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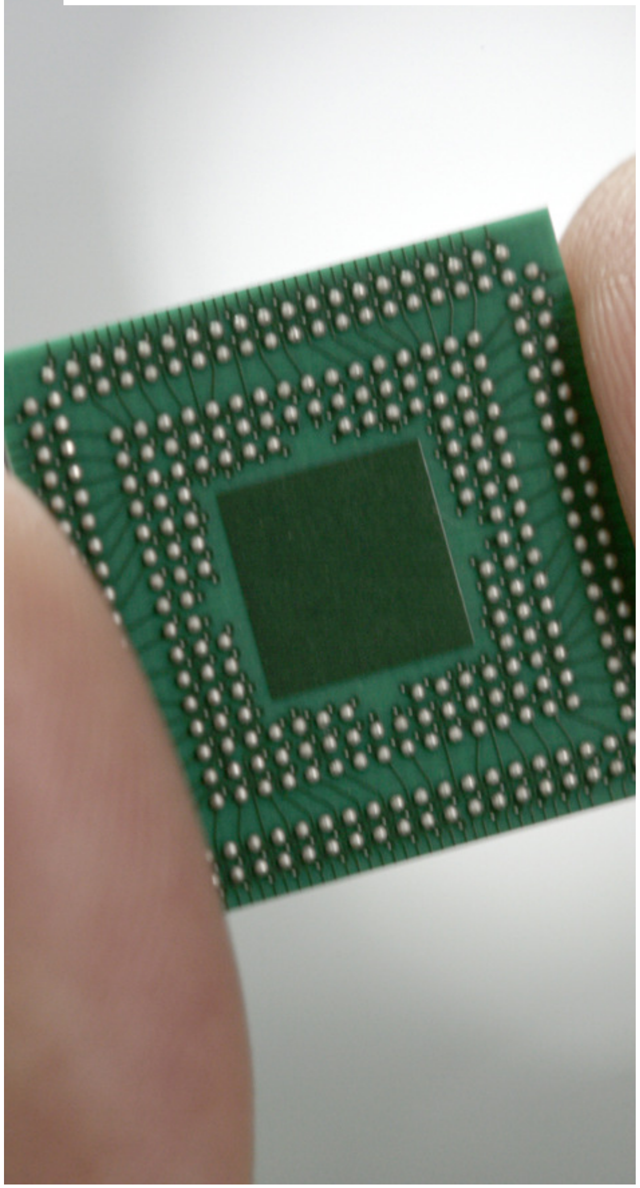

Two Timescales @ Industry

2012-03-11

IEEE 802.1 AVB Meeting – Waikoloa

Franz-Josef Goetz, Siemens AG

Why Two Time Scales for Industry

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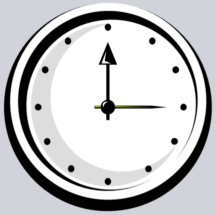
(1) Universal Time

- **Typical time source**
  - GPS Receiver
  - End station e.g. PLC (hand set universal time)
  - …

- **Need**
  - Universal time shall be available in whole network
  - Used to time stamping events (distributed systems)
  - Used to coordinate diagnostic information (e.g. measurement systems)
  - Used for recording process data
  - …



