Intelligent Ultra-Wide Band Network

Team Members - Sanyam Jain and Amod Deo

Mentor - Kareem Bonna
Advisor - Dr. Predrag Spasojevic

Our Team

Sanyam Jain
jain.sanyam@rutgers.edu
ECE Master’s Student

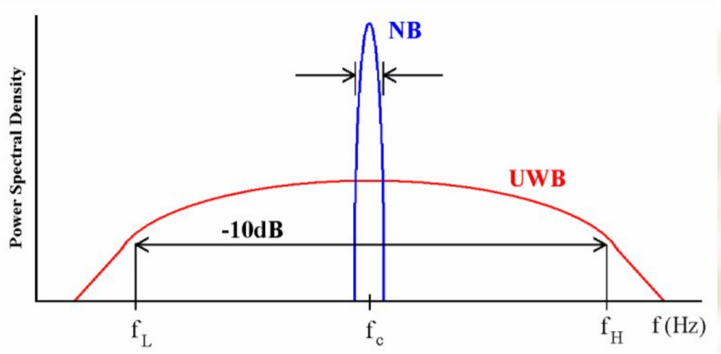
Amod Deo
amod.deo@rutgers.edu
ECE Master’s Student

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.**
  - $B_f = 2 \left((f_H - f_L)/(f_H + f_L) \right)$



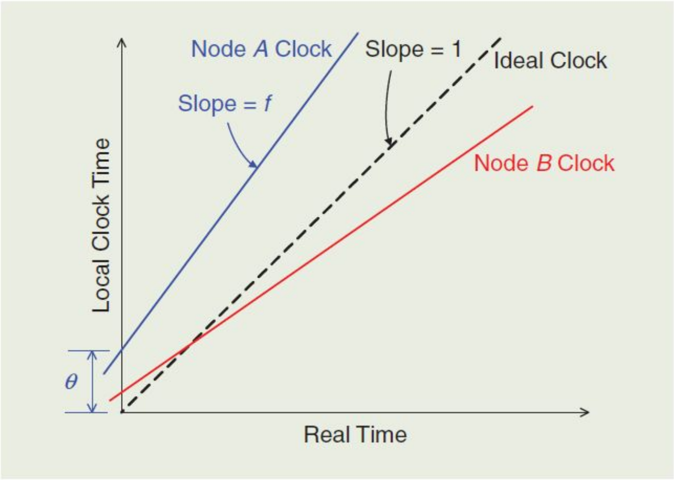
- Applications in Industry, Sports, Smart, Homes and many more.

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.

