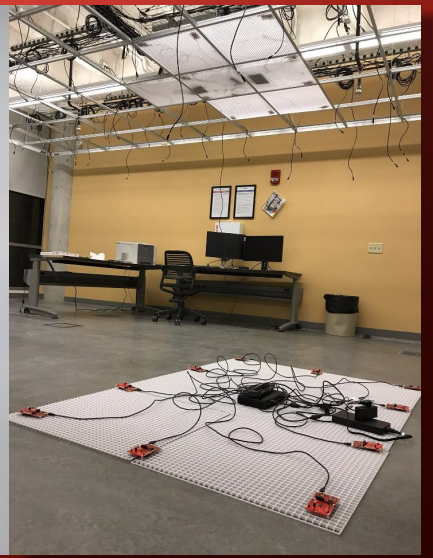
CyWi Testbed

Open-Source Wireless Innovation Lab for 5G and Beyond

Team: SDDEC19-02

Advisor/Client: Dr. Hongwei Zhang

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



Project Plan

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

Experiment Lifecycle

- Specification
  - Users provide requests in spec scripts
- Resource Allocation
  - Server unpacks the spec script
  - Server reserves the requested resources (nodes, frequencies, etc)
- Node Self-configuration
  - Nodes receive data for configurations from the database/server
- Experiment Control
  - Performance monitoring, logs, traffic output are collected and exported to the user

Functional Requirements

- System must register users and assign individual accounts
- Resource scheduler must efficiently allocate node resources
- Experiments must be run remotely via web server
- Users will have the ability to export experiment results

Non-functional Requirements

- System status will be tracked and available to users
- Only registered users can access the system
- System must be crash resilient
- Database will be backed up on regular basis
- Software used will be open-source

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

Market Survey

- ORBIT - Rutgers University
  - WiFi, WiMAX, OpenFlow, and USRP2
  - Over 100 research papers have been published with data obtained from the testbed
- Powder - University of Utah
  - 4G/5G, MIMO, OpenAirInterface (OAI), OpenStack
- NetEye - Wayne State University
  - Wireless sensor networks (WSN)

Potential Risks & Mitigation

- Security Considerations
  - Restricted access to the locked lab room
  - User approval system for testbed account creation
  - 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

Current Cost Estimate

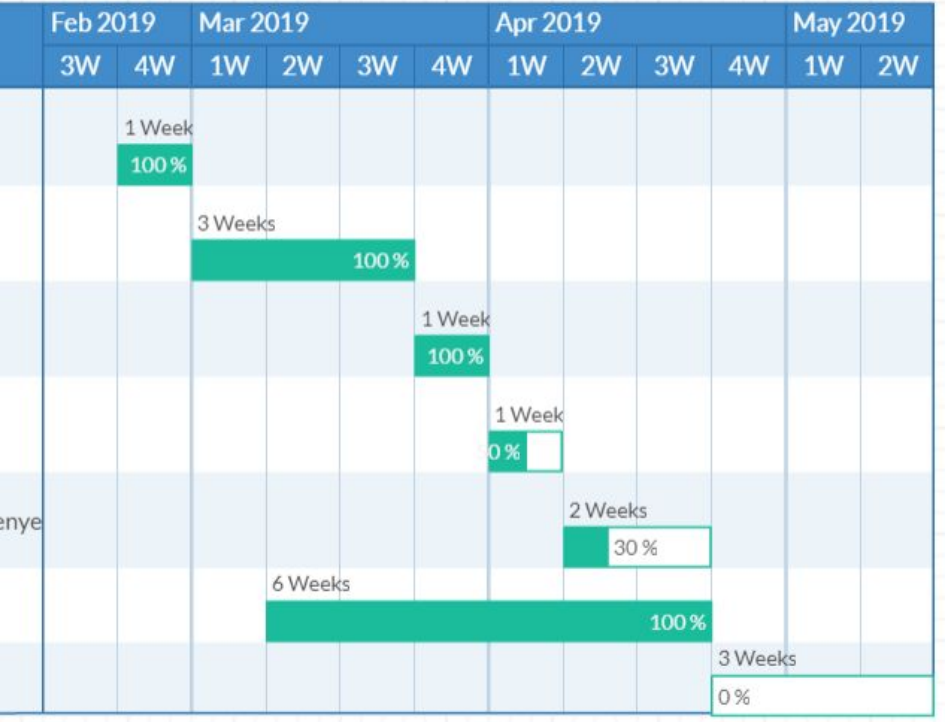
Total Budget	Undetermined
Cost of Hardware	**Price ($)**
2 x USRP B210	2 x 1,216 = 2,432
20 x TI CC26x2R	20 x 39.99 = 799.80
1 x Server Workstation	1,500
Total	4,731.80

