Course Description: 6.885
Distributed Algorithms for Mobile Ad Hoc Networks

1 People and places

Instructors: Prof. Nancy Lynch, 32-G668, MIT extension 3-7225, lynch@csail.mit.edu.
Available after class and by appointment.
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Course secretary: Joanne Talbot Hanley, 32-G672A, MIT extension 3-6054, joanne@csail.mit.edu.

Class meetings: Tuesdays and Thursdays, 11:00AM-12:30PM in room 3-370.

Web site and mailing list: We will set up a course mailing list. Please send email right away to Joanne, at joanne@csail.mit.edu, to join this list.
The course Web site is at URL http://stellar.mit.edu/course/6/fa08/6.885/. This site will contain downloadable copies of course handouts and related research papers, lecture notes and slides, and other information about the course.

2 What this course is about

This course will cover distributed algorithms for mobile (and some non-mobile) wireless ad hoc networks, including networks with interesting interactions with the real world. We will focus on algorithms that can be described precisely, and that have relatively well-defined correctness, fault-tolerance, and performance guarantees. Our aim is to understand the existing theory of wireless network algorithms and contribute to its further development. Thus, we would like to:

- Understand the nature of wireless ad hoc network settings. What are typical correctness, reliability, and performance properties that can be assumed? What are the “right” complexity measures to use for evaluating algorithms?
- Identify important, well-defined problems and subproblems that must be solved by distributed algorithms in wireless ad hoc networks. These will include problems of communication at various levels, time synchronization, localization, network configuration, resource allocation, tracking, data management, and coordination of mobile devices.
- Learn about the most important existing algorithms for many of these problems, and identify places where additional algorithmic work is needed.
- Identify some inherent limitations (lower bound and other impossibility results) on the solvability of problems in wireless networks.
- Identify useful abstraction layers for programming wireless networks.
The course is aimed at theory-of-computing graduate students with a strong interest in mobile ad hoc networks, and at graduate students working in systems and application areas who are interested in algorithms, analysis, and other theory.

We will proceed roughly through the “layers” of a wireless network design:

**Part I: Basics**
- Physical layer
- MAC layer
- Time synchronization
- Localization

**Part II: Communication**
- Global broadcast
- Point-to-point routing without location information
- Capacity of wireless networks
- Location services
- Point-to-point routing with location information

**Part III: Building and maintaining network structures**
- Topology control
- Clustering
- Unit-disk graphs and related models
- Wakeup problem
- Maximal independent sets, coloring, etc.

**Part IV: Middleware**
- Local infrastructure: local groups, local consensus, local reliable broadcast, etc.
- Token circulation, leader election, resource allocation, group communication
- Compulsory protocols
- Virtual node layers

**Part V: Applications**
- Data aggregation
- Population protocols
- Computing properties in mobile networks
- Implementing atomic memory
- Robot and vehicle motion coordination
3 Prerequisites

6.885 is intended for graduates students who might carry out research in the general area of the course. Undergraduates should get permission of the instructor to sign up.

To take 6.885, you should have:

- “Mathematical maturity”. In particular, you should be very good at reading and understanding mathematical definitions, proofs, and complexity analysis.
- General knowledge about some distributed systems. For instance, MIT’s undergraduate course 6.033, Computer Systems Engineering, would be good background.
- Experience with sequential algorithms and their analysis. MIT’s undergrad course 6.046 is sufficient.
- (Desirable, but not essential) Experience with distributed algorithms, as in MIT’s course 6.852.

We do not expect any particular knowledge of wireless networks or wireless network algorithms.

4 Source material

The course will be based on a collection of research papers, listed in Handout 3. We will put instructions for obtaining these on the course Web site.

The following book may provide useful background on the basics of mobile ad hoc networks. We are placing it on reserve in the Barker Library.


Prof. Nitin Vaidya, of the University of Illinois, is writing a set of notes for his spring 2009 course on (practical) wireless communication. He has agreed to make paper copies available to students in our class. Prof. Hari Balakrishnan also has some notes for this networking course, and will make the relevant lectures available to us.

5 Course requirements

We will be reading and discussing a lot of papers. Students in the class will be required to read one or two papers before each class, to participate in the class discussions, and to answer basic questions about the readings (in “mini-problem-sets”).

