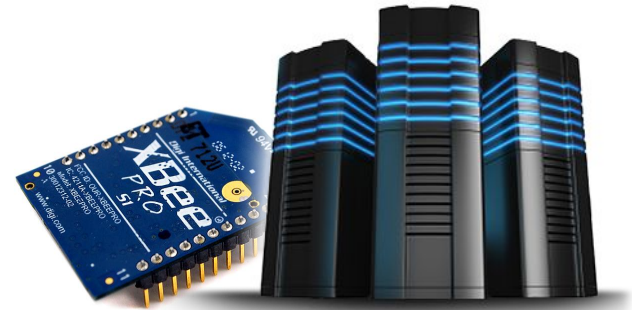


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# Networking & Server

*Final Presentation*

Raydan Bala  
Raegan Diana  
Ernesto Lorenzo



# Project Background & Motivation

## Project Background:

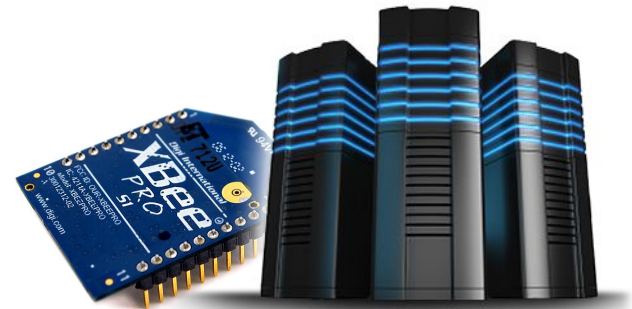
**Networking:** Physical and virtual network testing and simulation

**Server:** Data translator and aggregator

Sending and Receiving data between the weatherboxes and server

## Motivation:

- To learn more about servers and gain more experience software development as well as some experience with servers
- Gain experience in various hardware tools