Universal time in each end station

Why Two Time Scales for Industry

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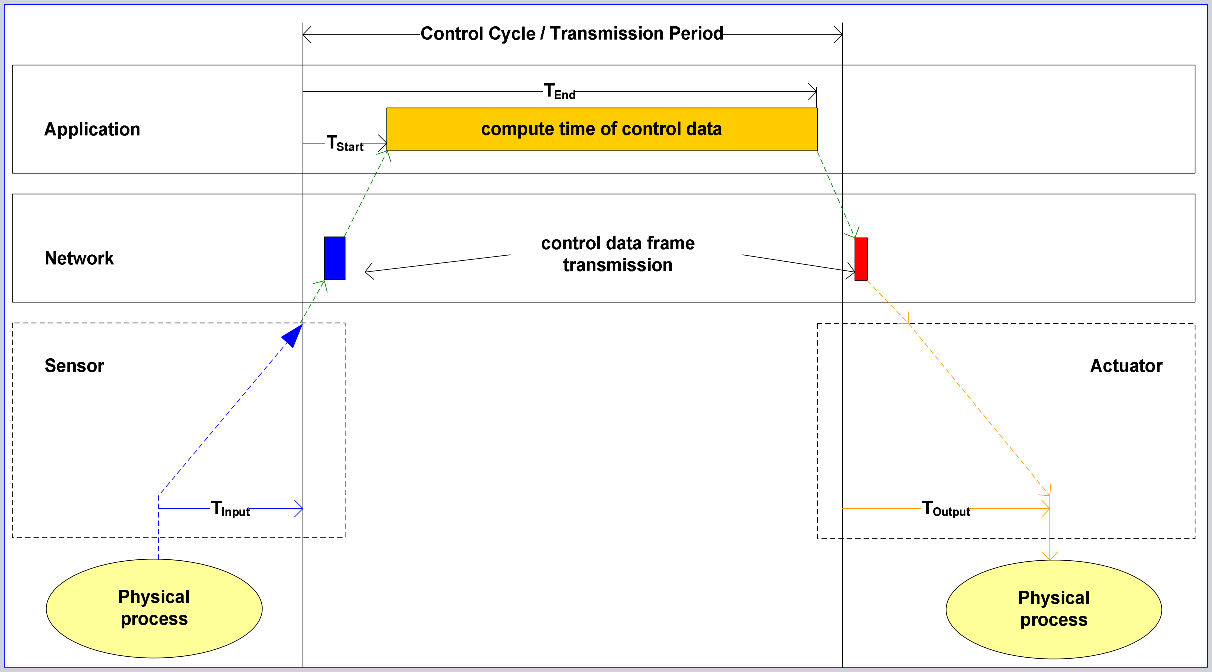
(2) Working Clock

- **Typical time source**
  - End station e.g. PLC
  - …
- **Need**
  - Synchronization for scheduled control data traffic
    - Time aware traffic shaper in end station
    - Time aware traffic shaper in bridges (if required)
  - Synchronization of sampling time
    - Input system (e.g. sensors)
  - Synchronization of actuators
    - Output system
  - Synchronization of applications (e.g. motion control loops)



Uses Cases for different Time Scales

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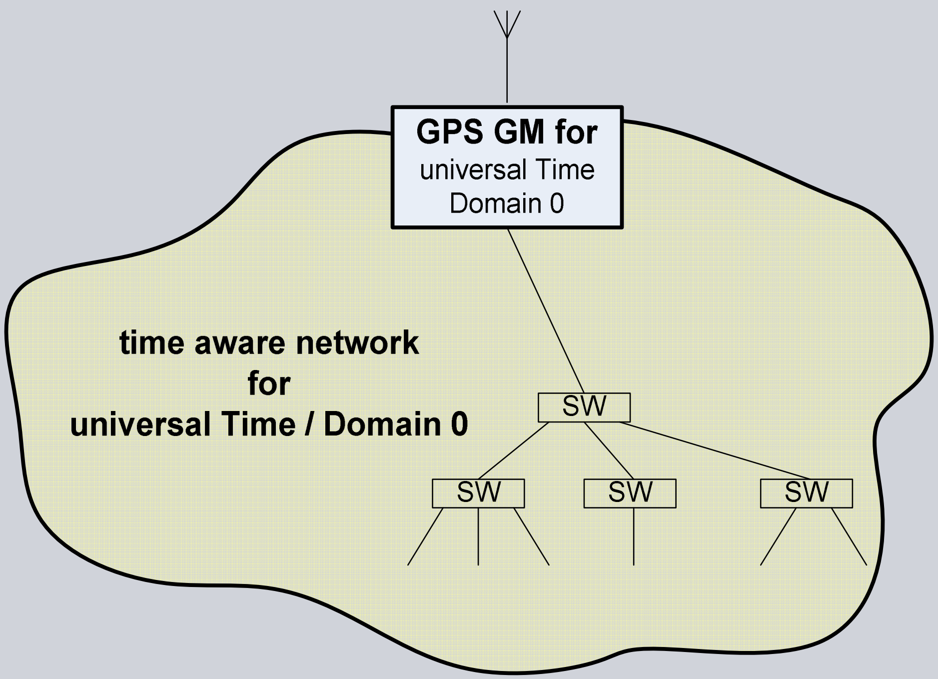
UC 1: gPTP (Gen 1) is used to synchronize universal time

