# IEC/IEEE 60802

# ClockTarget / ClockSource / ClockSlave / ClockMaster / LocalClock / PTP clock / ApplicationClock

# Requirements and assigned features

(Have additional a look at 60802-Steindl-EndStationModel-0321-v07.pdf)

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Günter Steindl (Siemens AG)

# Industrial Automation

Synchronization quality and thus, measurement is defined between ClockSource and ClockTarget.

Thus, the requirements of the ClockTarget (and the ClockSource) influence (and are influence by) , together with the LocalClock, the 802.1AS errors.
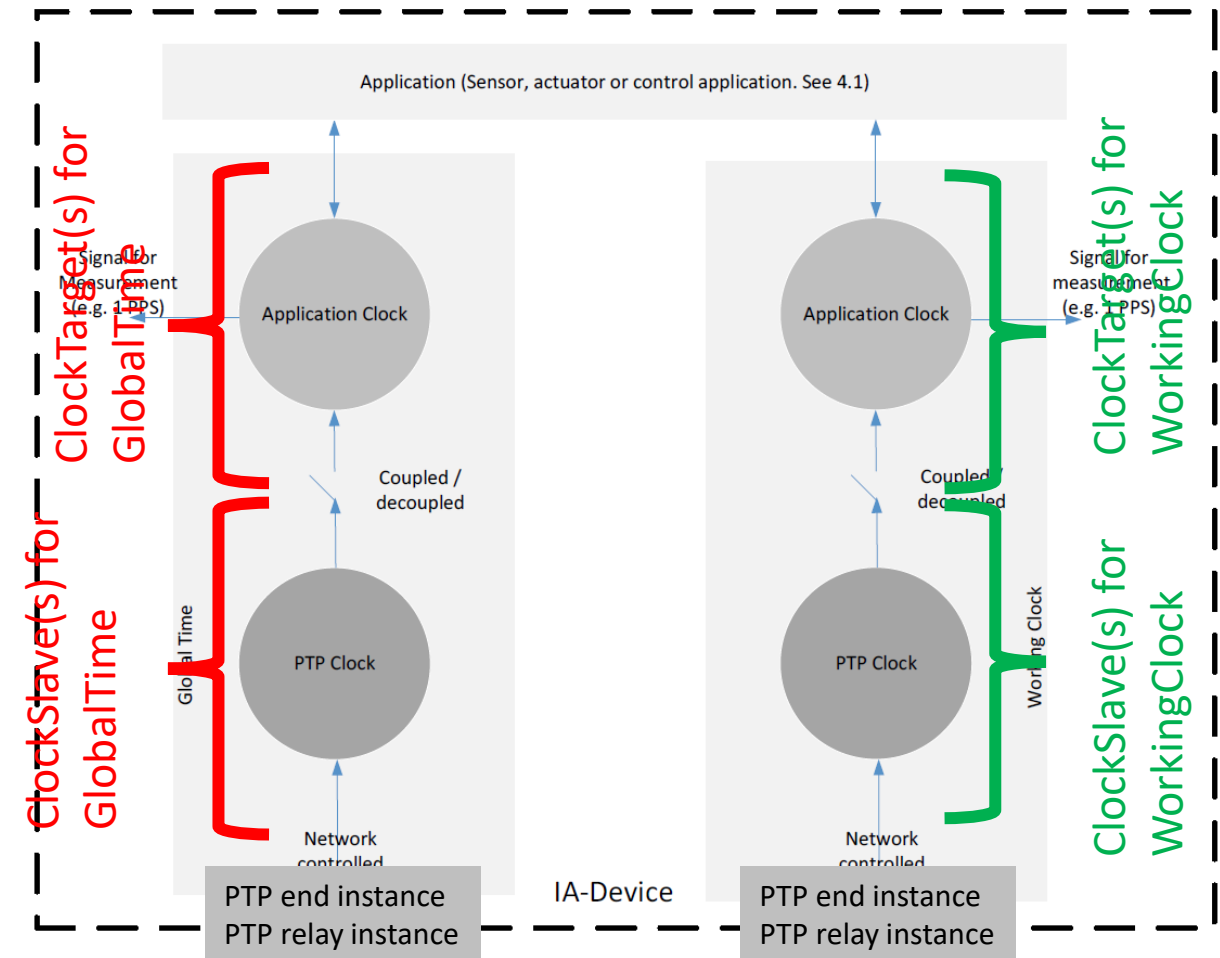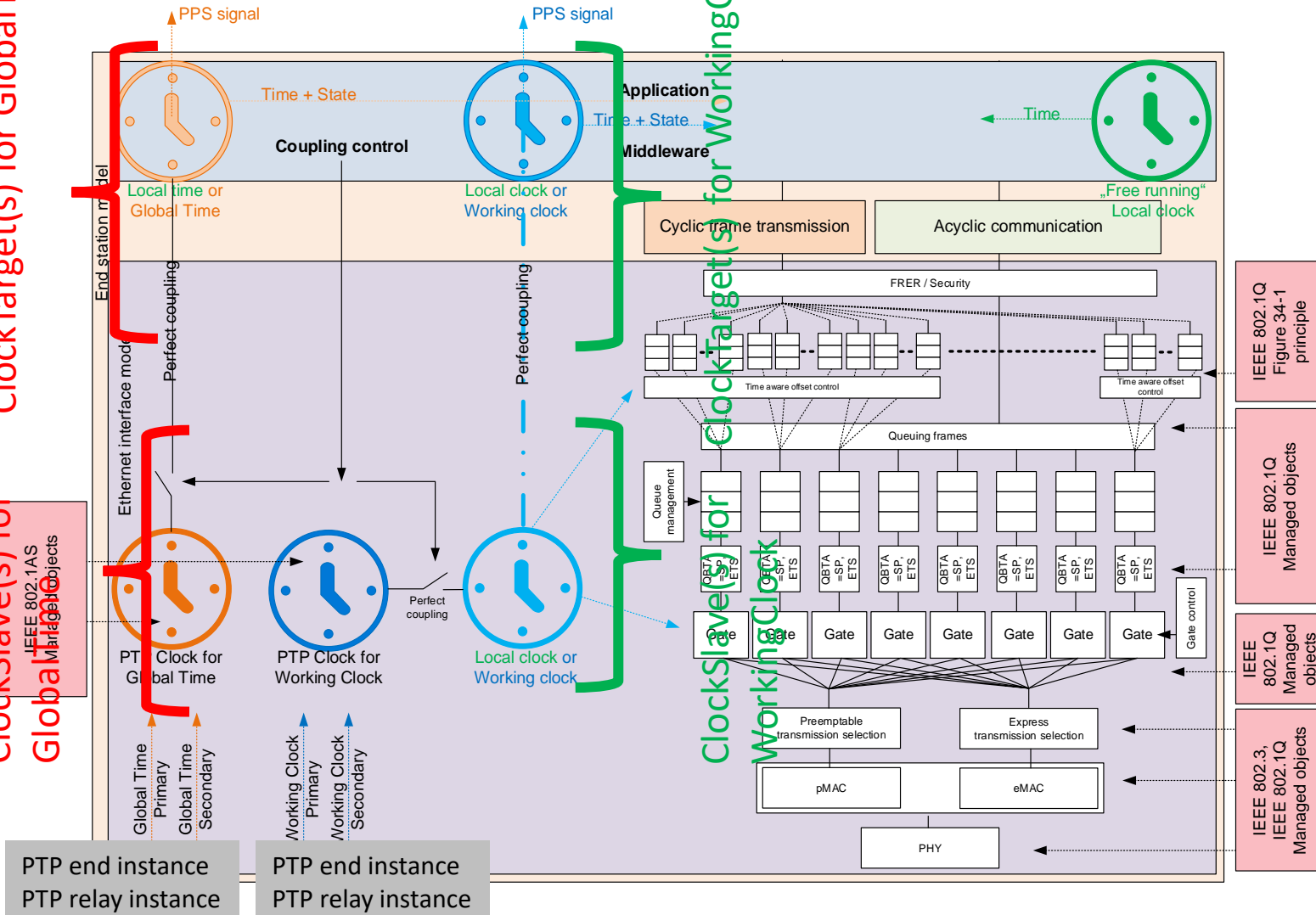


Figure 7 – Clock usage principles

# Synchronization model



The end station interface and end station model needs to include synchronization.

Working Clock (**ClockTarget**) is used by both, end station interface and end station application.

Global Time (**ClockTarget**) is used by the end station application.

Application requires availability of Global Time and Working Clock at all times and thus, the end station maintains two instances of Working Clock and Global Time as **ClockTarget**.

