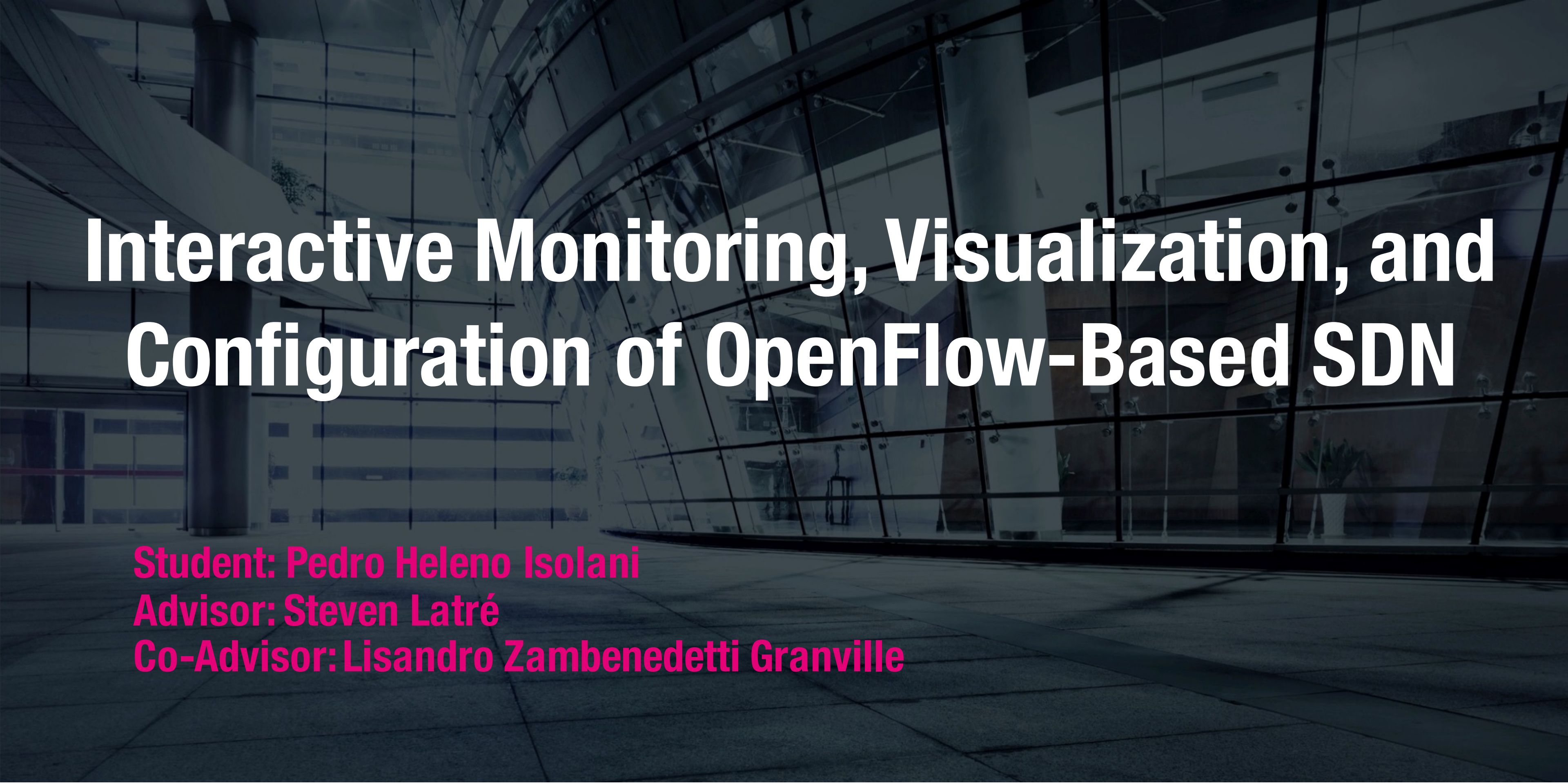

Interactive Monitoring, Visualization, and Configuration of OpenFlow-Based SDN

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I E T F

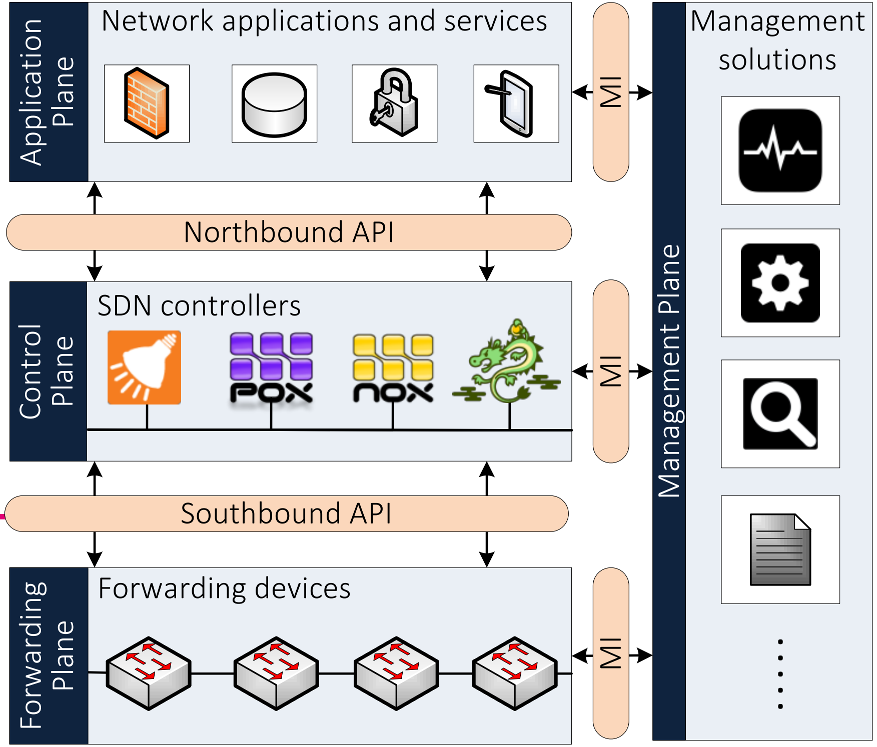
Motivation – SDN Architecture

I. Network control and forwarding planes are clearly decoupled

II. Forwarding decisions are flow-based instead of destination-based

III. The network forwarding logic is abstracted from hardware to a programmable software layer

IV. An element, called controller, is introduced to coordinate network-wide forwarding decisions



The most relevant SDN implementation

OpenFlow

Motivation – Control Channel Issues

SDN reduces or even eliminates some traditional management problems [1]