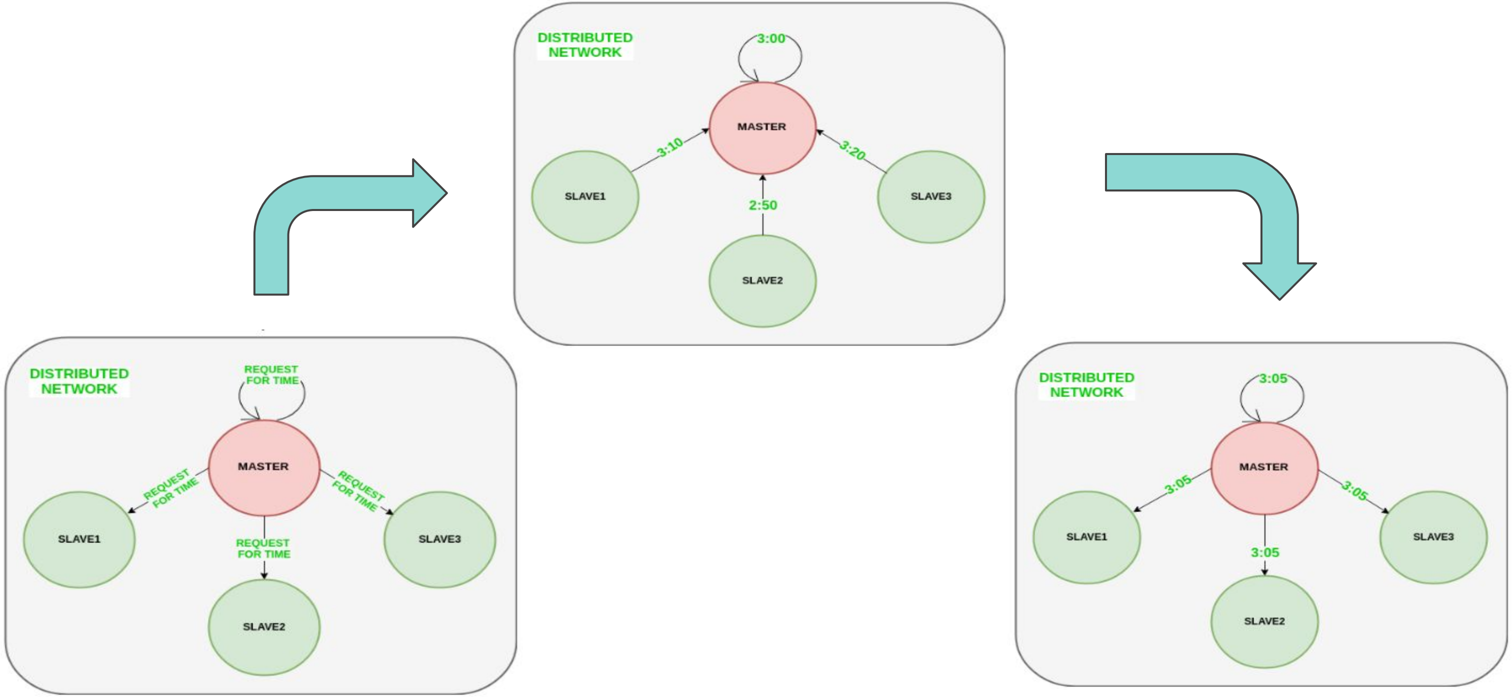
- Clock will drift away from the ideal time $C_i(t) = \Theta + f.t$ (Θ clock offset and f is clock skew).

- **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.



