# 802.11 Wireless LAN Time Synchronization

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# Executive Summary

Many Time-sensitive applications use wired-Ethernet

Applications could benefit from precision Wireless time

Precision Time is achievable over Wireless (802.11) LANs

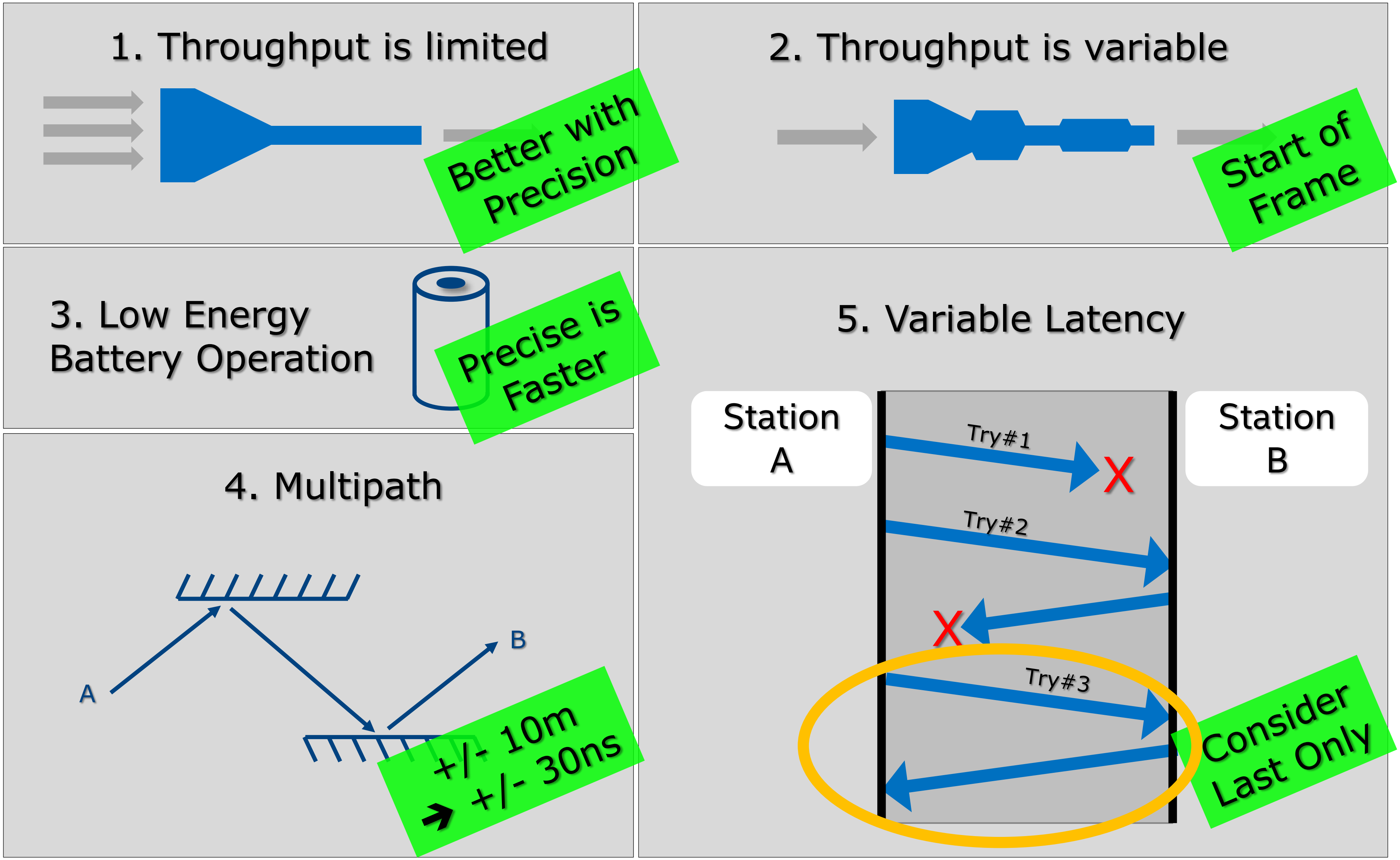
Standards are in place

Momentum is growing

# Application requirements for Wireless LAN Synchronization

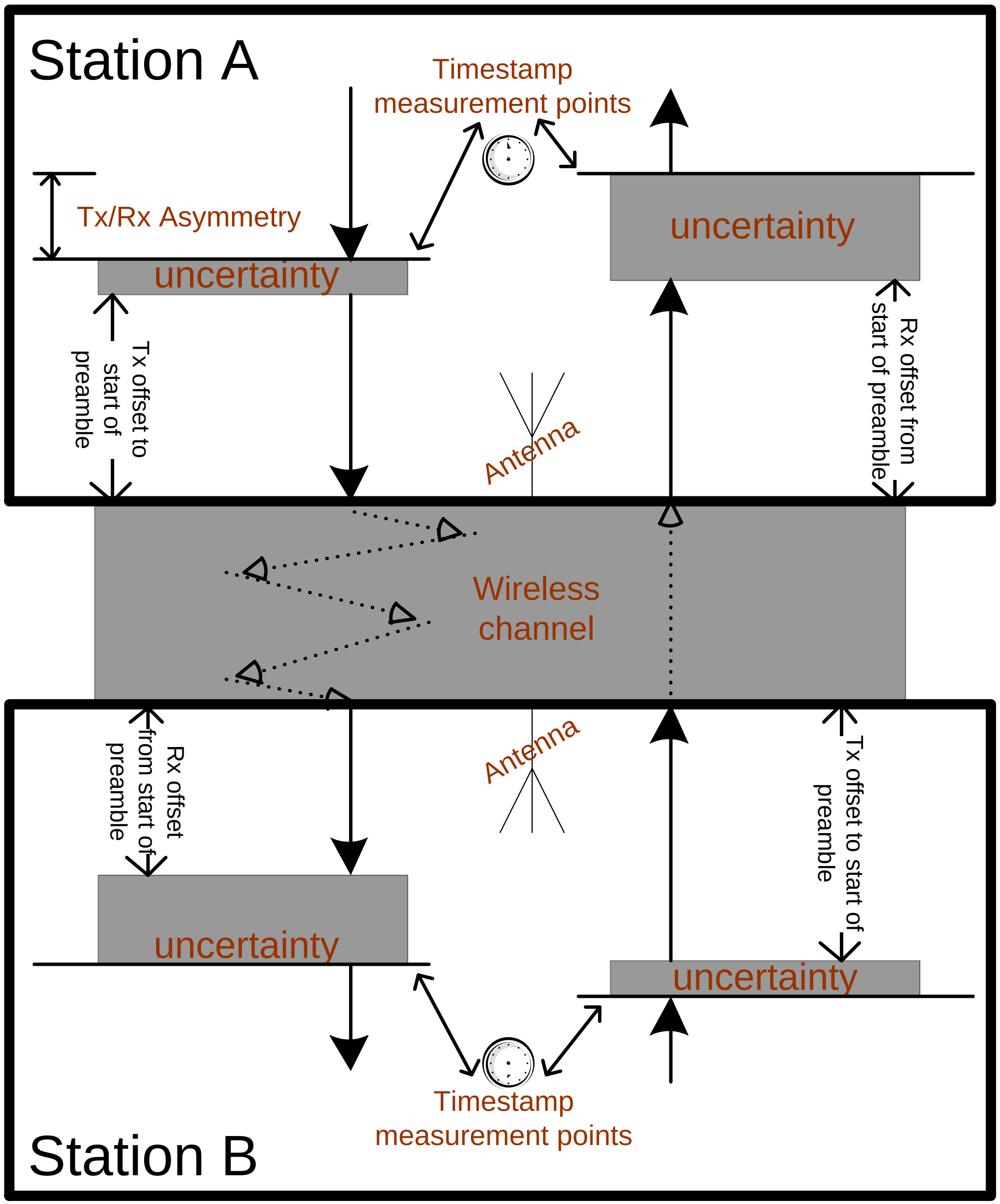
| # | Application Area | Accuracy Target | Notes |
|---|---|---|---|
| 1 | Home Theater | 10us | Low Jitter & Wander |
| 2 | Live Sound | 1us | Phased Array Speakers |
| 3 | Microphone Arrays | <1us | Phased Array Mics |
| 4 | Test and Measurement | 1us */÷ $10^4$ | Depends on physical process |
| 5 | Medical devices | <1ms | Signals relatively low frequency |
| 6 | Industrial Internet / IOT | 100us */÷ $10^4$ | Robotics/process control |

