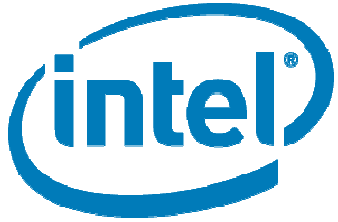

Proposed changes and application of 802.11 TGv for 802.1AS time synchronization

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11/14/2006

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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)

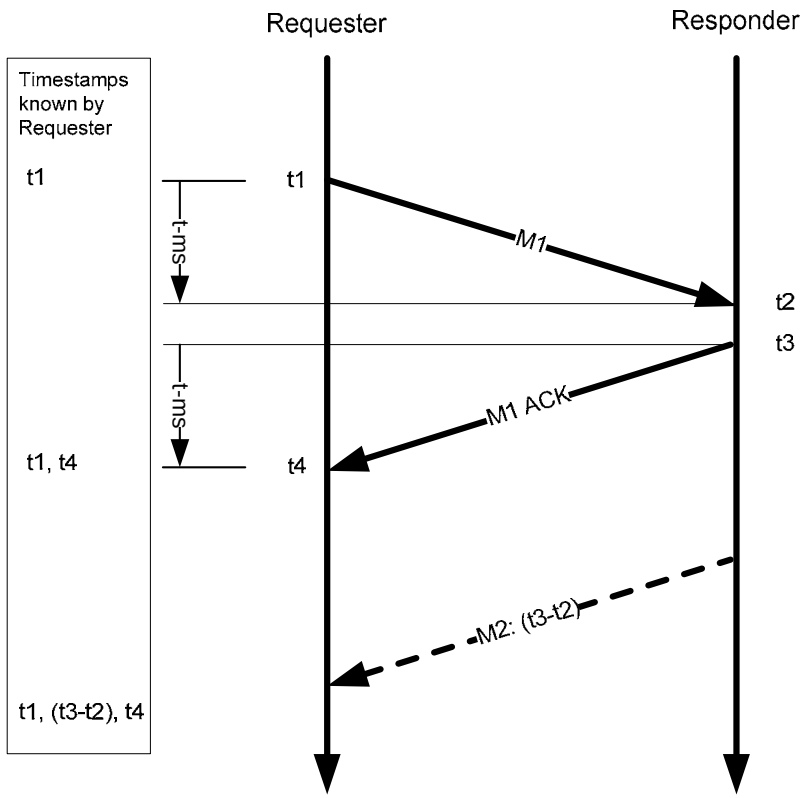
1. Requester schedules M1 for Tx
2. As it passes through the PHY, t1 captured
   - Using requester clock
3. Time t2 captured in PHY on Rx
   - Using slave clock
4. Responder MAC automatically sends M1 ACK very quickly (a control frame)
5. t3, t4 captured as above
6. M2 carries (**t3-t2**) to requester

If link delay is fixed & symmetric:

Link delay = [(t4-t1) – (**t3-t2**)] / 2

Clock offset between master and slave = [(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

14

Table 8—Beacon frame body

Order	Information	Notes
26	Presence Parameters	The Presence Parameters element is present only within Beacon frames generated by APs which support Wireless Network Management Presence Reporting.
27	Multiple BSSID	The Multiple BSSID element is present only within Beacon frames generated by APs which support multiple BSSIDs.
28	Multiple BSSID-Index	The Multiple BSSID-Index element is present only within Beacon frames generated by APs which support multiple BSSIDs.

