Report of the Timing/Synchronization Work at the January 10 – 13, 2005 IEEE 802.1/AV Bridging Meeting

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Outline

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Introduction

- There have been discussions in recent IEEE 1588 calls (12/1 and 12/15/2005) on possible logistics for doing protocol-related aspects of Residential Bridges (ResB) timing/synchronization work in IEEE 1588
  - In the 12/15/2005 IEEE 1588 call, two presentations [1], [2] were made outlining possible logistics for ResB work and then current thoughts on a rough ResB solution
  - Note that the name of the ResB Task Group (TG) was changed to Audio/Video Bridging (AVB) TG at the January 10 – 13, 2006 IEEE 802.1 meeting
    - The group will be referred to by this new name in the remainder of this presentation
- Reference [1] concluded that if the AVB timing/synchronization work is divided into protocol aspects and profile aspects, with the former being done in 1588 and the latter in 802.1, the 1588 work would be within the scope of the current 1588 v2 PAR
- While this point was not disputed, concerns were expressed as to what impact the AVB work would have on IEEE 1588
  - Concerns were discussed briefly at the end of the December 15 call, and then provided in more detail in [3]

Introduction (Cont.)

- It was concluded in [1] that the protocol-related items needed for AVB would be within the scope of the current IEEE 1588 v2 PAR
  - Possible logistics were suggested where the protocol-related work would be done in IEEE 1588 and the profile-related work would be done in IEEE 802.1 (and possibly a small amount in IEEE 802.3 if necessary)
  - With these logistics, a new or modified IEEE 1588 PAR would not be needed
- However, while the IEEE 1588 Committee did not dispute that a new PAR would not be needed with this division of work (at least, no concerns on this particular item were mentioned in the December 15 call), concerns were expressed as to what impact the AVB work would have on IEEE 1588
  - Concerns were discussed briefly at the end of the December 15 call, and then provided in more detail in [3]
- Concerns included
  - Whether the AVB work would unduly delay the completion of 1588 v2
  - Whether the AVB solution would make the interoperability of 1588 v2 with v1 more difficult than it already is
- The specific concerns described in [3] pertained to
  - Message semantics
  - Different frame formats and data types
  - Grandmaster selection algorithm

Introduction (Cont.)

- The 1588 Committee indicated the discussion of the AVB work could continue in its 1/19/2006 call
- The AVB TG felt it would be beneficial to discuss the concerns and general aspects of the timing/synchronization solutions that have been discussed for AVB and their relation to IEEE 1588, in its January 10 – 13, 2006 face-to-face meeting
  - It was felt that it would be further beneficial if interested participants of IEEE 1588 could also attend the meeting; 1588 participants were invited and conference bridge facilities were made available for the half-day devoted to timing/synchronization
- The current presentation is a report of that meeting
  - Presentations
  - Topics discussed
  - Next steps

Timing/Synch Topics at Jan 10–13 AVB Meeting

- Half-day session devoted to AVB Timing/Synchronization
  - Interested IEEE 1588 participants were invited, and conference bridge was made available
    - 5 participants of IEEE 1588 attended in person, including the 1588 Chair (3 of the participants (including the author) also attend IEEE 802.1)
  - Three presentations were made during this session
    1) IEEE 1588 chair gave verbal presentation on current development status of IEEE 1588 v2 (with emphasis on items felt to be of most interest to AVB)
    2) Residential Ethernet: Time of Day Timer Synchronization (Reference [4])
       - Summarized the synchronization scheme that has been discussed in the AVB TG and is documented in the White Paper [6] and the extract of the White Paper [7]
    3) Comparison of Synchronization Protocol Aspects Currently Discussed for ResB with IEEE 1588 (Reference [5])
       - Compared the protocol aspects of IEEE 1588 and the AVB White Paper synchronization schemes [6], [7] and examined possible ways of harmonizing the two with minimal changes to either
  - At the conclusion of the presentations, there was a general discussion, including next steps

Timing/Synch Topics at Jan 10–13 AVB Meeting

- Other Timing/Synchronization Topics discussed at January 10 – 13 AVB meeting
  - The Timing/Synchronization PAR was edited, first in AVB TG and then, to a lesser extent, in main 802.1 meeting [8]
  - The 5 Criteria (5C) were not changed (relative to the most recent draft) [9]
  - The IEEE 802.1 Chair will submit the PAR and 5C to the IEEE Executive Committee (EC) 30 days prior to their March, 2006 meeting
    - A vote on this was not necessary at this meeting; the official vote authorizing this occurred at the November, 2005 IEEE 802.1 meeting (a plenary meeting)

