Real-world Wireless Mobility in Emulab's Sensor Network Testbed

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When evaluating the latest wireless network protocols and applications, researchers must consider how to implement wireless conditions and device mobility. Most use simulation, but simulation has been shown to give incorrect results because it does not fully capture the effects of radio signal propagation on wireless data transmissions. Full evaluation of new protocols and applications necessitates study of their interaction with a real world environment. Unfortunately, creating a real world testbed and mobilizing it is tedious and difficult.

We have extended the well-known Emulab Network Testbed to support both fixed and mobile wireless sensor devices. This testbed currently employs several robots that remote users can position anywhere in a 60 m^2 temporary indoor area. The robots carry an Intel Stargate with an X-Scale 400 MHz CPU running Linux, an 802.11 wireless Ethernet card, and a Mica2 sensor network Mote with a 900 MHz radio. Static Mica2 motes are attached to the ceiling and walls in the same area. The wall-mounted motes contain a sensor module useful for detecting sound, light, and motion.

Robot motion can be scripted using the ns language or dynamically issued from a Java applet in the standard Emulab web interface. A high-precision localization system provides precise positions of robots so a user knows the location and orientation of all wireless antennae under their control. Users have full control over the wireless devices on each robot and can install custom software on the Stargate and Mote. Emulab provides experiment specification, control, monitoring, and integration with other wireless and wired resources in the testbed.

To provide users with precise, real-time robot control, we extended the core of Emulab with several new components. A backend to Emulab functions primarily as a data broker and translator of user position requests for robot control, and provides users with real-time robot position information. robotd maneuvers robots to user-specified positions based on input from visiond, and plans paths around any obstacles in the area. visiond is a localization system which provides high-precision position and orientation estimates for the robots. visiond uses computer vision, custom dewarping algorithms, and interpolative error correction to extract robot positions from an overhead grid of videocameras with wide-angle lenses.

We are providing a live demonstration of this system and its applications at SECON '05. Several on-site computers will allow the interested conference attendee to maneuver the robots in real-time through our web interface, and monitor (via streaming video and telemetry from individual robots) robot motion in our experimental lab area in Utah. We will provide several interesting interactive demonstration scenarios, showing the utility of mobility combined with a real-world sensor network. These include:

- *Evaluation of common sensor network localization algorithms.* Robots move to locations with different radio conditions, and mote localization-estimated positions are compared to ground truth.
- *How to quickly create and change network topologies to evaluate applications under varying wireless propagation conditions.* Using knowledge from RSSI mapping, users can move robots to "interesting" experimental areas.
- *Evaluation of ad-hoc, multihop routing procotols under mobility.* A customized version of the Surge GUI shows route changes while robots move.
- *How to use logging features to analyze experimental data.*
- *Demonstration of automatic mapping of RF conditions in the environment.* Several robots simultaneously drive through the lab, creating a map of radio signal strength.

Interested conference attendees will be able to interactively move robots and tweak experiment parameters as well. We will also help attendees run their own custom sensor network experiments if they would like to try out the system!

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