Various Methods for Attaining a Resilient and Secure Timing Architecture

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

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Agenda

1. Resilient Global BMCA
2. Majority Vote Algorithm
3. Systems Redundancy Schemes
4. Summary

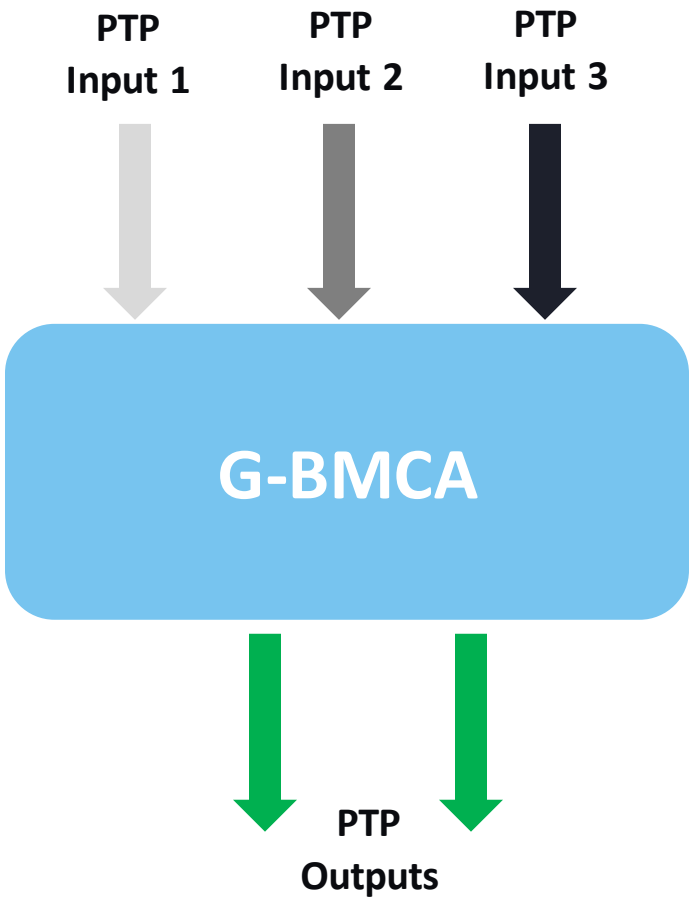
Resilient Global BMCA (G-BMCA) Algorithm

IEEE 1588 Definition:

The best master clock algorithm specifies the way that a PTP Instance determines which of all the PTP Instances (including itself) is the “best”

Advantages of G-BMCA

- G-BMCA is an extension to the standard/alternate BMCA defined by IEEE 1588 and ITU-T standards Committee
- Standard/alternate BMCA assume a single profile. G-BMCA can run with a mix of profiles using a mapping function of the various PTP parameters
- In addition to the data set comparison, G-BMCA includes the comparison of PTP performance using a “Figure of Merit” metric
- G-BMCA has the option to run on multiple clock domains to support parallel paths of synchronization (i.e., east/west domains) to protect against reference/path failures



