Contribution to 802.1as :

Media-dependent layer specification for interface to Coordinated Shared Network (CSN)

Rev	Date	Auth	Comments
0.0	31-Jul-08	Phkl	Initial Draft
0.1	12-Aug-08	Phkl	1st review
0.2	18-Aug-08	Phkl	2nd review

1 Coordinated Shared Network Characteristics

A Coordinated Shared Networks (CSN) is a contention free, QoS able, time division multiplexed access, network. One of the node of the network acts as the network coordinator node granting transmission opportunities to the other nodes of the network.

CSNs support two types of transmission: unicast transmission for PTP (node to node) transmission and broadcast transmission for PTMP (node to all other nodes) transmission. Each node to node link has its own bandwidth characteristics which could change overtime as a result of the periodic ranging of the link. The broadcast transmission characteristics are the lowest common characteristics of all the links of the network.

A CSN network is physically a shared network, in that a CSN node has a single physical port connected to the half-duplex medium, but is also a logically fully-connected mesh network, in that every node could transmits to every other node using its own profile over the shared medium.

2 AVB Cloud with Mixed 802.3 and CNS paths

Figure 1 describes a CSN network acting as a backbone for 802.3 time-aware bridges (AVB) and time-aware end-stations (AVS).

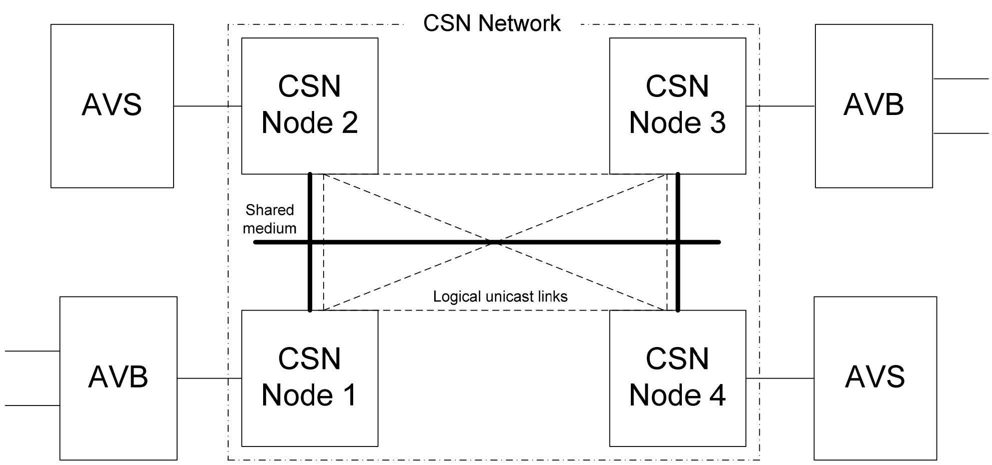

Figure 1: Example of CSN Backbone in an AVB Cloud

3 Path Delay Calculation

The path delay measurement over the CSN Backbone uses the same path delay protocol and messages specified for the path delay measurement between two 802.3 time-aware bridges and/or end stations, in the Clause 11.2.1 of the IEEE 802.1as/d3.1 Specifications:

- Pdelay_Req,
- Pdelay_Resp,
- Pdelay_Resp_Follow_Up

3.1 Path Delay Calculation at the CSN Boundaries

At the boundaries of the CSN network, a CSN node terminates Pdelay requests sent by the AV Bridge and generates Pdelay requests to the AV Bridge to measure the path delays between the AV Bridge and the CSN node.

In addition successive Pdelay_Resp and Pdealy_Resp_Follow_Up allows the requester side to calculate the neighborRateRatio as defined in the Clause 10.2.7.3 of the IEEE 802.1as/d3.1 Specifications: (the *measured ratio of the frequency of the LocalClock entity of the time-aware system at the other end of the link attached to this port, to the frequency of the LocalClock entity of this time-aware system.*

