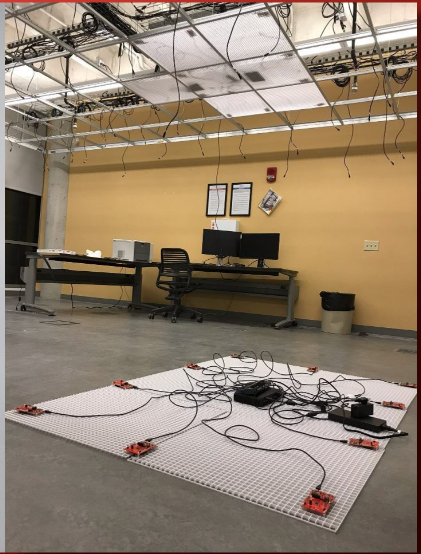
CyWi Testbed

Open-Source Wireless Innovation Lab for 5G and Beyond

Team: SDDEC19-02

Advisor/Client: Dr. Hongwei Zhang

http://sddec19-02.sd.ece.iastate.edu/



Problem Statement

- Smart agriculture (e.g. modern machinery control) demands robust 5G solutions
- Industry 4.0 requires Cyber-Physical Systems (CPS) and Internet of Things (IoT)
- Wireless labs and testbeds speed up the pace of innovation
  - Simulations are not sufficient - radio frequency (RF) research needs physical labs
- CyWi will enable users to define, execute, and analyze wireless experiments

Operating Environment

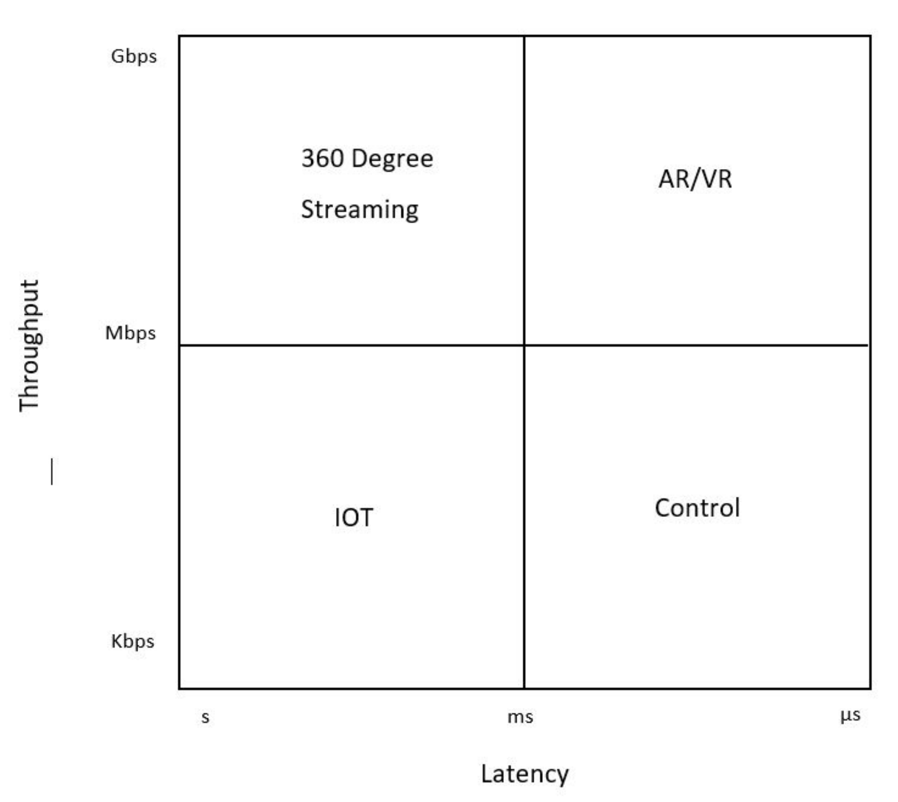
- Given this testbed houses sensitive radio equipment the environment must be controlled
- Lab space in Coover provides a climate controlled, secured environment
- Key restricted access to the lab provides security

Constraints and Considerations

- Limited ceiling tiles arranged in a grid of 11x10 tiles
- Limited budget for powerful SDRs and quantity of CPS motes
- Project scope is large and multi-year -- documentation is crucial for continued future development

Users and Intended Use

- Students learning about wireless signals and protocols
- Test basic wireless topology
  - Mesh, star, and point-to-point
- Researchers have the flexibility with SDR to study wide spectrum of networking solutions



Functional Requirements

- Users have remote access to the lab on the ISU network
- Users have the ability to flash wireless devices
- Experiment output data can be exportable
- Radio attenuation is configurable

