Proposed changes and application of 802.11 TGv for 802.1AS time synchronization

Kevin Stanton
Intel Corporation
11/14/2006

Contributions by: Geoff Garner, Dirceu Cavendish, George Claseman
Agenda

- Time sync goals for 802.11
- Protocol options for 802.11
- Proposed edits to p802.11v
.11 Time Synchronization Goals

- Wireless mobility, fast clock-master selection/handover, low power
- Single time reference across LANs
- Consistent application-interface at stations
- Straight-forward bridging of time between media types
- 10us end-to-end accuracy over seven hops
  - Clocks possess appropriate jitter and wander
- Cost consistent with CE devices

Non Goals:
- Fixed-latency delivery of content
- Wide-area network time synchronization
Location estimation: 802.11 TGv using TOA

Goal: Measure distance between 802.11 entities (in ns)

1. Requester schedules M1 for Tx
2. As it passes through the PHY, t1 captured
   - Using requester clock
3. Time t2 captured in PHY on Rx
   - Using slave clock
4. Responder MAC automatically sends M1 ACK very quickly (a control frame)
5. t3, t4 captured as above
6. M2 carries (t3-t2) to requester

If link delay is fixed & symmetric:

\[
\text{Link delay} = \frac{[ (t4-t1) - (t3-t2) ]}{2}
\]

Clock offset between master and slave
\[
= \frac{[ (t2-t1) - (t4-t3) ]}{2}
\]

BUT Requester doesn’t know t3 and t2...

Will work ONLY if link delay is Fixed & Symmetric
Protocol options for 802.11

1. Apply 1588 messages directly to 802.11
   - The brute force method

2. Use modified TGv location estimation and either:
   - A. Send t3 and t2 instead of (t3-t2)
     - Define timestamp point
     - Either Slave sends Request or Master sends both Request & Response
   - B. Supplement link delay measurement with 1588-like SYNC message timestamp in HW
   - C. Ignore link delay – only send t2 back, don’t measure t3,t4

3. Use TSF time to communicate time to stations
   - Accuracy may be too low
   - Requires separate message to communicate time offset
# 802.11v

## Table 8—Beacon frame body

<table>
<thead>
<tr>
<th>Order</th>
<th>Information</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Presence Parameters</td>
<td>The Presence Parameters element is present only within Beacon frames generated by APs which support Wireless Network Management Presence Reporting.</td>
</tr>
<tr>
<td>27</td>
<td>Multiple BSSID</td>
<td>The Multiple BSSID element is present only within Beacon frames generated by APs which support multiple BSSIDs.</td>
</tr>
<tr>
<td>28</td>
<td>Multiple BSSID-Index</td>
<td>The Multiple BSSID-Index element is present only within Beacon frames generated by APs which support multiple BSSIDs.</td>
</tr>
</tbody>
</table>

---

### Figure v16 —Wireless Network Management Capabilities

<table>
<thead>
<tr>
<th>B0</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
<th>B15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Log</td>
<td>Diagnostics</td>
<td>Multicast Alert</td>
<td>Presence</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

Bits: 1 1 1 1 12
802.11 TGv Presence Request/Response

- **MLME-PRESENCEREQUEST**: 
  - `request()`
  - Peer MAC Address, Dialog Token, Response Requested, Presence Parameters

- **MLME-PRESENCEREQUEST**: 
  - `confirm()`
  - Dialog Token, ResultCode

- **MLME-PRESENCEREQUEST**: 
  - `indication()`
  - Peer MAC Address, Response Requested, Presence Parameters

- **MLME-PRESENCEREQUEST**: 
  - `request()`
  - Peer MAC Address, Dialog Token, Management Action Pending, Presence Parameters

- **MLME-PRESENCEREQUEST**: 
  - `ack()`
  - Dialog Token, ResultCode

- **MLME-PRESENCEREQUEST**: 
  - `indication()`
  - Peer MAC Address, Dialog Token, Response Requested, Presence Parameters

- **MLME-PRESENCEREQUEST**: 
  - `ack()`
  - Dialog Token, ResultCode

- **MLME-PRESENCEREQUEST**: 
  - `ack()`
  - Dialog Token, ResultCode

- **MLME-PRESENCEREQUEST**: 
  - `ack()`
  - Dialog Token, ResultCode

Actually current TGv draft returns only (t3-t2). Tomorrow, official request for support of returning t2,t3
A possible clock tree
Now view other documents...

