IEEE 802.1ASbt for Industrial Networks

High-Availability/Redundancy

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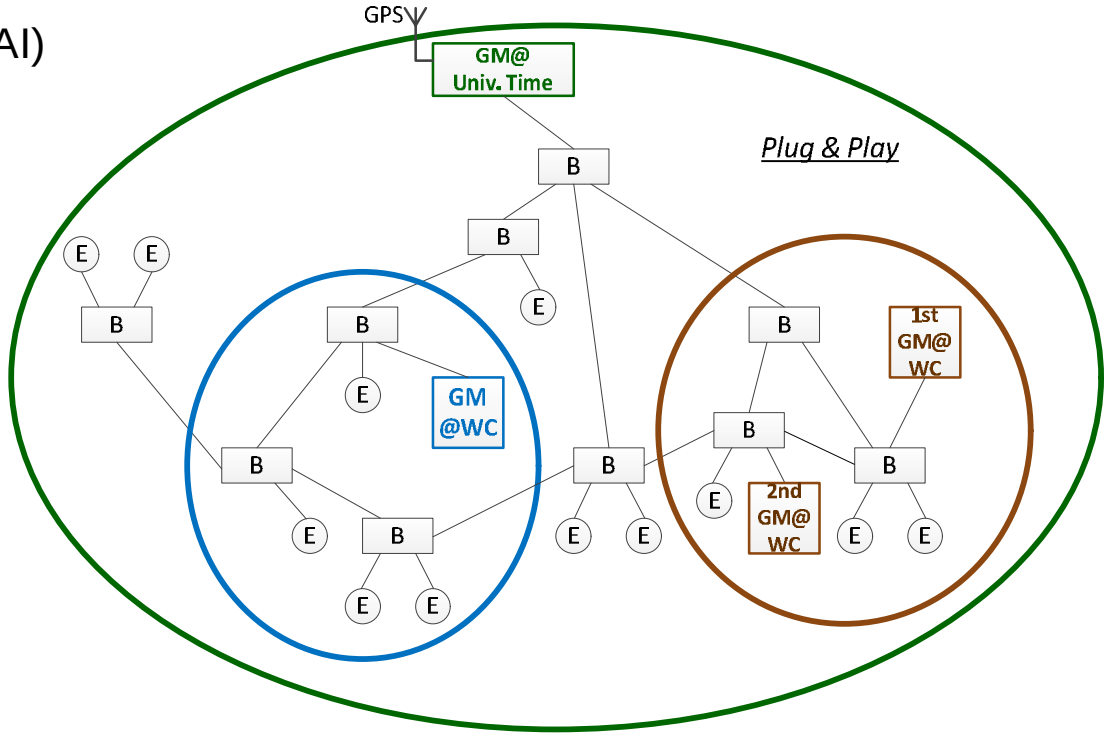
Recap: Industrial Requirements on 802.1ASbt

- Two time-scales [1]
  - Universal Time (traceable to TAI)
  - Working Clock (ARB time)
- High availability/redundancy [2]
  - Redundant disjoint sync path
  - Redundant GM
  - Segment protection



1. www.ieee802.org/1/files/public/docs2013/as-goetz-TwoTimeScales-4-Industrial-20130114-v01.pdf
2. www.ieee802.org/1/files/public/docs2013/asbt-goetz-HighAvailableSync-0319-v02.pdf

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- **Multiple Domains for Multiple Time-scales**
- **High-Availability/Redundancy with ISIS-4-gPTP**

General Proposal
Multiple Domains for Multiple Time-scales

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- A Time-aware system shall support at most two sync domains
  - e.g. universal time and at most one working clock

