

Hands-on Introduction to Wireless Sensor Networks



Course Description

Wireless sensor networks are already enabling the Internet of Things (IoT). While universities and R&D centres around the world are investigating such networks from theoretical and algorithmic perspectives, it is also important to give students a hands-on exposure to such a network of actual devices.

For this course, students would work with ultra-low power devices based on Texas Instruments MSP430 microcontroller and CC2520 radio. Students will program these devices, debug the code and test their algorithms. Students will gain exposure to embedded systems programming. Students may encounter field issues with wireless devices and gain experience in solving them.

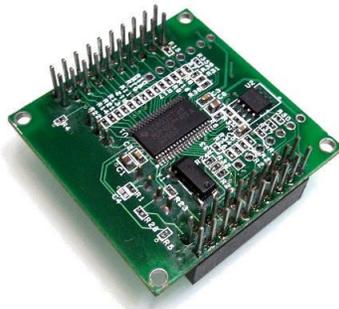
Students will require a computer with any OS for the duration of the course. Bootable USB loaded with Ubuntu Linux will be provided. Wireless devices will be supplied by WiSense. These devices are supplied along with open source software toolchain and web-enabled network monitoring software. It is extremely easy for students to learn this system and contribute to the Internet of Things. Basic source code is provided. The course will build on this and allow students to improve the system by incrementally making changes to specific parts of the system.

Skills Imparted

Wireless networking. Protocol engineering. IEEE 802.15.4 stack. Introduction to routing algorithms. TI MSP430 programming. Embedded system development using C. Debugging. Working with open source toolchain on Ubuntu Linux and Eclipse IDE. Managing code changes using version control systems.

Audience

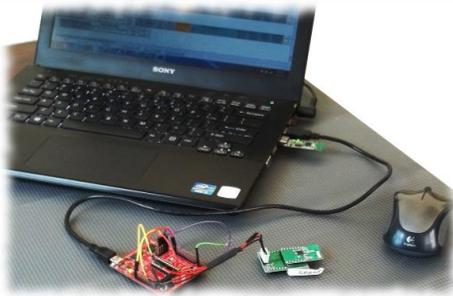
This course is applicable for all engineering students interested wireless technology, IoT and embedded systems. C programming basics is a prerequisite for this course.



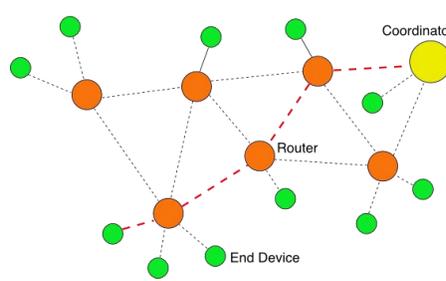
Course Outline

- Introduction to Wireless Sensor Networks. (1 hour)
 - Background and motivation.
 - Network architecture and topology.
 - Design constraints and considerations.
 - Applications of WSN.
- Basics of protocol engineering. (1 hour)
 - Stack architecture, SAPs and primitives.
 - IEEE 802.15.4 stack architecture.
 - ZigBee stack architecture.
 - Comparisons against RFID, Bluetooth, NFC and Wi-Fi.
- PHY and MAC of IEEE 802.15.4 protocol. (4 hours)
 - PHY parameters, modulation, bandwidth, spectral masks.
 - Link budgeting, receiver sensitivity.
 - Duty cycles, sleep and wakeup concepts.
 - Contention-based vs. schedule-based protocols.
 - Types of nodes, superframe structure, GTS management.
 - Slotted CSMA-CA. Data transfer procedures.
- Getting started with WiSense devices. (4 hours)
 - Understanding the modules and their interfaces.
 - Compiling the code. Programming the devices.
 - Monitoring the network.
 - Introduction to open source software toolchain.
- Understanding TI MSP430 architecture. (4 hours)
 - Internal architecture and modules.
 - Memory architecture.
 - Analyzing the ELF binary.
- Understanding the WiSense software. (8 hours)
 - Naming and addressing of nodes.
 - Functionality of RFD, FFD and PAN Coordinator.
 - Interfacing with the gateway.

Programming a device



Multihop mesh routing



Low standby current of $\sim 1 \mu\text{A}$



- Configuring and accessing sensors.
 - Handling interrupts.
 - Managing system events.
 - Writing code for memory constrained environments.
 - Avoiding locks. Using non-blocking callbacks.
- Introduction to routing. (8 hours)
 - Essential difference between wired and wireless protocols.
 - Proactive vs. on-demand protocols.
 - Route discovery, maintenance and recovery.
 - DSDV, CGSR, WRP, AODV, TORA, ABR, LOAD.

Exercises

There will be a written exam at the end of course. During the course, the following exercises will be assigned to students:

- Improve routing algorithm based on chosen constraints.
- Optimize code given the constraint of memory.
- Reduce power consumption by reprogramming the radio.
- Reconfigure the sensors to try out different methods of measurement and reporting.
- Experiment with various core functionalities of MSP430.

Our Contact

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WiSense is a technology solutions startup from Bangalore. It builds wireless products and solutions that are industry compliant. These can be used as experimental kits in engineering colleges. They can also be deployed for industrial use.

WiSense products enable a host of applications based on wireless sensor networks. Examples include home automation, smart buildings, industrial automation and green cities. Their products can potentially power the Internet of Things (IoT) for the Indian market where it is important to keep costs down without sacrificing on product quality or reliability.

Trainers



Arvind Padmanabhan

Arvind Padmanabhan graduated from the National University of Singapore with a master's degree in electrical engineering. With fifteen years of experience, he has worked extensively on various wireless technologies including GSM/GPRS, WCDMA, HSPA, WiMAX and IEEE standards. His experience spans all aspects of product development from requirement analysis to product validation, from tool development to process optimization.

He delivers courses that offer students essential skills to perform their jobs effectively in the workplace. He brings an historical perspective to technology and thereby shares valuable insights into innovation and problem solving.

Ram Krishnan

Ram Krishnan has more than sixteen years of experience in embedded software and protocol development. His expertise includes IEEE 802.15.4, wireless mesh networking protocols and software development for energy-constrained devices. His prior work has been on smart grids and powerline communications.

He brings to training an in-depth knowledge of the Texas Instruments development platforms and chipsets. His involvement in creating the WiSense software will enable students to learn first-hand the essentials of embedded systems programming.