IEEE 802.1 Time Synchronization

Support of Automatic Configuration in Working Clocks with Redundancy

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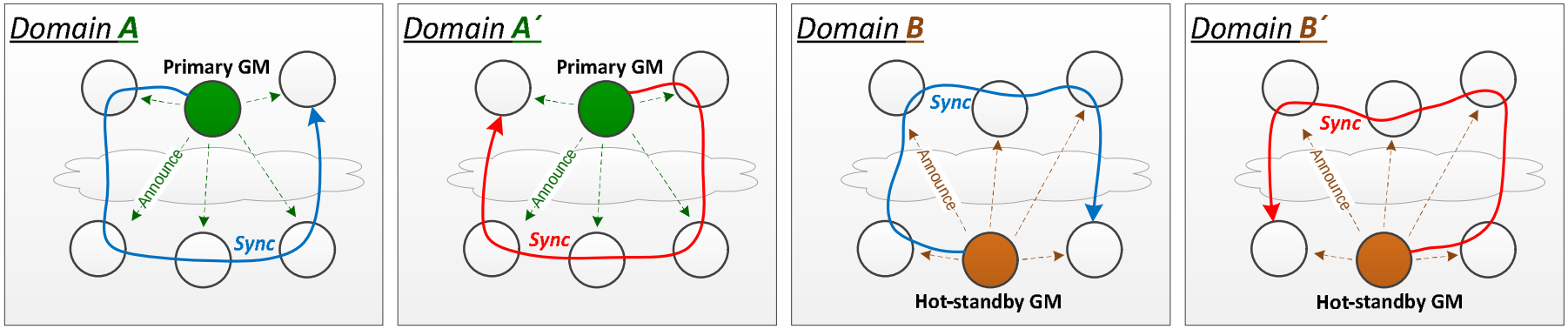
Recap

- Major feedbacks on the presentation at the Sept. Interim Meeting [1]
  - That proposal is semi-automatic, because management is still needed for configuration of *priority1* attributes
  - selection of redundant GM is conducted in more than one domains, which is fault-prone especially in error situations or misconfiguration



Proposals presented at the Sept. Interim Meeting

[1] http://www.ieee802.org/1/files/public/docs2015/as-chen-goetz-sync-redundancy-0915-v01.pdf

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Overview

- This presentation shows a new scheme, which supports automatic configuration of redundant GM in a working clock, including
  - a protocol for automatic GM selection/maintenance/reselection
  - a domain number encoding scheme for correlation of GM and Sync

