Intelligent Ultra-Wide Band Network

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WINLAB | Wireless Information Network Laboratory

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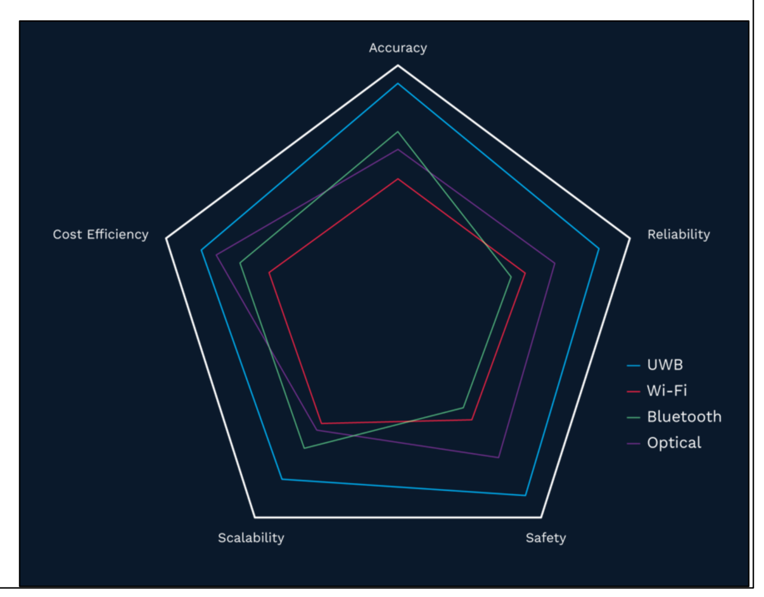
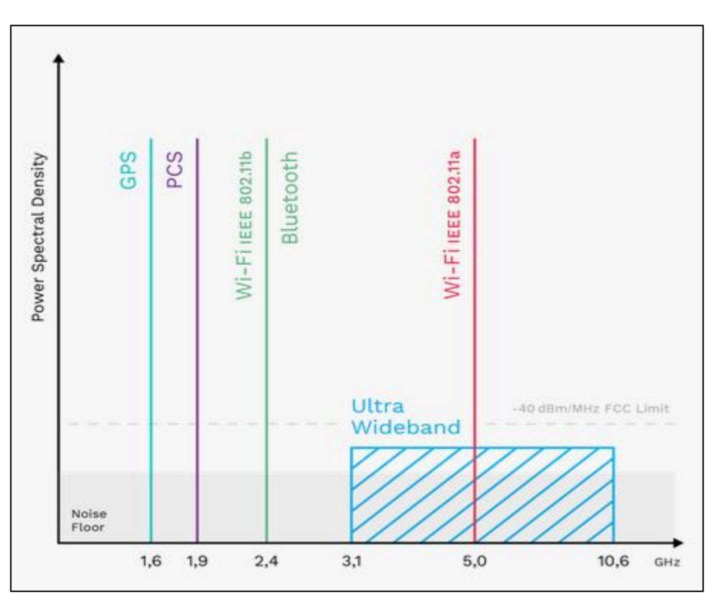
Motivation

- 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)



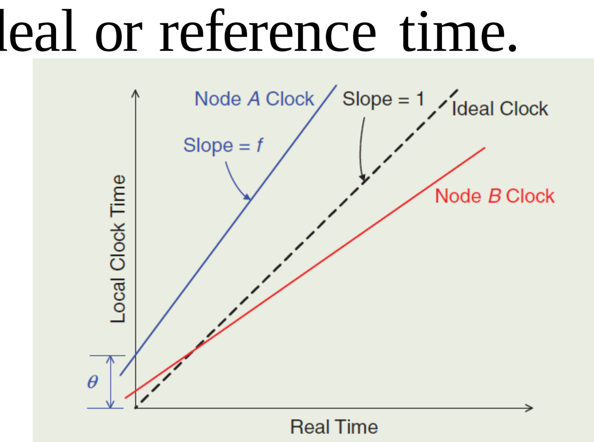
Ultra-Wide Band

- 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.
- $C_i(t) = \Theta + f.t$ (Θ clock offset and f is clock skew)

