

802.1AS + Extensions for Industrial Communication

Siemens AG

IEEE 802.1 Plenary Session

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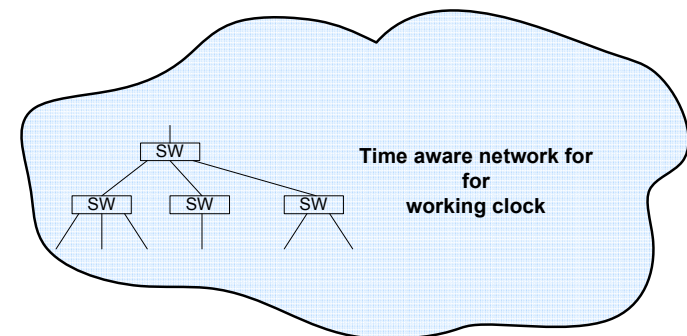
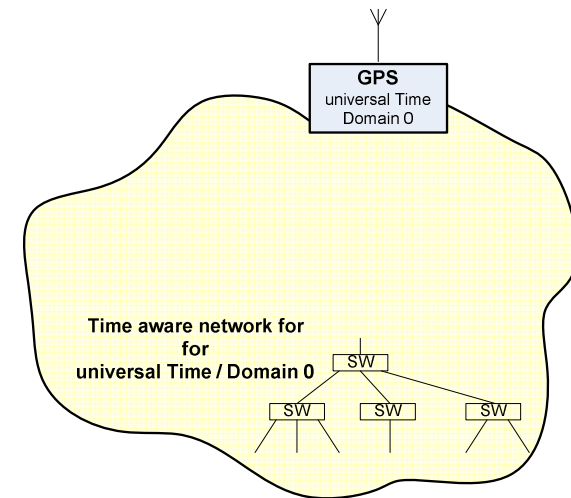
TAI Time + Working Clock used for Industrial Communication

TAI Time

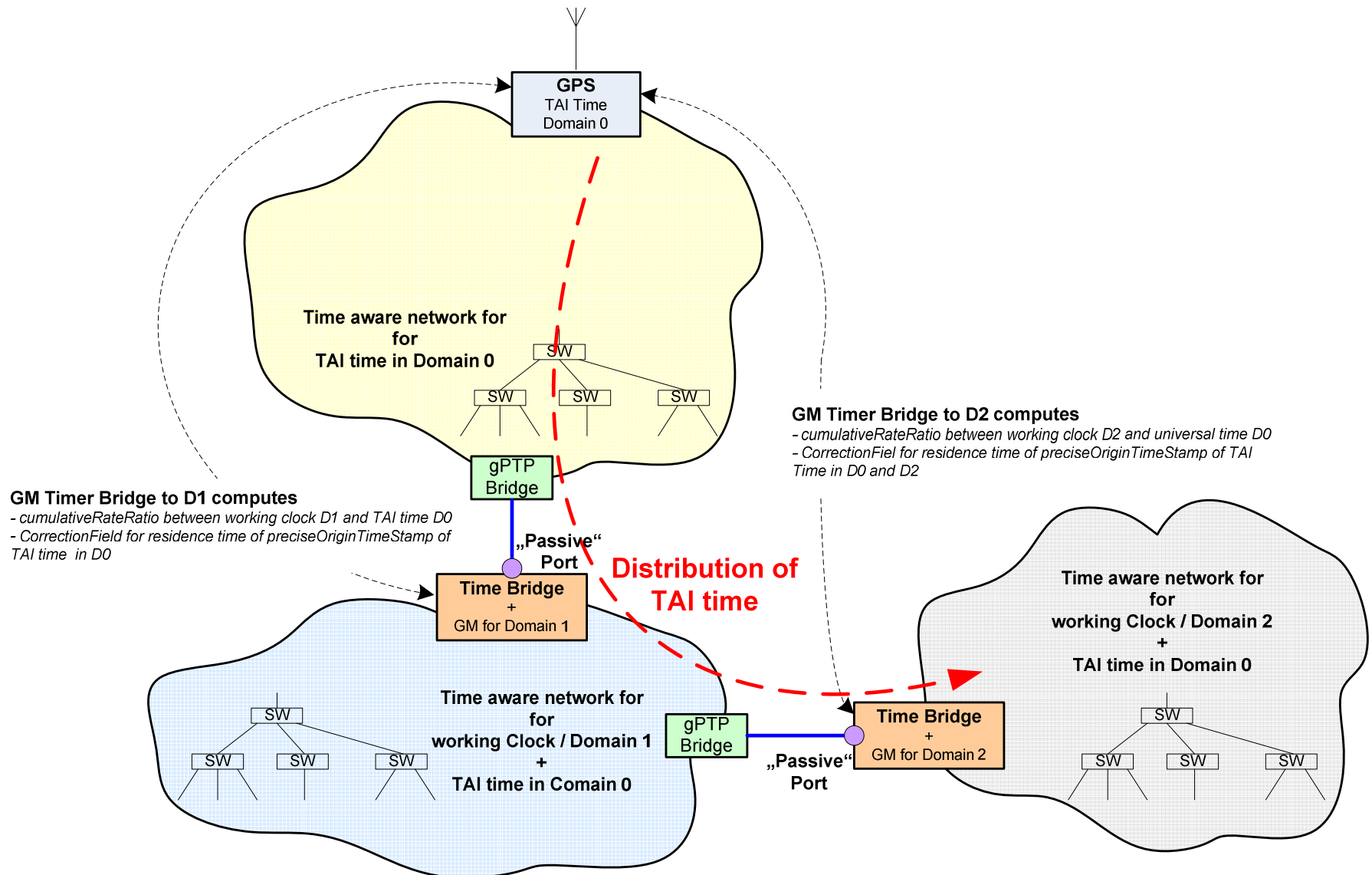
- High accuracy ($<1\mu\text{s}$ or $10\mu\text{s}$) over 64 hops
- Used to timestamp events (distributed systems)
- Used to coordinate diagnostic information (e. g. measurement systems)

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 ($<1\mu\text{s}$) 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



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
- GMTTime */*preciseOriginTimestamp*/*
- correctionField */*residence time of preciseOriginTimeStamp in the network*/*
- cumulativeRateRatio */*rate ratio to GM of related domain*/*

- Announce message TLV

- relatedDomain
- keyFiled
- 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

$$GMTime_{D0} = preciseOrigingTimestamp_{D0} + followUpCorrectionField_{D0}$$

$$GMrateRatio_{D1/D0} = \frac{((GMTime_{D0})_N - (GMTime_{D0})_0)}{((GMTime_{SyncEventIngressTimestamp_D1})_N - (GMTime_{SyncEventIngressTimestamp_D1})_0)}$$

$$cumulativeRateRatio = GMrateRatio_{D1/D0}$$

- Time Bridge calculates correctionField_{D0}

$$CorrectionField = followUpCorrectionField_{D0} +$$

$$(GMTime_{SyncEventGetGMTimestamp_D1} - GMTime_{SyncEventIngressTimestamp_D1}) \times (GMrateRatio_{D1/D0})$$

- Calculate **GMTime_{D0}** at t in end station of domain D1

$$GMTime_{D0} = GMTime + CorrectionField + (followUpCorrectonField_{D1} \times GMrateRatio_{D1/D0})$$

$$GMTime(t_{D1})_{D0} = GMTime_{D0} + (t_{D1} - GMTime_{SyncEvnetIngressTimestamp_D1}) \times (GMrateRatio_{D1/D0})$$

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 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
 - establish Time Bridge automatically between different domains



Thank you!