## Introduction

The OpenFlow communications protocol remains one of the most used protocols for network virtualization today. This protocol has received widespread adoption and support from companies such as Google, Cisco, IBM, and Hewlett-Packard.

The continued research in networking virtualization has given rise to another topic of interest, wireless virtualization. The OpenFlow wireless extension adds wireless virtualization support to the OpenFlow protocol, allowing the same network virtualization control to both wired and wireless networks.

### Tools and Protocols

#### Software Tools

**OpenFlow Communications Protocol**
A protocol used extensively in software defined networking, OpenFlow gives a remote controller access to the forwarding plane of any OpenFlow supported network switch over the network.

**NOX**
Known as a network operating system, NOX gives OpenFlow developers the ability to develop OpenFlow controllers in both C++ and Python.

**Open vSwitch**
Open vSwitch is a multi-layer, OpenFlow compatible virtual switch. It is used to split a single physical port into multiple virtual ports.

**Capsulator**
Capsulator is an Open vSwitch extension which allows packets to be encapsulated and tunnelled through the network between two virtual ports.

**Flowvisor**
Flowvisor is a special OpenFlow controller that acts as a proxy between OpenFlow switches and one or many OpenFlow controllers, effectively splitting a network into multiple slices.

#### Hardware Tools

**PC Engine Access Points**
The wireless access points used are based on the PC Engine chipset. These access points have a Debian based operating system running OpenFlow, Open vSwitch, Capsulator and SNMP.

**Flowvisor Network Slicing and Resource Allocation**
Using Flowvisor, the network is split into two separate slices, one for bicasting and one for downloading. Both slices have enforced isolation resulting in increased safety and stability. Flowvisor is also used to manage resource allocation among each slice.

### Demonstrations

**OpenFlow Wireless Bicast Video Streaming**
This demonstration requires the bicast controller and a wireless client (laptop) with two bonded wireless network interface cards (NIC), each connected to a different access point on the network. A video is streamed from the BCRL network to the wireless client. The bicast controller detects which access point(s) the client is connected to and forwards the correct packets to those access points. Periodically, the client will disconnect one NIC from its access point and reconnect it to another access point. The bicast controller will then reroute the packets accordingly, resulting in a seamless video streaming transition, free of video scrambling as seen to the left.

**Tests and Protocols**

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#### References


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