Characteristic
- Plug and play
- Distributed over hole network
- Discontinuities allowed
- Dynamic sync tree reconfiguration
- Time source redundancy

Need
- Guaranteed take over time
- Sync path reconfiguration time
- Required accuracy (<100µs) over 128 hops

Restriction
- One Sync Domain
- Only two step mode



Uses Cases for different Time Scales

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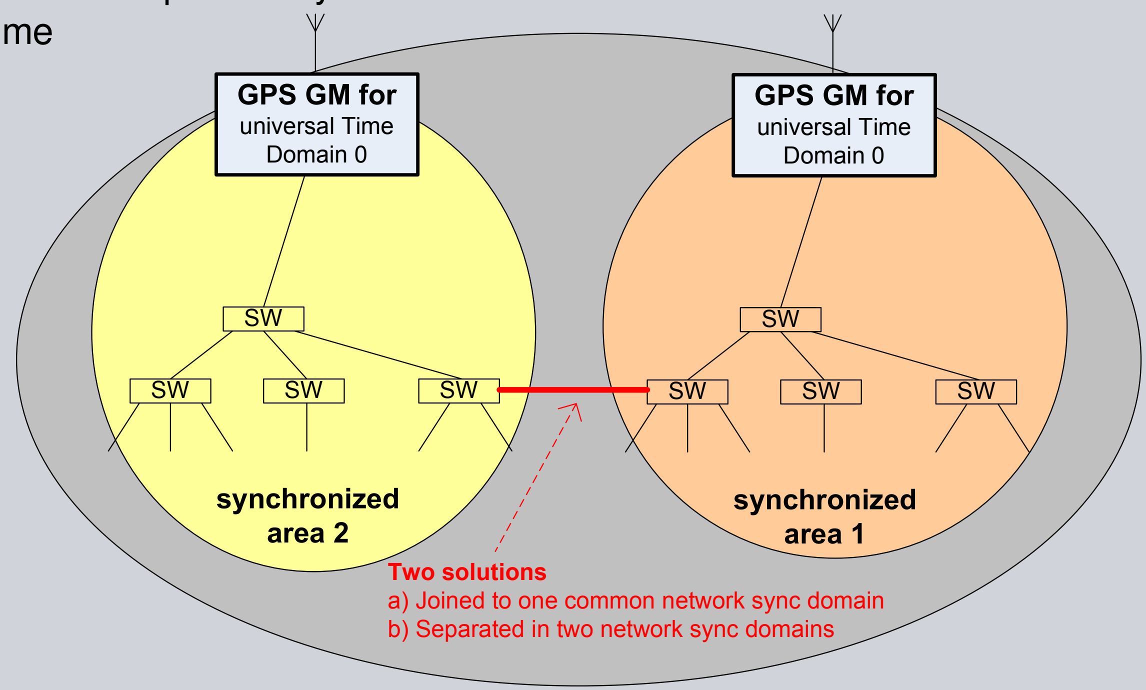
UC 2: Universal time is used for working clock

Characteristic
- Limited to restricted area (limited number of hop count) to guarantee accuracy
- Seamless operation of working clock can not be guaranteed

Need
- Join synchronized components without interruption of synchronization
- Connect further components at runtime
- Maintenance
- …

Restriction
- No guarantee for monotonic increasing time for working clock
- Working clock depends on universal time



