802.1AS use cases in 10B-T1S and improvement

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

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AS updates for 10B-T1S

- **802.1ASds PAR**
  - Amendment: Support for the IEEE Std 802.3 Clause 4 Media Access Control (MAC) operating in half-duplex
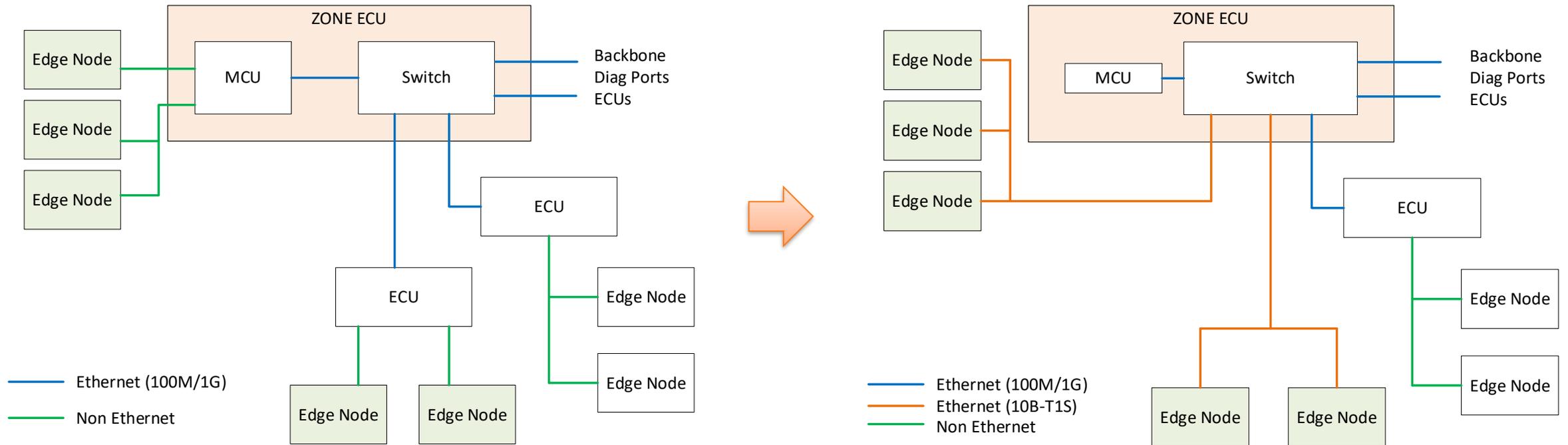- **10B-T1S**
  - 802.3cg CL147
  - point-to-point full & half-duplex : CL147.7
  - multidrop half-duplex : CL147.8
  - Applications in Industrial Automation, AeroSpace, Medical devices, Automotive and more.

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This presentation

- **Covers**
  - 10B-T1S multidrop use-case in Automotive
  - Single gPTP domain use-case
- **NOT Cover**
  - detail implementation
  - Hot-Standby

