IEC / IEEE 60802 - IA profile

An example of timeliness use case
to be covered by IEEE 802.1AS-Rev

-To be discussed-

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Timeliness use cases

1 General

Working Clock and Time are two timescales needed to fulfill the requirements for timeliness. The maintainance of these two timescales is done by protocols as PTCP and IEEE 802.1AS. Both defines roles which are covers by the devices.

Both, Working Clock and Time, are needed and used concurrently. Figure 1 and Figure 8 show this principle. Thus, each Ethernet interface and each application need to be able to handle Working Clock and Time timescale concurrently even in case of role changes as stated in Table 1 and Table 2.

2 Time

2.1 General

Time is used to align events and actions plant wide. The assigned timescale is TAI which could be converted by algorithm into local date and time.

Figure 1 shows the principle structure of time synchronization which has the goal to establish a worldwide aligned timescale for time. Thus, often satellites are used as source of the timescale.

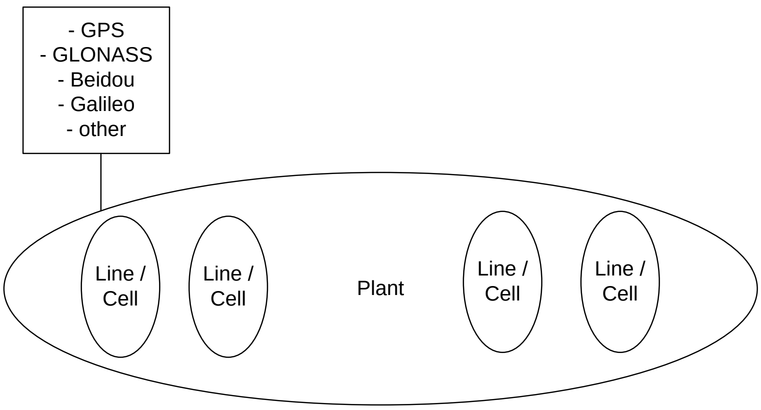

Figure 1 – Time synchronization

If lesser quality for the maintenance of this timescale is enough, then local sources for the timescale are used.

In case of system failure PLC local time sources may work as fallback.

Table 1 shows the used roles.

Table 1 – Time – Roles and use cases

Role	Device	Comments
Time master	PLC, others	PLC may be the time master if the quality is enough for the application or as fallback.
Time slave	All	All devices are time slaves to allow plantwide alignment of events.

2.2 PLC – Time master and time slave

2.2.1 General

Support of the Time timescale is a required function for each PLC. Thus, a PLC is part of the plantwide synchronization tree for time.

Multiple Time masters in hot standby, normally an integrated function of a PLC, ensuring the robustness of the synchronization for their domain in case of temporary synchronization tree disturbance.

2.2.2 Multiple interfaces

Figure 2 and Figure 3 show the synchronization trees in case of operational and broken connections for products with multiple Ethernet interfaces.