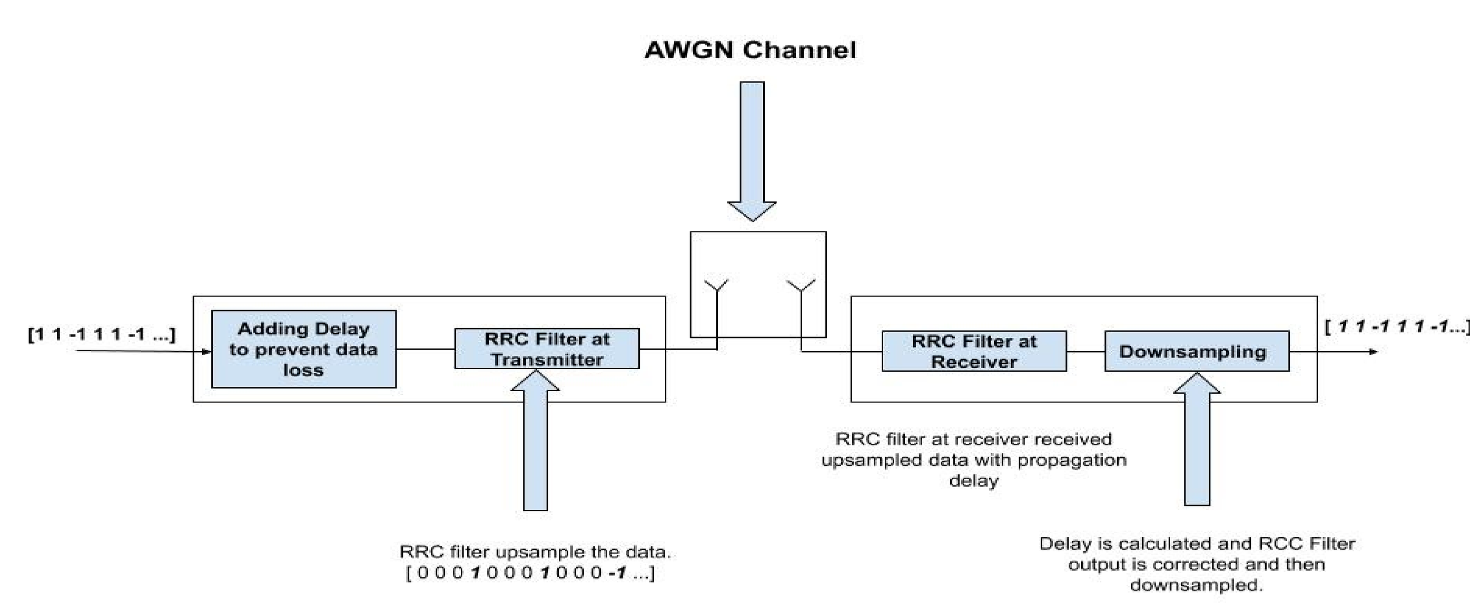


Clock Synchronization

- 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

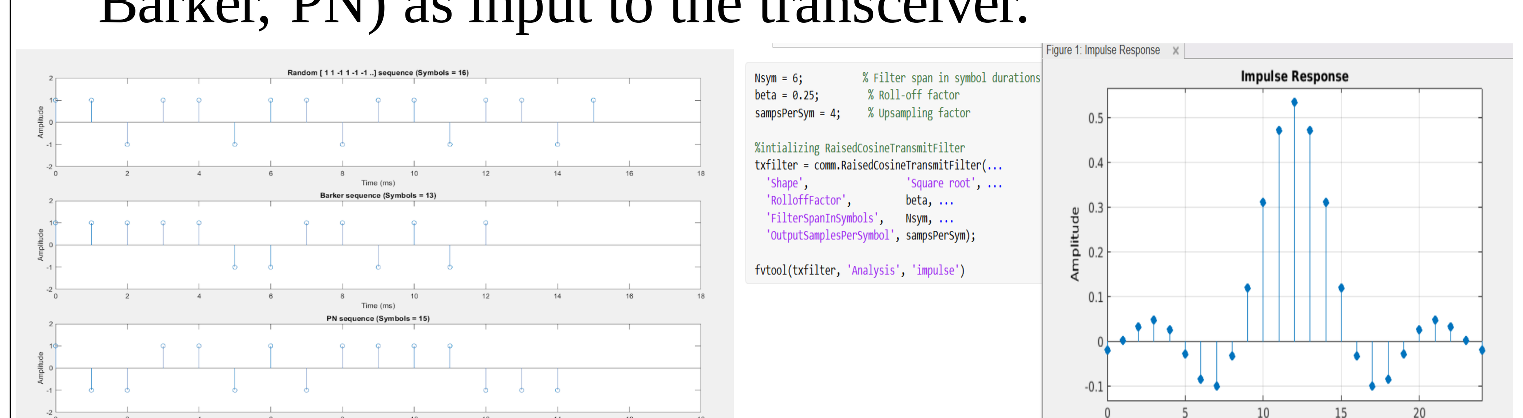
MATLAB Simulation

- 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



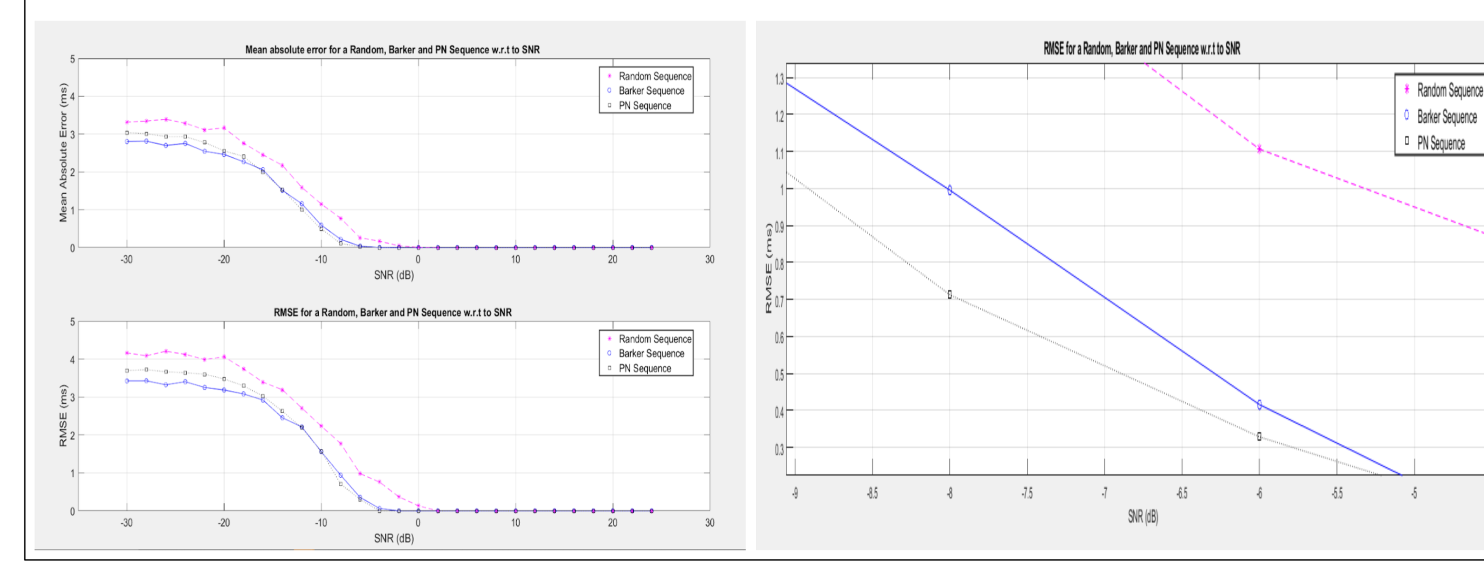
Simulation Parameters

- 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

[1] Y. Wu, Q. Chaudhari and E. Serpedin, "Clock Synchronization of Wireless Sensor Networks," in IEEE Signal Processing Magazine, vol. 28, no. 1, pp. 124-138, Jan. 2011

[2] S. P. Chepuri, R. T. Rajan, G. Leus and A. van der Veen, "Joint Clock Synchronization and Ranging: Asymmetrical Time-Stamping and Passive Listening," in IEEE Signal Processing Letters, vol. 20, no. 1, pp. 51-54, Jan. 2013

[3] B. M. Sadler and R. J. Kozick, "A Survey of Time Delay Estimation Performance Bounds," Fourth IEEE Workshop on Sensor Array and Multichannel Processing, 2006., Waltham, MA, 2006, pp. 282-288

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