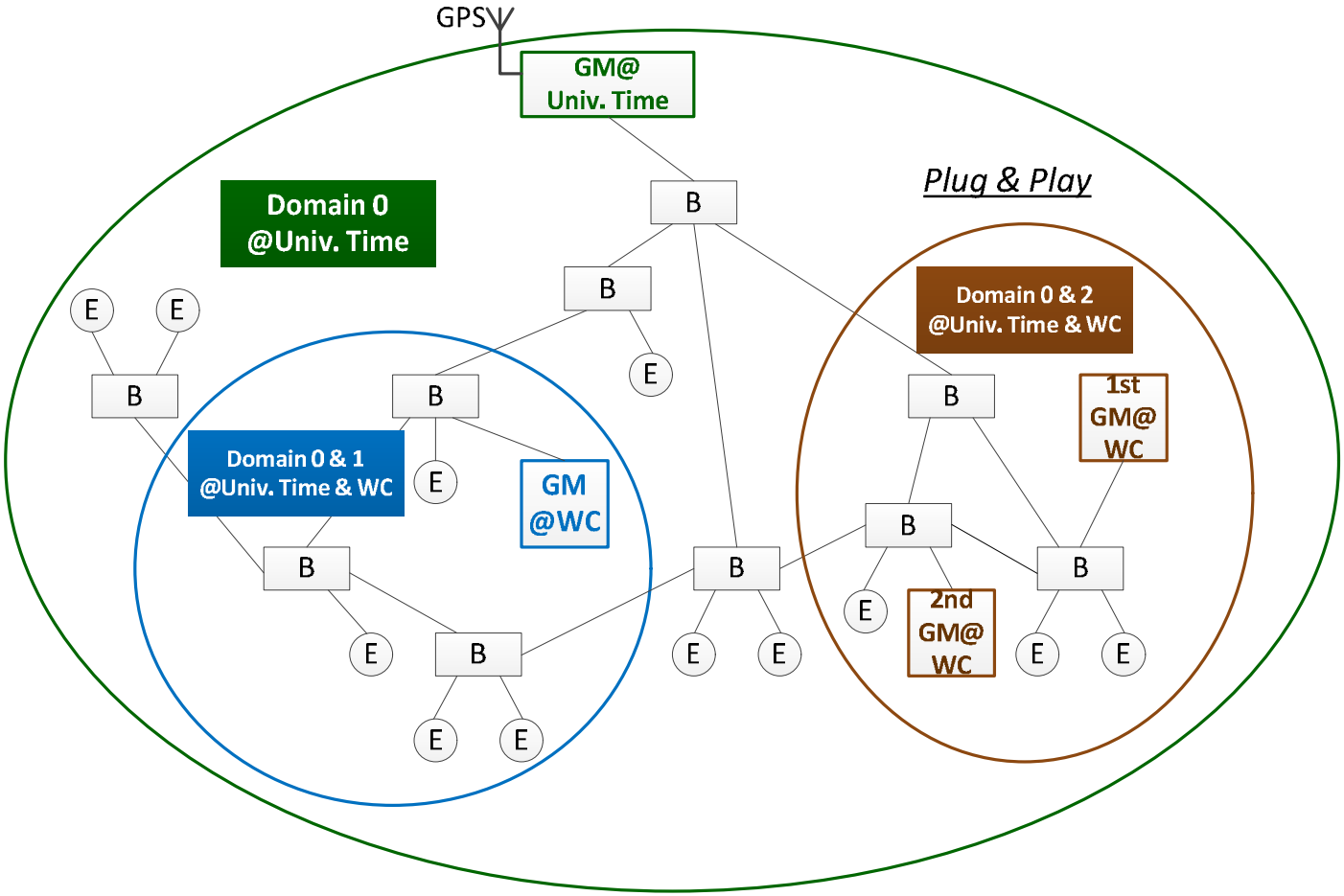
- Different sync domains are generally independent with respect to
  - Synchronization spanning tree
  - Time-scale
  - Parameter sets

  which means each Time-aware system involved in multiple domains should maintain multiple instances of gPTP (only for domains specific ones)

- Only one single PDelay exchange for all domains (time-scales)
  - PDelay measurement is independent of time-scale (gPTP uses local free-running clock for delay measurement and *neighborRateRatio* estimation)

- Detection of sync domain boundaries to restrict forwarding of sync msgs
  - Never forward sync msgs in foreign sync domains
  - Carry supported domain numbers using SupportedDomainsTLV in PDelay msgs
    - see as-goetz-multiple-sync-domains-1112-v01.pdf