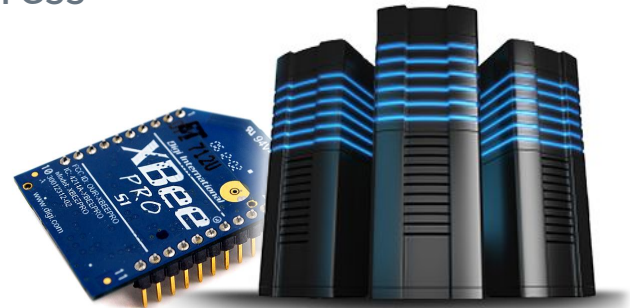
# Goals

## Server:

- Create a data translator
- Comment code so it is easier for others to update

## Networking:

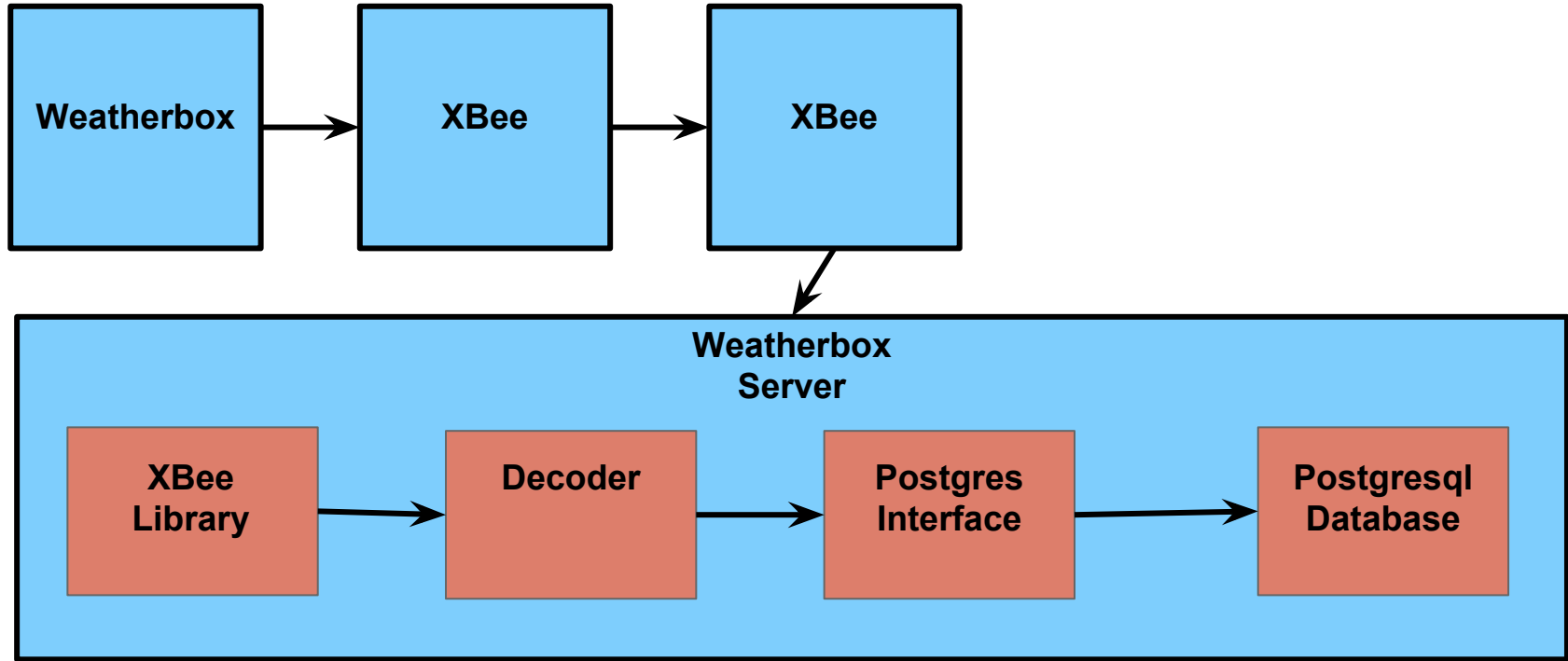
- Document functionality of various XBees
- Create a way to reduce debugging progress



# Block Diagram



# Block Diagram



Server

# Overall Design

## Networking:

- Computers = best way to test functionality
- Compare XBee modules

## Server:

- Python 'struct' library is best way to pack/unpack data
- Packing format generated based on simple input file

# Data Translator Testing Method

## Packing Capability:

- Is the code capable of packing according to a specified format
- Does the code pack test data properly

## Packing Methods Tested:

- “Manual Packing”
- Bitarray Packing
- Struct Packing

# Testing Packing Methods

## “Manual” Packing:

- Completely Hardcoded
  - Created an array out of passed data
  - Converted each array entry into hex from binary and stored into a new array
    - Issue: Doesn't actually pack data, just converts it

## Bitarray:

- Packs data
  - Issue: Data must be depicted as boolean values, and format cannot be specified



# Current Data Translator Code

## Struct:

- Packs data
- Can easily pack/unpack data according to a specified format

## Packing Format:

- Packing format is no longer hard coded into functions
  - Both functions now read from a text file and generate packing/unpacking format based on file

# Results of Current Code

## Given Input:

- Given data to pack: data = (5, 151, 8, 300, 2, 25, 10, 45, 49, 10, 55)
- Input test file based on schema3:
  - uint16, uint16, uint8, uint32, uint8, uint16, uint16, uint32, int16, uint16, uint16

## Output:

- Generated packing format: struct\_fmt = H+H+B+I+B+H+H+I+h+H+H
  - Same as hard coded packing format also based on schema3
- Packed Data: Printing packed data

