Mobility Emulation Through Spatial Switching on a Wireless Grid

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Abstract

Experimental research involving large-scale mobile systems is expensive and cumbersome. We present the design and implementation of a mobility emulation system that uses novel software techniques and controlled interference injection to facilitate experiments with a large number of "mobile" IEEE 802.11 radios. With the provision for artificial creation of coverage zones and interference patterns, we demonstrate how this system will substantially lower the barrier to large-scale mobile systems experimentation.

1 Introduction

Experimentation with large-scale mobile systems is tedious because of various factors. Logistical difficulties hinder experiments involving node mobility and their repetition. Variability in channel conditions over time and space lead to poor reproducibility of results. Further, with IEEE 802.11 radios, an average radio range of close to 30 meters (for 802.11b) implies the requirement of large areas to study issues such WLAN hand-off.

Simulation-based research methodologies have been unable to accurately model the radio link and physical layer intricacies [1].

Emulation-based approaches offer interesting tradeoffs between pure simulation and full-scale experiments with acceptable levels of realism and reproducibility. Prior approaches to mobile systems emulation include the usage of software MAC filtering (e.g. [2]) and signal attenuation (e.g. [3]). By emulating at the network layer and above, the first approach has the same disadvantage as simulators. The second approach is tedious to setup, cannot be remotely controlled and faces scalability issues for large numbers of nodes.

Figure 1: *The ORBIT indoor testbed, comprising of 128 IEEE 802.11 a/b/g interfaces, attached to 64 stationary nodes, arranged in an 8 by 8 grid*

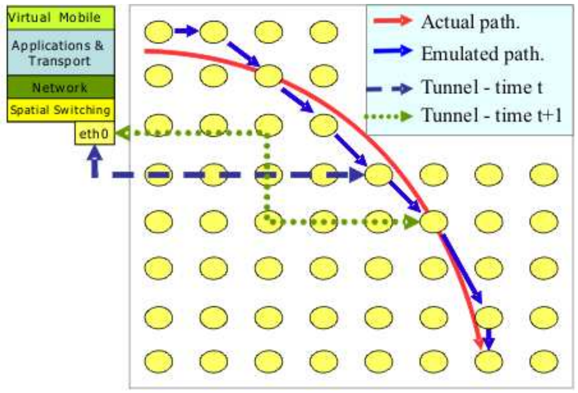

Figure 2: *Mobility emulation through spatial switching. All layers above the MAC reside on the "Virtual mobile" node, throughout the experiment. The link and physical layers of different nodes on the grid are used over time, based on the specified mobility pattern.*

We present the design and implementation of a system that emulates mobility by switching to different stationary radios over time. This system has been deployed on the stationary ORBIT [4] indoor wireless grid, which is remotely accessible for repeatable wireless experimentation. The setup of the current ORBIT prototype is shown in Fig. 1. A unique feature of our approach is the implementation of spatial switching in software, which enables support for tens of mobile nodes and remote accessibility. Software spatial switching is achieved by tunnelling the packets of the emulated mobile node, over Gigabit Ethernet links, to different grid node radios over time, as shown in Fig. 2. A split-stack architecture is used, where all layers above the MAC reside on the same machine throughout an experiment but, as time progresses, the link and physical layers of different nodes on the grid are used. Since packets are transmitted over real radio interfaces, this emulator can be used to evaluate the effects of real-world link and physical layers on higher layer protocols.

In order to create artificial coverage zones and emulate real-world connectivity issues, a second feature unique to our approach is the injection of controlled interference into the testbed environment. By raising the noise floor using a vector signal generator [5], the system can emulate different distances between nodes.

The mobility emulator is remotely accessible through `ssh` login and a web interface. Typically, the experimenter provides configuration files that specify the path and speed of every mobile in the experiment. A preprocessor converts these into a switching plan for the entire experiment duration. Using ORBIT's scripting interface [6] the nodes can be preloaded with arbitrary network software stacks, and experiment results can be collected in a central database.

2 Demo description.

We demonstrate the ability of our emulation system to support a variety of mobile systems experiments with repeatable results. Conference attendees will remotely access the system through a web interface and can modify experiment parameters. Attendees will also be able to see status indicators in the ORBIT lab through a webcam. Orbit nodes contain status indicators that show which nodes are active (switched on) and participating in the experiment. The demonstration is divided into two parts.

In Part 1, we investigate the effect of CSMA/CA performance as the number of transmitting nodes increases. We use a streaming video service, for an infrastructure-based WLAN. A single AP is serving up to twenty five mobile stations that move into the coverage area at different points in time. The attendees can observe both plots of runtime per-user throughput and video quality.

In Part 2, we compare the performance of two WLAN hand-off mechanisms as a single mobile client will move from the coverage area of one AP into the coverage area of another. Conference attendees will observe the performance of a VoIP application running on the mobile. This part will also demonstrate how the performance of related mobile systems [7] can be evaluated.

The purpose of these experiments is to serve as a tutorial for attendees and to demonstrate how the mobility emulator on the ORBIT testbed can be used for mobile systems research. After the demonstration, interested attendees will be able to schedule future time slots on the testbed for conducting experiments of their own interest.

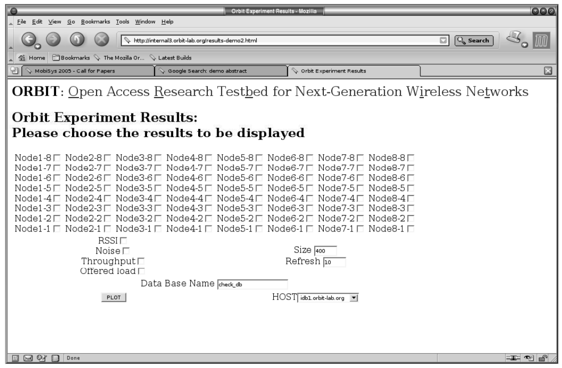

Figure 3: *The web interface to display results.*

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