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Application of 10B-T1S

- **Convert legacy sensors/actuators traffic to 10Mbps**
- **Mainly communicate to high-performance CPU than between nodes**
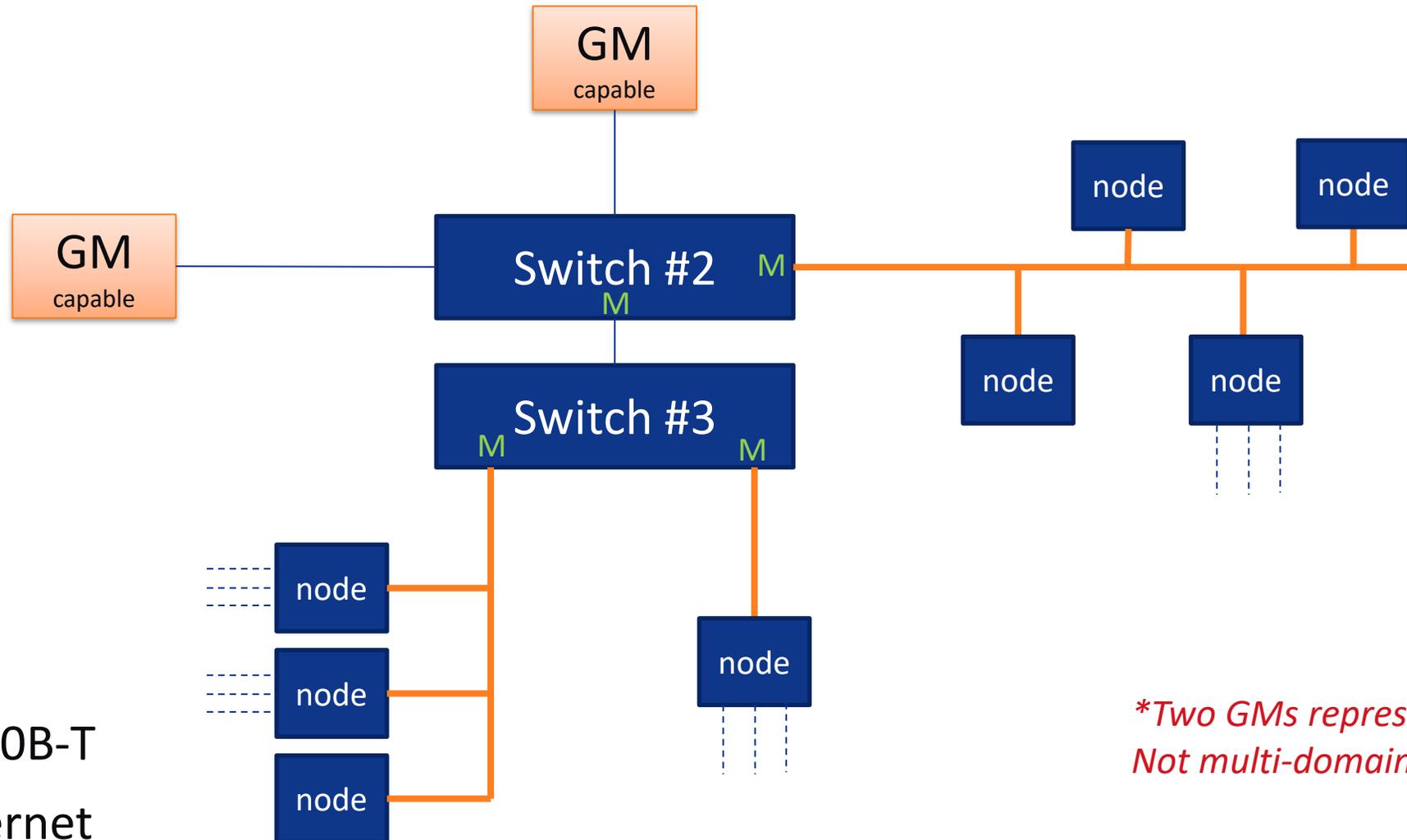- **Pre-configured harness**

10BASE-T1S in AUTOSAR - https://www.youtube.com/watch?v=4smu4FF-Iso
The 10BASE-T1S OA3p Interface - https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/other/eipatd-presentations/2021/d2-01.pdf

Single domain 802.1AS use-cases in 10B-T1S

1. GMs outside of multi-drop 10B-T1S
2. A GM in multi-drop 10B-T1S
3. A GM in point-to-point 10B-T1S
4. GMs in multi-drop 10B-T1S
5. Only 10B-T1S with Switch
6. Multi-drop 10B-T1S without Switch