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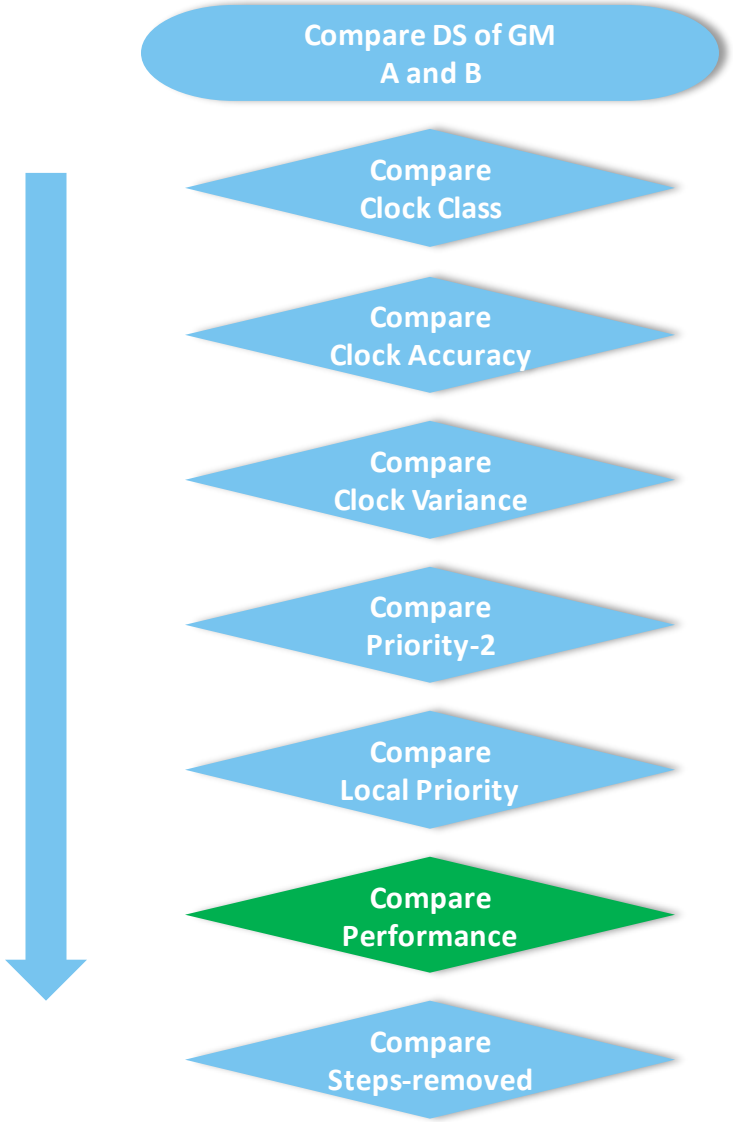
Resilient Global BMCA Advantages



- Ability to turn on/off “Performance” check
- Conservative location of the “Performance” check in the G-BMCA chain
- Future enhancements will include the ability to move the “Performance” check anywhere in the BMCA chain

