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

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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
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

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

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

- **Flow path**
- **Packet-In**
- **Send-Packet**
- **Modify-State**

Source Host → Switch A → Switch B → Switch C → File Server

1. Data packet
2. Packet-In
3. Modify-State & Send-Packet
4. Modify-State
5. Modify-State
Scenario

Campus Network

- 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 timeout configuration

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

77% of idle rules
Channel Load

Control channel load x Idle timeout

Packets processed per second x idle timeout
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
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

![Diagram of Conceptual Architecture](image)
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

- Nodes Information
- Interactive Charts
- Configurations
- Topology View
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 forward 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.
References


THANK YOU FOR YOUR TIME

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