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Agenda

- Purpose
- Working Basis and Hypothesis
- High Level Background
- Routing PTP with BC, TC E2E, TC P2P
- Switching PTP with BC, TC E2E, TC P2P
- Conclusion

Purpose

- It is expected precise time/phase alignment calls for BC and/or TC support from network.

Actual support might not be necessary in all cases.

Actual support might not be possible every time.

- Network equipments would be involved.
- Beyond the timing aspects, networking aspects shall be considered to engineer the PTP communication paths.

Some packet transport techniques disrupt packet timing engineering.

Particularly, for transition and coexistence.

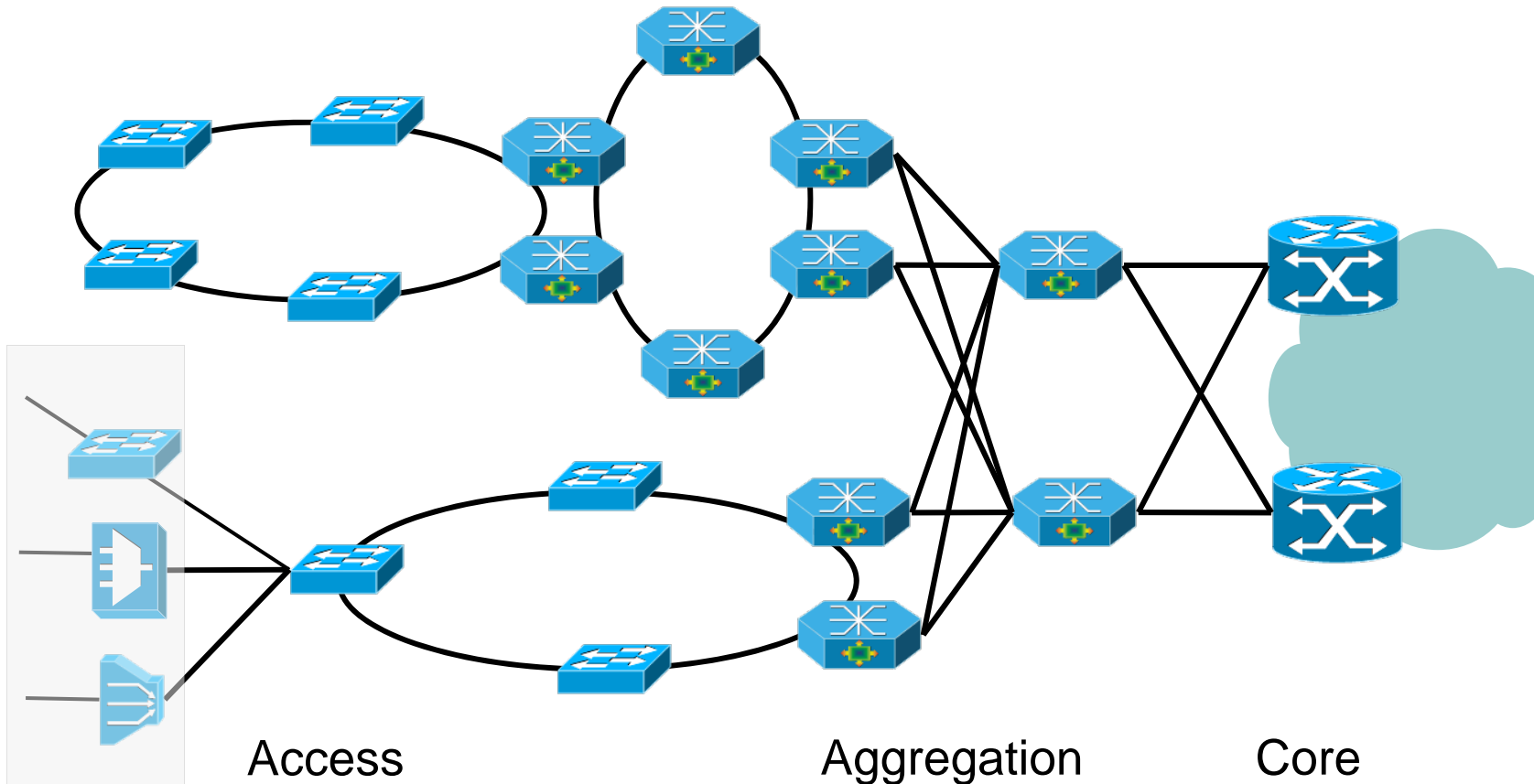
- Key work item would be to align transport and timing engineering.

Working Basis and Hypothesis

- Bi-directional PTP (TWTT) for time/phase alignment
- IP addressing and PTP event messages
 - PTP over UDP over IP - Annexes D & E
 - Announce, Signaling and Management messages left aside
 - Mainly IP unicast; IP multicast would require separate session
- Unique network administrative domain

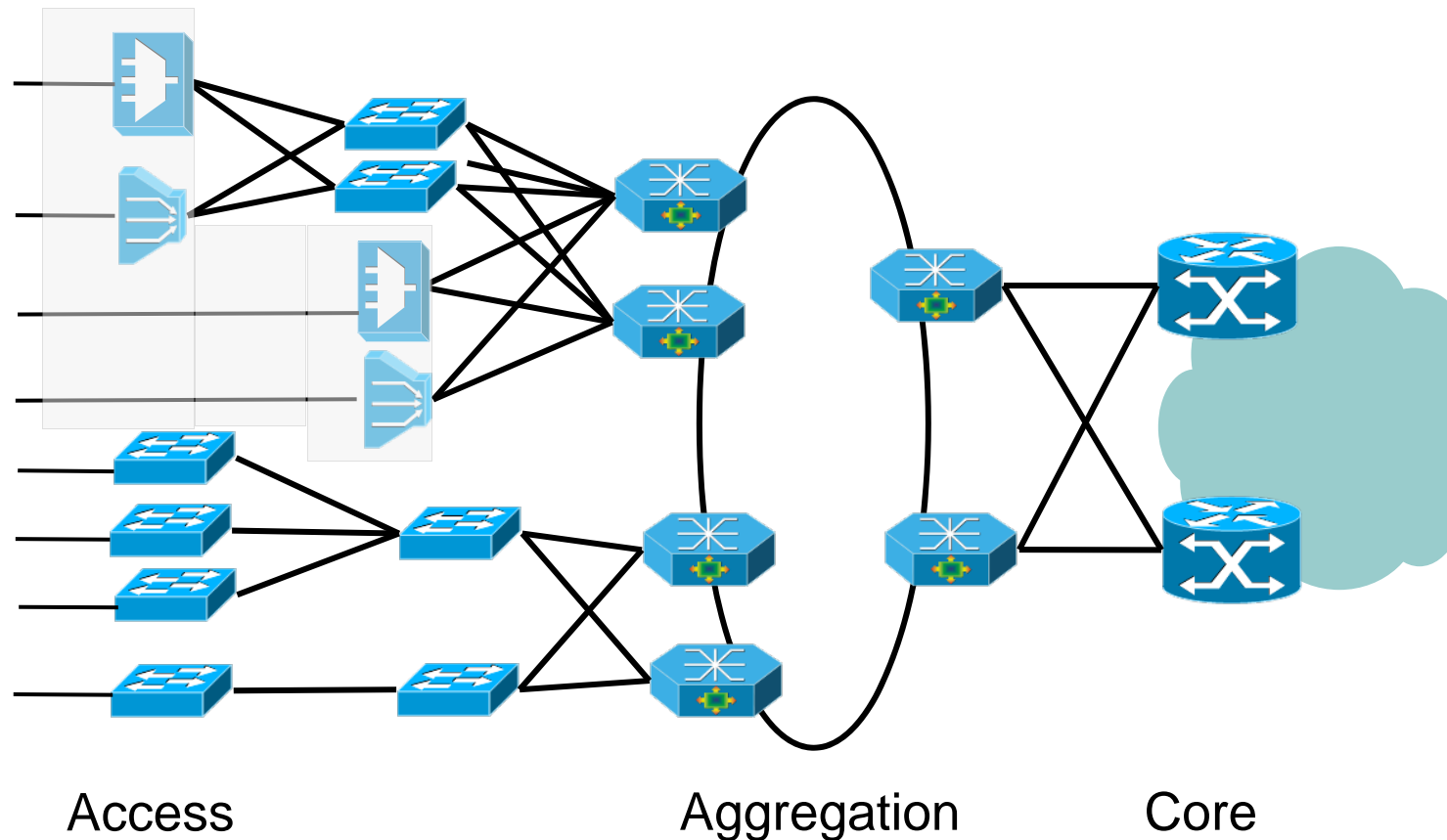
Packet Network Topologies – 1

- Meshed and ring topologies can be mixed in packet networks to achieve proper distribution and redundancy.



