

EEC 687/787.50 Mobile Computing Spring 2007

Time and location: MW 2 – 4 pm, Room SH 306

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Room: SH 437
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Instructor office hours: TR 4 – 6 pm or by appointment

Objectives

EEC 687/787 Mobile Computing (4-0-4). Prerequisite: EEC 584. Mobile computing and wireless networks are new and dynamic areas of research and development. The rapid advances in miniaturization of computing devices and "untethered" communication technology, together with the increasing demands for ubiquitous access to information, have introduced new challenges as well as new opportunities in many traditional areas of computer science and engineering. In this course students will have a comprehensive overview of mobile computing and wireless networks. Through homework assignments, they will learn how to design and evaluate new mobile network solutions. Topics covered: Protocols for wireless networks (CSMA/CA, Mobile IP, Mobile ad hoc network routing algorithms, and Mobile TCP), IEEE 802.11 (PHY/MAC for WLAN), ns-2 network simulator.

Prerequisites

This will be a fast-paced course that covers both the theoretical background and the practical issues of mobile computing and wireless networks. The algorithmic and programming background required is C, C++ and script languages such as Tcl and Awk. A basic knowledge of computer networks and operating systems will be required. Prerequisites by topic: Computer networks, TCP/IP protocols, Digital communication.

Course requirements

Course requirements include four homework assignments, mostly programming assignments based on ns-2 network simulator. Students will form a group of two for class project, which consists of four stages and must involve ns-2 simulation. The first stage of the project is to form a group and choose a topic from the suggested subjects. For the project, you need to review about at least twelve papers to understand what

other researchers have already done in the chosen area as well as to appreciate good research in mobile computing and wireless networks. There will be many (pop) quizzes but no midterm/final examinations.

Course materials

References:

- "Mobile Communications, Second Edition," Jochen Schiller, Addison Wesley, Second Edition, 2003.
- IEEE Std 802.11-1999, Local and Metropolitan Area Network, Specific Requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.
(<http://standards.ieee.org/getieee802/download/802.11-1999.pdf>)
- Wireless and Mobility Extensions to ns-2 (http://www.isi.edu/nsnam/ns/doc/ns_doc.pdf).
- Principles of Wireless Networks, by K. Pahlavan and P. Krishnamurthy, Prentice Hall PTR, 2002.
- Wireless Communications and Networks, W. Stallings, Prentice Hall, Inc., 2002.
- Ad Hoc Networking, edited by C. E. Perkins, Addison-Wesley, 2001.

Grading

- 30% Homework assignments (individual, four – 5 or 10% each)
- 40% Project (group of two, four stages – 5%, 10%, 5%, 20%)
- 30% Quiz (pop quizzes)
- Project #4 is graded based on reviews by peers as well as the instructor

Collaboration

I strongly encourage you to discuss any topic with other students. However, when the time comes to write the homework or program, such discussions are no longer appropriate---the solution or program must be your own. Do not copy another person's homework or program under any circumstances. To do so is a clear violation of ethical/academic standards that, when discovered, will be referred to the school administration for disciplinary action.

Late homework/project policy

A homework/project that is not completed and turned in the beginning of the due date class will not be graded.

Homework assignments (Tentative)

Homework #1: Physical layer (due Feb. 5 M)

Goal: Ns-2 supports three different radio propagation models: Free-space model, Two-ray ground model and Shadowing model. Free-space model is used when distance is shorter than reference distance and Two-ray ground model is used otherwise. Shadowing model is more realistic but a non-deterministic model in the sense that the received signal strength not only depends on distance but also on random noise. What is the effect of radio propagation model on network performance with the standard ad hoc network scenario in ns-2 (50 nodes, 300x1500m network area, 802.11, AODV, 20 CBR sources, two 256-byte packets/second, maximum node speed 5m/s, pause time of 100 seconds, simulation time of 900 seconds)? Shadowing model includes parameter(s) to determine the level of randomness. Investigate the performance changes with different values of the parameter(s).

Output: Simulation report including excel charts with explanation and discussion. Measure the PDR and delay versus node mobility in terms of pause time (0~900 seconds). Consider also to measure different metrics such as signal strength or point-to-point delivery ratio versus distance.

Bonus: Investigate whether RTS/CTS exchange is an important factor in this regard? In other words, how does 802.11 MAC perform with and without RTS/CTS (how do you deactivate RTS/CTS exchange?) when using different propagation models?

Homework #2: PHY/ Routing layer (due Mar. 19 M)

Goal: Noise in received signal strength causes a wireless link unstable and "asymmetric." In other words, under static environment, a live wireless link at some particular point of time may be found broken at a later time. It is also possible that a link is usable in one direction but not the other way around. Does any of the routing algorithms supported in ns-2 (AODV, DSR, DSDV, and TORA) work well with asymmetric and unstable links? Prove your claim using ns-2 simulation.

Output: Simulation report including excel charts with explanation and discussion. Measure the PDR and delay versus node mobility in terms of pause time

(0~900 seconds). Consider also to measure different metrics such as the number of route discoveries or RERR messages generated in case of DSR/AODV.

Bonus: Discuss how you can improve those network protocols to accommodate asymmetric and unstable links.