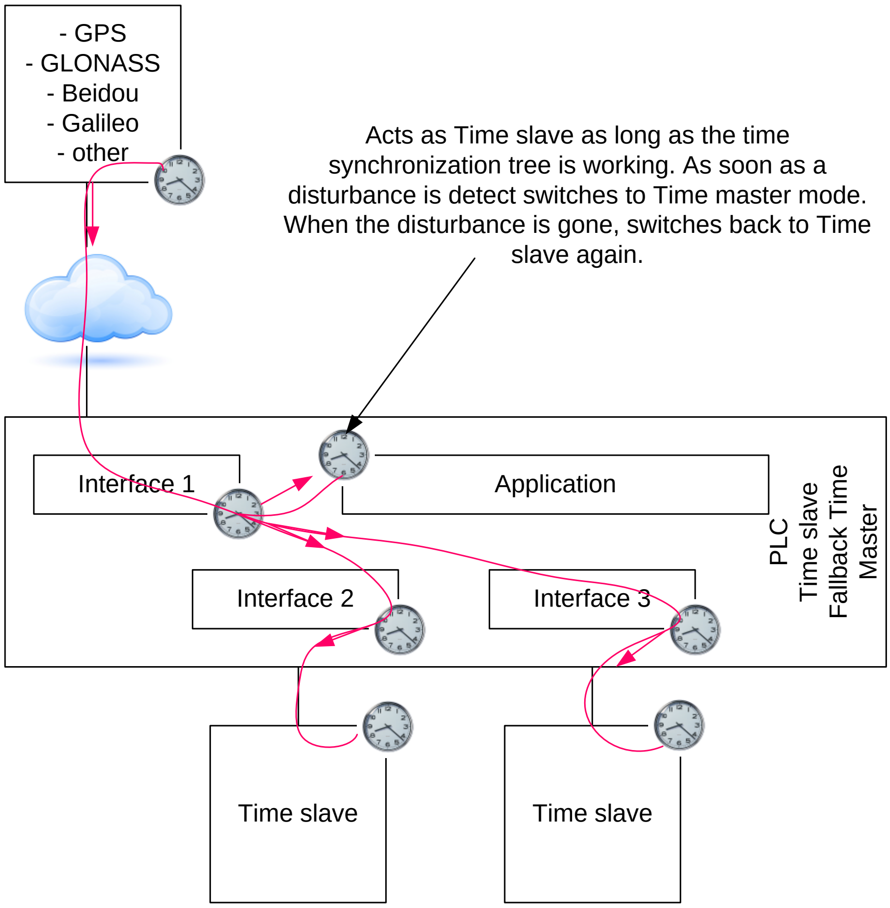

Figure 2 – Synchronization tree for Time

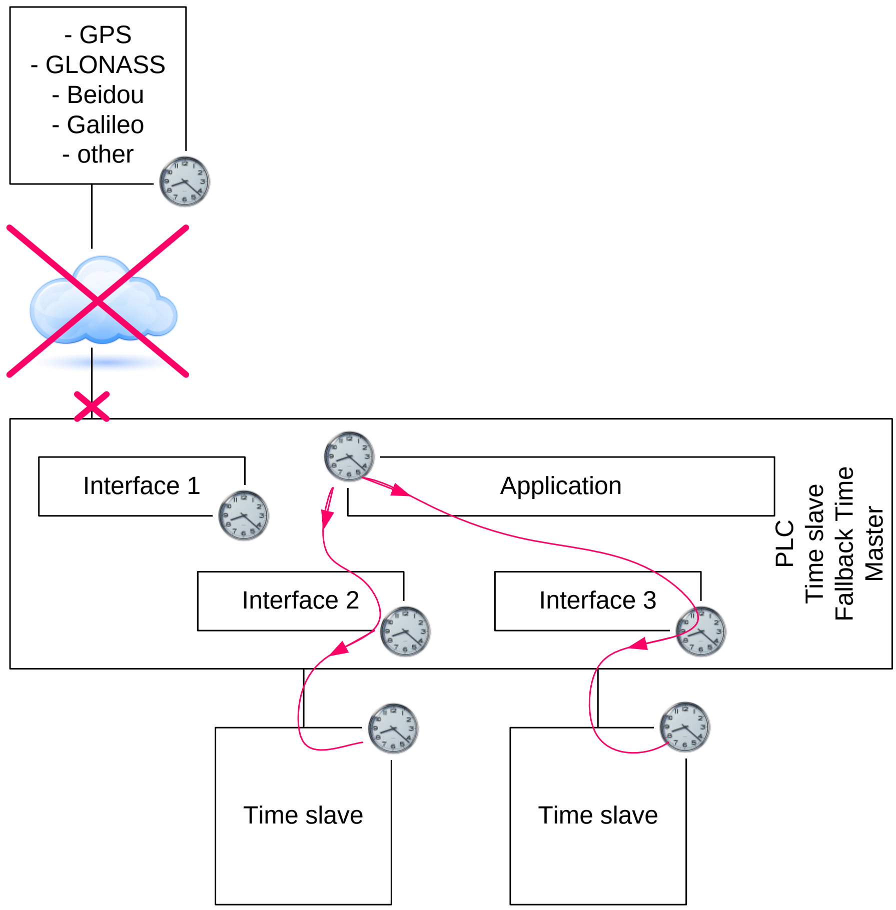

Figure 3 – Brocken synchronization tree for Time

A.1.1.1 Single interfaces

Figure 4 and Figure 5 show the synchronization trees in case of operational and broken connections for products with one Ethernet interfaces.

