Course Project List

Lecture #4
Prof. Raj Rajkumar

Previous Lecture

- Firefly Hardware Platform
- Nano-RK Real-Time Operating System
- Embedded Programming Tips and Tricks
- Lab Descriptions

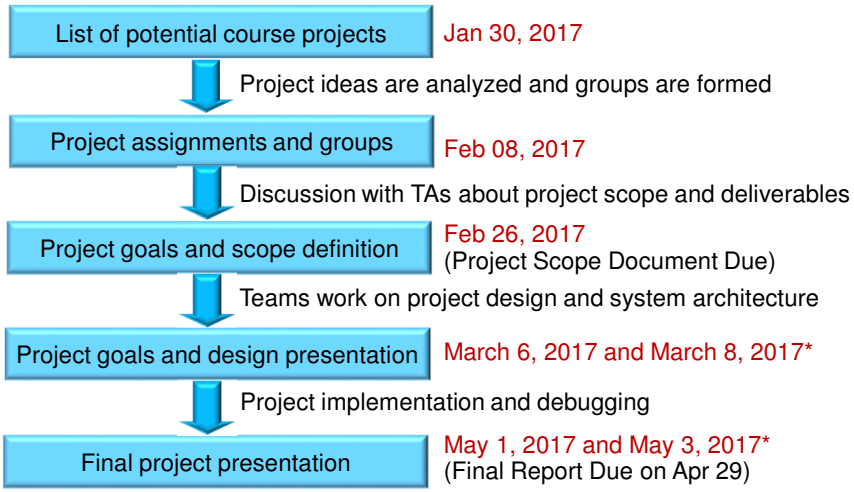
Outline of This Lecture

- Overview of Course Projects
- Project Schedule
- Project Grading Criteria
- Possible Project Ideas

Project Goals

- Hands-on experience with a Wireless Sensor Network
- Ability to understand and formulate a problem
- Design skills to develop implementable designs
- Implementation and demonstration
- Evaluation and benchmarking system performance
- Documentation and presentation of the problem, design, and implementation

Project Timeline



* Dates are tentative and may change depending on scheduling conflicts

Demos

- Intermediate Demo: April 4*
- Final Demo: May 4 or 5*

Pending any schedule conflicts

Technical Details

- Project selection
  - First-come first-served
    - Submit early and often ☺
    - All projects will be scoped to be of similar complexity
- Project scope document
  - Requirements, design, responsibilities and schedule
  - 6 to 8 pages
- Final project report
  - Due on the last day of classes for the semester
  - Design, implementation and detailed evaluation
  - Submit source code in SVN

Grading Criteria

- Project design presentation: 4 points
- Project scope report: 4 points

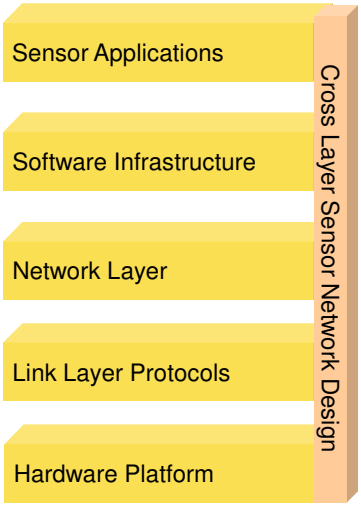
Mid-Term

- Intermediate project demo: 10 points
- Final project demo: 28 points
- Final project presentation: 7 points
- Final project report: 7 points

Final

- Total: 60 points

Project Domains



Project Guidelines

- Be creative!
- Think cross-layer design
  - Don't just build apps
  - Don't just work on infrastructure layer
  - Traverse the complete stack
  - You can even build some hardware if desired
    - Anybody can learn a programming language and write "software"
    - Not easy to design and develop hardware (chip or board)
- Talk to your TA mentor and Raj
- Define your scope
- Read a lot
- Talk to your mentor often
- Do a lot
- Learn a lot

List of Projects (1 of 2)

1. Smart Buildings
2. Multi-Robot Coordination
3. Solar Energy Harvesting
4. City Sensing
5. Smart Pillow (or Bed)
6. “Where Am I?” Indoor Localization
7. Reverse-GPS Outdoor Localization

List of Projects (2 of 2)