Summary of Presentation 2

- Outlined synchronization approach of White Paper [6] and extract from it [7]
- Grandmaster selection
  - Every ResB station is capable of becoming GM, but only 1 is selected
  - Selection is based on preference value
  - Preference value is based on the following hierarchy of components
    - 4-bit System tag (this may be set to indicate a desired preference for a particular clock; with 4 bits, can have 16 preference levels)
    - Unique ID, e.g., MAC address (analogous to uuid_field in IEEE 1588)
    - Hops count, i.e., distance from current GM)
    - Port tag, i.e., port id
- Message semantics
  - Two-way message exchange; master and slave continually send messages to each other at sync interval
    - Timestamp message sent by slave refers to previous sync
    - Timestamp message sent by master contains time of previous timestamp sent by master and times that the third most recent timestamp was sent by slave and received by master

Summary of Presentation 2 (Cont.)

- Compensation scheme and synch information contained in messages
  - Local clocks are free-running (± 100 ppm) and are not adjusted
    - Rather, phase and frequency corrections are calculated based on information exchanged between master and slave, and are used to calculate corrected frequency and phase
  - Frequency offset of slave relative to master is calculated by comparing change in slave free-running clock time relative to master free-running clock time over a frequency adjustment interval
    - This interval is chosen to be longer than (i.e., a multiple of) the synch interval, to reduce the effect of clock noise, phase measurement granularity, and timestamp measurement errors
  - Each successive clock also calculates and sends to slave cumulative frequency offset relative to grandmaster
  - Using the cumulative frequency offsets from grandmaster and free-running phase values, each clock can calculate a phase corrected for frequency offset
  - Corrected phase values are used in two-way message exchange to obtain clock delta of slave relative to master
  - Clock deltas are accumulated over synchronization chain to obtain cumulative clock delta at egress from grandmaster
  - Time history of cumulative clock deltas at network egress is filtered

Summary of Presentation 2 (Cont.)

- Information needed in timestamp messages for compensation scheme (note that this is a summary of the information needed by the algorithm, and not the exact frame format)
  - Free-running clock time when previous message was sent
  - Frequency corrected time when previous message was sent
  - Frequency corrected times when message two messages ago was sent by node at other end of link and received by clock sending the current message
  - Cumulative frequency offset
  - Cumulative clock delta

Summary of Presentation 3

- This presentation compared IEEE 1588 and the AVB White Paper scheme (briefly described in the summary of Presentation 2) in the following three areas:
  - Grandmaster selection algorithm
  - Frame formats and data types (i.e., information contained in frame needed for compensation scheme)
  - Message semantics
- In making the comparison, the presentation gave some amount of background information on IEEE 1588 in these areas
- The presentation then proposed ways of harmonizing the AVB White Paper scheme and IEEE 1588 with minimal changes to each
  - The conclusions are summarized here; see [5] for details

Summary of Presentation 3 (Cont.)

- Appears that IEEE 1588 and AVB White Paper GM selection algorithms can be made almost equivalent if the following is done
  - Set all clock stratum numbers to 3 (or higher)
    - In this case clock identifier and variance fields are not relevant in algorithm
  - Allow one clock to be designated as preferred
- If the above is done, an AVB network will end up as a single PTP subdomain with one GM
- AVB devices should not be required to execute the branches of the IEEE 1588 grandmaster selection (BMC) algorithm (i.e., the dataset comparison and state decision algorithms) that pertain to stratum 1 or 2 clocks, as these branches will never be invoked
- If the above is done, the 2 algorithms will differ only in that the AVB scheme uses a 4-bit preference field and therefore allows 16 different preferences, while IEEE 1588 uses a single bit to designate that a clock is preferred (1 preference level)

Summary of Presentation 3 (Cont.)

- Did not address differences in frame format and data representation of AVB White Paper and IEEE 1588 schemes; deferred to a later date, as arguments as to which is better depend heavily on implementation and existing hardware and firmware
- However, the AVB White Paper frequency and phase compensation algorithm uses additional information not transported in IEEE 1588
  - Former uses the 5 bullet items given in slide 10
  - Latter uses the items in bullets 2 and 3 of slide 10
    - Essentially, IEEE 1588 transports only the corrected time information, while the AVB White Paper scheme needs free-running time information to enable frequency offsets to be calculated, as well as cumulative phase and frequency information
- However, Presentation 3 references work (reference [11] in that presentation) that uses a compensation scheme similar to the AVB White Paper scheme in that both phase and frequency are compensated and frequency offset is measured, but requires only corrected times (i.e., not free-running times)
  - This scheme was implemented (in hardware) using IEEE 1588 messages
- Presentation 3 suggested that this scheme may be a way of obtaining performance equivalent to the AVB White Paper scheme without needing to transport the additional information
  - The scheme must be analyzed in more detail

Summary of Presentation 3 (Cont.)