Future Cost Estimate

Total Budget	Undetermined
Cost of Hardware	**Price ($)**
30 x USRP B210	30 x 1,216 = 36,480
110 x TI CC26x2R	110 x 39.99 = 34,398.90
11 x Intel NUC Kit	11 x 799.99 = 8,799.89
1 x Server Workstation	1,500
Total	81,178.79

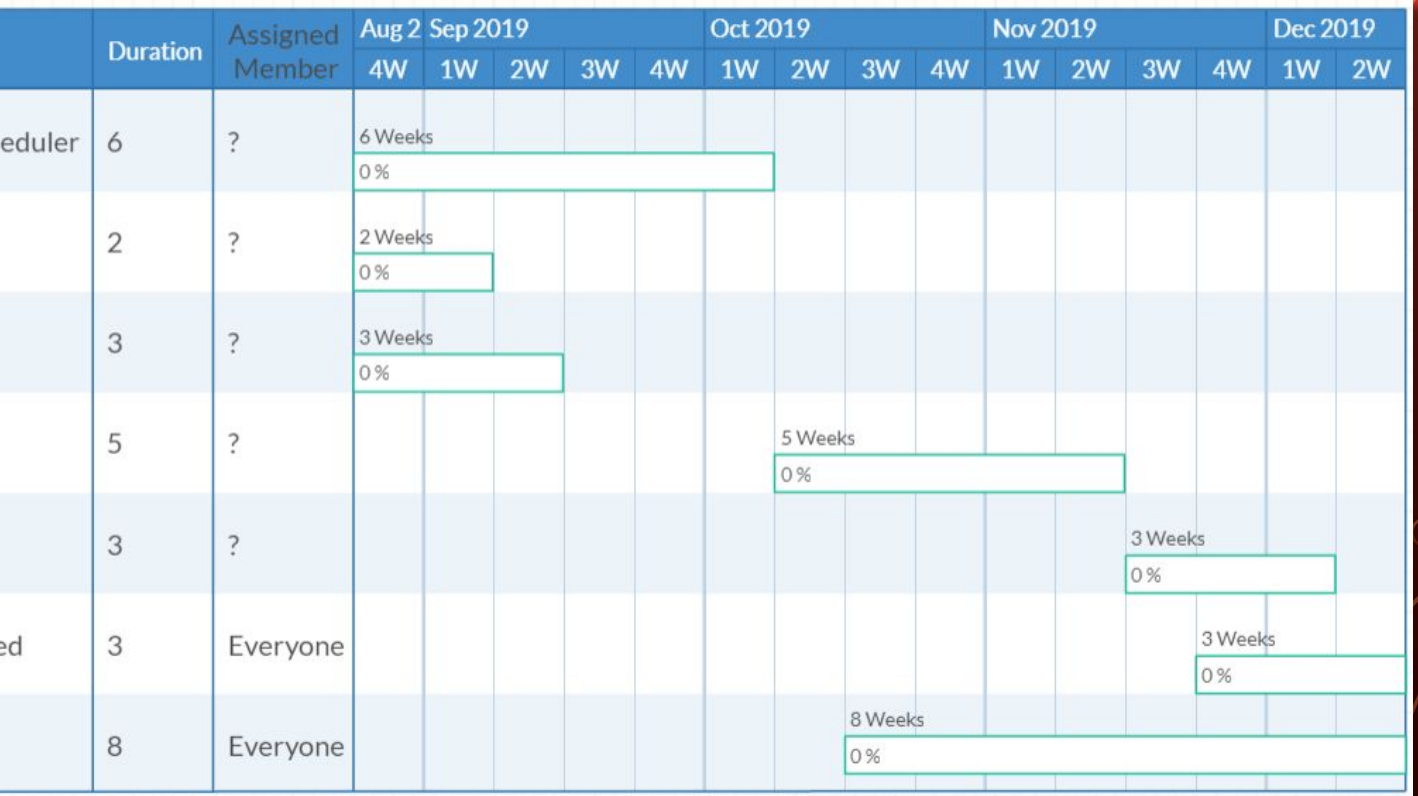
Project Milestones & Schedule

ID	Task Name	Duration	Assigned Member
1.0	Define the Test bed	1	Everyone
2.0	Order Hardware	3	Everyone
2.1	Install Hardware	1	Everyone
3.0	Set Up Node Controllers	1	Everyone
3.1	Configure SDR and IOT Nodes	2	Shay & Tyler & Jian & Chenye
3.2	Research SDR and IOT Nodes	6	Everyone
4.0	Implement Node Configuration Manager	3	Ryan & Pawel



