Automation Domain Synchronization Requirements

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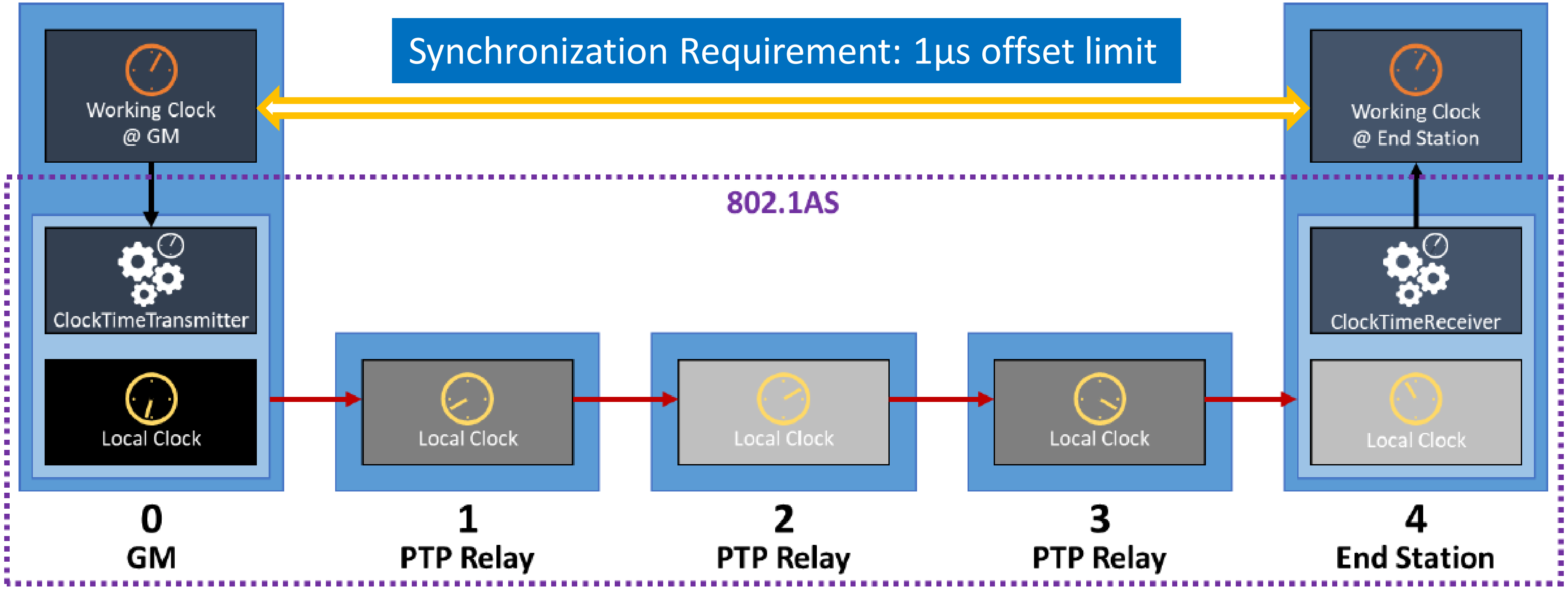
Line Topology



Influence of Grand Master on Synchronization Performance

Grand Master can be realized in different ways:

- The ClockMaster can get the time information from a ClockSource (which has its own oscillator different from the LocalClock oscillator), but in the simplest case it can rely on the oscillator of the LocalClock

- The ClockMaster can contain a control loop which guarantees a monotone Master Time, if necessary. Otherwise the time of the ClockSource can be forwarded directly to the adjacent Slave element as the Master Time.