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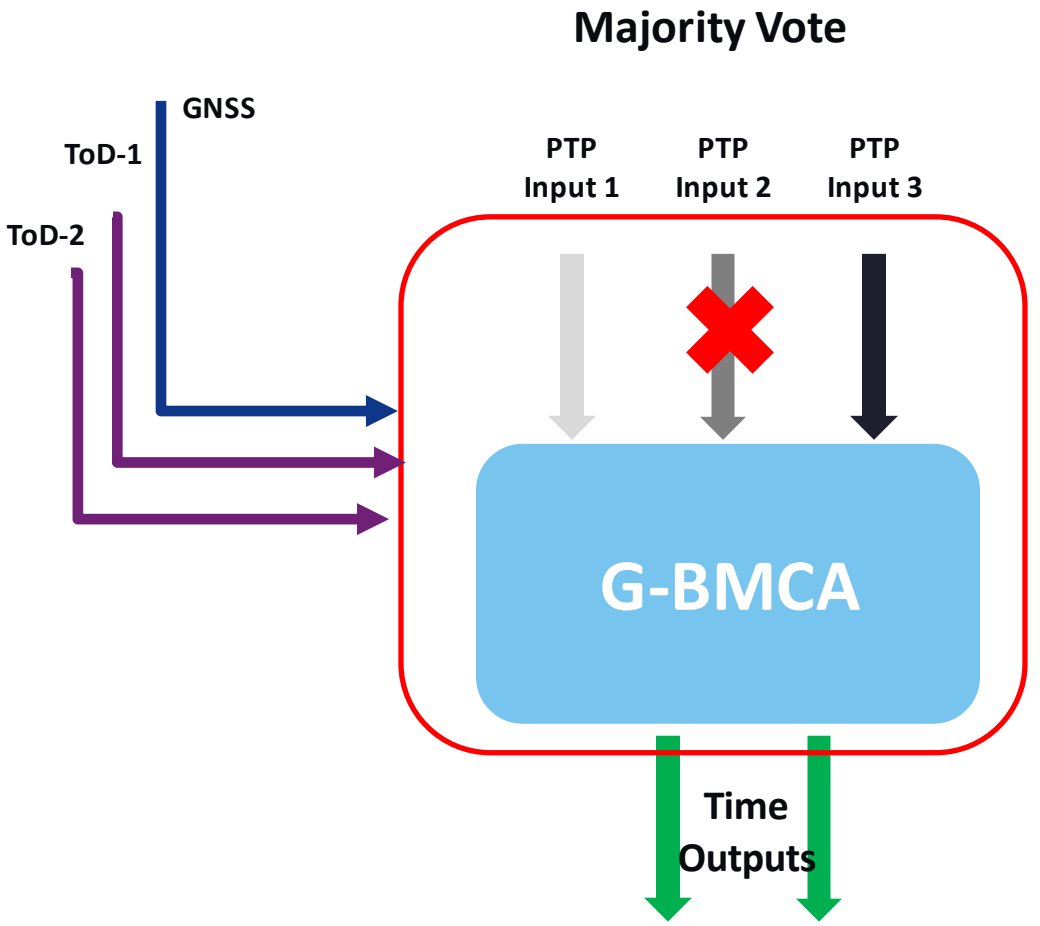
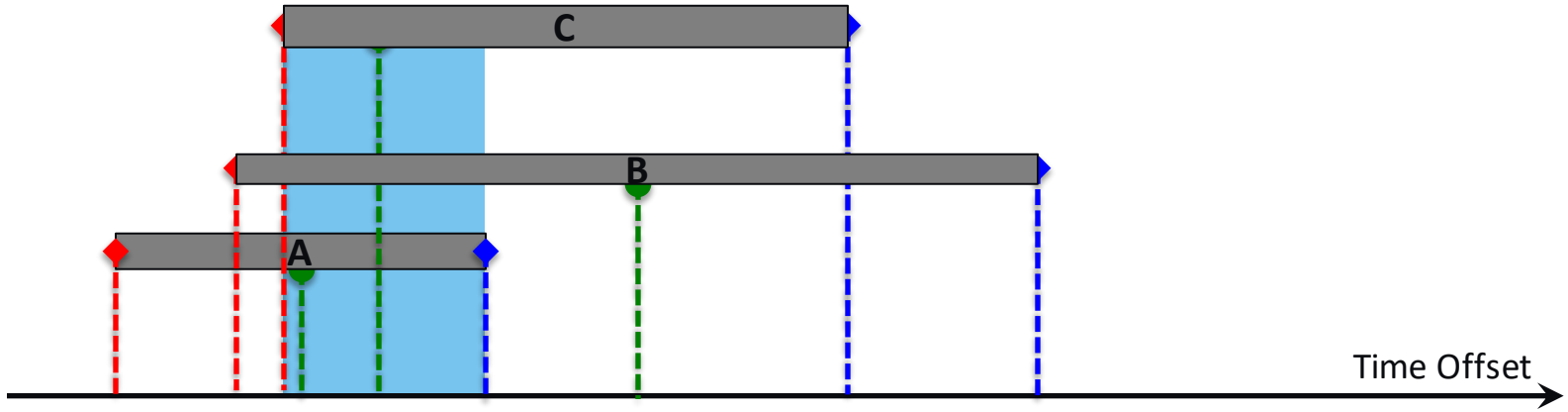
Majority Vote Algorithm Essentials

- **Why?**
  - Security - spoofing attacks
  - Resiliency - unintentional clock errors
- **What?**
  - Prior to the G-BMCA decision tree, Majority Vote (MV) can exclude any 1 of 3 time references
  - MV determines if there are any outliers and rejects them
- **Supported Combinations:**
  - Three instances of PTP clients on the same system
  - Two instances of PTP clients plus GNSS time reference
  - Two instances of PTP clients plus G.8271 ToD time reference



Majority Vote Algorithm–How?

