Time Synchronization for AV applications across Wired and Wireless 802 LANs

[for residential applications]

A presentation to 802.11 TGv

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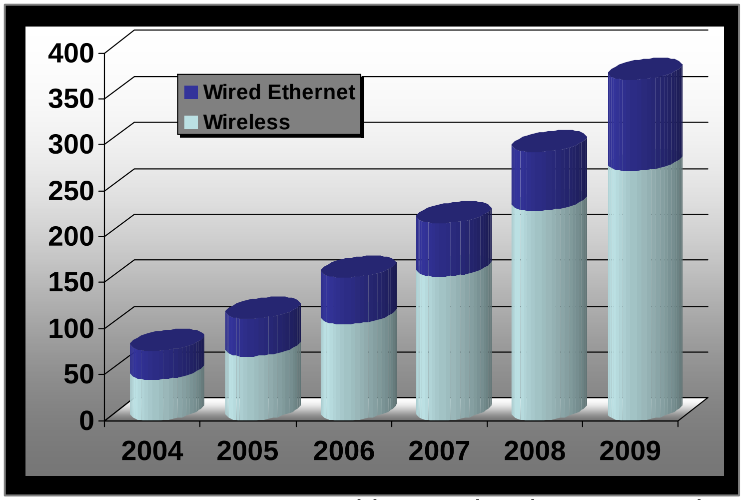
Agenda

- Motivation
- Time synchronization goals
- Protocols
- Options for 802.11
- Summary

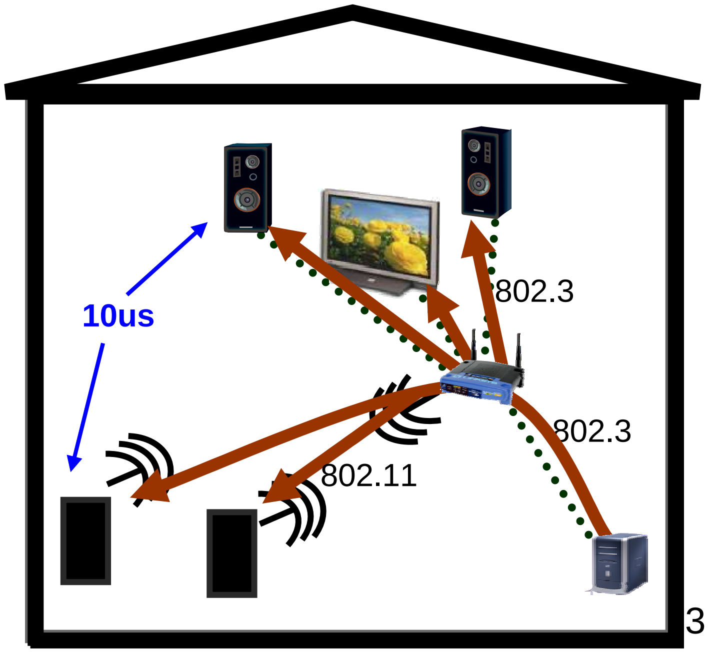
Motivation

- Wireless speakers have strong customer demand
  – Diffusion Group: 53% want
- Most homes have both 802.11 *and* 802.3
- Multi-speakers/displays requires Time Synchronization
  – Both for simultaneous "Start" and to counteract long-term drift
  – 11us for tightly coupled stereo
  – 15-45ms for lip sync
- Time synchronization required for "media push" and multicast
- MAC-client-only solutions lack accuracy and guarantees

802 Time synchronization standard needed over heterogeneous LANs



Source: Home Networking Nodes (IDC Aug'05)



Standards from the 802.1 AV Bridging Task Group

- 802.1AS – Time Synchronization
  - Based on emerging IEEE 1588 version 2
- Stream Reservation Protocol
  - Used to reserve bandwidth for streams
  - Admission Control
- Traffic Shaping
  - Bounded latency through bridges
  - Guaranteed bandwidth for fixed-bandwidth links
- Recommended Practice
  - Specifies network parameters
  - Defines a “defended network”