• The 802.11v proposal
• 802.11AS new section on 802.11
Backup
PTP Boundary Clock

802.1AS

Frequency Adjustments

PTP SYNC/ FOLLOWUP/PDELAY
generation/consumption

Media independent Layer

Best Master Selection Algorithm

Time offset from master, link delay

802.3

802.11

offset = [(t2-t1)-(t4-t3)] / 2

link dly=[(t4-t1)-(t3-t2)]/2

802.11-specific

Presence Request/Response
Frame generation/consumption

Notes:
1. All stations send/receive Announce messages
2. An AP has one .3 port and multiple .11 associations
3. Boundary clocks require a synchronized clock (but this could still be modeled as a free-running counter with knowledge of the frequency and phase offset to the GM

Present in either the AP or non-AP STA, whichever is farther from the GM

Timestamp

802.3

802.11

Notes:
1. All stations send/receive Announce messages
2. An AP has one .3 port and multiple .11 associations
3. Boundary clocks require a synchronized clock (but this could still be modeled as a free-running counter with knowledge of the frequency and phase offset to the GM

Intel

2006_11_14_as-stanton-proposed-changes-to-11v
Layering for 802.1AS

- Interoperability, client time service
- Protocol:
  - “Generic Messages Protocol” recommendation
  - Media may use the “Generic Messages” or define their own
- Measurement:
  - Define extension to MAC Service Interface to get timestamp information
  - Define measurement accuracy options, as appropriate for application
10. Layer management

10.1 Overview of management model

Both the MAC sublayer and PHY conceptually include management entities, called MLME and PLME, respectively. These entities provide the layer management service interfaces through which layer management functions can be invoked.

Figure 190—GET and SET operations
The Timestamp Difference field contains the time difference between the time that a unicast Presence Request frame was received from a STA, defined to occur at the PHY-RXEND indication of the received Presence Request frame, and the time that the corresponding ACK frame was sent to the STA, defined to occur at the PHY-TXSTART confirm of the ACK frame transmission.

The Timestamp Difference Units field contains the units for the timestamp difference field, as indicated in Table v35.

<table>
<thead>
<tr>
<th>Timestamp Difference Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Microseconds</td>
</tr>
<tr>
<td>1</td>
<td>Hundreds of Nanoseconds</td>
</tr>
<tr>
<td>2</td>
<td>Tens of Nanoseconds</td>
</tr>
<tr>
<td>3</td>
<td>Nanoseconds</td>
</tr>
<tr>
<td>4</td>
<td>Tenths of Nanoseconds</td>
</tr>
<tr>
<td>5 - 255</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

The Timestamp Difference Accuracy field contains the expected standard deviation of the timestamp difference of the timestamp in the units indicated in the Timestamp Difference Units field.
Time Synchronization: A high level view

- Grand Master selected
- Clock tree established
- Offset to Grand Master determined
  - Per “Link”
  - Accumulated downstream
- Time service provided to MAC client
Current p802.11v

Table v31 —Presence Parameters Information Element

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Field Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Presence Indication Parameters</td>
</tr>
<tr>
<td>2</td>
<td>Presence Indication Channels</td>
</tr>
<tr>
<td>3</td>
<td>Presence Request Options</td>
</tr>
<tr>
<td>4</td>
<td>Presence Status</td>
</tr>
</tbody>
</table>

7.3.2.40.1 Presence Indication Parameters field

The Presence Indication Parameters field contains STA presence reporting characteristics. The format of the Presence Indication Parameters field is shown in Figure v61.

<table>
<thead>
<tr>
<th>Element ID (1)</th>
<th>Length (7)</th>
<th>Normal Report Interval</th>
<th>Normal number of frames per channel</th>
<th>In-Motion Report Interval</th>
<th>In-Motion number of frames per channel</th>
<th>Inter-frame Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octets:</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>