Example


GPS
GM@
Univ. Time
Domain 0
@Univ. Time
Plug & Play
Domain 0 & 2
@Univ. Time & WC
Domain 0 & 1
@Univ. Time & WC
GM
@WC
1st
GM@
WC
2nd
GM@
WC
B
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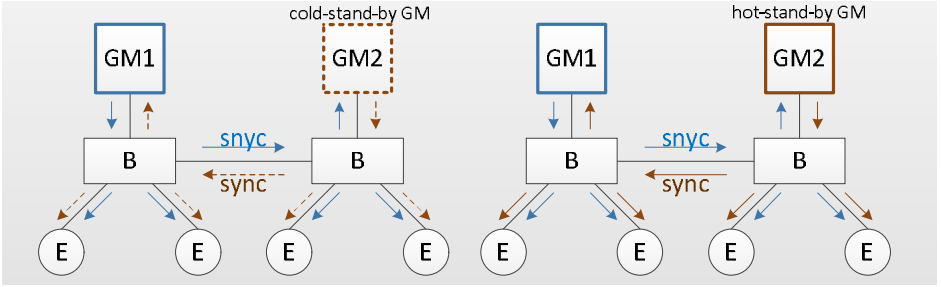
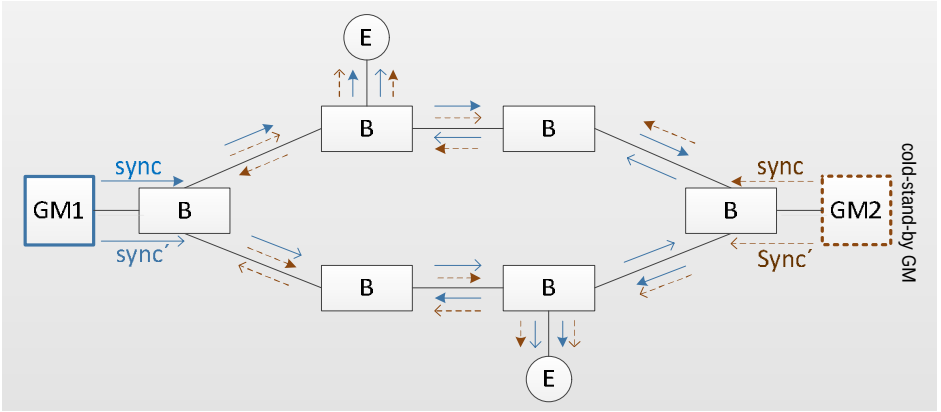
- Multiple Domains for Multiple Time-scales
- **High-Availability/Redundancy with ISIS-4-gPTP**

General Types of Redundancy for Synchronization

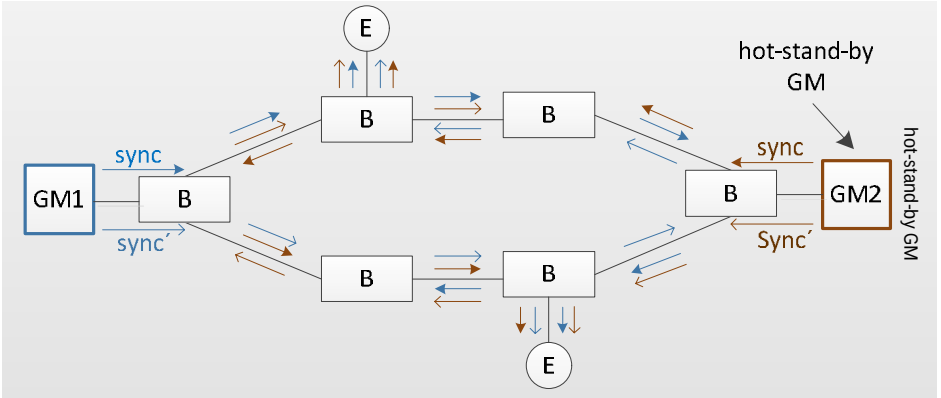
- Master redundancy
  - Cold-stand-by GM
  - Hot-stand-by GM



- Sync path redundancy
  - Simultaneously transmission of redundant sync messages over redundant path



- Both master and sync path redundancy



Industrial Requirements and Assumptions for Redundant Synchronization with 802.1ASbt