# Common Objections (to precision wireless time)




The Timestamp Point Matters

# Timestamps and wireless path asymmetry




The Antenna is the *Timestamp Reference*

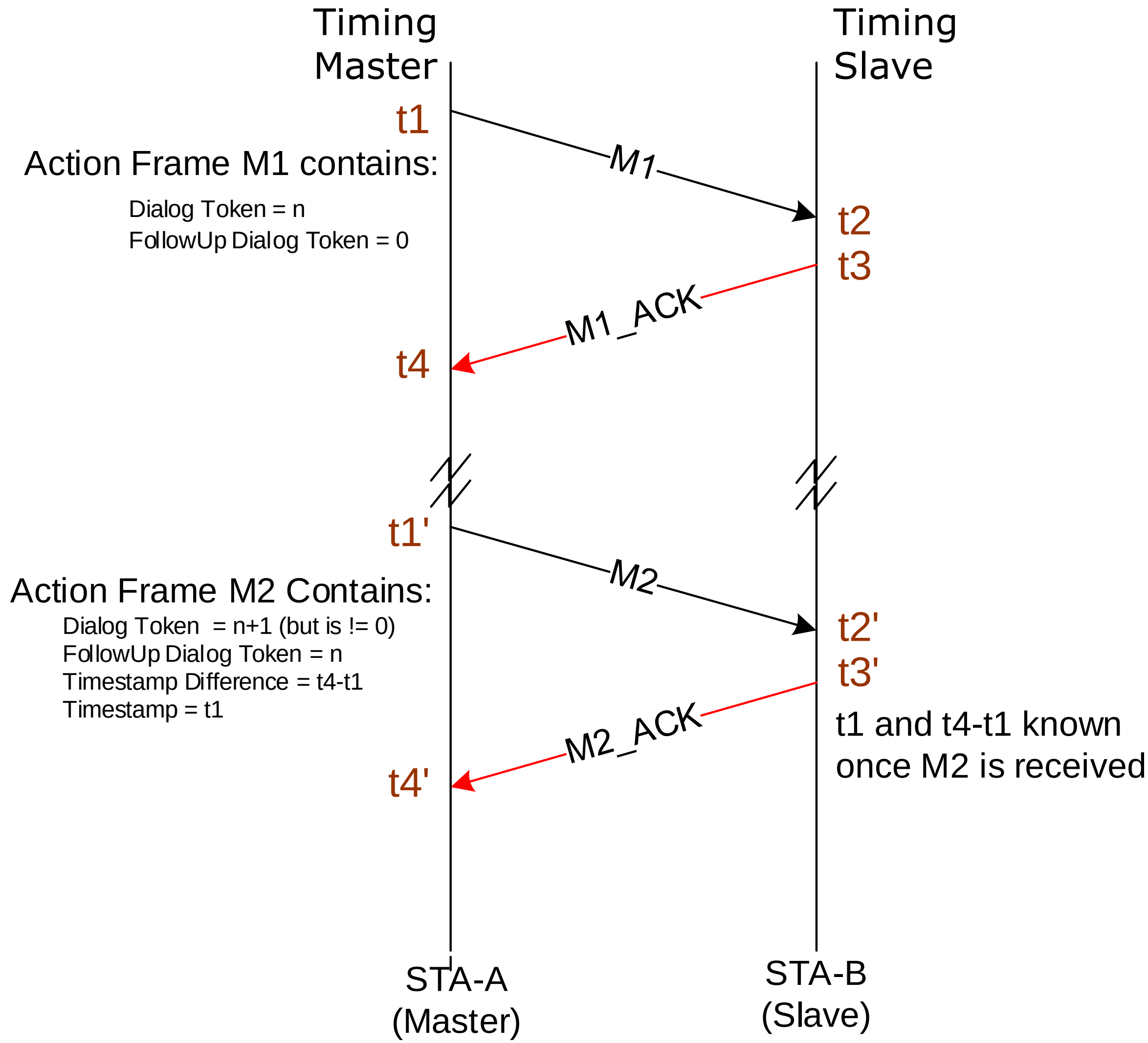
Delay known between the antenna and *Timestamp Reference*

