AV Time Synchronization for Wired and Wireless 802 LANs

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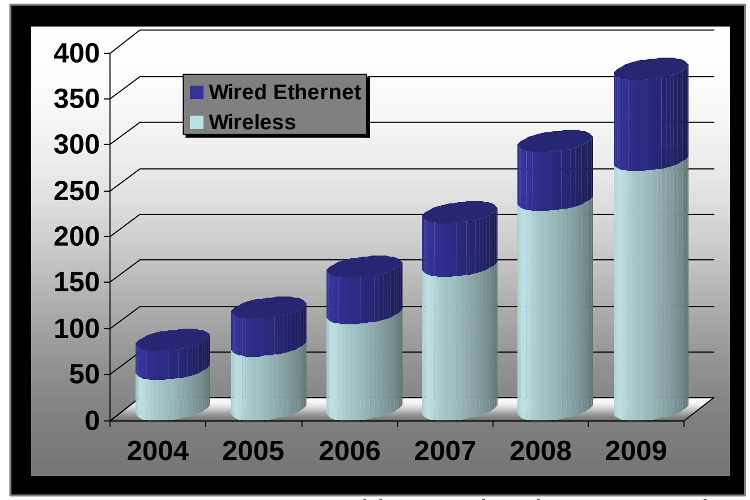
Agenda

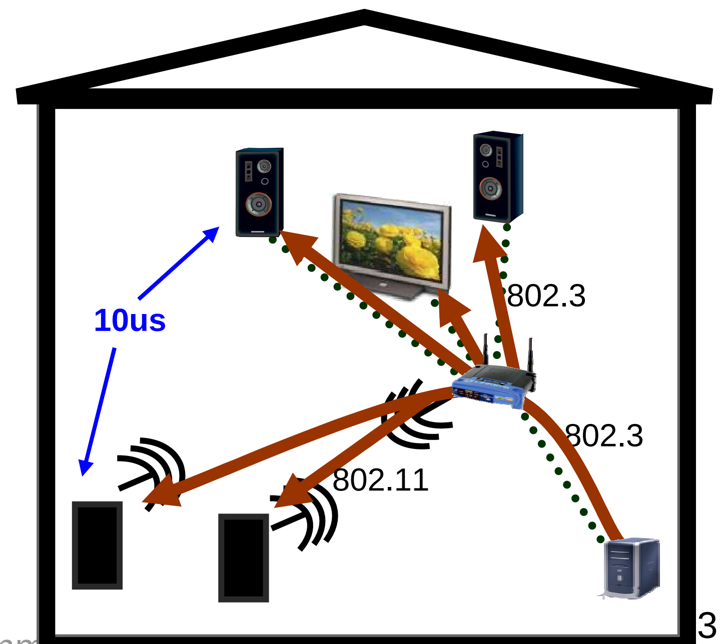
- Motivation
- Time synchronization goals
- Protocols
- Options for 802.11
- Summary

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



Source: Home Networking Nodes (IDC Aug’05)



802 Time synchronization standard needed over heterogeneous LANs

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”

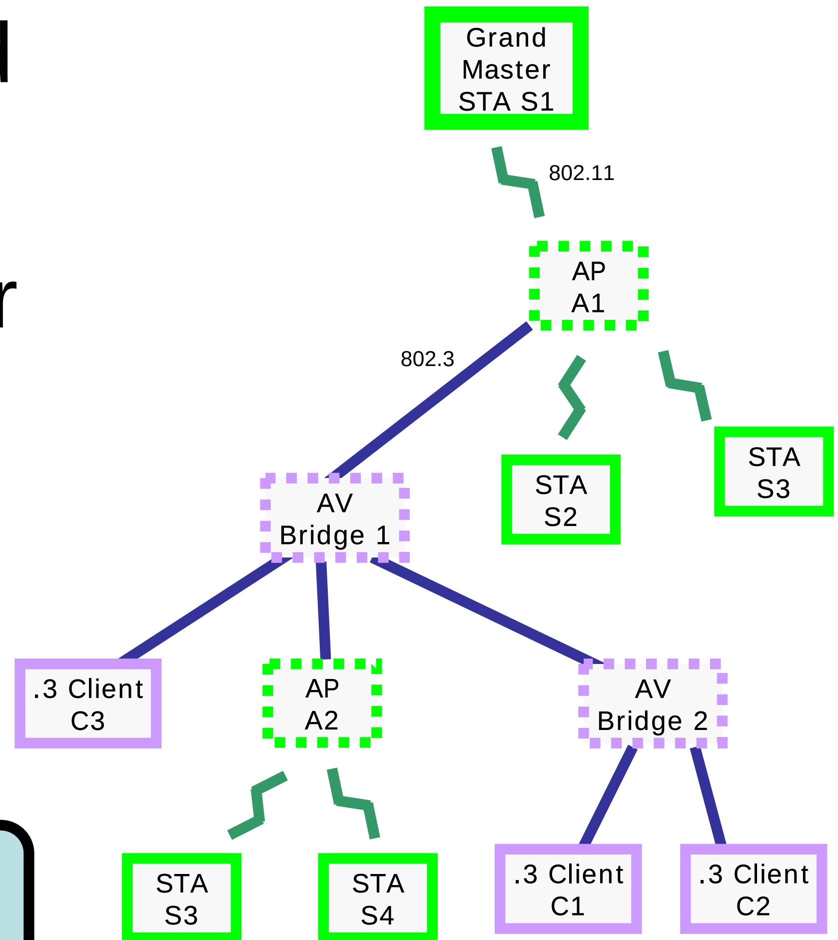
Effort now comprehending both wired and wireless LANs