The coupling of these two instances is controlled by the application.

Working Clock timescale is assumed as ARB.

Global Time timescale is assumed as PTP.

Additionally, (just for information) the application uses a free running **LocalClock** which make sure that even smallest timespans are only influenced by the oscillator quality.

# ClockTarget and ClockSource

**ClockTargets** connected to PTP Relay Instances and PTP End instances that are not grandmaster capable shall meet the following requirements under all of its allowed working conditions and for its lifetime:

a) The fractional frequency offset of its **ClockTarget** and its **LocalClock** relative to the TAI frequency is in the range of -50 ppm to +50 ppm.

b) The absolute value of the maximum rate of change of fractional frequency offset of its **ClockTarget** is ≤ 3 ppm/s and of **LocalClock** ≤ 1 ppm/s. Note that this includes for the **ClockTarget** the affect of rate and offset compensation.

c) During operation, the **ClockTarget time** increases monotonically, where monotonic means that for a time y that occurs after time x, the **ClockTarget**'s timestamp of y is greater than or equal to the **ClockTarget**'s timestamp of x.

d) The **ClockTarget** of the PTP instance can be controlled by applying a frequency change over a period of time. This will also result in a phase change of the **ClockTarget**, as the phase of a clock is the product of the applied frequency change and the duration of time of the frequency change. The frequency applied can have a fine resolution in order to speed up or slow down the clock smoothly, and it has a total range of frequency adjustment.

e) For the Global Time, the total range of frequency adjustment shall be +/-1000 ppm over any observation interval of 1 ms, which means that the **ClockTarget** can change up to 1 µs over an interval of 1 ms.

f) For the Working Clock, the total range of frequency adjustment shall be +/-250 ppm over any observation interval of 1 ms, which means that the **ClockTarget** can change up to 250 ns over an interval of 1 ms.

g) For a **ClockSlave**, decoupled from ClockTarget, higher maximum rate of frequency adjustments and maximum rate of change of fractional frequency offset are allowed. As soon as its coupled (or coupled again) a) to f) apply.
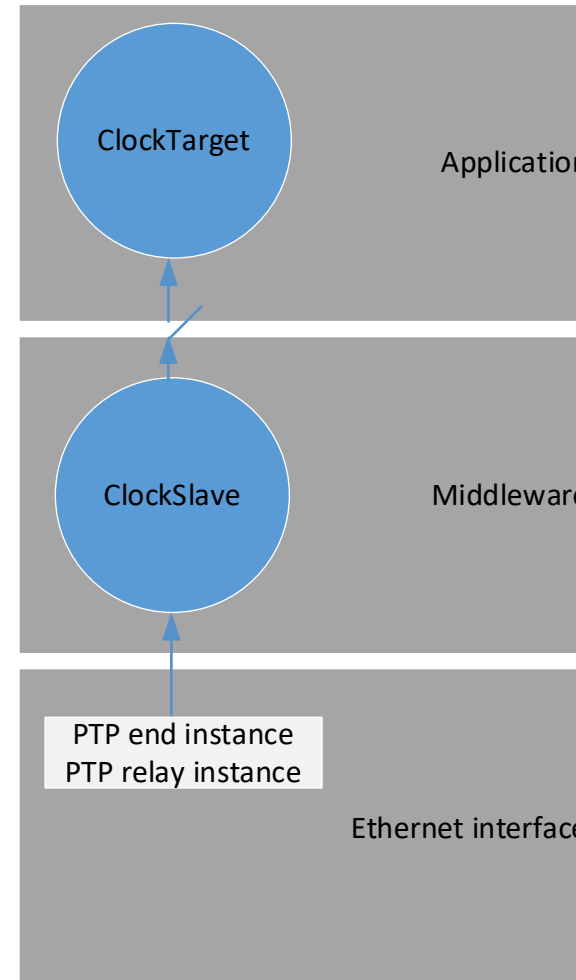

**ClockSources** coupled to a **ClockMaster** connected to PTP Relay Instances and PTP End instances used as grandmaster shall ensure that their behavior allows the controlled/disciplined ClockTargets to stay in the above stated ranges. This includes the cases in which the **ClockSource** is controlled (affect of rate and offset compensation) by another **ClockSource** for example a GPS time source also.

