Intelligent Ultra-Wide Band Network

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Motivation
- Ultra-Wide Band (UWB) is a wireless technology that, despite its long history, can be viewed as new.
- UWB can transmit data over wide frequency spectrum, therefore, unused frequency capacities can be used ideally.
- Given the robustness of UWB, it can be used where different wireless connection technologies overlap.
- UWB is therefore one of the key technologies for particularly demanding application areas such as the Internet of Things (IoT)

Ultra-Wide Band
- Ultra-Wide Band is a fast, stable, short-range and low power radio protocol.
- UWB utilizes a wider frequency range and is defined by bandwidth which exceeds the lesser of 500 MHz or 20% of the arithmetic center frequency.
- FCC Regulations:
  - Power Spectral Density (PSD) is limited to −41.25 dBm/MHz.
- Applications:
  - Industry
  - Sports
  - Smart Homes
  - And many more…

Clock
- Every individual sensor in a network has its own clock can be represented $C(t) = t$, $t$ is ideal or reference time.
- Clock will drift away from the ideal time even if it is initially perfectly tuned.
- $C_i(t) = \Theta + f_i$ ( $\Theta$ clock offset and $f$ is clock skew )

Clock Synchronization
- Clock Synchronization is a procedure for providing a common notion of time across a distributed system.
- Various random delays and limited/non rechargeable power sources make clock synchronization difficult.
- Clock Synchronization is crucial for number of fundamental operations performed by Wireless Sensor Networks like:
  - Data fusion - Process and integrate the collected data.
  - Power Management - Duty cycling helps the nodes to save energy resources
  - Transmission Scheduling - Scheduling requires clock synchronization

MATLAB Simulation
- MATLAB simulation for basic communication in baseband with delay computation
- Below is the block diagram for transmission and reception using root raised cosine filter with fixed delay computation

Simulation Parameters
- Data symbols for different coding sequence (Random, Barker, PN) as input to the transceiver.

Simulation Results
- Mean Absolute Error, Root Mean Squared Error (RMSE) for delay Error plotted for different values of SNR (1000 iterations for each SNR value.
- Below is SNR requirement for different coding scheme to maintain accuracy of 1ms.
  - Barker = −8 dB
  - PN = −8.9 dB
  - Random seq([1 1 -1 -1]) = −5.4 dB
- Thus from above plot PN sequence stands out most resilient (out of three) for our accuracy level (1ms)

Conclusion and Future Work
- Delay computation is adversely impacted with deteriorating values of SNR. So, depending on channel, SNR should be maintained at higher values.
- Choosing the right coding scheme also plays important role in delay computations.
- We can use cross-correlation between transmitted and received signal to compute delay for a short training sample and correct the actual data with computed delay.

Future Work:
- Run simulation to compute/estimate random delays for AWGN channel and UWB frequency range.
- Simulate clock synchronization scheme for a small UWB wireless sensor network.

References