Intelligent Ultra-Wide Band Network

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Problem Statement

- To study the basics of Ultra-Wide Band (UWB) wireless communication.
- Simulate clock synchronization in UWB wireless sensor network.
Ultra-Wide Band (UWB)

- Fast and stable transmission of data, indoors and outdoors.
- Not tied to any frequency.
- Signal bandwidth ($B_f$) exceeds the lesser of 500 MHz or 20% of the arithmetic center frequency (FCC Regulation).
  - Power Spectral Density (PSD) is limited to $-41.25$ dBm/MHz.
  - $B_f = 2 \cdot \frac{(f_H - f_L)}{(f_H + f_L)}$

- Applications in Industry, Sports, Smart, Homes and many more.
Clock and Clock Synchronization

- 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 $C_i(t) = \Theta + f.t$ ( $\Theta$ clock offset and $f$ is clock skew ).
- Clock Synchronization is procedure for providing a common notion of time across a distributed system. It is crucial for number of fundamental operations performed by WSN.
Berkeley’s Algorithm for Clock Synchronization
Simulation Output for Berkeley’s Algorithm

Output at Master Node

Client Data received at master with addr: 127.0.0.1:51637
Client Data received at master with addr: 127.0.0.1:51439
Client Data received at master with addr: 127.0.0.1:51539
Synchronization cycle initiated...
Clients being synchronized: 3

Output at Slave node

Starting communication with server
Time at the client is: 2020-07-01 20:59:27.151405
Current time sent to master node Starting to receive synchronized time from server

Synchronized time for client received from master: 2020-07-01 20:59:30.534092
Time at the client is: 2020-07-01 20:59:32.158472
Current time sent to master node
Synchronized time for client received from master: 2020-07-01 20:59:35.550552
Matlab Simulation for basic communication in baseband with delay computation

Block Diagram Transmission and Reception Using Root Raised Cosine Filter with Fixed Delay Computation
Data symbols for different coding sequence. 6 trailing zeros will be added to flush complete data from RRC filters (both at receiver end and transmitter end) and prevent data loss.

- A Barker code or Barker sequence is a finite sequence of $N$ values of $+1$ and $-1$.

- They have low autocorrelation properties and are less likely to interfere with other sequence.

- PN codes are deterministic codes that mimic randomness properties.

- If the current state and the generating function of the PN code are known, the future state of the code can be predicted.
Impact of SNR on cross correlation and thus on delay computation
Mean Absolute Error and 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 from above plots

- Delay computation is adversely impacted with deteriorating values of SNR. So depending on channel, SNR should be maintained higher values.

- Choosing right coding scheme also plays important role in delay computation.

- 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.
References

Thank You!!
Questions?