# XBee Test Methods

## Line of Sight Range:

- RSSI values measured at 25 yard increments



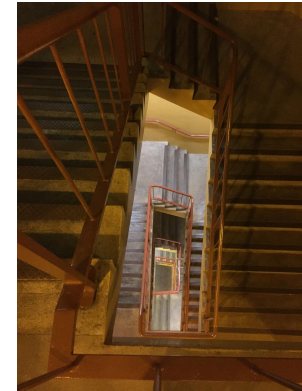
## Through Wall:

- RSSI measured between concrete walls



## Holmes:

- RSSI measured through each floor of Holmes



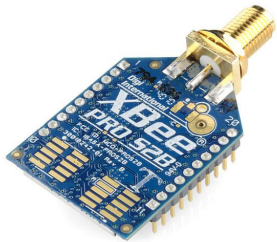
## **RSSI: Received Signal Strength Indicator**

- Measure of the power level that a RF device is receiving from the radio infrastructure at a given location and time

# Tested XBees

## XBee Pro S2B

- 1 mile range
- 250 kbps data rate
- 295 mA @ 3.3 V power consumption



## XBee S1 Wire Antenna

- 300 ft range
- 250 kbps data rate
- 50 mA @ 3.3 V power consumption



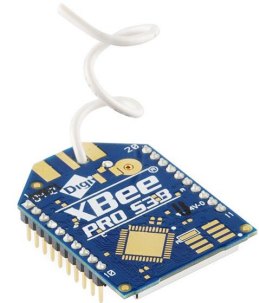
## XBee Pro S1 Trace Antenna

- 1 mile range
- 250 kbps data rate
- 215 mA @ 3.3 V power consumption



## XBee Pro S3B

- 28 mile range
- 200 kbps data rate
- 215 mA @ 3.3 V power consumption



# Through Wall Testing

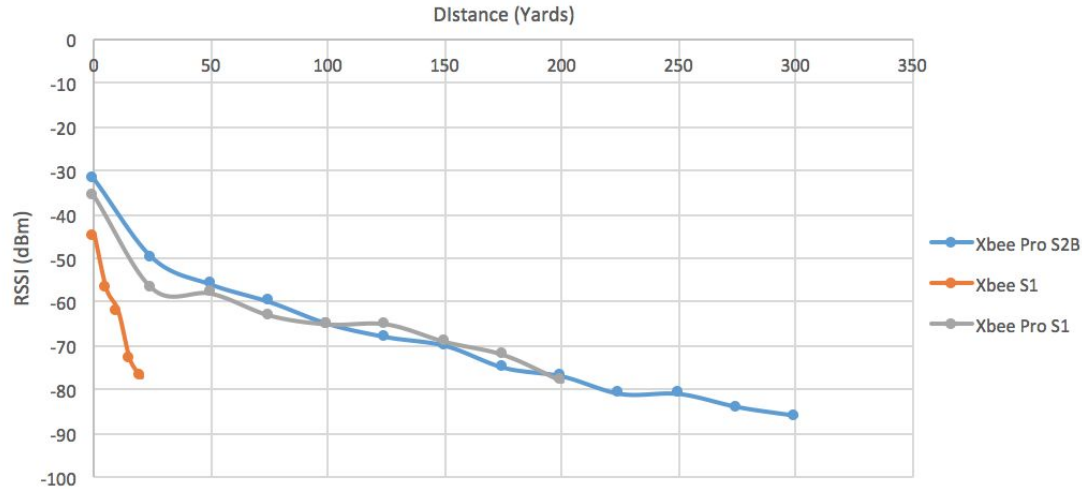
|                           | No Wall<br>(dBm)                | 1 Wall<br>(dBm)                 | 2 Wall<br>(dBm)                 |
|---------------------------|---------------------------------|---------------------------------|---------------------------------|
| XBee Pro S2B              | <b>-32</b><br>0/25 Packets lost | <b>-56</b><br>0/25 Packets lost | <b>-77</b><br>0/25 Packets lost |
| XBee S1 wire antenna      | <b>-67</b><br>0/25 Packets lost | <b>-75</b><br>0/25 Packets lost | -<br>All Packets lost           |
| XBee Pro S1 trace antenna | <b>-70</b><br>0/25 Packets lost | -<br>All Packets lost           | -<br>All Packets lost           |
| XBee Pro S3B              | -<br>All Packets sent           | -<br>All Packets sent           | -<br>4/5 Packets lost           |

