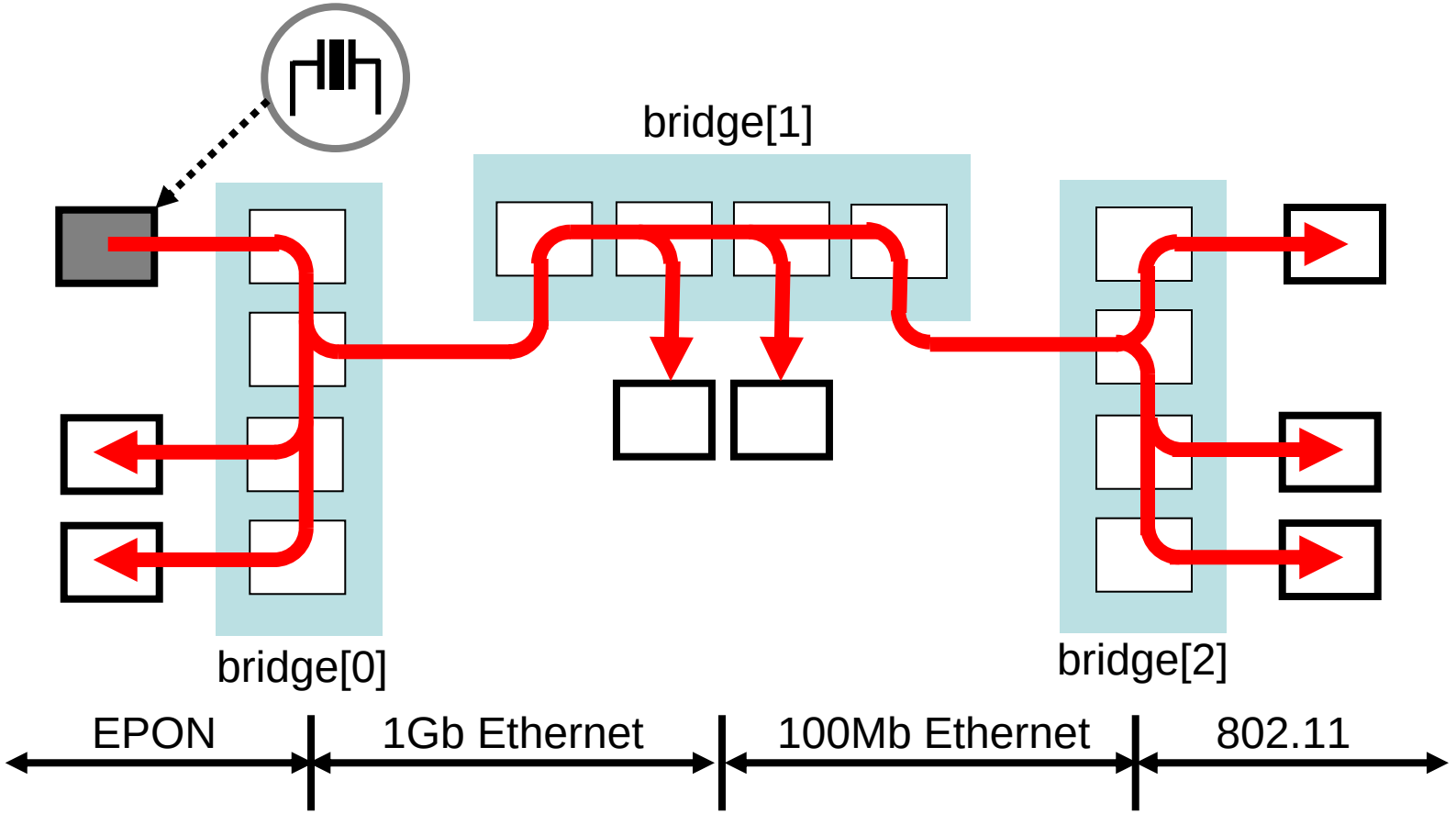
802.1AS:
Time-of-day synchronization (interworking layer?)

