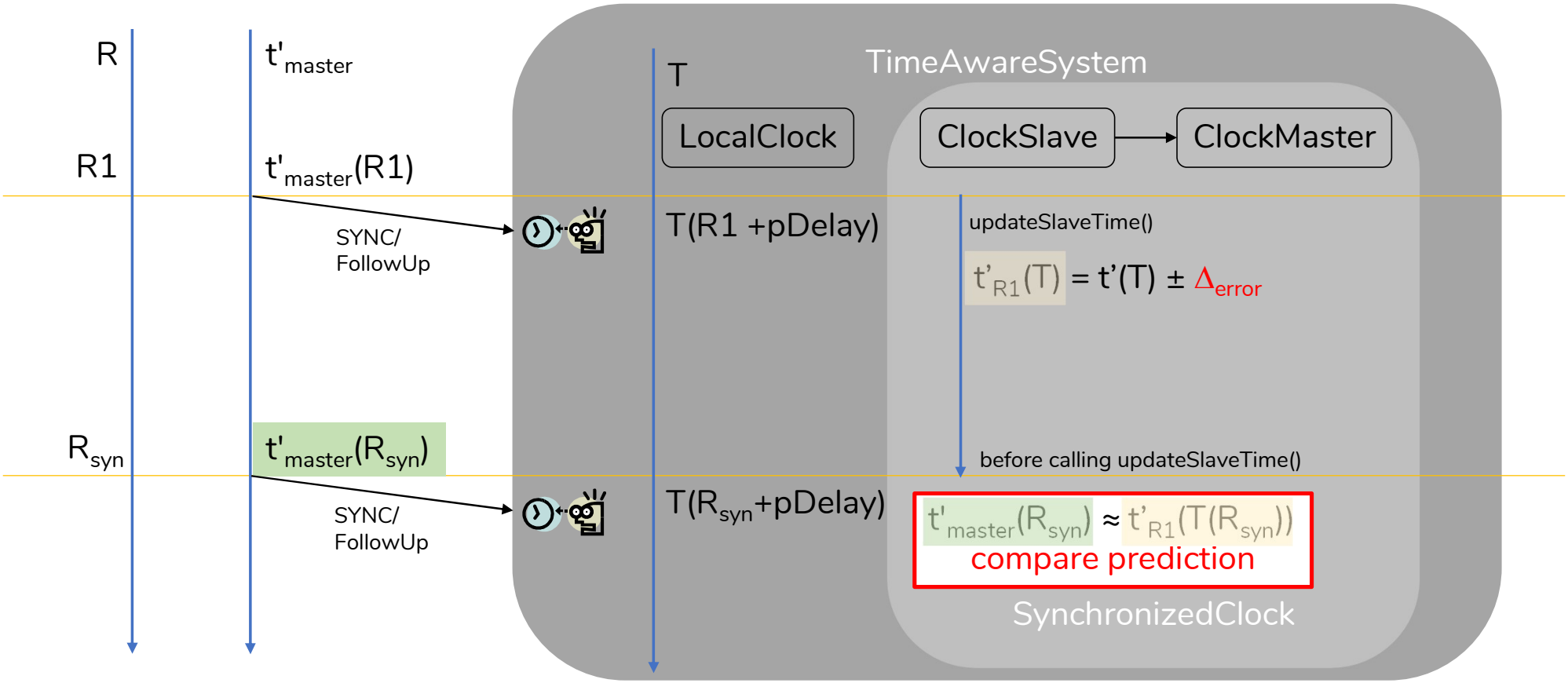


Does the application (ClockTarget) actually get the correct time?

