High Available Synchronization with IEEE 802.1AS bt

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Structure of this Presentation

1. Methods in IEEE 1588 v2 and IEEE 802.1AS to establish the Sync Path

2. Further Requirements on Synchronization @ IEEE802.1AS – Gen 2

3. Methods to meet the Requirements for High Available and High Accurate Synchronization

4. Proposals how a Sync-Relay of a Time Aware System can distinguish multiple Sync Path

5. Proposal for Distributing Synchronization Information with ISIS-SPB
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Method how IEEE 1588 v2 establish the Sync Path

Today: Two Methods already used to established a sync path

- **IEEE 1588v2: (PTPv2 – Transparent Clocks, TC)**
  - Announce, Sync and FollowUp messages are *multicast* frames
    => Announce, Sync and FollowUp messages are forwarded by the MAC-Relay of a TC in typical implementations
  - When network consist of ordinary clocks (OC) and transparent clock (TC)
    - **Today:** typical usage in industrial networks
      - Port roles for TC are established by RSTP this means that when receiving a Sync message, the ingress port is the slave-port and the egress port is the master-port
      - No guaranteed path for sync message by network reconfiguration
  - Announce, Sync and FollowUp are *forwarded by MAC-Relay* entity
    - *In typical implementation of TC 1588v2*

⇒ Network must provide a mechanism to prevent loops e.g. RSTP
⇒ Redundant disjoint path for redundant sync messages are not supported
Methods in IEEE 1588 v2 and IEEE 802.1AS to establish the Sync Path

- **IEEE 802.1AS – Gen 1 (gPTP)**
  - Announce, Sync and FollowUp messages are peer-2-peer frames
    - => no flooding of announce messages and overload situations
    - => exchange of source address to be standard conform
      - – manipulate correction field in payload of sync message at each hop
    - => Sync- and FollowUp messages are forwarded by Sync-Relay (higher layer entity)

- **Network consists of time aware systems which has to support the BMC**
  - – end stations, bridges and routers

- **Sync tree is established by BMCA (like boundary clocks BC) which assigns fix port roles**
  - – slave port or master port

- **But:**
  - Forwarding of sync and FollowUp frames is based on a Sync-Relay
    - – independent of bridge MAC relay

  - The methods for correction residence time of sync message within a time aware system are the same as specified for transparent clock (TC)

⇒ By using BMCA gPTP has specified it’s own network independent loop prevention mechanism
⇒ **Redundant disjoint path for redundant sync messages are not supported**
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Further Requirements on Synchronization @ IEEE802.1 AS bt

- Two Time Scales (Universal Time & Working Clock) for industrial application
- ...
- High accuracy and availability
  - Redundant disjoint sync path
    - Simultaneously transmission redundant sync messages over redundant path (e.g. path A and path B)

=> Receiving redundant sync messages
  - Better sync quality – using redundant sync message (e.g. from path A and path B)
  - Zero switchover time by single point of failure to guarantee accuracy (using low quality oscillators in rough environment)
  - Maintenance and surveillance

- Cold- or hot-stand-by grandmaster

Proposed method to fulfill these further requirements:
⇒ Knowledge about physical topology, link state information and a appropriate routing algorithm is required to establish sync path

⇒ IEEE 802.1 has introduced ISIS-SPB (intermediate to intermediate system shortest path bridging) as link state protocol
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Methods to meet the requirements for high available and high accurate Synchronization

Use case 1:
Time aware domain with one active grandmaster but redundant sync messages transmitted over redundant path with or without auto-re-configuration of sync path

The sync paths for sync messages from GM 1 and GM 2 are determined from information distributed by ISIS

Time aware bridge
End station (slave only)

Time aware bridge which is grandmaster

Time aware bridge which is grandmaster capable but passive

The Sync messages from GM 2 will be transmitted over path 3 and path 4 when GM 2 becomes grandmaster

Sync messages form GM 1 are transmitted over path 1 and path 2
Methods to meet the requirements for high available and high accurate Synchronization

Use case 2:
Time aware domain with hot-stand-by grandmaster and redundant sync messages transmitted over redundant path and with or without auto-re-configuration of synch path.