Structured Industrial Network with Universal Time and Working Clocks

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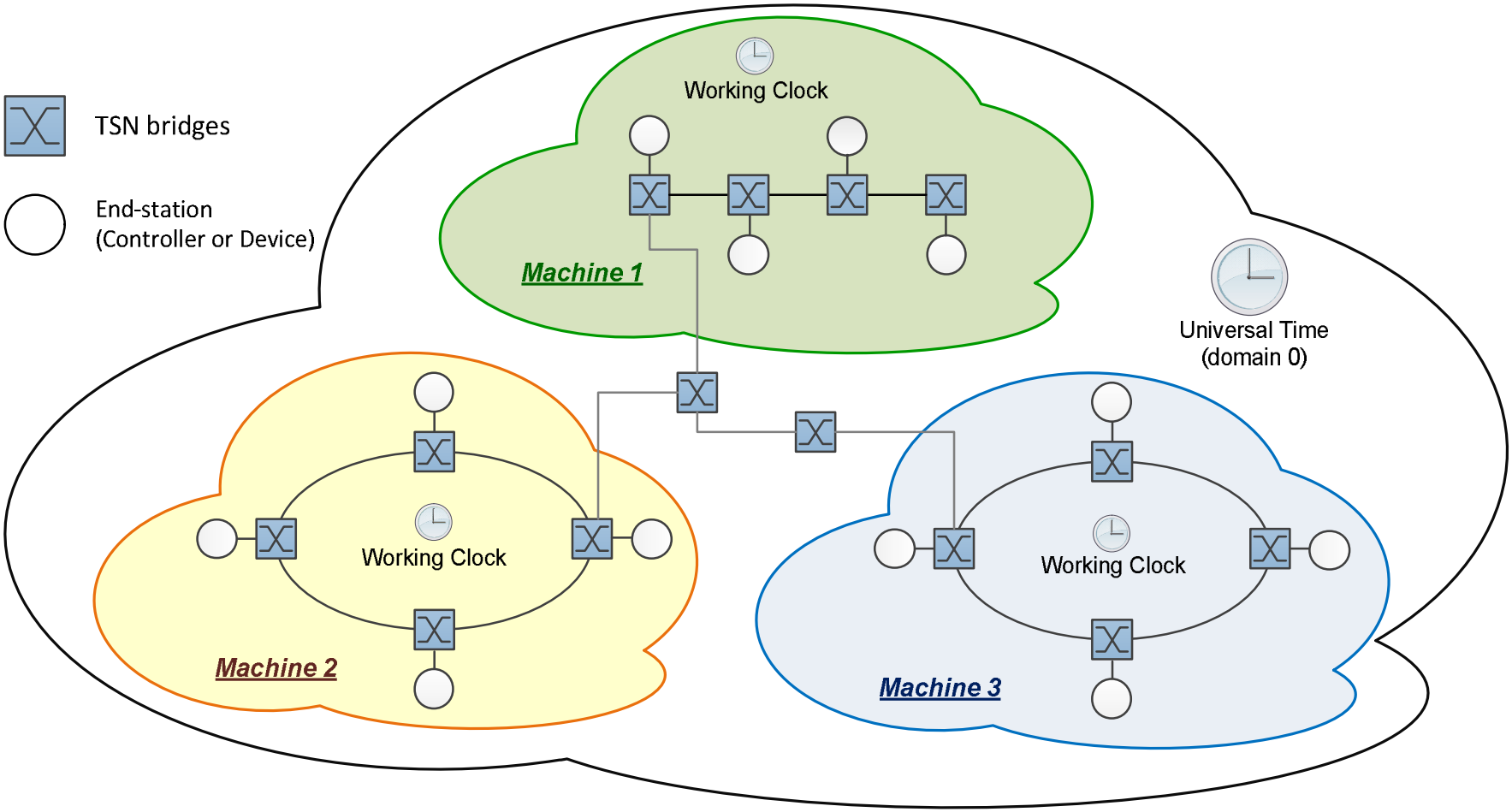

Requirements on Automatic GM Selection for Working Clocks with Redundancy

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- Use a distributed protocol to perform GM selection at run-time
  - assume not using a centralized controller to directly assign GM
  - support automatic configuration and re-selection in failure cases
- Select all redundant GMs in the same domain to achieve robustness and consistency, which guarantees that
  - both the primary GM and the hot-standby GM are selected from a same set of time-aware stations of a working clock
  - The selected primary GM and the hot-standby GM are NOT on the same clock (but the hot-standby GM is required to be synced to the primary one)

1. Automatic GM Selection in Working Clock

Proposal: BMCA+ with Announce+ msgs for automatic GM selection

Main features

- A distributed scheme to determine the best and the 2nd best clocks as primary and hot-standby GMs at run-time
- To be executed in a dedicated domain without Sync
  – call it "**Announce Domain**"
- Only for GM selection, **NOT** for construction of Sync tree
  - Sync trees will be established via *externalPortConfiguration* using other domain numbers – call them **"Sync Domains"**
- It is **plug&play**, no pre-configuration of attribute values like *priority1* is required!

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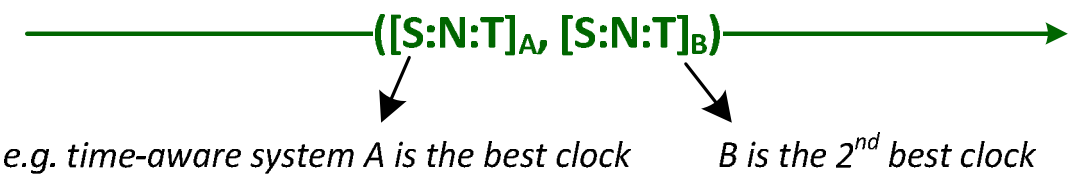
Announce+ Msgs

- Announce+ msgs
  - are peer-to-peer, carrying information of the best and the 2nd best clocks
  - are sent periodically or upon receiving new info
  - use sequence number for loop-prevention (not using a spanning tree)
  - use hold-time for failure detection/GM reselection

