Analysis of Grandmaster Change Time in an 802.1AS Network

Geoffrey M. Garner
SAMSUNG Electronics (Consultant)

IEEE 802.1 AVB TG
2010.09.13

gmgarner@alum.mit.edu

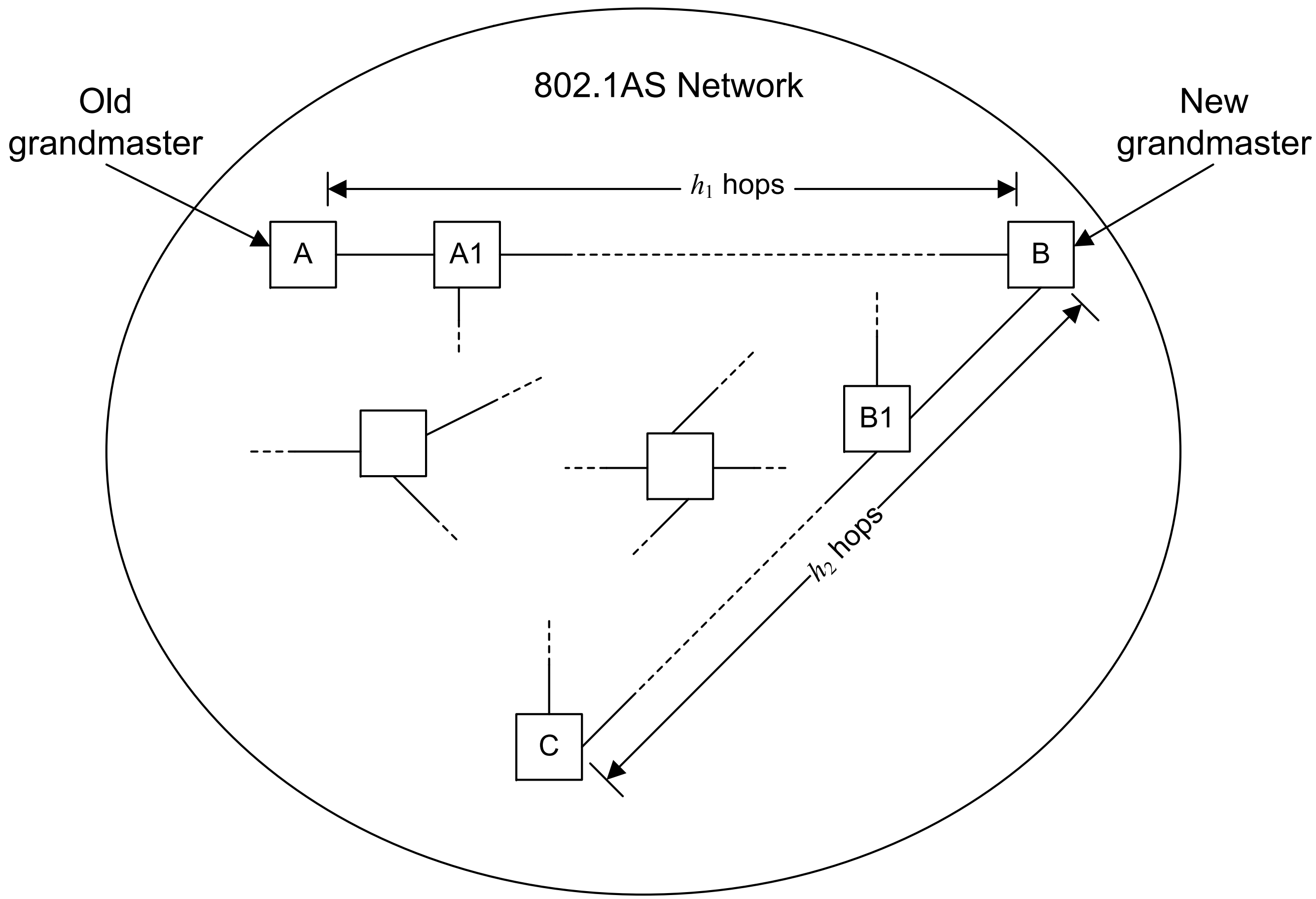
Outline

- Introduction
- Assumptions
- Sequence of events when grandmaster changes
- Analysis of time for grandmaster change
- Conclusion

Introduction

- This presentation analyzes the time required for a grandmaster (GM) change in an 802.1AS network
- The specific scenario considered is one where the current grandmaster leaves the network and a new time-aware system becomes grandmaster
- The grandmaster change time is the time interval from the sending of the last Sync message by the old grandmaster to the receipt of the first Sync message that is traceable to the new grandmaster by a time-aware system that is the maximum number of hops (i.e., 7 hops) from the new grandmaster
- The analysis uses default parameters and assumptions of 802.1AS networks (see the following slides)
  - These default parameters and assumptions are consistent with IEEE P802.1AS/D7.2 (see reference [1])

802.1AS Network and Assumptions - 1



- ❑Time-aware system A is old grandmaster
- ❑Time-aware system B is new grandmaster
- ❑C is a time-aware system for which the grandmaster change time will be determined

802.1AS Network and Assumptions - 2

- The old and new grandmasters are separated by h_1 hops
- Time-aware system C is h_2 hops from the new grandmaster
  - Eventually, h_1 and h_2 will be taken to be the maximum number of hops over which synchronization is assumed to be transported in an 802.1AS network, i.e., 7 hops
- Sync interval = 1/8 s (see 11.5.2.3, 12.6.2, and 13.9.2 of [1])
- Announce interval = 1 s (see 10.6.2.2 of [1])
- Sync receipt timeout = 3/8 s (3 sync intervals, see 10.6.3.1 of [1])
- Announce receipt timeout = 2 s (2 sync intervals, see 10.6.3.2 of [1])
- Residence time ≤ 10 ms (see B.2.2 of [1])
- Minimum time between successive Sync messages sent on a port = 1/16 s (½ sync interval; see the PortSyncSyncSend state machine, Figure 10-8 of [1])
- Link speed is 100 Mbps (worst-case)

