Carleton University

Department of Systems and Computer Engineering

SYSC 5801 ***Wireless Sensor Networks*** ***Winter 2018***

Course Outline

Instructor*: Thomas Kunz, CB 5202, 520-2600 x3573, tkunz@sce.carleton.ca*
Office Hours: Tuesdays 2-3 pm

This course presents an in-depth study on protocols designed for Wireless Sensor Networks (WSNs). The course exposes students to existing WSN applications and the research efforts being undertaken in this field. Theoretical analysis and factors influencing protocol design are also highlighted. The course explores state-of-the-art protocols for WSNs. Moreover, the synchronization and localization problems in WSNs are investigated along with existing solutions. To apply these concepts, students will work on two assignments, using Cooja, the simulator that comes with Contiki. Contiki styles itself as the Open Source OS for the Internet of Things.

Resources: the course heavily draws on the following textbooks:

- *Fundamental of Wireless Sensor Networks: Theory and Practice*, by Waltenegus Dargie and Christian Poellabauer , John Wiley & Sons 2010 ISBN 978-0470997659
- *Wireless Sensor Networks*, by Ian F. Akyildiz and Mehmet Can Vuran, John Wiley & Sons 2010, ISBN 978-0-470-03601-3.
- *Protocols and Architectures for Wireless Sensor Networks*, by H. Karl and A. Willig, Wiley, May 2005

None of them is mandatory for the course, I will post my lecture slides on the course website, http://kunz-pc.sce.carleton.ca/sysc5801/, as well as other reference material. I will also post marks, etc. on this webpage.

Prerequisites: EACJ 5607 (ELG 5374) or SYSC 5201 (ELG 6121) or permission of the Department. Note that having a prerequisite means that I will expect that you know the basics of data networking. For example, questions on the final exam could be drawn from the prerequisite knowledge.

Marking Scheme: The course is offered as a research-centric course, requiring significant student participation. There are two assignments during the term worth 15% each, one in-class presentation (worth 10%), a final exam (20%) and a course project report, worth 30%. All documents have to be submitted as PDF files (softcopies via e-mail to tkunz@sce.carleton.ca), and follow certain formatting guidelines (in particular length and font size limitations). See below for a discussion of these requirements. This marking scheme will be normative (i.e., your final grade will be determined by the various components described here, no late deadlines will be granted nor is there room for additional make-up work after the term to improve your final grade).

Due Dates: A project proposal is due in class on Wednesday, February 28 at 5 pm. The first assignment will be handed out in class on Wednesday, January 31, due Wednesday, February 14 at 5 pm. The second assignment will be handed out Wednesday, February 28 and is due Wednesday, March 14 at 5 pm. Note all submission deadlines are well before class, to avoid any conflicts. You need to submit your work by e-mail, and the timestamp of your e-mail will determine whether you submitted on time.

	Due Date	Weight
Assignment 1	February 14, 5 pm	15 %
Project Proposal	February 28, 5 pm	10 %
Assignment 2	March 14, 5 pm	15 %
In-class Presentation		10 %
In-class Final Exam	March 26	20%
Final Project Report	April 11, noon	30 %

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You will be asked to give an in-class presentation in March, schedule to be determined after the Winter break. The final project report is due Wednesday, April 11, by noon, again to be submitted electronically to tkunz@sce.carleton.ca).

Assignments: Depending on the class size, assignments and course projects may be done in groups or individually. I will make a final decision the latest by the last day to register for courses (January 19). In the assignments, we will use Cooja, the network simulator that comes with Contiki, to emphasize specific WSN protocol challenges. These assignments will require you to design simulation experiments, run them, collect the data, and analyze the results. In your submissions, you should describe your scenarios, what outcomes you were expecting, the results you collected, the explanation of why you obtained the results you got, and discuss to what extent these results confirm or contradict your initial assumptions. We will discuss this process to some extent in class before the first assignment.