Infomation carried in the Announce+ Msgs to execute BMCA+



S – **systemIdentity:** *[priority1, clockClass, … , clockIdentity]*
N - **sequence number**: *generated by the owner of associated systemIdentity*
T - **holdtime**: *lifetime of associated systemIdentity*

BMCA+ Algorithms
(1) Startup

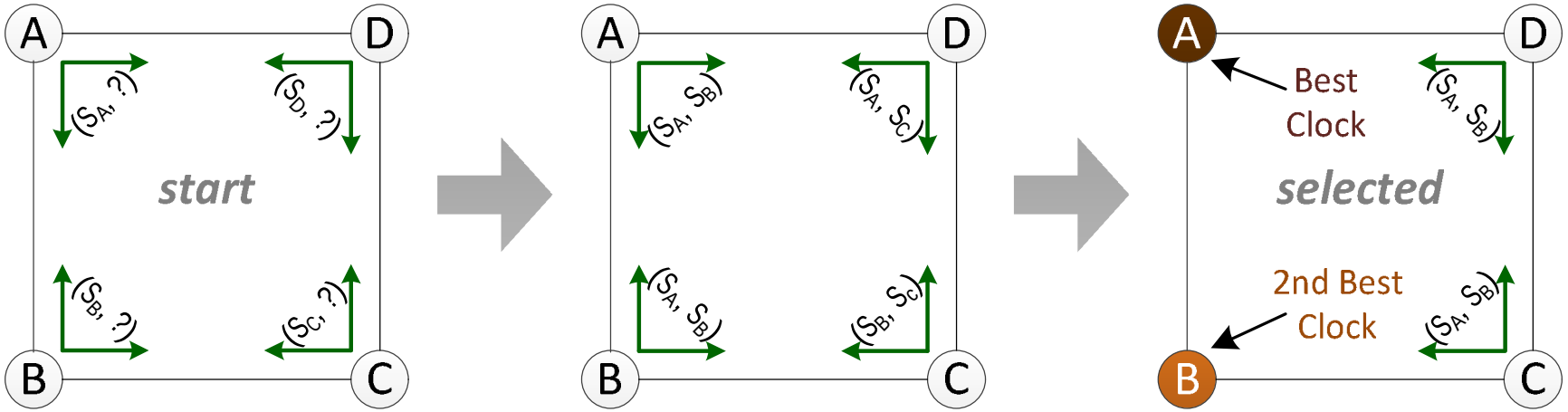


Fig. 1 The Startup phase of BMCA+

S_x: systemIdentity of the time-aware system X, (in this example we assume $S_A<S_B<S_C<S_D$)

—(S_A, S_B)→ Announce+ msg with the current best and 2nd best clocks info

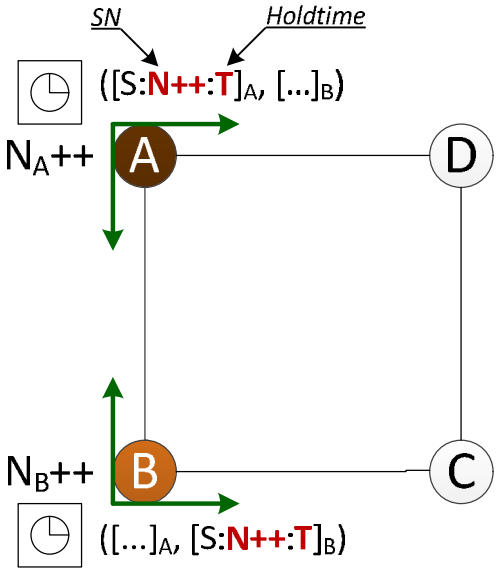
(note: for simplicity, only systemIdentity is shown in the above figure)

BMCA+ Algorithms
(2) Periodic Announce+ Transmission

- Each selected best clock periodically sends out Announce+ msgs containing an incremented sequence number – **refreshing process**
  - Upon receiving a refreshing Announce+, one should
    - conduct updating and then forward it (not over the receiving port) , if seeing an incremented SN for the same best clock
    - do nothing, if seeing a repeating SN for the same best clock – **loop prevention**