Stack can introduce a delay

Local-Clock time-stamping can introduce a delay

Predict next originTimestamp



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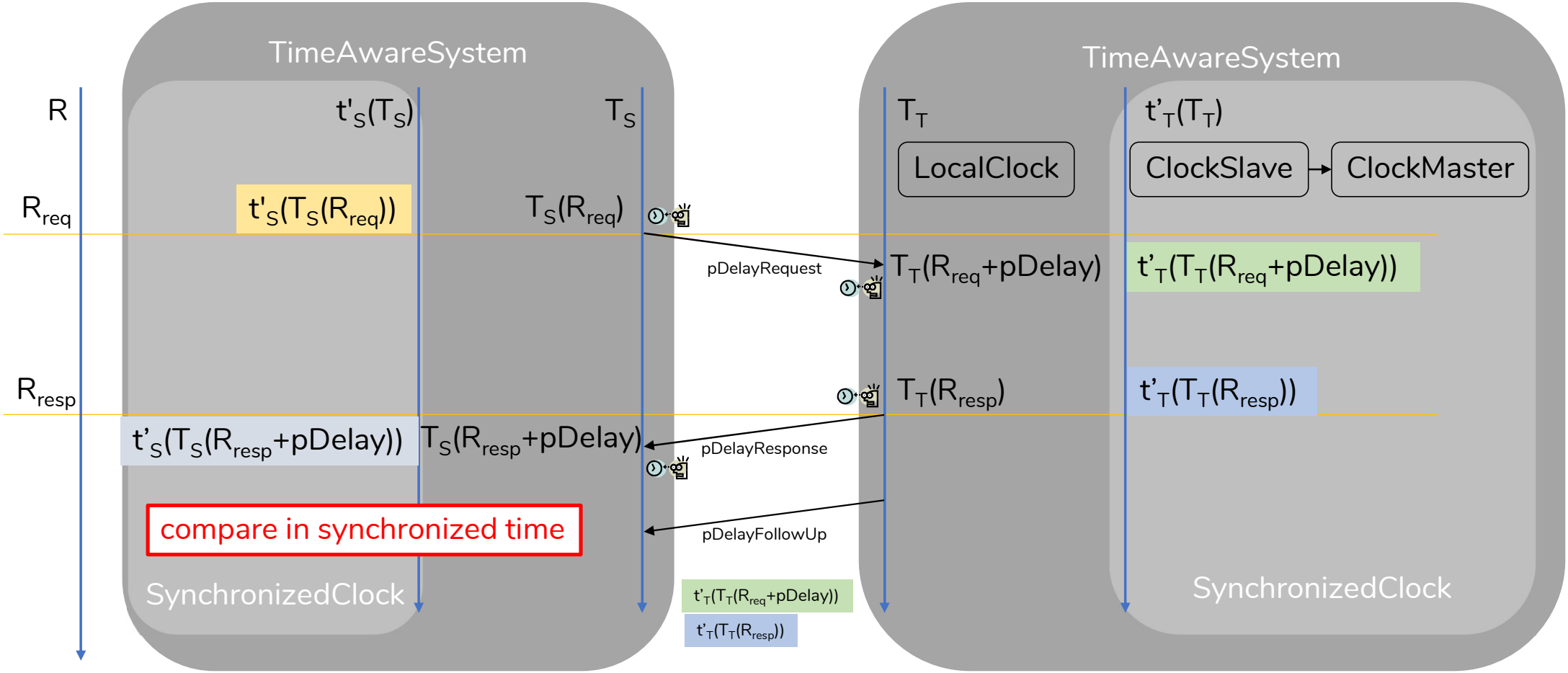
Use pDelay to probe SynchronizedClock



