OFf: Bugspray for Openflow

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Motivation

- Debugging SDN applications is hard
- “Runs as designed” may be insufficient
- Deployments must cope with wide range of operating conditions
- How can we answer the following question:

Will my SDN app run as designed when deployed in a live setting?

Our Solution: OFf!

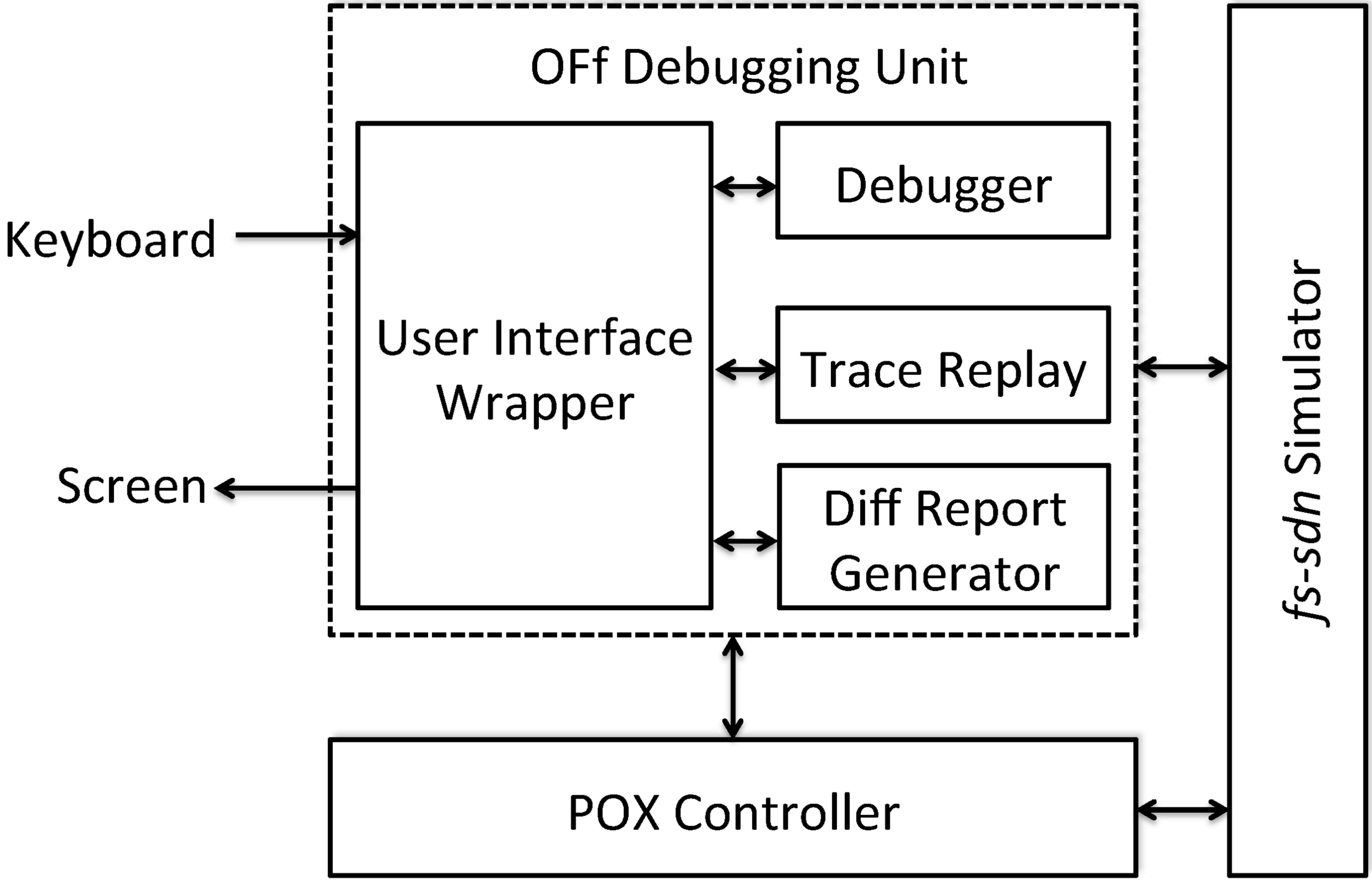
Design Goals of OFf

- A debugging and test environment for SDN developers
- Default debugging options
    - Stepping, breakpoints, watch variables, etc.
- Comprehensive testing for SDN applications
    - Packet replay, packet tracing, visualization, alerts, etc.
- Tie unwanted network behavior to controller
- Simple, light-weight and no hardware support
- Facilitate transition to live environments