Non-functional Requirements

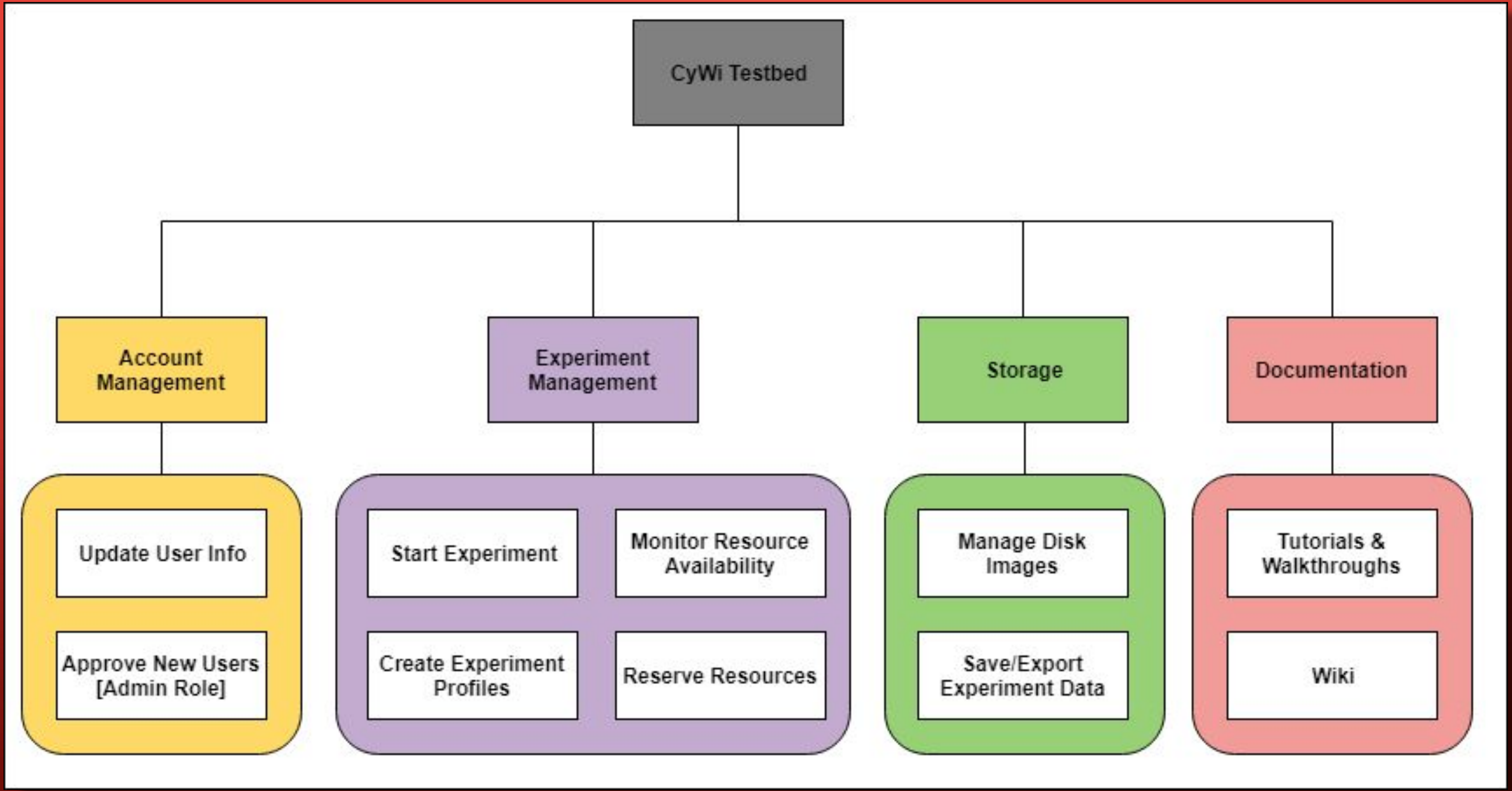
- Software is open-source
- Only registered users have remote access
- System has backup redundancy

Potential Risks & Mitigation

- Security Considerations
  - Restricted access to the locked lab room
  - User approval system for testbed use
  - Server will store minimal user personal information
- Safety Concerns
  - Few during installation, electrical wiring (performed by ETG)
  - Large quantity of cables connecting all components could have been a hazard so the nodes were mounted on the ceiling