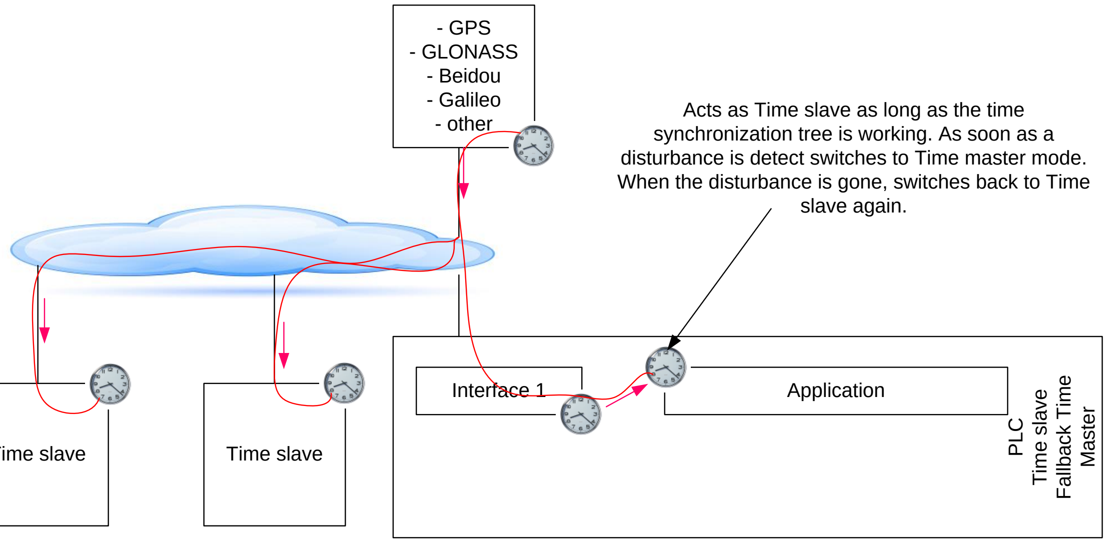

Figure 4 – Synchronization tree for Time

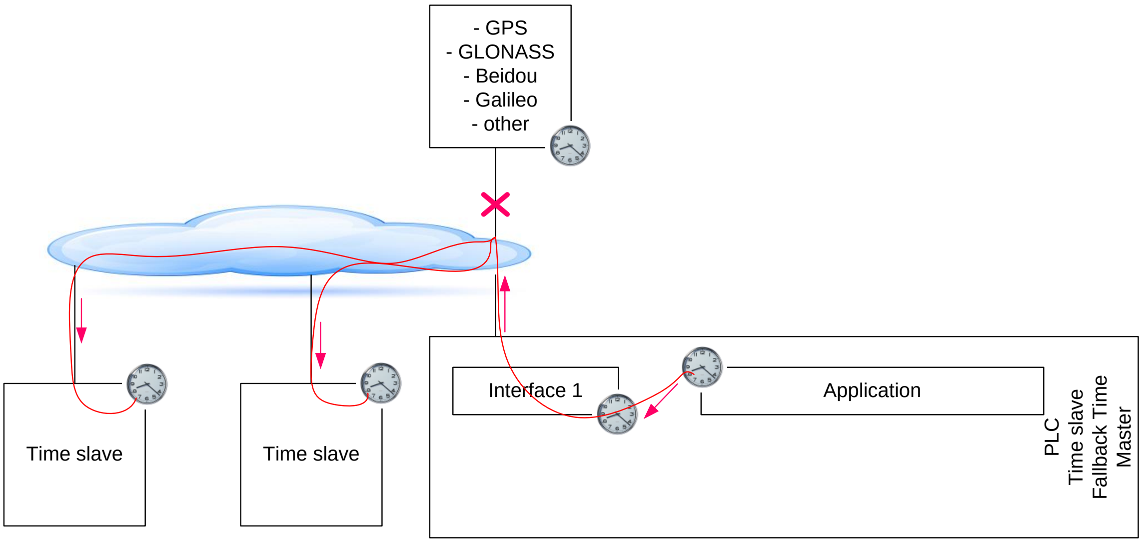

Figure 5 – Broken synchronization tree for Time

A.1.2 Time slave

A.1.2.1 General

Support of the Time timescale is a required function for most devices. Thus, these devices are part of the plantwide synchronization tree for time.

These devices switch to their local time entity maintaining the Time timescale in case of temporary synchronization tree disturbance.

Single or multiple Ethernet interface do not differ in case of broken synchronization tree for these devices. Thus, only single Ethernet interface is shown.

A.1.2.2 Single interfaces

Figure 6 and Figure 7 show the synchronization trees in case of operational and broken connections for products with one Ethernet interfaces.