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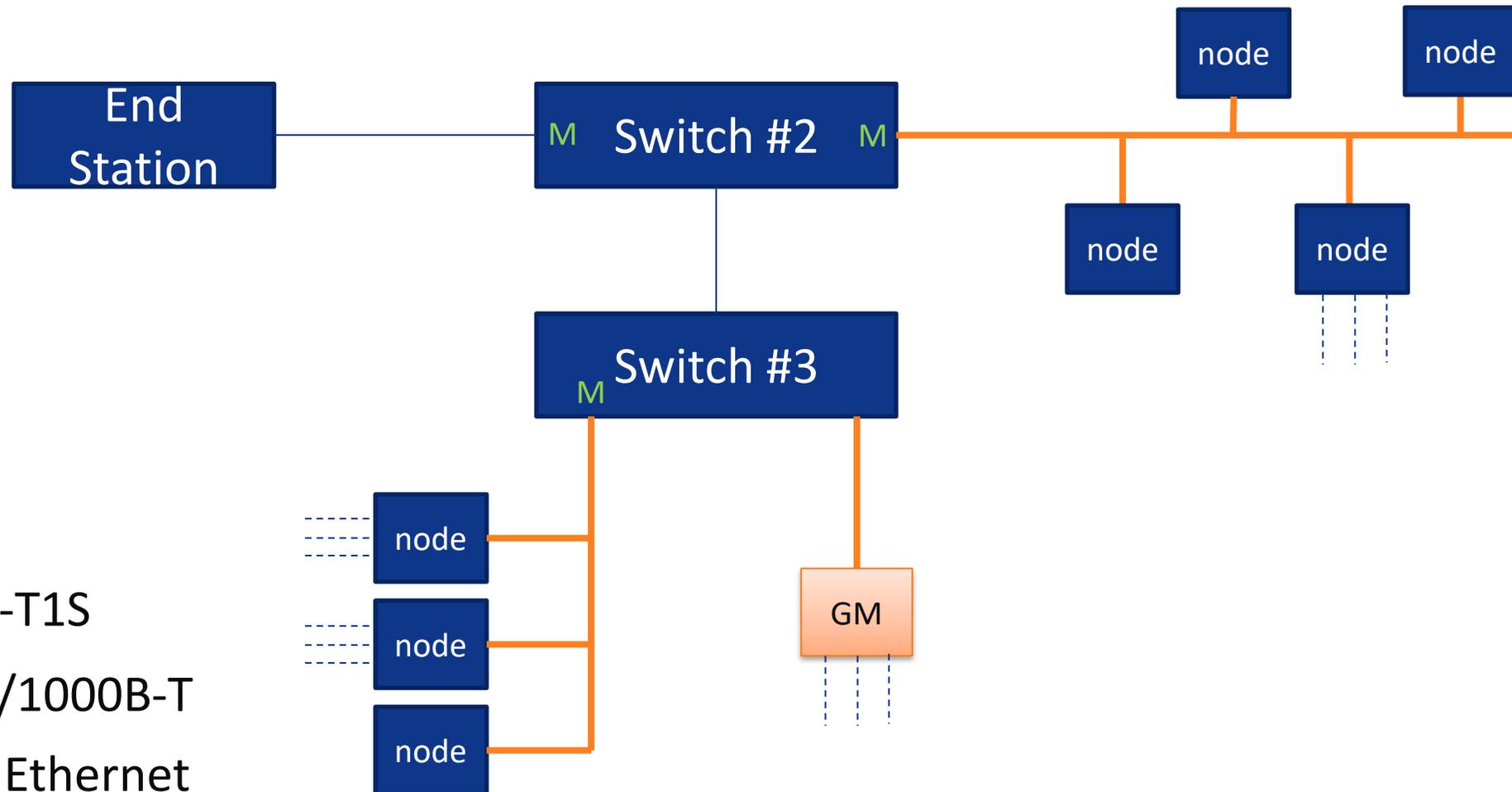# Case #1. GMs outside of multi-drop 10B-T1S

GM capable

GM capable

Switch #2 M
M

Switch #3 M M

node

node

node

node

node

node

node

node

10B-T1S

100/1000B-T

Not Ethernet

Two GMs represent BMCA-capable. Not multi-domain

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Case #2. A GM in multi-drop 10B-T1S

End Station

M Switch #2 M

node   node

node   node

M
Switch #3
M

node

node

node

node

GM

— 10B-T1S

— 100/1000B-T

--- Not Ethernet

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Case #3. A GM in point-to-point 10B-T1S

10B-T1S
100/1000B-T
Not Ethernet

Case #4. GMs in multi-drop 10B-T1S

End Station

M Switch #2 M

node

node

node

node

node

M

Switch #3

M

node

node

GM-capable

GM-capable

node

───── 10B-T1S

───── 100/1000B-T

- - - - Not Ethernet

*Two GMs represent BMCA-capable.
Not multi-domain*

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Case #5. Only 10B-T1S with Switch
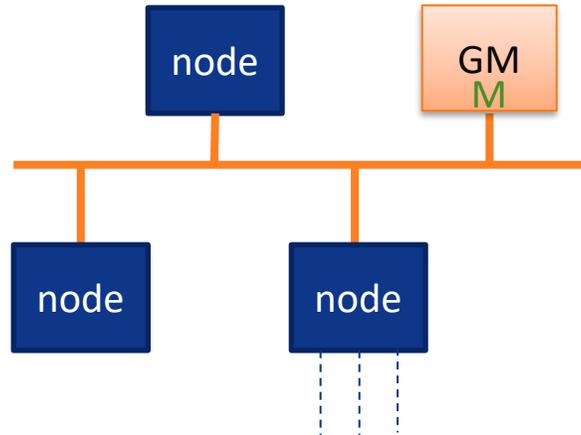