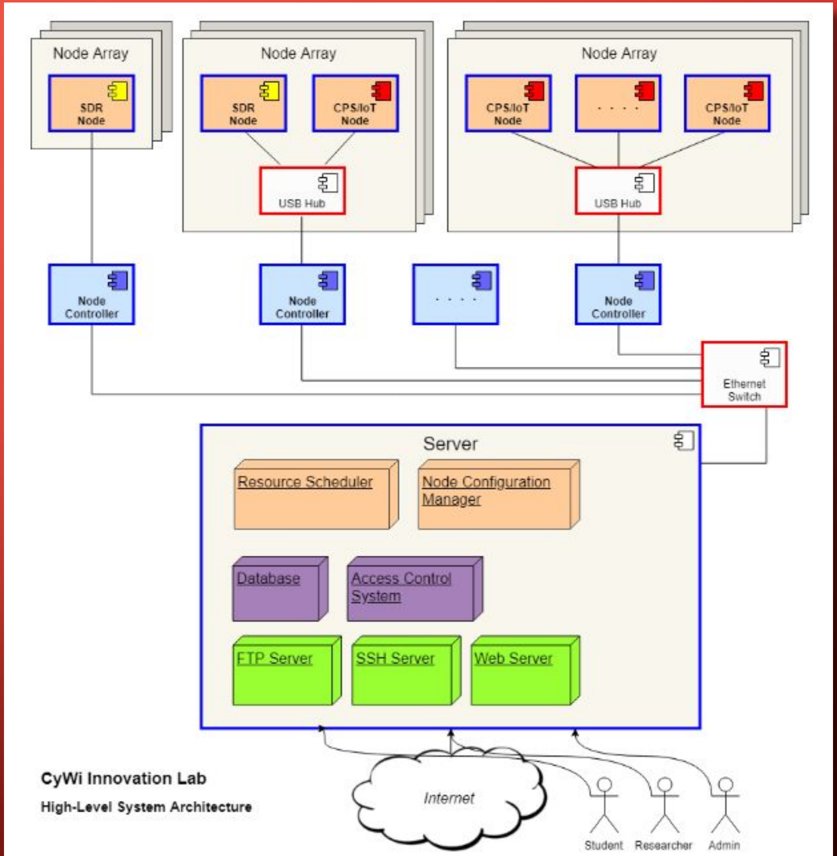
System Design

Functional Decomposition



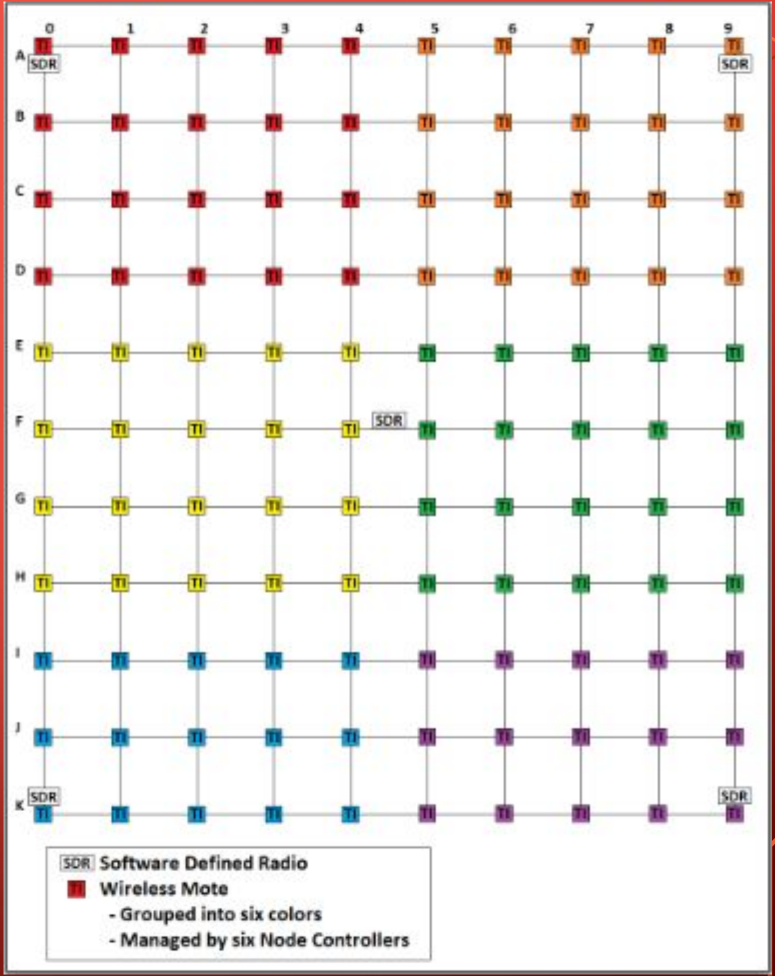
High-Level System Architecture Diagram

- Users connect via the Web
- Services include SSH, FTP, HTTP
- Node Controllers are accessible and provide management to SDR nodes, but are transparent to the CPS motes