Packet Network Topologies – 2

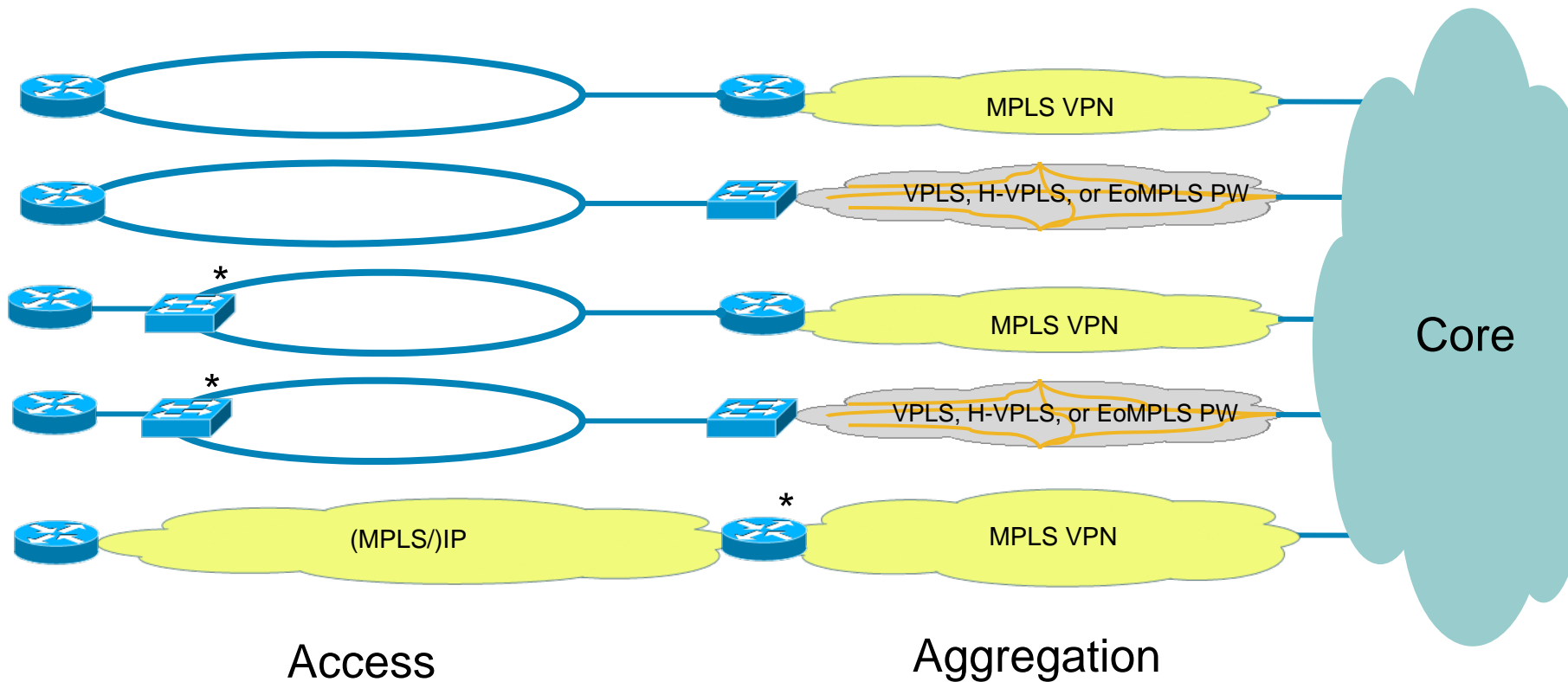
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Packet Transport Services For Aggregation and Access (Examples)

- G.8032 enabled Ethernet rings
- MPLS/IP

- MPLS VPNs
- VPLS/H-VPLS transport



* DSL and PON can provide the last miles connectivity.

Timing and Transport Services

- Transport services are designed for various applications.
- Transport techniques tend to create virtualization.
- They aim to provide bandwidth, low latency, low jitter and low repair time to those various applications.
- Precise timing service expects low PDV and low asymmetry.
- To achieve this goal, it expects close relationship with nodes and links.
- Those are opposite goals.

Nomenclature for Diagrams



Non PTP network/NE using IP routing.



Non PTP network/NE not using IP routing.



Boundary Clock built in network equipment



Transparent Clock built in network equipment
E2E or P2P model will be specifically mentioned.



Master

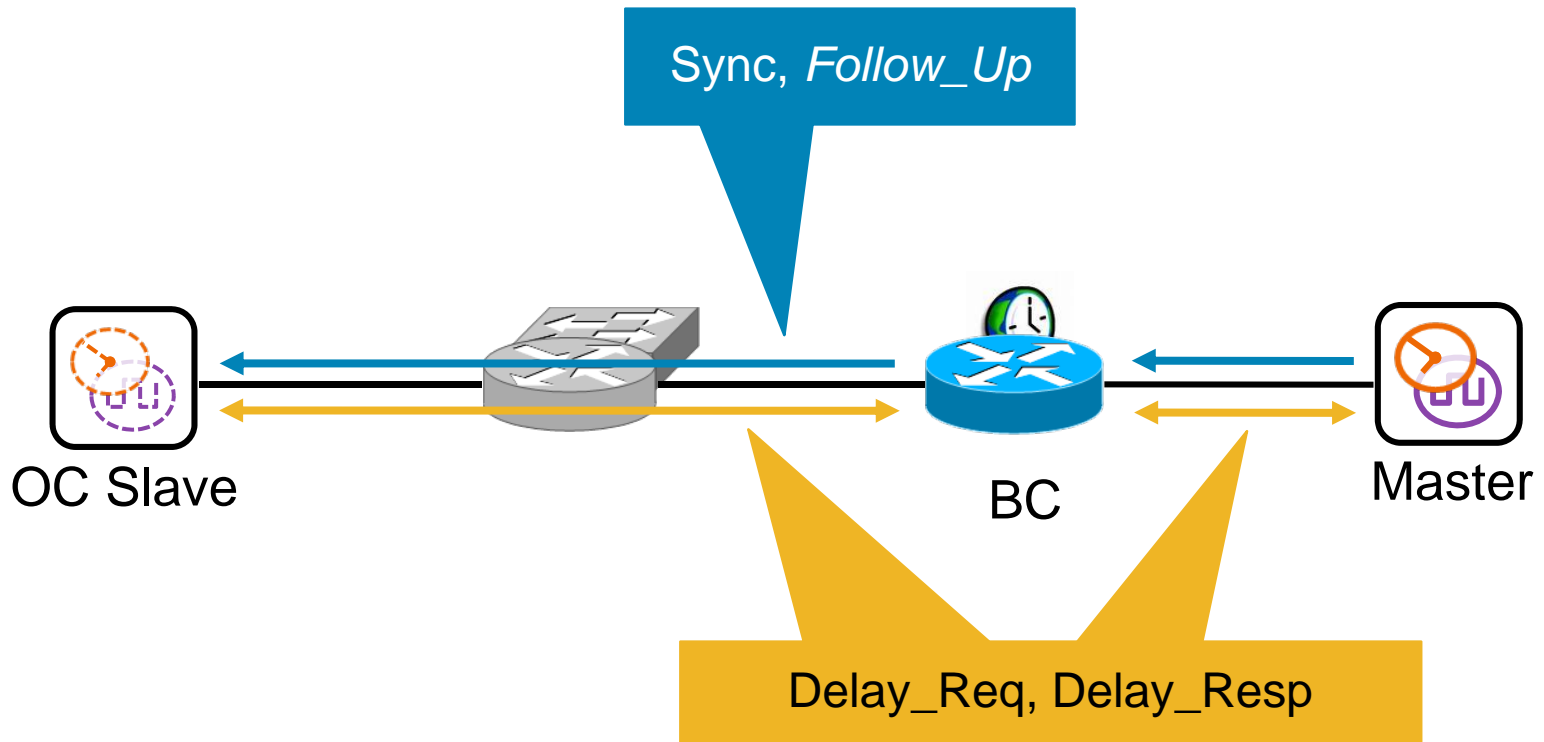
GrandMaster or BC used as reference master
Can be independent or built in network equipment



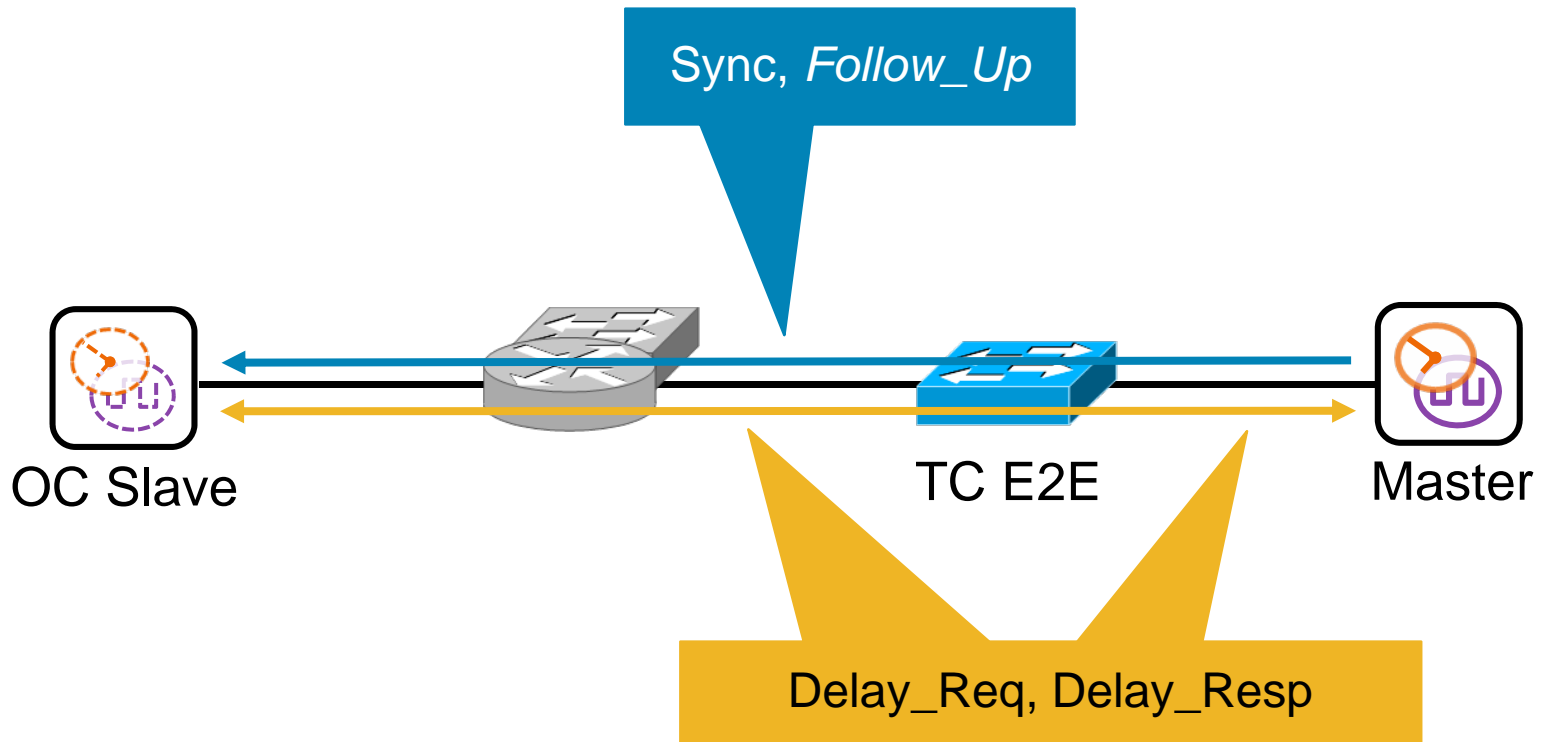
OC Slave

Ordinary Clock in Slave-Only state
Can be independent or built in network equipment