- *E.g.*, enabling network configuration in a high level language
- *E.g.*, providing support for enhanced network diagnosis and troubleshooting

Monitoring, Visualization, and Configuration can be considerably different from traditional networks

- *E.g.*, SDN controller behavior impacts on resource consumption and forwarding performance

Centralized controller creates bottlenecks at the control channel [7]

Devoflow [8] and **DIFANE [9]** attempted to alleviate these bottlenecks by distributing the control logic of OpenFlow

How OpenFlow control messages can be used without affect network performance?

Motivation – Control Channel Issues

Moreover…

SDN proposals use monitoring information to automate tasks

- *E.g.*, **reduce control traffic overhead** [2] [3] [4]
- *E.g.*, **protecting the network** [5] [6]

In what proportion the SDN controller behavior can affect both resource consumption and traffic forwarding performance?

No solution is available to integrate monitoring information with interactive visualization and configuration tools for SDN

Contributions

I. Quantify overheads imposed by OpenFlow messages on the control channel

Control Channel Analysis

II. Propose an interactive approach to SDN management through monitoring, visualization, and configuration including the administrator in the management loop

Interactive approach through monitoring, visualization, and configuration

Control Channel Analysis

Quantify overheads imposed on the control channel

- *OpenFlow v.1.0*
- *Controller's Forwarding behavior implementation*
- *Compus network scenario*

Analyzing

- *Control Channel load (installation and monitoring of forwarding rules)*
- *Resource Usage (active and idle rules)*

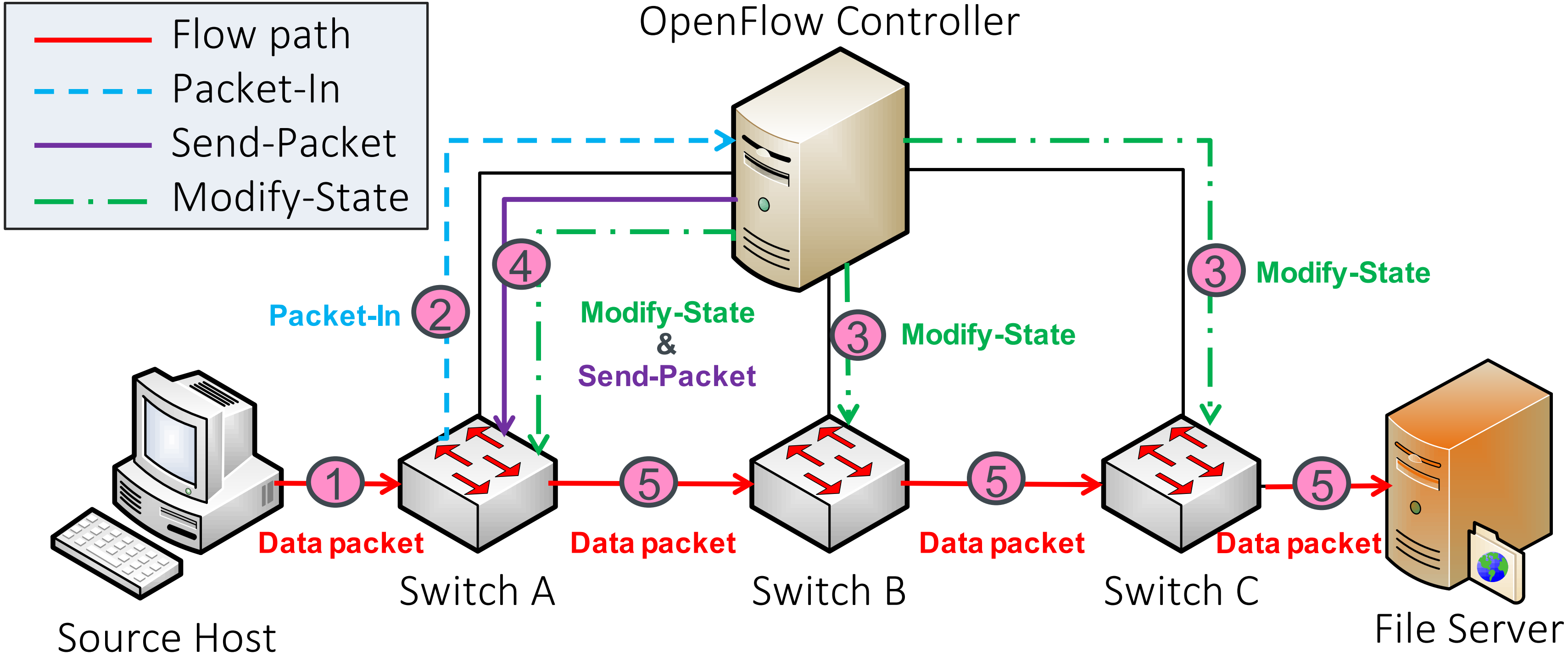
- *Note: A rule is considered IDLE when it's counters do not change between two monitoring polls*