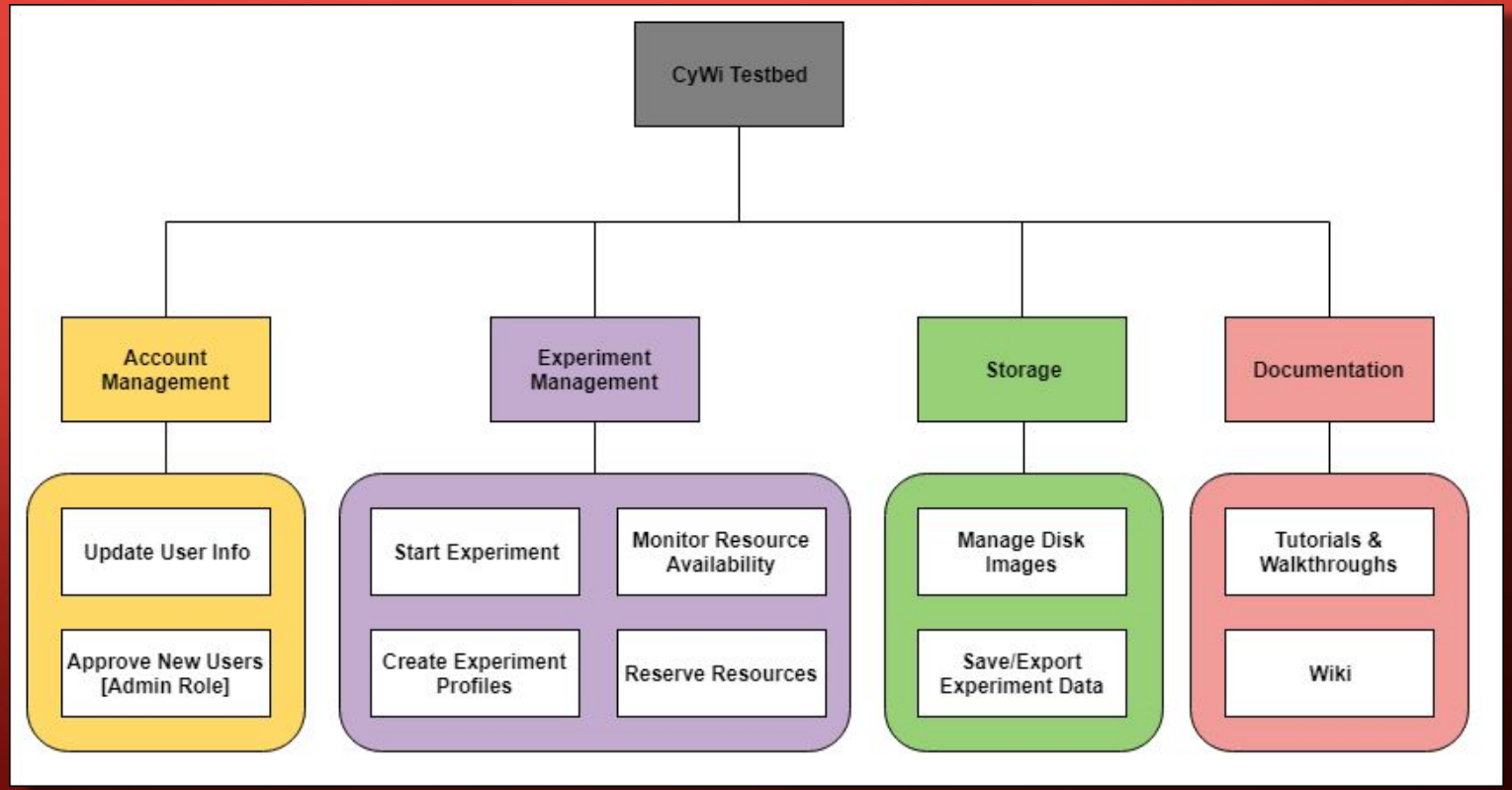
Project Milestones & Schedule

ID	Task Name	Duration	Assigned Member
1.0	Implement Resource Scheduler	6	?
2.0	Implement Database	2	?
3.0	Implement Web Server	3	?
4.0	System Integration	5	?
5.0	Set Up Cloud Service	3	?
6.0	Demonstrate The Test Bed	3	Everyone
7.0	Write Article	8	Everyone