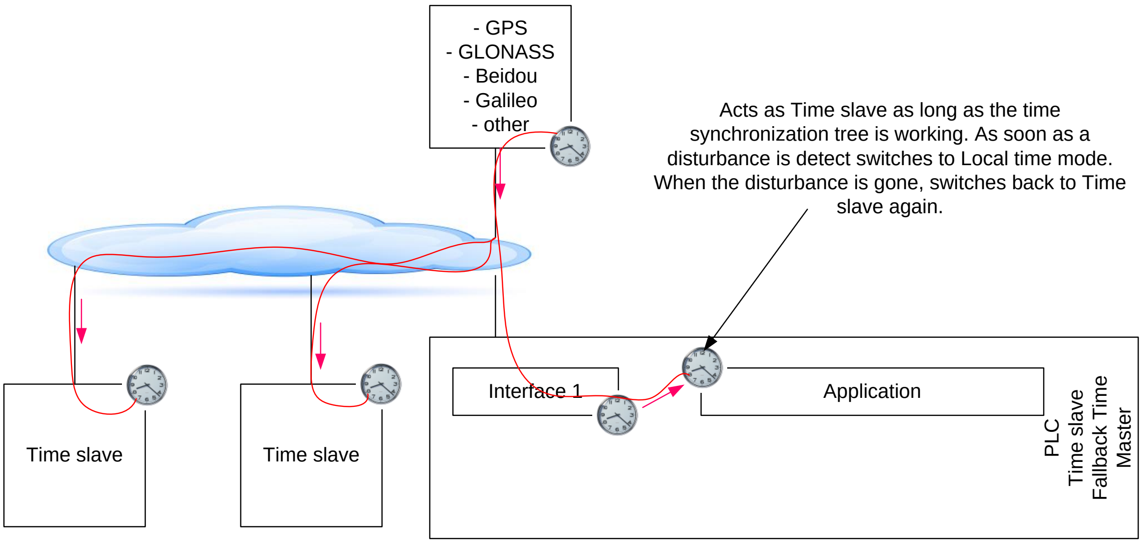

Figure 6 – Synchronization tree for Time

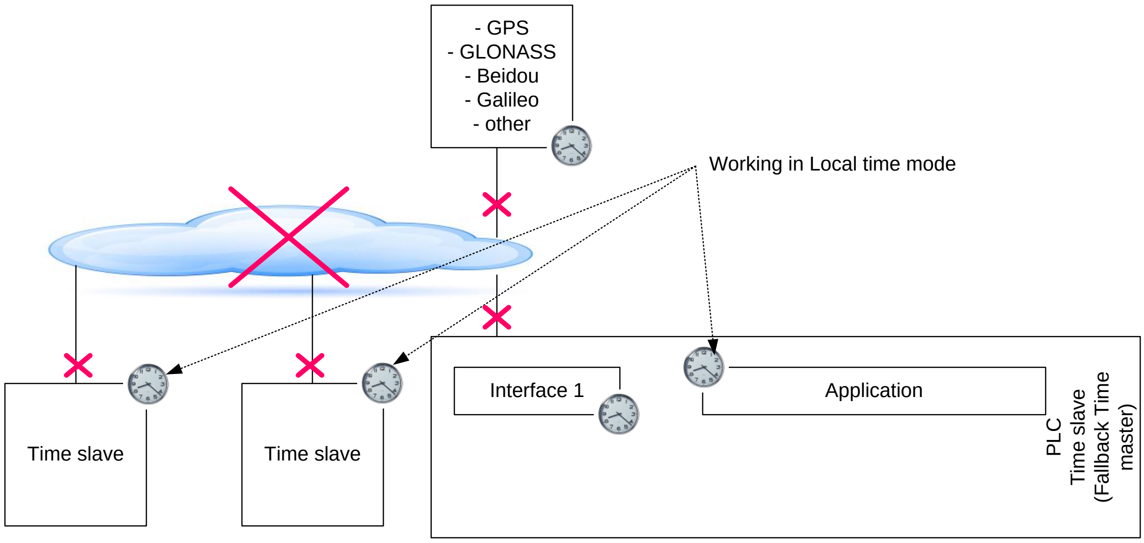

Figure 7 – Broken synchronization tree for Time

3 Working Clock

3.1 General

Working Clock is used to align actions machine or cell wide. The assigned timescale is arbitrary. Robots, motion control, numeric control and any kind of clocked / isochronous application rely on this timescale to make sure that actions are precisely interwoven as needed.

