Project Example Topics

18-759 Wireless Networking, Spring 2010

We describe a number of examples of types of projects that we believe are feasible. However, you are welcome to define your project. It is very important that your project matches the background and interests of your team. Note that the examples include both fairly well-defined projects and very open-ended projects.

Wireless Protocols

Internet access via Cabs

Passengers often need access to the Internet while travelling in a cab. For example, this could allow them to check their important emails, or to get information about tourist attractions in a city. In this project you will investigate the mobility patterns of cabs in a typical urban city and design a protocol that is specifically designed to facilitate Internet access via cabs.

In the first part you will use the extensive data-sets that capture the movement of cabs in San Francisco city. These data-sets are available at the CRAWDAD site(www.crawdad.org) and provide the gps coordinates of about 500 cabs for a 30 day period. Using these data-sets you are expected to provide important insights regarding cab movements. For example: amount of time spent in highways vs. city environment, typical speed of the vehicles in different settings, popular spots, congested spots and durations, etc. These insights can be valuable for planning a network for Internet access from cabs.

In the second part you are expected to design a scheme that exploits one or more of the insights from part 1 to improve Internet access performance. For example, you can think of a scheme that opportunistically uses nearby cabs if they have the relevant data, but uses an infrastructure otherwise. You are expected to do a realistic evaluation of the scheme using an appropriate platform (simulation/emulation).

The Rate Anomaly Problem in Congested Multi-AP Deployments

Rate Anomaly problem occurs when stations transmitting at lower rates consume a significant portion of the wireless medium and therefore significantly reduce the throughput of stations transmitting at higher rates. In this project you will investigate the extent of this problem in congested practical settings and design a protocol that addresses this problem in a multi-AP setting.

In the first part you will analyze traces from real world environments like congested hot-spots and a conference setting with many wireless users. Traces of such settings are available at the CRAWDAD site (www.crawdad.org). You are expected to analyze these traces and quantify the impact of rate anomaly problem.

In the second part you are required to design a protocol that improves the overall throughput of the system by intelligently switching clients to an alternate AP in order to reduce the impact of rate anomaly problem. You are expected to do a realistic evaluation of your proposed scheme.

Software dissemination

Applying techniques from various wireless multihop broadcasts to disseminate software and other updates (e.g. geocast info) among cell phones in an area.

Sensor MACs that use topology

Sensor typically have no motion and have relatively regular traffic patterns. While a completely rigid MAC (TDMA) may be undesirable, is there some notion of long term MAC adaptation that can occur. Perhaps it can also take advantage of long-term learning to learn about hidden terminals, exposed terminals, etc. to reduce collisions in a contention based MAC. Suggested reading: papers on SMAC (e.g. Infocom 02) and BMAC (e.g. Sensys'04) papers on energy-efficient sensor MACs.

Congestion control for sensors

There was a 2006 Sigcomm paper from Ramesh Govindan that proposed a congestion control system for wireless sensor networks. The proposed system focused on tree like aggregation workloads and controlling the aggregation rate. Do we really need to specialize congestion control for tree topologies or can we get something like XCP to work well in multihop wireless environments? If we could get XCP to work well, it would seem that the solution would also apply to other wireless settings (e.g., mesh, ad hoc) and we would have a nice general solution. Suggested reading: above sigcomm paper

Dynamic spectrum access

The FCC's recent ruling on TV white spaces has opened up a lot of spectrum for use by unlicensed devices. Many research questions must be addressed however before widespread use is possible. These include how to coordinate channel selection among nodes in a network, load balancing, dealing with dynamic incumbents. A good starting point is the MSR paper on WhiteFi in Sigcomm 2009.

Hardware is cheap

The MSR DAIR project (paper in HotNets 2005) showed that deploying extra hardware can help with monitoring and diagnosing wireless networks. What would you change about how 802.11 is deployed/works with this in mind. E.g. should every device have 3 radios – one for each orthogonal channel? Could we implement a much cooler MAC with this in mind? Similarly, why have DAIR as a separate diagnosis infrastructure. Shouldn't they all just be APs? If that is the deployment style, how does this affect management, security, etc. ? Localization could certainly benefit. What else? As we get more channels how do these ideas scale?

Evaluation of wireless technologies

Which one can you trust?