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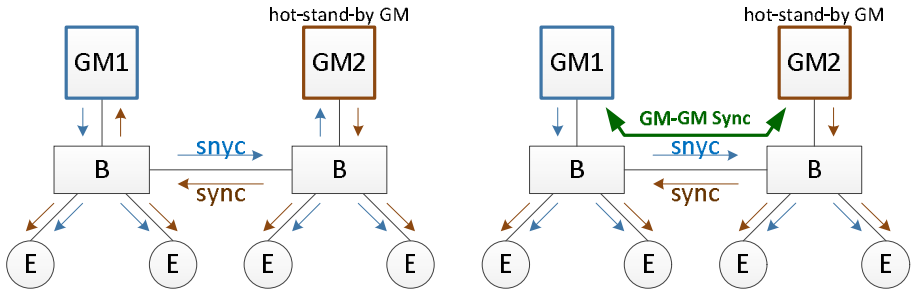
- Redundant GM (typically one)
  - One is chosen as the primary GM (GM_P)
  - The other is the redundant GM (GM_R), working in either cold- or hot-stand-by mode
  - Typically, GM_P is the best clock and GM_R is the second best clock
  - It is expected that GM_P and GM_R use the same time-scale
  - It is assumed that GM_P and GM_R are synchronized with each other to reduce jitter in case of GM changeover, using
    - normal sync msgs
    - or separate sync msgs



GM-GM Sync uses normal sync (left) or separate sync (right)

- Redundant sync path
  - Auto configuration/reconfiguration
  - Most disjoint redundant sync path for redundant sync msgs

The above features are not yet supported in 802.1AS Gen 1.
Redundancy issues within one time scale should be handled within its corresponding sync domain.

Introduce ISIS into 802.1ASbt

- What is ISIS
  - A link state protocol creating a database about network topology through distributing local information (e.g. who are my immediate neighbors) to the entire network
  - Local database is synchronized through periodic advertisement, thus capable of reacting to topology change
  - A lot of things can be done based on such a database with global information
    - e.g. calculation of most-disjoint redundant paths for streams using a specific routing algorithm

- Why introduce ISIS into 802.1ASbt
  - ISIS is being discussed in the 802.1Qca (path control and reservation) of TSN WG, which *extends the application of IS-IS to control bridged networks (beyond the capabilities of Shortest Path Bridging) and specifies additional protocols, procedures and managed objects, and provides explicit path control, bandwidth and stream reservation, redundancy (protection or restoration) for data flows and distribution of control parameters for time synchronization and scheduling*

- What is ISIS capable of for gPTP
  - Recognition of gPTP topology
  - Calculation of sync path to establish sync tree (e.g. shortest path or most disjoint redundant path, depending on used routing algorithms)
  - ISIS can carry information and perform functions of other protocols, thus could be also used to simultaneously delivery best clock information as gPTP announce msg does

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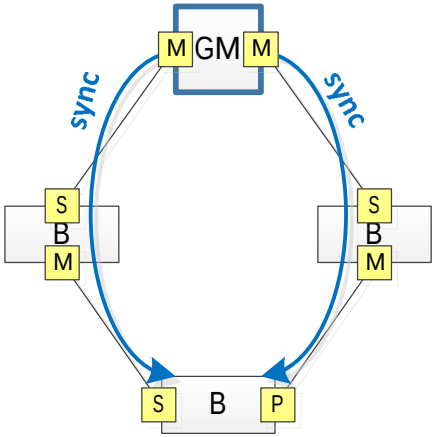
General Proposals

- Use ISIS-4-gPTP to discover gPTP topology
- Use ISIS-4-gPTP to establish sync tree (1:n) (incl. most disjoint redundant sync trees)
- There are two options to select GM and distribute GM information **(to be discussed)**
  - **Proposal 1: ISIS-4-gPTP + Extended BMCA**
    - extend BMCA to select not only the best GM, but also the 2nd best GM or 3rd best GM
    - use Announce msgs to distribute GM information of the best GM, the 2nd best GM, 3rd best GM ….
  - **Proposal 2: ISIS-4-gPTP w/ integrated extended BMCA functions**
    - use ISIS mechanisms to distribute clock information (priority, class, etc.) of all GM capable devices and to build/synchronize local database for such information (very similar to Link-State-Database)
    - using this database, GM selection (incl. best GM, 2nd best or more) can be done locally

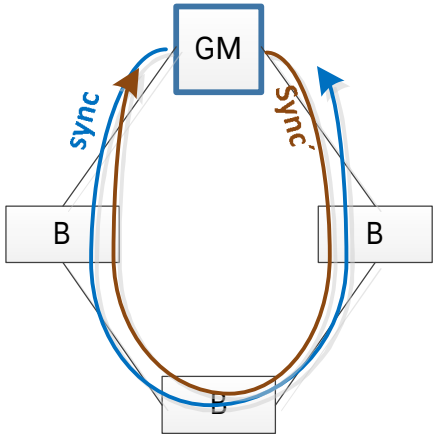
GM Selection Option 1:
Extend BMCA to Support Multiple GMs