- Use hold-time for GM failure detection
  - Each selected best clock distributes the hold-time in the Announce+ msgs
  - If one does not receive a new refreshing Announce sent out by a current best clock within the hold-time, it will assume that best clock is gone and do reselection.
  - Hold-time shall be larger than the refreshing interval,

    e.g. Hold-time = 3 x refreshing interval



Summary:
Advantages of BMCA+ for Selection of Redundant GM

- BMCA+ supports selection and maintenance of multiple best clocks in one process (instance), which requires only one domain
  - .1AS BMCA relying on a RSTP tree can only select and maintain one best clock per domain, thus requiring multiple domains for multiple best clocks, which is error-prone in case of misconfiguration (consistency issue)

- BMCA+ scales better than the IS-IS method
  - In contrast to ISIS, BMCA+ requires only a small number of nodes (i.e. the number of best clocks to be selected) to perform periodic refreshing process (flooding), which applies also to the number of timers per node to perform hold-time monitoring.

- BMCA+ can be optimized for reduced convergence time in GM reselection
  - in addition to the needed number of active GMs, let BMCA+ select one more best clock as a backup GM
    - if needing only one active GM, select two best clocks (best and 2nd best)
    - if needing two active GMs (one primary and one hot-standby), then select three best clocks (best, 2nd best and 3rd best)

2. Example of Domain Number Allocation in a Working Clock

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Goals:

- automatic domains number allocation for a working clock with redundancy
- specify which domain numbers used in Announce+ and Sync Msgs over redundant trees
- correlate each GM with its associating Sync trees

Assumptions:

- use different domains for redundant Sync trees – *1588 proposal*
- use a separate domain to perform exclusively GM selection - *proposal in this presentation*
- assume not using a centralized controller to allocate domain numbers

Solution Example: encoding of domain number

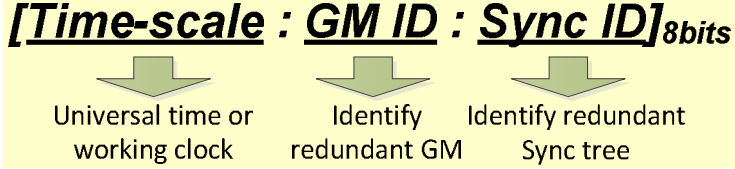
- not intended for .1AS resident in domain number 0

- divide the 8-bit domain number into three segments
  - ***Time-scale*** is set by network management

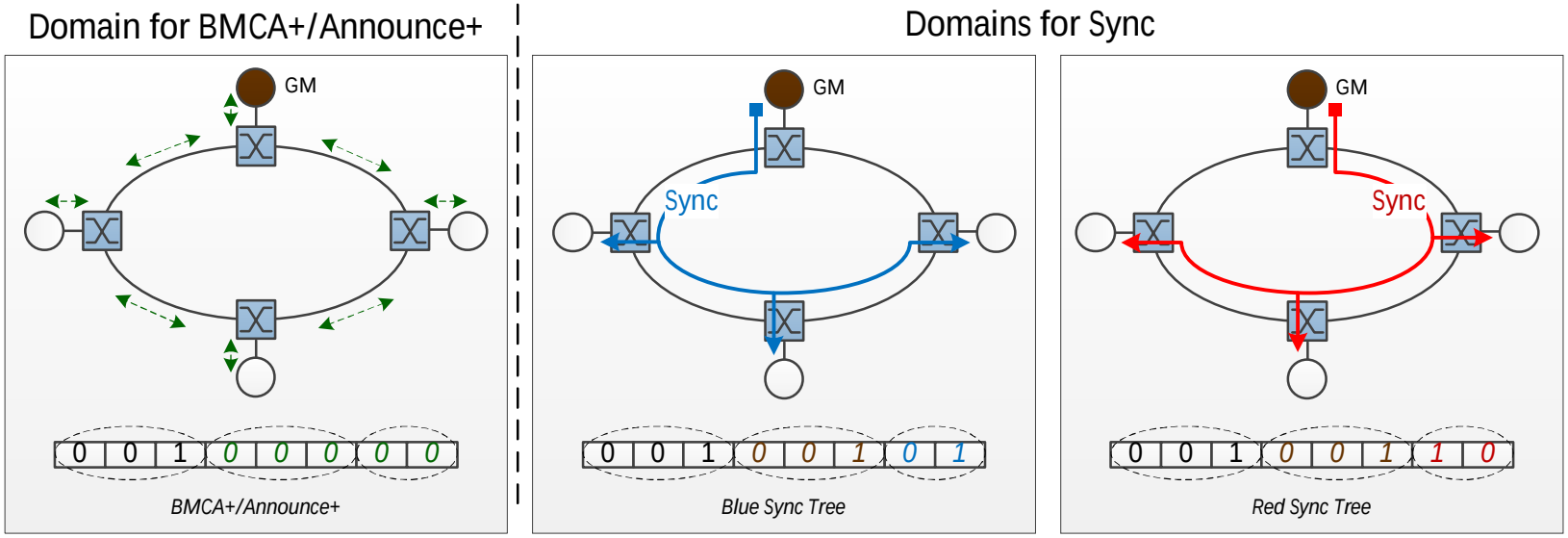
  - ***GM_ID*** is determined at run-time by the BMCA+ and distributed in the Announce+ Msgs assigned to each selected GM.