Figure 8 shows the principle structure of Working Clock synchronization which has the goal to establish a line / cell / machine wide aligned timescale. Thus, often PLCs, Motion Controller or Computerized Numerical Controller are used as Working Clock source.

If multiple PLCs, Motion Controller or Computerized Numerical Controller need to share one Working Clock timescale, an all-time active Ethernet Bridges may be used as Working Clock source.

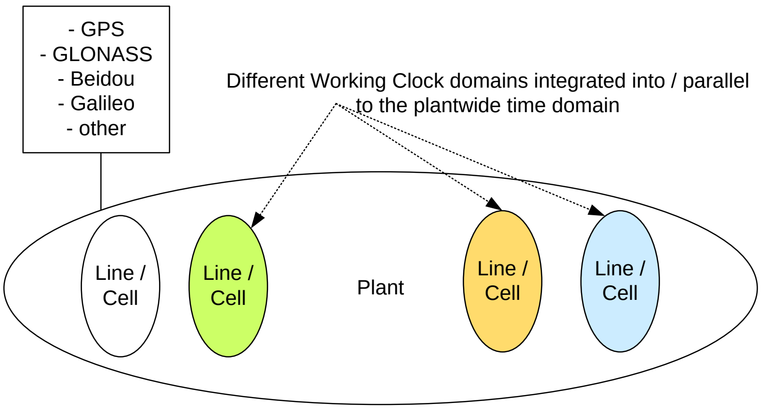

Figure 8 – Working Clock synchronization

Quality requirements for the Working Clock timescale are higher than for Time timescale.

In case of system failure master switchover time is critical to ensure the required Working Clock timescale quality.

Table 2 shows the used roles.

Table 2 – Working Clock – Roles and use cases

Role	Device	Comments
Working Clock master	PLC, others	Including redundant Working Clock master function
Working Clock slave	All	—

3.2 Working Clock master and slave

3.2.1 General

Support of the Working Clock timescale is a required function for each PLC. Thus, a PLC is part of the cell / machine wide synchronization tree.

Multiple Working Clock masters either in "hot standby" or "switchover" mode, normally an integrated function of a PLC, ensuring the robustness of the synchronization for their domain in case of temporary synchronization tree disturbance.

"Hot standby" with two concurrent sync trees supports bump less switchover. "Switchover" using one sync tree creates a bump when switchover.

Isochronous real-time applications (TSN HIGH) work no longer when losing synchronization, real-time applications (TSN LOW) should still work. Thus, SendListControl and CycleControl shall work with local WorkingClock during startup, lost global WorkingClock and re-synchronization of global WorkingClock.

3.2.2 Multiple interfaces

Figure 9, Figure 10, and Figure 11 show the synchronization trees in case of operational and broken connections for products with multiple Ethernet interfaces.