- Exchange in the Announce msgs not only the best GM Information, but also 2nd best GM (even 3rd best or more)

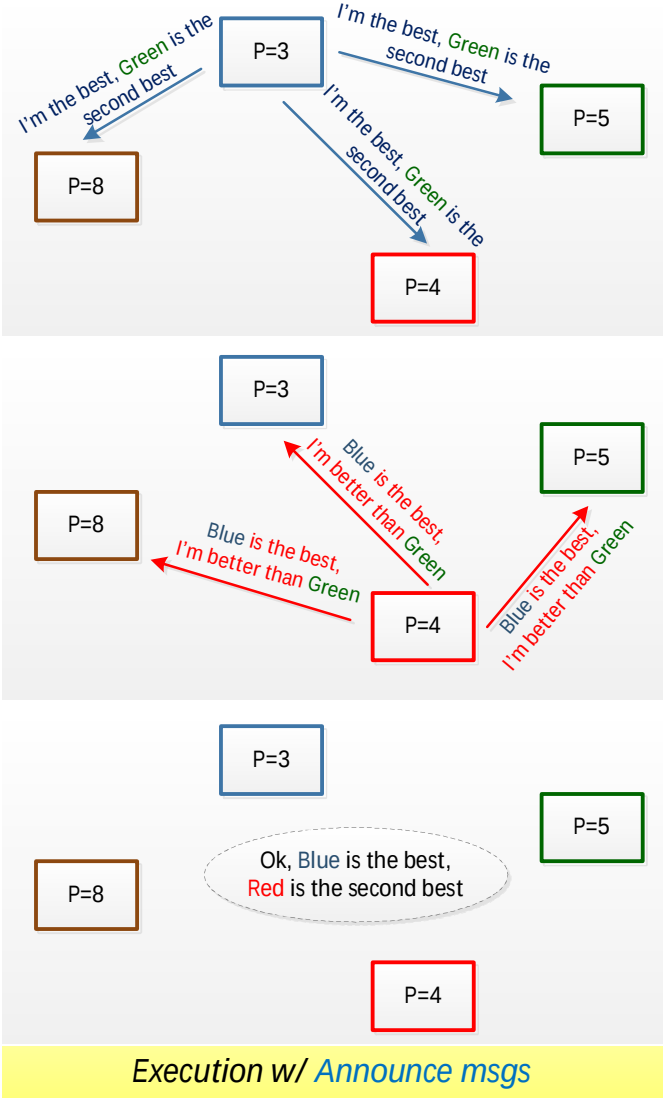
- But sync path/port roles are not to be determined by the BMCA, in case that redundant sync path is desired, because
  - BMCA w/ RSTP-like features does not support generating most-disjoint redundant sync path in a multicast gPTP network.