10B-T1S

Not Ethernet

Two GMs represent BMCA-capable. Not multi-domain
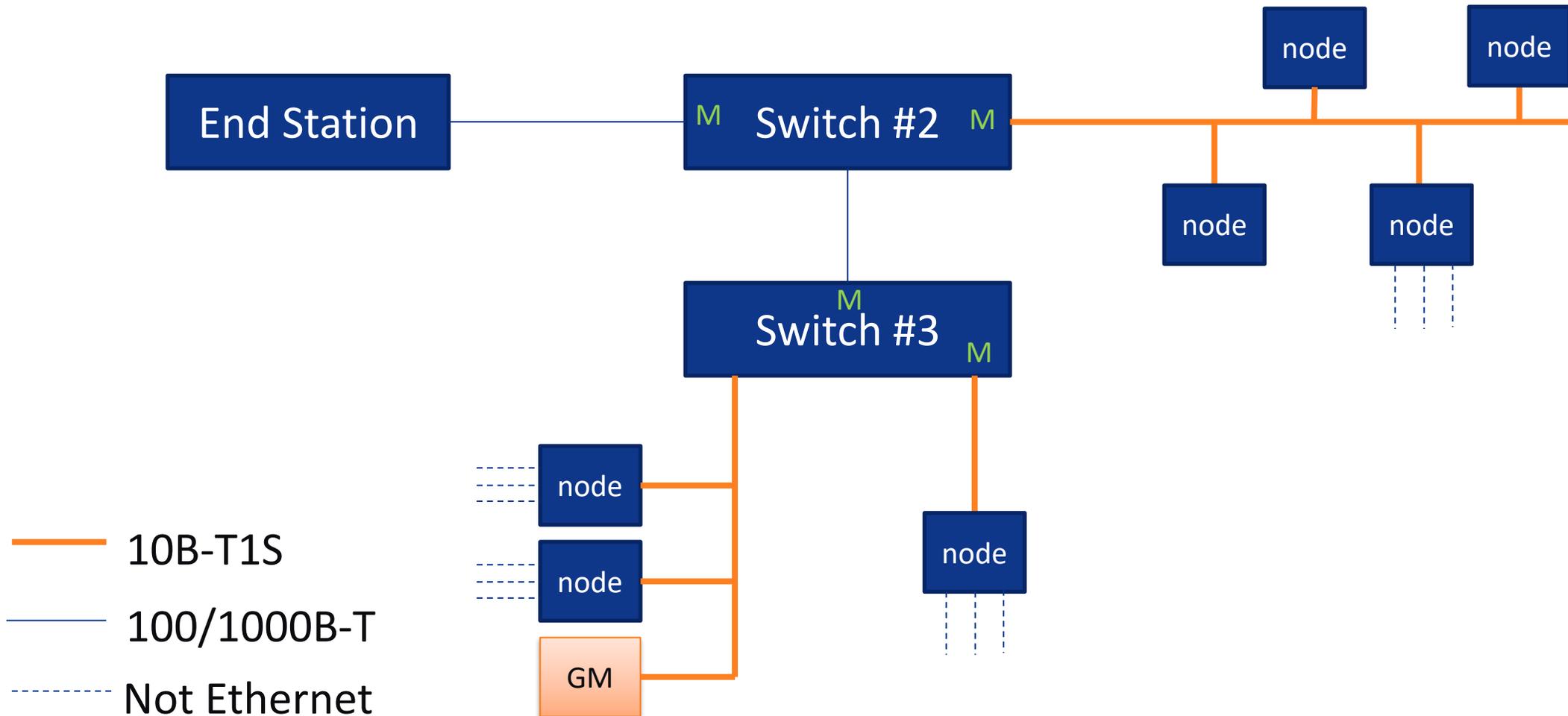