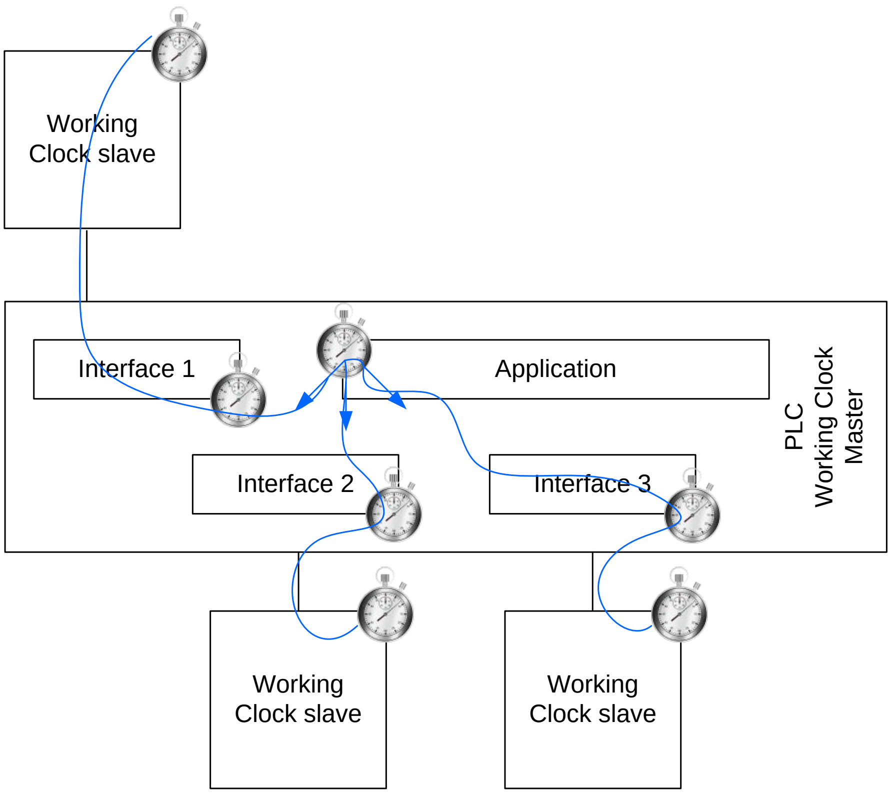

Figure 9 – Synchronization tree for Working Clock (simple)

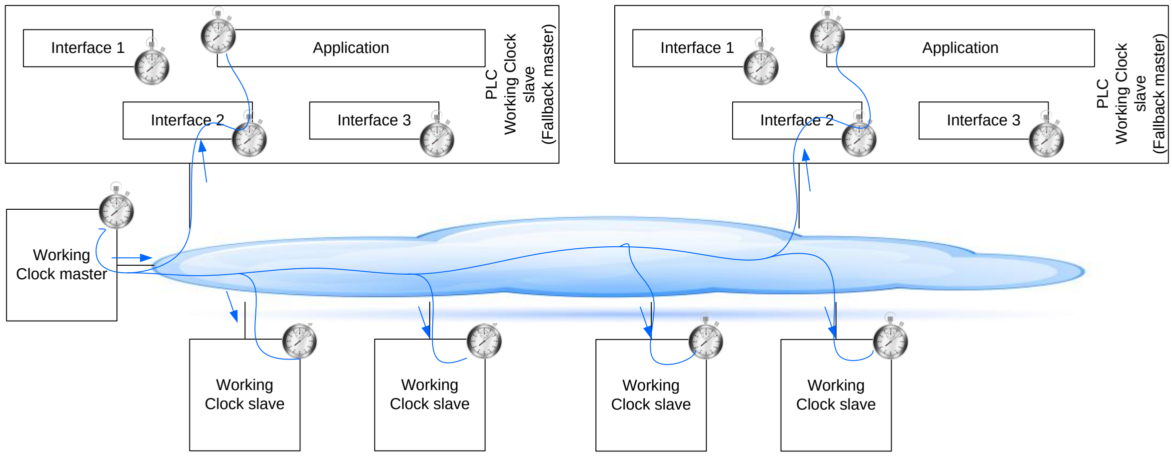

Figure 10 – Synchronization tree for Working Clock

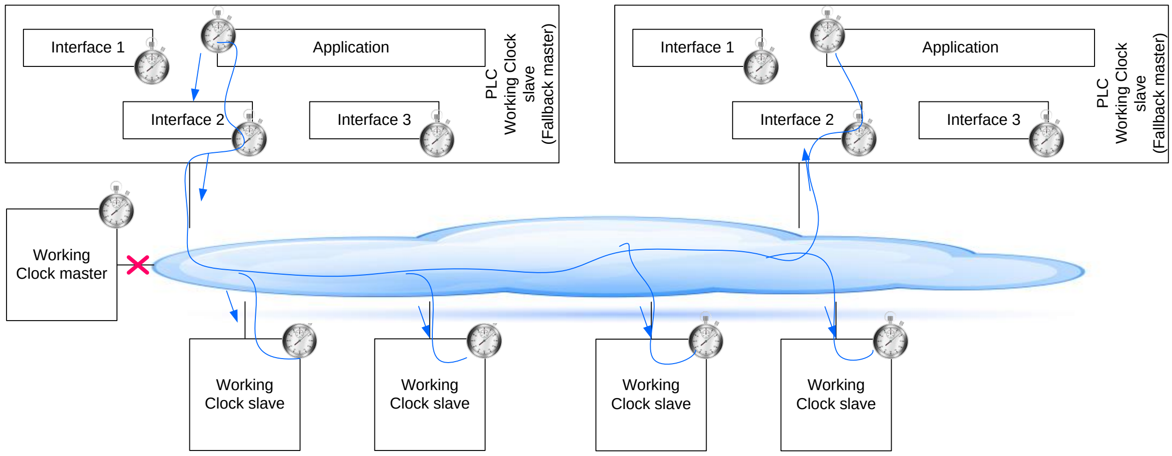

Figure 11 – Broken synchronization tree with "switchover" SyncMaster for Working Clock

3.2.3 Single interfaces

Figure 10 and Figure 11 show the synchronization trees in case of operational and broken connections for products with one Ethernet interfaces. These could be seen as devices with multiple Ethernet interfaces just using one of them.

