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Why cumulativeScaledRateOffset is important - and needs to remain a mandatory feature

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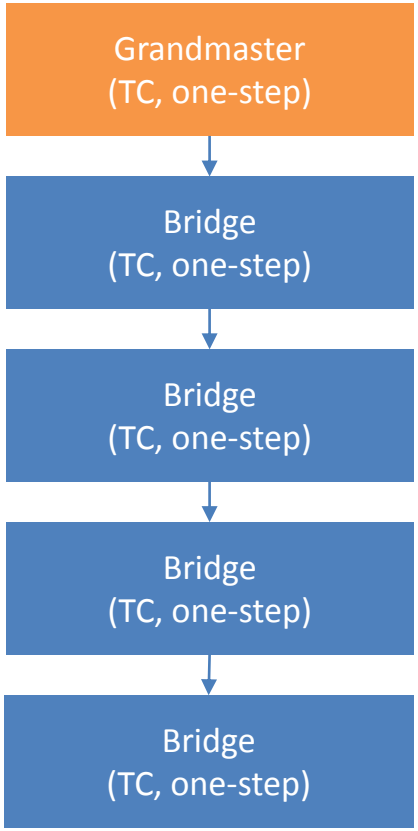
Background

- This is an updated version of http://www.ieee802.org/1/files/public/docs2015/as-boiger-TC-cumulativeScaledRateOffset-issue-0515-v01.pdf
- A former proposal to add a transparent clock (TC) to 802.1AS proposed to not update the cumulativeScaledRateOffset in 802.1AS TCs
- The current proposal (http://www.ieee802.org/1/files/public/docs2015/asrev-mjt-one-step-details-0407-v04.pdf) still states that “for a ‘TC path’ the cumulative rate ratio *may* be unchanged“
- It is mentioned that the errors in time synchronization due to this behavior “might be OK, it would be a *cost* of using TC mode”

Example Calculations

- The following two examples shows how the error due to a missing cumulativeScaledRateOffset update can be calculated and a rational for the chosen numbers.
- This are just two examples - not worst case scenarios
- Example 1 shows a TC-only “network”
- Example 2 shows a mixed network (TC and two-step)
- Example 3 shows the consequences of the proposed special signaling message

Example 1



Neighbor Rate Ratio	Rate Ratio relative to GM	cumulativeScaledRateOffset	Residence Time	Accumulated Error*
N/A	N/A	0 ppm	N/A	N/A
+100 ppm	+100 ppm	0 ppm	400 µs	40 ns
0 ppm	+100 ppm	0 ppm	400 µs	80 ns
0 ppm	+100 ppm	0 ppm	400 µs	120 ns
0 ppm	+100 ppm	0 ppm	400 µs	160 ns

* accumulated time synchronization error due to wrong cumulativeScaledRateOffset

Example 1: Rationale for the chosen values

Neighbor rate ration:

IEEE 802.1AS-2011 specifies:

> "The fractional frequency offset of the LocalClock relative to the TAI frequency (see Annex C) shall be within ±100 ppm."

In this example the worst case frequency offset between any system is 100 ppm. According to IEEE 802.1AS the worst case is 200 ppm.

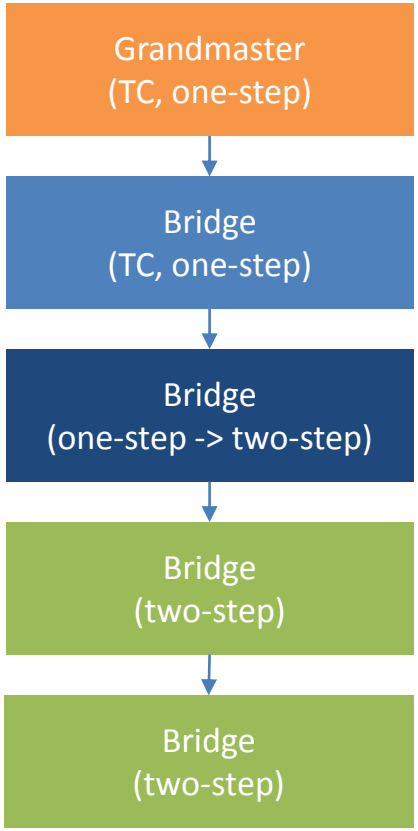
Residence Time:

In example 1 a residence time of 400 µs is chosen.

Assuming a 100 Mbit/s AVB network this is less than a maximum frame followed by a maximum burst of class A AVB frames (this would total to almost 500 µs).

In AVB/TSN networks time is just a (but important) service of the network, other traffic has higher priority.