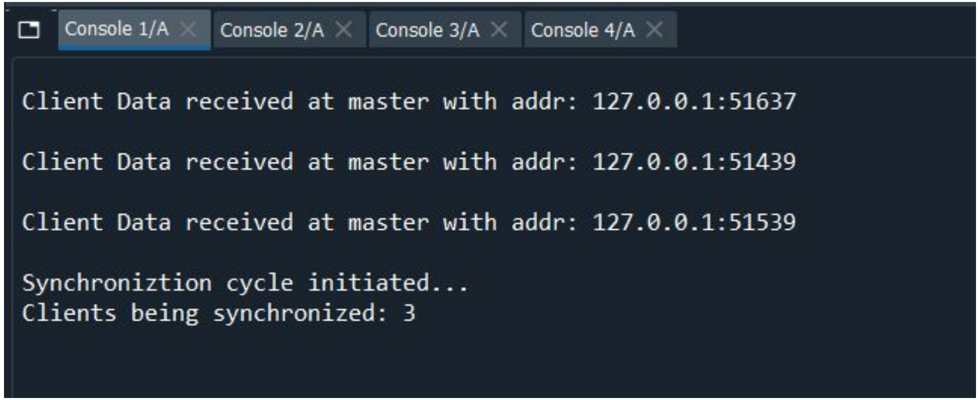
Clock Model of Sensor Nodes

Berkeley's Algorithm for Clock Synchronization

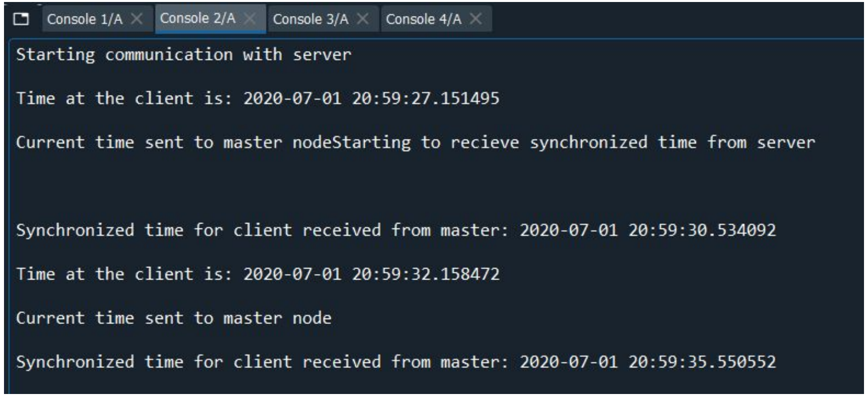


Simulation Output for Berkeley's Algorithm

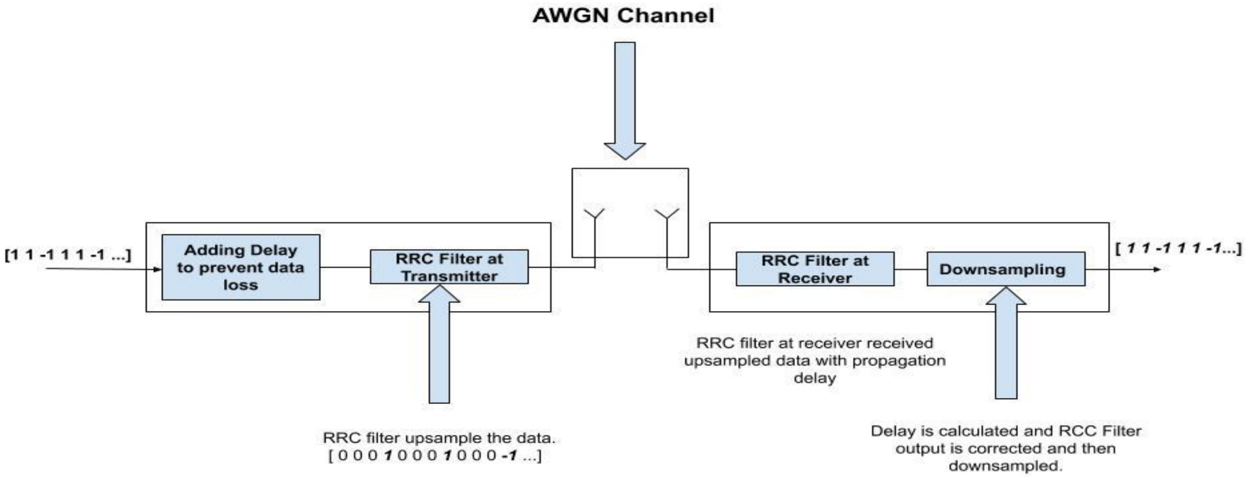
Output at Master Node