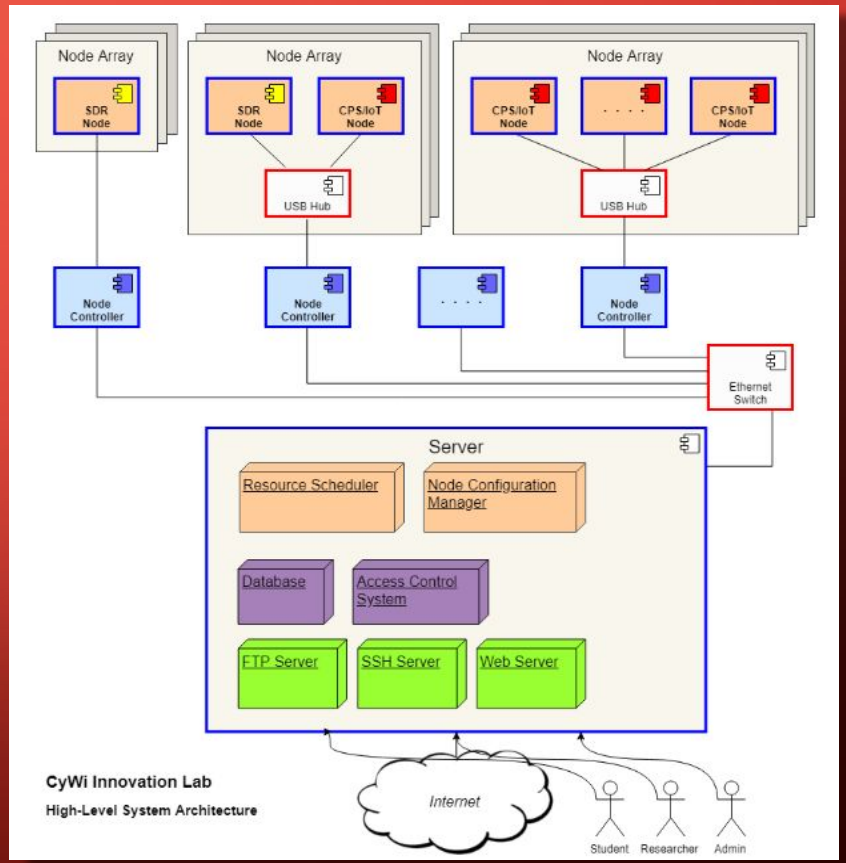
System Design

Functional Decomposition



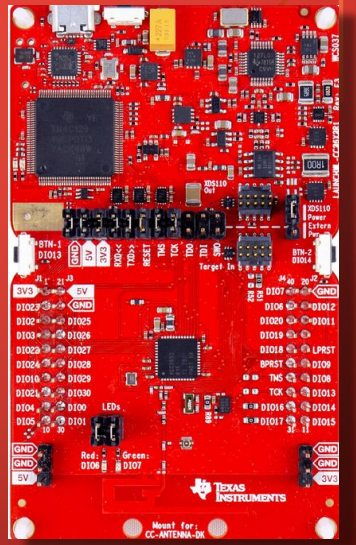
High-Level System Architecture Diagram

- Users connect via web interface
- Services include SSH, FTP, MySQL, Access Control, Resource Scheduler, Node Configuration Manager
  - Emulab platform will provide many of these functions
- Node Controllers are accessible and provide management to SDR nodes, but are transparent to the CPS motes



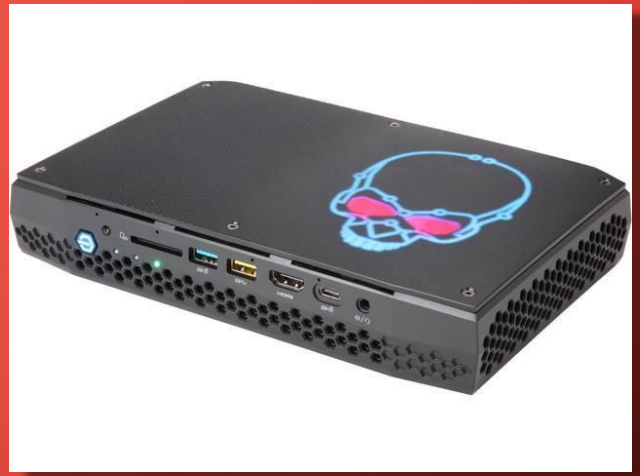
Hardware Platforms

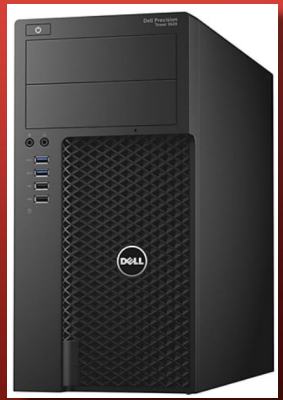
- **CPS Motes:** Texas Instruments CC26X2R Wireless Development Boards
  - Bluetooth 5 Low Energy
  - Zigbee (802.15.4)
  - Wi-Fi
- **SDR Nodes:** Ettus Research USRP B210
  - Frequency Range: 70MHz – 6GHz
  - Throughput: 61.44MS/s
  - USB 3.0 Connectivity



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: 16GB
  - Storage: 4 TB raid 1
  - GPU: integrated





Software Platforms

CPS Motes: Texas Instruments CC26X2R Wireless Development Boards

- WiFi, Bluetooth, and Zigbee
- SimpleLink Wireless Development Tools

SDR Nodes: Ettus Research USRP B210

- Linux Ubuntu 16.04
- OpenAirInterface 5G Development Tools
- GNU Radio

Test Plan

- Most of the functional testing will be unit testing
- As we finish and test more small pieces, we will integrate and test as a larger system

Main Functional Tests

- Account Registration
- Resource Reservation/Scheduling
- User's Spec Script Execution
- Experiment Results Exportation
- Remote Web Server Access