Effort now comprehending both wired and wireless LANs

Time Synchronization Goals

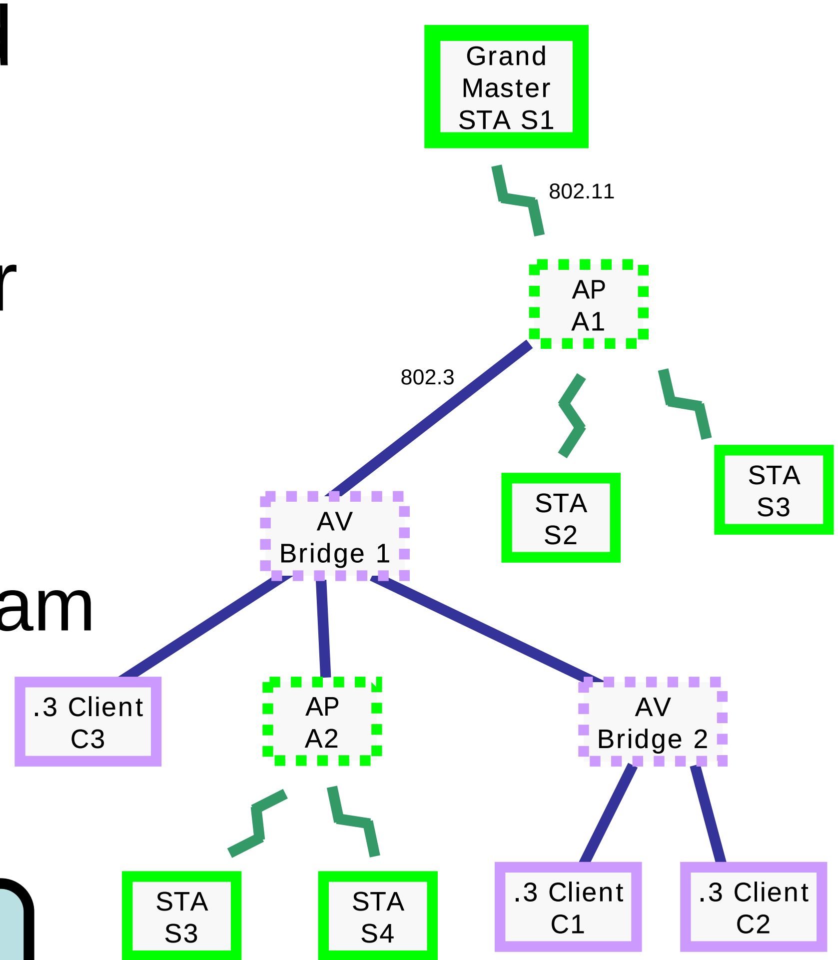
- Wireless mobility, fast clock-master selection/handover, low power
- Single time reference across LANs
- Consistent application-interface at stations
- Straight-forward bridging of time between media types
- 10us end-to-end accuracy over seven hops
  - Clocks possess appropriate jitter and wander
-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

Non Goals:

- Fixed-latency delivery of content
- Wide-area network time synchronization

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



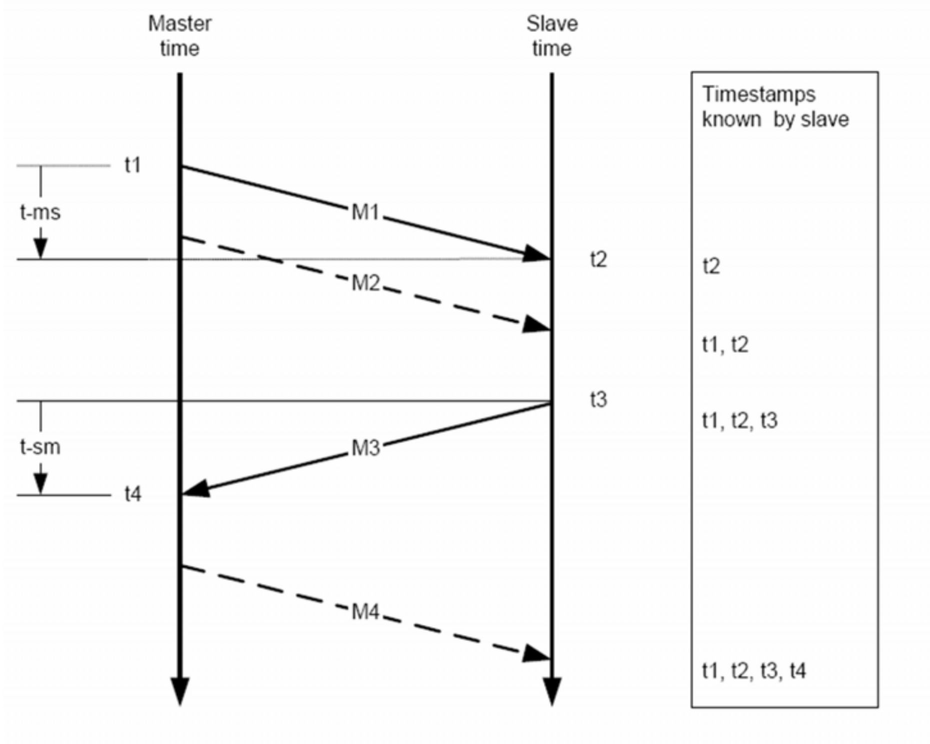
Next we look at link-layer behavior

Time sync with IEEE 1588v1

[Similar to a proposed method for 802.1AS]

Goal: Synchronize clocks of networked nodes

1. Master schedules SYNC (M1) for Tx
2. As it passes from MAC to PHY, t1 captured
   - Using master clock
3. Time t2 captured as passes from PHY to MAC
   - Using slave clock
4. FOLLOWUP (M2) carries t1 to slave
5. Slave schedules M3 for Tx
6. t3, t4 captured as above
7. M4 carries t4 to slave



If link delay is fixed & symmetric:

Clock offset between master and slave
= [(t2-t1) – (t4-t3)] / 2

Will work ONLY if link delay is Fixed & Symmetric

Location estimation: 802.11 TGv using TOA

Goal: Measure distance between 802.11 entities (in ns)

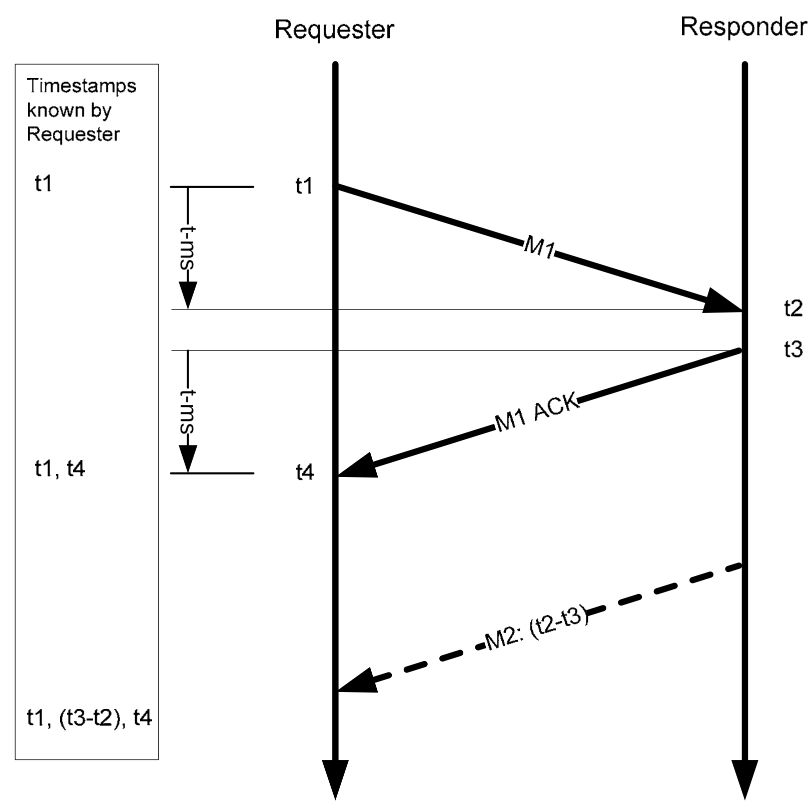
1. Requester schedules M1 for Tx
2. As it passes through the PHY, t1 captured
   - Using requester clock
3. Time t2 captured in PHY on Rx
   - Using slave clock
4. Responder MAC automatically sends M1 ACK very quickly (a control frame)
5. t3, t4 captured as above
6. M2 carries (**t3-t2**) to requester