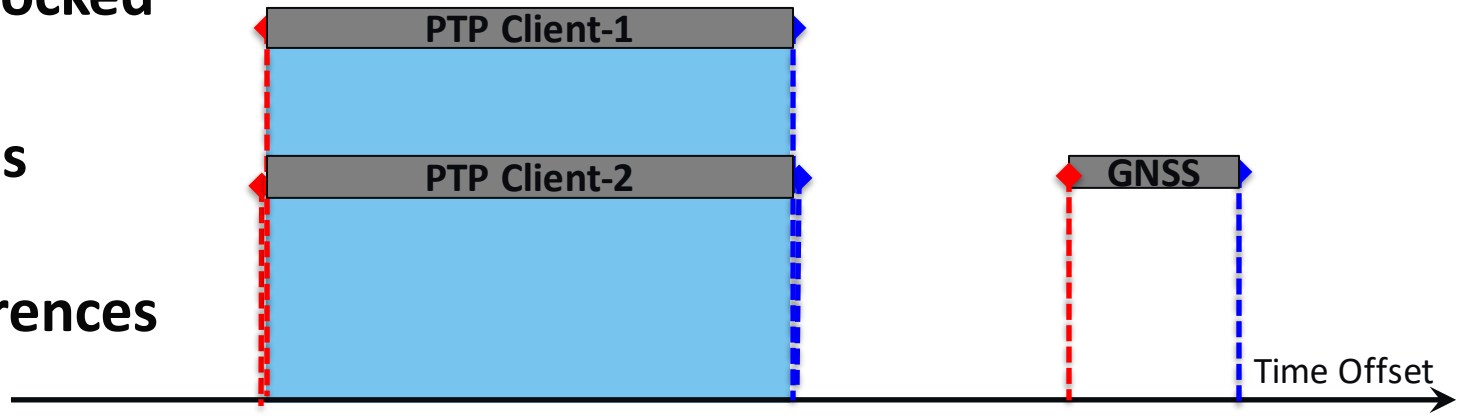
- Time offsets are calculated based on a single reference point
- User defined threshold to determine correctness intervals
- Dynamic adjustment of correctness intervals for hysteresis
- Use a common algorithm to locate “Intersection Interval”
- A change in state (reject or valid) will need to persist for few seconds before the change is reported



Example 1: Intersection of 3 clocks, all clocks are valid

Example 1–One Clock Outlier

- Unit Under Test (UUT) is initially locked to GNSS reference
- Industry standard testing device is added into the scenario injecting arbitrary time with dual PTP references
- UUT rejects the higher priority reference (GNSS)




```
System Date and Time                    : 2021-10-08 02:00:32
  Clock Time Status                     : LOCKED
  Currently Selected Time Reference     : PTP Client (PI-1)
  Time State Duration (min)             : 44
  Clock Frequency Status                : LOCKED
  Currently Selected Frequency Reference : PTP Client (PI-1)
  Frequency State Duration (min)        : 48
  System Uptime                         : 0 day(s) 1 hour(s) 7 minute(s)
4 second(s)
Timing Service Eth7 Mode                : PTP Client (PI-0)
  Timing Service Eth8 Mode              : PTP Client (PI-1)
  Timing Service Exp Mode               : NONE
  Active Management Interface           : ETH1
  Redundancy Mode Status                : Stand-alone
  Frequency Stability (MDEV ppb)        : 0.114922
  Phase Stability (TDEV ns)             : 47.772
  Active Alarms                         : 12
  System Frequency PQL                  : 2
  Operation Mode                        : gateway-clock
  Last Config Time                      : 2021-10-10 05:25:29
  System Status                         : ok
```

Alarm Status

ID	Severity	Date-Time	Description
242	MINOR	2021-10-08 03:10:20	GNSS input reference majority vote rejection

Majority Vote Status

Reference	status
GNSS	reject
PTP (PI-0)	valid
PTP (PI-1)	valid
PTP (PI-2)	not-used

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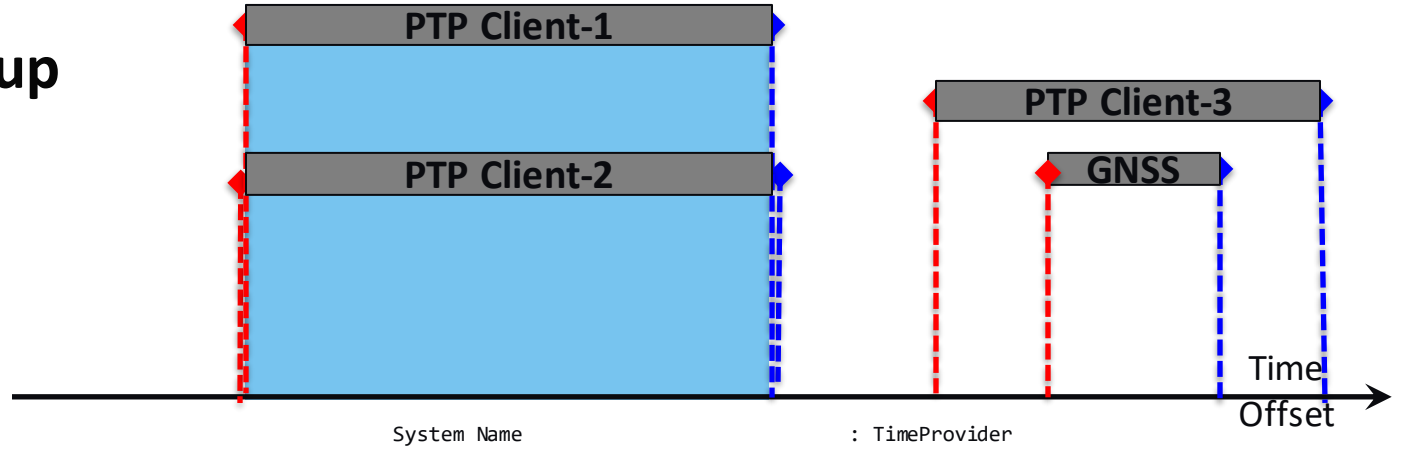
Example 2–No Overlap