Test Plan

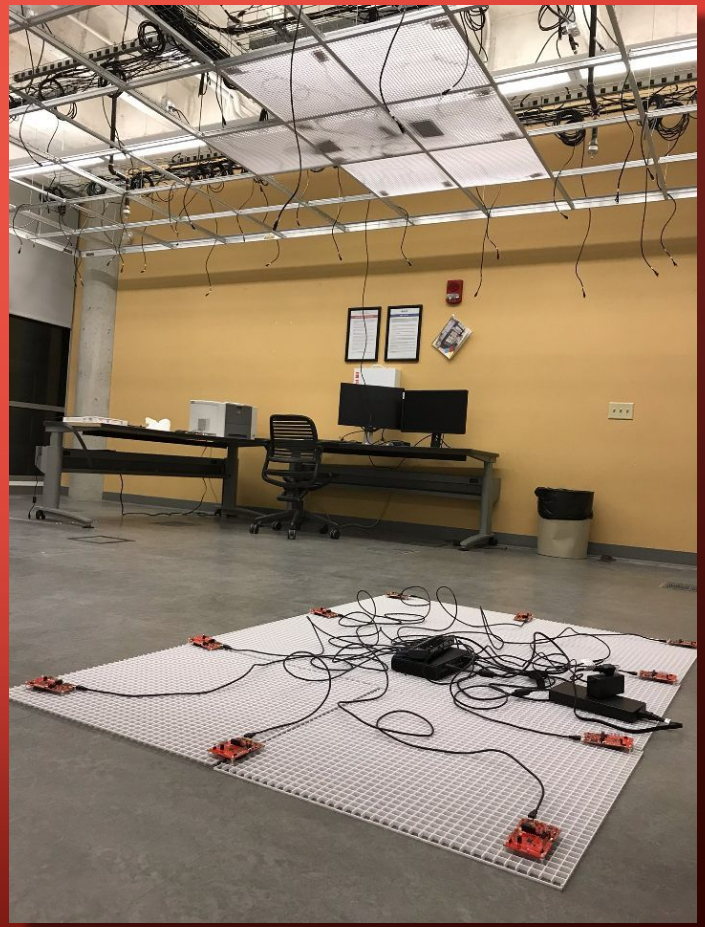
- Most non-functional tests will involve how the system continues to run and back up data
- Also includes security and accessibility

Non Functional Tests

- Availability
- Database Backup
- System Status and Resiliency
- Responsive UI
- Security
- Accessibility

Tests Performed (Results)

- CPS Motes
  - SimpleLink platform runs without errors
  - Transmissions at full power achieved 0.08% packet loss
- SDR Nodes
  - Currently, we had not yet had success communicating with the SDRs
  - Bugs by Ubuntu to be resolved
- Server
  - Pending hardware arrival



Conclusion

Current Project Status In Relation To Roadmap

- Defined testbed and roadmap plan
- Node Controllers installed
- CPS motes and SDR nodes are installed
- Node Controllers don't have Linux installed yet
- Server is ordered and currently in transit (pending ETG)
- Node Controller Manager is pending server installation

Individual Team Member Contributions

- Shay (CPS) - Zigbee network setup and performance testing
- Tyler (CPS) - Bluetooth network setup and performance testing
- Chen-Ye (SDR) - OpenAirInterface research and hardware order/setup
- Jian (SDR) - Powder demonstration and Linux setup
- Ryan (Server) - Hardware analysis and ordering
- Pawel (Server) - ORBIT/Powder demonstrations and Emulab installation research

Plans for Fall 2019

- Node Controller interaction with SDR nodes and CPS/IoT motes
- Emulab installation and integration with the rest of the system
- Basic profile configurations and images for testbed tutorials/walkthroughs
- Web interface creation and optimization
- Testing - includes RF signals, configurations, user interface, etc
- Iterative platform refinements
- Documentation, Documentation, Documentation!

Thank you for listening.
Any questions?