IEEE 802.1ASbt for Industrial Networks

Industrial Requirements for Synchronization in Working Clock Domains

IEEE 802 Plenary Meeting - July 2014, San Diego

Feng Chen, Siemens AG
Franz-Josef Goetz, Siemens AG

SIEMENS

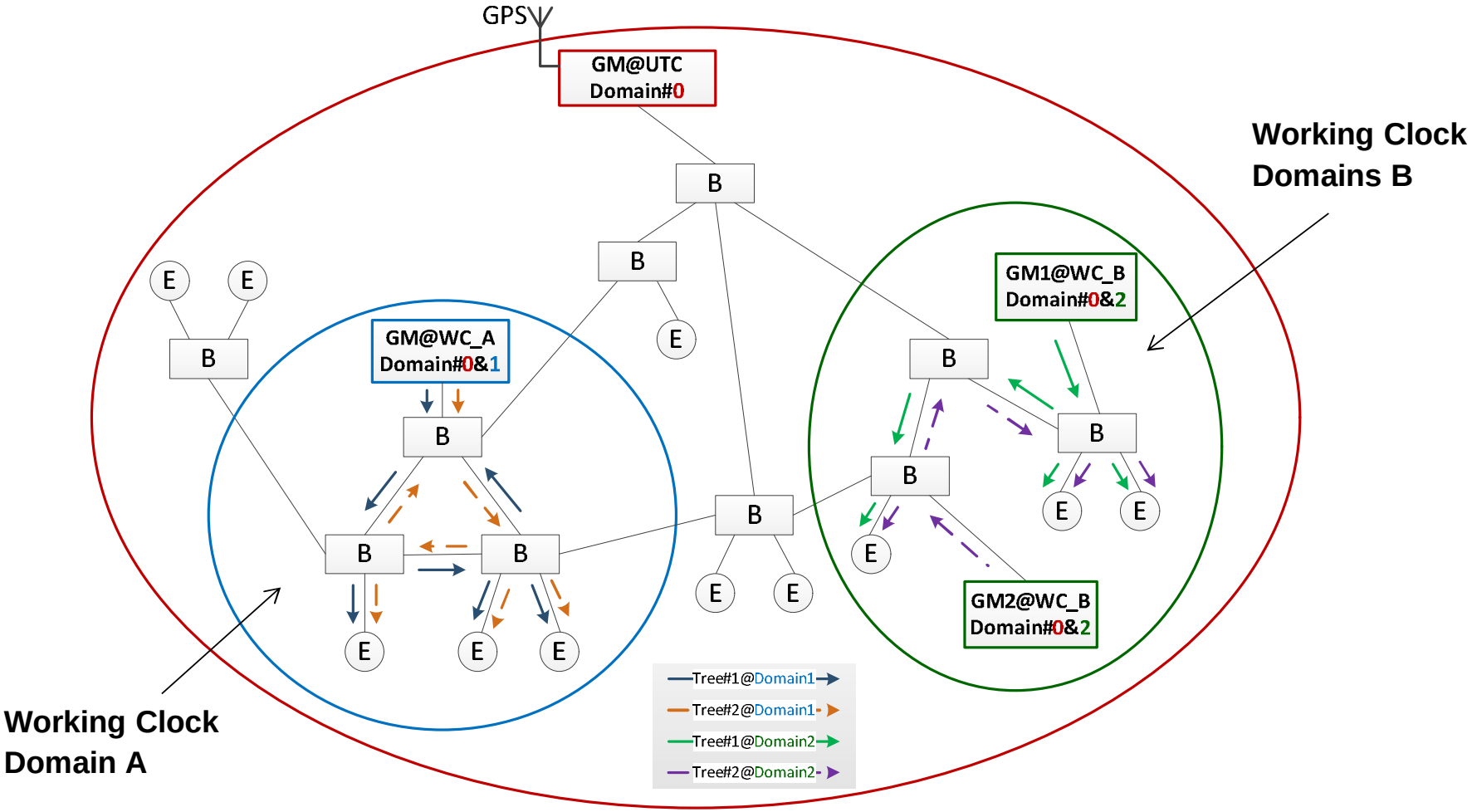
Contents

- Recap: (May in Norfolk)
  - "domains" is for time-scales, but better NOT for redundancy (redundant GMs)
  - the needs of using pre-calculated (or pre-reserved) paths for redundant sync
  - proposal for extending BMCA to support multiple grandmasters (GMs) (1st, 2nd, etc.) selection

    see http://www.ieee802.org/1/files/public/docs2014/as-chen-domain-redundancy-0514-v01.pdf

- In this presentation
  - focus on working clock sync domains where sync-demanding industrial control applications reside
  - address industrial requirements for high available time synchronization
  - present our proposals for redundancy features to be supported by ASbt
  - *Note!! We discuss redundancy only within the same working-clock domain, redundancy between different working-clock domains is NOT within the discuss scope*

Working Clock Domains



Why two time-scales are needed for industrial applications can be found here
http://www.ieee802.org/1/files/public/docs2013/as-goetz-TwoTimeScales-4-Industrial-20130114-v01.pdf

High Availability with Redundancy for Synchronization in Industrial Automation

SIEMENS

- Industrial automation requires high availability for time synchronization with zero GM take-over time or zero sync path switch-over time in case of master or link failure

- High availability is primarily achieved by redundancy, which can be realized by using either of the following two methods (or both of them)
  - **Redundant GM**: at least two GMs within the same sync domain, one as primary and the other one as secondary
  - **Redundant sync over disjoint paths:** one GM transmitting two sync msgs over two disjoint sync paths simultaneously

The goal of both methods is to let each end-station always receive multiple sync messages, so that in case of single point of failure receiving at least one sync can be guaranteed.