- Third PTP reference sourced from House Time Scale is added to the setup
- There is no intersection, therefore majority vote cannot be determined. All clocks are marked valid
- Higher priority was set to the GNSS input which is now selected as system reference




```
Reference Criteria                    : priority
Reference Switch Mode                 : auto-return


Operation Mode                        : gateway-clock
Majority-Vote Mode                    : enable
Majority-Vote Threshold               : 1000 ns

Time Reference Config
```

Reference	Priority
GNSS	1
PTP	2
TOD-1	4
TOD-2	4

Majority Vote Status

Reference	status
GNSS	valid
PTP (PI-0)	valid
PTP (PI-1)	valid
PTP (PI-2)	valid
TOD-1	not-used
TOD-2	not-used

```
System Name                           : TimeProvider
  Serial Number                       : SCA20070010F
  System Date and Time                : 2021-10-10 21:25:50
  Clock Time Status                   : LOCKED
  Currently Selected Time Reference   : GNSS
  Time State Duration (min)           : 832
  Clock Frequency Status              : LOCKED
  Currently Selected Frequency Reference : GNSS
  Frequency State Duration (min)      : 832
  System Uptime                       : 0 day(s) 14 hour(s) 42
minute(s) 45 second(s)
  Timing Service Eth1 Mode            : NONE
  Timing Service Eth2 Mode            : NONE
  Timing Service Eth3 Mode            : NONE
  Timing Service Eth4 Mode            : NONE
  Timing Service Eth5 Mode            : PTP Client (PI-2)
  Timing Service Eth6 Mode            : NONE
  Timing Service Eth7 Mode            : PTP Client (PI-0)
  Timing Service Eth8 Mode            : PTP Client (PI-1)
  Timing Service Exp Mode             : NONE
  Active Management Interface         : ETH1
  Redundancy Mode Status              : Stand-alone
  Frequency Stability (MDEV ppb)      : 0.007607
  Phase Stability (TDEV ns)           : 3.162
  Active Alarms                       : 0
  System Frequency PQL                : 1
  Operation Mode                      : gateway-clock
  Last Config Time                    : 2021-10-08 04:07:24
  System Status                       : ok
```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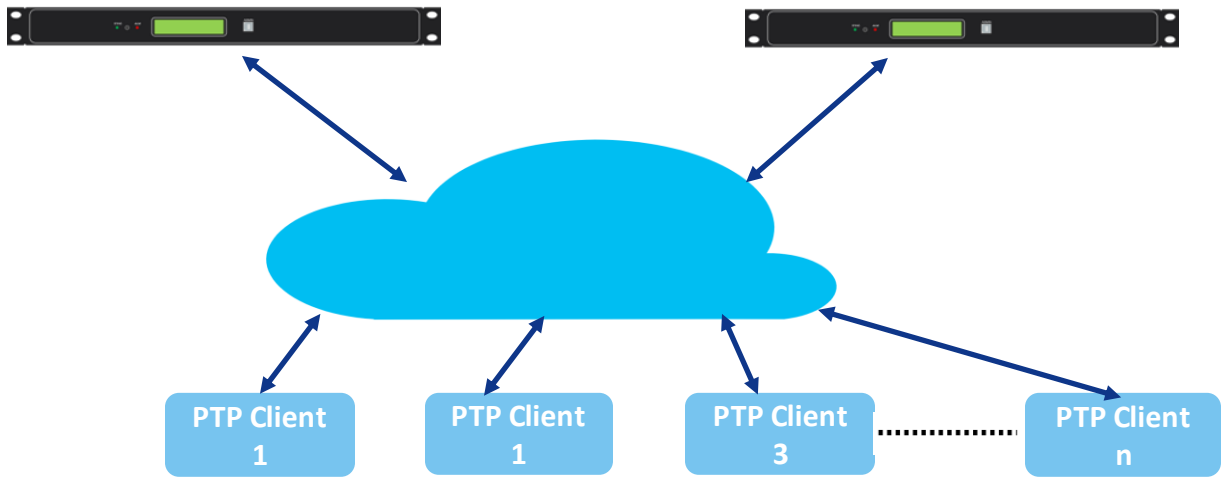
Introduction of Various Redundancy Schemes

