Clock synchronization over 802.11 for AV applications

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Agenda

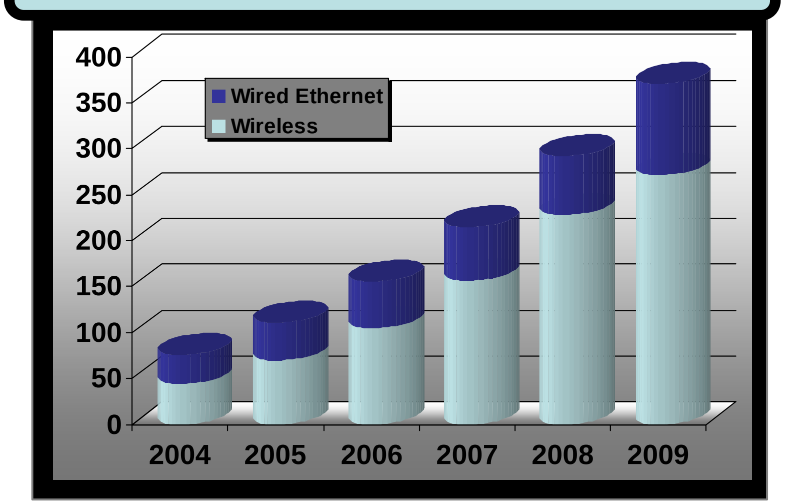
- Motivation for Ethernet/WiFi (802.3/802.11) time synchronization
- Relevant wireless characteristics/protocols
- Wireless synchronization protocols/model

Motivation

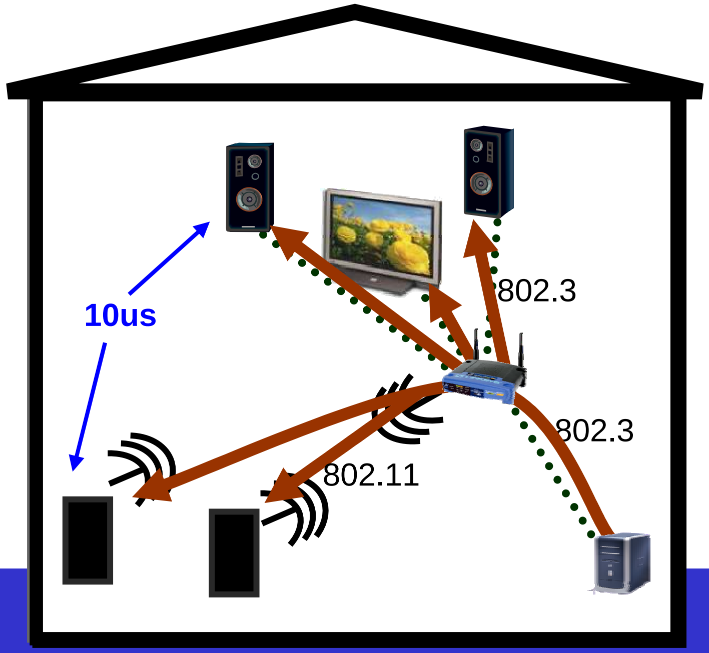
- Wireless speakers have strong customer demand
  - Diffusion Group: 53% want
- 802.11 is important for home
- Multi-speakers/displays requires Time Synchronization
  - Both for simultaneous “Start” and to counteract long-term drift
  - 11us accuracy for tightly coupled stereo
  - 15-45ms for lip sync
- Clock synchronization required for “media push” and multicast
  - See Geoff Garner’s presentation at this conference for details

Time synchronization standard needed over 802.3 and 802.11 LANs

Homes have mix of Ethernet and WiFi



Source: Home Networking Nodes (IDC Aug’05)