Sequence of Events when GM Changes - 1

1) Old GM, A, leaves the network and stops sending Sync and Announce messages
2) The immediate downstream neighbor of A on the path to B, A1, experiences sync receipt timeout
   – A1 experiences sync receipt timeout before it would experience announce receipt timeout because the former is shorter than the latter
3) A1 invokes the best master clock algorithm (BMCA) and then sends an Announce message downstream, in the direction of B. A1 considers itself to be GM, and will continue to consider itself to be GM until it receives updated Announce information

Sequence of Events when GM Changes - 2

4) Each successive downstream time-aware system on the path to B receives an Announce message, invokes BMCA, and then sends Announce messages on its slave ports. Each downstream time-aware system, in the direction of B, continues to consider that A is GM until it receives an Announce message
   - It will be seen shortly that this Announce propagation process, after sync receipt timeout occurs, is relatively rapid compared to the sync receipt timeout time

5) B receives an Announce message, invokes BMCA, and becomes GM

6) After becoming GM, B sends the first Sync message on the path to C

7) The immediate downstream neighbor of B on the path to C, B1, receives the Sync of (6) , synchronizes to B, and sends Sync downstream on the path to C

8) Eventually, C receives the first Sync that reflects B as the new GM, and synchronizes to B

Analysis of Time for GM Change - 1

- The time for the above processes to complete is equal to the sum of:
  a) Sync receipt timeout time
  b) $h_1 - 1 = 6$ Announce message delay times (the reason it is $h_1 - 1$ and not h_1 is that it is A1 (and not A) that experiences sync receipt timeout and then sends Announce
  c) $h_2 = 7$ Sync message delay times
- Sync receipt timeout time = 3 sync intervals = 0.375 s

Analysis of Time for GM Change - 2

❑Announce message delay time

- Assume the time to invoke BMCA on receipt of Announce message is negligible
- Assume Announce message has grown to maximum size due to path trace TLV (see 10.5.3.2.8 of [1])
- Assume a maximum-sized frame is in front of the Announce message, and has just started transmission
- With the assumption of 100 Mbps link speed, the transmission delay for a maximum-sized frame is approximately 125 μs
- Assume the propagation delay on the link is negligible compared to 125 μs
- Then the Announce message delay time is approximately 2(125 μs) = 250 μs

Analysis of Time for GM Change - 3

❑Sync message delay time

- According to PortSyncSyncSend state machine (Figure 10-8 of [1]), a time-synchronization information is sent by the media-independent layer on each slave port as soon as possible after it is received on the master port, subject to the constraint that at least ½ sync interval has elapsed since the previous time synchronization-information was received on the master port
- The purpose of the constraint is to prevent bursting and bunching of time-synchronization messages
- Normally, there is no bursting and bunching of time-synchronization messages, and a message is sent as soon as possible after receipt of a time-synchronization message, i.e., after the residence time
- However, if bunching does occur, the ½ sync interval delay will occur on only one of the links in the path, because the delay will prevent bunching at the downstream time-aware systems

Analysis of Time for GM Change - 4

❑Sync message delay time (cont.)

- As with the Announce message, it is assumed that there is one maximum-sized frame in front of the Sync message, and that the propagation delay is negligible compared to the transmission delay for a maximum-sized frame (125 μs)
- Therefore, the delay between receipt of a Sync message and the sending of a Sync message is the sum of
  - The residence time, i.e., 10 ms, except for possibly one link where the residence time is replaced by ½ Sync interval, i.e., 1/16 (= 0.0625) s
  - The transmission delay for a Sync message on a 100 Mbps link, i.e., (64 bytes)(8 bits/byte)/10^8 bits/s) = 5.12 μs
  - The transmission delay for a maximum-sized frame, i.e., 125 μs
- The total Sync message delay time at a time-aware system where bunching did not occur on the inbound link = 10 ms + 5.12 μs + 125 μs = 10130 μs
- The total Sync message delay time at a time-aware system where bunching did occur on the inbound link = 0.0625 s + 5.12 μs + 125 μs = 62630 μs

Analysis of Time for GM Change - 5

- Total time for GM change =

  sync receipt timeout time +

  6(Announce message delay time) +

  sync message delay time assuming bunching occurred on upstream link +

  6(sync message delay time assuming bunching did not occur on upstream link)

- Total time for GM change = 0.375 s + 6(250 μs) + 62630 μs + 6(10130 μs) = 0.4999 s ≅ 0.5 s
- Note that the above assumes bunching of Sync messages occurred on one link; if there is no bunching, the time for GM change = 0.375 s + 6(250 μs) + 7(10130 μs) = 0.4474 s ≅ 0.45 s
- Note that the largest component of the GM change time is the sync receipt timeout time, i.e., 0.375 s
  - The time for the Announce messages to propagate is 6(250 μs) = 1.5 ms, which is small compared to the total GM change time

Conclusion

- Under the assumptions and default parameter values for an 802.1AS network (as given in [1]), the worst-case time for grandmaster change is 0.5 s
- If there is no bunching of Sync messages, the worst-case grandmaster change time is 0.45 s
- Note that the largest component of the GM change time is the sync receipt timeout time, i.e., 0.375 s
  - The time for the Announce messages to propagate is 6(250 μs) = 1.5 ms, which is small compared to the total GM change time

References

1. IEEE P802.1AS/D7.2, *Draft Standard for Local and Metropolitan Area Networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*, August 18, 2010.