OpenFlow 1.0 Control Messages

Message Type	Sub-type	Description
Controller-to-switch	*Features*	Obtain features and capabilities about the switches
	Configuration	Set query configuration parameters in switches
	Modify-State	**Manage the state of the switches**
	Read-State	**Retrieve statistics about switch tables, ports, flows, and queues**
	Send-Packet	**Send packets to a specific switch port**
	Barrier	Ensure message dependencies and receive notifications
Asynchronous	***Packet-In***	**When a packet do not match with a flow entry or an matched flow entry action is “send to the controller”**
	Flow-Removed	When a flow entry expires in the switch flow table
Symmetric		
	Echo	Sent by both controller and switch to establish connectivity
	Vendor	Functionality to store a staging area for other OpenFlow revisions

Selected sub-types represent 97.78% of the number of messages and 99.70% of the overall control traffic

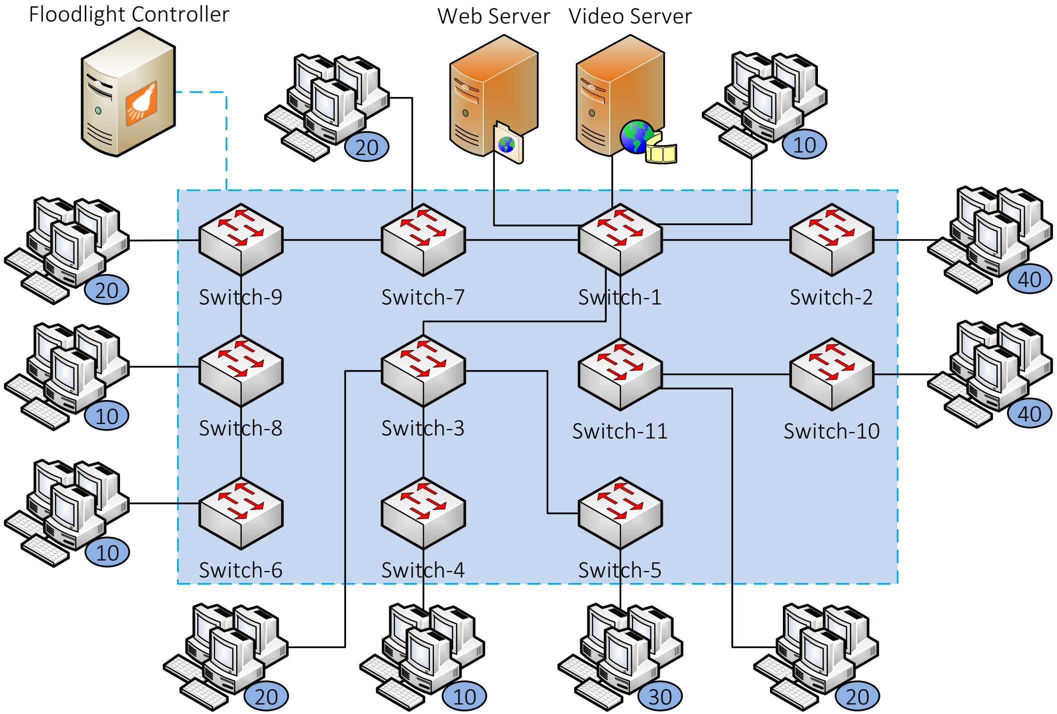
Forwarding Behavior



Scenario

Campus Netwok

- Hosts: 230
- Switches: 11
- Web Servers: 1
- Video Servers: 1
- Controllers: 1
- Controller: Floodlight v.90
- OpenFlow Version: 1.0
- Emulated over **Mininet**



