Course Syllabus
Course number: EE 652/CSCI 652
Low-Power Wireless Networks

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Catalogue Description
Implementation of low-power wireless protocols for medium access, scheduling, multi-hop routing, congestion control, localization, and synchronization. IP stack for the Internet of Things. Wireless sensor network applications. Prerequisite: EE/CSCI 450; recommended preparation: CSCI 402, strong programming skills, and experience with Linux.

Enrollment & Prerequisites
A key prerequisite for this course is EE/CSCI 450 (Intro to Networks). Students are expected to have strong programming skills (C/C++). It is recommended that they have taken CSCI 402 and have experience with Linux.

Course Goals
From this course, students will gain a thorough introduction to the area of low power wireless networks. Low power wireless networks such as wireless sensor networks are unattended distributed systems consisting of large numbers of inexpensive devices – each capable of a combination of sensing, communication and computation. Such networks are expected to be deployed in high densities in order to obtain detailed information about the operational environment, forming the next-generation Internet of Things. Sensing applications of low power wireless networks range from environmental monitoring and seismic studies to mobile target tracking.

Low power wireless networks provide a fundamentally new set of research challenges – involving design and analysis of self-configuration protocols and distributed algorithms that are energy-efficient, fault-tolerant and scalable. This is a new and rapidly developing research area
with many open problems of cross-disciplinary interest. The course aims to provide students with
a comprehensive introduction to this area, an in-depth understanding of low-power wireless
networks, and a training in programming and implementing protocols for these systems. Students
will also have an opportunity to contribute to this area through the publication of results from the
required group research project for this class.

Students will critically examine recently proposed mechanisms for the deployment and spatio-
temporal configuration of wireless embedded devices, energy-efficient and throughput-efficient
data gathering, handling challenging wireless link conditions, localization and time
synchronization, etc. Through this course students will learn how to design and analyze such
mechanisms for different application-specific contexts.

A substantial emphasis will be placed on software implementation. All students are expected to
learn how to program wireless sensor motes using Contiki and run simulations using COOJA.
Prior experience with programming is essential.

This course also aims to train students in the craft of academic research. Substantial emphasis will
be placed on reading research papers in a critical and analytical manner. Students will be required
to turn in regular written critiques of papers. There will be in-class discussion of 2-3 papers many
weeks of the semester.

The final project (see below for details) will be closely monitored through out-of-class meetings
and emails, and will span the full research cycle – from problem formulation to obtaining &
analyzing results to paper writing.

**Course Outline**

The following are the key topics we will be covering in the paper readings and in-class lectures
and discussions.

1. Sensor network: vision, state of the art, and applications  
2. Introduction to Contiki  
3. Wireless Link Quality  
4. Routing and Dissemination  
5. Time Synchronization  
6. Time and Frequency Scheduling  
7. Low Power Medium Access  
8. Congestion / Rate Control  
9. Localization  
10. Mobility

The readings will be assigned in class on a weekly basis and will typically consist of academic
papers available from the Internet.

**Assignments and Research Project**

- There will be 2-3 programming assignments given in the first eight weeks of the course. They
  are presented in increasing order of difficulty.
After the initial period of programming assignments designed to make them competent at programming wireless embedded devices, the students will focus primarily on the research project.

Besides the weekly lectures, critiques, and discussion, a large component of the course will be a substantial research project on sensor networks. This project typically starts 6 weeks before the end of classes.

The projects are to be done in groups of two to three students.

The instructor often suggests some possible topics, but the students are free to propose something on their own so long as a) it involves significant innovation in terms of protocol design or enhancement, and b) it involves significant effort to implement and evaluate. Typical projects from past years include:

- Design and evaluation of a novel time-synchronization mechanism suitable for long-propagation delay environments
- Design and implementation of full indoor localization service
- Implementation and experimental evaluation of a MAC protocol enhancement for scalable data collection from IEEE 802.15.4-based embedded devices
- Design and evaluation of a distributed rate control protocol that works with backpressure-based collection
- Design and experimental validation of a virtual queue-based enhancement for the BCP routing protocol to eliminate trapped packets.

There will be multiple checkpoints for the projects such as:

- Initial proposal (1 week into the project)
- Team meetings with instructor (mandatory for the first 2 weeks to get feedback on and help formulate directions; thereafter, as needed.)
- Mid-term oral and written progress report (3 weeks into the project). These are worth 25% of project grade
- Final oral presentations (~6 weeks into the project). Each team member must present equally. These are worth 25% of the project grade.
- Written final reports (due at the end of the semester; 6-7 weeks after the project is initiated). Format: 8 pages, double-column, single-spaced 10-11 pt., similar to a peer-reviewed paper, including sections for introduction, related work, problem formulation, detailed descriptions of design/enhancement, experimental evaluation, and conclusions. In addition, each group submits a signed document indicating how the work in the project was shared among individual members of the group, and all code development and data obtained as part of the project. These are worth 50% of the project grade.
Grading Policy

In this advanced course, it is expected that all students will be motivated, responsible for their own learning, and participate actively. Each student must present and participate actively in the discussions each week in class, complete all assignments in a timely manner, and contribute significantly to the group research project. The course grading policy is accordingly as follows:

- Assignments & Presentations: 50%
- Research projects: 50% (25% of this is for mid-term oral and written reports, 25% of this is for final oral report, 50% of this is for final written project report.)

Statement on Academic Conduct and Support Systems

Academic Conduct
Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards [https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/]. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [http://policy.usc.edu/scientific-misconduct/].

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity [http://equity.usc.edu/] or to the Department of Public Safety [http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us]. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men [http://www.usc.edu/student-affairs/cwm/] provides 24/7 confidential support, and the sexual assault resource center webpage [sarc@usc.edu] describes reporting options and other resources.

Support Systems
A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute [http://dornsife.usc.edu/ali], which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs [http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html] provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information [http://emergency.usc.edu] will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.