Wireless acoustic sensor network (WASN)

- Task: Sensor network for cooperative signal processing
- Problem: Diverging clocks cause sampling rate mismatch

Our Approach
- Sensor clock synchronization via time stamp exchange
- Kalman filter for improved state estimation

Hardware platform

- Ethernet jacks for connecting 4 microphone boards
- Microphones per board: 4
- Analog signal transmission
- POE power supply
- ZigBee transceiver (802.15.4)
- Sigma-delta analog-digital converter
- Direct digital synthesis (DDS) circuit
  - Generates sampling frequency (8.192 MHz)
  - Frequency adjustable by ±0.0279 Hz ≈ 0.003 41 ppm
- ARM Cortex-M3 microprocessor unit
  - Estimates frequency deviation and phase offset
  - Implementation of Kalman filter
- Mountable BeagleBoard-xM (ARM Cortex-A8 & DSP)
  - Multichannel buffered serial ports (McBSP) for communication
  - Signal transmission via wired network
  - Implementation of signal processing algorithms
- Synchronization independent of signal processing

Platform components

- Crystal oscillator drives DDS circuit
  - Triggers ADCs
  - Oscillations counted by MPU and used as time stamps
- Precise time stamp generation with low latency and jitter
- M3 MPUs exchange time stamps via ZigBee
- MPUs estimate the frequency deviation and phase offset
- Slave readjusts DDS via serial peripheral interface to match master frequency

Frequency deviation estimation

- Two-way message exchange algorithm (Chaudari 2012) to estimate frequency deviation \( \epsilon(k) \) and phase offset \( \phi(k) \)

Sensor network

- Iteration scheme and information flow
  - System uses gossiping for information exchange
  - Kalman filter for improved estimates
- DDS adjustment requires control mechanism

Experiments

- Long term experiment showing the synchronization of a slave to a master clock

Publications


ITG Conference on Speech Communication 2014, Erlangen, Germany