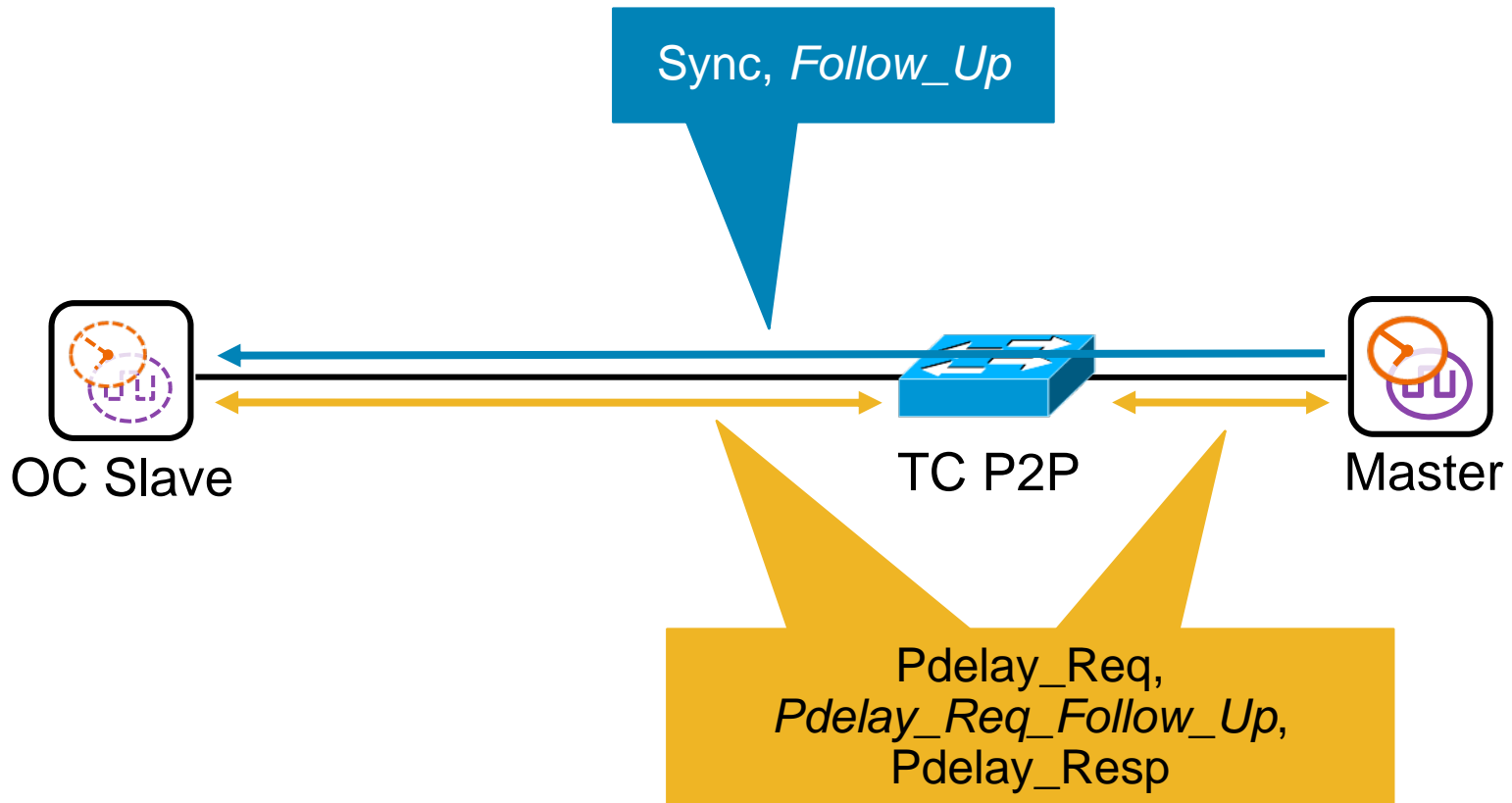
PTP Messages with BC



PTP Messages with TC E2E



PTP Messages with TC P2P – 1

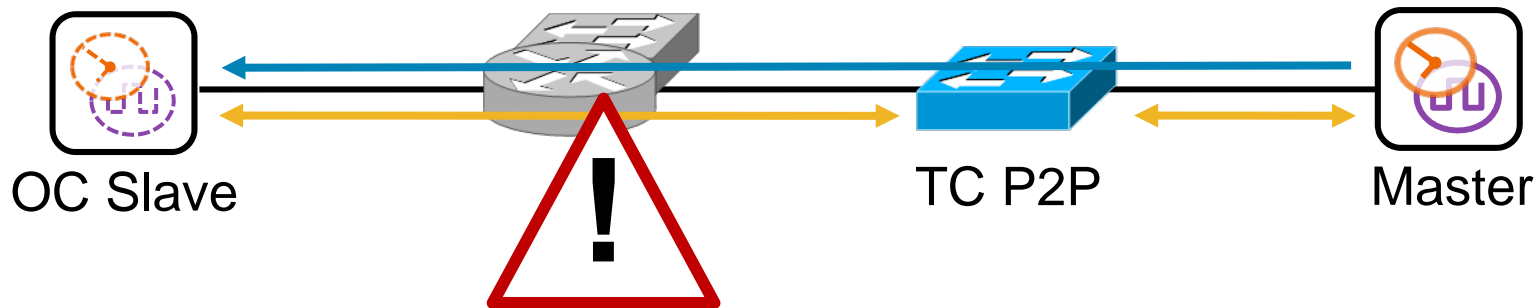


PTP Messages with TC P2P – 2

1. A router would stop the PTP-pdelay multicast message sent with TTL=1.

Pdelay messages must have a TTL=1 i.e. cannot be routed.

Alternative: tunnel or bridge the Pdelay messages.



2. If using multicast, an Ethernet switch would broadcast the Pdelay MAC address with risk of N:1 topology TC P2P cannot resolve.

If IP multicast, PTP-pdelay IP group address 224.0.0.107 becomes MAC address 01-00-5e-00-00-6B which is not a reserved address.

Complicating the Usual Simple, Flat Network Representations

- Network engineering shall define the appropriate PTP communication path.
- It means: “Will the network services fit the timing service requirements?”
- Routing protocols are clever... too clever for PTP?
- Because TCs do not process the Announce messages and do not run BMCA, they are not active member of the PTP hierarchy.

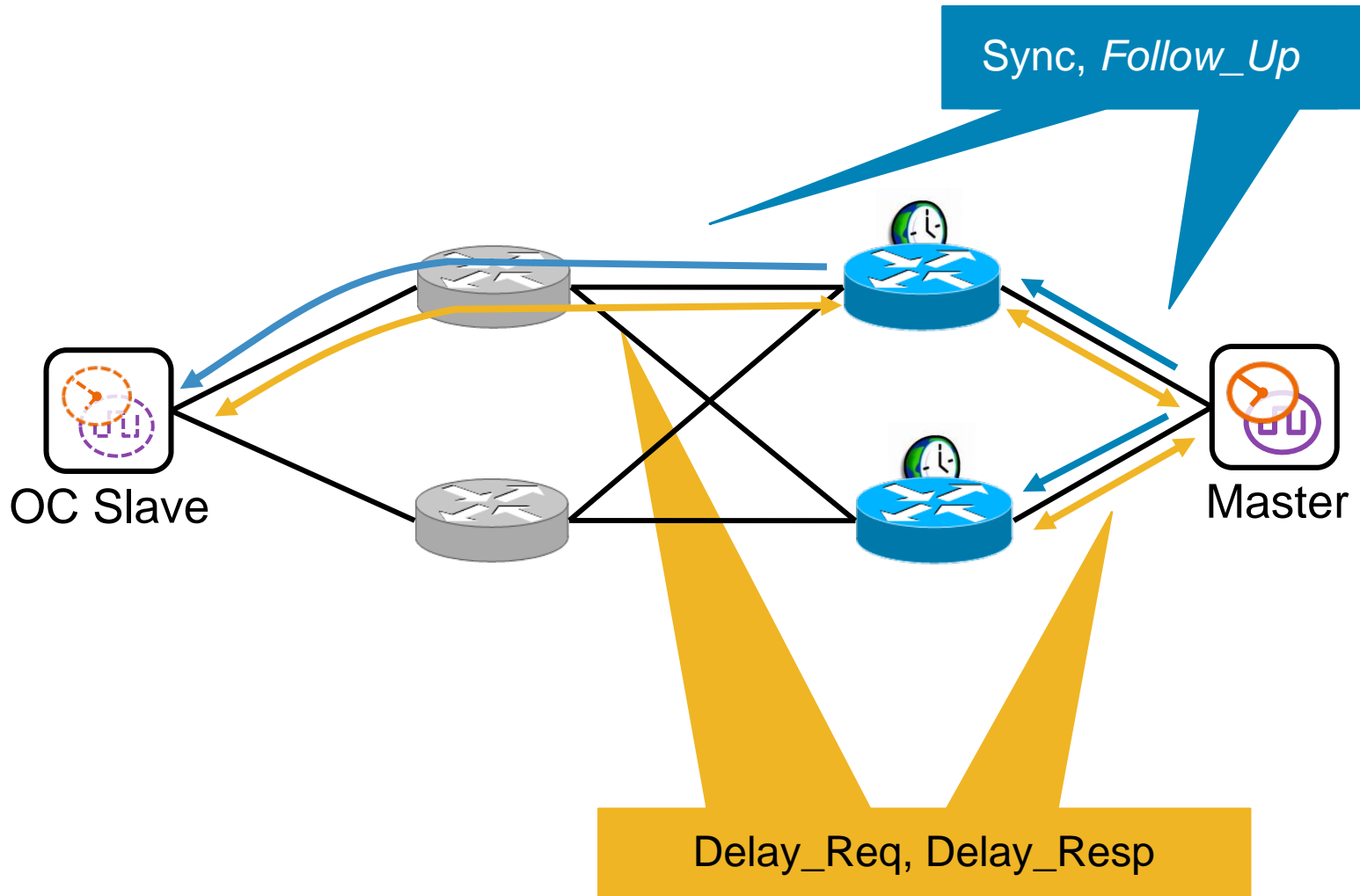
TCs cannot cope with certain PTP communication path complexity.