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…

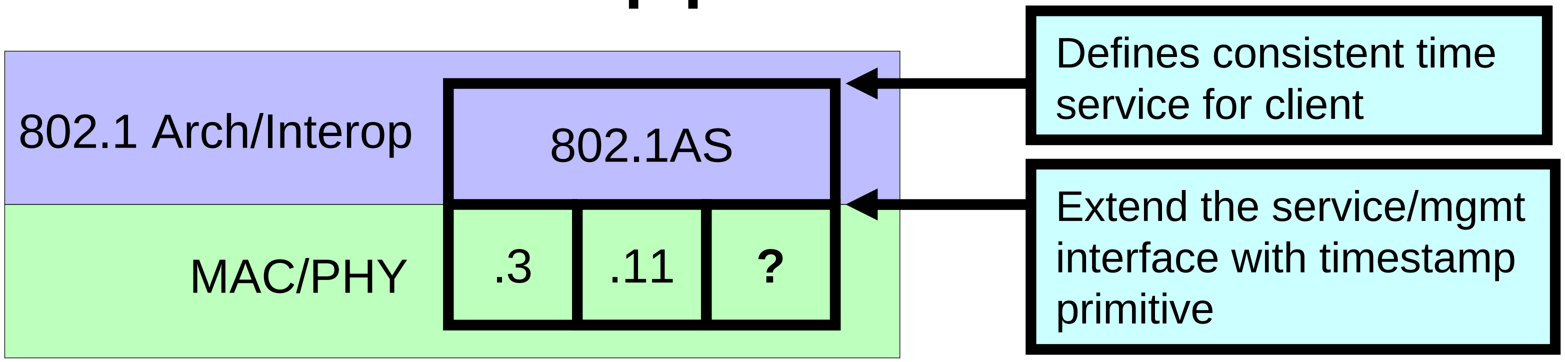


Will work ONLY if link delay is Fixed & Symmetric

Protocol options for 802.11

- Apply 1588 messages directly to 802.11
  - The brute force method
- Use modified TGv location estimation and either:
  - A. Send t3 and t2 instead of (t3-t2)
    - Define timestamp point
    - Permit Presence Response to go either direction
  - B. Supplement link delay measurement with 1588-like SYNC message timestamp in HW
- Use TSF time to communicate time to stations
  - A. Accuracy may be too low
  - B. Requires separate message to communicate time offset

Our approach in 802.1



- Interoperability, client time service
- Protocol:
  - Include “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

Summary

- Time synchronization needed for AV applications

  …over multiple media types, with
  - Consistent time formats, etc.
  - Optimized protocol per media
  - High end-to-end accuracy, low cost
- Please work with us meet application requirements across 802.3 and 802.11 [and…]
- Please support the development of service/management interface enhancements

BACKUP

Worst-case TSF Synchronization Accuracy

Revision with
Corrections, Clarifications & Enhancements

IEEE
P802.11-REVma/D5.1 January 2006

11.1.2 Maintaining synchronization

Each STA shall maintain a TSF timer with modulus 2^{64} counting in increments of microseconds. STAs expect to receive beacons at a nominal rate. The interval between beacons is defined by the dot11BeaconPeriod parameter of the STA. A STA sending a beacon shall set the value of the beacon's timestamp so that it equals the value of the STA's TSF timer at the time that the data symbol containing the first bit of the timestamp is transmitted to the PHY plus the transmitting STA's delays through its local PHY from the MAC-PHY interface to its interface with the WM [e.g., antenna, light-emitting diode (LED) emission surface]. The algorithms in this clause define a mechanism that maintains the synchronization of the TSF timers in a BSS to within 4 symbols plus the maximum propagation delay of the PHY.

802.11v

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

Figure v65 —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 v33.

Table v33 —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.