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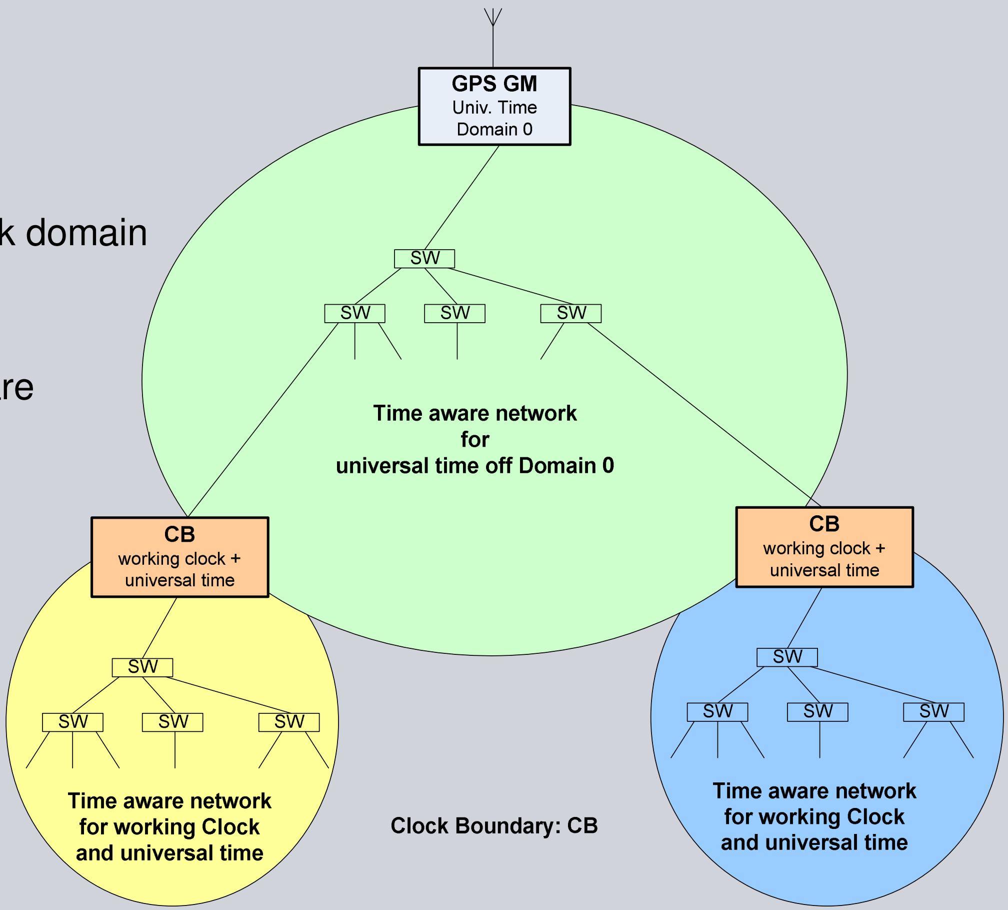
Uses Cases for different Time Scales

UC 3: Independent time scales

A) Hierarchical working Clock

- **Characteristic**
  - To guarantee accuracy within a working clock domain the working clock domain is separated by clock boundaries (CB's)
  - Temporary discontinuities of universal time are compensated by clock boundaries (CB's)
  - Time offset between universal time and working clock is announced e.g. alternate timescale TLV
  - *Options: Working clock is syntonized or synchronized to universal time*
- **Restriction**
  - Topology constraints (hierarchical)



(see http://www.ieee802.org/1/files/public/docs2011/as-goetz-altern-timescale-0311-v01.pdf)