ROUTED ENVIRONMENT

Some simple scenarios involving routed paths.

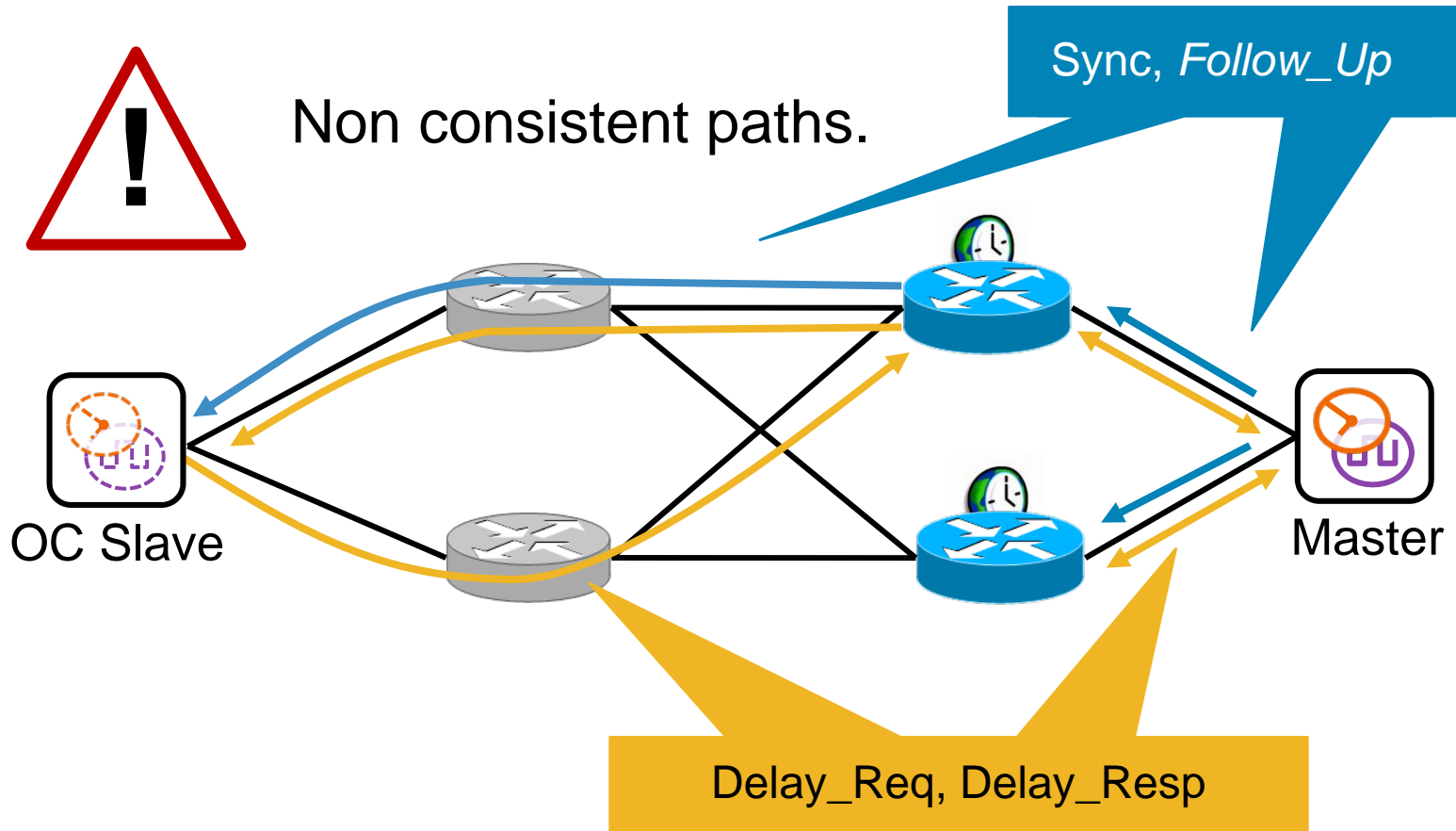
Routing PTP Messages

BC – 1



Routing PTP Messages

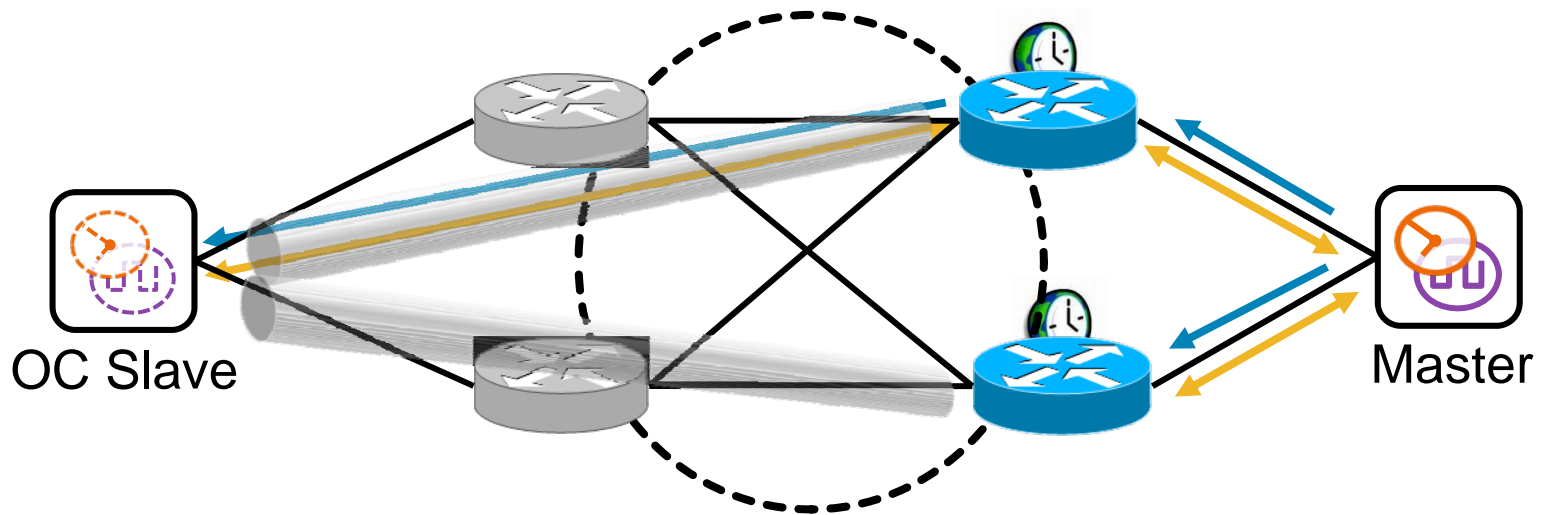
BC – 2



Note: Also true with network services as such as:
MPLS VPN, VPLS, PWS

Routing PTP Messages

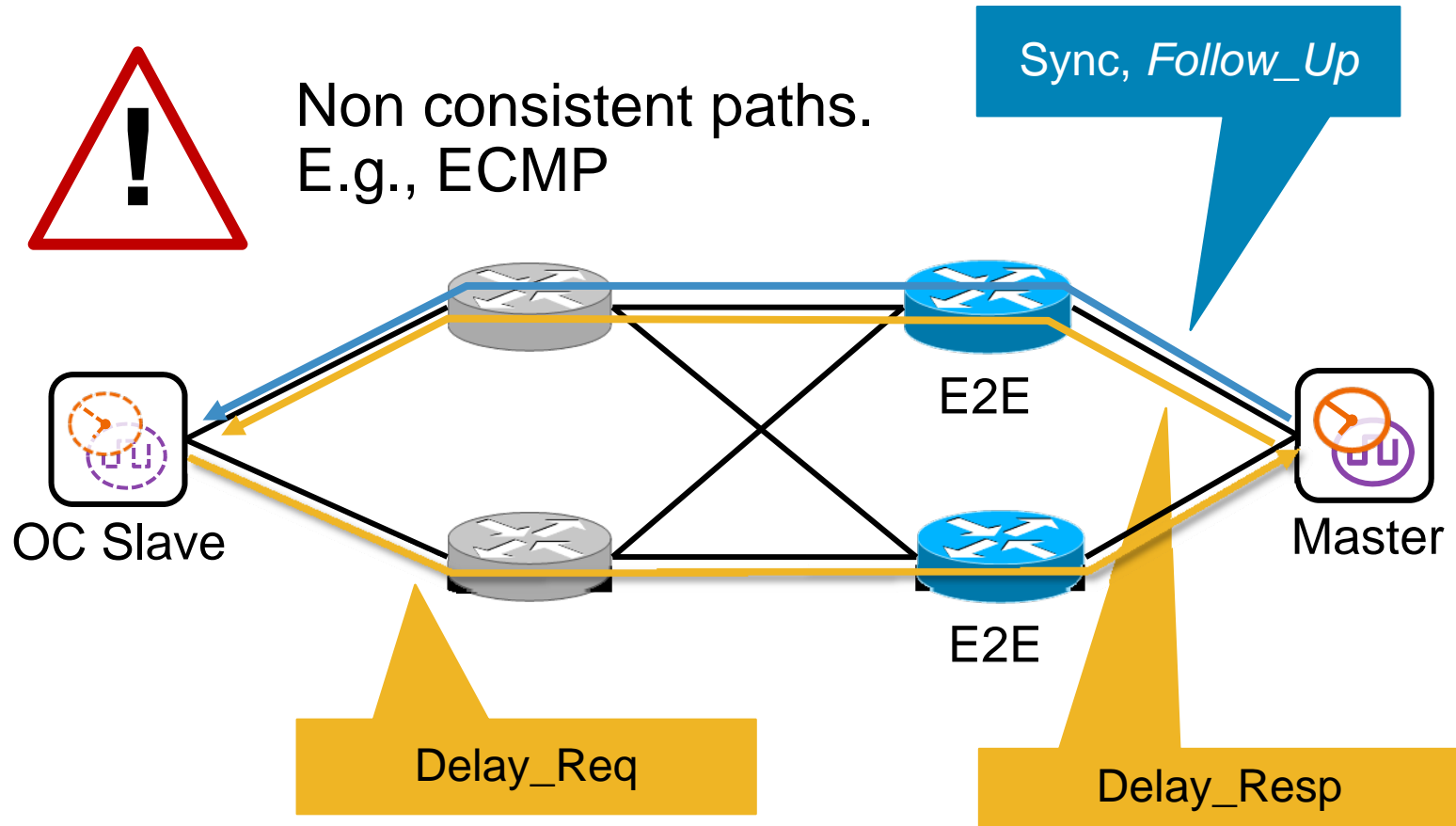
BC – 3



- Solution: Traffic engineer PTP/IP traffic
E.g., with MPLS TE (RSVP-TE), MPLS-TP