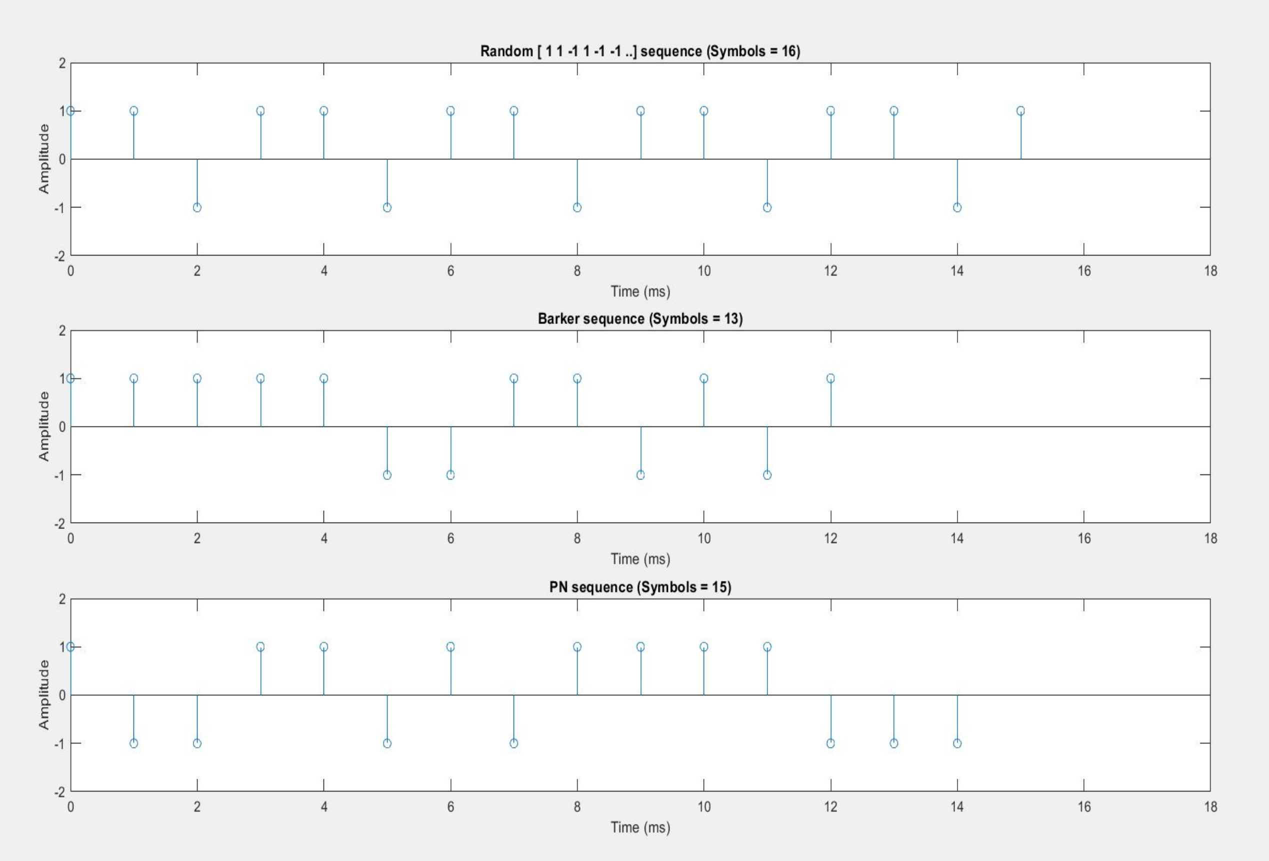
Output at Slave node



Matlab Simulation for basic communication in baseband with delay computation



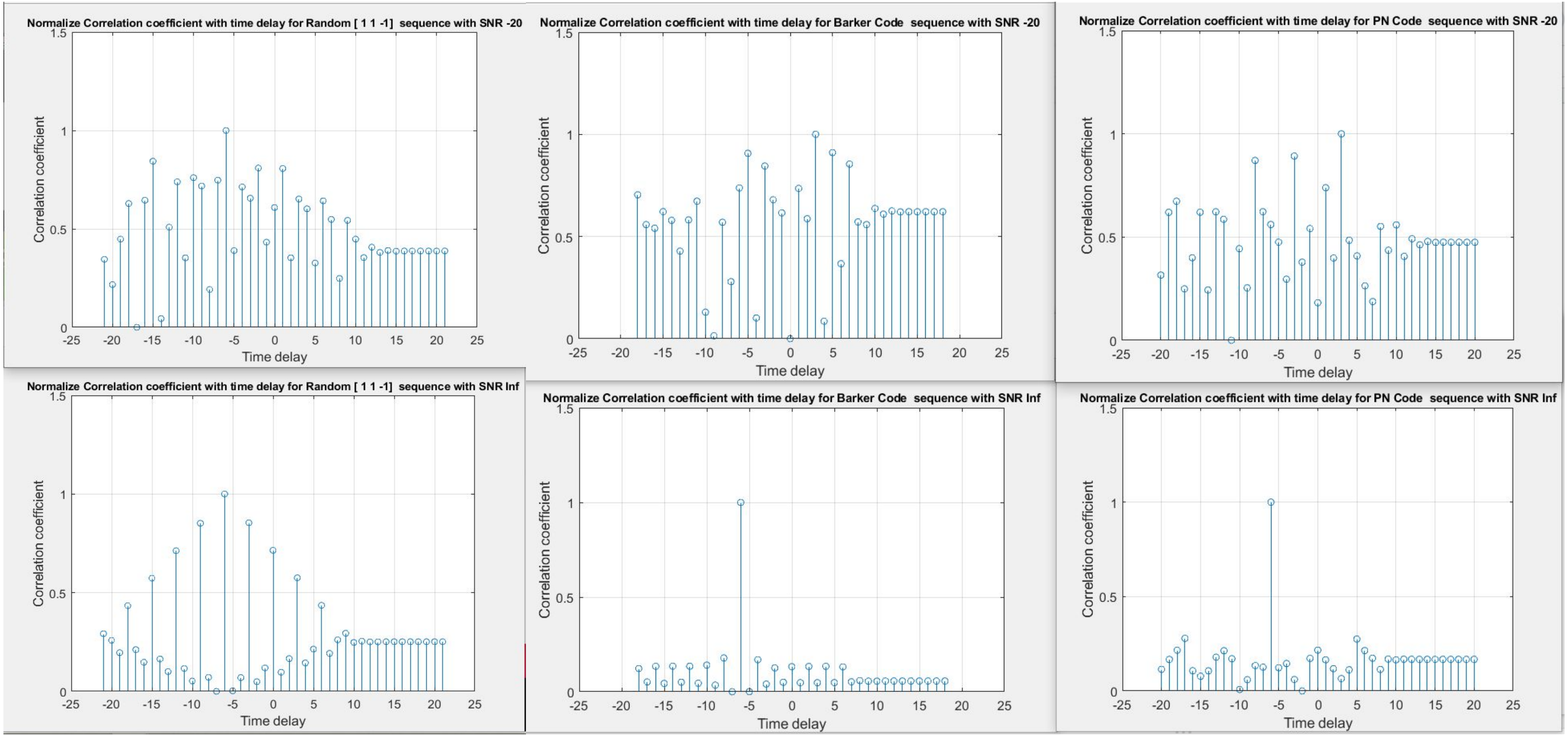
Block Diagram Transmission and Reception Using Root Raised Cosine Filter with Fixed Delay Computation