Uses Cases for different Time Scales

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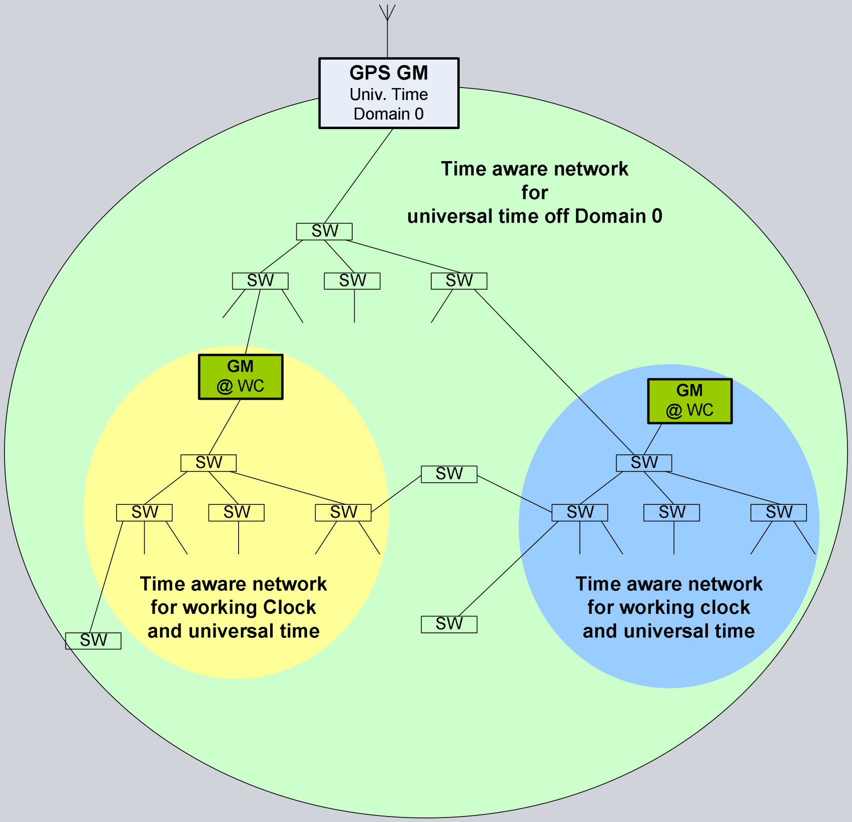
UC 3: Independent time scales

B) Topology independent working clock

- **Characteristic**
  - Working clock islands to guarantee high accuracy
    - High accuracy (<1µs) over 64 hops
  - Working Clock domains are planned or engineered (offline or online)
    - Components are configured at runtime while synchronization of universal time is already established and disturbed
  - Working clock shall be independent
    - Not must not be traceable to TAI or UTC
    - Typically is a monotonic increasing time
    - *Options: Working clock is syntonized or synchronized to universal time*



- **Restriction**
  - *No (to study)?*

Additional requirements for Working Clock

Seamless working clock operation

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High availability for working clock

Requirements

- Guaranteed take over time by grandmaster change < 200ms
- Guaranteed switch over time for slaves < 250ms
- Handle single point of failure (robustness)

Proposed solutions

- Preconfigured path for sync messages
- Preconfigured alternate path for sync messages
- Multiple grandmaster capable end station (typ. 2 - 3) or bridges in a working clock area w
  - At least one of capable grandmaster works in hot standby
- Error detection (synchronization quality and compare variance of sync propagation time)
- Redundancy sync messages (http://www.ieee802.org/1/files/public/docs2011/as-kweber-syncRedundancy-110914.pdf)

Conditions in industrial environment

- frequency change (Δf / f) / Δt @ industry
  (short term 0 – 3 ppm within a second, long term 0 – 5 ppm within a minute)

Multiple independent Time Scales in one network for Seamless Operation of Working clock

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Proposal

- **Mechanism specified in .1AS Gen 1 are used to synchronize universal time**

- **Mechanism for .1AS Gen 2 to support working clock in different time domain**

  - **Pdelay mechanism is used to identify and establish domain boundaries**
    - Introduction of domain identifier
    - Time aware bridges supports domain boundaries to isolated working clock domain (do not forwarding sync and announce messages to other domains)
    - Domain independent peer-to-peer path delay measurement

  - **Two sync and announce messages within a working clock domain**
    (grandmaster, slave and time aware bridges)
    - Introduction of domain identifier
    - Domain specific correction of residence time for sync messages (if domains are not syntonized)
    - Domain specific sync path and port roles

  - **Two timescales simultaneously (grandmaster, slave and time aware bridges)**
    - Universal time
    - Working Clock

=> Makes it easier to integrate further mechanism for seamless working clock operation (high availability)
(e.g. multiple sync path, alternate grandmaster, …)

Multiple independent Time Scales in one network for Seamless Operation of Working clock