Each student will also help in presenting one of the course topics in class, and will carry out a term project focusing on one of the topics.

5.1 Readings and class participation

Readings that cover the material for each class will be announced ahead of time. These will be a collection of research papers on a particular topic, with one or two singled out as “must-read” and the others optional. We expect you to read the papers before class, and to come to class prepared with questions and discussion ideas.

Remember, the purpose of the course is to understand the existing theory for mobile ad hoc network algorithms and contribute to its advancement. We would like to reach consensus on some “design decisions” for this theory. Thoughtful class discussions will be critical to the success of this effort.
5.2 Lectures and slides

Some of the lectures will be presented by Prof. Lynch and Dr. Kuhn, and perhaps some by guest lecturers. The remainder of the lectures will be presented by students in the class. Students will work either individually or in teams of two (depending on students’ preferences and on the number of students in the class). The student(s) presenting a topic will usually need to read more papers on that topic than the rest of the class, in order to obtain enough perspective on the topic. We expect that you will prepare your presentation using Powerpoint. You must make your slides available after class for posting on our course web site.

When presenting a topic, you should not try to cover all details of the selected papers. Rather, you should try to understand what is important about the topic, bringing in material from the papers as needed to explain the main ideas. You may want to focus on particular parts of the papers, such as the key ideas of a particularly interesting proof, or a crucial assumption about the physical environment that affects the correctness of an algorithm.

Student presenters should make an appointment to meet with a member of the course staff a few days before their presentation, to show how they are planning to present the material.

5.3 Term projects and presentations

You are also required to carry out a term project, which should involve developing some new ideas on some particular topic in the scope of this course. This will involve producing a paper (of approximately 10-12 pages in 11 point font) and presenting the ideas at a final presentation session (a mini-symposium) during finals week.

You have great leeway in deciding on the topic; we encourage creativity! You might design an improved algorithm for a problem covered in class, or invent a new problem and an algorithm to solve it. You could try to prove an impossibility result. You could come up with a new model and explore its power. To save work, you might choose to carry out a term project in the same area as that of your class lecture, but this is up to you.

The project should be at least somewhat theoretical in nature. To emphasize this, we require that the term project paper contain at least one theorem (however small).

Your term project can be individual, or can involve a team of two students. A project proposal and a status report will be due before the final project due date.

Possibly-useful software: MEng Student Mike Spindel has produced a simulator for simulating mobile network algorithms. This may be useful to you for debugging and evaluating algorithms for your project. It does not run particularly quickly, but it is pretty easy to get something working (you write your algorithms in Python). It has special support for virtual nodes, (of a particular kind), but also works for ordinary non-virtual-node-based mobile network algorithms. Detailed information appears at https://carbide.mit.edu/trac/vne.

5.4 Mini-problem sets

We will assign questions and problems, mainly intended to encourage everyone to keep up with the readings. We do not intend these problem sets to take much time, nor to go much beyond the actual ideas in the papers. Specifically, a few (two or three) questions will be assigned every Thursday and will be due the following Thursday. (Note exceptions to these rules on the course schedule, Handout 2.) There will be a total of ten problem sets. No late homeworks will be accepted. If you haven’t finished, just hand in what you have completed. Each problem set should be no longer than two pages long.

Policy on homework collaboration: You are encouraged to discuss problems and solutions with other class members. You may also discuss them with anyone else you choose. However, you must always write up the solutions entirely on your own. Of course, be sure to acknowledge any people or written source material that provide you with substantial help.

Replacements for problem sets: Sometimes you will have an interesting idea related to the course material for
a particular week—a more interesting idea than what is covered by the problem assignment for that week. In this case, you may hand in a writeup of your ideas instead of solutions to the assigned problems for that week.

5.5 Exams

There will be no exams. However, we will use the final exam time slot for the project presentation mini-symposium.

5.6 Course grade calculation

Your course grade will be based on participation in class discussions, quality of lecture presentation and slides, quality of term project and presentation, and grades on mini-problem-sets. Here is how your grade will be calculated:

- Class participation (attendance, quality and quantity of participation): 20%
- Lecture and slides: 30%
- Term project and presentation: 30%
- Mini-problem sets: 20% (2% for each set)