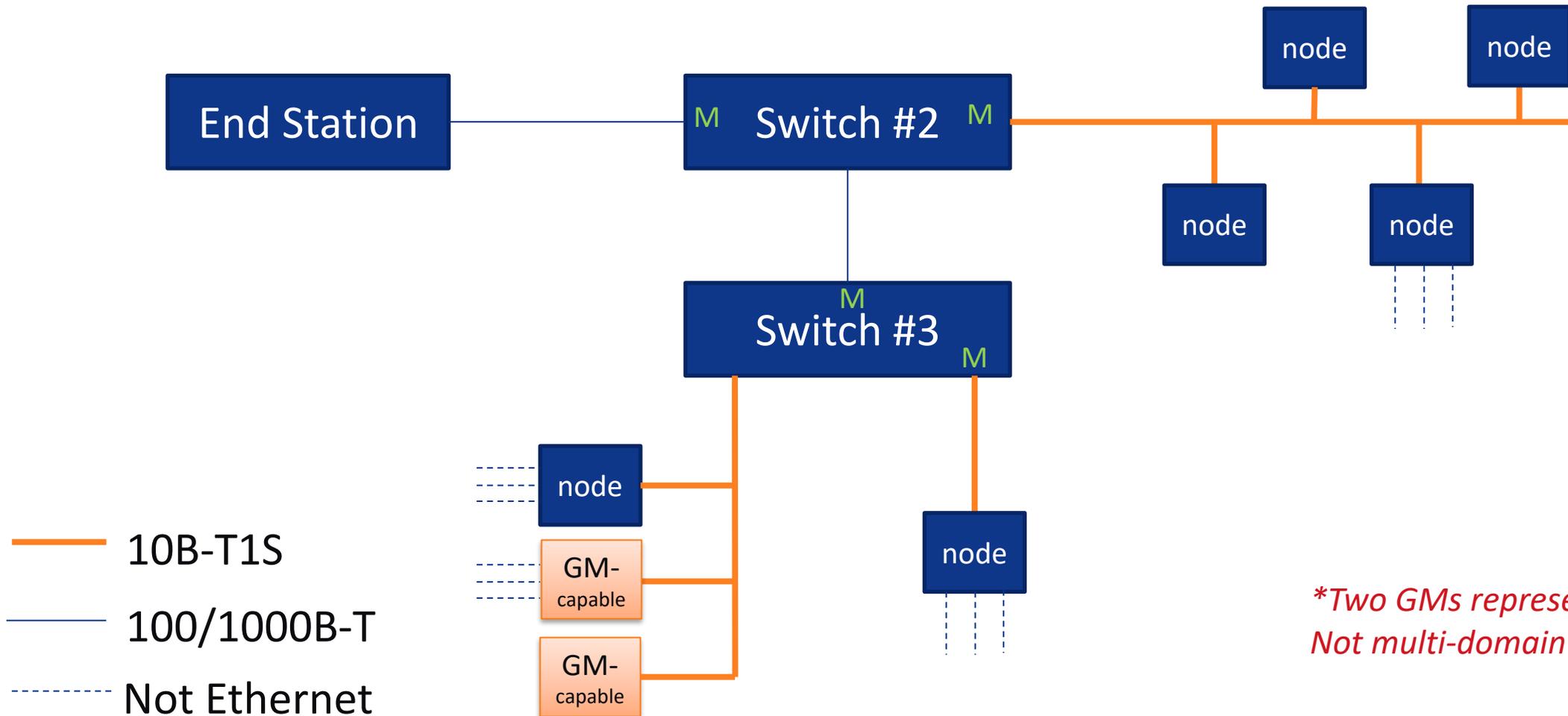
Case #6. Multi-drop 10B-T1S without Switch