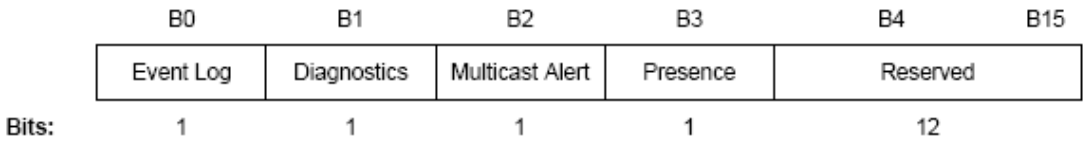
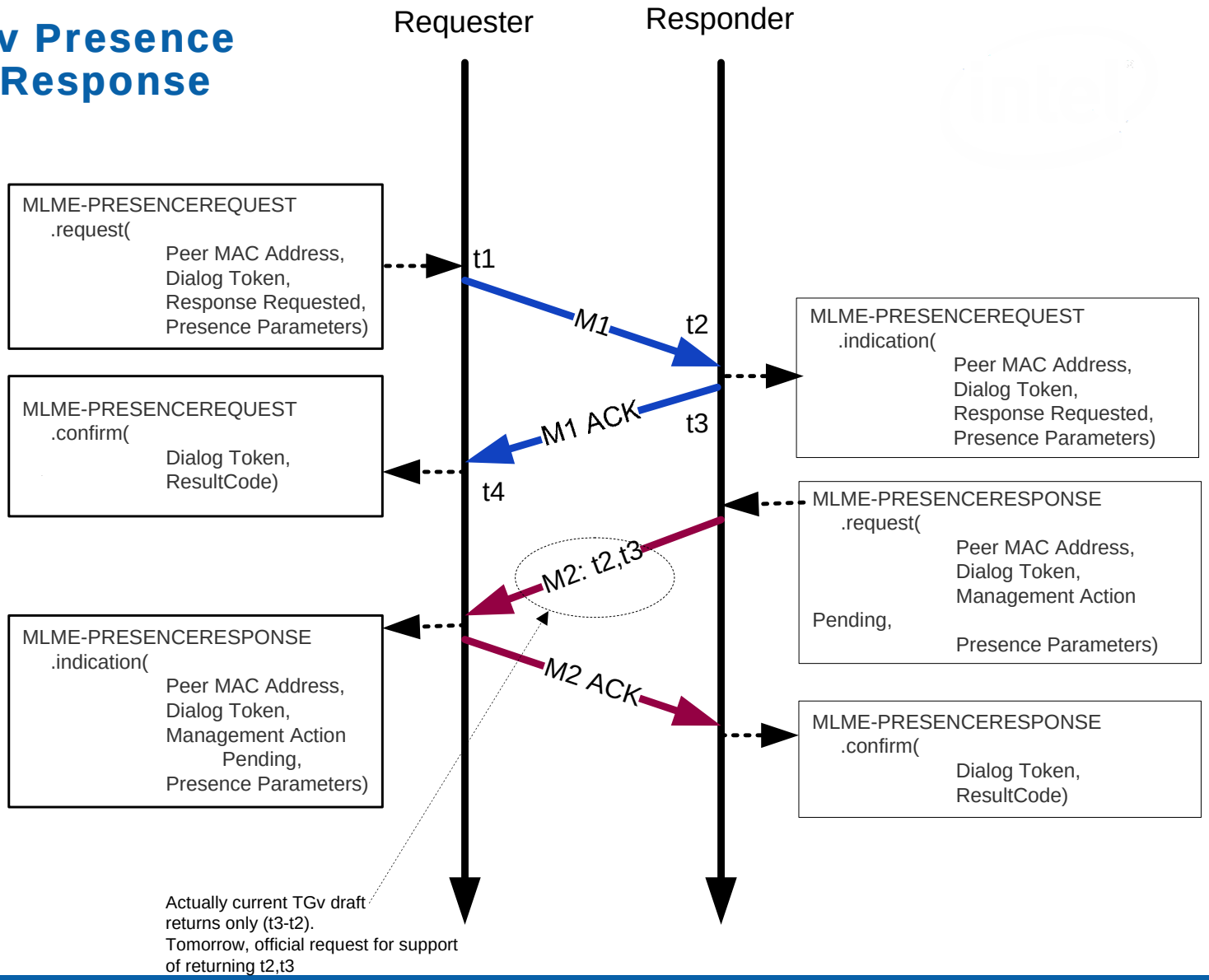