Thoughts by David V James

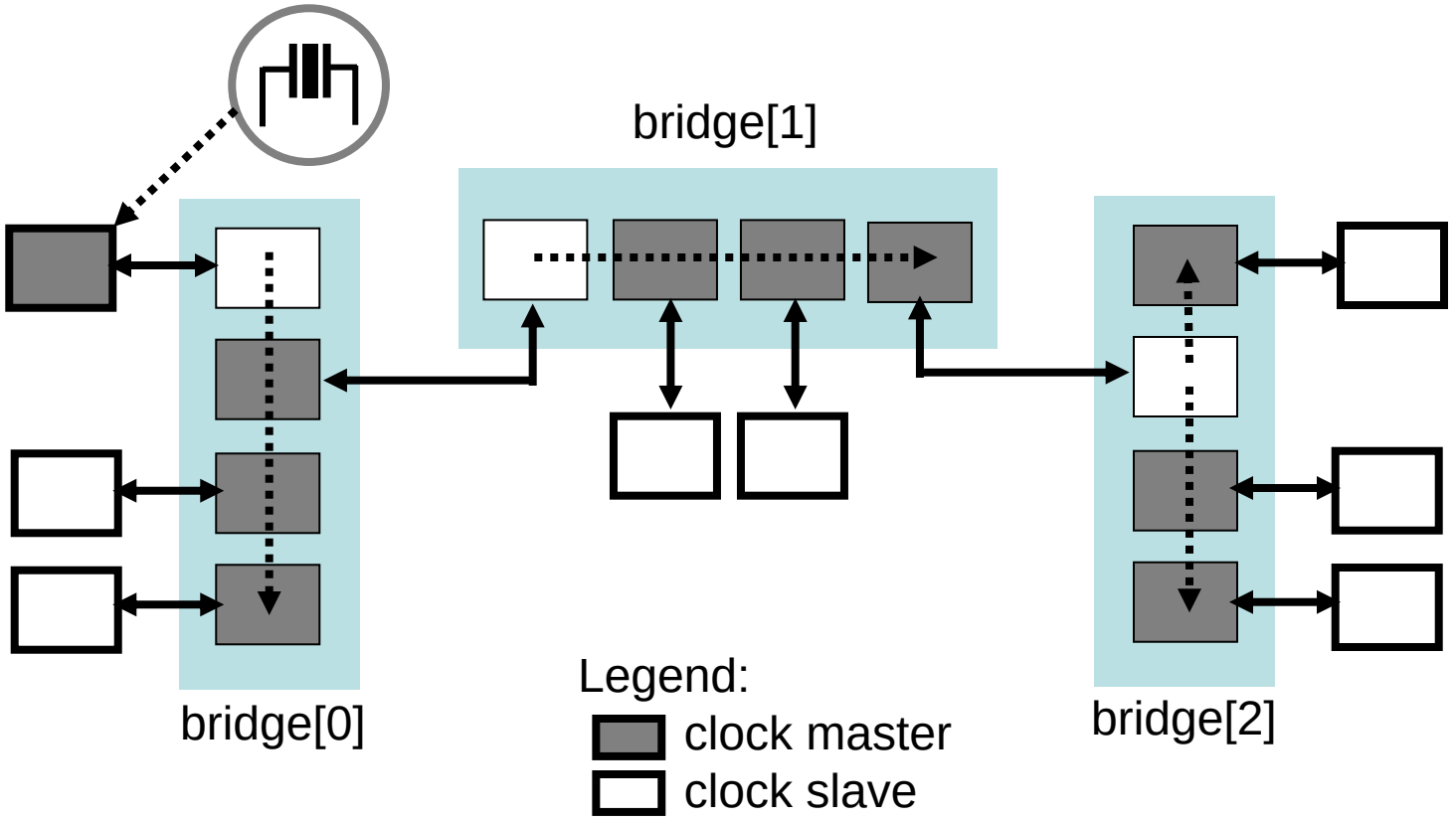
Cascaded TOD synchronization

Wall-clock distribution model



Cascaded TOD synchronization

Cascaded adjacent-synchronization hierarchy



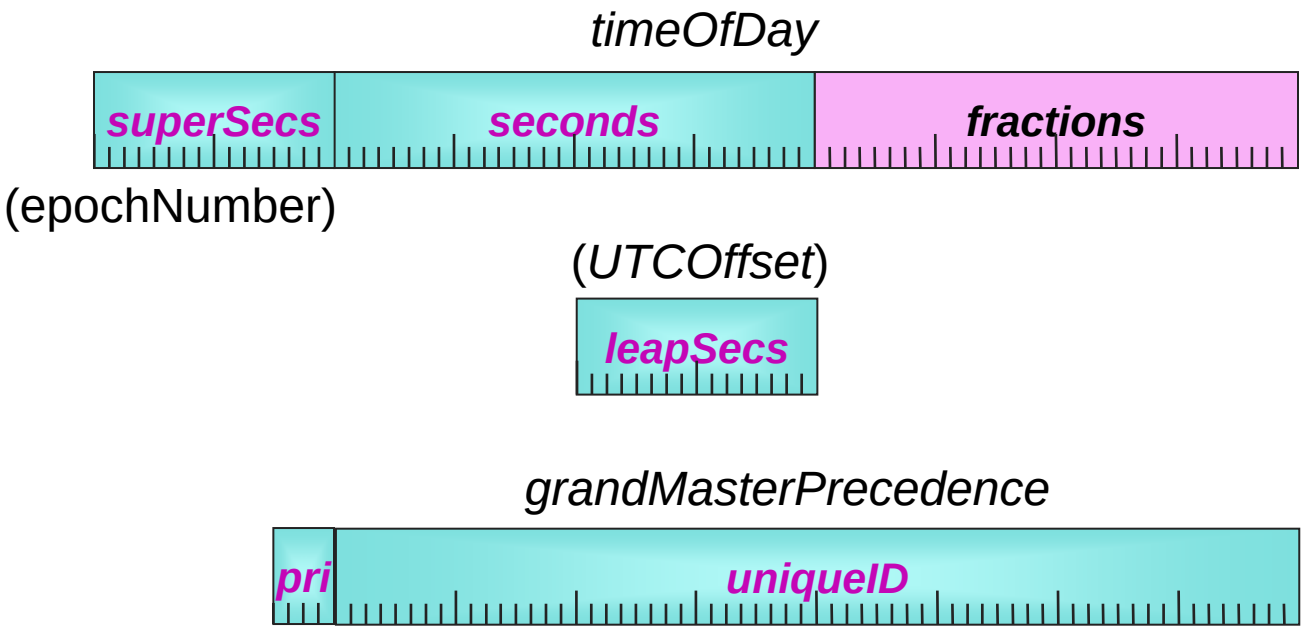
802.1as:

What are the interworking parameters?

When bridging across 802 networks…

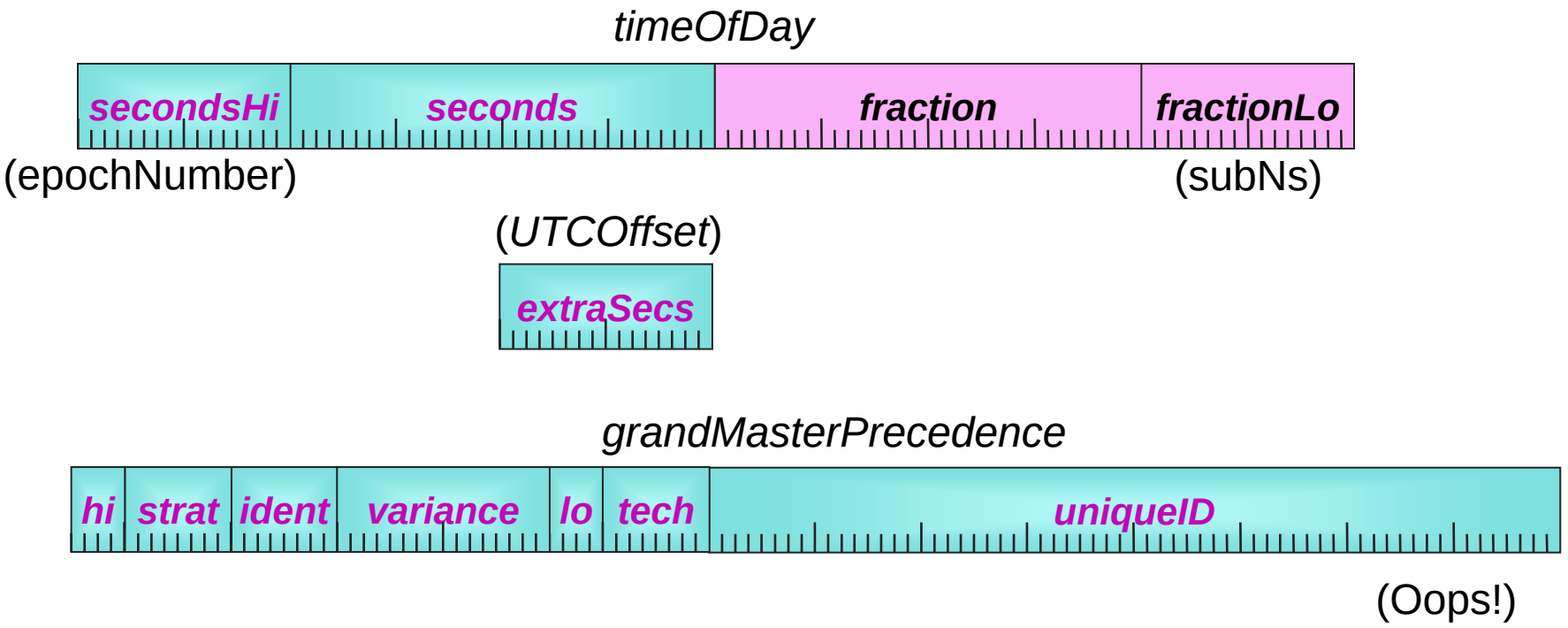
Interworking layer

What are the basic parameters?



Interworking layer

What are the extended parameters?



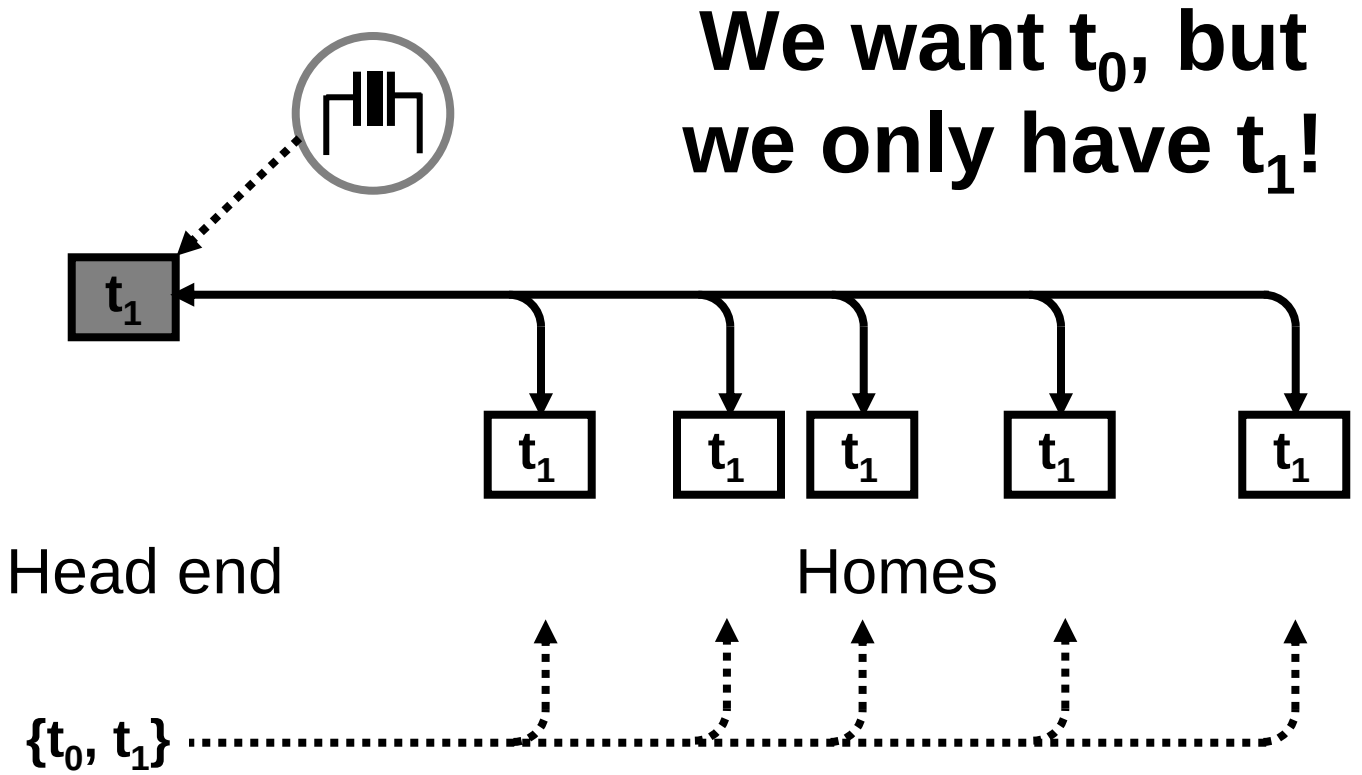
802.1as:

Time-sync on EPON which already does “almost” this

A possibility for illustration purposes…

EPON synchronization

Couple into the existing protocol!