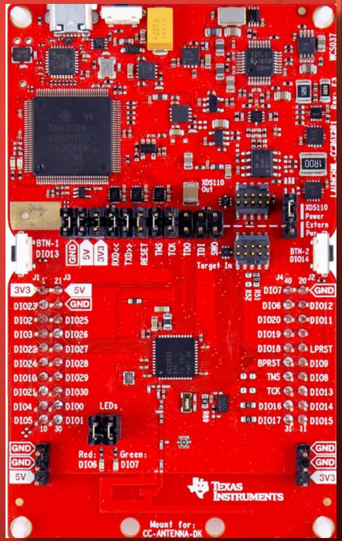


Hardware Layout

- 11x10 grid in 3038 Coover
- 1 node controller manages up to 20 CPS motes



Hardware Platforms

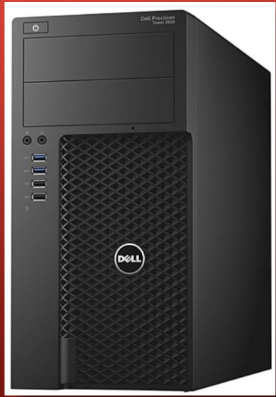


- **CPS Motes:** Texas Instruments CC26X2R Wireless Development Boards
  - Bluetooth 5 Low Energy
  - Zigbee (802.15.4)
  - Wi-Fi
- **SDR Nodes:** Ettus Research USRP B210
  - Frequency Range: 70MHz – 6GHz
  - Throughput: 61.44MS/s
  - USB 3.0 Connectivity

Hardware Platforms

- **Node Controllers:** Intel NUC8i7HVK Mini-PCs
  - CPU: Intel i7-8559U (2.7GHz up to 4.5GHz)
  - Memory: 32GB DDR4
  - Storage: 1xSATA, 1xM.2
  - GPU: Intel Iris Plus 655

- **Server:** Dell Precision 3000
  - CPU: Intel Xeon Bronze
  - Memory: 32GB
  - Storage: 4 TB zfs mirror 1 , 500 Gb M.2 ssd
  - GPU: integrated



Software Platforms

CPS Motes: Texas Instruments CC26X2R Wireless Development Boards

- Wi-Fi, Bluetooth, and Zigbee
- SimpleLink Wireless Development Tools

SDR Nodes: Ettus Research USRP B210

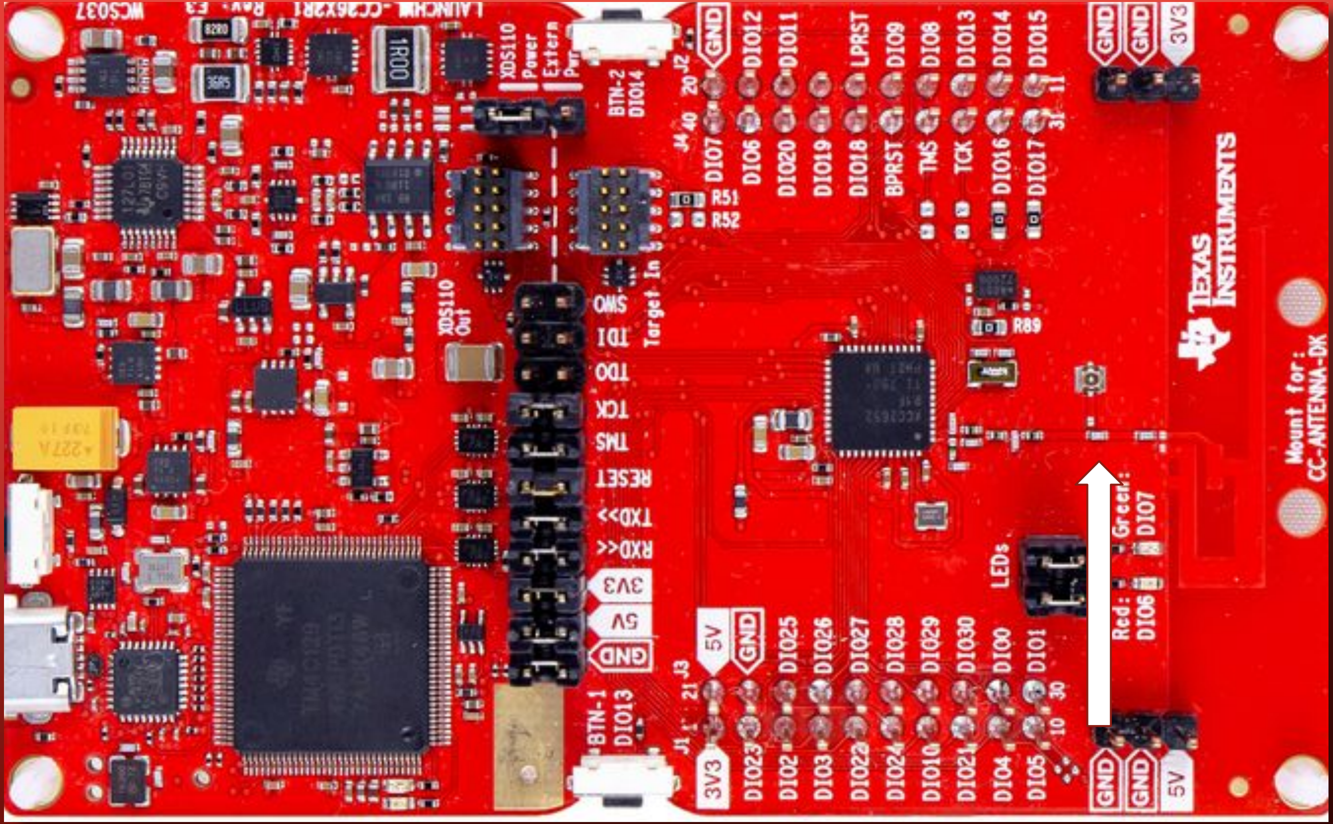
- Linux Ubuntu 16.04
- OpenAirInterface 5G Development Tools