# Holmes Hall Testing

|                              | Roof<br>(RSSI)                  | 4th Floor<br>(RSSI)             | 3rd Floor<br>(RSSI)             | 2nd Floor<br>(RSSI)             | Ground Floor<br>(RSSI) |
|------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|------------------------|
| XBee Pro S2B                 | <b>-32</b><br>0/25 Packets lost | <b>-57</b><br>0/25 Packets lost | <b>-66</b><br>0/25 Packets lost | <b>-70</b><br>0/25 Packets lost | -<br>All Packets lost  |
| XBee S1 wire<br>antenna      | <b>-67</b><br>0/25 Packets lost | <b>-79</b><br>6/25 Packets lost | -<br>All Packets lost           | -<br>All Packets lost           | -<br>All Packets lost  |
| XBee Pro S1 trace<br>antenna | <b>-70</b><br>0/25 Packets lost | -<br>All Packets lost           | -<br>All Packets lost           | -<br>All Packets lost           | -<br>All Packets lost  |
| XBee Pro S3B                 | -<br>All Packets sent           | -<br>All Packets sent           | -<br>3/5 Packets lost           | -<br>4/5 Packets lost           | -<br>All Packets lost  |

# Line Of Sight (LOS) Testing

Strength of Signal vs. Distance

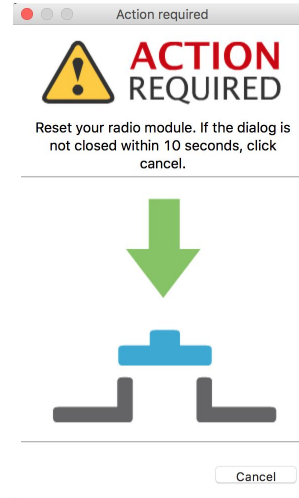


## XBee Pro S3B

- Begins to lose packets at around 59 yards

# Problems

- Time Management
- Metal contact
- Loopback hardware
- Better to have PCB with no plane under XBee
- Code able to create packing format only for certain variable types





# Bill of Materials

## Networking - Bill of Materials (BOM) v2

| Part Description                       | Mounting Type | Part Value | Manufacturer | Manufacturer P/N | Distributor | Distributor P/N   | Unit Cost | Sub-Cost |
|--|---------------|------------|--------------|------------------|-------------|-------------------|-----------|----------|
| Arduino Uno R3 (Atmega328 - assembled) | -             | -          | Arduino      | REV3             | Adafruit    | 50                | \$24.95   | \$49.90  |
| Sparkfun XBee Shield                   | PTH           | -          | Sparkfun     | WRL-12847        | Sparkfun    | WRL-12847         | \$14.95   | \$29.90  |
| XBee Pro S2B                           | PTH           | -          | Digi         | XBP24BZ7SIT-004  | Digi-Key    | 602-1677-ND       | \$30.75   | \$61.50  |
| XBee Pro 802.15.4 63MW PCB             | PTH           | -          | Digi         | XB24-API-001     | Digi-Key    | 602-1280-ND       | \$32.00   | \$64.00  |
| XBee DigiMesh 2.4 1MW Wire Ant         | PTH           | -          | Digi         | XB24-DMWIT-250   | Digi-Key    | XB24-DMWIT-250-ND | \$19.00   | \$38.00  |
| XBee Pro XSC S3B 900MHZ 250Mw          | PTH           | -          | Digi         | XBP9B-XCWT-002   | Digi-Key    | 602-1297-ND       | \$39.00   | \$78.00  |
| XBee Pro 900                           | PTH           | -          | Digi         | XBP09-DPSIT-156  | Digi-Key    | XBP09-DPSIT-156   | \$42.00   | \$84.00  |
| Battery Pack NiMH 7.2V 2100mAh         | -             | 7.2 V      | -            | -                | Digi-Key    | P017-F023-ND      | \$31.83   | \$63.66  |
| Duck Antenna RP-SMA                    | -             | 900MHZ     | Sparkfun     | WRL-09143        | Sparkfun    | WRL09143          | \$7.95    | \$15.90  |