Routing PTP Messages

TC E2E – 1

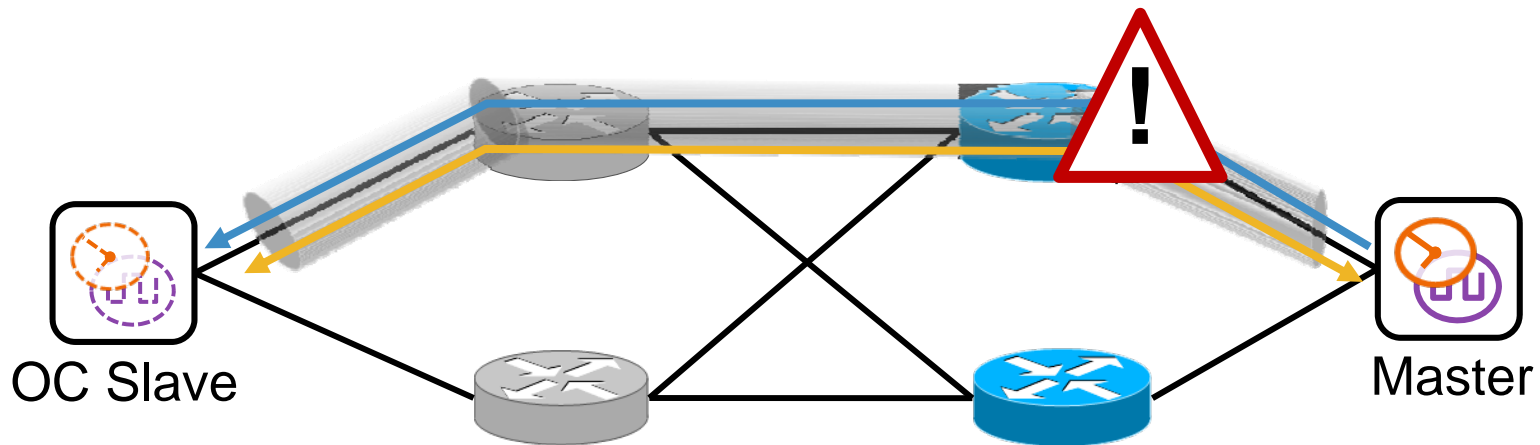


- The Residence Time measured with Delay_Req would not be forwarded to Slave.

Routing PTP Messages

TC E2E – 2

- Solution: Traffic engineer PTP/IP traffic



TC E2E function will be impaired by opacity of the transport technique.

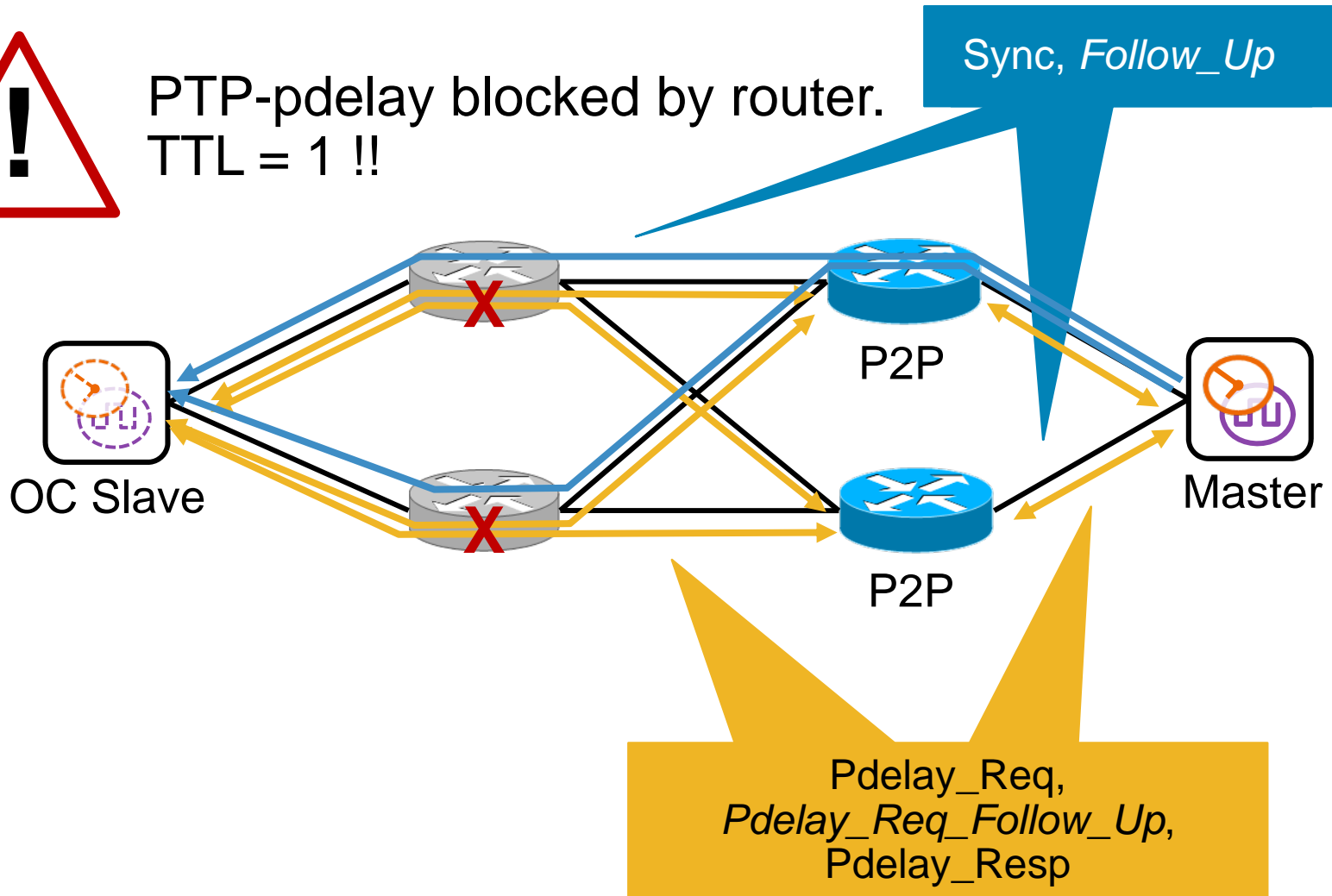
TC must detect and timestamp PTP messages within complex encapsulation.

Routing PTP Messages

TC P2P – 1



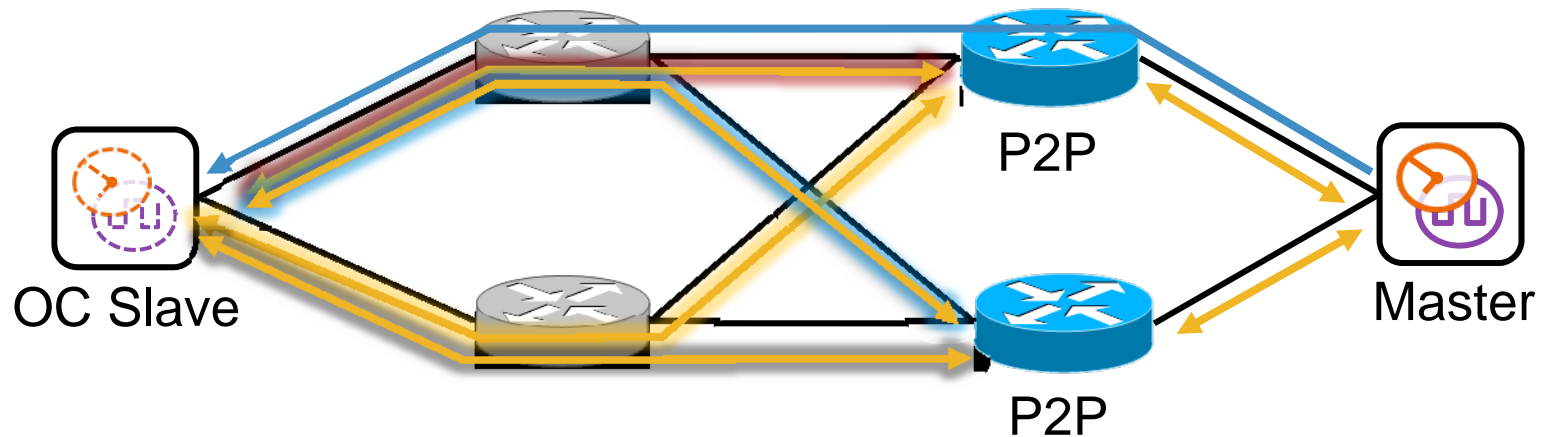
PTP-pdelay blocked by router.
TTL = 1 !!



Routing PTP Messages

TC P2P – 2

Possible Alternative: Tunnel Pdelay messages.