pDelay Source

pDelay Target

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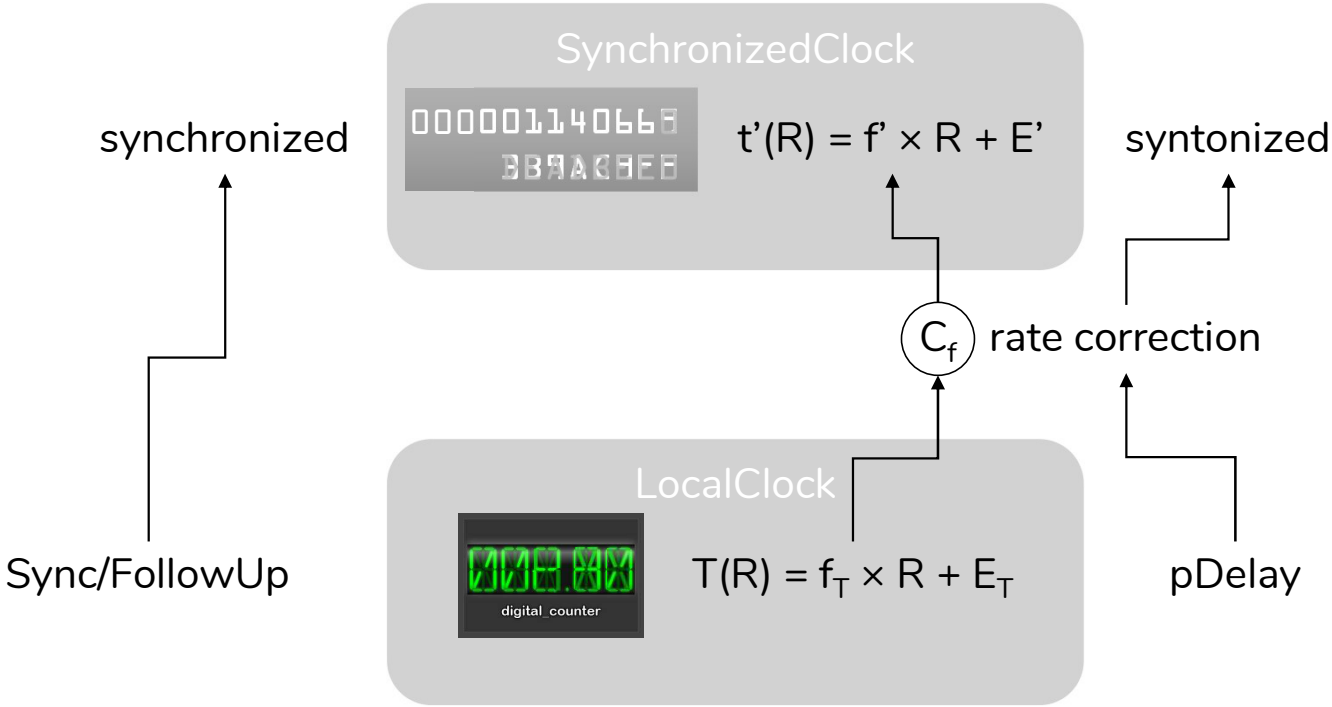
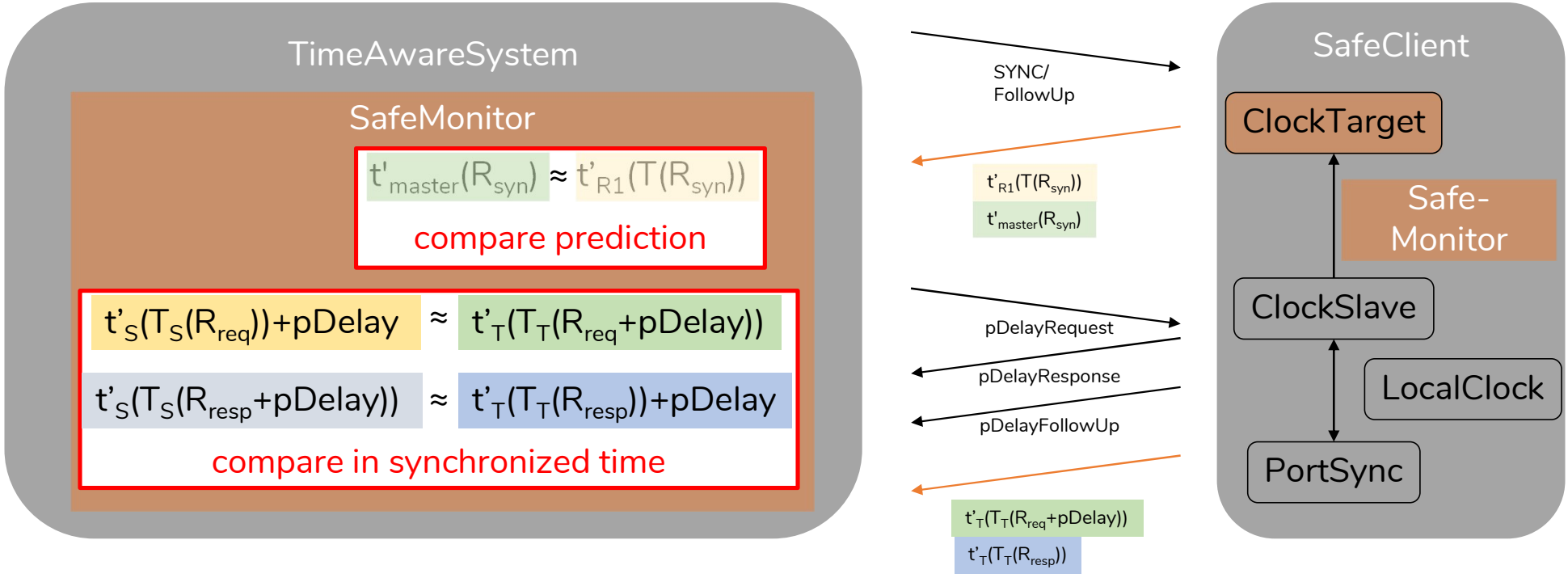
Why neighbourRateRatio from pDelay?



