Mininet-WiFi: A Platform for Hybrid Physical-Virtual Software-Defined Wireless Networking Research

Ramon dos Reis Fontes, Christian Esteve Rothenberg
University of Campinas (UNICAMP)
Campinas, Sao Paulo, Brazil
ramonrf,chesteve@dca.fee.unicamp.br

ABSTRACT

Software-Defined Wireless Networking (SDWN) is being considered an appealing paradigm to design and operate wireless networks through higher-level abstractions and programmatic interfaces such as the OpenFlow protocol. Identified benefits include cost savings, service velocity and customization, resource optimization through novel approaches to user mobility, traffic offloading, multi-layer and multi-path routing, and so on. This demonstration features Mininet-WiFi as a SDWN emulator with the ability to run realistic experiments in hybrid physical-virtual environments, where users attending the conference are able to experience first hand by connecting their devices and interacting with virtual WiFi stations in a wireless mesh network or reach the Internet through the emulated SDWN infrastructure. OpenFlow 1.3 metering and IP header re-writing actions will showcase HTTP flow redirection and rate limitation of real users' wireless traffic.

CCS Concepts

•**Networks** → *Mobile networks;* •**Computing methodologies** → **Modeling and simulation;**

Keywords

SDN; SDWN; OpenFlow; wireless; mesh networks

1. INTRODUCTION

Software-Defined Wireless Networking (SDWN) [1] aims at providing programmatic control of networks where wireless base stations (e.g. WiFi APs) enforce packet handling actions (policy decisions) sent by the controller(s). SDWN inherit the main principles from Software-Defined Networking (SDN) [2] such as a programmatic separation of the control and data planes, which allows network administrators to specify the behavior of the network in a higher-level and simplified manner by leveraging the logically centralized view and fine-control low-level data plane APIs like OpenFlow.

Efforts towards the realization of SDWN [1] are going on with different technological scope and implementation choices and prioritizing diverse objectives. However, SDWN roadblocks upfront include the lack of a common vision and synergistic standardization efforts in addition to practical challenges such as the lack of common, available platforms and tools to prototype and evaluate SDWN proposals through repeatable and realistic experiments. Compared to related work approaching the SDWN experimentation gap from a simulation approach [4], our efforts on Mininet-WiFi [5] depart from an emulation perspective and aim at supporting any OS/application stack and embracing real endpoints blended with the virtual environment.

Demonstration contributions. We showcase the ability of Mininet-WiFi to support SDWN experiments combining physical and virtual environments, allowing conference attendees to connect their WiFi-enabled devices to the emulator running in a laptop with a single USB-based 802.11 NIC. WiFi APs reachable from the physical world and the virtual nodes are managed by an OpenFlow controller and logically connected through virtual links. In addition, we will show mobile stations in motion and forming a mesh network, increasing overall capacity and coverage. Altogether, the demo covers (*i*) the ability of the wireless networking emulation in Mininet-WiFi to integrate physical and virtual environments, (*ii*) AP-management with OpenFlow 1.3 to realize routing, IP header re-writing, and QoS control through metering rules, (*iii*) the emulation of wireless mesh networks with basic routing capabilities.

2. MININET-WIFI

Mininet-WiFi [5] is a wireless network emulator in support of SDWN by extending the popular Mininet [3] with wireless channel emulation and WiFi APs support.