3.3 Working Clock slave

A.1.2.3 General

Support of the Working Clock timescale is a required function for all devices. Thus, these devices are part of the line / cell /machine wide synchronization tree.

These devices switch to their local time entity maintaining the Working Clock timescale in case of temporary synchronization tree disturbance.

Single or multiple Ethernet interface do not differ in case of broken synchronization tree for these devices. Thus, only single Ethernet interface is shown.

A.1.2.4 Single interfaces

Figure 6 and Figure 7 show the synchronization trees in case of operational and broken connections for products with one Ethernet interfaces.

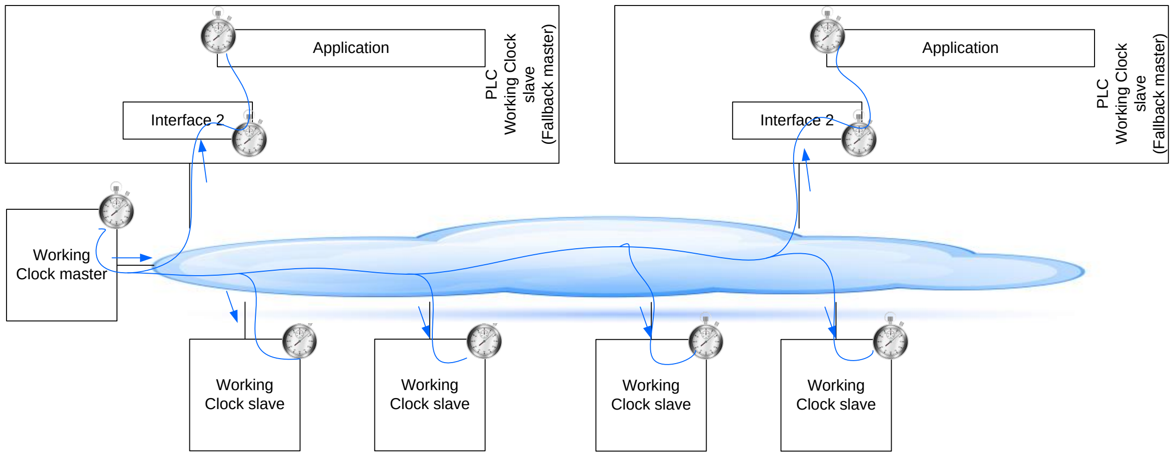

Figure12 – Synchronization tree for Working Clock

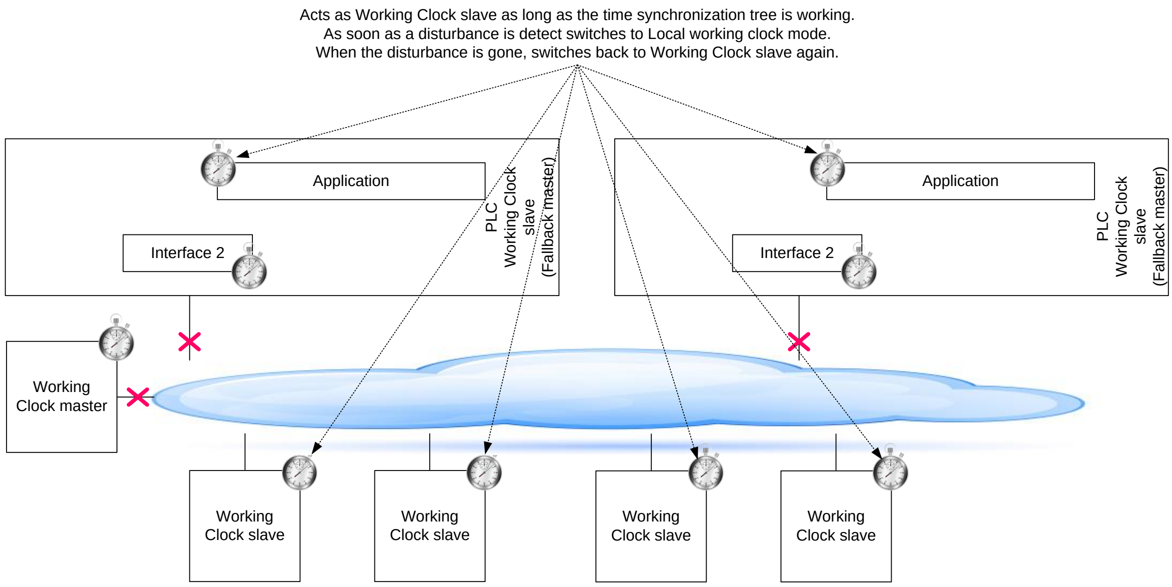

Figure 13 – Broken synchronization tree for Working Clock

A.1.2.5 Redundant SyncMasters

Figure 14 and Figure 15 show the synchronization trees in case of operational and broken connections for “hot standby” redundant SyncMasters together with products with one Ethernet interfaces.

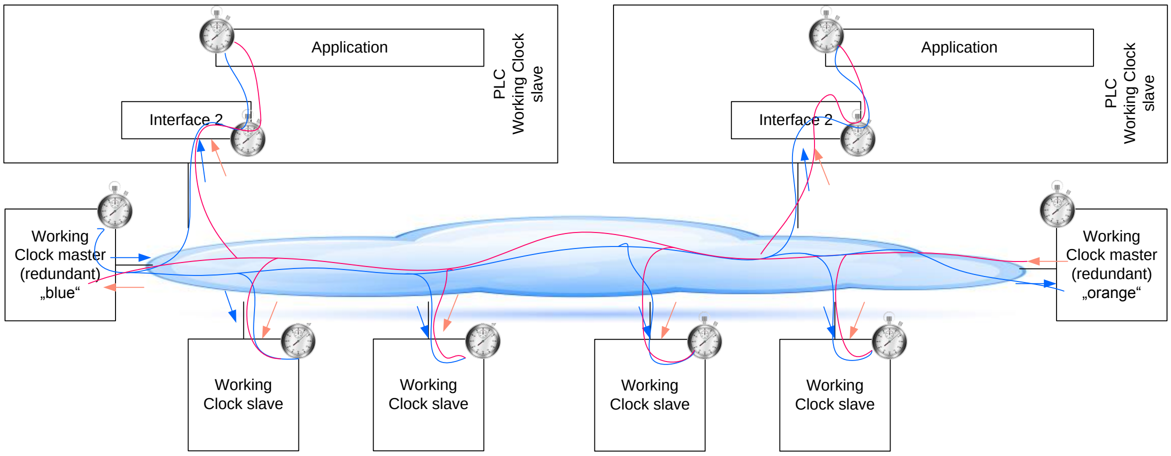

Figure 14 – Synchronization tree for redundant Working Clock

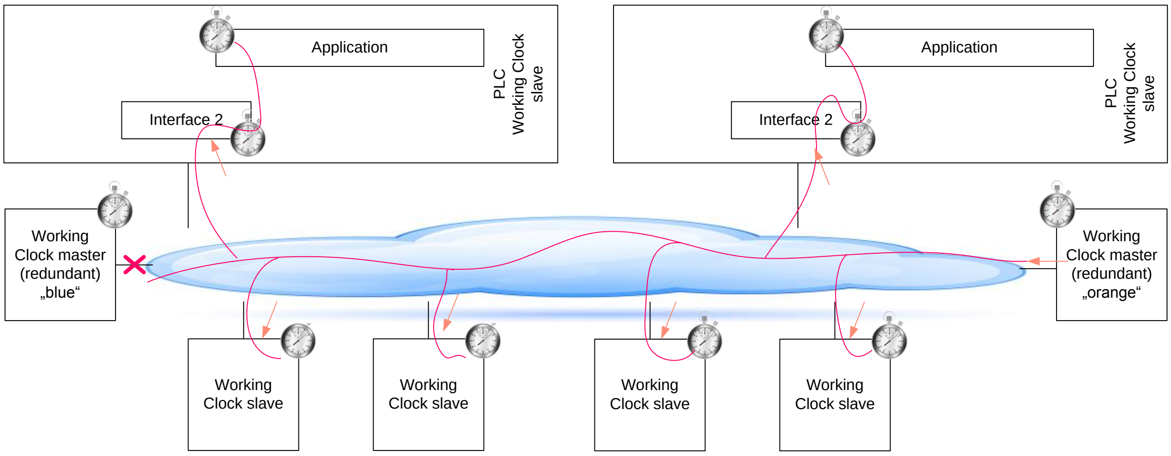

Figure 15 – Broken synchronization tree for “blue” Working Clock