There is some controversy in the wireless networking community about what are appropriate techniques for evaluating wireless technologies. Possibilities include simulation, various types of emulation, and testbeds. A number of projects can be defined that use different techniques to run similar experiments and compare the results. One option is to compare the following:

- Plain ns-2 simulation, probably the most widely used platform in academia
- ns-2 with extensions for improved physical layer accuracy, e.g. the package from the University of Karlsruhe (see: http://portal.acm.org/citation.cfm?id=1298155 and http://www.nabble.com/Announcement-of-NS-2-802.11Ext-td14664620.html).
- ns-3 is a modern simulator that is attracting a lot of attention in the wireless community.
- The CMU wireless network emulator or another testbed.

The domain for evaluation can be any topic covered in class. One option is to implement some of the techniques yourself. The other is to use open source implementations (e.g. for transmit rate control, ad hoc routing, TCP over wireless, etc.)

World models for the wireless emulator

The control software for the wireless network emulator is described in:

> A Software Architecture for Physical Layer Wireless Network Emulation, Glenn Judd and Peter Steenkiste, he First ACM International Workshop on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH 2006), held in conjunction with ACM MobiCom 2006, September 2006, Los Angeles.

One option for controlling experiments is through a "world model" in which the location and movement of wireless devices is emulated. The characteristics of the wireless channels in the experiment are then derived automatically from the properties of the devices in the world model. The current world model is unfortunately very primitive. A possible project would be to extend the world model (or add world models) to emulate more interesting physical environments. (At least) two approaches are possible:

- You could rely on external application to provide information about a particular wireless deployment environment of interest. An example is the SUMO vehicular traffic simulator for vehicular networking, or building maps for indoor wireless.
- You could create a world with artificial objects (e.g. walls) and then have the characteristics of the channels (e.g. attenuation, multi path) be determined (or

influenced by) the presence of these objects. Note that you would need to extend the control interface of the world model to account for the additional functionality.

- You could characterize the wireless channels in a specific environment (e.g. based on measurements, or results published in the literature) and then use that information to adjust the wireless channel characteristics of your world model.

Record/replay tools for testbeds

Simulations are great due to the ability to repeat experiments. Testbeds are much more realistic. Wireless channel emulators provide a good middle ground. However, they are only as good as the scenarios that are programmed into them. There is some work from Peter Steenkiste and UCLA's whynet project on how to record "scenarios" but they are preliminary/limited. Can we take tools such as the new software defined radios and create a new environment characterizer? Basically, you would need to figure out how to measure things like interference, multi-path and signal path loss for wireless signals and how to reproduce them in a wireless emulator. Suggested reading: wireless emulator paper in NSDI 2005.

Localization with a twist

Audio

Use audio on a collection of cell phones to localize each relative to the others. An reasonable starting point would be a combination of bat/cricket and some of the self-organizing coordinate designs (used in internet coor systems).

Cell phones as sensors

Using synopsis diffusion or other sensor aggregation techniques to compute estimates of aggregate readings (velocity/direction) among a group of cell phones

Some more traditional projects

Directional antennas

Omni-directional antennas are easy to use and they are by design supported by the 802.11 standard. For example, carrier sense is used to reduce collision rates and RTS/CTS can be used to avoid collisions in hidden terminal situations. Directional antennas increase spatial reuse and, therefore, capacity. They can also improve the distance and quality of links. Directional antennas can be installed manually, or it is possible to install software steerable antennas, for example, phased-array antennas. Directional antennas unfortunately have some disadvantages, specifically hidden and exposed terminal scenarios are more common and more complex, especially when using software-steerable antennas. The goal of the project is to design a protocol that makes use of directional antennas to improve network capacity. You would need to focus on a particular scenario, e.g. physical context, mobility properties, timescale for adaptation, etc. Directional antennas can be emulated on the wireless network emulator testbed.

Handoff

Increasingly, people are using WiFi while being mobile, e.g. web browsing or VoIP from a PDA. As a result, smooth handoffs between APs become much more critical. Unfortunately, the handoff procedure in existing WiFi drives are often designed for nomadic users, i.e. users who use their wireless device while being stationary in different locations. A number of projects can be defined to improve the performance of handoff, e.g. in the MadWifi driver for Atheros or possibly in simulation.

Software-defined Radios

Software-defined radios implement most of the radio functionality in software, so they offer a lot of flexibility. As a result, they are often used as the based for cognitive radios, i.e. radios that can adapt their characteristics (modulation, coding, MAC, etc.) to the specific context (e.g. interference, node density, traffic load, etc.).

The Cognet project (http://www.cs.cmu.edu/afs/cs/project/cmcl/archive/2007/Cognet07pdf.pdf) is implementing a cognitive radio platform based on GNU Radio and the USRP software-defined radio. It could be an attractive project for a number of PHY or MAC projects.