SIGCOMM '16, August 22-26, 2016, Florianopolis , Brazil

DOI: http://dx.doi.org/10.1145/2934872.2959070

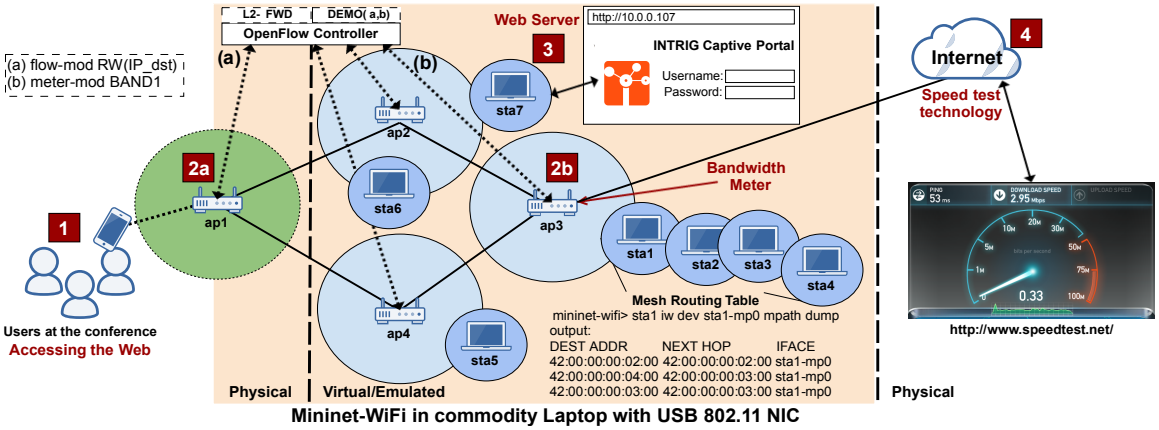

Figure 1: Components and demo workflow of physical-virtual wireless SDN with Mininet-WiFi.

The user can select among multiple wireless propagation and mobility models as well as arbitrary topologies and wireless network scenarios, including the emulation of (i) *ad hoc* and (ii) *infrastructure* wireless modes.

At the core of Mininet-WiFi is virtualization of 802.11 Linux drivers using `mac80211_hwsim`, the software simulator of 802.11 radio(s). The `hostapd` daemon is integrated in Mininet-WiFi to provide user space software AP capable of turning normal network interface cards into access points. Emulation of the wireless channel is implemented by using the parameters (e.g. node distance) of the chosen propagation model to re-configure in real-time the Linux TC parameters (e.g., bandwidth, packet loss, delay) of the virtual interfaces.

3. DEMO: PHY-VIRT WIRELESS SDN

We will showcase the researcher-friendly and feature rich emulation capabilities of Mininet-WiFi in the context of SDWN towards realistic experimental evaluation in a hybrid physical-virtual testbed setup by allowing users to connect their 802.11 devices and experience the demo first hand. Figure 1 illustrates the components and workflow of the demo, featuring a topology of 3 virtual APs and 1 physical APs in addition to mobile stations in the emulated environment.

Initially, the OpenFlow controller discovers the topology and installs the required L2 flow entries (Step 0) to allow connectivity between the APs. Next, the user connects to AP1 SSID and tries to access any Internet Web page via HTTP (Step 1). The OpenFlow controller installs one rule to re-write the IP destination address (Step 2a) to re-direct all user's HTTP traffic to a captive portal (Step 3) where the user is expected to authenticate in order to get Internet access and unlock the bandwidth limitation enforced as OpenFlow 1.3 metering actions (Step 2b). Finally, the user can communicate with the mobiles nodes in the virtual mesh network, verify the Internet connectivity (Step 4) across the physical-virtual environment, and assess the available bandwidth as a function of OpenFlow metering.

4. FINAL REMARKS & FUTURE WORK

Mininet-WiFi is a wireless network emulator in support of SDWN research as we showcased in a scenario with *ad hoc* and *infrastructure* wireless modes using a single experimental platform integrating virtual and physical nodes. Along increasing the overall scalability and the fidelity of the emulated wireless channel, our roadmap includes research-friendly features towards repeatable and realistic experiments, including the ability to import packet and signal traces of the physical medium derived from a real wireless testbed (R2Lab).[1] A comprehensive user manual and videos of the demonstrations are available in our open source repository.[2]

Acknowledgments

This work was partially supported by grant #2014/18482-4, São Paulo Research Foundation (FAPESP).

5. REFERENCES

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