Improved Start-Up time:

- Can start on each link after link-up
- pDelay and neighbourRateRatio are already known when first Sync-Message arrives

Stations on a Link can monitor each other



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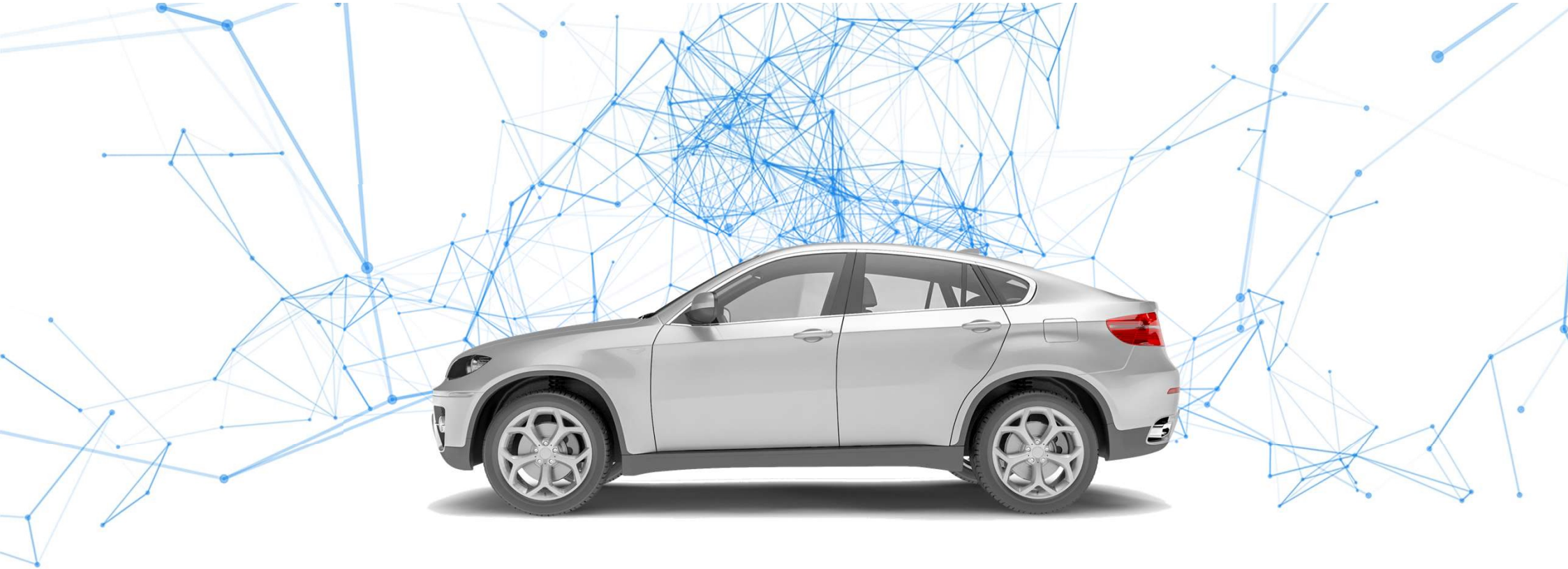
List of Data-Points per Link

Event Message	Transmit time-stamp	Receive time-stamp
Sync-Message	$T_{master}(R_{sync})$ $t'_{master}(T(R_{sync}))$ [also in FollowUp-Msg]	$T_{client}(R_{sync}+pDelay)$ $t'_{client}(T(R_{sync}+pDelay))$
pDelayRequest-Message	$T_S(R_{req})$ $t'_S(T_S(R_{req}))$	$T_T(R_{req}+pDelay)$ [also in pDelayFollowUp-Msg] $t'_T(T_T(R_{req}+pDelay))$
pDelayResponse-Message	$T_T(R_{resp})$ [also in pDelayFollowUp-Msg] $t'_T(T_T(R_{resp}))$	$T_S(R_{resp}+pDelay)$ $t'_S(T_S(R_{resp}+pDelay))$

Autosar has **add**ed **interfaces** to record these time-tuples, should IEEE802.1AS and IEEE1588 follow?
The knowledge of Synchronized Time at each port requires Boundary Clocks
Do NOT specify use of the time-tuples in IEEE!

Boundary Clock: create new OriginTimeStamp for transmitted Sync-Message
Transparent Clock: keep incoming OriginTimeStamp, add CorrectionField in Local-Time to transmitted Sync-Message



THANK YOU

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