# Requires information about synchronization

An user using remote management shall be able to get the following information from an automation device:

- Status of ClockTarget

- Status of ClockSlave

- Status of PTP xxx instance

This information is a prerequisite for any automation application to start or diagnose operation.



Information required accessible by remote management (YANG module):
ClockTarget:
- Who is the Grandmaster?
- Which domainNumber?
- Which ITU-T G.781.1 state?

Information required accessible by remote management (YANG module):
ClockSlave:
- Who is the Grandmaster?
- Which domainNumber?
- Which ITU-T G.781.1 state?

Information required accessible by remote management (YANG module):
PTP xxx instance:
- Who is the Grandmaster?
- Which domainNumber?

# Example for synchronization between production cell and production machine

Machines are often designed as autonomous working machines. This machine can be integrated into the production cell without disturbing the production process in the machine.

Application of the machine decides when to align its ClockSource for the WorkingClock to the ClockSource of the production cell.

For the WorkingClock, an alignment to the start of an "internal machine clock" is often enough. This alignment can often achieved fast enough by speeding up or slowing down the ClockSource.

As soon as an alignment to the "internal machine clock" is achieved, cell and machine can interact in an synchronized manner.

Speed up and slow down needs to be limited to a given value, for example 3ppm/s.

The whole transmission path from ClockSource to all ClockTargets needs to stay "in sync" in this case.
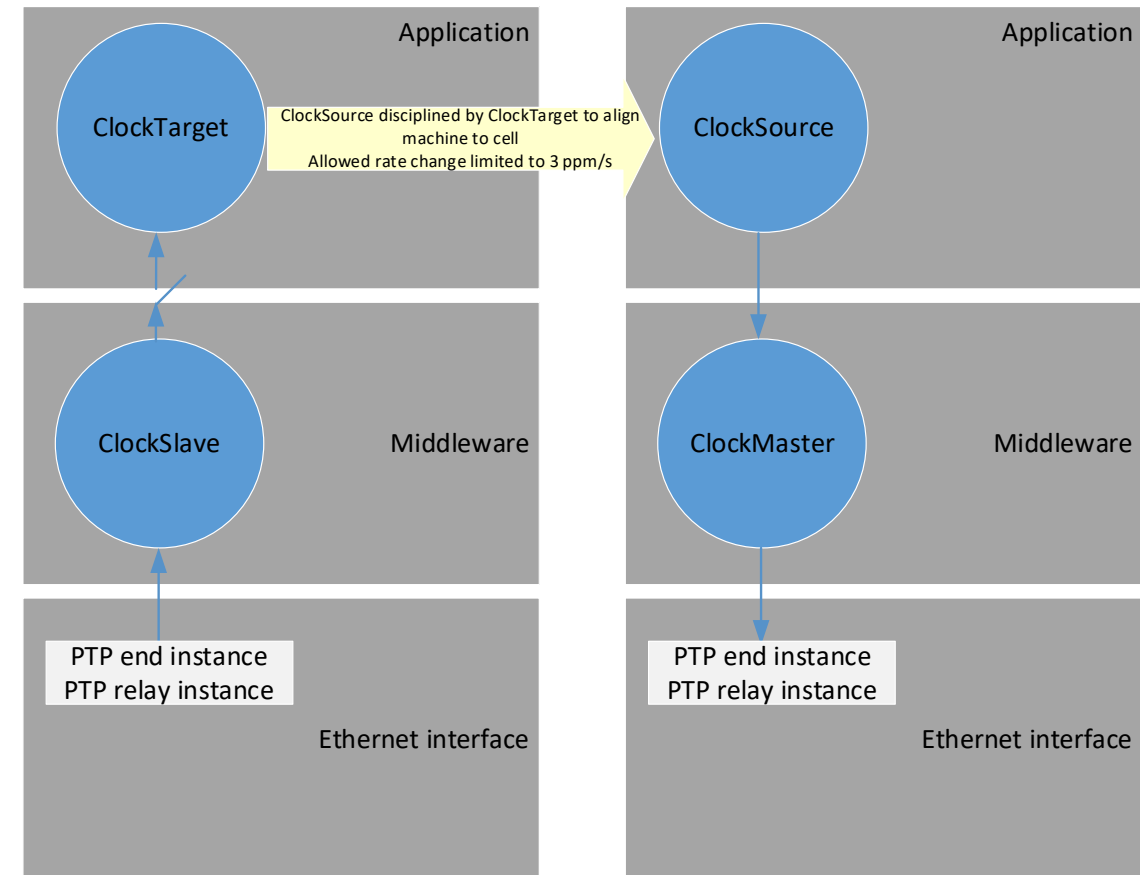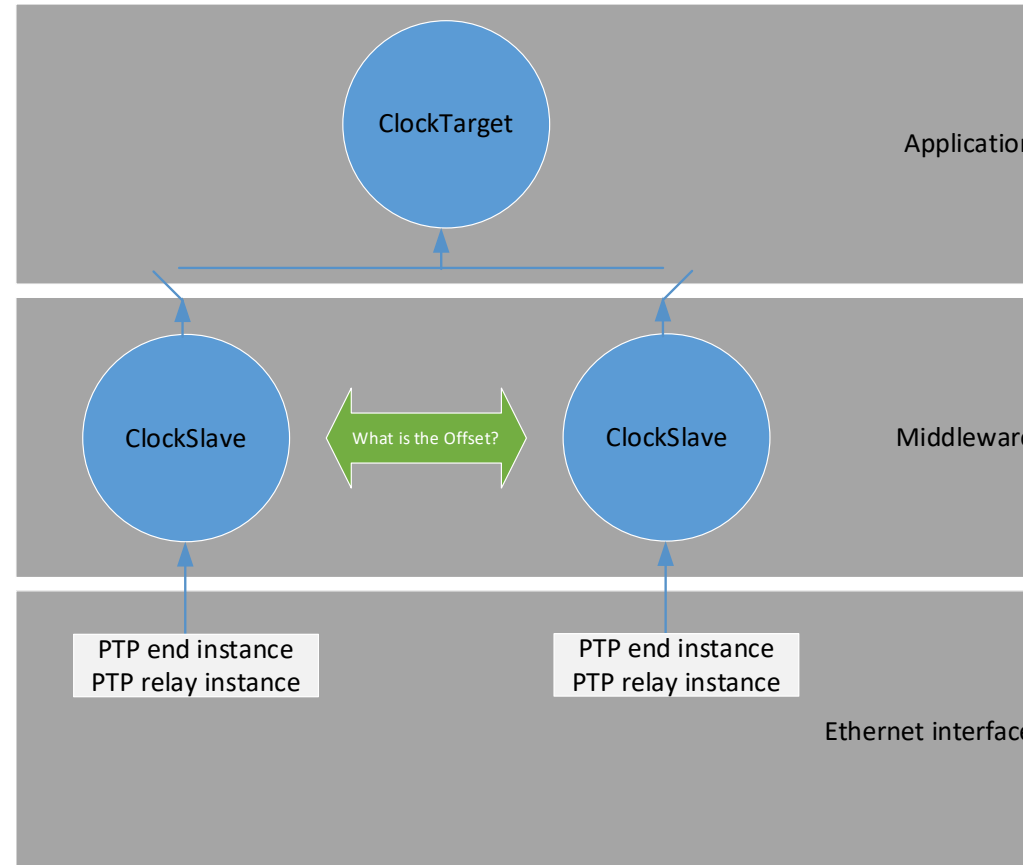
# Hot standby – required information

An user using remote management shall be able to get the following information from an automation device:

- Status of ClockTarget

- Status of both ClockSlave(s) for hot standby

- Status of PTP xxx instance for both domainNumbers

This information is a prerequisite for any automation application to start or diagnose operation.



Information required accessible by remote management (YANG module): ClockTarget:
- Who is the Grandmaster?
- Which domainNumber?
- Which ITU-T G.781.1 state?

Information required accessible by remote management (YANG module): ClockSlave:
- Who is the Grandmaster?
- Which domainNumber?
- Which ITU-T G.781.1 state?
- Host standby: Offset between the two ClockSlaves

Information required accessible by remote management (YANG module): PTP xxx instance:
- Who is the Grandmaster?
- Which domainNumber?

# Conclusion

Synchronization quality and thus, measurement is defined between ClockSource and ClockTarget.

That's the customer visible quality values!

Remote accessible status information is needed for ClockSource, ClockTarget, ClockMaster and ClockSalve

➢Any error analysis need to include the whole path
  from ClockSource to ClockTarget!

➢Any certification testing need to be done by comparing ClockSource
  to ClockTarget

# Questions ?