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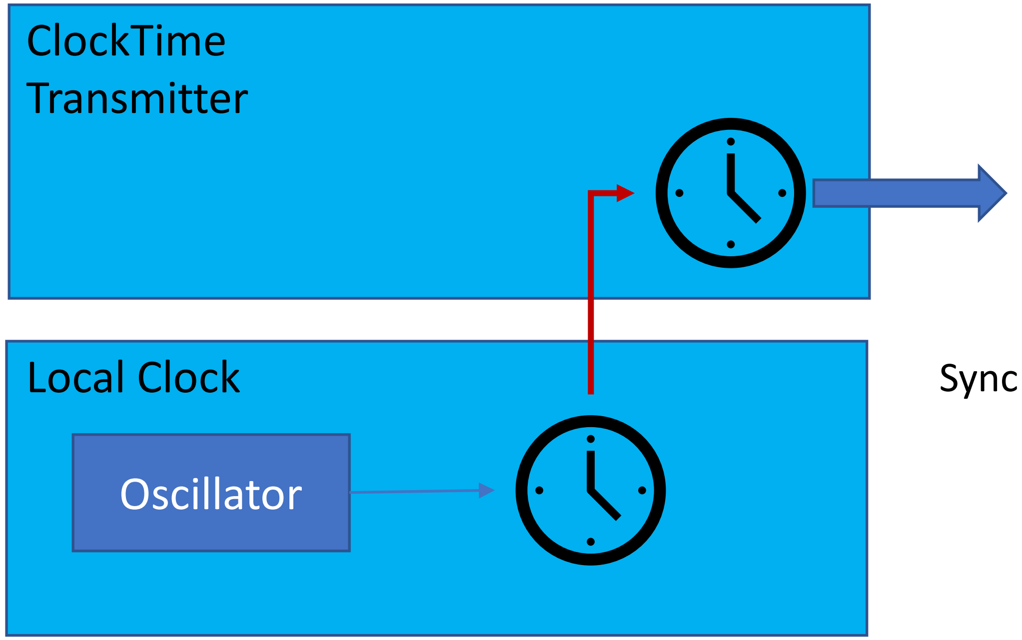
➔ The above scenarios define the Master Time and the internal (gmRR) and the external RR/NRR seen by the Slave elements in the line topology

Grand Master Element: Implementation 1



The ClockTime-Transmitter (ClockMaster) counts the ticks of the Oscillator of the LocalClock, i.e. it is a replica of the LocalClock. It is assumed that the time provided by the LocalClock is strictly monotone.