  - ***Sync_ID*** is determined at run-time by each selected GM

Example: Encoded Domain Number



Working Clock Example 1
Machine 2 with Sync Path Redundancy



Announce+ — *Announce+ msgs*

X X X X X X X X — *Coded domain number*

Sync — Sync — *MRTs (Maximally Redundant Trees) configured via external interfaces for redundant transmission of sync msgs*

Encoding scheme for Working Clock with Sync Path redundancy

	Time Scale (3 bits)			*GM ID (3 bits)*			*Sync ID (2 bits)*	
Domain for BMCA+/Announce+	0	0	1	0	*0*	*0*	0	0
Domain for the Blue Sync Tree	0	0	1	0	0	1	0	1
Domain for the Red Sync Tree	0	0	1	0	0	1	1	0

Working Clock Example 2
Machine 3 with GM and Sync Path Redundancy

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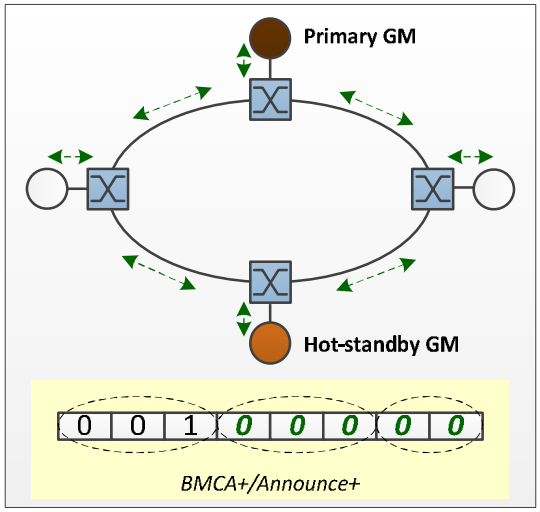
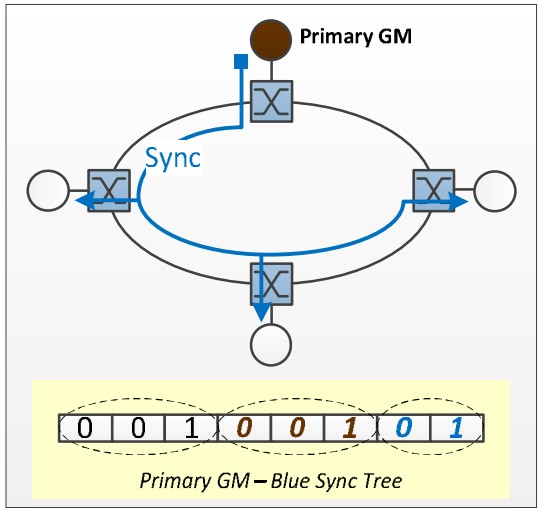
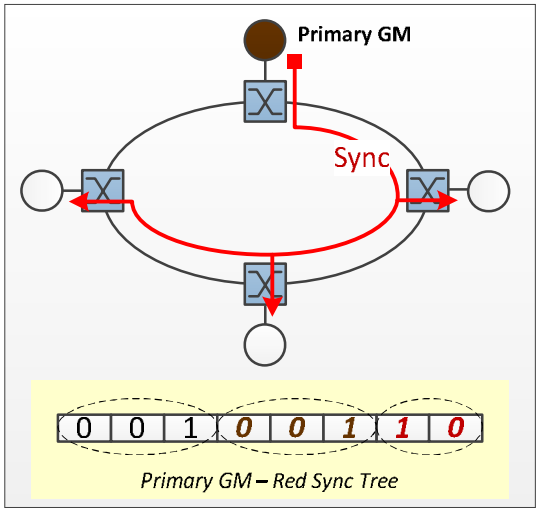
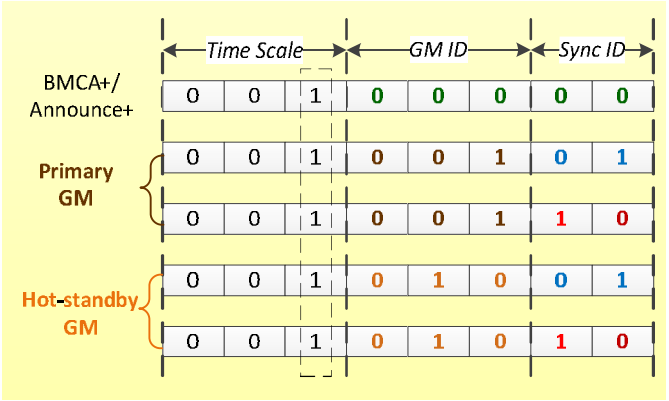
Domain for BMCA+/Announce+



