Interactive Distributed Embedded Systems

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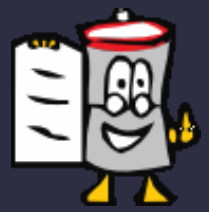
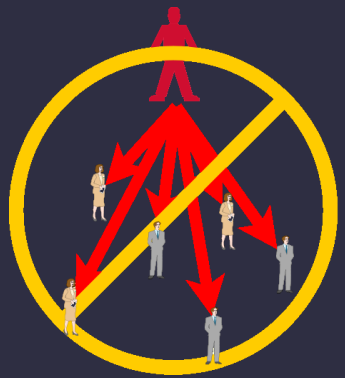

Goals for today's lecture

- Determine topics.
- Overview of embedded applications.
- Embedded system specification.

Outline

Topics I

Can these be posted to the website, or should they be removed from the slides before posting?

Application of networked embedded systems in IBSI (Intelligent Building System Integration) applications.

There are certainly good projects in this area. More detail on what you intend to do will help me make useful comments.

Applications of networked embedded systems in the Intelligent Highway systems.

What goals and technologies do you have in mind?

Applications of networked embedded systems in the military use.

What goals and technologies do you have in mind?

Topics II

Energy-efficient sleep monitor module for smartphones.

There are existing commercial solutions to this problem. What will you do with embedded systems to better solve it? This is clearly interactive. In what way is it distributed?

Cold-preserving auto-heating lunchbox.

Not clear what new embedded system ideas will be needed to solve the problem. There are power consumption and compactness problems but these may be mostly due to heating and cooling elements, not the embedded computer. What clever things can you do with the embedded computer to solve the problem better?

Topics III

Economic wireless multi-agent map building.

What is the "economic" aspect? What technologies will you build upon? There is already work on localization and room detection. I am not aware of work that automatically builds a graph, however. This looks quite promising and could be published in the MobiSys or UbiComp conferences. See work by Yifei Jiang and Stephen Tarzia.

Smart off grid energy management and health monitoring (Fuel Cells, Solar, Battery SOC, Wind, Thermal Electric Generator, Generator).

Good topic. Need to narrow down to more specific problem statement.

Soldier Localization in GPS limited areas.

How does this differ from conventional localization problems? How precise does it need to be?

Topics IV

Robotics swarm for data efficient 3D room mapping.

The key problems here may be in control, and there are a lot of papers on swarm control. If the hard problems are on something other than the embedded computing system, the probability I can help a lot decreases.

Mission critical soldier squad power management.

How does this differ from plain embedded system power management?

Topics V

Efficient low-cost brewery monitoring (fermentation, power usage, refrigeration efficiency).

A prototype during the course may be tractable. What do you need to sense and control? What are the most advanced commercial systems currently available? What are the most advanced research prototypes described in the literature?

Something related to smart home

Too vague to comment on.

Topics VI

Sensor network for monitoring water quality (i.e., for detecting/cleaning up pollutants).

Is their prior work on this topic? What if you want to solve this problem "at the tap"? What reusable sensors are available? What about using gas sensors and allowing outgassing from water in a controlled environment? What are the interactive and distributed components of the project?

System for alerting drivers to open parking spaces.

Are you sure this isn't a solved problem? Five years ago, there was a startup company in Evanston working on this problem. Having a magnetic field sensor in a disposable mote embedded in the pavement ought to work well. Need to make clear why this is an unsolved problem and what new ideas will be required.

Topics VII

System for detecting and reporting falls (for the elderly/disabled).

There are publications and prototypes of this idea already. Start with work by Majid Sarrafzadeh. What are your new ideas?

Topics VIII

Home automation: We can use current smart phone to remotely control some appliances at home in advance to facilitate life under certain situations, say start the shower 10 minutes before back home, or feed the dogs remotely when traveling outside.

This basic idea has been discussed in the research literature for years. There are a number of problems, e.g., (1) retrofitting sensors and actuators, (2) predicting behavior, (3) providing an easy-to-use interface, (4) maintaining and enhancing security, and (5) energy minimization. There is some work on using an RLC model of the house electrical or water system to detect changes in component states from a single sensing point. This topic definitely has potential, but you need to narrow down on a particular problem that hasn't been well solved in the past.

Topics IX

WSN: In some large WSN, power consumption is a problem. To conserve energy, we could turn off certain amount of sensors (or turn them into "sleep mode") while providing enough data through different sensor combinations and advanced algorithms.

The number of publications on wireless sensor networks is shockingly large. The idea of putting some nodes to sleep some of the time has been considered before. There has even been work on routing data in networks composed of nodes without (unreliable) batteries (See Xuejing He's work). What new ideas are you considering?

Topics X

Location-based service application: To deal with traffic jams, we can incorporate sensors in cars that allow cars to send location, speed, and other information to a computing center, the center will utilize all the information to produce an optimized route and speed plan for each car and send to corresponding vehicles.

Why route to a computing center? This could *really* be distributed. What is the potential for improvement in travel time? I can actually answer this reasonably well because Fabian Bustamante and I looked into a related problem a few years ago. At the time, it was unsolved (using distributed solutions) but I am not sure whether that is still the case.