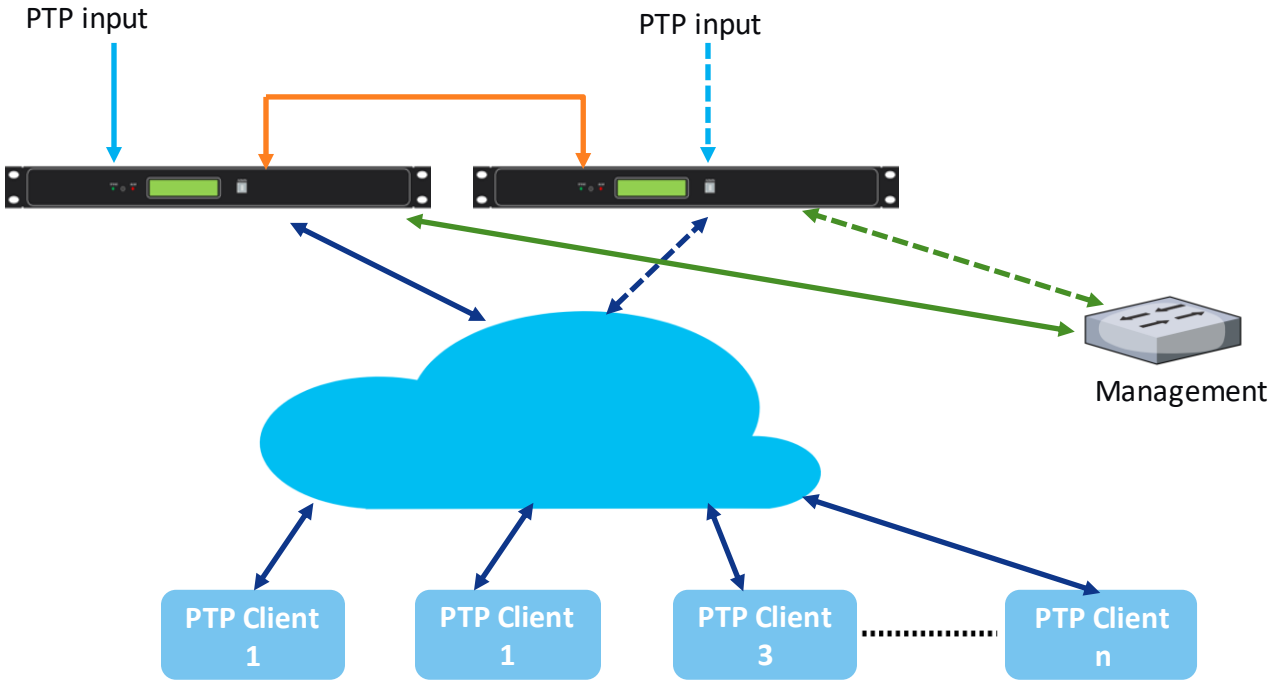
Geographical Redundancy/Network Redundancy

- Two or more PTP server units are deployed in separate locations in the network, same profile and same domain
- According to BMCA or A-BMCA: PTP clients will connect to the lower priority GM in case of a fail-over scenario or attributes degradation
- PTP server units are not synchronized and are not configured similarly. This is a plain fail-over network redundancy