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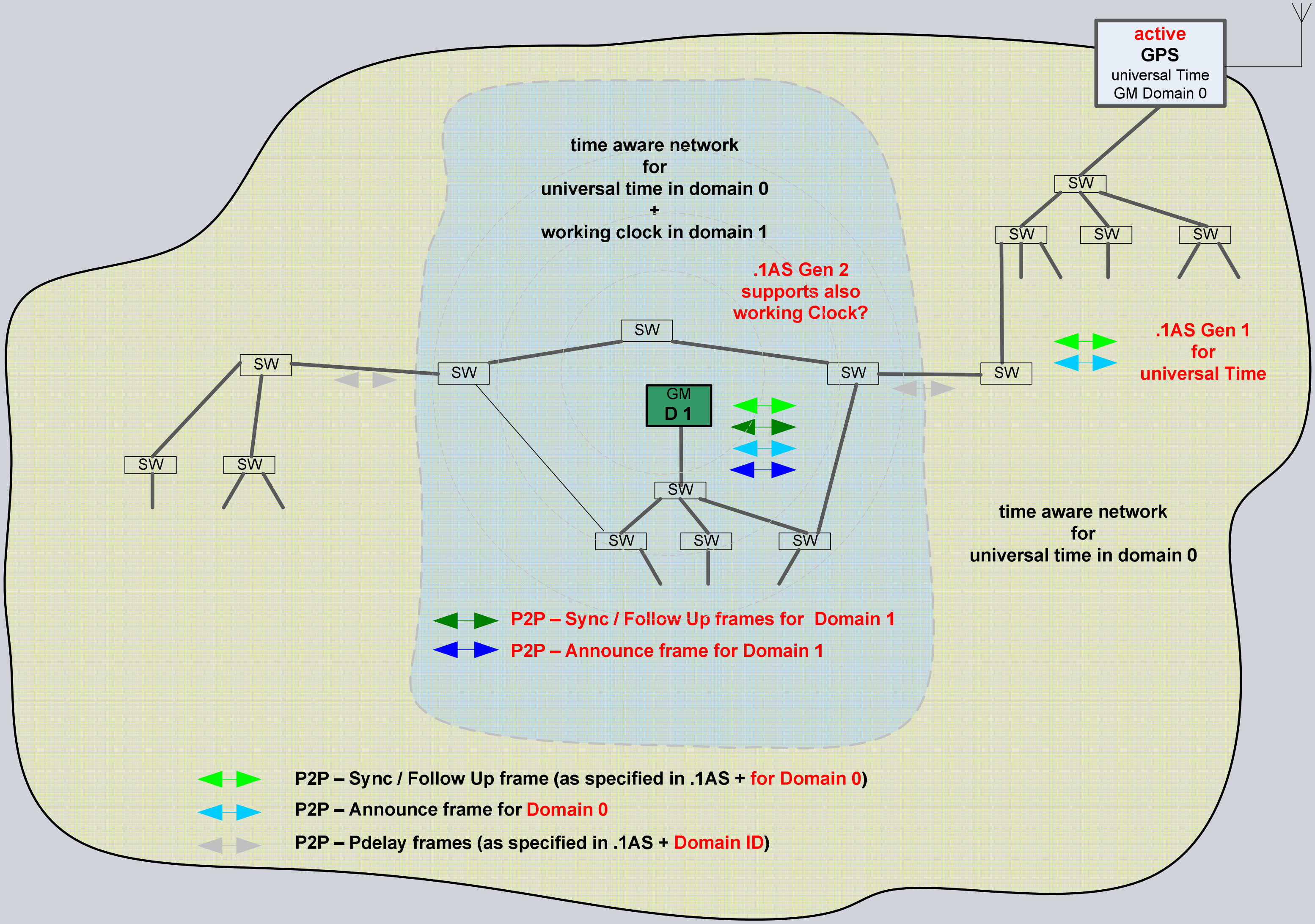

Multiple independent Time Scales in one network for Seamless Operation of Working clock

