802.1AS + Extensions for Industrial Communication

Siemens AG
IEEE 802.1 Plenary Session
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March 2011, Singapor
TAI Time + Working Clock used for Industrial Communication

**TAI Time**
- High accuracy (<1µs or 10µs) over 64 hops
- Used to timestamp events (distributed systems)
- Used to coordinate diagnostic information (e.g. measurement systems)

**One Working Clock within one domain**
- Synchronize applications (i.e. motion control)
- Working clock GM is not traceable to TAI or UTC
- Independent of TAI time synchronisation
- High accuracy (<1µs) over 32 hops
- Low quality oscillator (~50 ppm)
- Island for independent applications
- Island to guarantee high accuracy
- Independent units (e.g. motion control applications)
Use Case: Time Bridge for multiple Sync Domains

GM Timer Bridge to D1 computes
- cumulativeRateRatio between working clock D1 and TAI time D0
- CorrectionField for residence time of preciseOriginTimeStamp of TAI time in D0

Distribution of TAI time

GM Timer Bridge to D2 computes
- cumulativeRateRatio between working clock D2 and universal time D0
- CorrectionField for residence time of preciseOriginTimeStamp of TAI Time in D0 and D2
Proposal to add new Alternate Timescale TLV

- IEEE1588 specified ALTERNATE TIME OFFSET INDICATOR TLV
  - keyField
  - currentOffset
  - jumpSeconds
  - timeOfNextJump
  - displayName

=> The ALTERNATE TIME OFFSET INDICATOR TLV do not cover the requirements!

- New Alternate Timescale TLV’s for .1AS
  - Sync / followUp message TLV
    - relatedDomain
    - GMT /*preciseOriginTimestamp*/
    - correctionField /*residence time of preciseOriginTimeStamp in the network*/
    - cumulativeRateRatio /*rate ratio to GM of related domain*/
  - Announce message TLV
    - relatedDomain
    - keyField
    - jumpSeconds
    - timeOfNextJump
    - grandmasterPriority1
    - grandmasterClockQuality
    - grandmasterPriority2
    - grandmasterIdentity
    - timeSource
    - displayName
Calculations in Time Bridge D0 -> D1 + End Station in D1

- **Time Bridge calculates grandmaster rate ratio D1/D0**
  \[
  \text{GMTime}_{D0} = \text{preciseOrigingTimestamp}_{D0} + \text{followUpCorrectionField}_{D0}
  \]
  \[
  \text{GMRateRatio}_{D1/D0} = \frac{\left(\text{GMTime}_{D0}\right)_N - \left(\text{GMTime}_{D0}\right)_0}{\left(\text{GMTime}_{\text{SyncEventIngressTimestamp}_{D1}}\right)_N - \left(\text{GMTime}_{\text{SyncEventIngressTimestamp}_{D1}}\right)_0}
  \]
  \[
  \text{cumulativeRateRatio} = \text{GMRateRatio}_{D1/D0}
  \]

- **Time Bridge calculates correctionField}_{D0**
  \[
  \text{CorrectionField} = \text{followUpCorrectionField}_{D0} + \\
  \left(\text{GMTime}_{\text{SyncEventGetGMTtimestamp}_{D1}} - \text{GMTime}_{\text{SyncEventIngressTimestamp}_{D1}}\right) \times \left(\text{GMRateRatio}_{D1/D0}\right)
  \]

- **Calculate GMTime}_{D0 at t in end station of domain D1**
  \[
  \text{GMTime}_{D0} = \text{GMTime} + \text{CorrectionField} + \left(\text{followUpCorrectionField}_{D1} \times \text{GMRateRatio}_{D1/D0}\right)
  \]
  \[
  \text{GMTime}(t_{D1})_{D0} = \text{GMTime}_{D0} + \left(t_{D1} - \text{GMTime}_{\text{SyncEvnethgressTimestamp}_{D1}}\right) \times \left(\text{GMRateRatio}_{D1/D0}\right)
  \]
Calculations in Time Bridge D1 -> D2 + End Station in D2

- Time Bridge calculates grandmaster cumulative rate ratio D2/D0

\[
\text{cumulativeRateRatio} = \text{cumulativeRateRatio} \times \text{GMrateRatio}_{D2/D1}
\]

- Time Bridge calculates correctionField\(_D0\)

\[
\text{CorrectionField} = \text{CorrectionField} + (\text{followUpCorrectionField}_{D1} \times \text{GMrateRatio}_{D1/D0}) + (\text{GMTime}_{\text{SyncEventGetGMTimestamp}_D2} - \text{GMTime}_{\text{SyncEventIngressTimestamp}_D2}) \times (\text{GMrateRatio}_{D2/D0})
\]

- Calculate \(\text{GMTime}_{D0}\) at \(t\) in end station of domain D2

\[
\text{GMTime}_{D0} = \text{GMTime} + \text{CorrectionField} + (\text{followUpCorrectonField}_{D2} \times \text{GMrateRatio}_{D2/D0})
\]

\[
\text{GMTime}(_t_{D2})_{D0} = \text{GMTime}_{D0} + (t_{D2} - \text{GMTime}_{\text{SyncEventIngressTimestamp}_D2}) \times (\text{GMrateRatio}_{D2/D0})
\]
Proposal to support multiple Sync Domains

- gPTP default domain number is 0
  - used for universal time synchronization

- Other domain number (1..7) shall be allowed
  - used for working clock synchronization
  - establischt Time Bridge automatically between different domains
Thank you!