10B-T1S

Not Ethernet

Common use-case in Automotive

- **"Case 1. GMs outside of multi-drop 10B-T1S"**
  - Applications for 10B-T1S is mostly interaction with sensors/actuators
  - Sensors/Actuators traffics will be processed in high performance ECU in Switch or backbone connected to faster speed network
  - GM could already exist in in full-duplex point-to-point environment such as AV system
  - Multidrop nodes may not have an accurate clock as GM-capable

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Common use-case in Automotive

- Single domain
  - Assume that legacy networks can be merged into single gPTP domain in a 10B-T1S segment
    - Guess that time subdomains on right picture can be converted into a single domain
  - Multi-domains can be handled in Switch with high-speed network if needed.
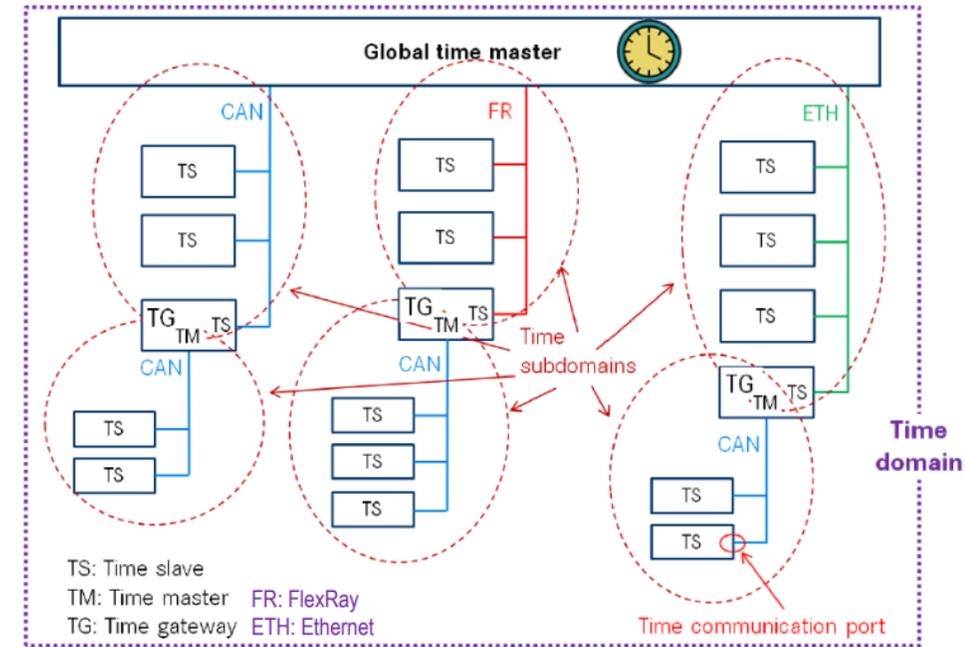 - Start with simple scenario of single-domain first

Figure 3: Terminology Example

AUTOSAR Time Sync over Ethernet- https://www.ieee802.org/1/files/public/docs2019/dg-cummings-autosar-time-sync-0519-v01.pdf

Possible Issues supporting 802.1AS in 10B-T1S

- **Collision in media**
  - Collision can happen in half-duplex
  - Collision may cause unexpected delays
  - Interval may not be guaranteed because of collision (and delay)
    - May miss syncInterval, pdelayReqInterval and announceInterval
    - No hard restriction of Interval margin, however, some test may fail
  - Timestamping in half-duplex
    - P802.3da CL90 adds TSSI for 802.3cg CL147 (10B-T1S) & CL168 (10B-T1M) half-duplex
    - 90.4.3.1.1 adds *"When using the half-duplex mode of operation, multiple TS_TX indications may be produced for a single MA_DATA.request as a result of collisions on the media."*
- **Multicast in mixing segment (multidrop)**
  - PTP messages deliver to multiple devices
  - Message expects a single response, but could get multiple responses

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How to avoid collision

- **802.1Qbv**
  - MAC solution
  - https://www.ieee802.org/1/files/public/docs2017/tsn-cgunther-802-3cg-multidrop-0917-v01.pdf
  - Not all MAC supports Qbv (especially End Station)
  - 802.1AS should run first before Qbv is configured
- **PLCA**
  - PHY solution
  - Need interaction between PHY and MAC
  - 802.3 CL148. optional in half-duplex multidrop mode
  - Avoid collision but cause another issue

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Propagation delay measurement

- **Use current 802.1AS CL11 full-duplex pDelay mechanism**
  - Multicast PTP message doesn't work well with multi-drop
  - Possible changes in StateMachine to support multi-drop
    - By using UNICAST address or another mechanism/update
- **Introduce a new MD pDelay mechanism**
  - Like 802.1AS CL12 for 802.11
- **Another way**
  - OpenAlliance Topology Discovery measures cable length. (measurement precision < 15cm, it is < 1nSec.) – there may be extra compensation factor such as temperature
  - Static method like setting min & max linkDelay like combining cable length with mathematical method
  - However, G.1.2 of 802.1DG D1.4 describes needs of pDelay message, especially neighbor rate ratio.