Testing

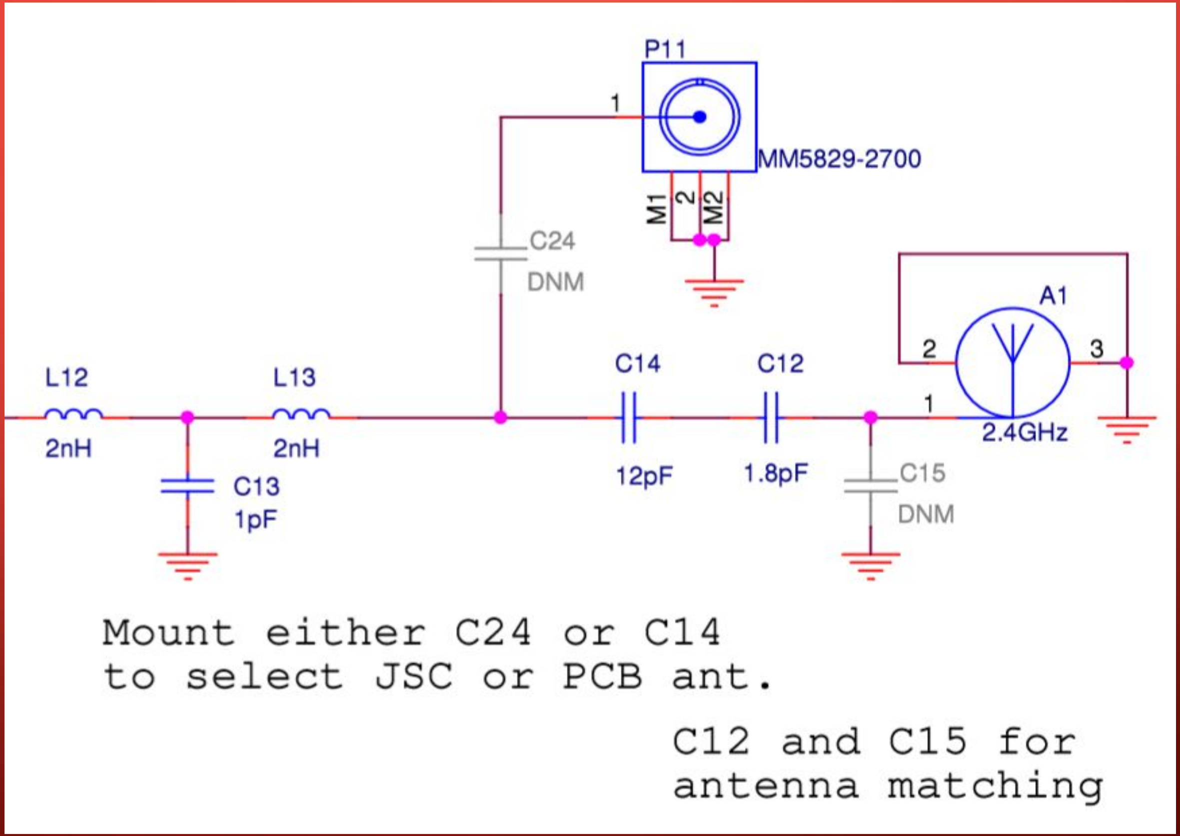
CPS Mote Antenna Attachment

- Needed attenuation for motes to prevent from traveling too far on minimum power
- Required an external antenna to be attached to allow for attenuators
- Turning a capacitor on the board allowed the use of an external antenna and attenuator via a SMA to JSC cable adapter