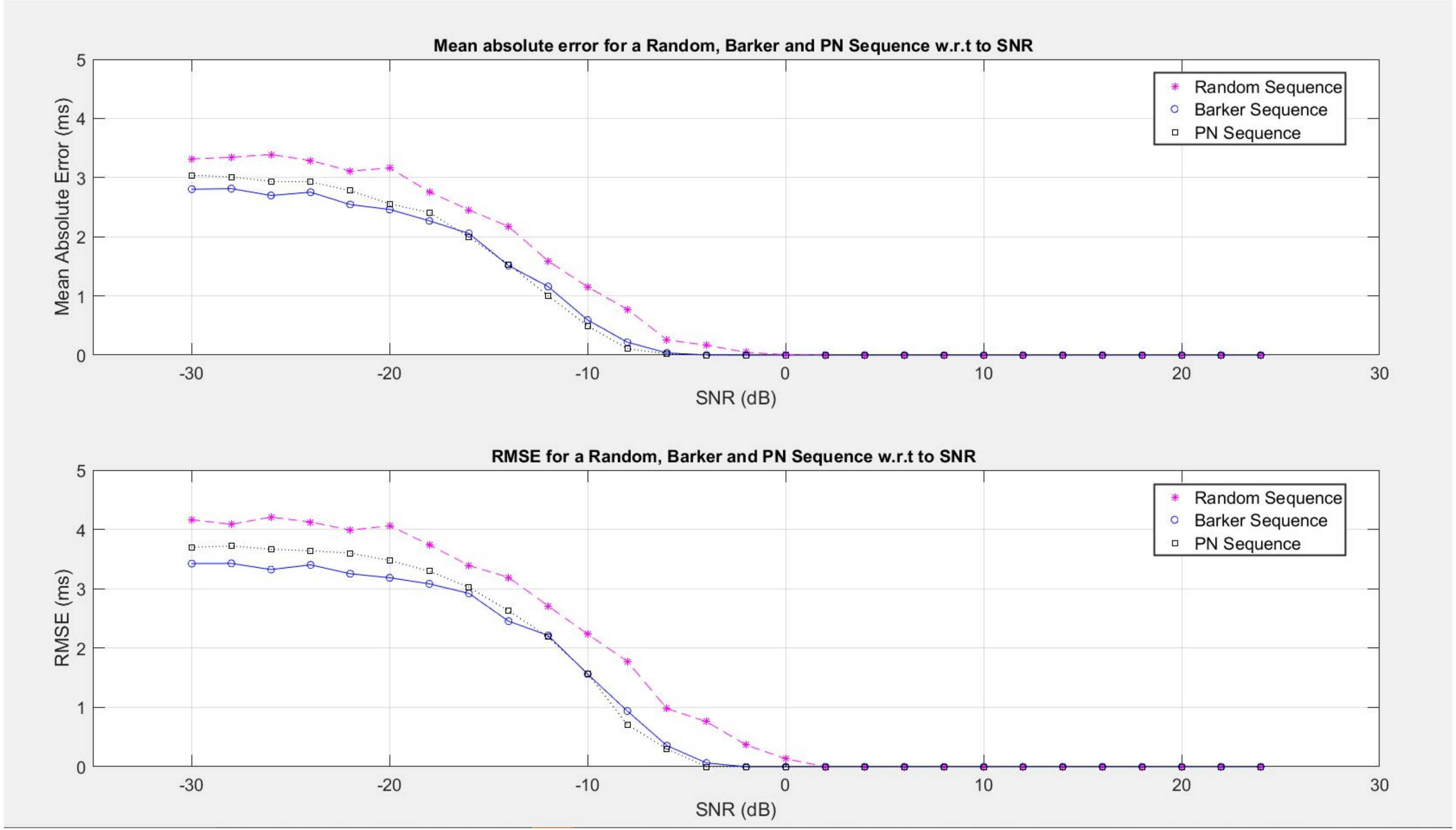
- A **Barker code** or **Barker sequence** is a finite sequence of *N* values of +1 and −1.
- They have low autocorrelation properties and are less likely to interfere with other sequence.
- **PN codes** are deterministic codes that mimic randomness properties.
- if the current state and the generating function of the PN code are known, the future state of the code can be predicted.