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BMCA in 10B-T1S

- **Don't see any problem to run current BMCA in 10B-T1S**
- **ANNOUNCE message to all nodes in multi-drop**

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Things to consider in 10B-T1S

- **Delay**
  - PLCA can cause variable delay at Tx path (MAC -> PHY -> Media)
- **Accuracy**
  - 10Mbps Low MII clock (2.5MHz) could be challenging to meet 40nSec granularity
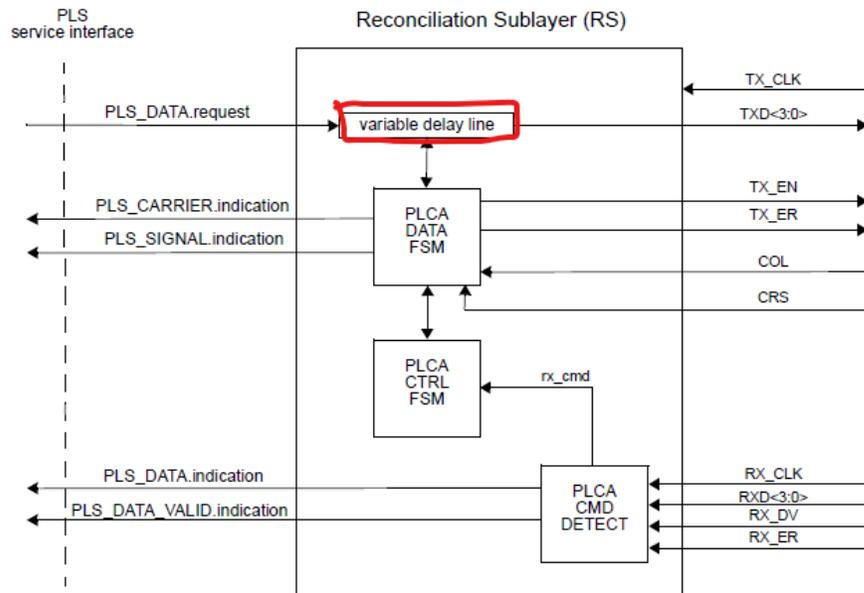- **Vendor may have proprietary solution**

Figure 148–2—PLCA functions within the Reconciliation Sublayer (RS)
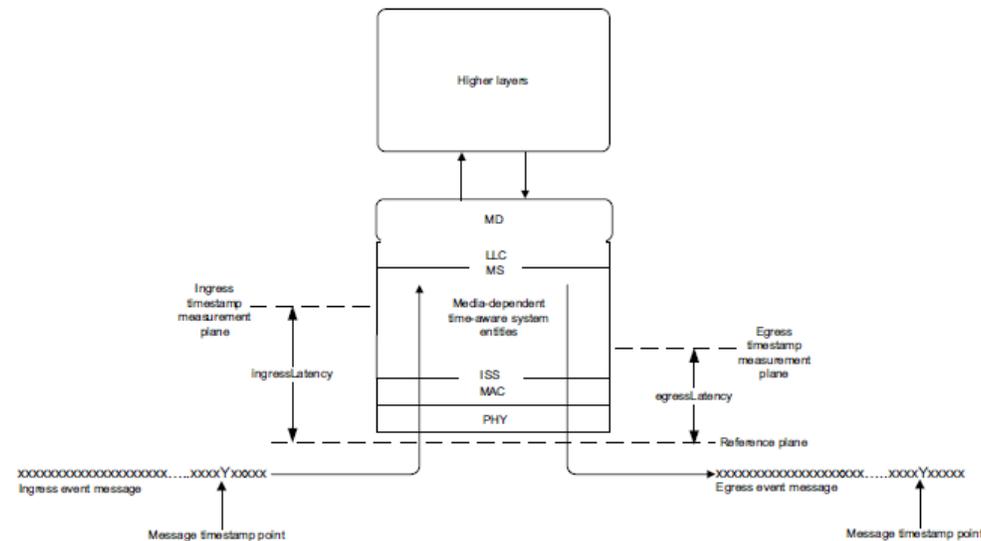
Figure 8-2—Definition of message timestamp point, reference plane, timestamp measurement plane, and latency constants

Summary

- **To support 802.1AS in 10B-T1S**
  - Timestamp on 10B-T1S PHY or on MAC with Half-duplex support
  - Collision Avoidance is needed
  - Hardware-supported media sharing will be needed for deterministic behavior
  - New propagation delay measurement will be needed
  - Solutions to overcome variable delay and accuracy issue
- **Future Experiment Plan**
  - Experiments with PLCA
  - Experiment a new propagation delay measurement
  - Experiments with different number of nodes in multi-drop mode