1. Need to maintain Pdelay messages path consistency
→ Number of tunnels to create and maintain?
2. Possible inconsistency of Pdelay measures.
→ Tunnel Pdelay messages with Sync messages.

CONCLUSION: Avoid this configuration.

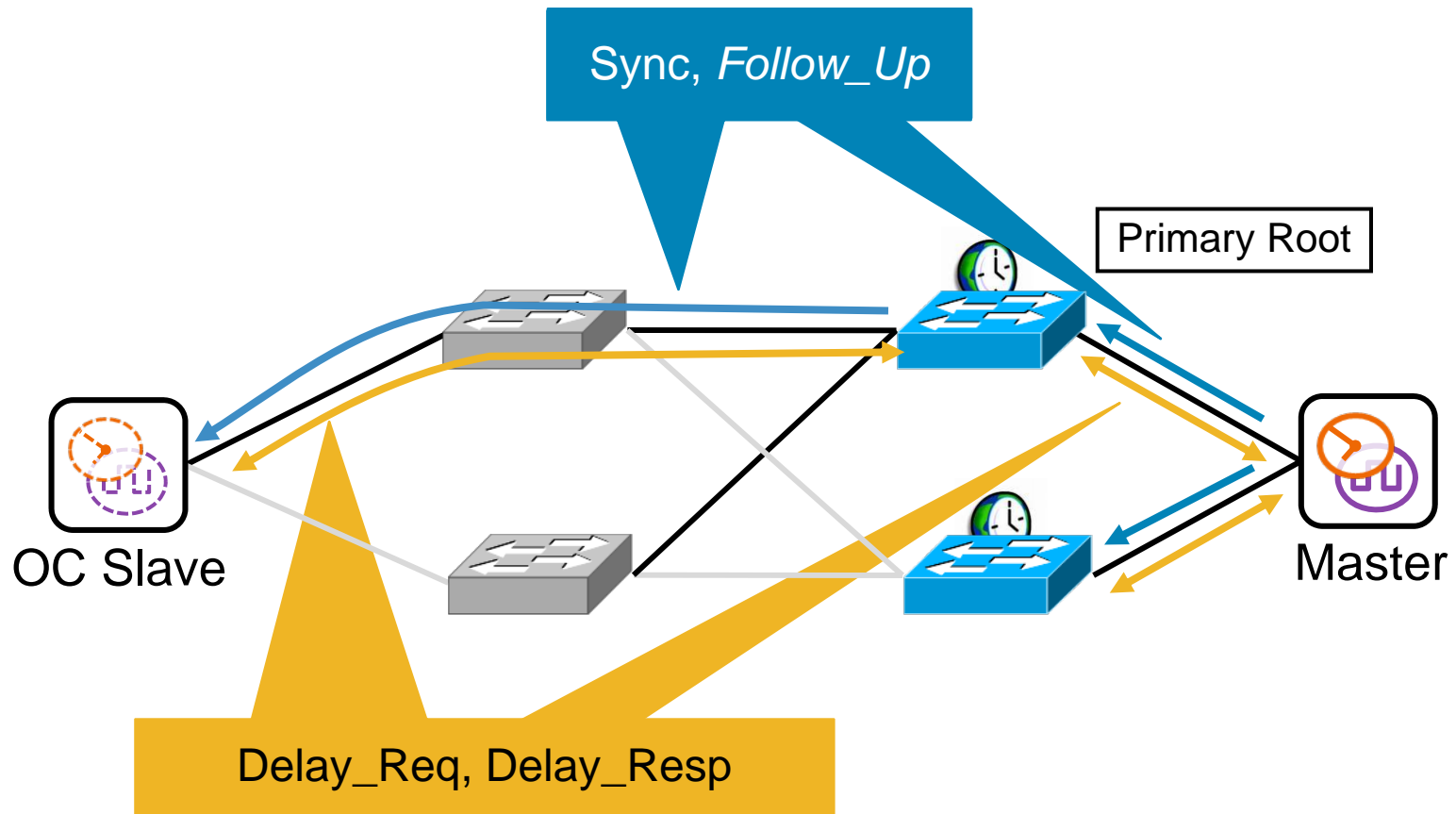
SWITCHED ENVIRONMENT

Some simple scenarios involving Ethernet switching.

Usually more suitable to PTP... but not to complex packet network services.

Switching PTP Messages

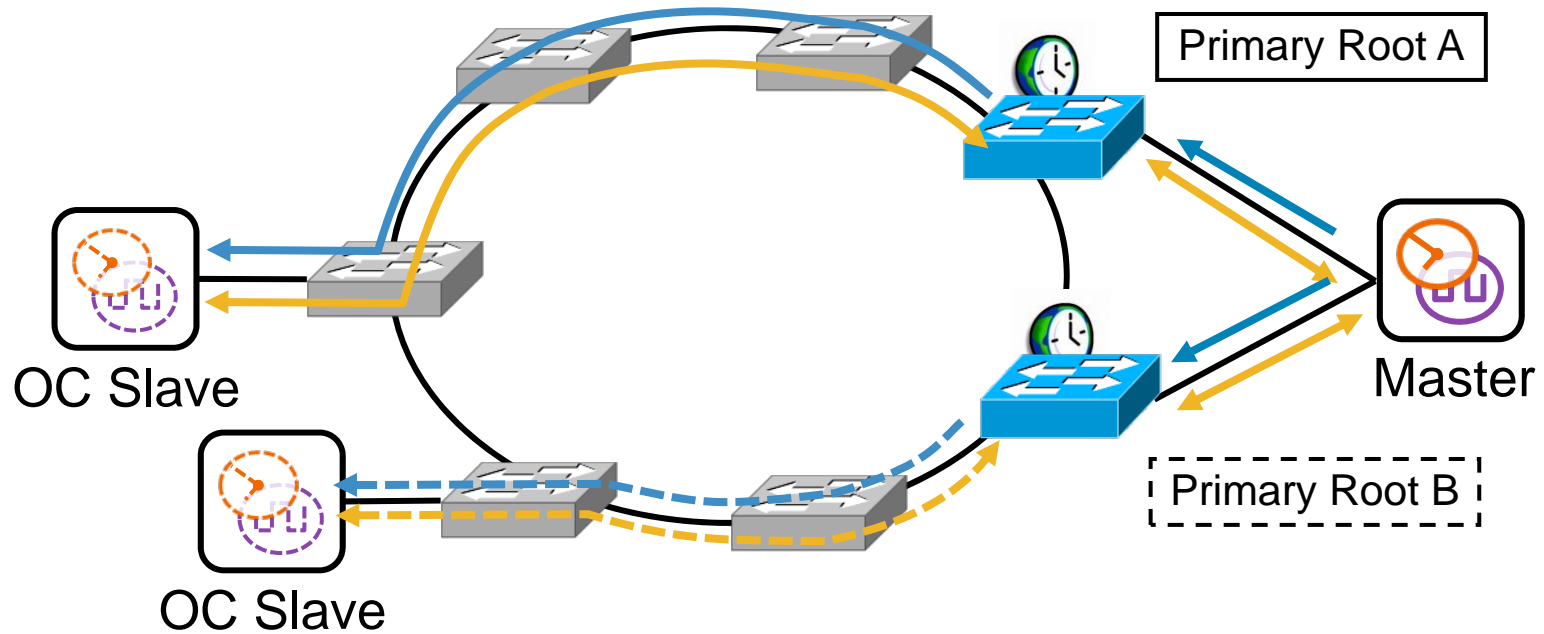
BC – 1



Assuming M/R/STP, NMS-configured Ethernet path (transport model) → Maintain path congruency

Switching PTP Messages

BC – 2 (MSTP or REP example)

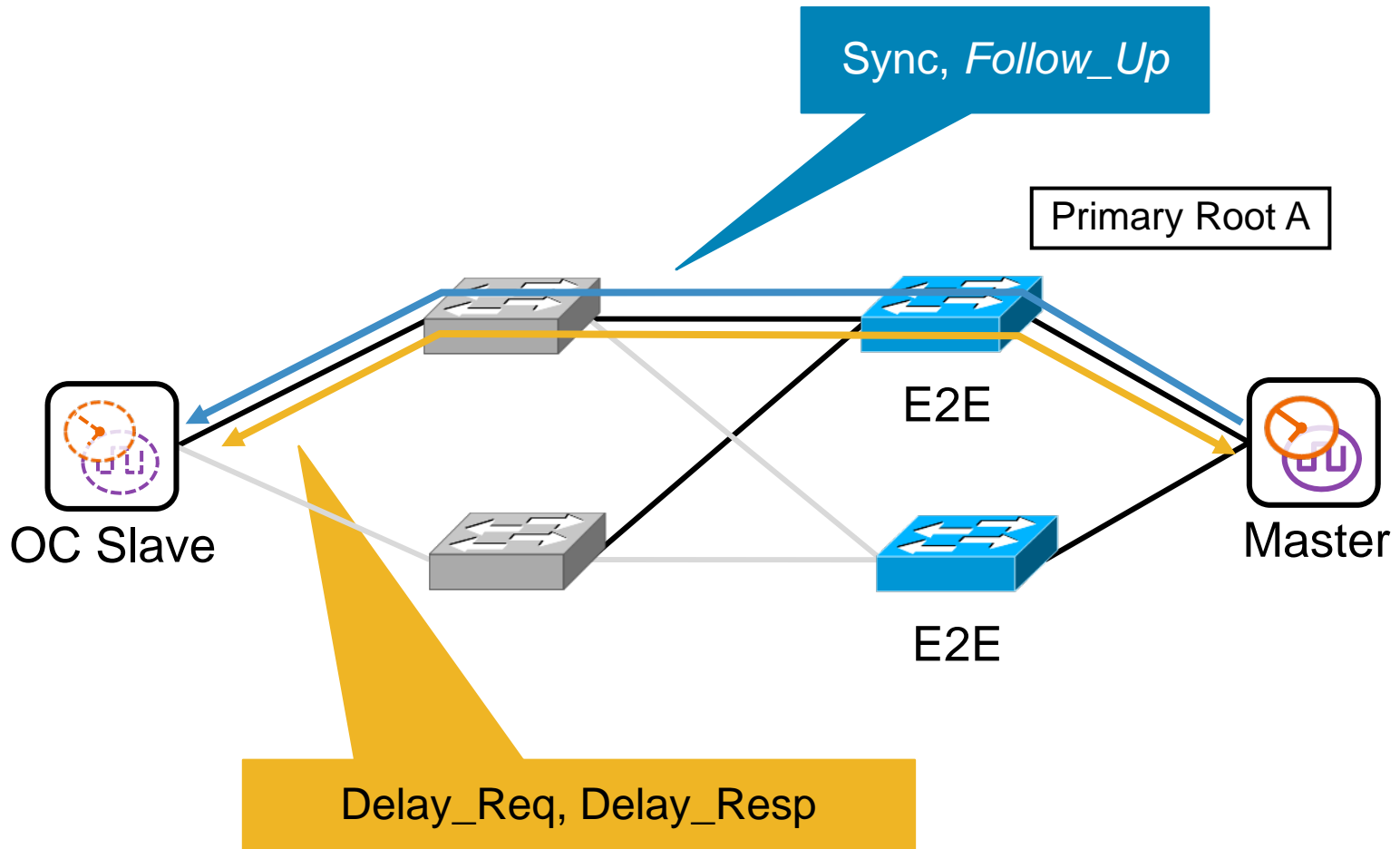


Examples:

- STP/MSTP/RSTP
- REP/G.8032

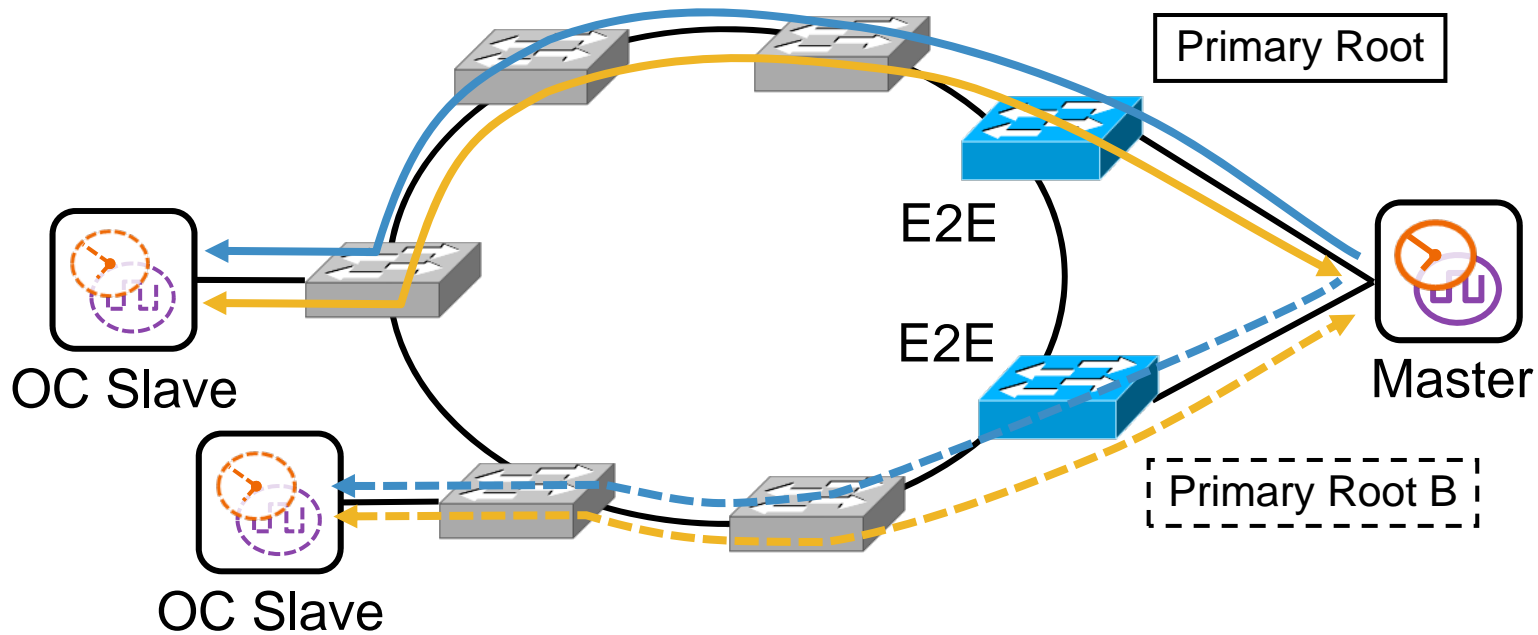
Switching PTP Messages

TC E2E – 1



Switching PTP Messages

TC E2E – 2

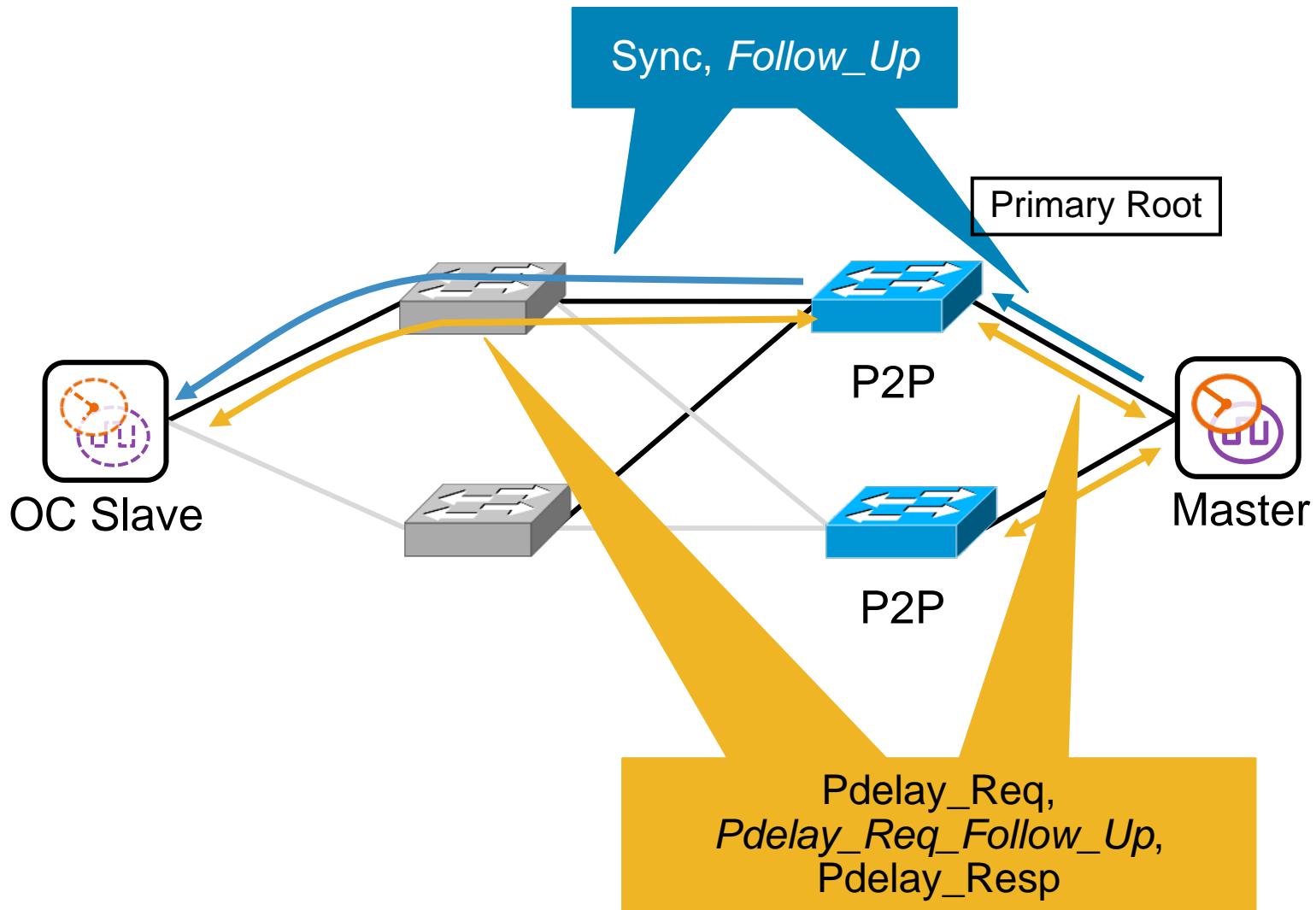


Examples:

- STP/MSTP/RSTP
- REP/G.8032

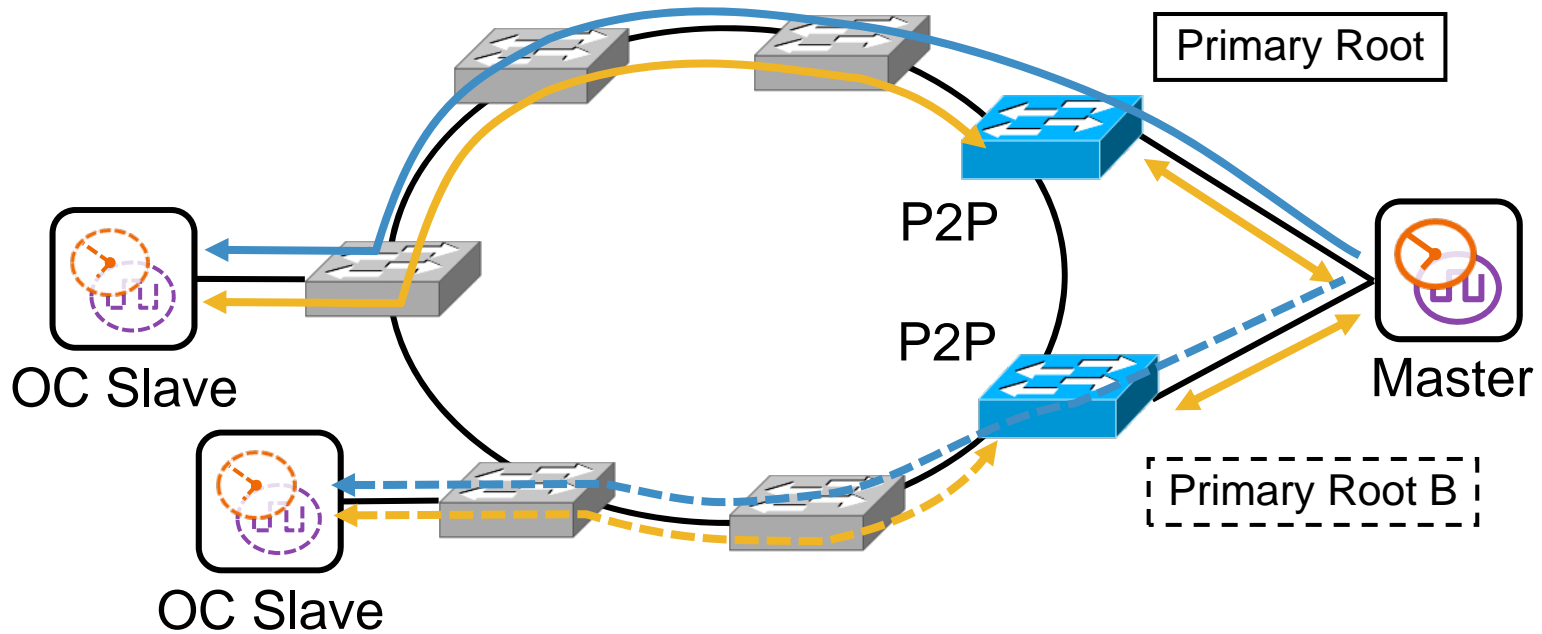
Switching PTP Messages

TC P2P – 1



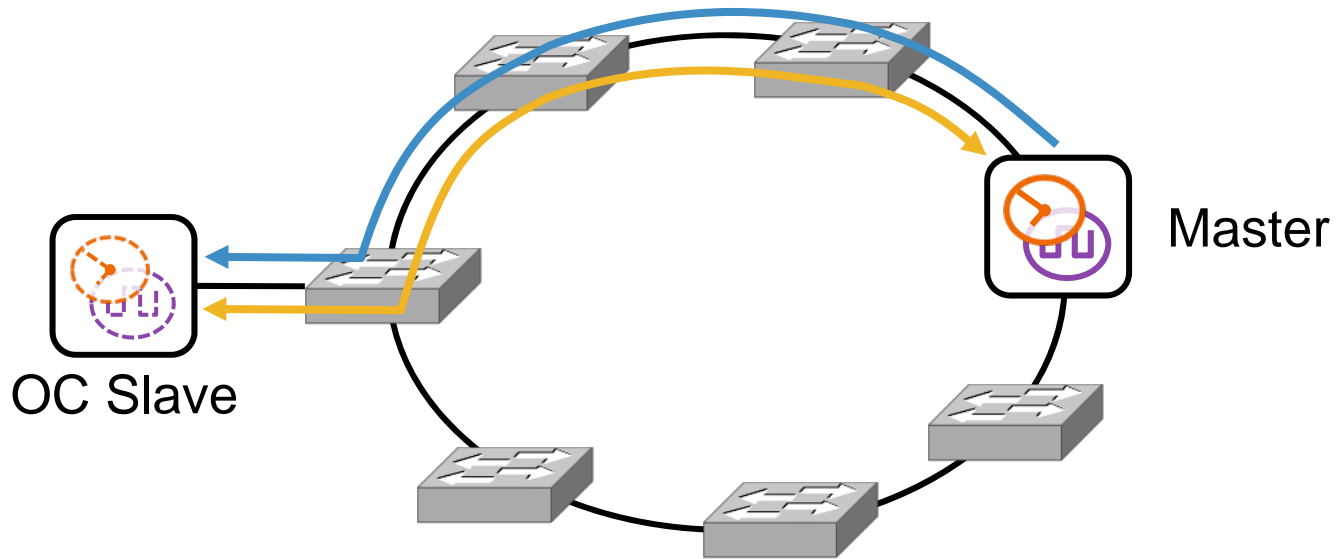
Switching PTP Messages

TC P2P – 2



- Examples:
 - STP/MSTP/RSTP
 - REP/G.8032

Switching PTP Messages Wrapping with RPR

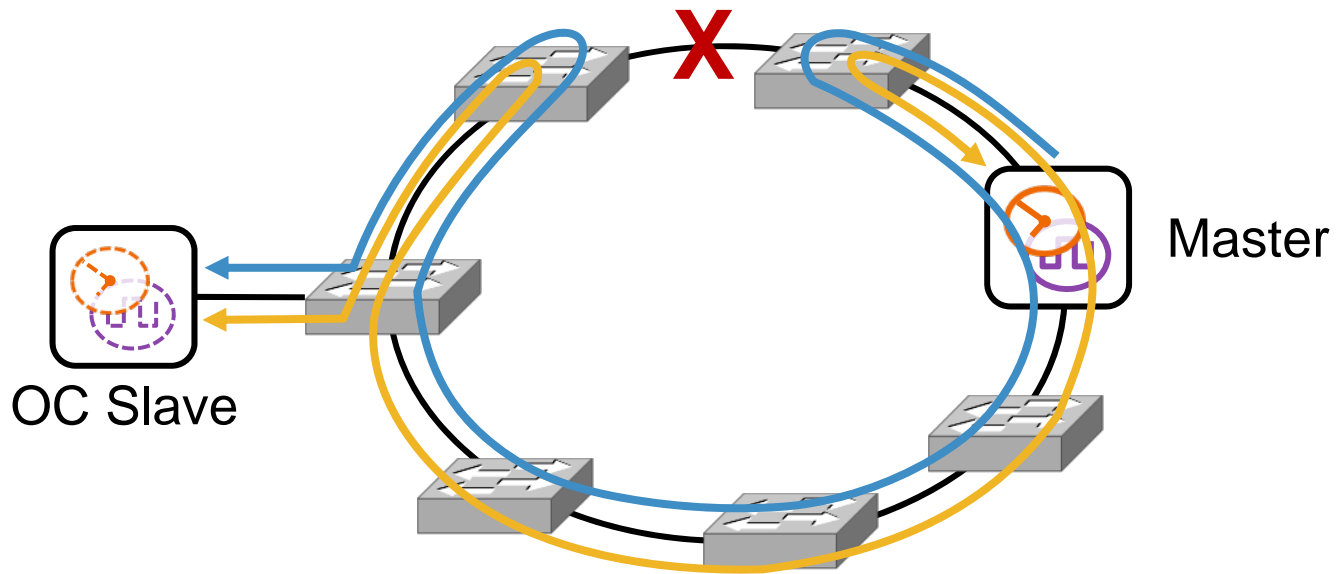


Some ring-based transport solutions may lead to hair-spinning (wrapping).

Example: IEEE802.17/RPR

Switching PTP Messages

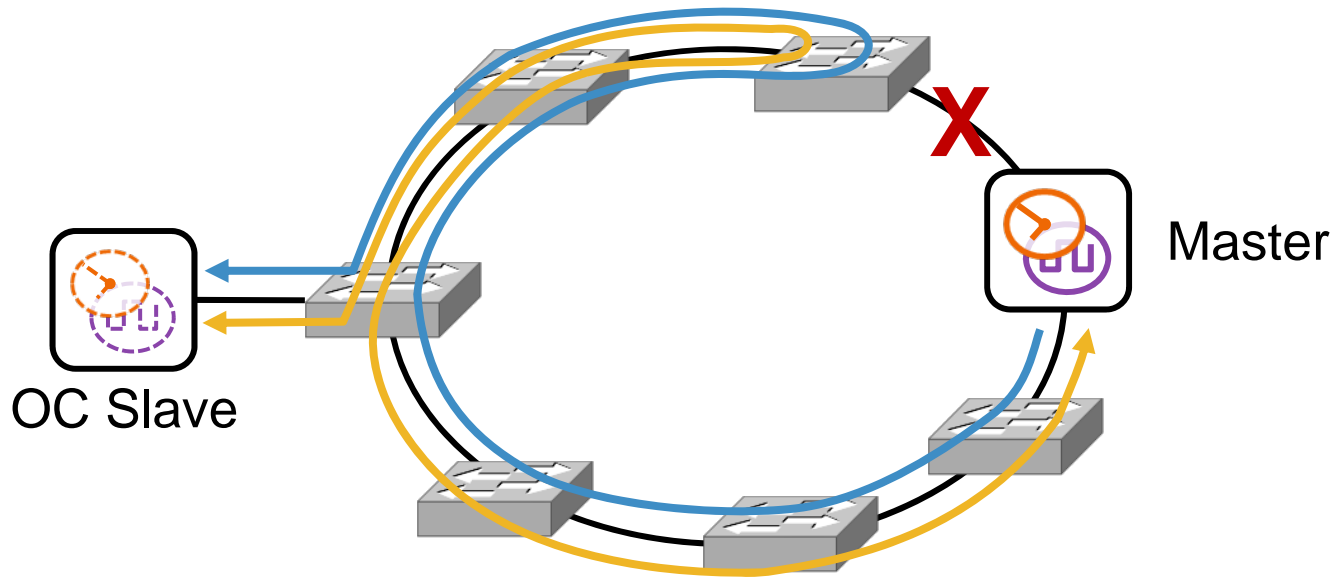
Wrapping issue with RPR



Extra delay, PDV and asymmetry would be injected.

Switching PTP Messages

Wrapping issue with RPR



Solution: use “Do Not Wrap” option

Conclusion

- Traditionally, packet networks have been designed for various data services.
 - Bandwidth, delay, jitter and repair time are main criteria.
- Timing distribution is now a key purpose for mobile backhaul.
 - PDV and asymmetry are the main concerns.
- Network design must integrate timing engineering...
- ...Particularly in multi-service, multi-purpose networks where multiple constraints exist.
- Need to engage with data packet network engineers to define appropriate PTP communication paths, in particular, when TC are implemented during migration.