Related work

- Debuggers
  - ndb (Handigol et al., 2012)
  - NetSight (Handigol et al., 2014)
- Replay tool
  - OFRewind (Wundsam et al., 2011)
- Static analysis and symbolic execution tools
  - Veriflow (Kurshid et al., 2013)
  - Header Space Analysis (Kazemian et al., 2012)
  - NICE (Canini et al., 2012)

OFf Architecture



OFf Commands

- longlist and shortlist source code
- pretty print expressions
- hide and unhide frames
- interactive interpreter with all variables in scope
- track, watch, or unwatch variables
- edit source files during debugging
- enable or disable break points on the fly
- sticky mode to visualize code

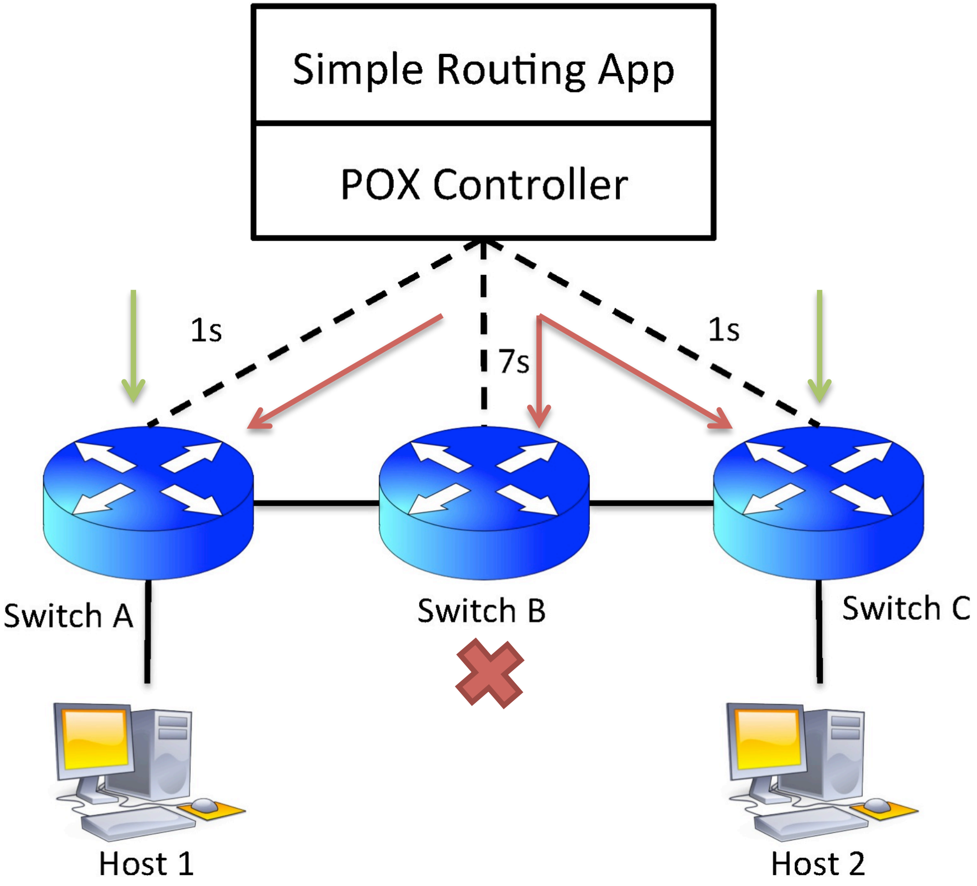
OFf Additional Features

- Trace packet through the network
  - *Holistic* view of flows, controller and switches
  - No additional hardware
- Replay packets later
  - No OFP modification
- Defect configuration changes
  - Topology changes
  - Rule/action changes
  - Performance variations

OFf in Action

- We demonstrate OFf in three scenarios
  - Incorrect ordering of updates
  - Bad multi-app interaction
  - Unexpected rule expiration
- Goal: Identify logical bugs in the source code that lead to transient outages and losses