Workload

User Traffic Profile

- *Emulated Internet Traffic*

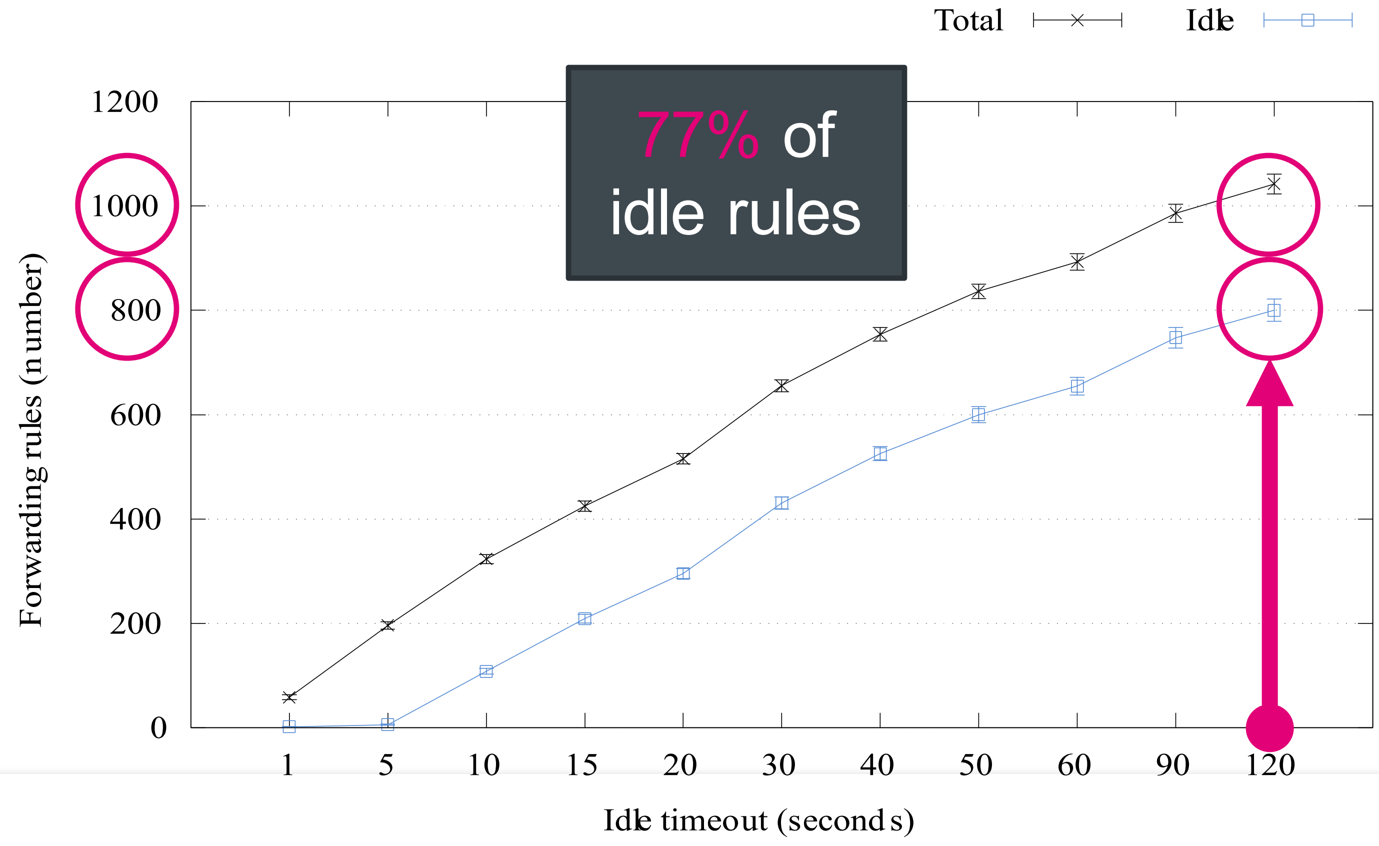
Varied Factor

- *Idle timetout configuration*

Idle timeout configuration indicates when a forwarding rule can be removed due to a lack of activity

Parameter	Value
Web request size	Lognormal Distribution ($\mu = 11.75, \sigma = 1.37$) Mean: 324 KBytes, Std. Dev.: 762 KBytes
User reading time	Exponential Distribution ($\lambda = 0.033$) Mean: 30 seconds
Video watch time	180 seconds
Video bit rate	300 kbps
Traffic Mix	Video: 75%, Web: 25%
User Mix	1 video user for every 6 Web users
Monitoring	Polling frequency: 5 seconds
Controller behavior	Floodlight's default *Forwarding Behavior* implementation
Experiment duration	30 min