Basic concepts

- The grand master can observe both times
  - Measured at the same time.
  - But, at almost any snap-shot time is acceptable.
- There is no need for distinct 1588 packets!
  - Lower level protocols already provide synchronization, since that facility is needed for other purposes.
  - That mechanism already exists (32-bit, 16ns ticks).
- But, the interworking interface should be defined…

802.1as:

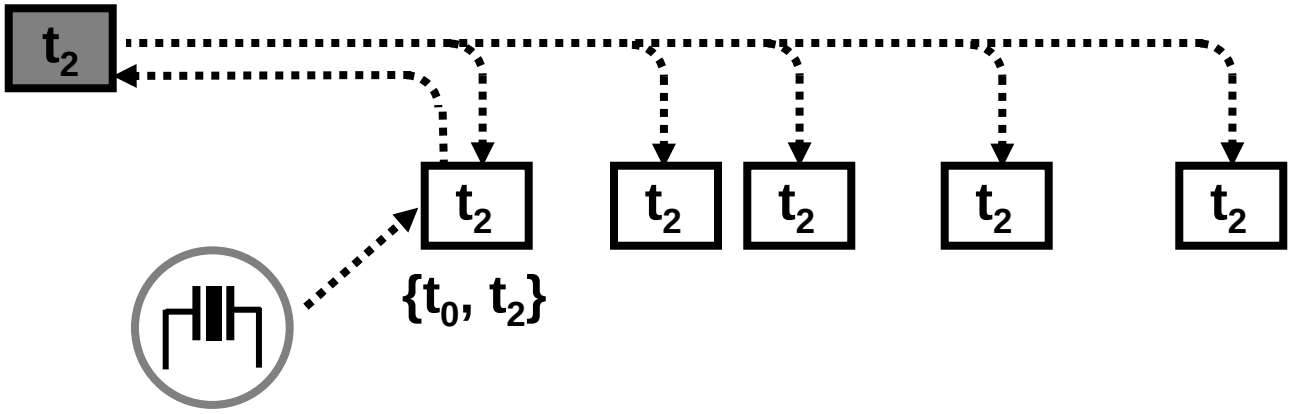
Time-sync on 802.11 which already does “almost” this

The “beacon” provides a time …

802.11 synchronization

Couple into the existing protocol!

We want t_0, but we only have t_2!



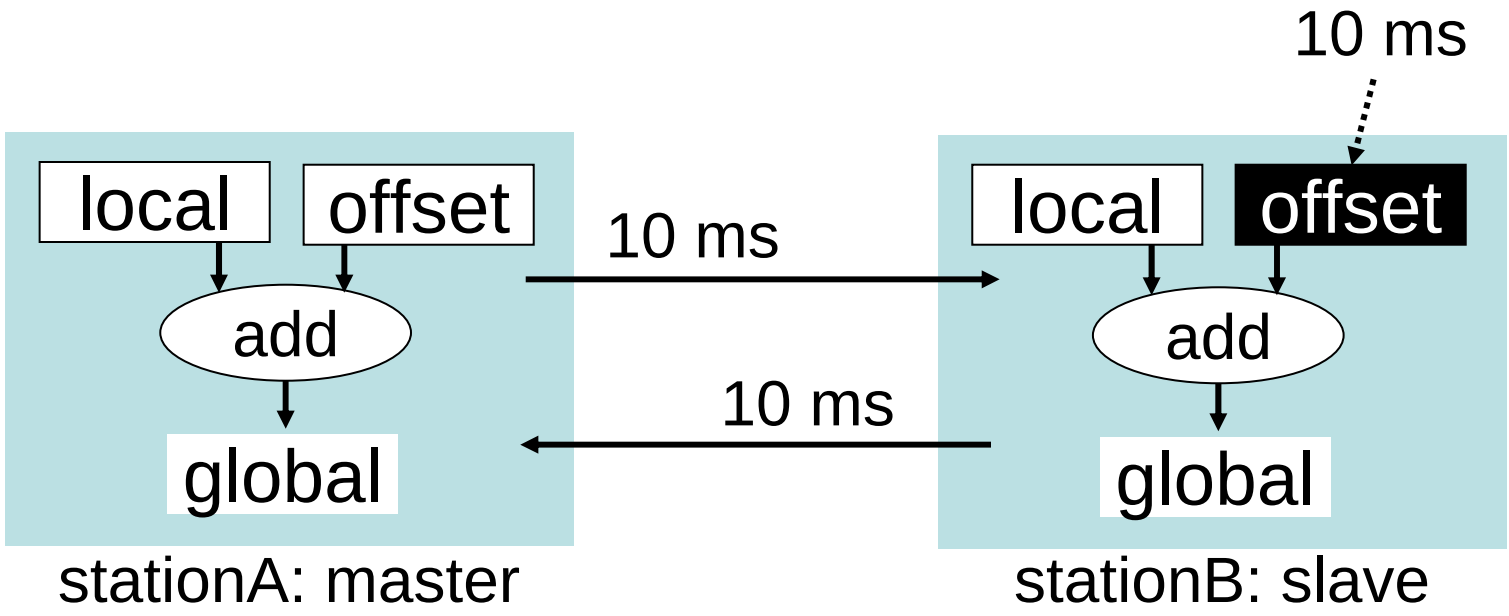
802.1AS:

Time-of-day synchronization point-to-point Ethernet links

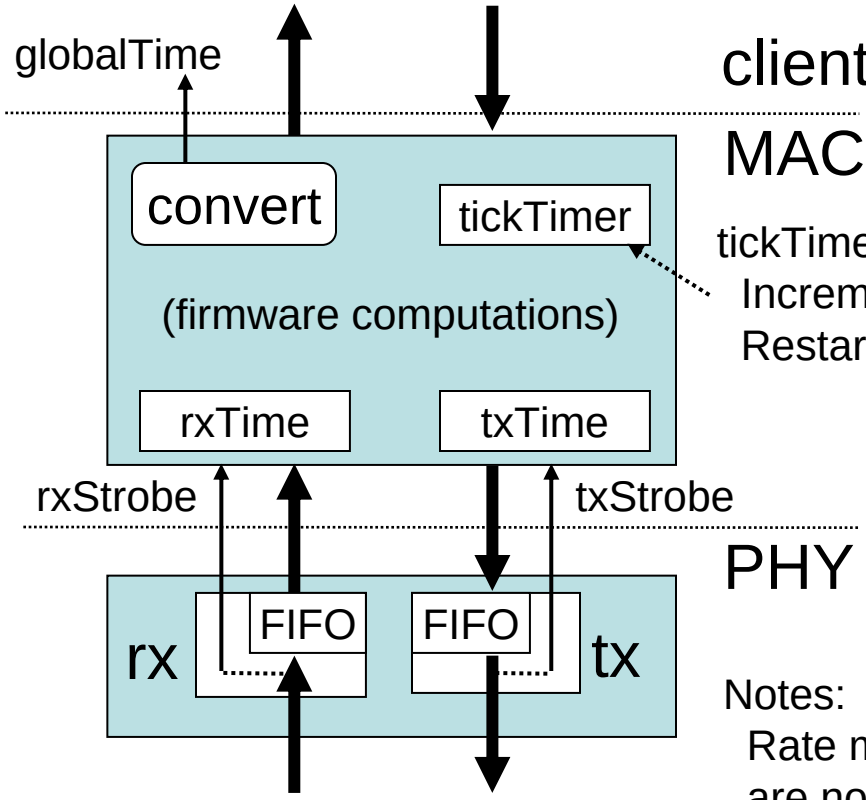
High-level principles…

Adjacent-station synchronization

Offset value adjustments



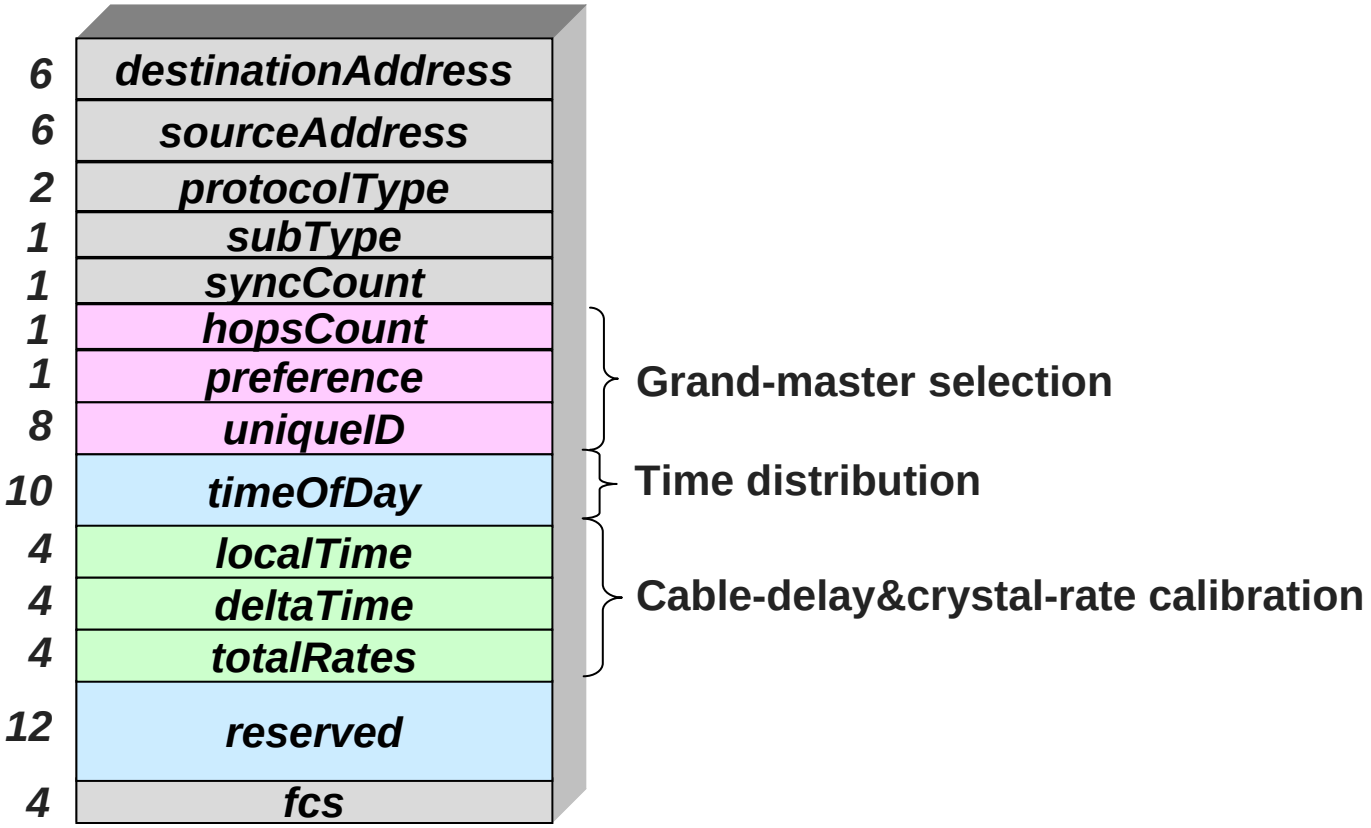
Minimal HW design model



tickTimer properties:
- Increment at <= 10 ns
- Restarts every second

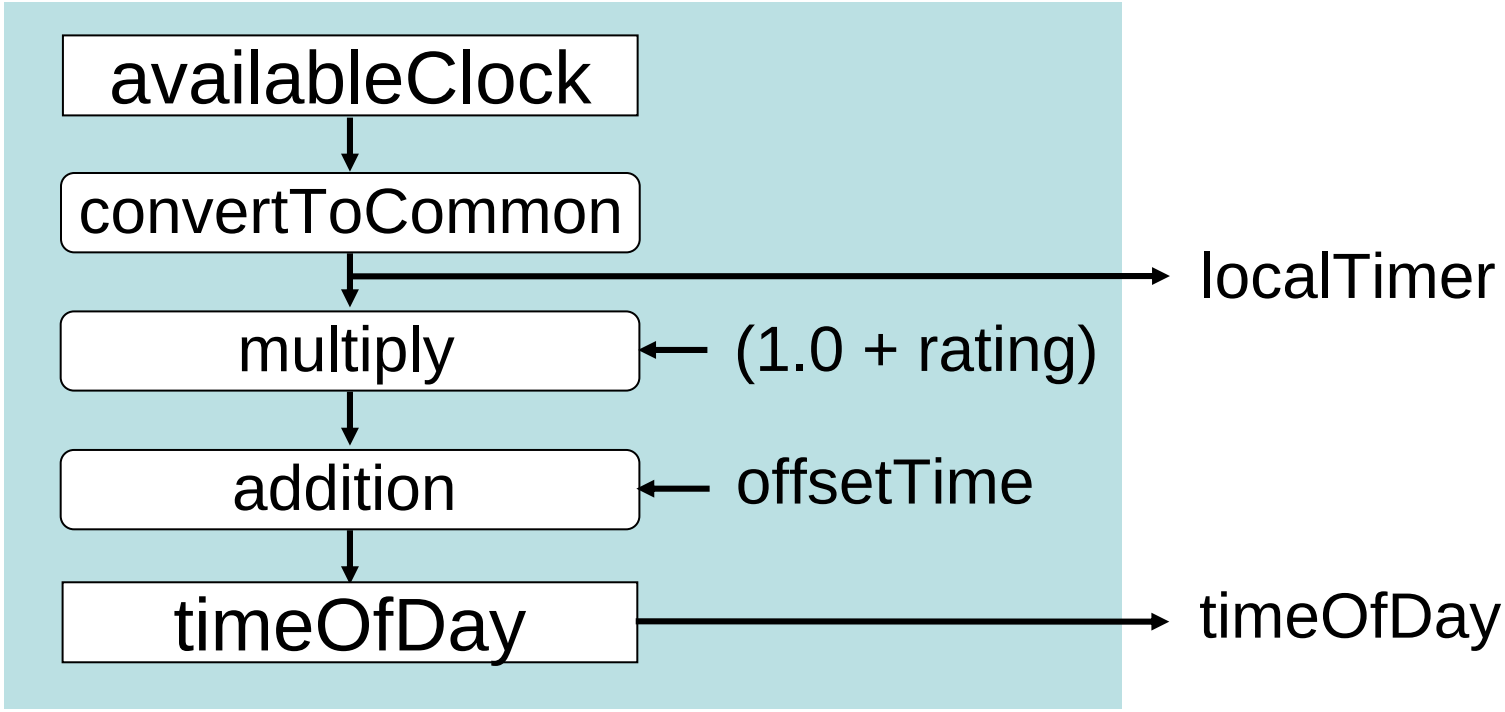
Notes:
- Rate matching FIFOs are not within our scope.