- For message semantics, IEEE 1588 uses a one-way with less frequent two-way messaging scheme
- The AVB White Paper scheme uses a pure two-way messaging scheme
  - However, the AVB compensation scheme can be made to work with a one-way with less frequent two-way messaging scheme, because the propagation delays are largely static
- However, a bigger issue is the concern raised in [3]; AVB will likely need to have sync refer to the previous sync message to limit message traffic (due to a short sync interval)
  - Indicated in [3] that this would pose a problem for other 1588 applications that have a long sync interval
- Note that this issue does not directly affect interoperability with v1 IEEE 1588 applications, because v1 covers only L3 operation
  - ResB will operate at L2, and L2 is not standardized in v1
- However, any non-ResB v2 L2 applications that have a long sync interval would be affected if the sync time stamp referred to the previous sync message

Summary of Presentation 3 (Cont.)

- Suggested in Presentation 3 that one possible solution might be to add an option for L2 sync messages in v2 to refer to either previous or current sync message
  - An additional field could indicate which option is being used
    - One possibility would be to use one of the reserved flag bits (in conjunction with the PTP_ASSIST bit that indicates whether or not a clock is followup capable)

General Discussion Following Presentations

- Suggested that the IEEE 1588 GM selection algorithm could be used for AVB network
  - One way to get the multiple preference levels would be to uses additional stratum levels; IEEE 1588 defines stratum 3 through 255, though they are not distinguished in BMC algorithm
    - Would be a simple matter to distinguish them
- Suggested equivalent approach, already defined for IEEE 1588 v2, for having sync message refer to previous sync message
  - Define an extension field for AVB applications, that will contain the time of the previous sync message
  - Unlike the approach suggested in Presentation 3, this would not require any new options
- Suggested that AVB seriously consider the use of the peer-to-peer Transparent Clock (P2P TC)
  - Suggestion made that use of P2P TC would give equivalent performance to AVB White Paper compensation algorithm
  - Use of P2P TC would not require the transport of any additional information in messages
- Counter suggestion made that one should look carefully at the actual information transported in each approach, and compare the total information transport in both cases

Next Steps

- 802.1/1588 Time Synch Design Meeting (think white boards/flip charts!)
  - ½ or full day on February 21, 2006 @ NIST (some think full day required)
  - Key participants invited from 1588 and 802.1 communities (All welcome)
- Proposed list of input documents identified for meeting:
  - IEEE 1588 v1 spec and latest descriptions of 1588 TC, short frame, and L2 efforts,
  - References [2], [4], and [5] below
- Desired meeting output:
  - Initial design for 802.1 time synch based on 1588
  - List of proposed changes or items to consider for 1588 to better support 802.1
- Discussions topics include:
  - Transparent clocks,
  - Short frames
  - Layer 2 mapping
  - BMC algorithm

References

1. *Logistics for ResB Timing/Synchronization Work*, prepared by Geoffrey M. Garner and edited in ResB conference calls, Rev. 2, December 14, 2005.
2. *Residential Ethernet: Time-of-Day Timer Synchronization*, maintained by David V. James, latest version is December 17, 2005 (December 12, 2005 presented in IEEE 1588 call on December 15, 2005).
3. John Eidson, Comments on Residential Ethernet Discussion of December 15, 2005, email attachment sent to IEEE 1588 reflector December 19, 2005.
4. David V. James, *Residential Ethernet: Time of Day Timer Synchronization,* presentation at January, 2006 IEEE 802.1 AVB TG meeting, Sacramento, CA, January 10, 2006. Available via http://www.ieee802.org/1/pages/avbridges.html
5. Geoffrey M. Garner, *Comparison of Synchronization Protocol Aspects Currently Discussed for ResB with IEEE 1588*, Samsung presentation at January, 2006 IEEE 802.1 AVB TG meeting, Sacramento, CA, January 10, 2006. Available via http://www.ieee802.org/1/pages/avbridges.html .

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6. David V. James and other contributors, *Residential Ethernet (RE) (a working paper)*, November 16, 2005 (latest version). Available via http://www.ieee802.org/3/re_study/public/index.html
7. David V. James, Extract of material on timing/synchronization from [6] and possible update and addition of detail, December 4, 2005. Available via http://www.ieee802.org/1/pages/avbridges.html .
8. Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks, Draft PAR, January 11, 2006.
9. Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks, Draft 5 Criteria, November 2, 2005.