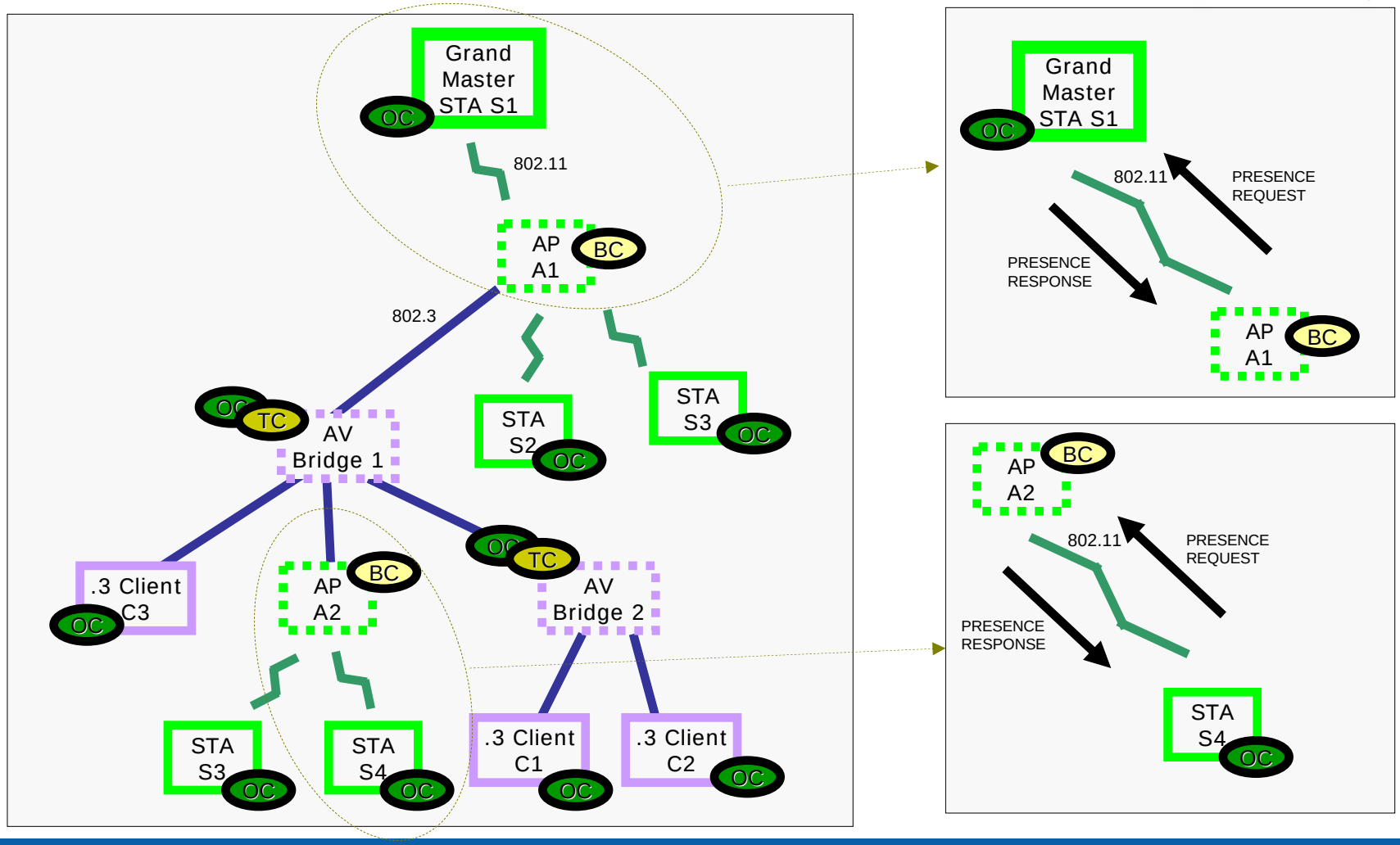