8. Occupancy Detection
9. Distributed Audio
10. Multi-Node Voice Communications
11. Efficient Sleep Scheduling
12. Multi-Channel Routing
13. Distributed Sensing and Actuation

Your Brainchild

- Come talk to us…

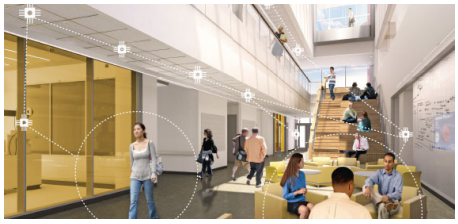
Platforms to Use

- FireFly nodes
- Arduino kit
- Raspberry PI
- Photon(IoT)
  - https://store.particle.io/?utm_source=Homesite&utm_medium=Button&utm_content=Proto&utm_campaign=buydevkit
- XBee Pro
- BLE
- LORA LP-WAN

In combination with laptops, smartphones, tablets, …

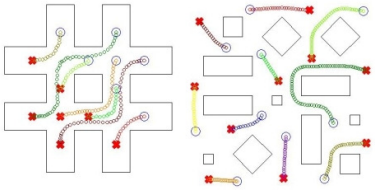
Smart Building

- **Objective:**
  - Implement a sensing-actuating system to automatically control the building's operations, such as heating, lighting, security, etc.
- **Challenges:**
  - Integrating multiple sensors and actuators
  - Some of them need quick response, but some do not
  - Multiple events can be happened simultaneously



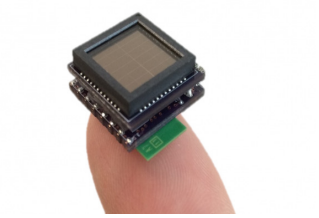
Multi-Robot Coordination

- **Objective:**
  - Sensor nodes navigate indoors from specific source to destination without running into each other
- **Challenges:**
  - Coordination wirelessly to avoid collision
  - Image sensing/recognition of floor pattern for positioning
- **References**
  - https://www.youtube.com/watch?v=8gy5tYVR-28



Solar Energy Harvesting for Outdoor Sensor Networks

- **Objective:**
  - Design and implement a solar energy harvesting system for sensor networks
- **Challenges:**
  - Understand energy harvesting mechanisms and components appropriately
  - Design the circuit for energy harvesting
  - Integrate it with FireFly sensor nodes
- **References**
  - V. Raghunathan et al., "Design considerations for solar energy harvesting wireless embedded systems", IPSN '05



City Sensing with Energy-Efficient WSN

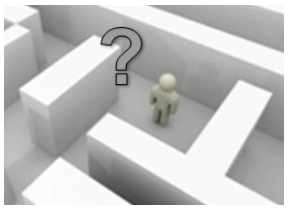
- **Objective:**
  - Monitor air-quality, temperature, and humidity to understand the city environment
- **Challenges:**
  - Design the circuit and sensing system
  - Sensor data fusion/interpolation
  - Energy-efficiency
- **References**
  - Y. Jiang et al., "MAQS: A Personalized Mobile Sensing System for Indoor Air Quality Monitoring", UbiComp '11
  - Y. Cheng et al., "AirCloud: a cloud-based air-quality monitoring system for everyone", SenSys '14

Smart Pillow

- **Objective:**
  - Provide sleep sensing/actuating system to avoid sleep apnea
- **Challenges:**
  - Monitoring/sensing the pulse during the sleep time
  - Actuation to adjust the pillow and head's position on it
- **References**
  - J. Zhang et al., "A real-time auto-adjustable smart pillow system for sleep apnea detection and treatment", IPSN '13

Where Am I?: Indoor Localization with Sensor Networks

- **Objective:**
  - Use cooperative and/or non-cooperative techniques to locate objects inside a restricted environment
  - Fine-grained localization
- **Challenges:**
  - Spatio-temporal granularity and accuracy
- **References**
  - P. Bahl and V. N. Padmanabhan, "RADAR: An In-Building RF-based User Location and Tracking System", INFOCOM '00
  - P. Lazik et al., "ALPS: A Bluetooth and Ultrasound Platform for Mapping and Localization", SenSys '15