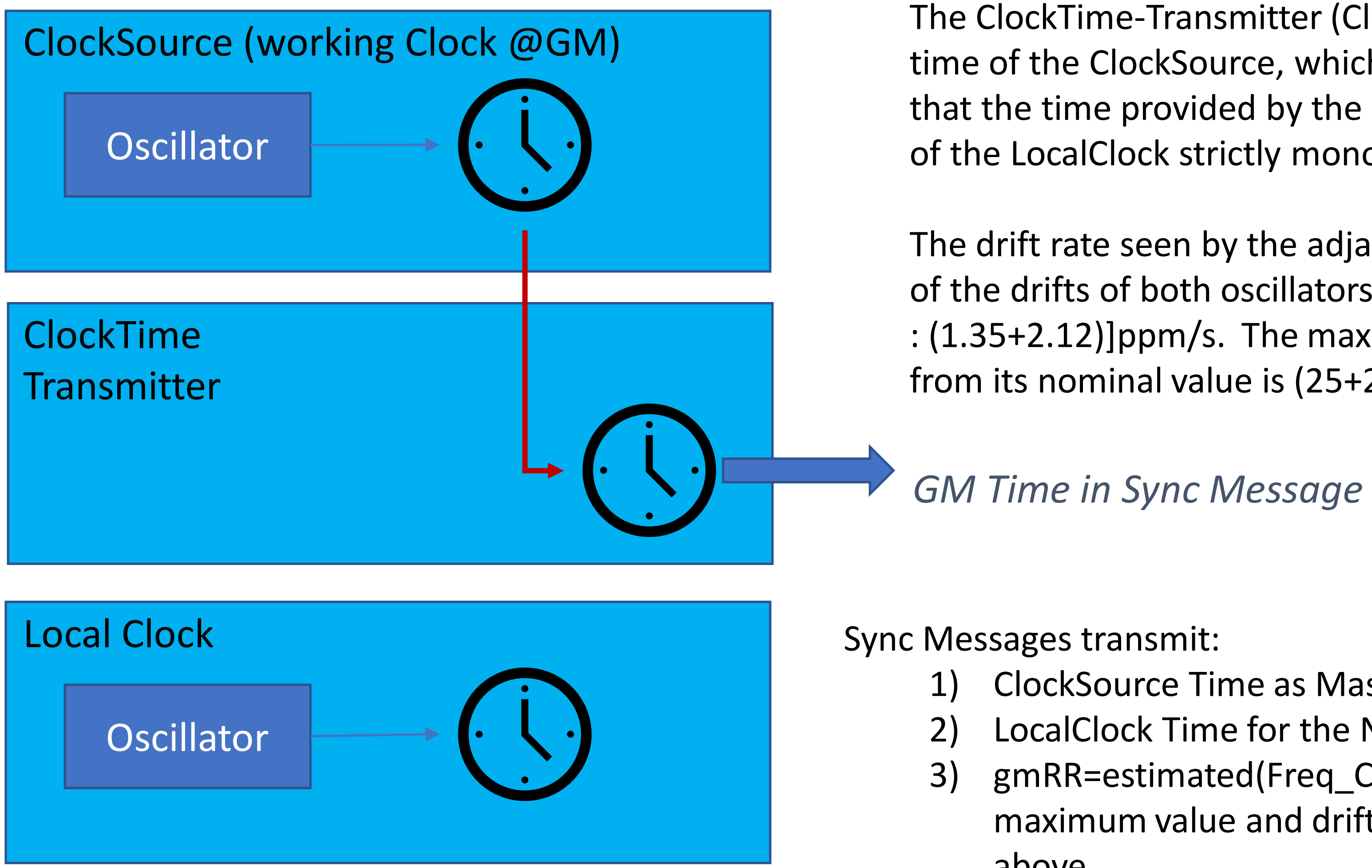
The maximum drift seen by the adjacent Slave element is in the range of [-1.35 : 2.12]ppm/s , with a maximum offset of 25ppm from the nominal frequency of the oscillator!

GM Time in Sync Message

Sync Messages transmit:

1) LocalClock Time as Master Time
2) LocalClock Time for the NRR calculation
3) gmRR=1 as internal RR