Figure v16 —Wireless Network Management Capabilities

802.11 TGv Presence Request/Response



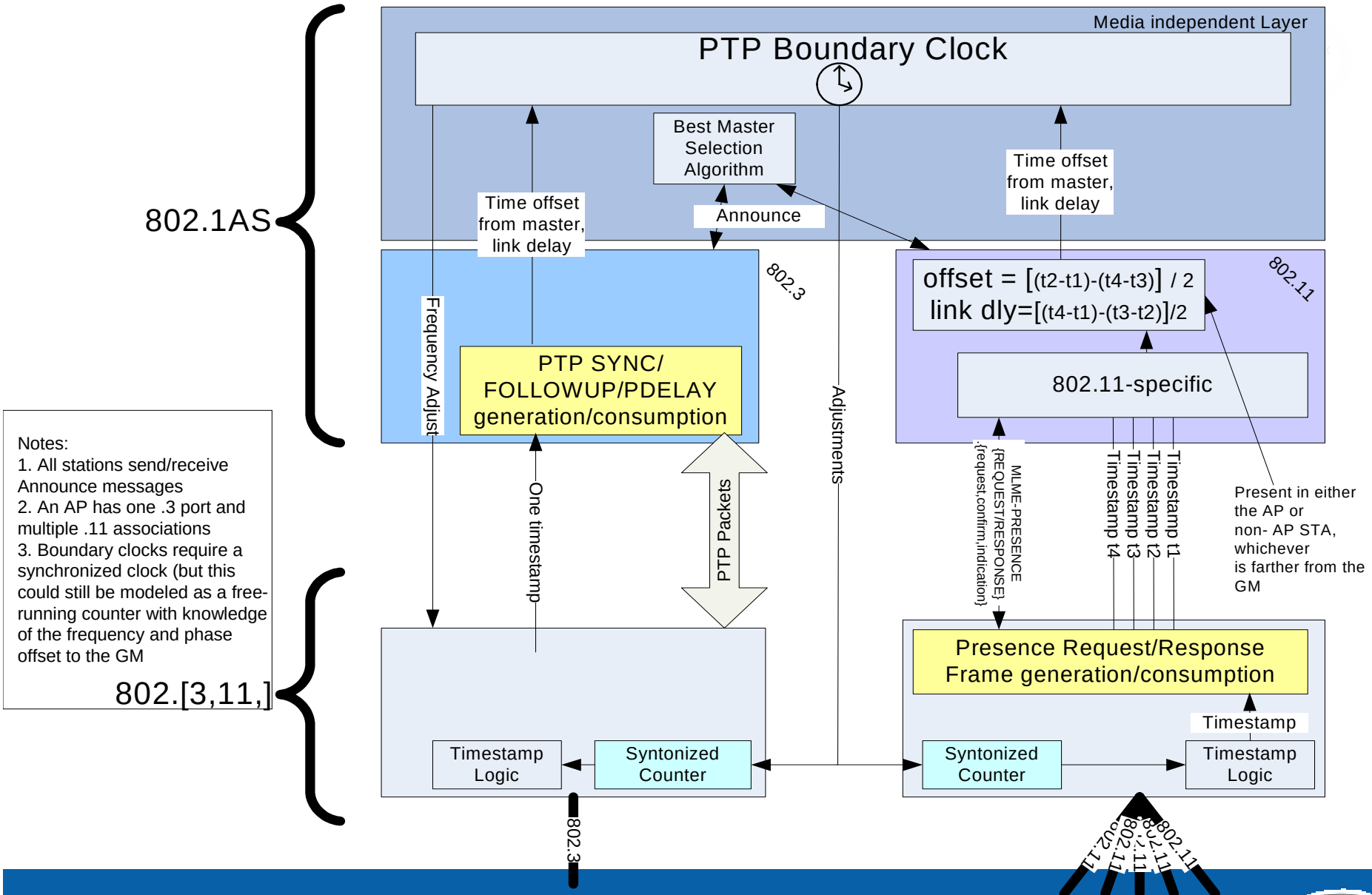
A possible clock tree



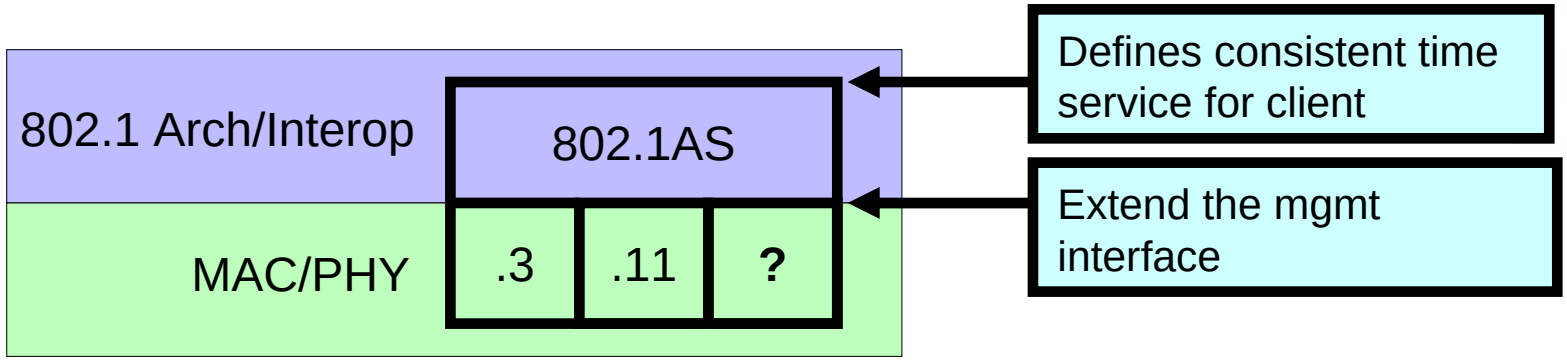
Now view other documents…

- The 802.11v proposal
- 802.11AS new section on 802.11

Backup


802.1AS
Media independent Layer
PTP Boundary Clock
Best Master Selection Algorithm
Announce
Time offset from master, link delay
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
Frequency Adjust
PTP SYNC/ FOLLOWUP/PDELAY generation/consumption
Adjustments
One timestamp
PTP Packets
MLME-PRESENCE {REQUEST/RESPONSE} .{request,confirm,indication}
Timestamp t4
Timestamp t3
Timestamp t2
Timestamp t1
Present in either the AP or non- AP STA, whichever is farther from the GM
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
802.[3,11,]
Presence Request/Response Frame generation/consumption
Timestamp
Timestamp Logic
Syntonized Counter
Syntonized Counter
Timestamp Logic
802.3
802.11
802.11
802.11
802.11

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

802.11maD7.0

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.