Homework #3: PHY/Routing layer (due Mar. 19 M)

Goal: This is a continuation of Homework #2. From the network software's perspective, asymmetric or unstable links are considered as temporary link breakages. This motivates consideration of non-deterministic routing solutions, where temporary link breakages can be handled on a temporary basis, *i.e.*, a routing path is pre-calculated but can optionally be determined on-the-fly when the primary path is not available. In DSR, an optimization technique known as "packet salvaging" is used so that the node encountered the forwarding failure may search its local storage for alternative routes. If a route is found, it is used to forward the undeliverable packets without resorting to an expensive route-discovery procedure. The "local repair" mechanism in the AODV routing protocol does a similar thing. DSR and AODV would suffer without these features (how can they be deactivated) but they suffer more when there are asymmetric links. Discuss for or against this claim and show it via ns-2 simulation.

Output: Simulation report including excel charts with explanation and discussion. Consider measuring different metrics such as average packet queue size in mobile nodes and the number of packets salvaged other than PDR and delay.

Homework #4: TCP layer (due Apr. 16 M)

Goal: TCP performance is critically limited in wireless networks simply because TCP has been designed for wired networks. The most important fact is that TCP regards packet loss as congestion and takes some necessary actions mostly targeted to generate less traffic. However, in wireless networks, packet loss is often due to node mobility and the network is able to function normally as soon as a new route is established because there was no congestion from the beginning. One recent paper showed that TCP performance can be greatly improved in wireless networks by reducing the congestion window. The goal of

this homework is to investigate the TCP performance with different congestion windows size via ns-2 simulation.

Output: Simulation report including excel charts with explanation and discussion. Show throughput instead of PDR because PDR is just for CBR traffic.

Bonus: Show the variance of throughput in addition to average throughput in order to see that TCP performance is balanced. It will be interesting to see the TCP performance versus hop count because TCP performance depends on the hop count between two end nodes. It is also interesting to reveal the instantaneous TCP performance since it is known that TCP performance fluctuates over time in a significant way.

Class Schedule (Tentative)

Date	Topic and reading	Assignments due (in class)
Week 01: Jan 17 W	Course overview	
Week 02: Jan 22 M Jan 24 W	Physical layer issues Reading: J. Schiller, "Wireless transmission," Ch. 2 Bonsall, A., Wang, D., and Stancil, D. D. Propagation Model Embedded in a Wireless Network Simulator. <i>The 3rd Annual Wireless Communications Conf</i> , 1998. Ns2 manual, "Radio Propagation Models," Ch. 18 (http://www.isi.edu/nsnam/ns/tutorial/nsindex.html). Ns-2 lab: Download, compile, run, summarize Reading: <u>Wireless and Mobility Extensions to ns-2</u> (http://www.isi.edu/nsnam/ns/tutorial/nsindex.html). Ns2 manual, "Trace and Monitoring support," Ch. 23 Ns2 manual, "Mobile networking in ns," Ch. 16	
Week 03: Jan 29 M Jan 31 W	Medium access control Reading: J. Schiller, "Medium Access Control," Chapter 3 Kammerman, A., and Monteban, L. WaveLAN-II: A High-Performance Wireless LAN for the Unlicensed Band. <i>Bell Labs Technical Journal</i> , Summer 1997 Ns-2 lab: General simulation – Mobility file, traffic file, alternatives	
Week 04: Feb 5 M Feb 7 W	IEEE 802.11 MAC Reading: J. Schiller, "Wireless LAN," Chapter 7.3.1~7.3.4 802 spec, "General description," Ch. 5 802 spec, "MAC service definition," Ch. 6 802 spec, "Frame formats," Ch. 7	Project #1 HW #1
Week 05: Feb 12 M Feb 14 W	IEEE 802.11 MAC management Reading: J. Schiller, "Wireless LAN," Chapter 7.3.5~7.3.8 802 spec, "MAC sublayer functional description," Ch. 9 802 spec, "MAC sublayer management entity," Ch. 11	
Week 06: Feb 19 M Feb 21 W	(No class, President's Day)	HW #2
Week 07: Feb 26 M Feb 28 W	Security in Mobile networks	
Week 08: Mar 5 M Mar 7 W	Project presentation	Project #2 (presentation)
Week 09: Mar 12 M Mar 14 W		
Week 10: Mar 19 M Mar 21 W	IP networking and Mobile IP Reading: J. Solomon, "Computer Networking Tutorial," Ch. 2, Mobile IP, Prentice Hall, 1998 J. Schiller, "Mobile network layer," Chapter 8.1~8.2	HW #3
Week 11: Mar 26 M Mar 28 W	MANET Routing Reading: J. Schiller, "Mobile ad hoc networks," Chapter 8.3	
Week 12:	Multicast in mobile networks	Project #3

Apr 2 M Apr 4 W		
Week 13: Apr 9 M Apr 11 W	Network reliability (TCP) in Internet Reading: J. Schiller, "Mobile transport layer," Chapter 9.1	
Week 14: Apr 16 M Apr 18 W	Network reliability (TCP) in mobile networks Reading: J. Schiller, "TCP over mobile networks," Ch. 9.2~9.3	HW #4
Week 15: Apr 23 M Apr 25 W	Mobile/Embedded systems Mobile Applications	
Week 16: Apr 30 M May 2 W	Project presentation	Project #4 (presentation)