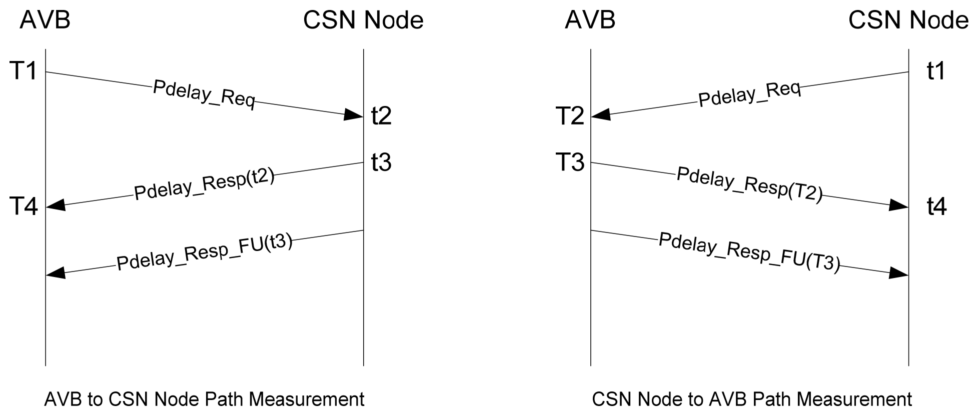

Figure 2: Path Delay Measurements at the CSN Boundaries

For the AVB, the neighborRateRatio is computed as the ratio of

$$(t3 - previous\_t3) / (T4 - previous\_T4)$$

and the path delay from the AVB to the CSN node is computed as

$((T4\text{-}T1) – (t3\text{-}t2) * neighborRateRatio) / 2.$

Similary for the CSN node , the neighborRateRatio is computed as the ratio of

$(T3 - previous\_T3) / (t4 - previous\_t4)$

and the path delay from the CSN node to the AVB is computed as

$((t4\text{-}t1) – (T3\text{-}T2) * neighborRateRatio) / 2.$

3.2 Path Delay Calculation between CSN Nodes

The path delay between the nodes of the CSN is the propagation delay between each node to node link.

This path delay could be measured with the same generic Pdelay_Req, Pdelay_Resp and Pdelay_Resp_Follow_Up sequence described in the previous section.

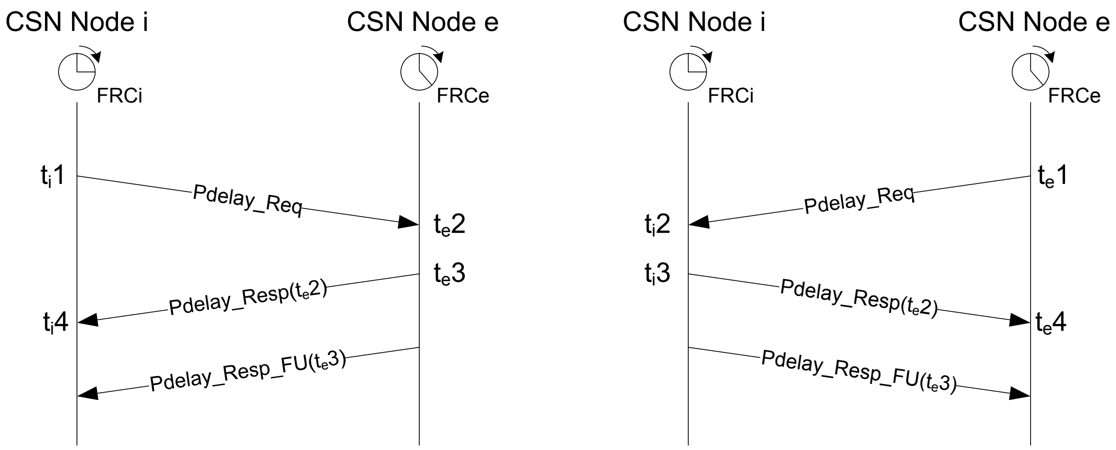

Figure 3: CSN Node to Node Path Delay Measurement

This path delay request should be first generated when a new node joins the CSN network and should be sent to each other nodes of the network.

Although the propagation delay between two CSN nodes is a constant, a path delay request should be periodically sent by each node to each other active node of the network to compute the neighborRateRatio between these nodes.