Time Synchronization Goals

- 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
- Cost consistent with CE devices

Time Synchronization:
A high level view

- Grand Master selected
- Clock tree established
- Offset to Grand Master determined
  - Per node, on every link
- Time service provided to MAC client

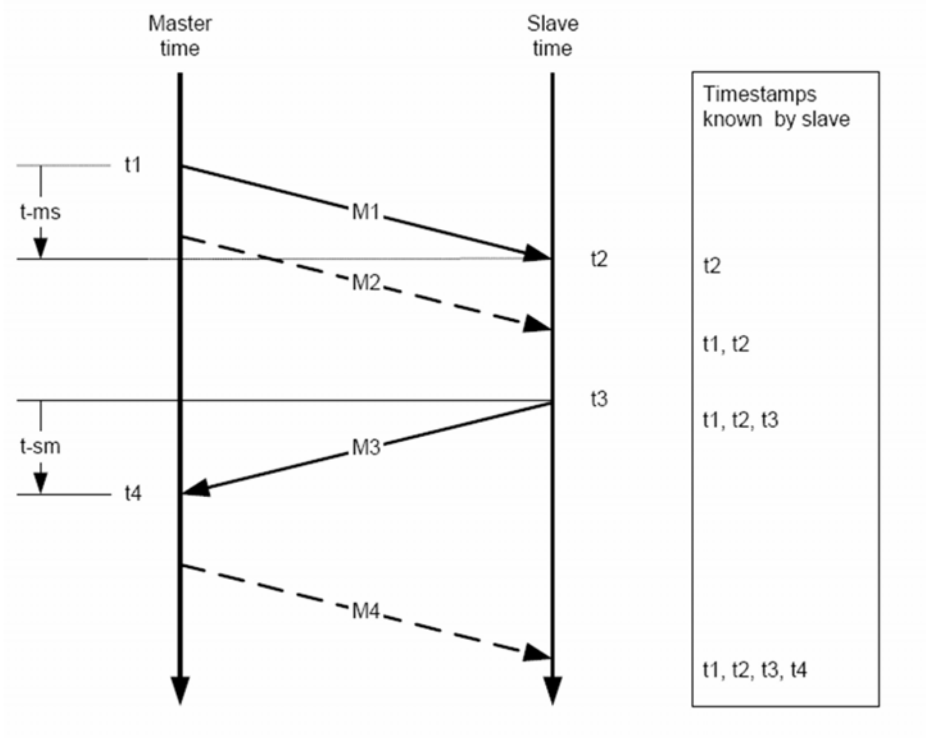


Next we look at link-layer behavior

Time sync with IEEE 1588v1
[Similar to 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 with 802.11 TGv

Goal: Measure distance between 802.11 entities (in ns)