Timestamps introduce *uncertainty*

NOTE: Correction of Rx/Tx Asymmetry is sufficient for Synchronization

The channel introduces path asymmetry (and additional uncertainty)

# Precision Time over an 802.11 link (Using 802.11-2012 TIMINGMSMT)




## First exchange:

- takes a measurement

## Subsequent exchange:

- Takes a measurement
- Also passes timestamps from prior measurement
  - In a FOLLOWUP TLV

## Free-running counter used for timestamps

## 802.1AS then computes:

```
neighborRateRatio =
    (t1'-t1)/(t2'-t2)
linkDelay =
    [(t4-t1)-(t3-t2)]/2
timeOffset=
    [(t2-t1)-(t4-t3)]/2
```

NOTE: M1 and M2 have exactly the same format—
they're TIMINGMSMT Private Action Frames (and Unicast, BTW)

# Standards for Wireless Time Synchronization

IEEE Std. 802.1AS™-2011 (which contains a profile of IEEE Std. 1588™-2008

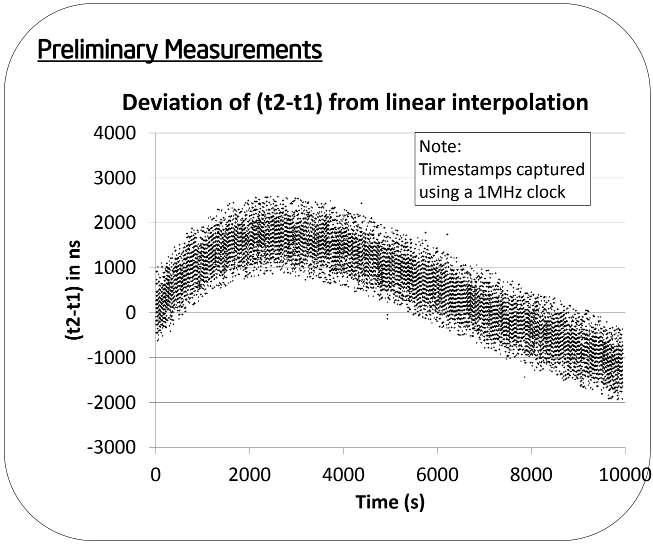
specifies the use of Timing Measurement

- Which is published in IEEE Std. 802.11™-2012

> “ A STA that supports the timing measurement procedure may transmit Timing Measurement frames addressed to a peer STA that also supports the timing measurement procedure. One higher-layer protocol for synchronizing a local clock time between STAs using this feature is specified in IEEE Std 802.1AS. ”

P802.11mc is adding Fine Timing Measurement

- It's nearly the same as Timing Measurement
  - Increased timestamp resolution (10ns→100ps)
  - Public Action Frame → Private Action Frame
  - Other changes expected
- Expected to be published in 2015




From: http://www.ieee802.org/1/files/public/docs2013/ASbt-kbstanton-TimingMeasurements-status-1113-v01.pptx intel®