Mote Antenna Attachment



Mote Antenna Attachment



Finished Mote

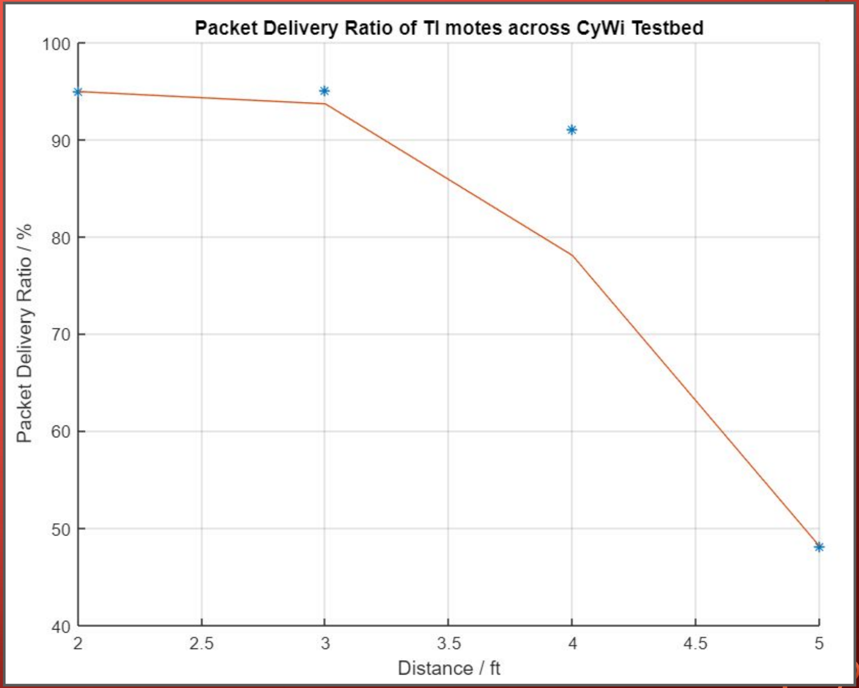
Mote Testing

Attenuation Testing

- Motes must be able to communicate with other their close neighbors at minimum power
- Must travel across the whole room at minimum power
- Starting at 1 foot, sent 1000 packets and evaluated the packet loss
- Increased by 1 foot increments until the two motes were no longer able to communicate

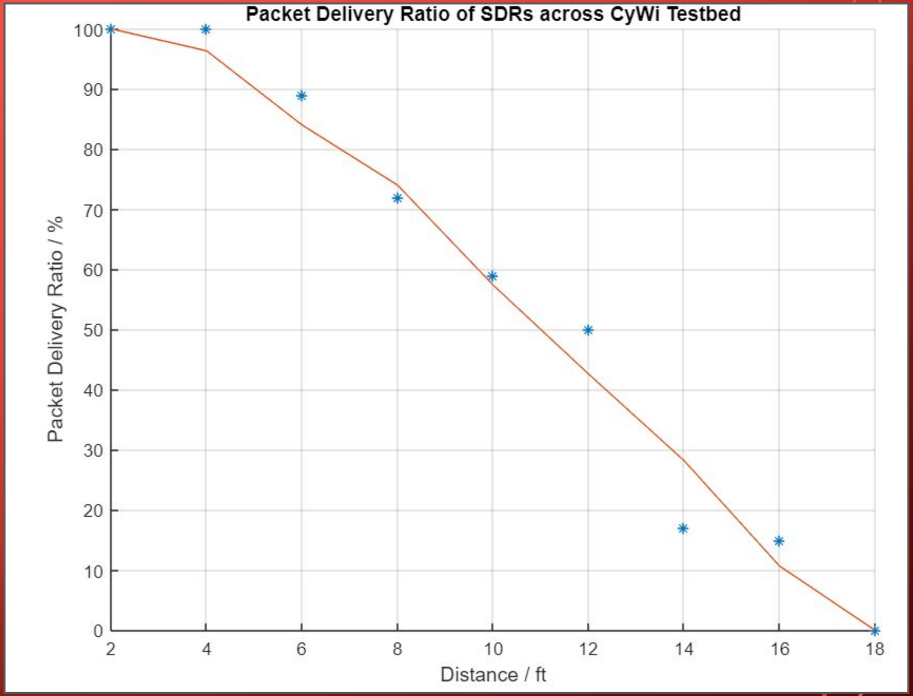
Mote Testing Results

- Optimal Attenuation - 20dbm on all motes
- 5-10% packet loss from 2-4 feet at minimum power
- 50% packet loss at 5 feet (lost connection at 8 feet)
- 1% packet loss across the room at maximum power