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

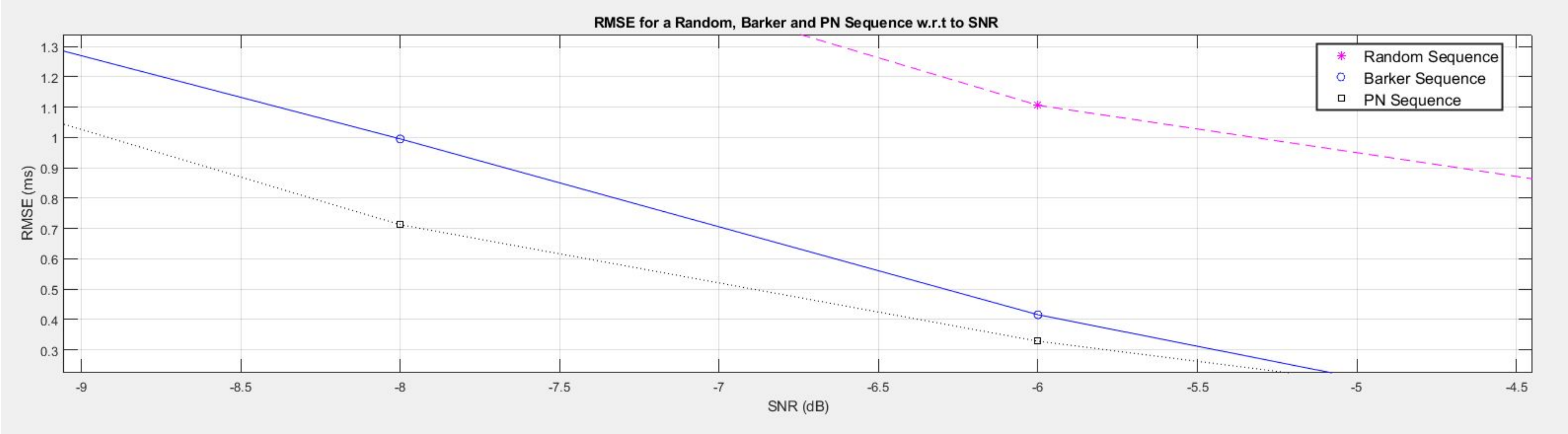
Random Sequence [1 1 -1 . . .]   Barker Sequence   PN Sequence



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

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3. 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, doi: 10.1109/LSP.2012.2222371.
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5. https://www.mathworks.com/help/comm/

Thank You!!

Questions?