One Sync Tree w/ BMCA



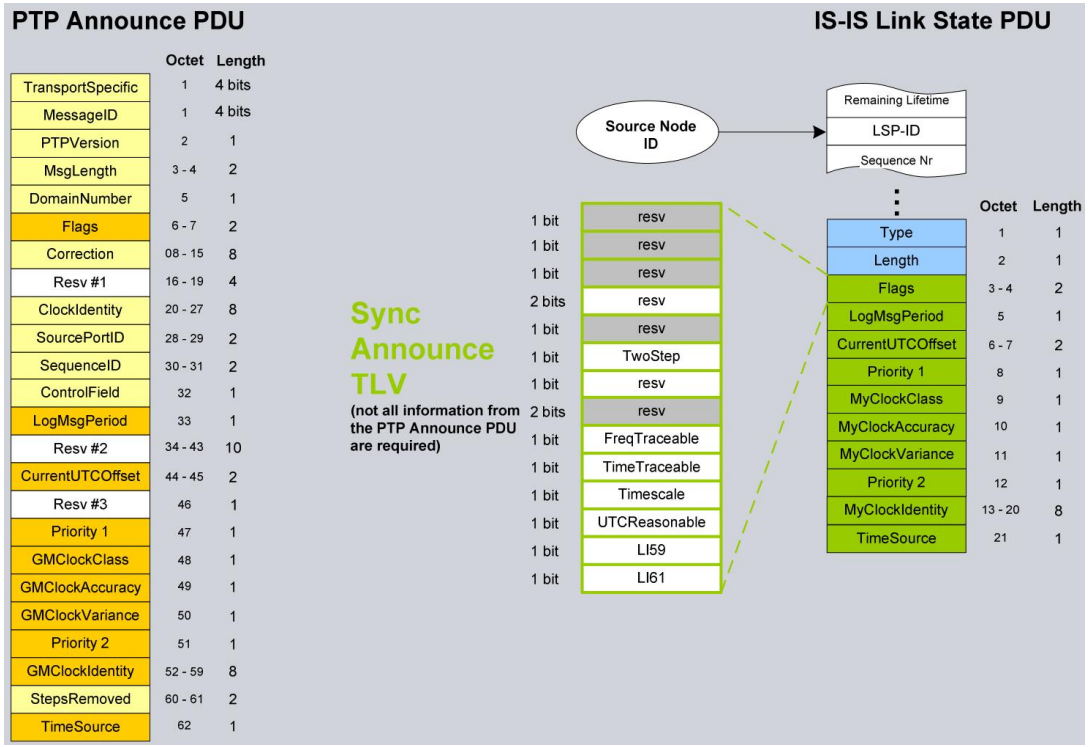
Redundant Sync Path
w/ two sync trees

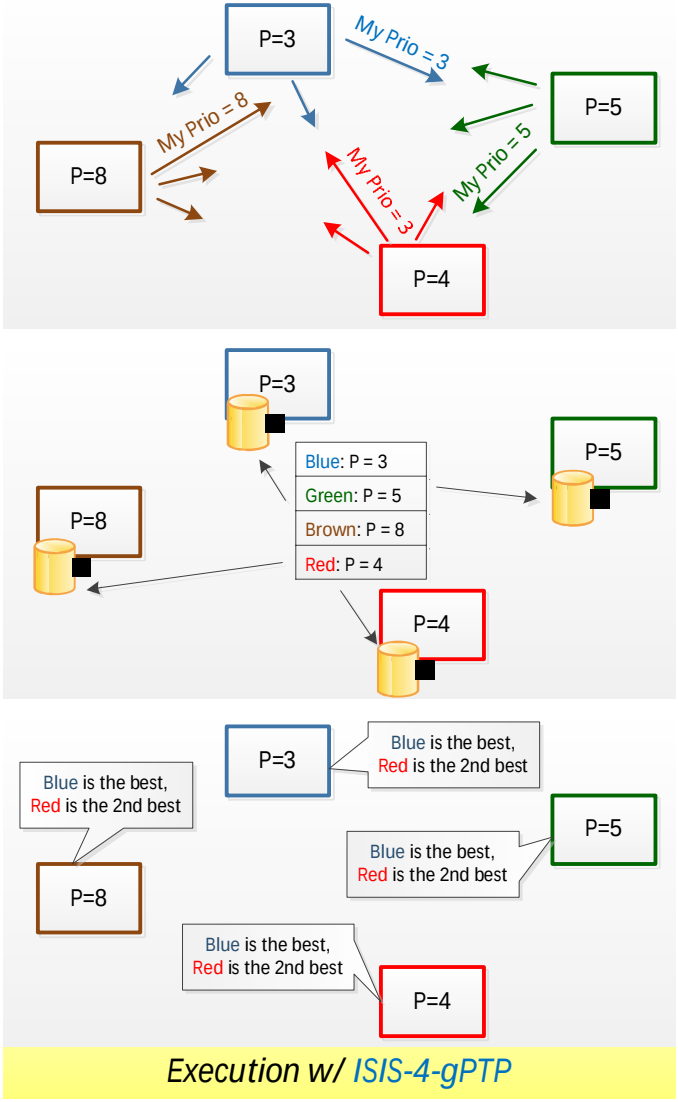


Execution w/ Announce msgs

GM Selection Option 2: Use ISIS Mechanism

- Information for BMCA to elect GM (primary, cold- or hot-stand-by GM) is distributed by ISIS, which carries "Sync Announce Sub-TLV" in Link-State-PDU





Execution w/ ISIS-4-gPTP

www.ieee802.org/1/files/public/docs2013/asbt-goetz-HighAvailableSync-0319-v02.pdf

