Teaching Statement for Marcus Chang

Teaching and advising students have always been an interest of mine and it is the main reason I wish to pursue a faculty career in academia rather than a research position in industry. This interest stems from my appreciation for the interaction with the students but also because of my recognition of the great synergy between research-based education and student-driven research.

As a graduate student at the University of Copenhagen, Denmark, I have served as both a Teaching Assistant on the *Wireless Sensor Networks* class in 2005 and was responsible for the sensor network part of the *Introduction to Distributed Systems* class in 2007. More recently, as a postdoctoral researcher at the Johns Hopkins University, I taught the *Network Embedded Systems/Sensor Networks* class in 2011. Although Dr. Terzis had previously taught the same course, I added my own contributions by updating the curriculum with the most recent research papers in the field and introduced a new set of assignments and project.

The most challenging part of this update was to keep the program coherent while adding new elements. Having a coherent program where the students can easily take elements from the class, identify them with real-life problems, and subsequently have hands-on experience solving them is very important to me and something I believe will make the students more engaged because they can easier understand how even the more difficult topics can be useful. Furthermore, to ensure that the learning curve was adapted to the students, which could have included both undergraduate and graduate students from different engineering fields, the students were handed an anonymous survey about their past experiences.

The purpose of the course was to give the students an insight into the embedded programming world in general and wireless sensor networks in particular. As wireless computational devices that interact with humans and the environment proliferate through our physical world, it has become extremely important to train students in the science and art of these cyber-physical systems. However, with the continuing miniaturization and increasing processing power available on current consumer devices, and especially with the smartphone deluge, embedded programmers must be proficient in a broad range of devices and wireless communication standards.

In order to explore the depth of embedded systems, the students obtained hands on experience with programming both powerful Android smartphones using the high-level Java language, but also extremely resource constrained microcontrollers using low-level nesC language (a C variant). Introducing these two diametrically opposite devices, in terms of resources, served two purposes: first, given how pervasive smartphones have become knowing how to program them is an invaluable skill that can become very useful later in the students' careers. Second, in order to achieve high power efficiency in battery-driven devices the students have to understand the low-power properties of the underlying hardware in order to leverage them in software.

To illustrate the breadth of embedded systems and connect this topic to something the students have hands-on experience on a daily basis, the class also covered multiple wireless standards for mobile devices (e.g., Bluetooth and 6LoWPAN) and both indoor and outdoor localization methods (e.g., GPS and WiFi fingerprinting). Knowing the strength and weaknesses of a broad range of wireless communication and localization standards will allow the students to make educated cost-benefit analyses when designing mobile applications in the future.

The course consisted of weekly lectures and seminars and a semester-long project. During the lectures I would present the week's topic in general while in the seminars we would look at a particular research paper in detail. Students took turns in leading the discussion during the seminars, first by presenting the weekly paper and afterwards by moderating the discussion. This allowed the students to explore the topic together and learn as a group, which in turn hopefully gave them a greater sense of accomplishment. Only to keep the discussion on track and ensure that the key aspects of the paper were covered would I participate when needed, but still respecting the seminar format by posing questions instead of lecturing, in order to give the students a chance to come up with the answers on their own, and answering the questions the students were unable to. To ensure that all the students had actually read the paper before each seminar, those students who did not present had to hand in a written review instead.

In order to excite the students and encourage them about research at Johns Hopkins, I included state-of-the-art research papers from our own group, when appropriate, and even had one of the authors as a guest presenter so the students could ask questions about topics not covered in the paper. This ensured that the curriculum remained engaging and relevant for the students.

For the semester project, the students had to work in groups and implement the key components (we provided the framework) for a body sensor network, where a wireless sensor was used as a probe controlled by an Android application which also visualized the measurements (see http://youtu.be/yknA9BCg8do?hd=1 for a demo). These components included the Android application, the wireless communication protocol, and the sensor sampling on the probe. The purpose of this application was to exemplify different abstract concepts from the course while at the same time giving the students something tangible and fun to play with.

To improve feedback to the students and ensure that nobody lagged too far behind, without a chance to catch up, the project was divided in three parts. In turn, this division posed the problem of how the students were going to evaluate the application during each part. To solve this problem, I handed out a set of binaries for each device so the students could focus on implementing one component at a time by following the documented interface between them.

As mentioned above, current embedded systems span a broad range of devices so in order to program a power efficient application, across multiple devices, requires deep cross-device and cross-layer optimizations. To emphasize this point, for the final part of the project the students had to go back and look at the entire application as a whole and use techniques covered during the course to improve power efficiency for all devices.

The project served multiple purposes. First, since this was a semester-long project the students had to exercise a large amount of project management in order to reach each milestone without falling too far behind. Second, the students had to exercise teamwork and implement components based on interfaces only, both skills needed when working on large projects in the industry. Last, during the final optimization phase the students had to show self-reliance when choosing which parts to optimize, and especially how, based on the limited amount of time available and what have been covered during the course.

According to the course evaluation, all the students found the course to be either good or excellent and gave the course and overall score of 4.67/5.0 which is well above the department mean of 3.99. Although time consuming, this being my first time in charge of a course, the teaching was deeply rewarding and I learned a lot from the experience.

During the 2011-2012 academic year our group's professor, Andreas Terzis, was on sabbatical. This absence gave me the opportunity to stand-in and advice his students on daily matters while Andreas handled the broader strategic decisions during weekly meetings. This teamwork has contributed to multiple paper submissions two of which have already been published.

In the future, I look forward to teaching courses similar to the Network Embedded Systems/Sensor Networks and more general Cyber-Physical System courses. Ideally, there should be a two-course series split between undergraduate and graduate level courses. The undergraduate course would have a stronger emphasis on smartphone applications and programming experiences, while the graduate course would focus on the fundamental research problems. This division would benefit both students seeking a job straight after college and also the students pursuing a research career in graduate school.

In order to better reach out and capture the students' attention, I will include more social tools in my teaching, similar to the YouTube video of the semester project. For instance, the school's online discussion board can be useful for sensitive information, but many students are not connected to the school's closed website as they are to, for example, Twitter and Facebook. For non-sensitive announcements, a tweet or status update would probably catch the students' attention more than a simple email, and likewise a Facebook post about extracurricular reading material or exciting research news.

On a similar note, instead of just making the lecture slides available online the whole lecture itself could be streamed live and made available for download, so the students can attend the non-mandatory lectures as they see fit. However, with many course lectures already available for online viewing from highly respectable universities, what really makes a good course stand out is the students' interaction with the teacher and especially the teacher's ability to rephrase the curriculum in a way the students can understand. Thankfully, the attached course evaluation suggests that I possess both qualities.

In conclusion, I have described my previous teaching experiences both in Denmark and in the United States, and also outlined my plans for future courses. I believe my passion for teaching will be an asset both for the school and for the students.