Frame format



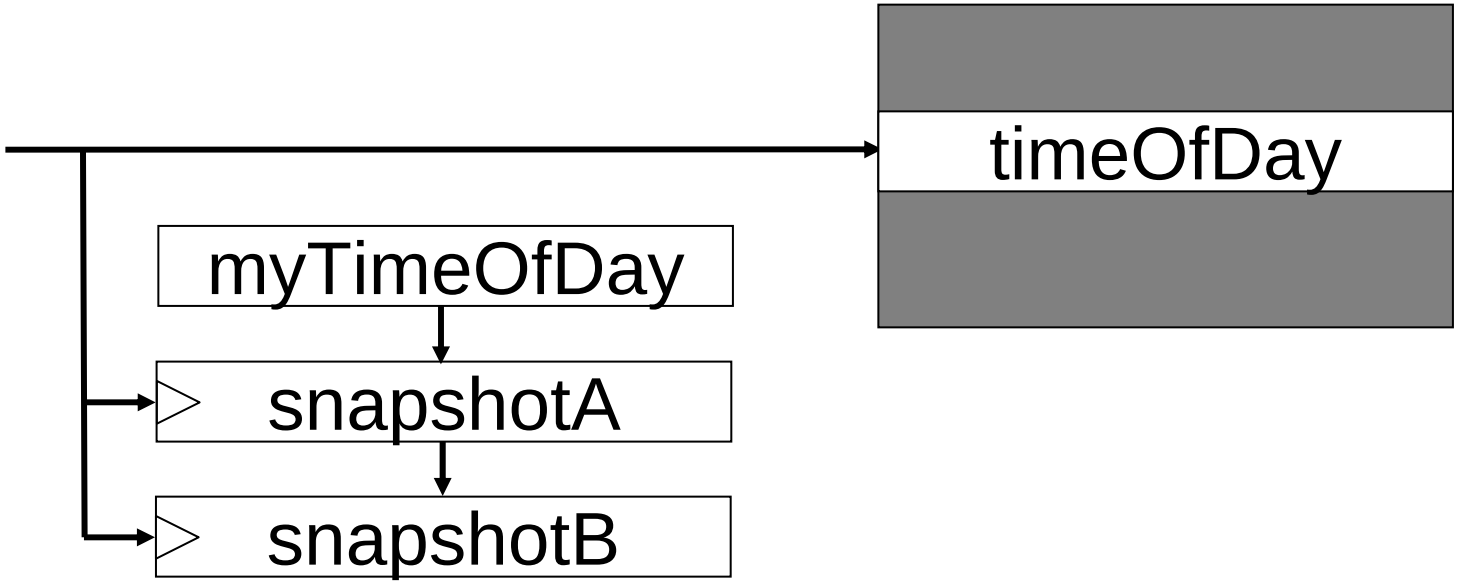
Clock calibration model

Conceptual clock-generation model



Adjusting timeOfDay values

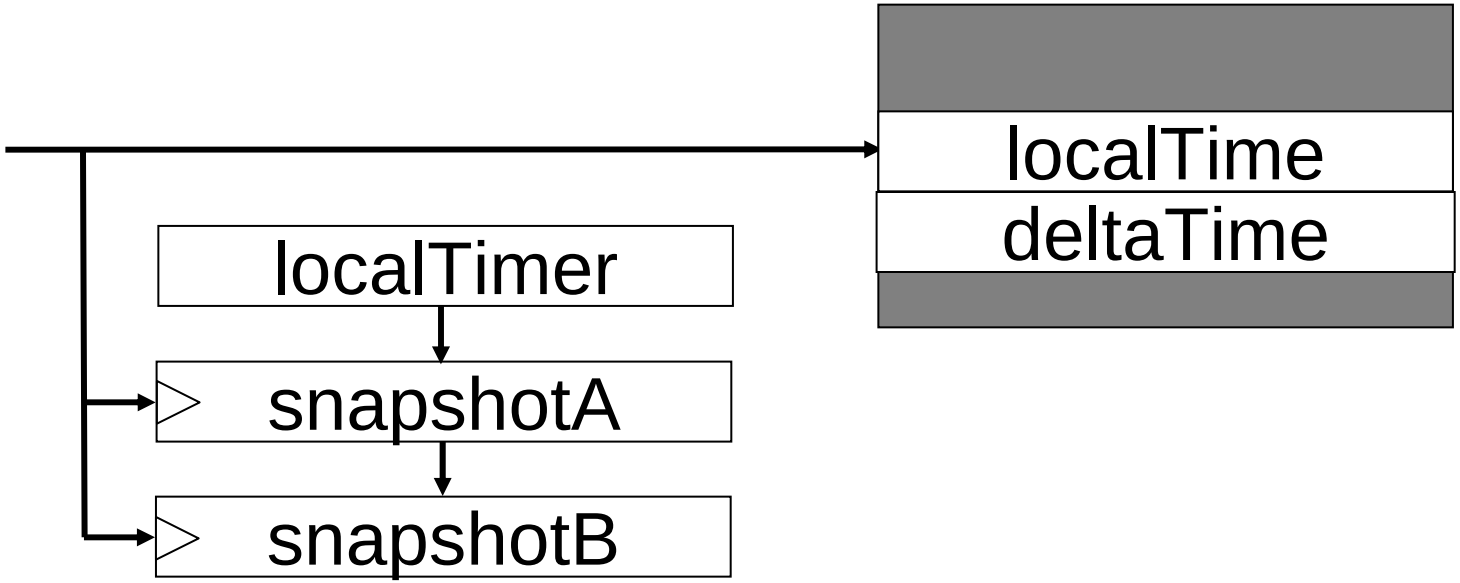
Snapshot value distributions



offsetTime += (timeOfDay – snapshotB) – cableDelay;

Computing cableDelay values

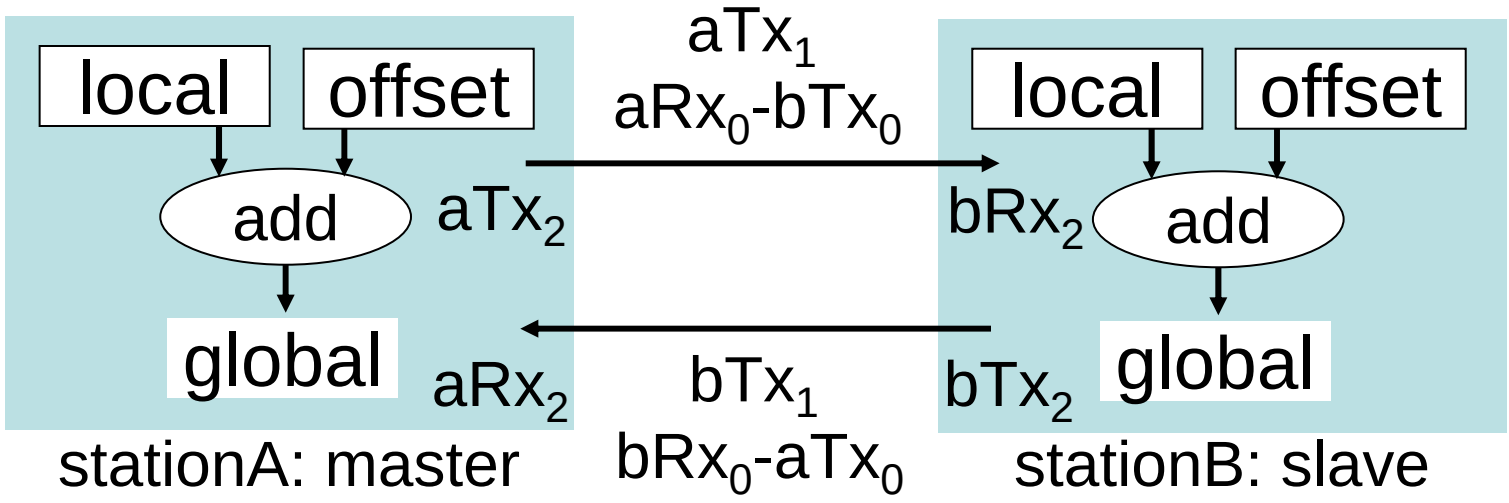
Based on localTimer reference values…



cableDelay = ((snapshotB - localTime) + deltaTime)/2;