The neighborRateRatio is always computed as the ratio of the rate of the upstream neighbor local clock to the rate of the local clock of the current node that receives the Pdelay_Resp and Pdelay_Resp_Follow_Up messages.

The ingress CSN computes its neighborRateRatio is as the ratio of

$(t_i4 - previous\_ t_i4) / (t_e3 - previous\_ t_e3)$

and the path delay from the ingress to egress CSN node is computed as

$((t_i4\text{-} t_i1) – (t_e3\text{-} t_e2) * neighborRateRatio) / 2.$

Similary the egress CSN computes its neighborRateRatio is as the ratio of

$(t_e4 - previous\_ t_e4) / (t_i3 - previous\_ t_i3)$

and the path delay from the ingress to egress CSN node is computed as

$((t_e4- t_e1) – (t_i3- t_i2) * neighborRateRatio) / 2.$

In CSN networks however:

- nodes are synchronized on the same CSN Network Reference Clock propagated to each node
- received frames are time stamped
- frames are transmitted at pre-deterministic Network time

If the media dependant characteristics of the CSN Network Reference Clock match the required path delay measurement requirements, the path measurement could be simplified to a two-way exchange only as described in Figure 4 :

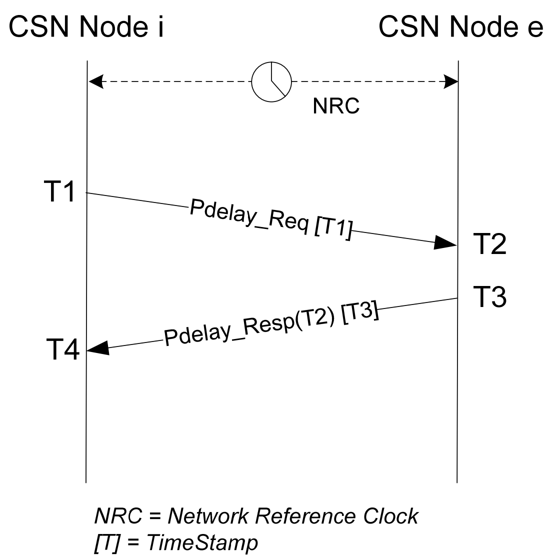

Figure 4: CSN Node to Node Simplified Path Delay Measurement

1. The Pdelay_Req message is transmitted @ T1. This CSN network time transmission timestamp information is natively included in the CSN message.
2. The downstream node timestamps the Pdelay_Req message reception and includes this timing (T2) information within the Pdelay_Resp transmitted @ T3. This transmission timestamp information is natively included in the CSN message.
3. The upstream node timestamps the Pd_Resp message reception @ T4.

The computation of the neighborRateRatio and the path delay remains unchanged.

4 Synchronization Messages

Once the path delays have been measured between the AVB and the ingress and egress CSN nodes and between the CSN nodes, the CSN backbone could propagate the synchronization messages received on its boundaries nodes. As for the path measurement the synchronization over the CSN backbone could use the Sync and Follow_Up messages and protocol specified for 802.3 in the Clause 10.2 of the IEEE 802.1as/d3.1 Specifications.

Sync messages received on a CSN ingress node from an upstream time-aware bridge or (talker) end-device are propagated to each node of the CSN. The Egress CSN nodes will in turn generate Sync and Follow_Up messages to the downstream time-aware bridge or (listener) end-device.

Within the CSN network two schemes could be applied: without or with reference to the CSN Network Clock.

4.1 Synchronization Message Propagation without CSN Network Clock reference

In this first scheme, each CSN node features a free running clock. The scheme is totally independent of the CSN reference clock and prevents the accuracy to be bounded to the media dependant characteristics of the CSN Network Clock. The propagation sequence is described in Figure 5 :

