A Cost-Effective Approach to Software-in-the-Loop Simulation of Pervasive Systems and Applications

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Overview

Testing pervasive systems in a controlled environment is not sufficient to find and evaluate the possible properties and issues. On the other hand, the simulation of large-scale systems is usually based on approximated models and simulation-specific code, which are not representative of all system details.

We propose a cost-effective software-in-the-loop simulation methodology, which allows:

- tests of deployment software on simulated devices and environments;
- maximization of code reuse;
- reduction in complexity since the only effort is to create adapters to integrate the deployment code with the underlying platform, consisting of a general-purpose simulation engine, provided with more specific (still reusable) packages.

The main advantage of such an approach is that real code has to be deployed once, and the simulation engine replicates it over virtual devices and environments as often as we wish.

Implementation

We use a discrete event simulation engine called DEUS, and three simulation packages, which cope respectively with node mobility, communication and logging. A reduced effort is needed to integrate deployment code with such packages, as it is sufficient to develop three adapters.

Mobility Package

The mobility package, called OSMobility, allows to simulate the motion of different entities (e.g. pedestrians and vehicles) in realistic geographical spaces. It is integrated with OpenStreetMap, an open database which provides geographical data for free to compute node trajectories, with a resolution degree ranging from millimeters to kilometers.

Communication Package

The communication package provides delay models which can be used to simulate message transmission between network nodes. The most simple model generates an exponential delay, whose expected value is computed from message size and nominal channel bandwidth. We have obtained a more sophisticated delay model by means of highly detailed ns-3 simulations, assuming LTE communications. In general, any delay model can be included in the package.

Logging Package

Deployment code running on a virtual node produces raw data (e.g. received request, service and success rates). Scheduled by the simulation engine, the logging package picks such raw data and produces aggregated ready to be analyzed and used for the generation of graphs.

Future Work

- Development of a rule engine for the simulation of node behavioral models
- Definition of best practices for the development of software adapters for the integration of deployment code and simulation packages
- Extension of the current implementation of the software-in-the-loop methodology to evaluate a wide range of information sharing protocols (e.g. Distributed Geographic Tables)