University of Maine, School of Computing and Information Science

SIE559 Geosensor Networks

Silvia Nittel

Contact Information:

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Office Hours:

Office hours for this course will be announced at the beginning of the semester. Alternatively, contact me by email to arrange a time to meet.

Course Description

In the last 15 years, several technology trends have influenced the field of geosciences in significant ways. The first trend is the more readily available technology of ubiquitous wireless communication networks and progress in the development of low-power, short-range radio-based communication networks, the miniaturization of computing and storage platforms as well as the development of novel microsensors and sensor materials. All three trends have changed the type of dynamic environmental phenomena that can be detected, monitored and reacted to. Another important aspect is the real-time data delivery by novel platforms today. In this course, we will survey the field of geosensor networks, and mainly focus on the technology of small-scale geosensor networks, decentralized adhoc computing and collaboration, example applications and their feasibility and lessons learnt as well as the current research questions posed by using this technology today.

Topics covered:

- Motivation, history and vision
- Platforms
- Data centric routing in wireless sensor networks
- Spatial database management interfaces for wireless sensor networks
- Decentralized, in-network, adhoc collaboration in geographic space
- Geosensor networks applications
- Testbed project

Credits: 3
Prerequisite: Graduate standing, programming experience in Java, C++, or C

Course Texts

This is a graduate course, and the material will be discussed by reading relevant research papers in the different areas.
For an introduction to geosensor networks, see this paper.

Week 1	**From Vannevar Bush to Smart Dust** Vannevar Bush, As we may think, The Atlantic, 1945 Mark Weiser, The Computer for the 21st Century, Scientifican American, 1991 D. Estrin et al.: Connecting the Physical World with Pervasive Networks J.M. Kahn, et al: Next Century Challenges: Mobile Networking for Smart Dust
Week 2	**State of the Art in Platforms** (student group presentations) tiny computing platforms, communication, batteries, sensors, software
Week 3	**Characteristics of software for resource constrained operating systems** • TinyOS, NesC • Contiki • Mantis D. Culler et. al: A Network-Centric Approach To Software for Embedded Devices J. Hill et al.: System Architecture Directions for Networked Sensors G.J. Pottie et al: Wireless Integrated Sensor Networks
Week 4	**Communication in Wireless Sensor Networks** • networking - state of the art (OSI, TCP/IP stack) • communication characteristics of radio based small devices and impact on communication protocols Akyildiz, I.F et al.. A Survey on Sensor Networks A. Woo, et al: Taming the Underlying Challenges of Multihop Routing in Sensor Networks J. Heidemann et al: Building Efficient Wireless Sensor Networks with Low-Level Naming
Week 5	**Data-centric Routing in Wireless Sensor Networks** • novel communication protocols in WSN (data centric routing, geographic routing, rumor routing) D. Estrin et al: Next Century Challenges: Scalable Coordination in Sensor Networks C. Intanagonwiwat, R. Govindan and D. Estrin, Directed diffusion: A scalable and robust communication paradigm for sensor networks Radi M, Dezfouli B, et al: Multipath routing in wireless sensor networks: survey and research challenges. S. Ruehrup, Theory and Practice of Geographic Routing, 2009

Week 6	**Arduino Lab & Discussion of Final Project**
Week 7	**Database Management for Wireless Sensor Networks** • TinyDB • Cougar P. Bonnet, et. al: Towards Sensor Database Systems S. Madden, et al: TAG: Tiny Aggregation Service for Ad-hoc Sensor Networks, 2002. Gehrke, Madden: Query Processing in Sensor Networks, Pervasive Computing, 2004
Week 8	**Geosensor Networks** I • Introduction • Spatial Data Management S. Nittel, A. Stefanidis, I. Cruz, M. Egenhofer, D. Goldin, A. Howard, A. Labrinidis, S. Madden, A. Voisard, and M. Worboys: Report from the First Workshop on Geo Sensor Networks S. Nittel A Survey of Geosensor Networks: Advances in Dynamic Environmental Monitoring, *Sensors* **2009**, *9*(7), 5664-5678; doi:10.3390/s90705664, published: 15 July 2009.
Week 9	**Mobile Geosensor Networks** I • Dynamic Transportation Systems • Habitat Monitoring • Situational Awareness Applications Winter, S., & Nittel, S. (2006). Ad hoc shared-ride trip planning by mobile geosensor networks. *International Journal of Geographical Information Science*, *20*(8), 899–916. doi:10.1080/13658810600816664 Mainwaring, A., Polastre, J., Szewczyk, R., & Culler, D. (2002). Wireless Sensor Networks for Habitat Monitoring. In *Proceedings of the 1st ACM International workshop on Wireless Sensor Networks and Applications* (pp. 88–97)
Week 10	**Monitoring Continuous Phenomena in Geosensor Networks** I • Quantitative Monitoring of Continuous Phenomena S. Nittel, G. Jin, Y. Shiraishi, In-Network Spatial Query Estimation in Sensor Networks, IEICE Transactions (A), Vol.J88-A, No.12, pp.1413-1421, December 2005.
Week 11	**Monitoring Continuous Phenomena in Geosensor Networks** • Qualitative Monitoring of Continuous Phenomena • Tracking Topological Changes of Continuous Phenomena M. Duckham, S. Nittel and M. Worboys :Monitoring dynamic spatial fields using responsive geosensor networks,ACM-GIS 2005, Bremen, Germany, November 2005. C. Farah, C. Zhong, M. Worboys and S. Nittel, Detecting Topological Change using Wireless Sensor Networks, *GIScience*, Park City, Utah, September 2008.