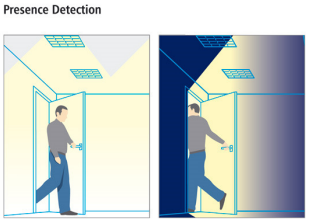


Reverse-GPS Time Synchronization for Localization

- **Idea:**
  - Time Synchronization is needed in many sensor network applications
  - Reverse-GPS is used for wildlife tracking applications, nodes are very low power
  - Packet transmission is cheaper than packet reception
- **Objective:**
  - Implement a reverse-GPS time-synchronization protocol
- **References**
  - A.W. Weiser et al., "Characterizing the Accuracy of a Self-Synchronized Reverse-GPS Wildlife Localization System", IPSN '16 Best Paper
  - http://www.tau.ac.il/~stoledo/Bib/Pubs/accuracy-ipsn16-ieee-copyright.pdf

Occupancy Detection

- **Idea:**
  - Count the number of people present in an enclosed area
  - Can be used to manage resources, dynamic crowd control, detect unwanted presence etc.
- **Objective:**
  - Use Radio Tomographic Imaging (or any other sensing technology) to count the number of people present in an area
  - Convey this information to a centralized service.
- Reference:
  - J. Wilson and N. Patwari, "Radio Tomographic Imaging with Wireless Networks", IEEE Transactions on Mobile Computing, 2009.



Distributed Audio

- **Objective:**
  - Build a low-cost wireless distributed audio platform
- **Challenges:**
  - Time-Synchronization
  - Bandwidth limitations
  - Effects on the sound output due to the distance between nodes
  - Communication latency?
  - Buffering sound samples?

Multi-Node Voice Communication

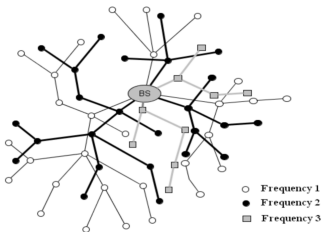
- **Objective:**
  - Build a short-distance communication system, that can have multiple participants talking to each other
- **Challenges:**
  - How do you effectively know which users are on the network?
  - How do you dynamically configure the network as people move around?
  - What sort of network topology/hierarchy may be required?
  - How do you allow multiple users to communicate simultaneously without using excessive bandwidth?

Effective Sleep Scheduling for Sensor Networks

- **Objective:**
  - Save energy consumed by both computation and packet transmission
  - Use a energy-saving scheduling scheme like ES-RMS/ES-RHS+
  - Implement an effective packet transmission schedule that is energy-efficient
- **Challenges:**
  - How do you control task execution to save energy?
  - How do you ensure that the energy-saving scheduling scheme does not effect network performance?
  - Compare the trade-offs involved
- **References**
  - http://www.andrew.cmu.edu/user/agr/pubpg/rtss-rhs-08.pdf

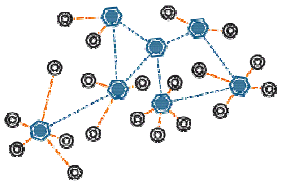
Multi-Channel Routing

- **Objective:**
  - Develop a multi-channel routing protocol to improve network bandwidth and avoid collisions
- **Challenges:**
  - Spatio-temporal granularity and accuracy
  - Synchronize sensor nodes to update channel switching information
  - Design an algorithm to allocate channels
- **References**
  - W. Yafeng et al., “Realistic and efficient multi-channel communications in wireless sensor networks”, INFOCOM ‘08



Distributed Sensing and Actuation Framework for Sensor Networks

- **Idea:**
  - Timestamps enable us to derive a happens before relationship between events.
  - Timestamping accuracy limits the granularity to which we can order events
- **Objectives:**
  - Design a framework for distributed sensing and actuation.
  - Provide the ability to annotate sensor values with their corresponding timestamps with the associated timing accuracy.
  - Provide the ability to perform actuation at a future time
  - **Requirement:** Implement a network-wide time-synchronization protocol



Summary

- **Project schedule**
  - Plan ahead and work early to meet the timeline
- **List of projects**
  - Form your teams
  - Choose your project (First-come first served)
- **Schedule meetings with mentors**
  - Define project scope
  - Negotiate extra credit options
  - Develop list of deliverables