The assignments will require you to use an existing simulator. I will not expect that you make substantial changes to it though. As the first assignment is not handed out until end of January, you should use that first month to download and learn Cooja: how it works, how to run simulations, how to collect data in files and how to post-process them. The more time you spend up-front learning about Cooja, the more time you will have later in the course to work on the core assignment problem, rather than dealing with "tool issues".

The easiest way to use Cooja is to download the Instant Contiki distribution from http://www.contiki-os.org/start.html. Once you have the software installed (preferably as a virtual machine), you can explore some of the examples provided in the `contiki/examples` directory. Ideally, before the first assignment is handed out, you should be able to do the following (using the example from the Getting Started page):

1. Run the simulation repeatedly, using a different random number seed
2. Store the simulation output in a textfile
3. Extract information from these trace files, such as:
    a. Total number of data packets sent
    b. Total number of data packets received (per node, in total)
4. Average these metrics for the number of runs and determine the 95% confidence interval (requires certain assumptions about the number of repetitions and the appropriate use of basic stats skills)

In-class Presentation: as a graduate student, you will be expected to give short presentations, either to present your work at a conference, or during your thesis defense, etc. To practice this, you will be asked to give a presentation in class, where you pick a topic, research a recent paper (or set of papers), and present and critique their work. The presentations will be brief (about 20 minutes). You can present on a problem related to your course project (see below) or select a completely different topic. The only two rules for a topic are that

1. The problem studied in the paper is clearly related to the course content
2. The paper or papers you choose were published in a major conference or journal and appeared within the last year. If you are unsure whether a specific publication qualified, please check with me.

Project: 50% of your mark will be determined by a course project. The goal of the project is to explore a technical concept related to the course, present the results in a cohesive format, and suggest in-depth a research project that would extend the reviewed state-of-the-art. The work should aim to explore previously unknown facts/insights. To ensure that students are on the right track, I require a 2-page proposal (submitted by e-mail) by February 28 the latest. This proposal should outline the suggested topic and why it is relevant to the course, provide the suggested structure of the final report, and list references to be used in the research.
The final report is limited to at most 15 pages (counting everything). The following points should be kept in mind when researching project topics:

- Use publicly available references, academic journals, conference proceedings (I expect each final report to be based on at least 8 articles that appeared in traditional academic venues, plus references derived from the WWW and other sources), the majority of which were published within the last two years (i.e., 2011 or later).
- Projects should not "rehash" course content: assume that everything discussed in the course, as demonstrated by the course notes, is known to a reader of the report.
- Reports and suggested research should focus on **technical** issues, not marketing hype/business cases.

The submissions have to use 11pt fonts or larger, printed single-sided with 1in margins all around. The text may be typeset single-spaced. Some other formatting requirements are:

- Cover page, table of content, abstract, and reference list are mandatory for the final report.
- The review of the related work should not exceed 7 pages, with the rest reserved for the introduction and motivation, the research proposal, suggested solutions, how to test/validate your idea, expected outcomes, etc. This includes a discussion of the experiments, results, and their analysis (including a comparison to related work).

Failure to adhere to these requirements will result in a loss of up to 30% of the project mark.

Plagiarism and Cheating: Plagiarism and cheating at the graduate level are viewed as being particularly serious and the sanctions imposed are accordingly severe. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy. The Policy is strictly enforced and is binding on all students. Plagiarism and cheating – presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student – weaken the quality of the graduate degree. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; and/or a reprimand; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course.

Accommodations: You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

- Pregnancy obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://www2.carleton.ca/equity/
- Religious obligation: write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://www2.carleton.ca/equity/
- Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable) at http://www2.carleton.ca/pmc/new-and-current-students/dates-and-deadlines/

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www2.carleton.ca/equity/

Course Outline

Course Outline (tentative):

- Introduction
- WSN Survey
- Intro to Contiki and Cooja
- Factors Influencing WSN Design
- Network Protocol Stacks
- Medium Access Control Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Cross Layering
- Topology Control
- Clock Synchronization
- Localization