Requirements on Forwarding of Sync Messages

IEEE 802.1ASbt for Industrial Networks

IEEE 802 Plenary Meeting - March 2015, Berlin
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Outline

- Requirements from industrial applications
  - for Universal Time
  - for Working Clock

- Constraints to meet the requirements from industrial
  - for Universal Time
  - for Working Clock

- Problem on forwarding of sync messages
## Requirements from Industrial Applications

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Universal Time</th>
<th>Working Clock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hop count</td>
<td>up to 128</td>
<td>up to 64</td>
</tr>
<tr>
<td>Sync accuracy at the last hop</td>
<td>$\leq \pm 100 \mu s$</td>
<td>$\leq \pm 1 \mu s$</td>
</tr>
<tr>
<td>Max. frequency drift rate *</td>
<td>3 ppm/sec</td>
<td>3 ppm/sec</td>
</tr>
</tbody>
</table>

* due to temperature changes, shock, vibration or aging, @SyncMaster, modelled as sine curve)
## Constraints to Meet the Industrial Requirements

<table>
<thead>
<tr>
<th>Parameters</th>
<th>For Universal Time</th>
<th>For Working Clock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time stamp accuracy</td>
<td>&lt; 8ns</td>
<td>&lt; 8ns</td>
</tr>
<tr>
<td>Time stamp resolution</td>
<td>&lt;= 8ns</td>
<td>&lt;= 4ns</td>
</tr>
<tr>
<td>Sync interval</td>
<td>125ms</td>
<td>31.25ms</td>
</tr>
<tr>
<td>Forwarding delay of Sync messages in bridges</td>
<td>&lt; 10ms</td>
<td>&lt; 1ms</td>
</tr>
<tr>
<td>Frequency tolerance</td>
<td>&lt;± 50ppm</td>
<td>&lt;± 25ppm for GM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;± 50ppm for others</td>
</tr>
</tbody>
</table>
Problem on Forwarding Delay of Sync Messages

One of the essential constraints to meet industrial requirements for working clock synchronization is *Forwarding delay of Sync messages in bridges < 1ms*

Consider the following use case

- 2 GMs (primary and secondary)
- 2 bridges, each with 64 ports
- 31 rings, each with 32 devices
- both redundant GM/Sync paths applied

⇒ Each bridge needs to forward

63 x 2 Sync Msgs per Sync interval

**Problem:** if forwarding of sync msgs (incl. port selection and Sync Msg replication) is primarily conducted by software, it is very difficult to guarantee that the Sync forwarding delay < 1ms

Sync Forwarding with bridging mechanism needs to be used.
Domain Specific Forwarding of Sync messages

Assumptions
- All sync messages use the same group MAC address
- Use different domain numbers for redundant GMs/Sync trees, thus each of redundant gPTP packet is transported within its own gPTP instance

Problem on Sync forwarding with bridging mechanism
- In principle the existing bridging mechanism cannot be used for sync forwarding e.g. domain number is present in the gPTP header
  => Special HW is needed to identify domain specific gPTP Sync Msgs

Discussion: possible ways to enable domain specific forwarding of Sync Msgs with existing bridging mechanism (one may not solve all the problems)
- VLAN-tagged PTP sync packet
- One group MAC address per domain
- Implementation-specific solution:
  Map domain-specific port roles sets to FDB (per domain slave port <-> master ports)
The standardization should take care that the gPTP model (also for redundant synchronization) allows a HW implementation using existing bridging mechanism + small add-ons per port!
Thank you for your attention!

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