CyWi: Wireless Innovation Testbed

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INTRODUCTION

Over the last decade, the development of Cyber-Physical Systems (CPS) and Internet of Things (IoT) has been in full force because of the multitude of advantages it can bring to everyday life. Despite many years of research, we are still at the infancy of IoT and Industry 4.0 capabilities. IoT can be used for a wide range of products such as SmartAg, connected autonomous vehicles, smart grids, and AR/VR. Powered with the capabilities of 5G, IoT promises to change every aspect of our lives. But to continue with this pace of innovation, researchers need space to run experiments and gather real-world data. This lab located in Coover Hall consists of a multi-node testbed and is available to both students and researchers to run experiments and gather real-world data.

DESIGN REQUIREMENTS

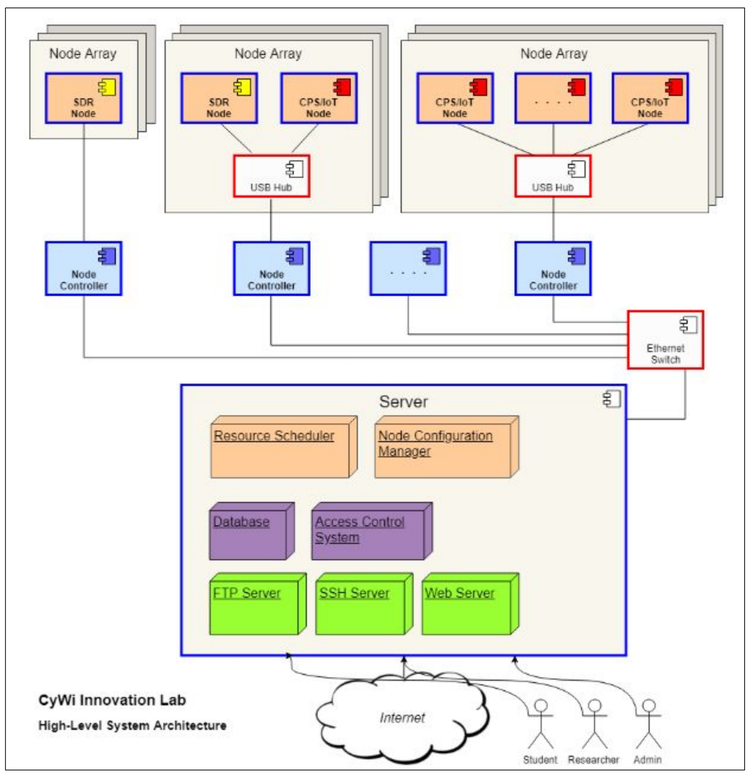
Functional Requirements:
- Users need remote access to the lab
- Users must have ability to flash wireless devices
- Experiment output data must be exportable
- Radio attenuation must be configurable

Non-functional Requirements:
- Software must be open-source
- Only registered users have remote access
- Testbed availability is shown to the users
- System has backup redundancy

Operating Environment:
- Located in 3038 Coover Hall
- Lab room access is physically restricted
- Currently, users are required to be on the ISU network to gain access to the testbed

DESIGN APPROACH

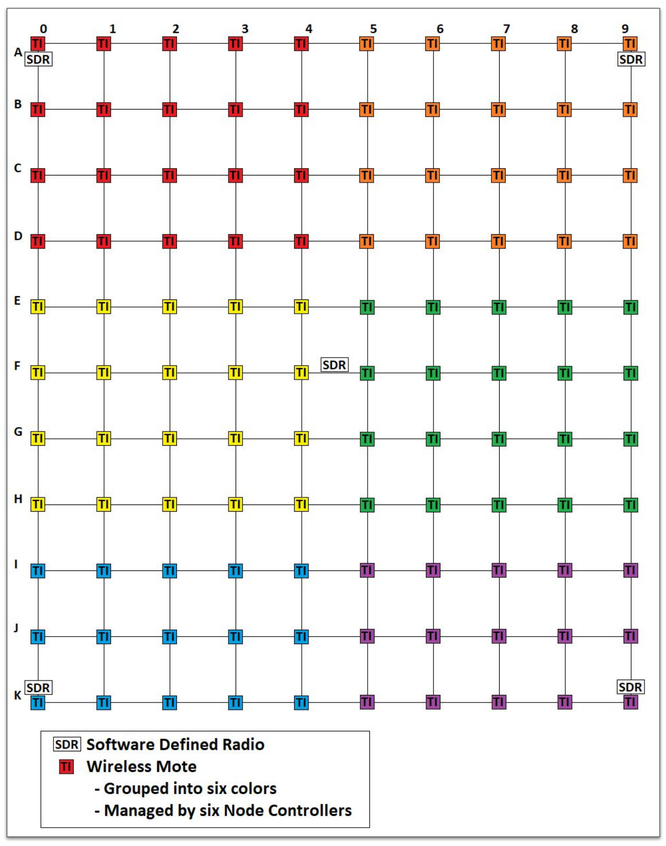
High-Level System Architecture:

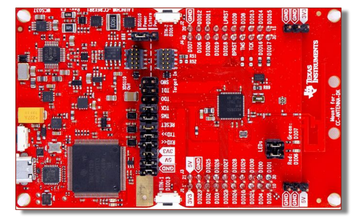


- Users access the testbed via Web and SSH to check out a user-specified set of CPS motes or SDR nodes
- CPS motes and SDR nodes can be individually flashed with software and configured at will
- Wireless experiments can then be set up by the user
- Experiment output (such as traffic logs) is gathered and stored on the server, and can be exported via FTP

- Wireless devices are housed on a ceiling grid in the lab room, each grid being 2x2 ft
- Users can change signal strength via software to control the range of experiments

Concept Sketch of Device Layout:





Cyber-Physical System (CPS) Motes
Texas Instruments CC26X2R Launchpad Wireless Development Boards support:
- Bluetooth 5 Low Energy (IEEE 802.15)
- Zigbee (IEEE 802.15.4)
- Wi-Fi (IEEE 802.11)

Software Defined Radio (SDR) Nodes
Ettus Research USRP B210
- Fully configurable signals
- Frequencies: 70MHz – 6GHz
- Throughput: 61.44MB/s

TECHNICAL DETAILS

- SDR nodes emulate real-time LTE connections between base station and mobile devices using standard OpenAirInterface protocols
- CPS motes are easily configurable by flashing C source code
- Server runs GNU/Linux and connects via Ethernet to Intel NUC8 mini-PCs which act as Node Controllers for the wireless devices
- SDR nodes and CPS motes connect to Node Controllers via USB links
- Server keeps all experiment data gathered by the Node Controllers and makes the data available for export

PROJECT RESOURCES

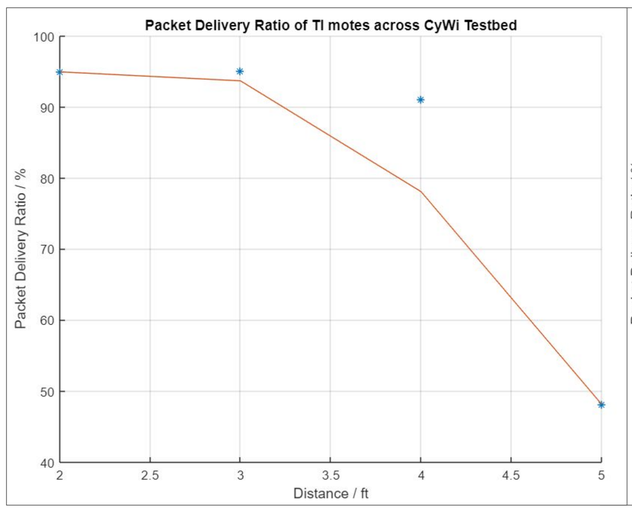
x5	USRP B210 SDR Nodes	$6,080
x60	TI CC26x2R CPS Motes	$2,400
x1	Server Workstation	$1,500
x110	JSC to SMA cables	$2,080
	Miscellaneous	$1,240
TOTAL EXPENSES		**$13,300**

ENGINEERING CONSTRAINTS AND LIMITATIONS

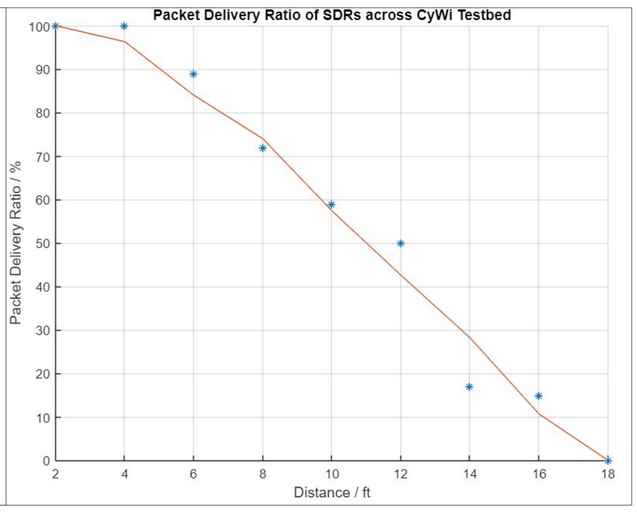
- TI Launchpad came with JSC connected antenna by default which required standard SMA adapter that had limited manufacturer in the market
- Due to budget limitations, total purchased number of USRP B210 SDR nodes had to be kept lower than expected
- Original design was to use existing open-source Emulab testbed software package for experiment management but this proved to be beyond our ability to implement

TESTING

- Both the CPS mote and SDR node signal transmit is too high at such close indoor range
- Radios have been fitted with attenuators to allow for maximum signal flexibility
- Signal strength is software-configurable so users have the option to reach all the way across the lab room at full strength or to limit transmission to a certain range (i.e., for multi-hop applications)



CPS Mote Signal Dependability
- With minimum power, the TI motes have reliable transmission up to 4 feet



SDR Node Signal Dependability
- With minimum power, the SDRs have reliable transmission up to 6 feet