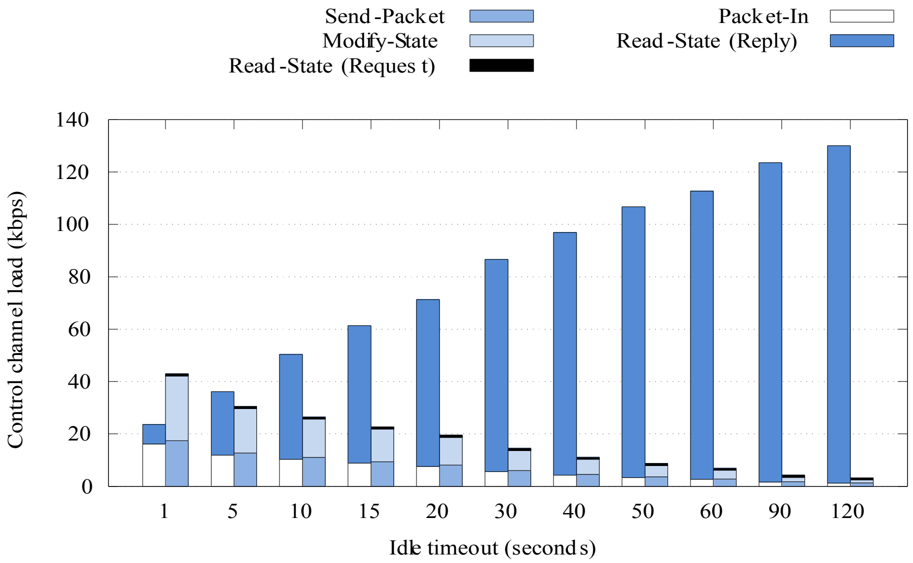
Forwarding rules



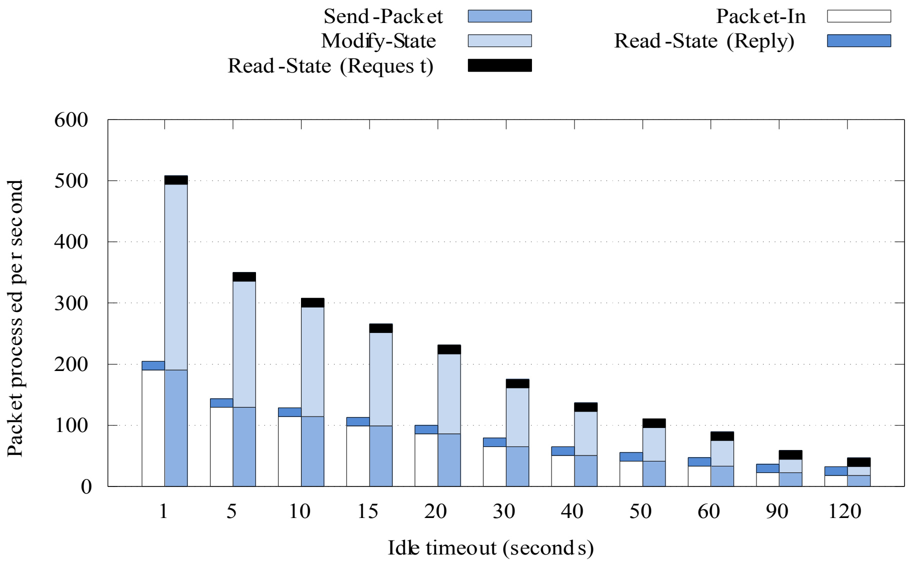
77% of idle rules

Channel Load

Control channel load x Idle timeout



Packets processed per second x idle timeout



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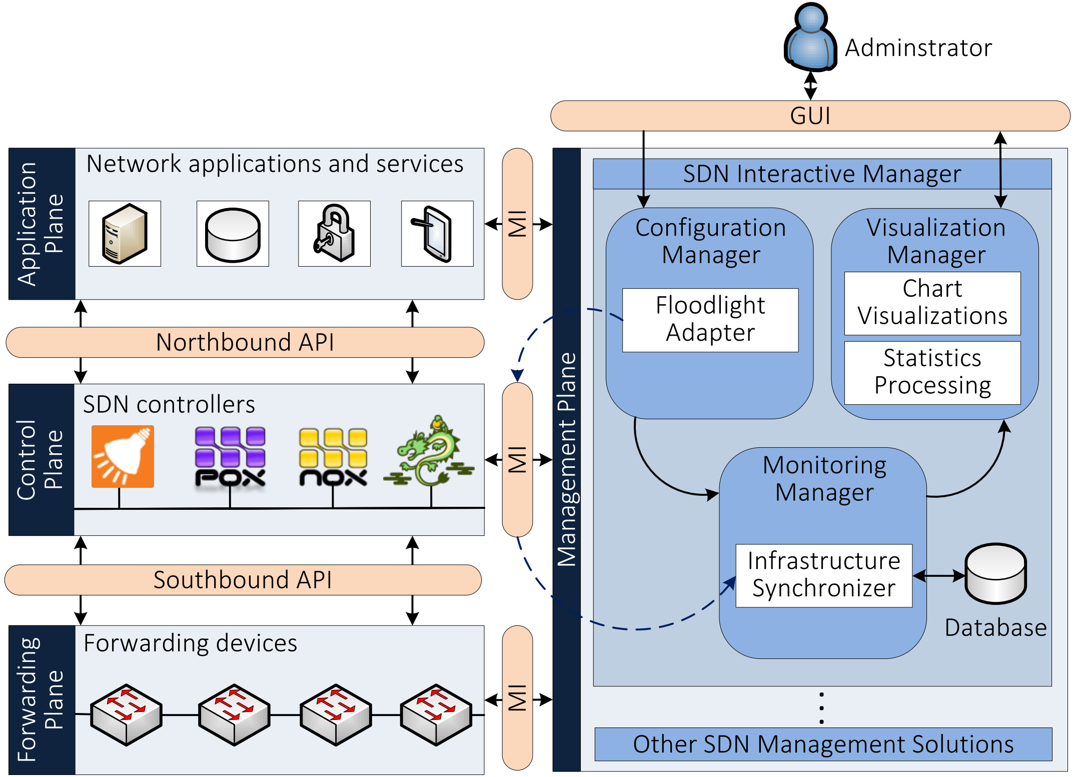
Interactive approach through monitoring, visualization, and configuration