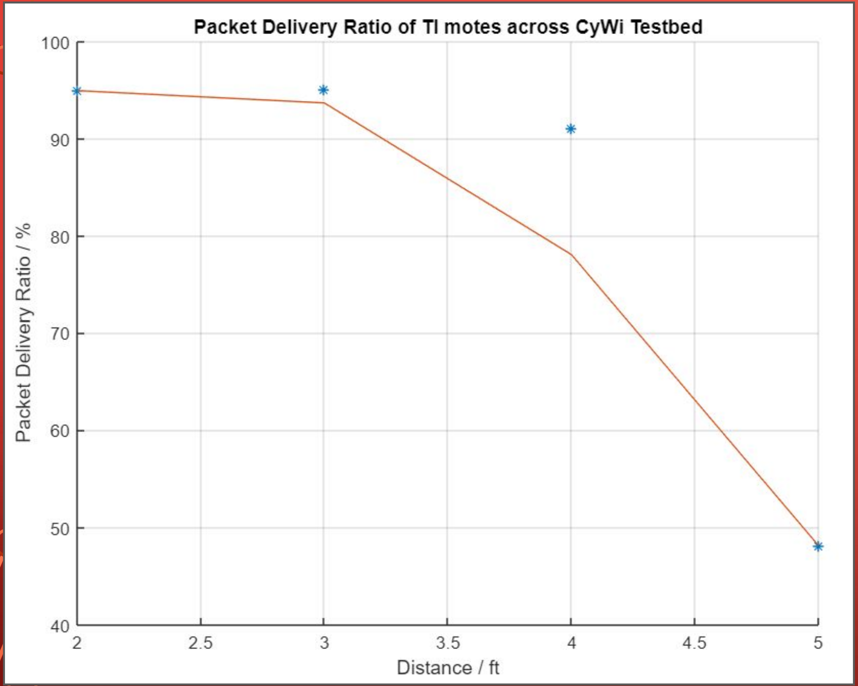


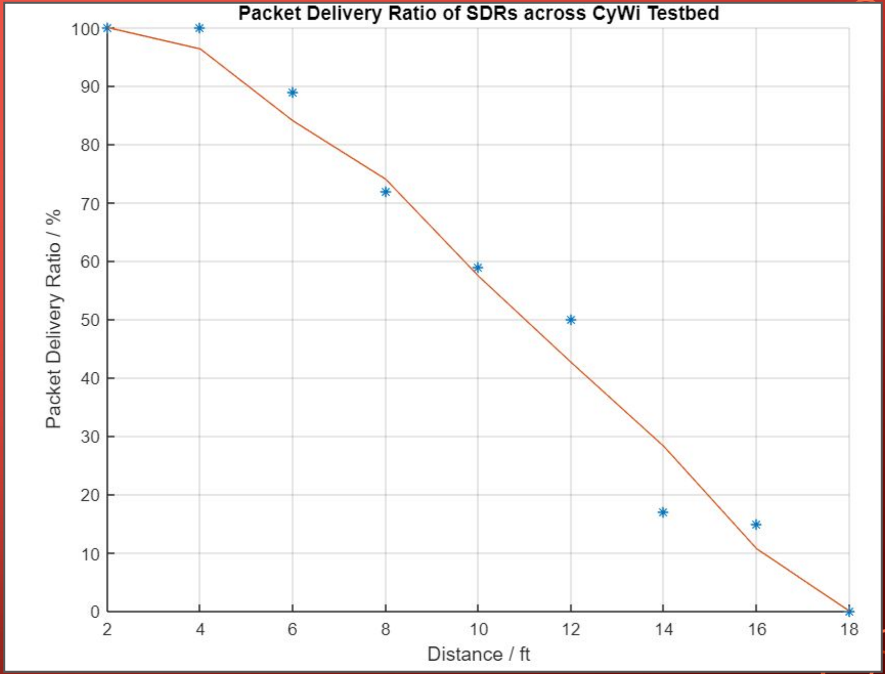
SDR Testing Results

- Optimal Attenuation - 18dBm
- Up to 100% PDR from 2-4 feet at minimum power
- 50% PDR at 12 feet
- 90++% PDR across the room at maximum power