The sync paths for sync messages from GM 1 and GM 2 are determined from information distributed by ISIS.

<table>
<thead>
<tr>
<th>BR</th>
<th>Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>End station (slave only)</td>
</tr>
<tr>
<td>GM DHD 1</td>
<td>Time aware bridge which is grandmaster</td>
</tr>
</tbody>
</table>

Sync messages from GM 1 are transmitted over path 1 and path 2.

Sync messages from GM 2 are transmitted over path 3 and path 4.
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Proposals how a Sync-Relay of a Time Aware System can distinguish multiple Sync Path

1. For each sync path a unique destination MAC address
   
   Problem: A list of multicast MAC address are required

2. Tagged sync messages (VLAN ID per sync path)
   
   Problem: Peer-To-Peer messages are not be tagged

3. Introduce Path ID
   
   Problem: Not in the IEEE 1588 & IEEE 802.1 AS standard

   Proposal:

   ![Sync Message Header Diagram]
Proposals how a Sync-Relay of a Time Aware System can distinguish multiple Sync Path

The table gives a high level overview about the information we propose to use for the purpose of forwarding sync messages over redundant path:

<table>
<thead>
<tr>
<th>Information</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Scale</td>
<td>• Universal time (traceable time)</td>
</tr>
<tr>
<td></td>
<td>• Working clock (free running, none traceable time)</td>
</tr>
<tr>
<td>Domain ID</td>
<td>• One time scale within one sync domain</td>
</tr>
<tr>
<td>Path ID</td>
<td>• Sync and Sync’ frames shall be transmitted on independent paths</td>
</tr>
<tr>
<td></td>
<td>• Path ID’s are used to mark redundant path (Path A, Path B, …)</td>
</tr>
<tr>
<td></td>
<td>• Path ID’s are used to mark grandmaster / time source</td>
</tr>
<tr>
<td></td>
<td>(e.g. GM1 / Path A, GM1 / Path B, GM2 / Path A, GM2 / Path B, …)</td>
</tr>
<tr>
<td>MAC Address</td>
<td>• All Sync frames have the same destination MAC Address.</td>
</tr>
</tbody>
</table>

⇒ Forwarding decision in Sync-Relay for the Sync & FollowUp message is based on
  ➢ Destination MAC Address, Domains ID & Path ID
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5. Proposal for Distributing Synchronization Information with ISIS-SPB
How can ISIS-SPB & gPTP work together?

Proposal: The communication path for sync messages shall be established by ISIS-SPB

Which information are needed from ISIS-SPB to pre-configure sync path?

- **Topology for Synchronization**
  - Which end stations and bridges support gPTP (are time aware system)?

- **General Configuration**
  - Which time scale should be synchronized (universal time, working clock, …)?
  - Which Domain ID is assigned to a time scale?
  - Is high availability required?
    - How many hot- or cold stand-by grandmaster?
    - How many redundant path for Sync messages?

- **Synchronization end-to-end connectivity for ISIS-SPB**
  - Which end stations and bridges supports gPTP?
    - Which time aware systems are grandmaster capable?
    - Which priority has a grandmaster capable time aware systems?
    - Which time quality has a grandmaster capable time aware systems?
    - Which time aware systems shall be synchronized?
    - …
ISIS-SPB for SYNC based on gPTP can cross L3 Router because all messages are peer-to-peer messages.
Proposal for Distributing Synchronization Information with ISIS-SPB for SYNC

New “Sync Instance Sub-TLV” in ISIS Link-State-PDU

- **Information for layer 2 sync routing**
  - Time Scale (e.g. universal time, working clock)
  - Sync Domain ID (for one time scale)
    - Path ID: path A, path B (optional)
  - Number of Hot-stand-by or cold-stand-by GM (*typical one*)