Link to the original proposal for redundant GM and redundant sync over disjoint paths
http://www.ieee802.org/1/files/public/docs2013/asbt-goetz-HighAvailableSync-0319-v02.pdf

High Availability with Redundancy for Synchronization in Industrial Automation

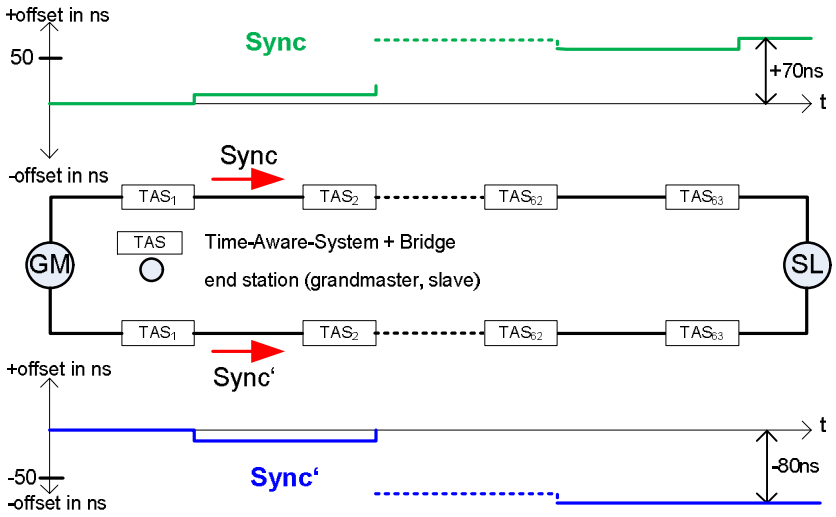
SIEMENS

- Benefits of high available synchronization for industrial automation
  - allow usage of cheap oscillators (lower requirements for hold-over time and frequency stability)
  - simply or improved PLC design (due to no lost of sync msgs, knowledge about sync quality redundant path)
  - guarantee high accuracy - in case of single failure
  - support long daisy chains (huge number of hop count e.g. 64)
  - maintenance function - knowledge about sync quality of primary and redundant sync path

- Reasons for inaccurate path delay measurement
  - time stamping accuracy / resolution
  - asymmetric delays (PHY, cable)
  - inaccurate neighbor rateratio measurement (neighbor frequency offset)
- Inaccurate sync residence time measurement for sync messages in Time-Aware-Systems
  - time stamp accuracy / resolution

⇒ **Huge hop count amplifies this problem**

Example for deviation between GM time (distributed over redundant Sync messages) and Slave local synchronized time



SIEMENS

Proposals for Redundant Grandmaster

- Two operating modes for one redundant GM
  - **Hot-stand-by:** always active transmitting sync
  - **Cold-stand-by:** only active when the primary one is not active

- Primary GM and redundant GM need to be synchronized to each other
  - because they are expected to distribute timing information based on the same working clock time-scale

  = > **proposal**: they should be configured **with the same domain number** (in the sense that domain is for separating different time scales)
  - using a different domain number for redundant GM will result in higher implementation and management overhead

- BMCA should be extended to support selection of multiple GMs, i.e. the best (usually be the primary GM), the 2nd best (be the redundant GM)

  see http://www.ieee802.org/1/files/public/docs2014/as-chen-domain-redundancy-0514-v01.pdf

Proposals for Redundant Sync over Disjoint Paths

- Each GM transmits redundant sync msgs over two disjoint sync paths (or trees) simultaneously
  - Disjoint sync trees for each GM can be offline configured or runtime calculated e.g. by “ISIS-AS” + path computation algorithm (ToDo)

- Sync trees are distinguished by ***TreeID***
  - ***TreeID*** allocation is done as a result of sych path calculation
  - can be encoded in the DomainID field of sync msgs, so that sync forwarding is strictly based on ***TreeID***
  - ***TreeID*** must be unique for different sync trees, e.g. in one working clock domain, both primary and redundant GMs having their own redundant sync trees will need 4 TreeIDs

Additional Requirement to Guarantee High Accuracy over long Daisy Chains

SIEMENS

To guarantee high accuracy for synchronization over long daisy chains (e.g. hop count) in an industrial environment further aspects should be considered:

- Smaller sync interval (timeouts)
  - e.g. sync interval of 31.25ms for working clock, reduction of sync interval shall be forbidden -> increase of complexity
- Residence time of sync message within a Time-Aware-System / network
  - e.g. guaranteed max. residence time for sync message 1ms / hop to minimize PLC reaction time (clock slave) for long daisy chains
- Worst case frequency change in an industrial environment
  - e.g. 6ppm/s by GM change, caused by temperature change, vibration, mechanical shocks, pressure, …

⇒ IEEE802.1ASbt shall specify an default industrial parameter set is to fulfill the industrial requirements on synchronization

Thanks!

Questions?