Time Calibration in Experiments with Networked Sensors

Olivier Mehani, Ronnie Taib, Benjamin Itzstein

Rebasing time series from networked measurement devices into a single timeline

Physiological experiments framework
- Experiments with physiological sensors
- Sample rates can be high ⇒ large volumes of data
- Sampling rates vary across time scales ⇒ unaligned records
- Sensors connected to different machines ⇒ synchronisation issues
- Little support for cross-sensor synchronisation
- Framework for storing and synchronising physiological data from various equipments
- Store high volumes of data in central location
- Scalable to allow addition of new sensors
- Low cost and easily deployable
  ⇒ The OML measurement framework [2] is a good candidate
- Synchronisation mechanisms
  ⇒ Problem!
- Synchronisation is hard
  - clock discrepancies
  - network latencies
- expensive solutions (e.g., GPS)
- Goal: Find a post hoc algorithm to resynchronise sample timestamps.

Post hoc Timestamp Correction
- Sample reporting event \( t_e \) is timestamped
  - at node \( n \) before transmission, \( c_n(t_e) = t_e + \Delta_n(t_e) \), and
  - at server incl. network delay, \( c_i(t_e') = t_e + \Delta_{n,s}(t_e) + \Delta_i(t_e) + \Delta_{n,i}(t_e) \).
- Use the TTP algorithm [3] to estimate actual time of event \( i \)
- Use round-trip times to server \( d_j \)
  \[
  T_{\text{est}}(i) = c_i(t_e) - \frac{1}{2} t_e c_i(j) + \frac{1}{2} t_e c_i(j) + \frac{1}{2} c_i(t_e) d_j
  \]
- Experimental evaluation

Experiment setup: known artificial clock offset and network delays are introduced, for later correction.
- 2 measurement nodes
- Event: simultaneous keypress via modified hardware
- Introduce artificial clock offset and network delays
  - up to 1 s offset
  - up to 2 s RTT
- both static and variable
- alone or combined
- Measure RTT and report RTT from each node once per second
- Compare timestamp differences for the same event

Results and future work

Pairwise comparisons of timestamps for a given event (static clock offset and network delay).

Summary
- Reduction of the estimated timestamp from the worst vantage point
- Still not as good as the best vantage point (but which one is it?)

Future work
- Improve TPP feed-forward approach further
- Study other synchronisation techniques
- Integrate into OML

References