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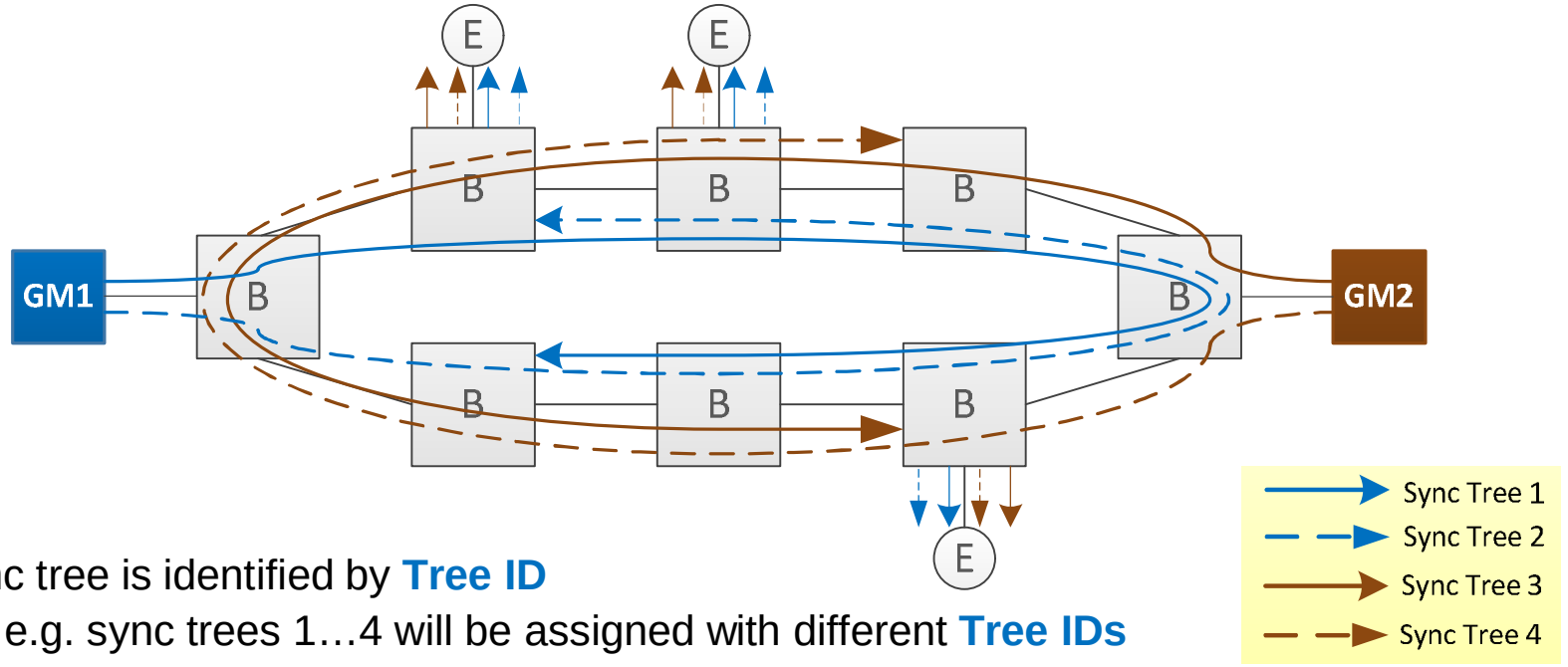
Use ISIS-4-gPTP to Establish Sync Tree

- ISIS needs following information to calculate sync tree for gPTP
  - knowledge of gPTP topology (who are time-aware systems)
  - Sync domain/time scale
  - Who are GM-capable
  - Is high-availability required
    - How many cold- or hot-stand-by GMs
    - How many redundant sync path originating from each GM

How to Distinguish Sync Trees



- Sync tree is identified by **Tree ID**
  - e.g. sync trees 1…4 will be assigned with different **Tree IDs**

- Sync forwarding is based on
  - Multicast MAC address (same for all gPTP sync msgs)
  - Domain ID
  - **Tree ID**

- **GM ID** is generally required to distinguish sync msgs from primary/hot-stand-by GMs

  www.ieee802.org/1/files/public/docs2013/asbt-goetz-HighAvailableSync-0319-v02.pdf