- Summary:

- XBee Pro S2B = \$30.75
- XBee Pro S1 = \$32.00
- XBee S1 = \$19.00
- XBee Pro S3B = \$39.00
- XBee Pro 900 = \$42.00

# Power Budget

## Networking - Power Budget v2

| Device Name               | Idle(mA) | Typical Current Draw (mA) | Max Current Draw (mA) | Avg Current Draw (mA) | Avg Power Consumed (mW) | Max Power Consumed (mW) |
|---------------------------|----------|---------------------------|-----------------------|-----------------------|-------------------------|-------------------------|
| XBee Pro S2B              | 15       | 205                       | 220                   | 15.02077333           | 49.56855198             | 49.56855198             |
| XBee S1 wire antenna      | 50       | 45                        | 45                    | 49.99945333           | 164.998196              | 164.998196              |
| XBee Pro S1 trace antenna | 55       | 250                       | 250                   | 55.02131999           | 181.570356              | 181.570356              |
| XBee Pro S3B              | 29       | 215                       | 290                   | 29.02033599           | 95.76710878             | 95.76710878             |
| XBee Pro 900              | 80       | 180                       | 210                   | 80.01093333           | 264.03608               | 264.03608               |
| Atmega 328P (3V)          | 0.7      | 1.7                       | 2.7                   | 1.2                   | 3.96                    | 8.91                    |
| Vreg 3.3V (XBee Shield)   |          | 0.35                      | 0.9                   | 0.175                 | 0.5775                  | 2.97                    |

- Summary:
  - XBee Pro S2B = 49.57 mW
  - XBee Pro S1 = 165.00 mW
  - XBee S1 = 181.57 mW
  - XBee Pro S3B = 95.77 mW
  - XBee Pro 900 = 264.04 mW

# Project Status

## Final Status:

- Work in Progress
- Complete XBee testing/documentation
- Majority of data translator completed

## Remaining Tasks:

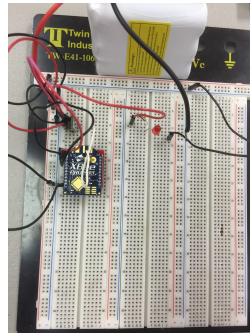
- Create both Postgres portions of server
- Add a few more features to data translator

## Remaining Problems:

- Range testing with Pro S3B
  - XBIB (RSSI)
- Testing with circuit vs computers

## Final Deliverables:

- Documentation of XBee testing
- Test setup for quick debugging
- Packing/unpacking functions that generate a packing format according to an input file



# Future Improvements

- Use Python Package XBee 2.2.3 to test two XBee at the same time
- Test different antennas
- XBee Pro 900 RPSMA
  - Pros: Greater penetration and longer range than S2B
  - Cons: Cost \$54.95 and greater power consumption than S2B
- Tests with circuit



# Thank You

Questions?



# Works Cited

## Website References:

[http://ftp1.digi.com/support/documentation/90000976\\_W.pdf](http://ftp1.digi.com/support/documentation/90000976_W.pdf)

[http://ftp1.digi.com/support/documentation/90000982\\_S.pdf](http://ftp1.digi.com/support/documentation/90000982_S.pdf)

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<http://thewanderingengineer.com/2013/05/06/testing-the-range-of-the-xbee-pro-900/>

<https://docs.digi.com/display/WirelessConnectivityKit/Performing+a+range+test>

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