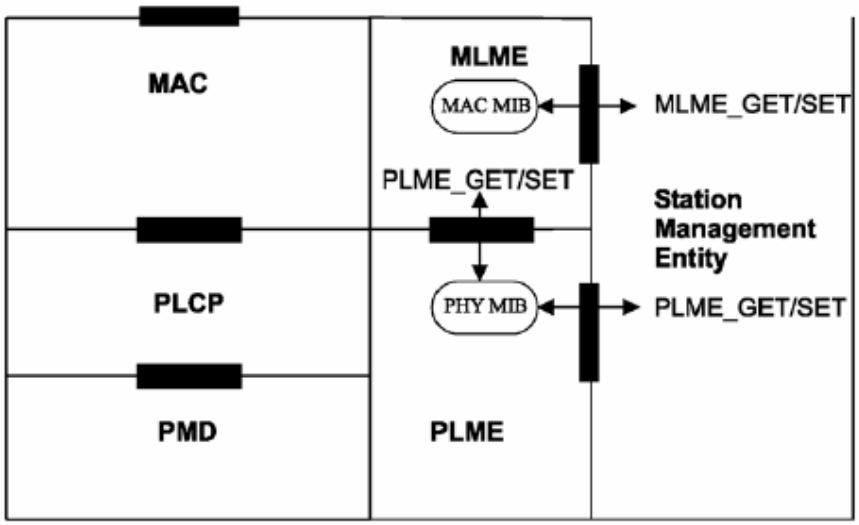


Figure 190—GET and SET operations

Current p802.11v

Element ID (7)	Length (6)	Timestamp Difference	Timestamp Difference Units	Timestamp Difference Accuracy
Octets: 1	1	4	1	1

Figure v67 —Timing Measurements Field

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.

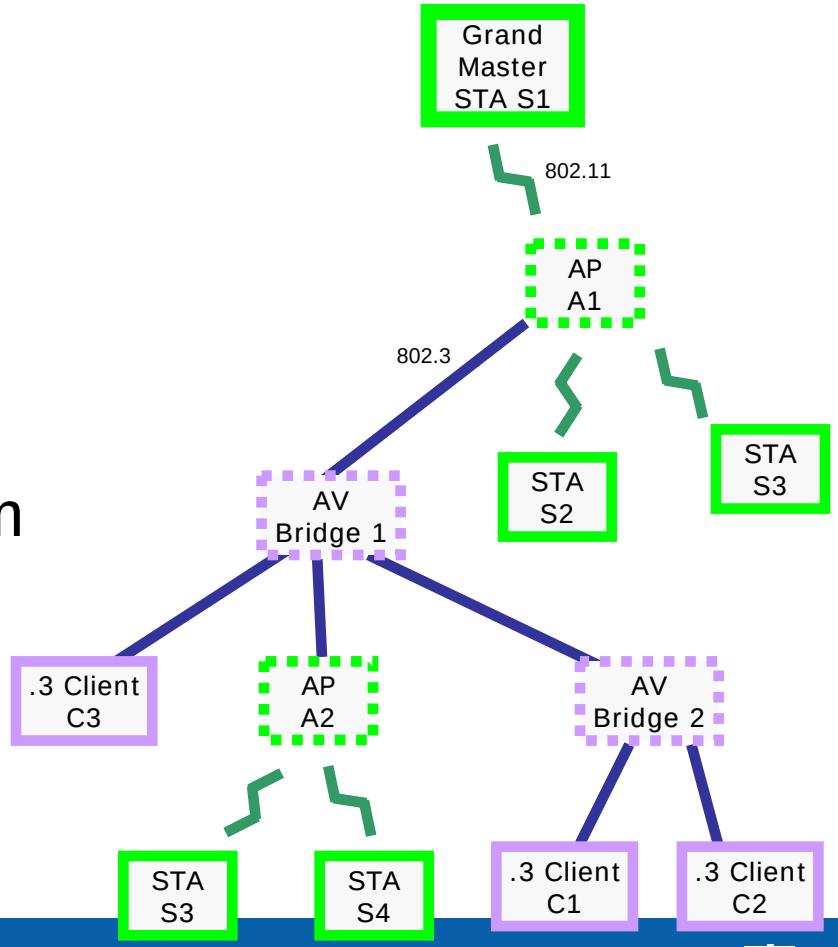
Table v35 —Time Difference Units

Timing Difference Units	Description
0	Microseconds
1	Hundreds of Nanoseconds
2	Tens of Nanoseconds
3	Nanoseconds
4	Tenths of Nanoseconds
5 - 255	Reserved

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

Identifier	Field Name
1	Presence Indication Parameters
2	Presence Indication Channels
3	Presence Request Options
4	Presence Status

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.

	Element ID (1)	Length (7)	Normal Report Interval	Normal number of frames per channel	In-Motion Report Interval	In-Motion number of frames per channel	Inter-frame Interval
Octets:	1	1	2	1	2	1	1

Figure v61 —Presence Reporting Parameters