Conceptual Architecture

SDN Interactive Manager

I. Monitoring Manager
II. Visualization Manager
III. Configuration Manager

A management loop with the Administrator interactions



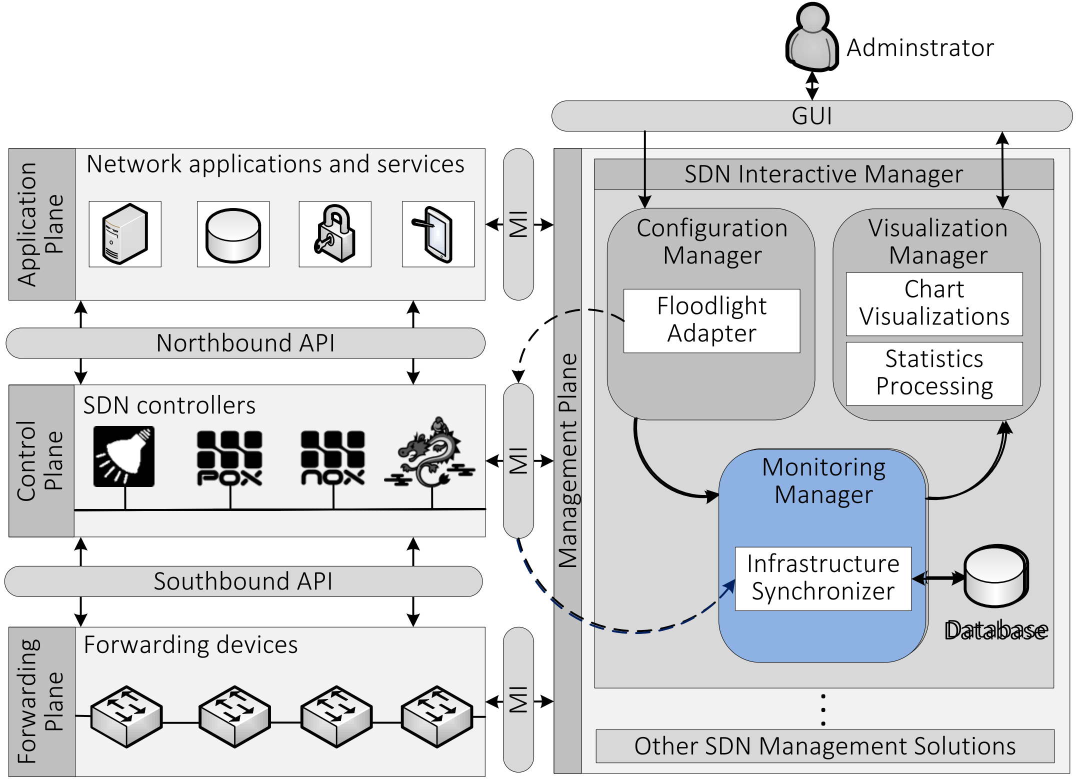
Conceptual Architecture

Monitoring Manager

Retrieves information about the network and store it in a local database

Modules

Infrastructure Synchronizer



Conceptual Architecture

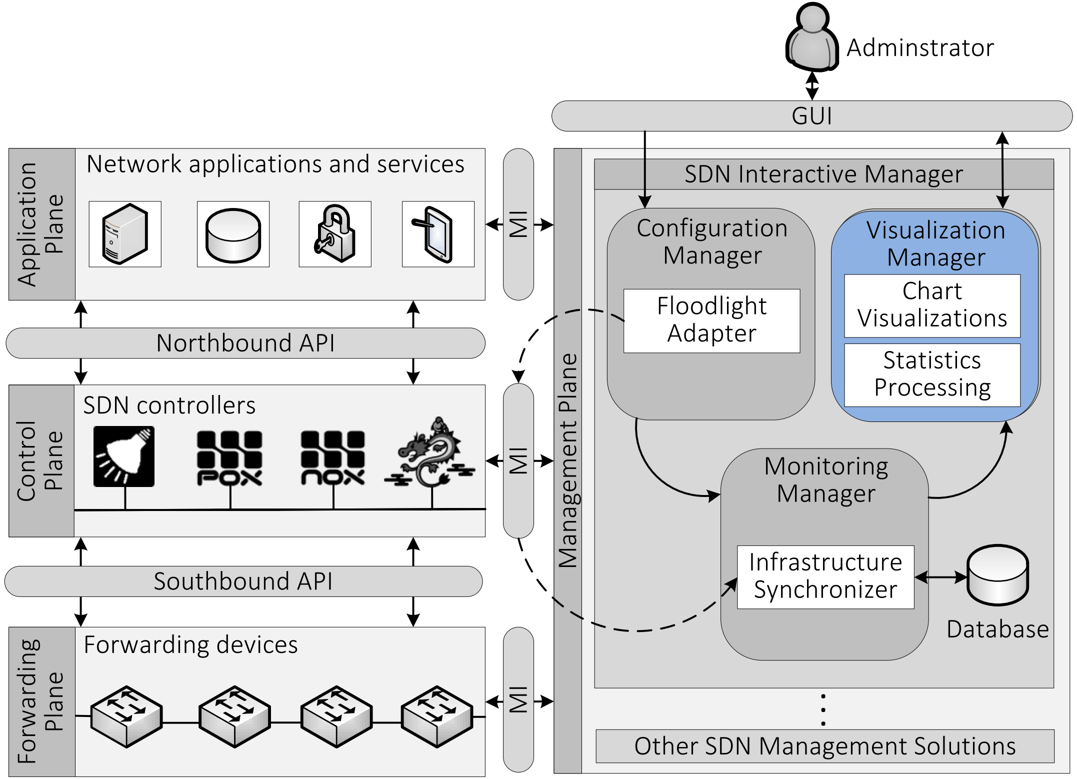
Visualization Manager

Aggregates data providing interactive visualizations to the administrator

Modules

Chart Visualizations

Statistics Processing



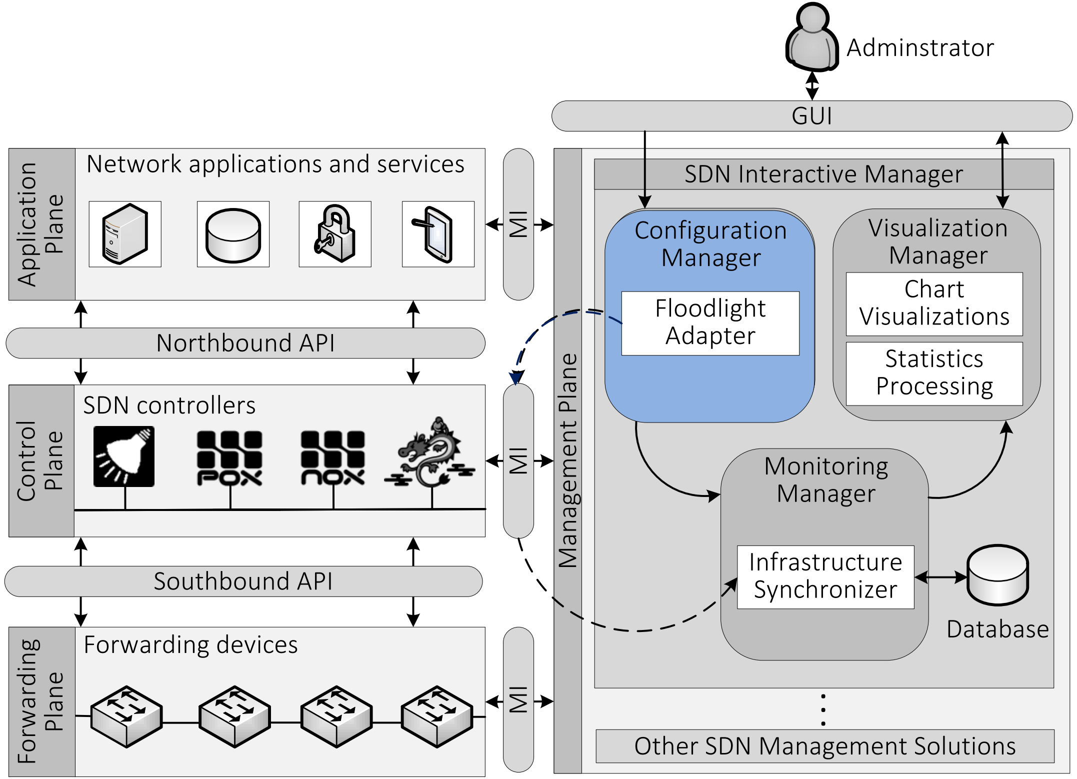
Conceptual Architecture

Configuration Manager

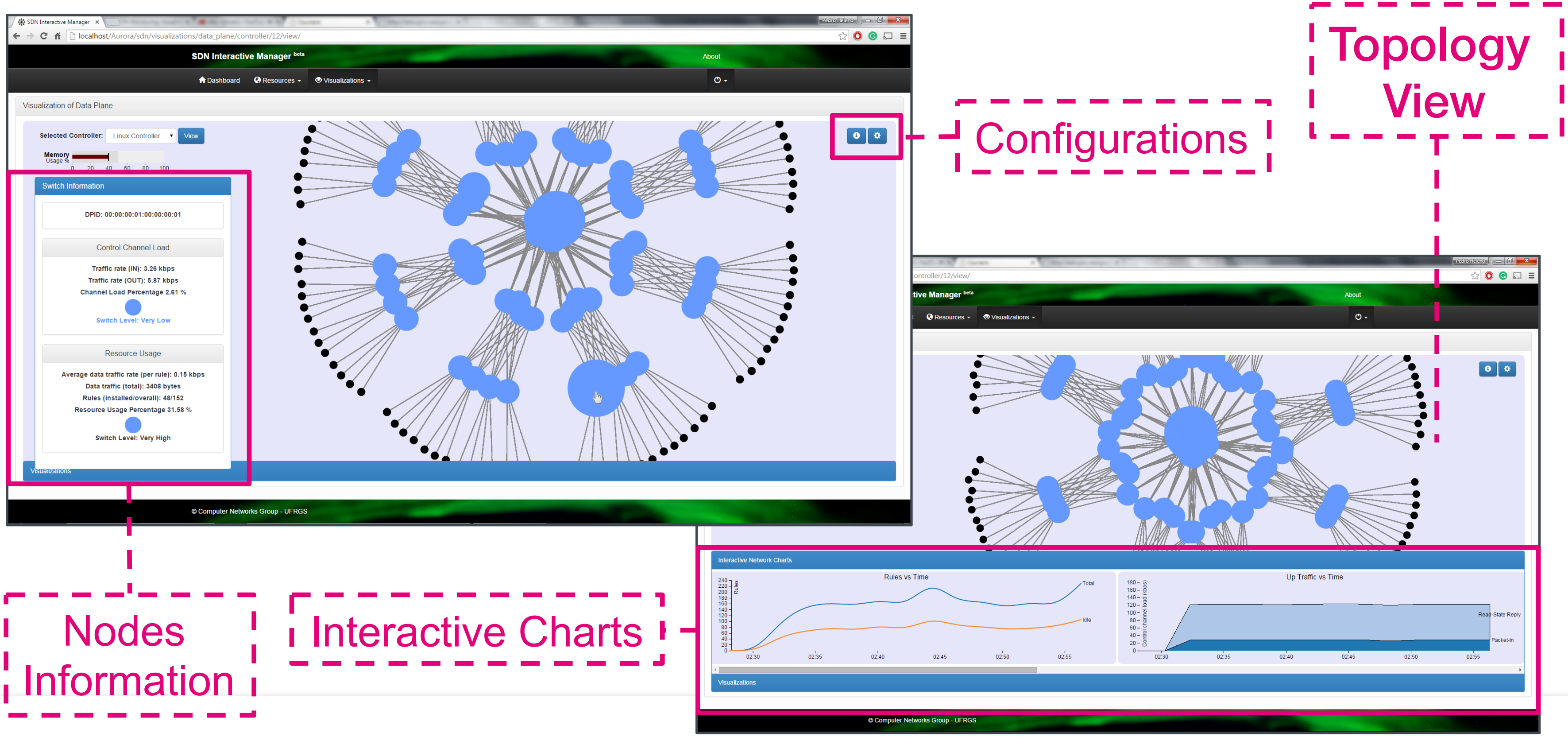
Checks and configures SDN-related parameters on network controllers

Modules