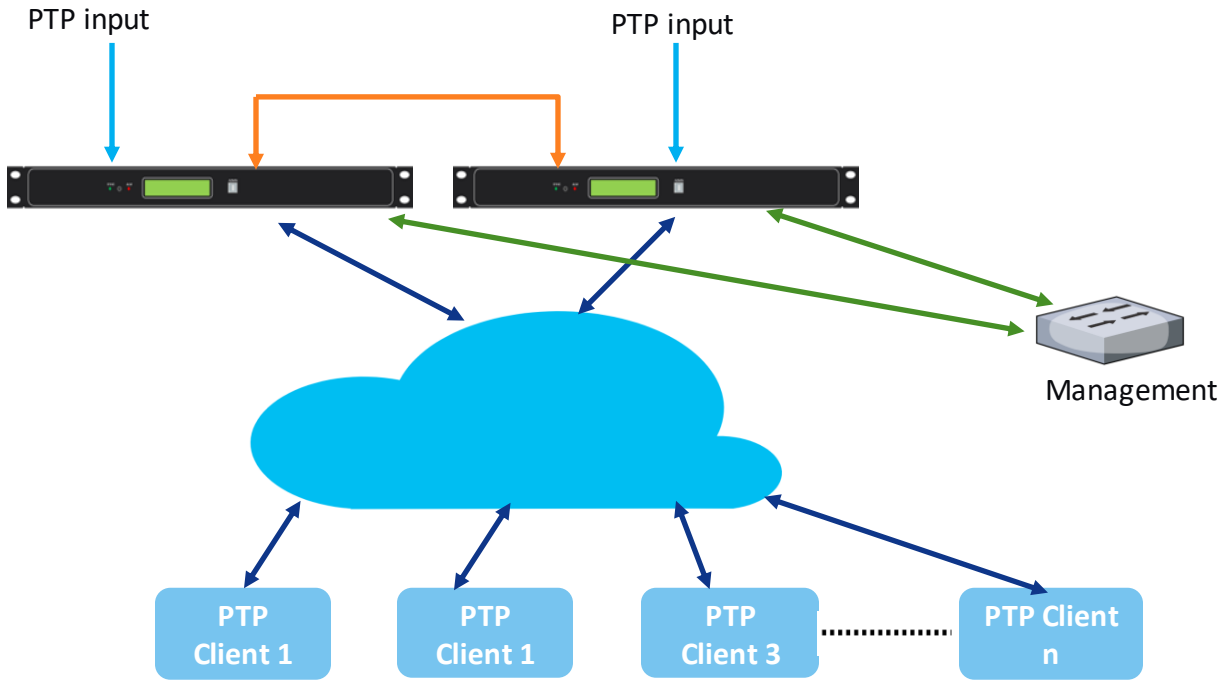
Active Standby Redundancy

- **“Hardware Redundancy” achieved by using either:**
  - Two identical units, one is active, the other is standby
  - Single redundant device with redundant clock modules
- **Behavior is essentially as a single unit**
- **Out-of-Band channel for sync and management between redundant Hardware units**
- **Both units have unified configuration, including software options**
- **Unified PTP client list transferred via OOB channel**
- **The two devices “look” like a single unit for all practical purposes and share the same GM Clock ID.**
- **Unit management is only live for active units in case of dual hardware or is single connected via a non-redundant management module**
- **PTP input is operative only on active units**