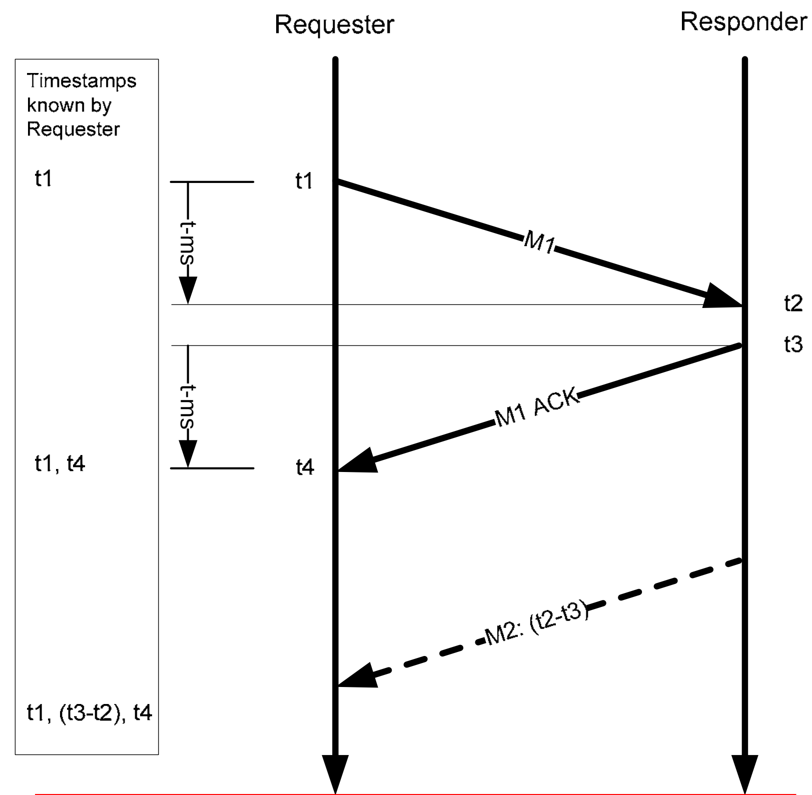
1. Requester schedules M1 for Tx
2. As it passes through the PHY, t1 captured
   - Using requester clock
3. Time t2 captured in PHY on Rx
   - Using slave clock
4. Responder MAC automatically sends M1 ACK very quickly (a control frame)
5. t3, t4 captured as above
6. M2 carries (**t3-t2**) to requester

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…

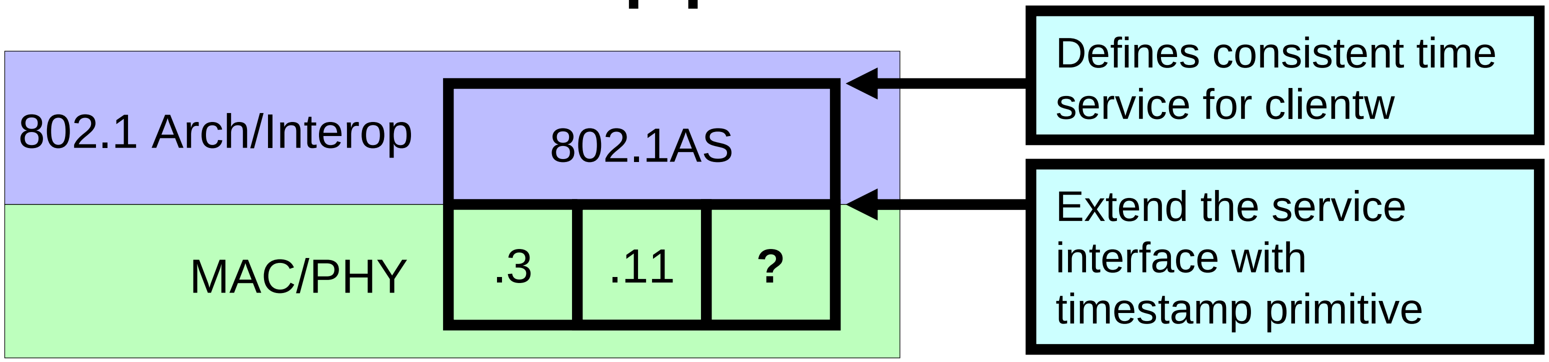


Will work ONLY if link delay is Fixed & Symmetric

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).
   B. Supplement link delay with 1588-like SYNC message timestamp in HW
3. 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 support the development of service interface enhancements

  - Specifying 802.3 layering today, moving soon to 802.11

BACKUP

July 2004 doc.: IEEE 802.11-04/0775r0

Synchronization Requirements and Solutions for 802.11n

Morgan H. Miki, John M. Kowalski
Sharp

Submission Slide 1 Morgan H. Miki, John M. Kowalski, Sharp

Sept. 2003 *Javier, Sai and Sunghyun*

Multimedia Clock Synchronization over 802.11 WLAN

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July 2001 doc.: IEEE 802.11-01/475r0a

Time Synchronization Function for Low Jitter Applications

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Submission Toru Ueda et al, Sharp

Wireless time sync challenges

- Link delay changes over time
  - Multipath delay spread
    - *Is statistically zero mean*
  - Changes in link distance (mobility)
    - This effect is negligble
      - » *100ns in 100 ms → 682 MPH (MACH 0.9)*
- Wireless data rate is lower than Ethernet
  - Must ensure small time sync overhead
    - *Wireless clocks typically have 5x better PPM (20PPM vs. 100PPM)*
      - » *Sync interval can be longer*
- Link errors in .11 are very likely (10% drop rate)
  - Retransmissions result
- Effective data rate changes
  - *Should only impact bandwidth – not delay of 1st octet*