New “Sync Metric Sub-TLV“ in ISIS Link-State-PDU

- **gPTP port information**
  - .1AS or PTP Version x capable

New “Sync Announce Sub-TLV” in Link-State-PDU

- **Information for BMCA to elect primary GM, cold- or hot-stand-by GM, slaves**
  - ClockIdentity
  - Priority
  - ...
Proposal for ISIS-SPB for SYNC
New Sync Instance Sub-TLV in Link-State-PDU

IS-IS Link State PDU

Source Node ID

Remaining Lifetime
LSP-ID
Sequence Nr

Octet Length
1 1
2 1
3 1
4 1
5 1
6 1
7 1

Sync Instance TLV

Type
Length
Time Scale
Domain ID
Number of sync path per GM
Number of cold stand-by GM
Number of hot stand-by GM
Proposal for ISIS-SPB for SYNC
New Sync Link Metric Sub-TLV in Link-State-PDU

IS-IS Link State PDU

- Source Node ID
- Remaining Lifetime
- LSP-ID
- Sequence Nr
- Sync Link Metric TLV

<table>
<thead>
<tr>
<th>Octet</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>1</td>
</tr>
<tr>
<td>Length</td>
<td>2</td>
</tr>
<tr>
<td>AS Capable</td>
<td>3</td>
</tr>
</tbody>
</table>
### Proposal for ISIS-SPB for SYNC
New Sync Announce Sub-TLV in Link-State-PDU

#### PTP Announce PDU

<table>
<thead>
<tr>
<th>Field</th>
<th>Octet</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TransportSpecific</td>
<td>1</td>
<td>4 bits</td>
</tr>
<tr>
<td>MessageID</td>
<td>1</td>
<td>4 bits</td>
</tr>
<tr>
<td>PTPVersion</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>MsgLength</td>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td>DomainNumber</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Flags</td>
<td>6-7</td>
<td>2</td>
</tr>
<tr>
<td>Correction</td>
<td>08-15</td>
<td>8</td>
</tr>
<tr>
<td>Resv #1</td>
<td>16-19</td>
<td>4</td>
</tr>
<tr>
<td>ClockIdentity</td>
<td>20-27</td>
<td>8</td>
</tr>
<tr>
<td>SourcePortID</td>
<td>28-29</td>
<td>2</td>
</tr>
<tr>
<td>SequenceID</td>
<td>30-31</td>
<td>2</td>
</tr>
<tr>
<td>ControlField</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>LogMsgPeriod</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>Resv #2</td>
<td>34-43</td>
<td>10</td>
</tr>
<tr>
<td>CurrentUTCOffset</td>
<td>44-45</td>
<td>2</td>
</tr>
<tr>
<td>Resv #3</td>
<td>46</td>
<td>1</td>
</tr>
<tr>
<td>Priority 1</td>
<td>47</td>
<td>1</td>
</tr>
<tr>
<td>GMClockClass</td>
<td>48</td>
<td>1</td>
</tr>
<tr>
<td>GMClockAccuracy</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>GMClockVariance</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Priority 2</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>GMClockIdentity</td>
<td>52-59</td>
<td>8</td>
</tr>
<tr>
<td>StepsRemoved</td>
<td>60-61</td>
<td>2</td>
</tr>
<tr>
<td>TimeSource</td>
<td>62</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Sync Announce TLV
(not all information from the PTP Announce PDU are required)

#### IS-IS Link State PDU

<table>
<thead>
<tr>
<th>Field</th>
<th>Octet</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSPID</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SeqNbr</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Flags</td>
<td>3-4</td>
<td>2</td>
</tr>
<tr>
<td>LogMsgPeriod</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>CurrentUTCOffset</td>
<td>6-7</td>
<td>2</td>
</tr>
<tr>
<td>Priority 1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>MyClockClass</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>MyClockAccuracy</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>MyClockVariance</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Priority 2</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>MyClockIdentity</td>
<td>13-20</td>
<td>8</td>
</tr>
<tr>
<td>TimeSource</td>
<td>21</td>
<td>1</td>
</tr>
</tbody>
</table>

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**IEEE 802.1 TSN-TG Meeting**
Next Steps?

Thank you for your attention!

Questions?