# Integrating FlowVisor Access Control in a Publicly Available OpenFlow Testbed with Slicing Support*

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**Abstract.** OpenFlow technology has recently attracted a lot of attention in the networking research community, as the ability to control the forwarding plane of a switch through software opens new exciting capabilities for protocol designers. Several network testbeds have added OpenFlow-capable switches to their equipment, while at the same time new OpenFlow-centric testbeds have been created. This demo describes a proposed approach to provide testbed slicing in a publicly available testbed featuring OpenFlow switching equipment. The approach leverages the slicing features of the FlowVisor software component and combines them with the NITOS Scheduler resource reservation framework. The resulting configuration was implemented and successfully integrated into the software framework of the publicly available testbed NITOS.

## 1 Introduction

OpenFlow (OF) technology, first introduced to the networking community in 2008 [1], has attracted a lot of attention both in the research community and in the industry. Several OF-centric testbeds have been deployed by research institutions, while international research projects, such as OFELIA [2] and FIBRE [3], have been launched, focusing on OF experimentation (either exclusively or as a main direction).

The NITOS testbed [4], a publicly available testbed in the premises of University of Thessaly (UTH) mainly focusing on wireless experimentation, has recently added two OF-capable switches to its equipment. The purpose of this demo is to describe the combination of two independent software components, the FlowVisor [5] and the NITOS Scheduler [6], in order to provide testbed slicing capabilities in the OF component of NITOS.

Testbed slicing constitutes in allowing multiple researchers to experiment in a testbed simultaneously, through the use of disjoint sets of resources. In an OF

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context this can be translated to assigning disjoint flowspaces to different users, so that, for instance, a user can not direct a flow to a specific switch port, if this port does not belong to a slice assigned to the user.

## 2 Integration of FlowVisor and NITOS Scheduler

The Scheduler-FlowVisor framework provides the required functionalities in order to

- Reserve a flowspace (in the case of NITOS a set of ports in an OF switch)
- Restrict access of users to flows according to the reservations

The FlowVisor is a transparent proxy between OF switches and multiple OF controllers that correspond to multiple users. It creates slices of network resources and delegates control of each slice to a different controller or user. While the FlowVisor provides the required isolation of different slices within an OF switch, it doesn't provide any solutions on how these slices can be reserved and how each of them can be accessible by authorized users only. In order to provide these extra features, we combined the FlowVisor's functionalities with the NITOS Scheduler resource reservation tool.

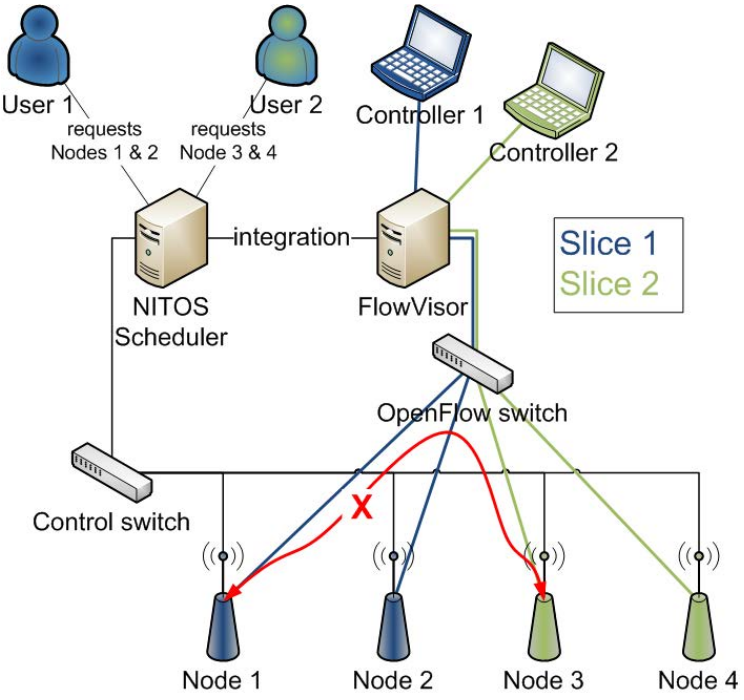


**Fig. 1.** NITOS Scheduler - FlowVisor integration

The NITOS Scheduler is a software framework dedicated to resource discovery, reservation and access control. It comprises a web frontend for reserving network resources for limited time intervals and a backend set of scripts to handle access to them.

The procedure can be summarized as follows:

1. When a slice is created in NITOS, a corresponding FlowVisor slice is also created and connected to a default NOX controller that instructs the OF switch to adopt standard switching behavior. At any later time a user in charge of this slice may redirect the controller to a new address where another, custom, OF controller has been setup and initialized.
2. A user reserves some nodes of the NITOS testbed. These nodes feature an experimental Ethernet interface connected to an OF switch. Along with the reservation of the nodes, a reservation of the flowspace corresponding to the switch ports connected to these nodes takes place (transparently to the user).
3. When the time interval of the reservation begins, the Scheduler backend submits a set of commands to the FlowVisor, instructing it to add the flowspace corresponding to these ports to the respective user's slice.
4. At the end of the reserved time interval the Scheduler instructs the FlowVisor to delete the added flowspace from the respective slice, so that users associated to the slice don't have access to the switch ports anymore.

## 3 Conclusion

We described the integration of testbed slicing capabilities in OF testbeds through the combination of FlowVisor and the NITOS Scheduler reservation software. This architecture, implemented as part of the NITOS testbed framework, can be readily applied to any other OF testbed.

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