Securing the SDN Northbound Interface

With the aid of Anomaly Detection

Jan J. Laan

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Traditional network
Introduction

SDN network

Advantages
- Centralized view
- Dynamic, flexible
SDN overview

Application plane

SDN Applications

Northbound interface

Control plane

Controller

East/westbound interface

Data plane

Southbound interface

Network elements (switches)
Introduction

Research question

Main question

How to perform a security assessment of the northbound interface of a SDN network?

Supporting questions

- What are the main threats, and associated security requirements, to the SDN northbound interface?
- What is the best approach to assess the security of a northbound interface?
- How secure are the northbound interfaces of current popular SDN controllers?
- How can best practices with regard to security be improved?
### Related work

<table>
<thead>
<tr>
<th>OperationCheckpoint [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northbound Access control for the Floodlight controller</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEFloodlight [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conflict resolution, authentication for the Floodlight controller NB API.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rosemary [3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A controller built with security by design, especially for the northbound interface.</td>
</tr>
</tbody>
</table>
Testbed

5 popular and/or interesting controllers for testing.

- Project Floodlight
- ONOS
- OpenDaylight
- OpenMUL
1: HTTPS support

Goal: Secure communication in the northbound interface
Check for supported HTTPS versions

1. Web interface stops working
2. SSL3 enabled
1: HTTPS support

Goal: Secure communication in the northbound interface
Check for supported HTTPS versions

<table>
<thead>
<tr>
<th></th>
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<th>OpenDaylight</th>
<th>Ryu</th>
<th>Open Mul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes(^1)</td>
<td>No</td>
<td>Partial(^2)</td>
</tr>
</tbody>
</table>

\(^1\)Web interface stops working
\(^2\)SSL3 enabled
2: Authentication

Goal: Only allow access to authorized users/applications
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<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Floodlight, Onos and OpenDaylight: Client certificates
OpenDaylight: HTTP Basic
3: Authorization

Goal: A user/application can only access the parts of the API he needs.
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Goal: A user/application can only access the parts of the API he needs.

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<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tr>
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</table>

Research project for Floodlight with access control.
4: Logging

Goal: non-repudiation, there is a trail of access to the northbound interface.
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Goal: non-repudiation, there is a trail of access to the northbound interface.
5: Documentation

Goal: Ease of configuration for security features
5: Documentation

Goal: Ease of configuration for security features

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<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
## Results summary

<table>
<thead>
<tr>
<th>HTTPS</th>
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<th>OpenDaylight</th>
<th>Ryu</th>
<th>Open Mul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authentication</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Partial</td>
</tr>
<tr>
<td>Authorization</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Logging</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Documentation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Insecure by default. Almost all security features are turned off initially.
Malicious applications

A scenario:

1. Application has access through the northbound interface
2. Application gets hacked
3. Hacker abuses access rights to disrupt the network
4. Security measures mentioned before will not prevent this
Malicious applications

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1. Application has access through the northbound interface
2. Application gets hacked
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Possible solution: **Anomaly detection**

Premise: *When an application becomes malicious, its behaviour changes.*
Anomaly detection

Statistical Anomaly Detection

1. Log all access to northbound interface
2. Divide data into "historical" (training) data and "current" (testing) data.
3. Compare weighted chances per API call per application for these data sets.
4. Calculate an anomaly score.
Statistical Anomaly Detection

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Time ->

# of API calls
**Anomaly detection**

**Floodlight Proof of Concept**

### REST API Anomalies

<table>
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<tr>
<th>Application</th>
<th>API call</th>
<th>Original Chance</th>
<th>New Chance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:0:0:0:0:0:1:HackDemoApplication</td>
<td>/wm/staticflowpusher/json</td>
<td>0.67</td>
<td>0.95</td>
</tr>
<tr>
<td>0:0:0:0:0:0:1:HackDemoApplication</td>
<td>/wm/core/getanomalies/json (new api call)</td>
<td>N/A</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Performance impact:** 7% (1.1ms extra latency)

**Needs further research for validation.**
Limitations

- Only works well for predictable applications.
- Can be "trained" to accept malicious behaviour.
- Requires parameter tuning.
Conclusion

SDN northbound interface security is poor at this time.

Adding access control and turning on other tested features will help.

Insecure by default, lack of security features.

Anomaly detection: interesting addition, needs further research.
Future work

- Implement authorization on controllers.
- In-depth analysis of a single controller.
- Validate detection rate of statistical anomaly detection
- Explore other means of anomaly detection (machine learning, data mining)


Anomaly types

The red line depicts the amount of API calls over time to an API function. Three types of anomalous traffic are shown.
Security assessment (STRIDE)

Spoofing
- (Lack of) user authentication
- Divert NB network traffic. (f.e. ARP spoofing)

Tampering
- Capture and alter network traffic (MitM)
- take over (hack) SDN application

Repudiation
- Log API access
Information disclosure
- Listen in on network traffic

Denial of Service
- Send many requests to the NBI.
- Request resource-intensive tasks from controller.

Elevation of Privilege
- Access unauthorized parts of the API