Grand Master Element: Implementation 2



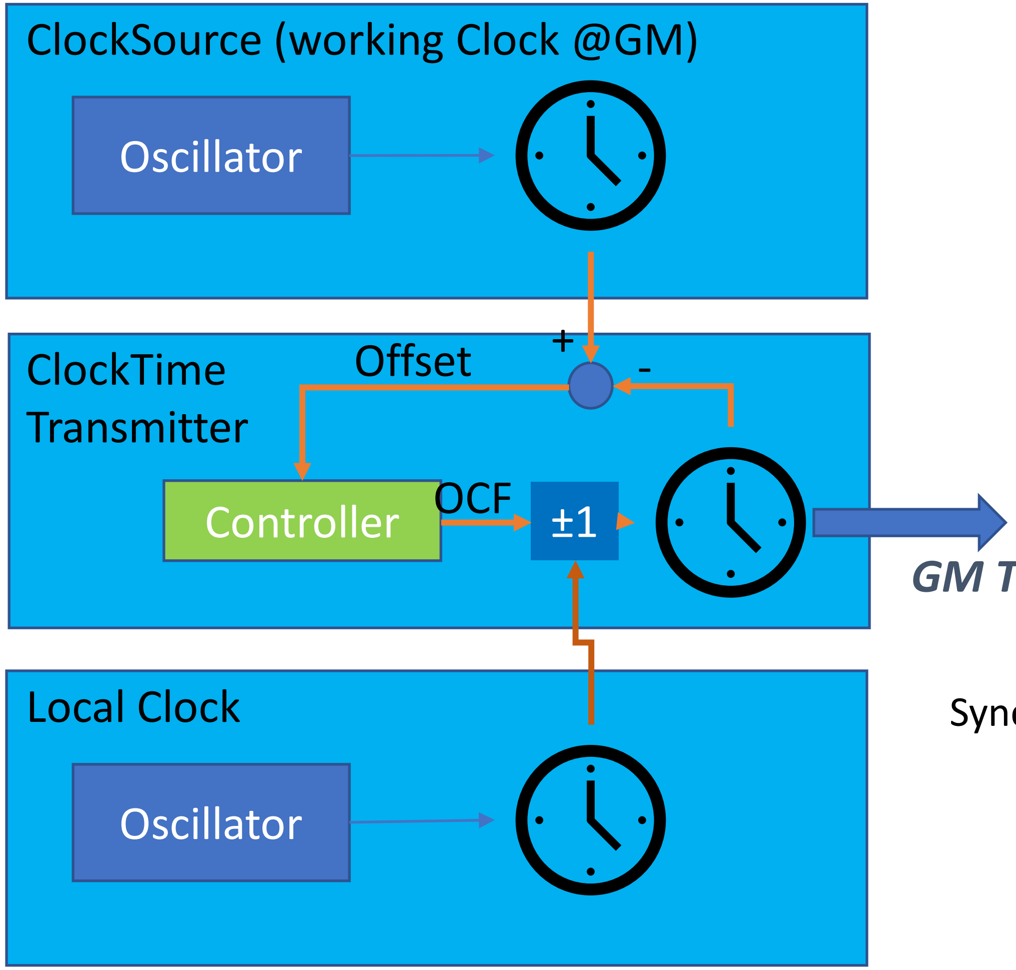
The ClockTime-Transmitter (ClockMaster) transmits directly the time of the ClockSource, which has its own oscillator. It is assumed that the time provided by the ClockSource is at least monotone and of the LocalClock strictly monotone.

The drift rate seen by the adjacent Slave element is a superposition of the drifts of both oscillators and it is in the range of [-(1.35+2.12) : (1.35+2.12)]ppm/s. The maximum constant offset of the gmRR from its nominal value is (25+25=50)ppm.

Sync Messages transmit:

1) ClockSource Time as Master Time
2) LocalClock Time for the NRR calculation
3) gmRR=estimated(Freq_ClockSource/Freq_LocalClock), whose maximum value and drift-rate are bounded as described above

Grand Master Element: Implementation 3



The ClockTime-Transmitter (ClockMaster) uses a control loop to discipline the LocalClock (which has its own oscillator) to follow the ClockSource in a smooth fashion. It is assumed that the time provided by the ClockSource is not guaranteed to be monotone but the time of the LocalClock is strictly monotone.

The drift rate seen by the adjacent Slave element is a superposition of the control limit of +-3ppm/s and the drift of the LocalClock Oscillator of [-1.35 : 2.12]ppm/s. Hence the over drift can be greater than 5ppm/s!

Sync Messages transmit:

1) Controlled time as the Master Time
2) LocalClock Time for the NRR calculation
3) gmRR=OCF (the control signal in ppm/s), whose drift-rate is bounded as described above

Conclusions

- Some Grand Master implementations can lead to drift rates even larger than 5ppm/s
- Only the simplest implementation (#1) corresponds to the scenario used in the simulations so far
- The scenarios #2 and #3 should also be covered in the simulation because they are very frequent in automation applications
- How to simulate these additional scenarios?
- Proposal:
    - #2: “easy” to implement, requires the frequency time-evolutions of two oscillators
    - #3: more involved. Needs the frequency time-evolutions of two oscillators and a control signal which generates the Master Time. A controller can be included in the simulation or some typical controller behavior has to me modelled as a known signal.