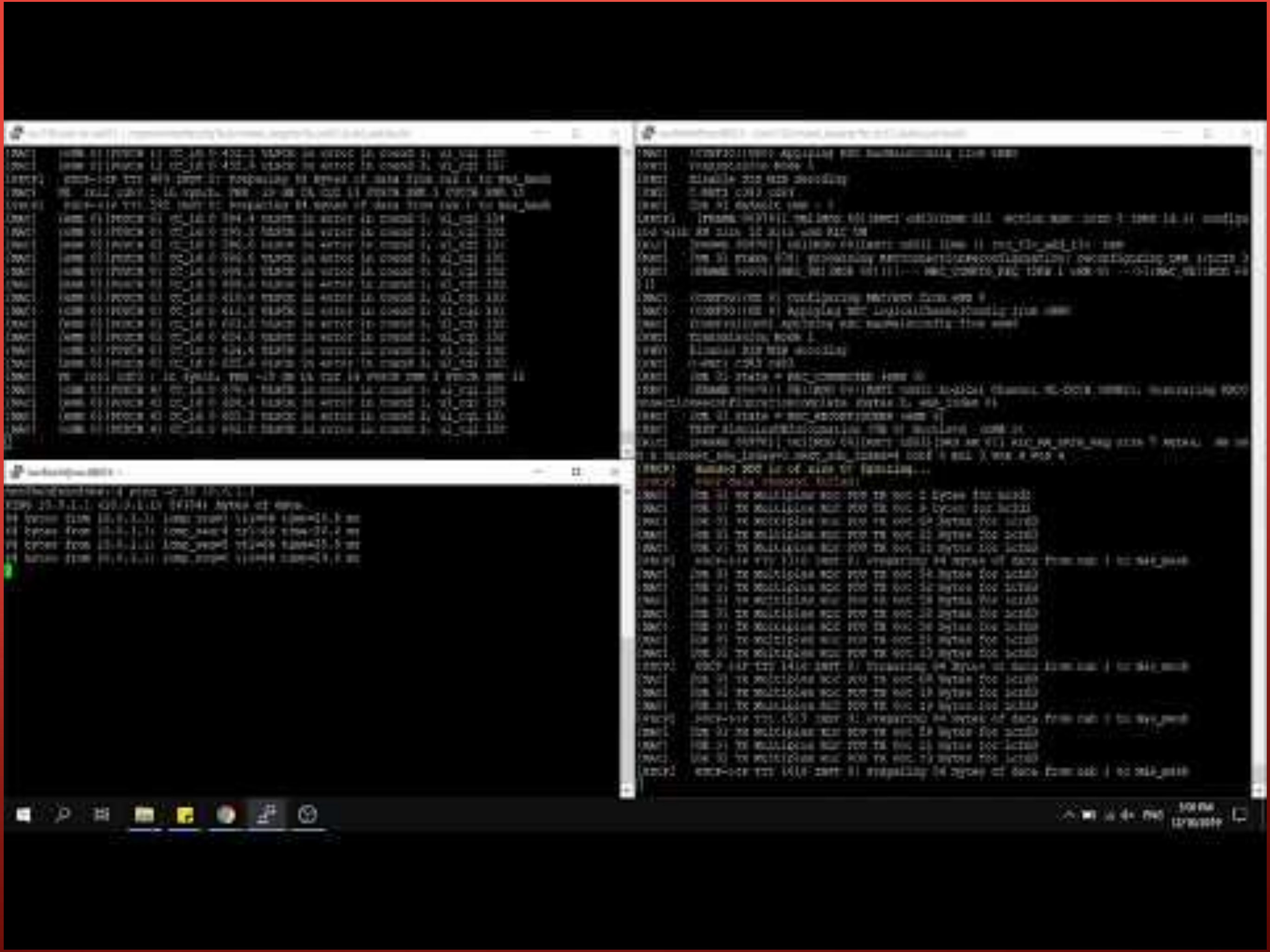


Tests Performed (Results)





Demo



Conclusion

Future Works

- Install additional motes and SDRs
- Implement Emulab
- Local database for users
- Disk image recovery

Individual Team Member Contributions

- Shay (CPS) - TI-RTOS and attenuation/performance testing
- Tyler (CPS) - Capacitor Soldering and attenuation/performance testing
- Chen-Ye (SDR) - OAI research and hardware order/linux environment setup
- Jian (SDR) - OAI demonstration and attenuation testing
- Ryan (Server) - Hardware analysis and ordering, and server set up
- Pawel (Server) - ORBIT/Powder demonstrations and Emulab installation research

Thank you for listening.
Any questions?