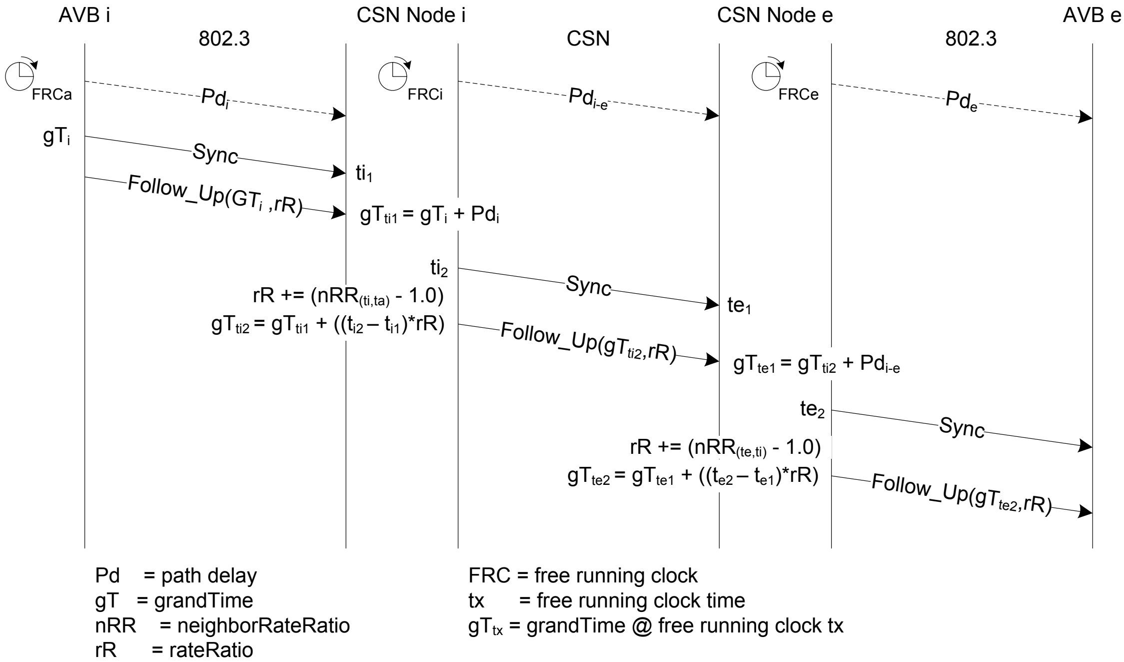

Figure 5: Sync Messages Propagation without CSN Network Clock

1. The Ingress CSN node ($Node_i$) receives a Sync message from the upstream AVB_i time stamped by its own free running clock @ ti_1

2. The Follow_Up message indicates that the Sync message received @ ti_1 was sent by the upstream AVB at grandTime gT_i and provides the accumulated rateRatio (relative to the grandTime)

3. $Node_i$ calculates the grandTime @ ti_1 by adding to the grandTime the path delay from the upstream AVB to its own node (Pd_i):

$$gT_{ti1} = gT_i + Pd_i$$

4. Node$_i$ sends a Sync message to the other nodes of the CSN network @ ti$_2$
5. Node$_i$ computes the new accumulated rateRatio:

   $$rR \mathrel{+}= (neighborRateRatio - 1.0)$$

   and calculates the grandTime @ ti$_2$ by adding to the grandTime received @ ti$_1$ the node residency time (the interval of time between the reception of the Sync message ands its transmission over the CSN) normalized by the rateRatio:

   $$gT_{ti2} = gT_{ti1} + ((t_{i2} - t_{i1})*rR)$$

6. Node$_i$ sends a Follow_Up messages to the other nodes of the CSN network with the gT_{ti2} timing information and the new accumulated rate ratio rR
7. The egress CSN Nodes (Node$_e$) receive the Sync message @te$_1$
8. The Follow_Up message indicates that the Sync message received @ tie$_1$ was sent by the ingress node at grandTime gT_{ti2} and provides the accumulated rateRatio
9. Each Node$_e$ calculates the grandTime @ te$_1$ by adding to the grandTime the path delay from the ingress node to its own node (Pd$_{i-e}$):

   $$gT_{te1} = gT_{ti1} + Pd_{i-e}$$

10. Each egress Node$_e$ sends a Sync message to their downstream AVB @ te$_2$
11. Each Node$_e$ computes the new accumulated rateRatio:

    $$rR \mathrel{+}= (neighborRateRatio - 1.0)$$

    and calculates the grandTime @ te$_2$ by adding to the grandTime received @ te$_1$ the node residency time (the interval of time between the reception of the Sync message ands its transmission to the AVB) normalized by the rateRatio:

    $$gT_{te2} = gT_{te1} + ((t_{e2} - t_{e1})*rR)$$

12. Each Node$_e$ sends a Follow_Up messages to their downstream AVB with the gT_{te2} timing information and the new accumulated rate ratio rR

