OpenAirInterface Simulation Platform

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ABSTRACT

The OpenAirInterface Simulator is a tool for simulating wireless network environments with the objective of performing protocol and application performance evaluation, and secondly for real-time layer 2/3 protocol implementation validation. This simulation environment comes in two flavors: hard real-time multi-CPU deployment and virtualized single-CPU deployments. The real-time version is deployed in a specific environment where each wireless node corresponds to one real Linux machine. This configuration intends to test, in an accurate way, real-time applications over wireless networks. The virtualized, or user mode version intends to test real applications on a larger scale creating a series of virtual machines inside the real one. Even though, for small networks, a real time application could also be tested in this version, the behavior of the layer 2 protocols is still non-real time. Its main focus, therefore, is in on non real-time applications and testing of layer 2/3 protocols.

This simulation suite is designed for protocol and application designers who require validation of software in a controlled environment as close to reality as possible. It intends to decrease the cost and complexity of performing software measures and evaluation for real applications and protocols.

Keywords
OpenAir Interface, virtualization, simulation, wireless networks.

1. INTRODUCTION
Performance evaluation of protocols and applications for wireless networks is typically done through the use of regular simulators, small testbeds, or expensive protocol testers. The first approach, even though enabling the creation of relatively large networks, abstractions of some crucial parts of the network stack are made in order to make the simulation feasible. This abstraction can hide important issues that unfortunately may only be revealed when the software is implemented and deployed on a large scale. The use of testbeds, on the other hand, is not only expensive but also the measurements produced on them are hard to predict and reproduce.

The best environment to evaluate applications and protocols for wireless networks would one where one could use a real network stack (e.g. provided by Linux or BSD), which is easy to configure, with nodes deployed predictable way and that results

could be reproduced to verify the true difference between two different solutions. The simulation suite described here intends exactly to fulfill all these requirements.

The tool is a suite composed of two complementary simulation tools a real-time and a virtualized one. The real-time version of the simulator is designed to emulate the wireless behavior in a real network focusing real-time applications and protocols. It makes use of the open-source real-time operating extension to Linux, RTAI (www.rtai.org). The virtualized version of the tool emulates a wireless network behavior inside a real machine using virtualization using OpenVZ (openvz.org).

OpenAirInterface [1] is an open-source hardware/software development platform for collaborative innovation in the area of digital radio communications. It implements in software the PHY (Physical) and MAC(Medium-access)/RLC(Radio Link Control)/RRC(Radio Resource Control) layers for wireless communications as well as providing a IPv4/IPv6/MPLS network device interface under Linux. In addition to the protocol simulation environments described here which do not make use of radio hardware, fully-functional real-time two-way RF hardware (5 MHz channels at 1.9 GHz) is provided. The initiative targets 4th generation wireless systems (UMTS Long-term-evolution (LTE), 802.16e/j) and rapidly-deployable MESH networks using a similar radio interface technologies. The layer-2 protocols strongly resemble ETSI 3GPP formalism, although LTE MAC protocols are still in the standardization process. The development can be seen as an open-source testbed for advanced algorithmic prototyping and performance evaluation.

2. ARCHITECTURE
The proposed simulation tool is build on top of the OpenAirInteface platform, using a subset of the implementation, and combines a series of open source tools to provide a complete and functional wireless network simulator for both next generate cellular and mesh networks.

The simulator is responsible for behavioral modeling of the PHY layer and provides a complete implementation of a MAC/RLC/RRC layers. The MAC layer makes use of feedback signaling for both wideband channel quality indicators and queuing information to provide means for multiuser scheduling and radio resource assignment and hybrid-ARQ protocols. It targets a physical layer based on time-slotted OFDMA (orthogonal frequency-division multiple-access) with

synchronous networks. The PHY behavioral simulator is responsible for managing the network topology and providing realistic RF measurement information as stimulus for the protocols (e.g. time-vary wideband channel measurements and signal strength indicator). The signal emulation module implements a mathematically defined time-varying radio channel model. The latter is designed specifically to express, as closely as possible, the real radio/medium relation as seen by the MAC layer. The behavioral simulation module is placed in each receiver and its function is twofold: first it provides PHY measurement data which is used to stimulate the OpenAirInterface MAC measurement interface; second, it induces error patterns in the received PHY data packets according to models for packet error rates in the channel decoder (including models for hybrid-ARQ processes).

To easily perform the experiments and collect results a graphical tool was built. With this tool the user may define the topology scenarios, store the simulation description as XML file and create scripts to run the simulation.

2.1 Real Time simulator

The real-time version of the simulator runs under the RTOS RTAI (www.rtai.org), where the layer-2 protocols (PHY emulation, MAC, RLC, RRC, PDCP) run in the real-time kernel, This provides a fine grain control over the simulation, which allows timing for data exchange which respect the framing parameters of the underlying radio subsystem. In this version of the simulator each node runs inside a real machine and the data exchange between the MAC layers of nodes in the network is emulated using gigabit ethernet. This enables a standard Linux cluster to emulate a wireless network. The advantages of this technique over the creation of testbeds using real RF hardware are numerous but we want to highlight two. First, the possibility of using a regular set of machines to work as a wireless deployed network. The second, and more important one is the possibility of repeating experiments in the same conditions just varying the pieces of software one wants to compare. The collection of results and metrics in uncontrolled environments, such as testbeds, is often hard and the results maybe not completely representative of typical deployment scenarios.

2.2 User Mode simulator

The user mode simulator runs in the OS ring 3 and uses the OpenVZ [2] virtualization tool to create a series of virtual machines inside a real one. From what concerns each virtual node, it is a completely autonomous and separate entity, using its own resources and network stack. However, in truth, it is a virtual instance of a Linux operating system inside the real machine. This technique permits even the creation of both homogeneous and heterogeneous networks.

All virtual machines are "physically" connected through a virtual bridge inside the real machine. Each node has access to the other virtual nodes, as well to the Internet.

3. DEMONSTRATION

The demonstration presented at the conference intends to show both versions of the simulator in nearly the same configuration. For this purpose a small clustering network will be formed with three nodes, one cluster head (basestation) and two cluster member nodes (MN1 and MN2). Real applications will be shown on top of the simulation environment.

The applications tested presented, for the demo proposal, will be: ping, VideoLan streaming and a Skype real time conversation. The applications will be started from MN1 to MN2.

The data regarding the machines status during the demo will be collected and displayed graphically in real time to the audience. The set of tools of the OpenAirInterface simulator suit comprehends also a tool to show a series of the machines performance information.

4. CONTRIBUTIONS

This tool intends to provide the means for the development of new applications and protocols in an environment as close to reality as possible. This simulator permits the user to use a comparable network stack to what is found in wireless devices today, with an easy and flexible scenario configuration system. The tool also gives the user the possibility to repeat and compare results of experiments in a fair way for real wireless environments. In addition, the simulator is entirely composed of open source software which permits the customization of protocols for each layer in the protocol stack. Examples of uses of the simulator are:

- Performance evaluation and scalability studies on multiuser wireless scheduling policies

- Distributed routing and topology management protocol development and performance evaluation

- Mobility management protocols in cellular networks

- Multihoming and multimodal protocol development

- Physical layer behavioral modeling

5. REFERENCES

[1] OpenAir Interface, *http://www.openairinterface.org/*

[2] OpenVZ, *http://openvz.org/*