Floodlight Adapter



Prototype GUI



Topology View

Configurations

Nodes Information

Interactive Charts

localhost/Aurora/sdn/visualizations/data_plane/controller/12/view/

Visualization of Data Plane

Selected Controller: Linux Controller

Switch Information

DPID: 00:00:00:01:00:00:00:01

Control Channel Load

Traffic rate (IN): 3.26 kbps

Traffic rate (OUT): 5.87 kbps

Channel Load Percentage 2.61 %

Switch Level: Very Low

Resource Usage

Average data traffic rate (per rule): 0.15 kbps

Data traffic (total): 3408 bytes

Rules (installed/overall): 48/152

Resource Usage Percentage 31.58 %

Switch Level: Very High

Interactive Network Charts

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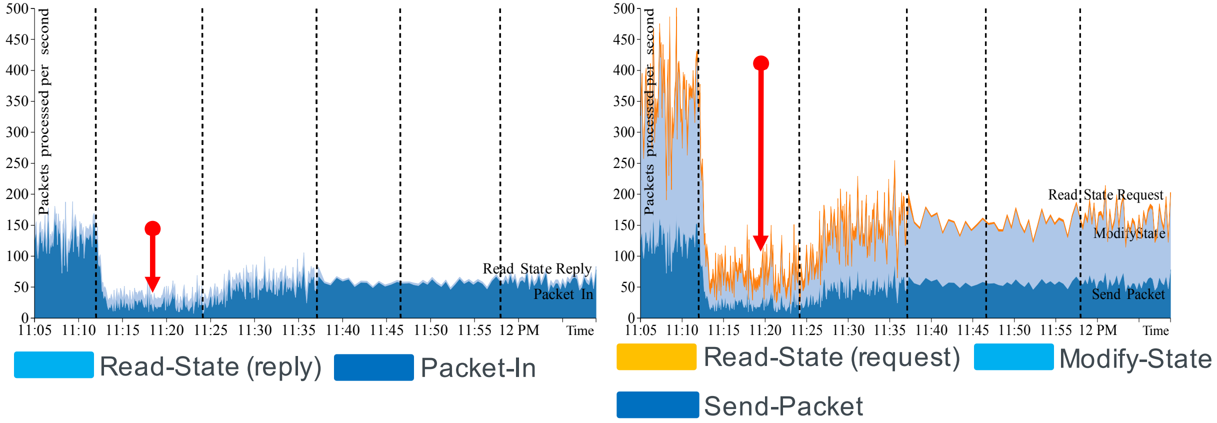
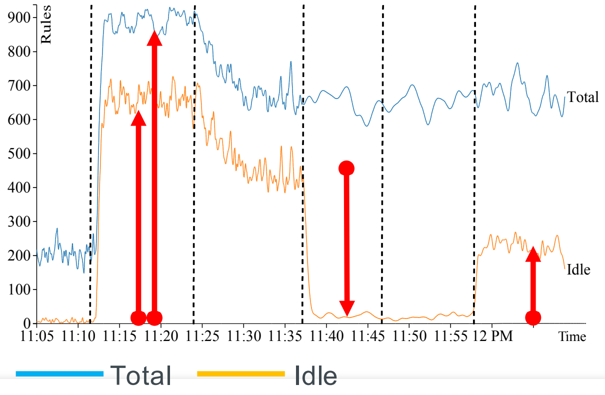
Evaluation