Topics XI

Secure and reliable cyber-physical system network application: In EECS461, we have designed and implemented an adaptive cruise control (i.e. the vehicles on a road can adaptively switch between position control and velocity control according to their relative location), and have done the simulation and rapid prototyping on MPC5553. However, we have not done hardware implementation yet. I propose design two small vehicles tracking a white line on a floor. Human can use Android phone to control their speed in real-time. The two vehicles can broadcast their positions to each other wirelessly. Using this information, the two vehicles can adaptively adjust their control strategies, thus they can intelligently avoid collision with each other. Besides, as the course goes on, we may come up more improvements both theoretically and practically on the system that I havent figured out now (due to the time constraints). I think this project can greatly improve our hands on experience of design automotive distributed embedded system.

This basic idea has already been implemented by UofM graduate students using remote control cars. What new idea will you be considering?

Topics XII

Wireless sensor network: I have done some literature survey on the current design challenges of wireless sensor network. I feel interested in studying replacing the traditional centralized algorithms that collect data from multiple sensor nodes with localized algorithms. And I am especially interested in doing some optimization on the current localized algorithms and do comparison with the localized algorithm in terms of the adaptive cruise control topic I have just mentioned before.

There has been a lot of work on in-network data aggregation and compression, but I expect that there are many important unsolved problems in the area. What sort of sensing application are you considering? Knowing that would help me give relevant suggestions.

Topics XIII

Renewable energy: There has been research on optimizing for particular energy sources, such as wind energy and solar energy. However, I want to view this problem from a system perspective. Specifically, I want to integrate sensors into different kinds of energy sources. The sensors broadcast the environmental condition, such as sunshine and wind speed, to the host machine. The host machine then can use this information to automatically optimize the overall system's energy efficiency.

What is your optimization objective? What are the actuators and sensors in your system? Can you adapt energy-consuming tasks to the current states of energy sources? I don't understand the idea well enough to comment yet.

Topics XIV

Using a smart device that we can convert between text and voice, then by wireless network, transmit the converted information to another smart device.

Is the main problem here text-to-voice translation or wireless data transmission? I don't see what the unsolved problem is here.

Transmit compressed sound or video data by wireless network to different customers who can listen or watch the remote sound or video.

Smartphone users do this now. What technique do you propose that has not been prototyped in the past?

Topics XV

Remote monitoring: When the alarm is triggered, can do remote monitoring of the situation at home.

What are the main challenges here? There are commercial solutions supporting this now, but they are expensive and many are subscription based. What new ideas are you proposing to evaluate?

Carbon footprint monitor for car: This would be a system that uses OB-11 and interfaces with a smartphone to determine carbon emissions in that car and displays it in a interface that a non-technician can use.

Li Shang at University of Colorado has been working on a related problem. See his 2012 Pervasive Computing article.

Topics XVI

AC phase measurement: This would be a small system that plugs into a wall socket and measures the ac phase to determine load.

Phase, alone? That can tell you relative LC components. Can you be more specific about your analysis? Check to see if there was a similar project by Sam DeBruin last year. I believe that theoretical work on this topic was done at CMU two or three years ago, and that it led to a publication.

Topics XVII

Using Raspberry Pi in school networks: this would be a software project to get simple networking software to evaluate how well elementary, middle, and high school networks could be built around Raspberry Pi nodes as the primary student computers.

Aren't 802.11 interfaces typically used for these computers? If so, how does this question differ from "Can 802.11 interfaces be used to support wireless communication?"

Projects to consider I

Whisper

Secure, censorship-resistant, easy-to-use communication using commodity smartphones. See http://whispercomm.com.

Air quality sensing project

Brief discussion of this in previous example. Contact Yun Xiang or me for more information.

Greenhouse production optimization

Use network of wireless sensor to gather information about change in growing environment in response to actuator and external environment state changes. Contact Xuejing He or me for more information.

Projects to consider II

Panappticon

Event tracing infrastructure for Android OS and applications. Allows critical paths of user-observable transactions to be identified. Contact Lide Zhang or me for more information (and preprint).

Outline

Begin study of topics of interest

- Due before class on 14 Jan.
- Use electronic resources, research papers, and questions posted to the mailing list to answer the following questions for each of the three topics of interest, using 3-5 sentences for each.
  1. Why will work on this topic be useful to its users in the next five years?
  2. Is this topic of special relevance to distributed interactive embedded systems?
  3. Identify a potential research project that is related to this topic and can be completed within the time-frame of this course.
- Your one-page report should back up your claims using research, technical, and business publications. It should contain roughly five references.

Continue study of topics of interest

- Due before class on 16 Jan.
- Revise your 14 Jan report based on my feedback in class on Monday and into structure shown in examples on website.
- I will use this revised report to provide additional feedback.

Project proposals

- Due before class on 21 Jan.
- Written project proposals with clear plan for checkpoint 1 and checkpoint 2.
- Follow style in example on website.
- Clearly describe and cite closest related work.
- Identify infrastructure you will use or build upon.
- Indicate new research problems that must be solved.
- Indicate what will be completed by each of the checkpoints, and by the end of the course. Some revision of checkpoint 2 and the final results are expected.

Reading assignment

- Due before class on 16 Jan.
- One-paragraph written summary.
- Fang-Jing Wu, Yu-Fen Kao, and Yu-Chee Tseng. From wireless sensor networks towards cyber physical systems. *Pervasive and Mobile Computing*, 7:398–409, July 2011.

Upcoming lectures

- Embedded system design optimization.
- Embedded system research communities and review process.