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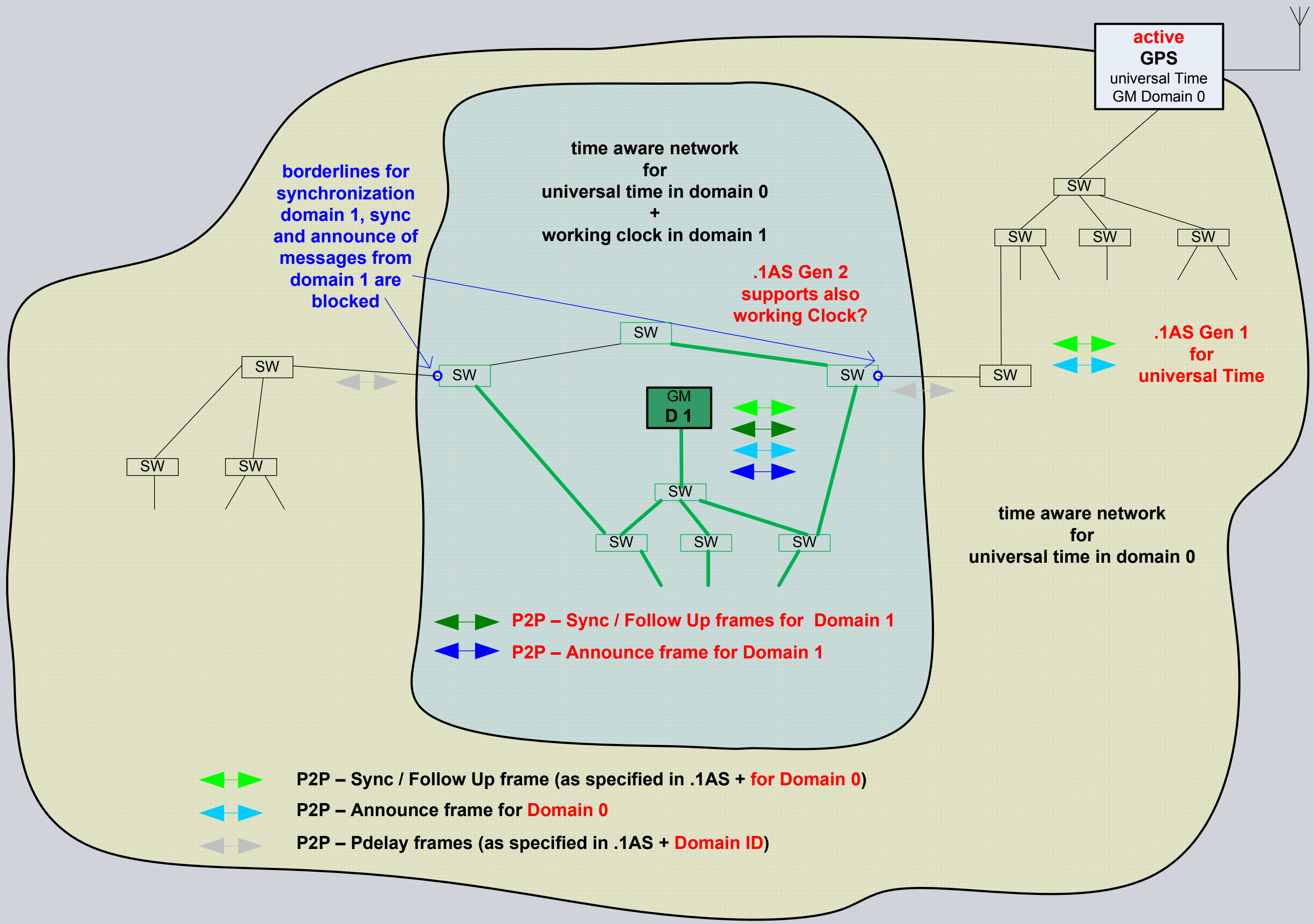

Finish

Further Questions?

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Further Extension for .1AS (Gen 2)

Bring in:

- E2E GM rate ratio – mandatory (at the moment local matter)
  - Huge hope count (64 hops <-> 8 hops)

- To discuss: 80 Bit (PTP) time stamp for Pdelay messages