	G. Jin and S. Nittel, Efficient tracking of 2D objects with spatio-temporal properties in wireless sensor networks, *Journal of Parallel and Distributed Databases,* Vol 29(1-2), pp.3-30. February 2011
Week 12	***Thanksgiving***, break
Week 13	**People as Sensors** • Citizen Science and geosensor networks • Collective Sensing Campbell, A. T., Eisenman, S. B., Lane, N. D., Miluzzo, E., Peterson, R. a., Lu, H., … Ahn, G.-S. (2008). The Rise of People-Centric Sensing. In *IEEE Internet Computing* (Vol. 12, pp. 30–39). doi:10.1109/MIC.2008.90 Resch, B. (2013). People as Sensors and Collective Sensing - Contextual Observations Complementing Geo-Sensor Network Measurements. In J. M. Krisp (Ed.), *Progress in Location-Based Services* (Lecture No., pp. 391–406). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-642-34203-5
Week 14	**Ontologies and Geosensor Networks Applications** • Ontologies to extract knowledge from raw data • Ontologies to integrate heterogeneous Geosensor networks
Week 15	Student final project presentations

Textbooks (optional):
Wireless Sensor Networks: An Information Processing Approach, Feng Zhao, Leonidas Guibas, Morgan Kaufman

Embedded, Everywhere. National Academy of Engineering, 2001 (free .pdf)

Reading material, powerpoint slides of lecture material and assignments will be available via Umaine/Blackboard.

Software:

We will use:

- Prototyping with Zigbee and Arduino

Course Goals and Objectives

- Introduce students to concepts of wireless sensor networks.
- Develop an understanding of decentralized, ad-hoc computation and collaboration in geosensor networks

- Learn in particular new advances in the subject areas of geosensor network data management systems.
- Develop skills needed to critically analyze technical literature.
- Get practice designing a research or application project related to geosensor networks
- Practice skills to communicate your ideas to an audience in a presentation or a scientific discussion.

Grading, Class Policies and Course Expectations

As a graduate level course, you are expected to exhibit high quality work that demonstrates sound understanding of the concepts and their complexity. Earning an "A" represents oral and written work that is of exceptionally high quality and demonstrates superb understanding of the course material. A "B" grade represents oral and written work that is of good quality and demonstrates a sound understanding of course material. A "C" grade represents a minimally adequate completion of assignments and participation demonstrating a limited understanding of course material.

Grading criteria:

Assignments and class participation– 60%

Final Project – 40%

Academic honesty

Academic honesty is expected. Plagiarism is unacceptable in this course and will result in a failing grade.

Students with disabilities:

If you have a disability for which you may be requesting an accommodation, please contact Ann Smith, Coordinator of Services for Students with Disabilities (Onward Building, 581-2319), as early as possible in the term.

Extended disruption:

In the event of an extended disruption of normal classroom activities, the format for this course may be modified to enable its completion within its programmed time frame. In that event, you will be provided an addendum to the syllabus that will supersede this version.

UMaine's Sexual Discrimination Reporting:

The University of Maine is committed to making campus a safe place for students. Because of this commitment, if you tell a teacher about an experience of sexual assault, sexual harassment, stalking, relationship abuse (dating violence and domestic violence), sexual misconduct or any form of gender discrimination involving members of the campus, your teacher is required to report this information to the campus Office of Sexual Assault & Violence Prevention or the Office of Equal Opportunity.

If you want to talk in confidence to someone about an experience of sexual discrimination, please contact these resources:

For confidential resources on campus: Counseling Center: 207-581-1392 or Cutler Health Center: 207-581-4000.

- For confidential resources on campus: Rape Response Services: 1-800-310-0000 or Spruce Run: 1-800-863-9909.
- The following resources on campus can offer support but may have to report the incident to others who can help: Office of Sexual Assault & Violence Prevention: 207-581-1406, Office of Community Standards: 207-581-1409, University of Maine Police: 207-581-4040 or 911.

See the OSAVP website for a complete list of services at http://www.umaine.edu/osavp/