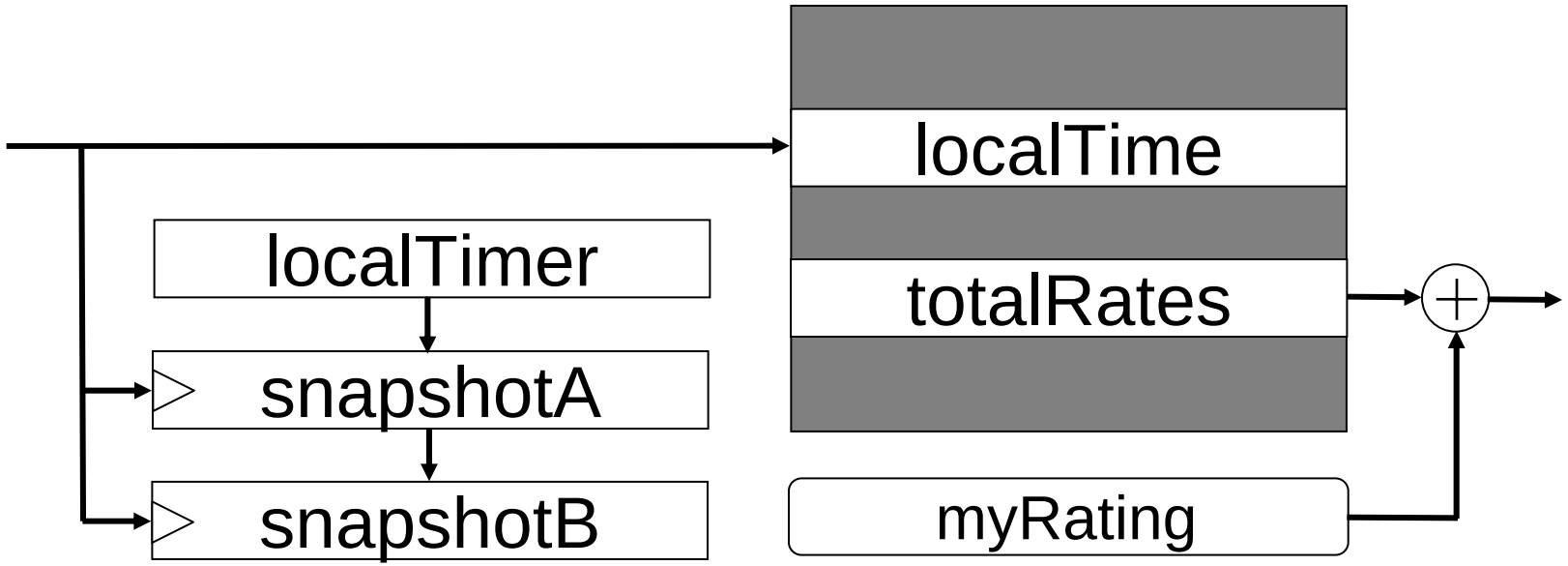
Cable-delay parameters

Snapshot value distributions



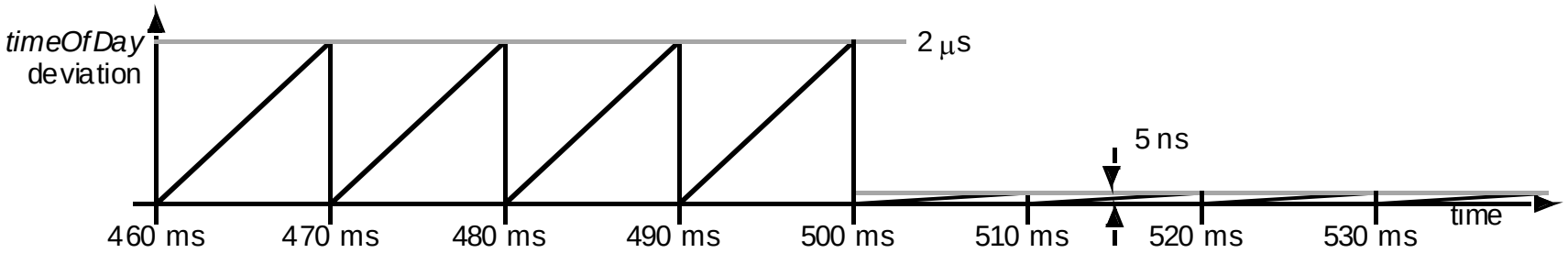
Calibrating rate values (100ms)

Based on localTimer reference values…



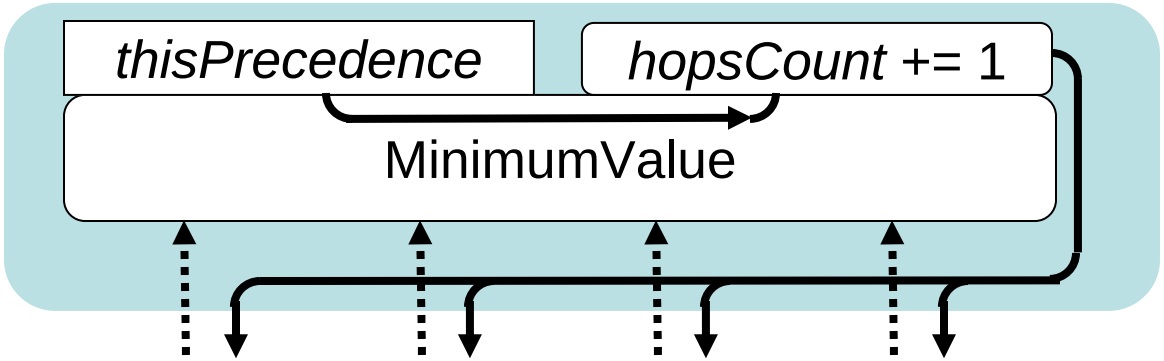
myRating = (localDiff – snapDiff)/snapDiff;
localDiff = localTime[n+10] – localTime[n];
snapDiff = snapshotB[n+10] – snapshotB[n];

Uncompromised precision

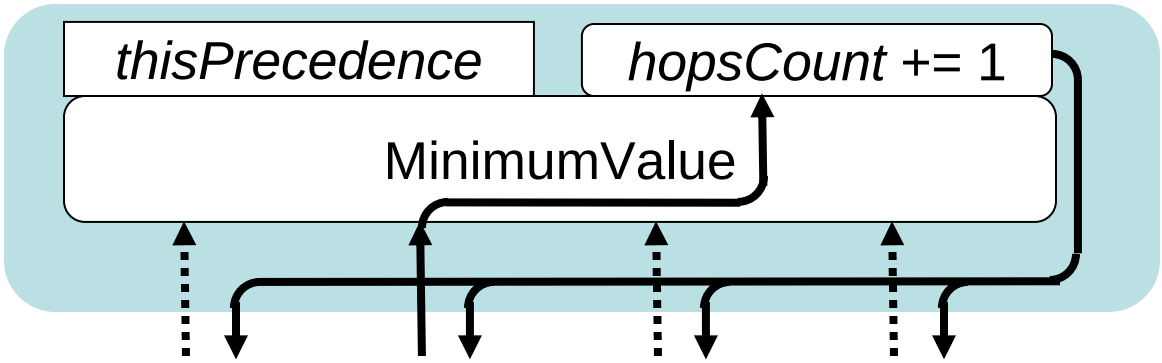


Grand-master selection protocol

Grand-master precedence comparisons



Grand-master



Clock-slave

802.1AS:

Keeping it simple (KISS)—focus on the fundamentals

1588 Instrument legacy is interesting, but…

Minimal packet types

Required 1588 messages:

1) Sync
2) Follow_Up
3) Announce
4) Pdelay_Req
5) Pdelay_Resp
6) Pdelay_Resp_Follow_Up

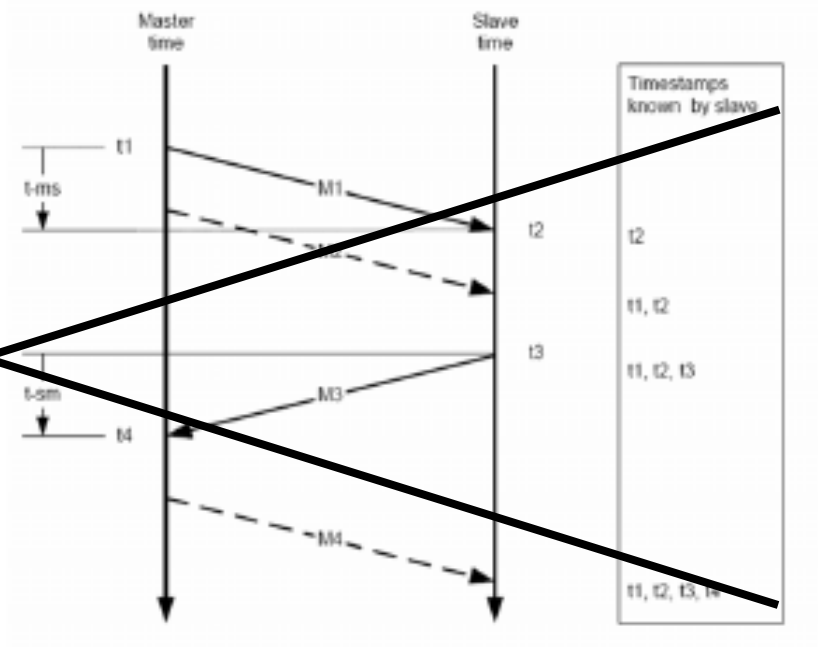
Possibly required 1588 messages:

7) management messages (only those that are needed)
8) signaling messages (only those that are needed)>>