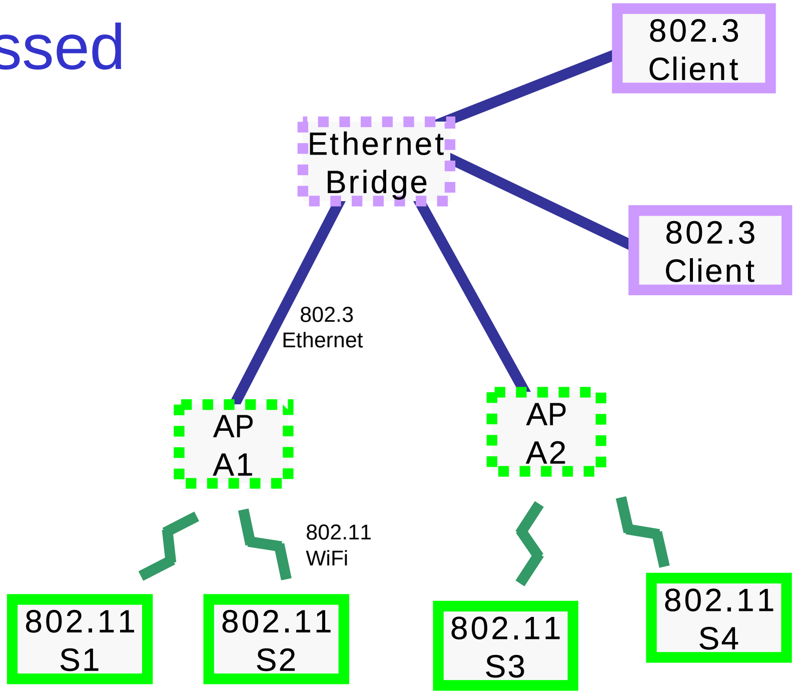
Standards from the 802.1 “AV Bridging” Task Group

- 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”

This effort is now comprehending both wired and wireless LANs

Relevant 802.11 characteristics

- Wireless station “associated” with ONLY one Access Point (AP)
- Unicast frame processed by addressed station and ACK’d
- Migration between APs is explicitly signaled
- APs communicate via Ethernet (typically) for handoff
- High frame error rate
- Multicast very unreliable
- Lower throughput (than Ethernet)
- Link delay changes over time



Location estimation protocol (802.11 TGv)

Goal: Measure distance between 802.11 stations (in ns)

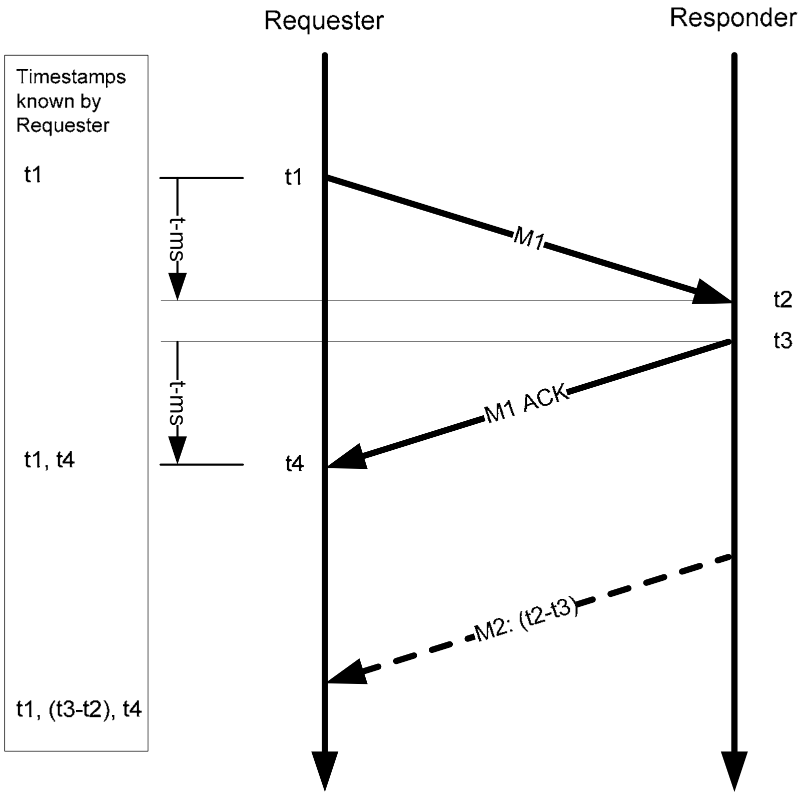
1. Requester schedules M1 for Tx
2. As it passes through the PHY, t1 captured
   - Using requester clock
3. Time t2 captured in PHY on Rx
   - Using slave clock
4. Responder MAC automatically sends M1 ACK very quickly (a control frame)
5. t3, t4 captured as above
6. M2 carries (**t3-t2**) to requester

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 Announce plus 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
   - 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

2A is most appropriate for 802.11
and delivers the best accuracy/scalability

Time synchronization for 802.11

The approach:

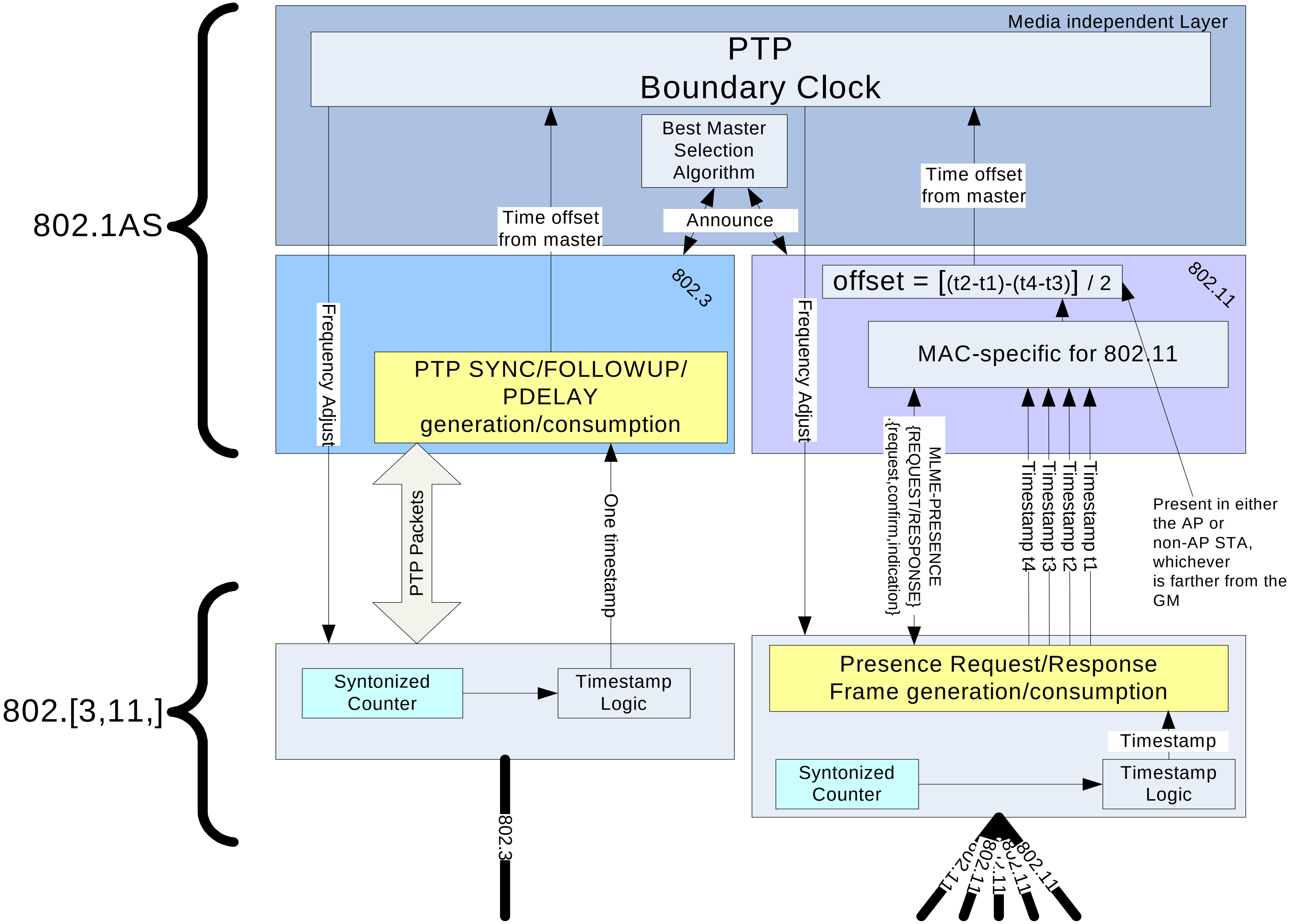
- Use 802.11v to take the measurements
- Place a Boundary Clock in every AP
- Use standard ANNOUNCE messages
- Configure 802.11 stations to be selected LAST as Grand Master

Remaining issues:

- Accuracy, bandwidth, power requirements
- Protocol stability with unreliable multicast
- Requires 802.11v modifications
  - “Requester” also sends “response”

p1588 already provides the framework for wireless time synchronization

802.11 AP Architecture



Summary

- Time synchronization needed for 802.3 and 802.11
- Wireless protocol already under definition
- 802.1AS working toward joint 802.3/802.11 synchronization architecture