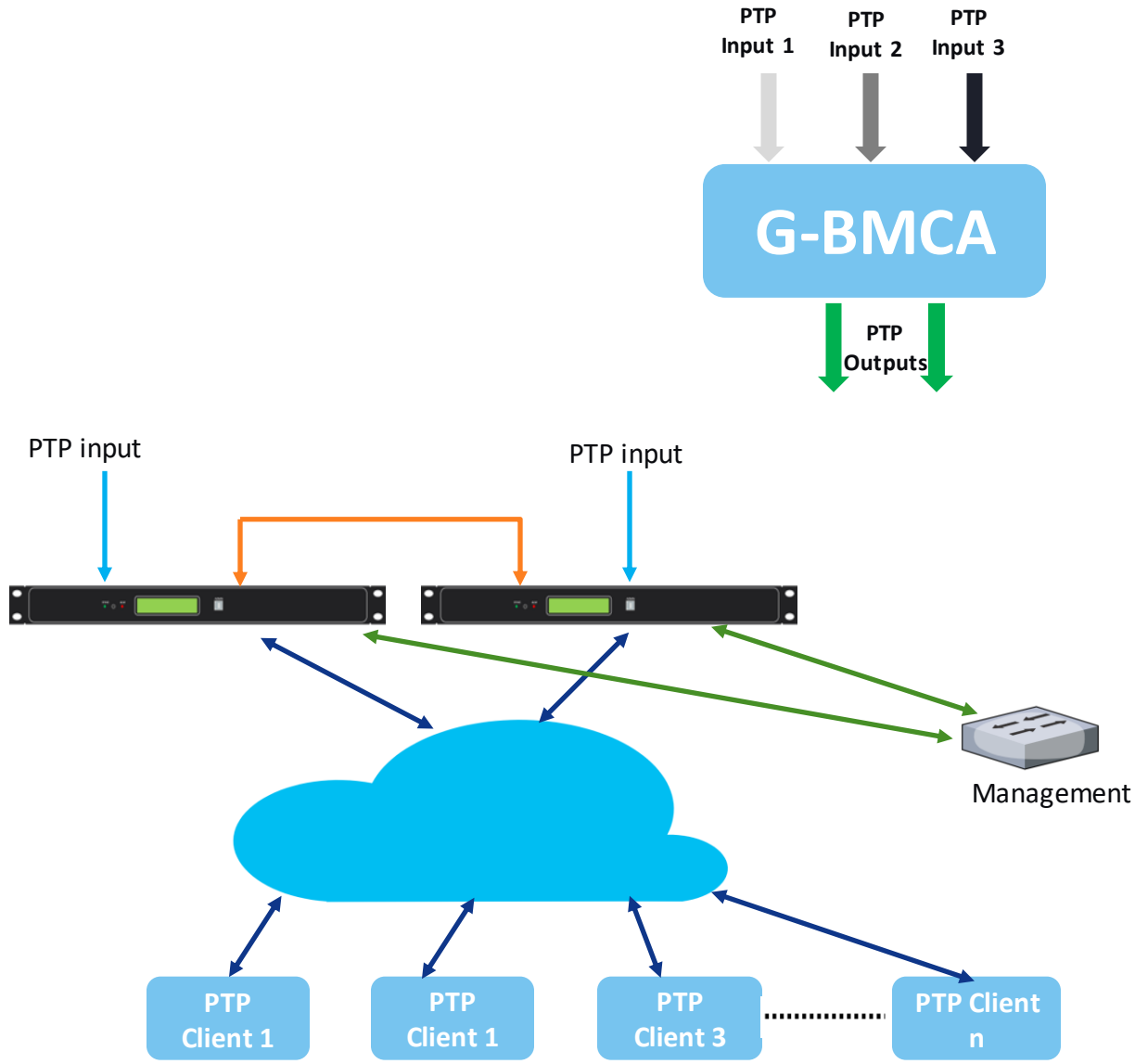
Active-Active Redundancy

- Two separate devices act as two separate GMs with Common Time Base
- Out of Band (OOB) channel is only for sync, not management
- Management is active on both units
- The two units are not necessarily configured similarly
- Much more flexibility but also potential risks for configuration errors
- PTP input or inputs available and active on both active units at the same time
- BMCA with Health status methods are used as arbitration method to determine SyncSender and SyncReceiver roles.



Active-Active Redundancy (Contd.)

- **Active-Active redundancy is an extension of G-BMCA and Majority Vote features into hardware redundant platform**
- **Determination of SyncSender and SyncReceiver roles takes advantage of either or both capabilities**
- **Active-Active variant of redundancy allows support of additional architectures and use cases:**
  - Redundant SSU with Frequency only inputs
  - vPRTC with mesh DWDM optical networks



Summary

- There is a growing need in the industry to assure selected timing sources are valid and that the content isn't spoofed or modified
- IEEE 1588-2019 standard, under Security Annex P, introduced in Prong C Guidance to address security and resilience with architecture methods as described in this presentation
- The use of techniques such as Global BMCA and Majority Vote are some of the methods being developed to ensure resilience timing performance
- The Active-Active redundancy scheme is used to extend the reach of those techniques to support even more resiliency using 1:1 hardware redundancy

Thank you

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