Example 2



Neighbor Rate Ratio	Rate Ratio relative to GM	cumulativeScaledRateOffset	Residence Time	Accumulated Error*
N/A	N/A	0 ppm	N/A	N/A
+100 ppm	+100 ppm	0 ppm	400 µs	40 ns
-100 ppm	0 ppm	- 100 ppm	10 ms	960 ns
0 ppm	0 ppm	- 100 ppm	10 ms	1960 ns
+100 ppm	+100 ppm	0 ppm	10 ms	2960 ns

* accumulated time synchronization error due to wrong cumulativeScaledRateOffset

Example 2: Rationale for the chosen values

Neighbor rate ration:

IEEE 802.1AS-2011 specifies:

> "The fractional frequency offset of the LocalClock relative to the TAI frequency (see Annex C) shall be within ±100 ppm."

In this example the worst case frequency offset between any system is 100 ppm. According to IEEE 802.1AS the worst case is 200 ppm.

Residence Time:

IEEE 802.1AS-2011 requires a maximum residence time of 10 ms.

IEEE 802.1AS-Cor1 changes this "shall" to a "should".

In case of generated Sync messages due to "missing Sync messages" the residence time can be > 125 ms.

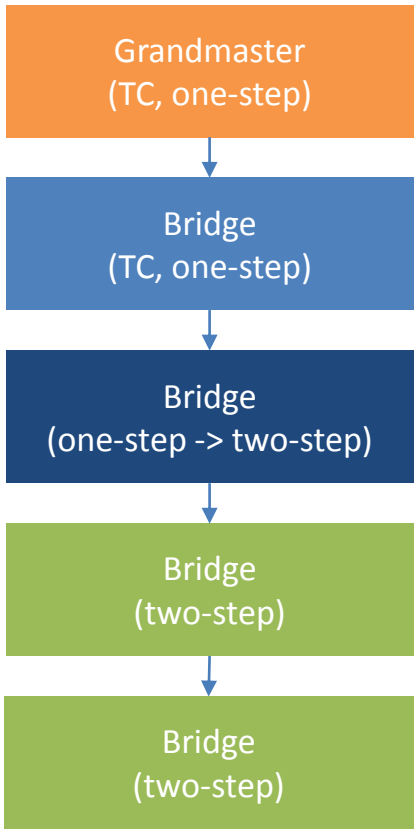
Example 3 – with special signaling message

- The most current TC proposal adds a signaling message that tells the downstream bridge not to calculate the neighbor rate ratio (http://www.ieee802.org/1/files/public/docs2015/asrev-mjt-one-step-details-0407-v05.pdf p.16)

- This does not solve the problem as the reference to the grandmaster is lost on the TC like path

- In case the reference to the grandmaster is lost somewhere in the network, all downstream devices can not rely on this information

Example 3 – with special signaling message



Neighbor Rate Ratio	Rate Ratio relative to GM	cumulativeScaledRateOffset	Residence Time	Accumulated Error*
N/A	N/A	0 ppm	N/A	N/A
+100 ppm	+100 ppm	0 ppm	400 µs	40 ns
0 ppm	+100 ppm	0 ppm	10 ms	1040 ns
-100 ppm	0 ppm	- 100 ppm	10 ms	40 ns
0 ppm	0 ppm	- 100 ppm	10 ms	960 ns

* accumulated time synchronization error due to wrong cumulativeScaledRateOffset

Impact on IEEE 802.1AS

- A wrong cumulativeScaledRateOffset significantly reduces the time accuracy of the proposed TC like devices (compared to current IEEE 802.1AS)
- A wrong cumulativeScaledRateOffset completely screws up the time synchronization in mixed networks (TC, one-step, two-step)
- cumulativeScaledRateOffset currently allows for a fast sync after start-up (we would loose this feature without a correct cumulativeScaledRateOffset)
- cumulativeScaledRateOffset currently allows for a fast sync after a grandmaster change over (neighbor rate ratios are already calculated)

Updating cSRO needs to remain mandatory!

- IEEE 802.1AS currently provides a plug-and-play type of time synchronization
- The user currently can assume that he can achieve a very good time synchronization within his gPTP domain (the goal for IEEE 802.1AS was 1 µs over 7 hops FE network)

- The plug-and-play character and the goal of 1 µs over 7 hops need to remain

- We need to make sure that IEEE 802.1 AS-Rev at least provides the same time synchronization accuracy than IEEE 802.1AS (people should not fear that IEEE 802.1AS-Rev devices in their IEEE 802.1AS-2011 network will screw up their time synchronization)

➔ Updating cumulativeScaledRateOffset and the correction of the residence time needs to be mandatory!

Thank You