Parameter	1	2	3	4	5	6
Idle timeout	5	60	30	30	30	30
Polling	5	5	5	40	30	15

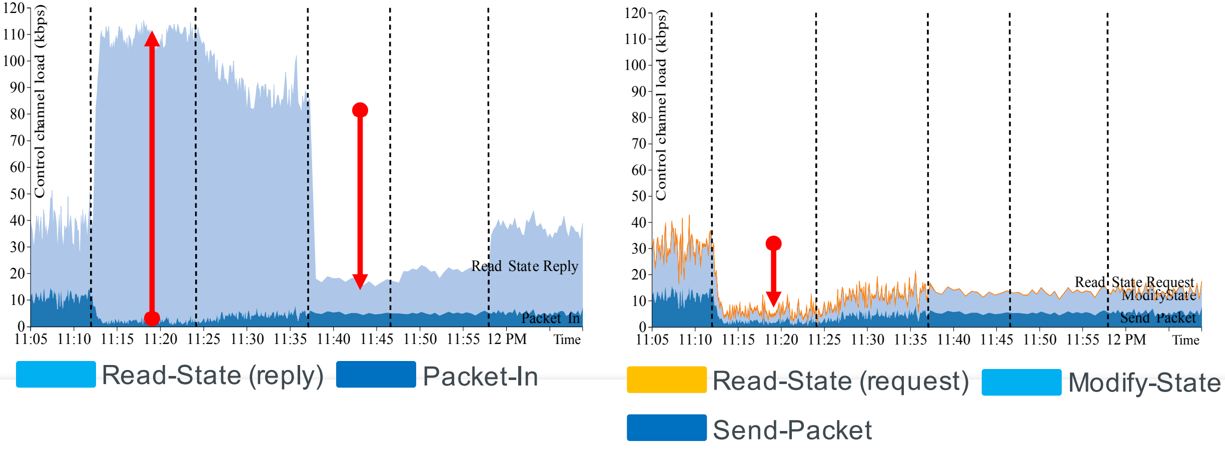
Packets processed per second x idle timeout



Rules x idle timeout



Control channel load x Idle timeout



Conclusions & Open Questions

Control Channel Analysis

- The proportion of both resource usage and control channel load are affected by a single parameter (*i.e.*, **idle timeout of forwarding rules**)

Interactive Monitoring, Visualization, and Configuration

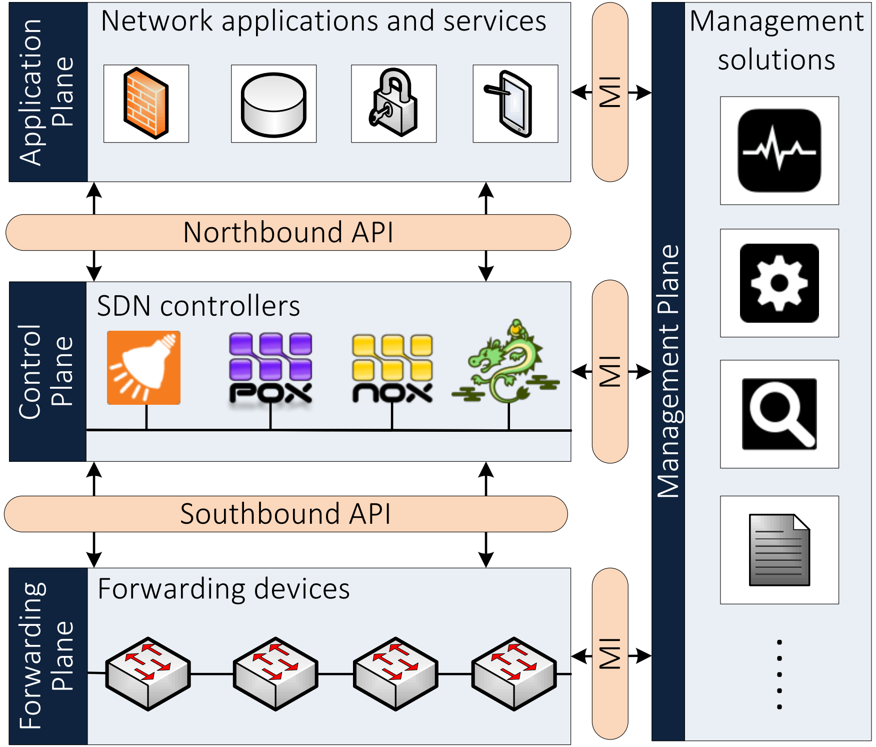
- Retrieve statistics about the control channel traffic
- Allow the administrator to interact with SDN
- Based on interactive visualizations, administrators are able identify potential issues and change configurations of SDN parameters

Conclusions & Open Questions

Deal with control channel was not so simple!

- Different controller implementations
- Control channel counters are not addressed
- Absence of a common Management Interface (MI).

A standardization process for the MIs could foster the development of SDN management solutions



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THANK YOU FOR YOUR TIME

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