Periodic 10ms transmissions

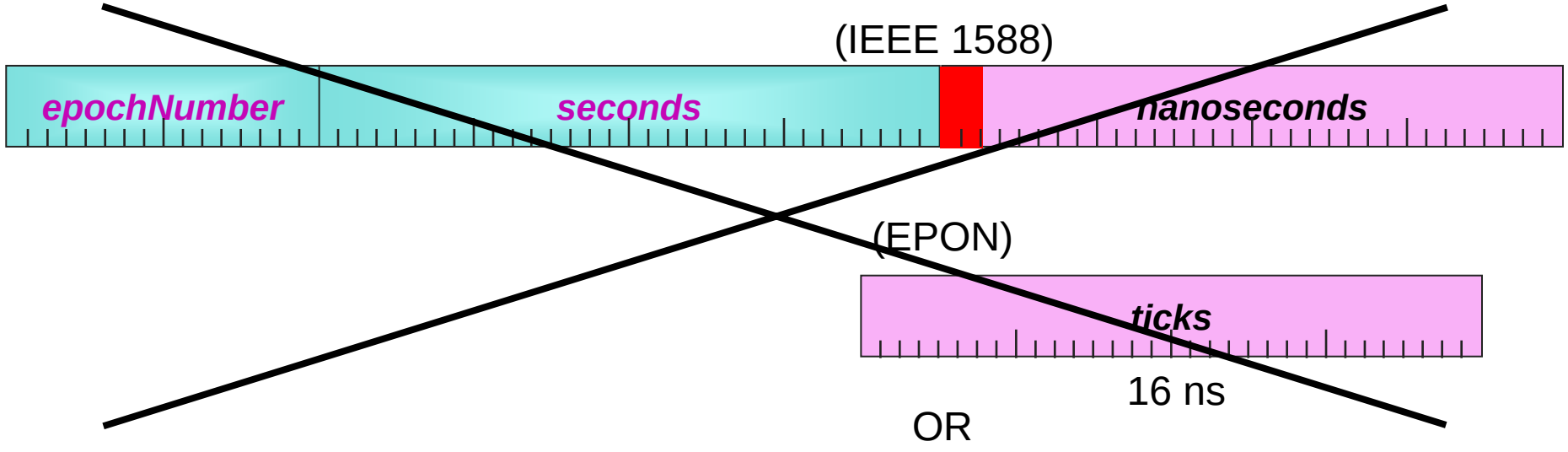
No timing dependencies

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



Send every 10ms

Normal time-of-day “integers”



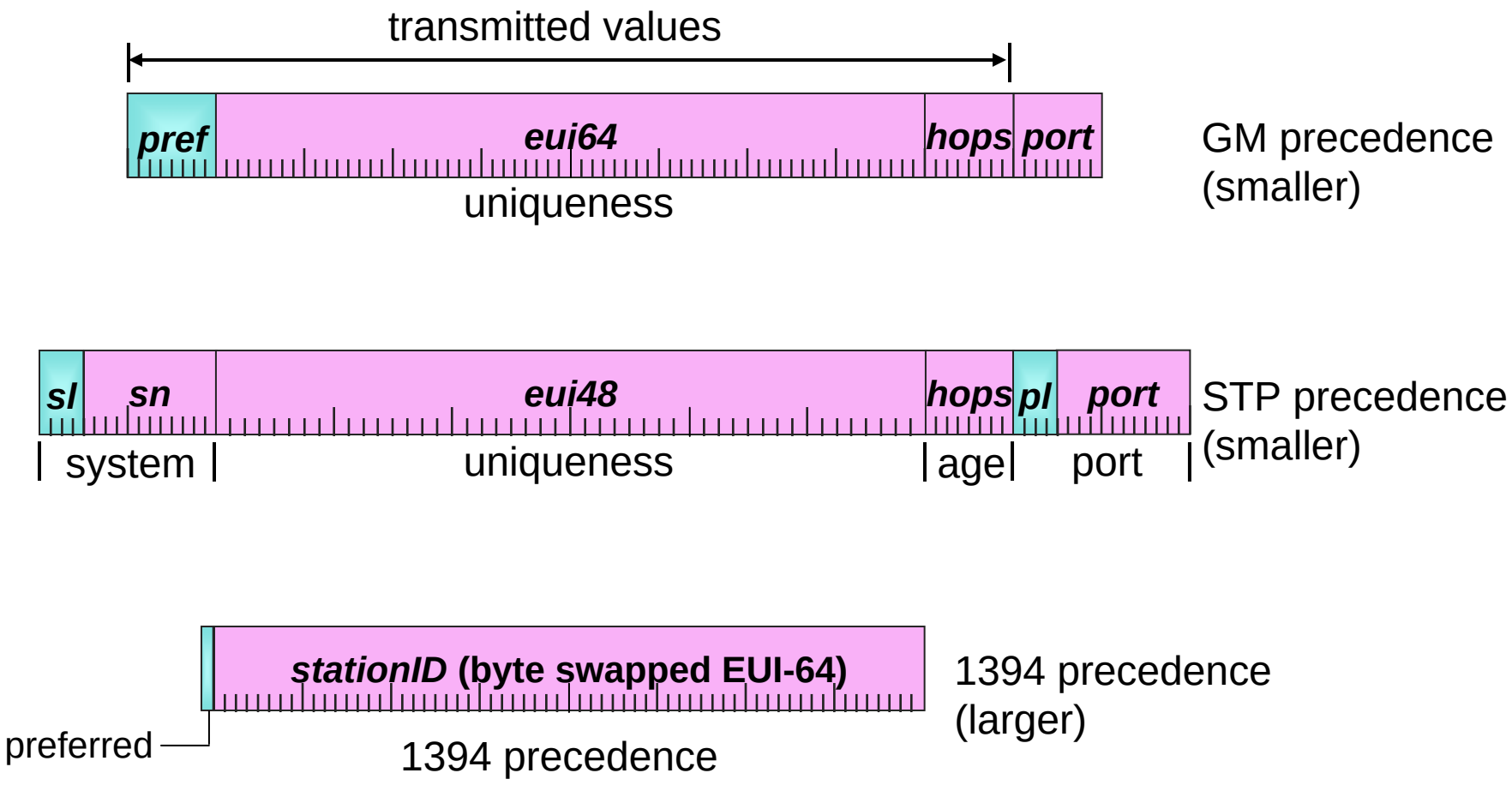
TIME FOR QUESTIONS

TBD

802.1AS:
Time-of-day synchronization (interworking layer?)

Backup slides

Grand-master precedence



Rate adjustments

Compute nearest neighbor errors

- Based on adjacent baseTimer information

- Cumulative values are computed
  - Rate differences are added in a cascaded fashion
- The grand-master “timer” is assumed to be correct
- Rate changes after grand-master changes
  - Saving rate offsets complicates the protocols
  - Could degrade the new-grand-master accuracy

