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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

- Meshed and ring topologies can be mixed in packet networks to achieve proper distribution and redundancy.
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.
- **GrandMaster or BC used as reference master**
  Can be independent or built in network equipment
- **Ordinary Clock in Slave-Only state**
  Can be independent or built in network equipment
PTP Messages with BC

Sync, Follow_Up

OC Slave

BC

Delay_Req, Delay_Resp

Master
PTP Messages with TC E2E

OC Slave

Sync, Follow_Up

TC E2E

Delay_Req, Delay_Resp

Master
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

OC Slave

Master

Sync, Follow_Up

Delay_Req, Delay_Resp
Routing PTP Messages
BC – 2

Non consistent paths.

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
Non consistent paths. E.g., ECMP

- 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 !!

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OC Slave

Master

P2P

Sync, Follow_Up

Pdelay_Req, Pdelay_Req_Follow_Up, Pdelay_Resp
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

Sync, Follow_Up

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

Sync, Follow_Up

Primary Root A

OC Slave

Delay_Req, Delay_Resp

Master
Switching PTP Messages
TC E2E – 2

Examples:
- STP/MSTP/RSTP
- REP/G.8032
Switching PTP Messages

TC P2P – 1

Sync, Follow_Up

Primary Root

OC Slave

Master

P2P

Pdelay_Req, Pdelay_Req_Follow_Up, Pdelay_Resp
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.