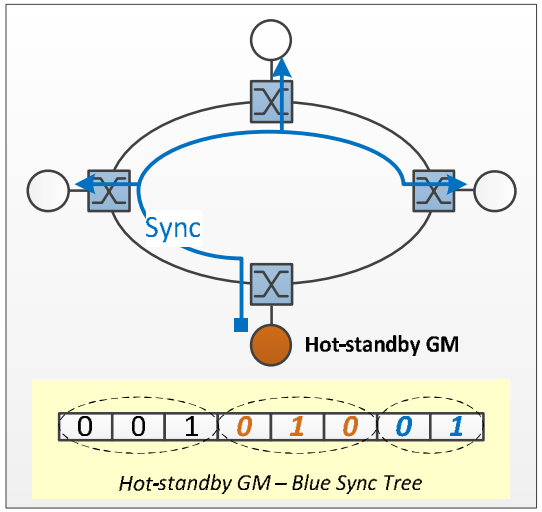
Domains for Sync

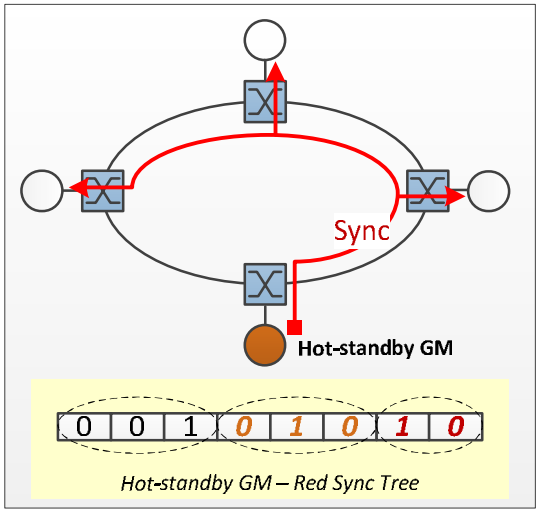






Encoding scheme for Working Clock with GM + Sync Path redundancy





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Conclusion

The goal is to support automatic configuration of a working clock with redundancy for industrial automation

- BMCA+/Announce+ for automatic GM selection and re-selection
- A domain number encoding scheme for automatic domain number allocation within a working clock for correlating GM (primary or hot-standby) to its corresponding Sync trees.

These proposals are extensions to the 1588 proposals for support of redundancy

- no violation of the basic rules defined by 1588, including
  - one domain per sync tree per GM,
  - Use *externalPortConfiguration* to establish redundant Sync trees
  - the default BMCA is disabled

  ⇒ **But 1588 proposes to transmit Announce msgs over the Sync tree in each domain where the sync tree is established externally. To support BMCA+, we propose that .1AS-Rev should allow us to turn off such Announce transmission.**
- pure software issues, no effect on hardware

Thank you for your attention!

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