Backup slides for

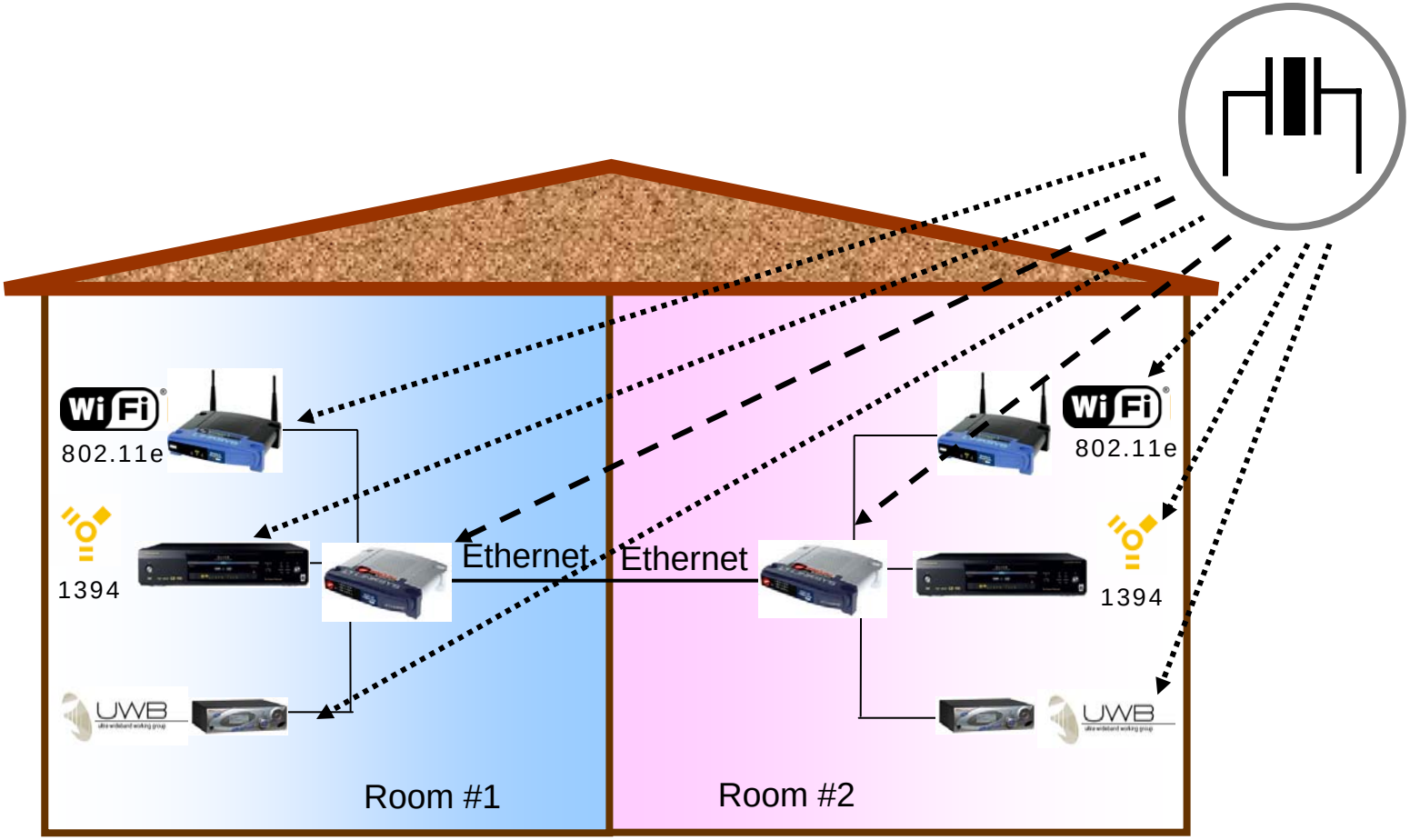
Residential Ethernet:
Time-of-day timer synchronization

Maintained by David V James

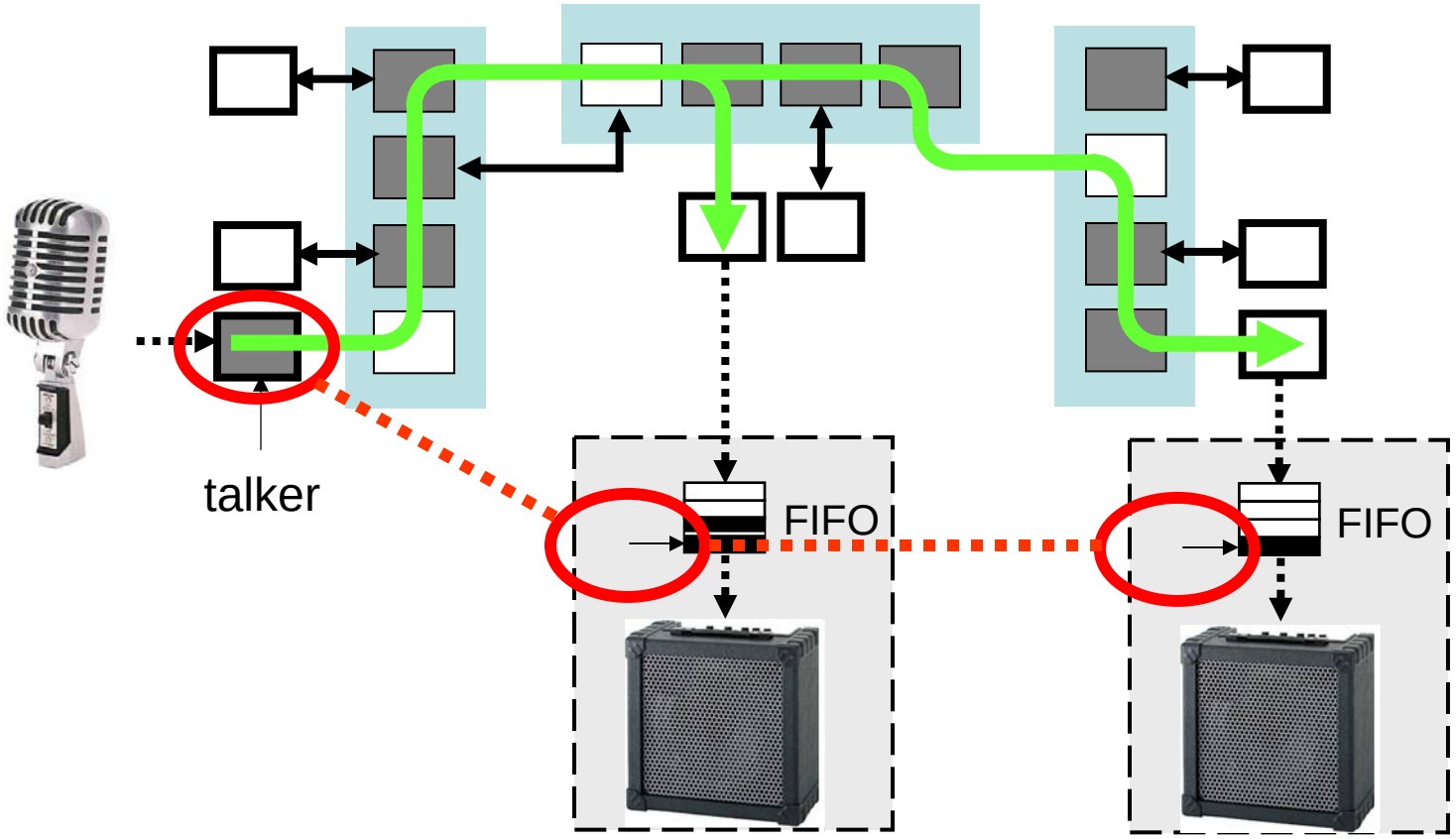
RE-SG basic requirements

- Cheap via simplicity
  - Delayed snapshots
  - Periodic symmetric transmissions
- Cheap and precise
  - Limited to snapshot capture accuracy
  - Minimal grand-master handover transients
- Cheap and robust
  - Single-phase grand-master selection
- Cheap and responsive
  - Short rogue-frame lifetimes

House reference clock

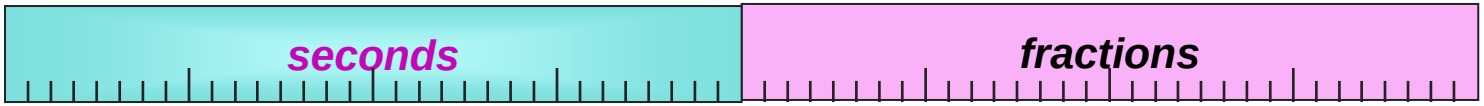


Precise time synchronization



Time-of-day format options

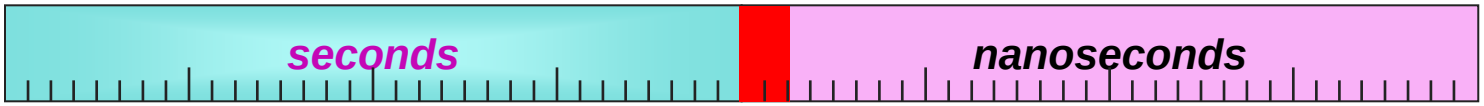
(NTP RFC-1305, SNTP RFC-2030)



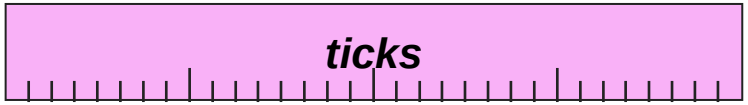
>150 years <250 ps

(IEEE 1588)

(+epoc)



(EPON)



16 ns

OR

(…)

Basic requirements

- KISS (keep it simple, stupid)
  - Delayed snapshot processing
  - Periodic symmetric transmissions
  - Etc., etc.
- NTP (RFC-1305) and SNTP (RFC-2030)
  - Definition of the 64-bit time-of-day value
- For a detailed summary, see:
  - http://dvjames.com/esync
  - dvjTimeSync2005Dec12.pdf (or later revision)

Template picture