4.2 Synchronization Message Propagation with CSN Network Clock reference

If the media dependant characteristics of the CSN Network Reference Clock match the required synchronization requirements, the sync message propagation over the CSN network could be simplified to a single message propagation as described in Figure 6 .

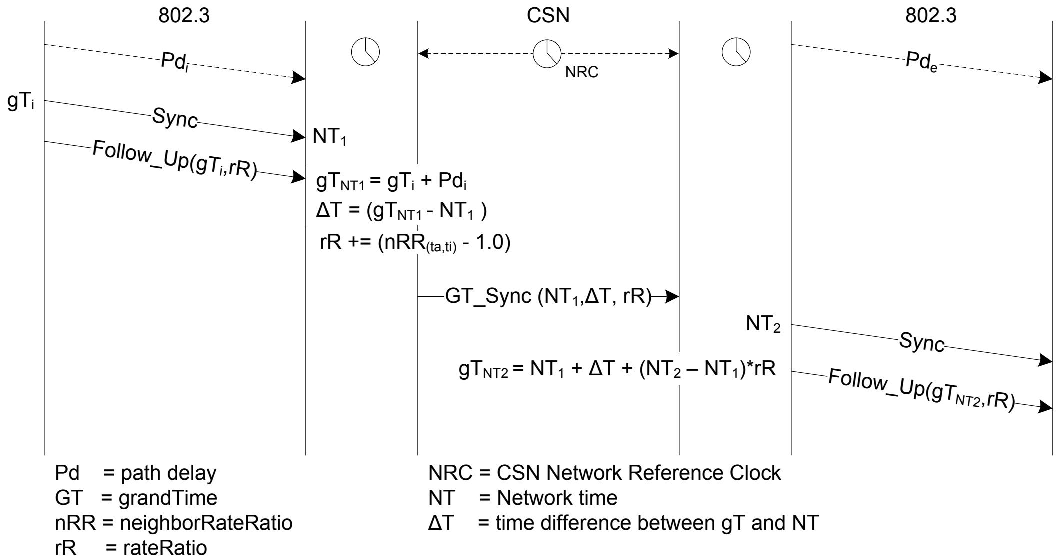

Figure 6: Sync Messages Propagation with CSN Network Reference Clock

1. The Ingress CSN node (node$_i$) receives a Sync message from the upstream AVB$_i$ time stamped by the Network time @ NT_1

2. The Follow_Up message indicates that the Sync message received @ NT_1 was sent by the upstream AVB at grandTime gT_i and provides the accumulated rateRatio (relative to the grandTime)

3. Node$_i$ calculates the grandTime @ tNT_1 by adding to the grandTime the path delay from the upstream AVB to its own node (Pd_i):

   $$gT_{NT1} = gT_i + Pd_i$$

   the time difference between the grandTime and the CSN Network time:

   $$\Delta T = GT_{NT1} - NT_1$$

   and computes the new accumulated rateRatio:

   $$rR \mathrel{+}= (neighborRateRatio - 1.0)$$

4. The node$_i$ broadcasts a synchronization message to the other nodes of the CSN network to indicates NT1 , ΔT and the accumulated rateRatio to the egress nodes.

5. Each egress Node$_e$ sends a Sync message to their downstream AVB @ NT_2

   Each Node$_e$ calculates the grandTime @ NT_2 by adding to the grandTime received @ NT_1 the CSN residency time (the interval of time between the reception of the Sync message by the egress node ands its transmission to the downstream AVB) normalized by the rateRatio:

   $$gT_{NT2} = NT_1 + \Delta T + (NT_2 - NT_1)*rR$$

6. Each $Node_e$ sends a Follow_Up messages to their downstream AVB with the gT_{NT2} timing information and the new accumulated rate ratio rR