Incorrect Ordering of Updates



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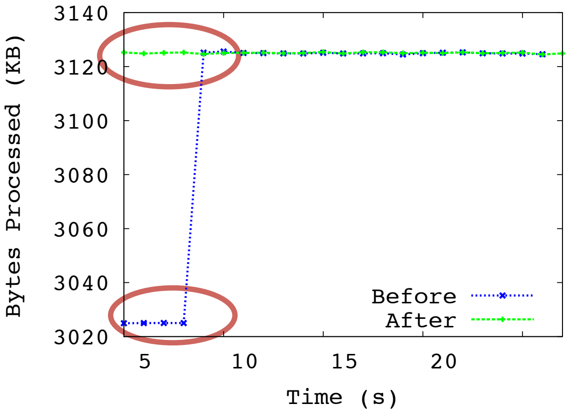
Solution: Incorrect ordering

- Installation order - C, B, and then A
- Handle barrier messages



- Using OFf
  - Replay packets
    - find packets that are dropped at B as rules are not installed
  - Set a break point => sticky mode => watch at B
  - Infer ordering problem and fix
  - Trace and Diff Reports to verify fix

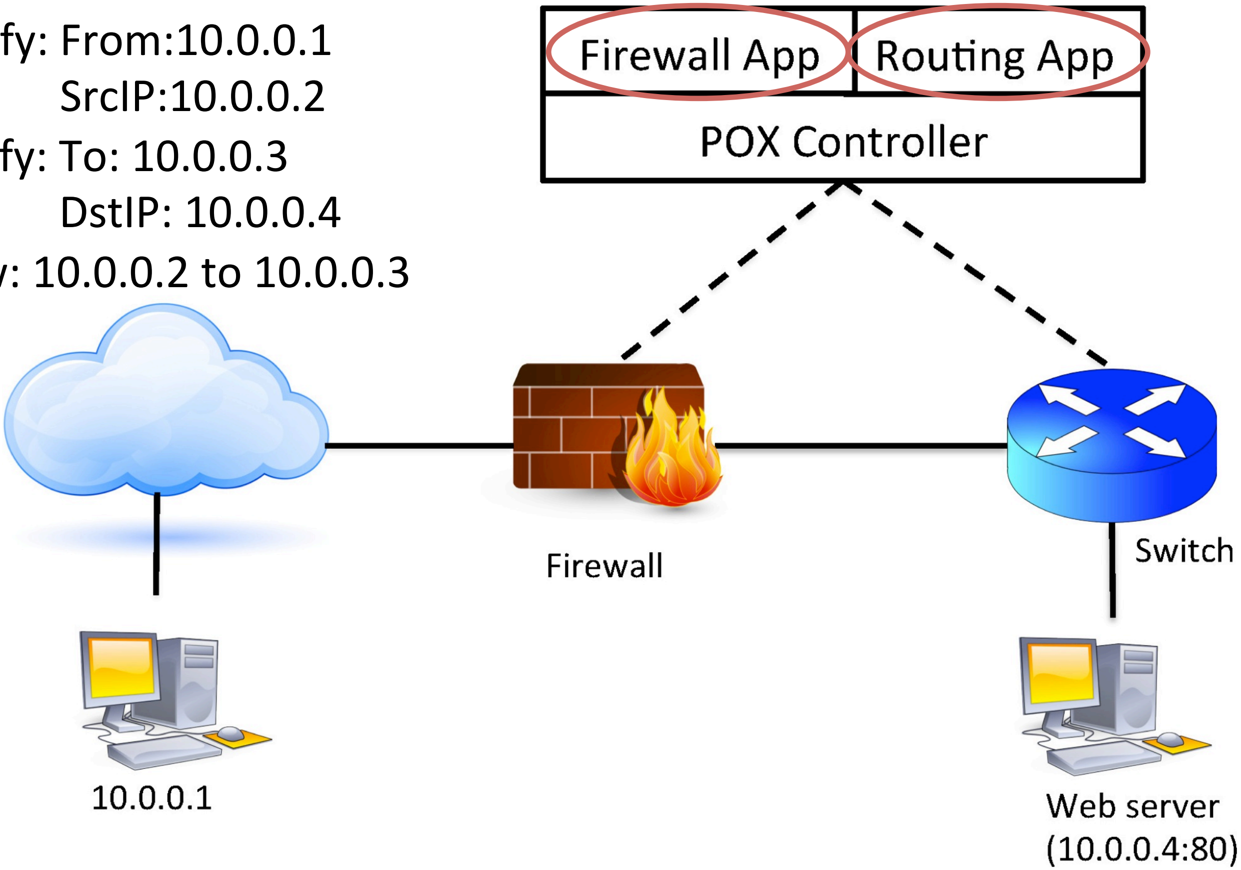
Bad Multi-app Interaction

~~Block: 10.0.0.1 to 10.0.0.4~~

Modify: From:10.0.0.1
SrcIP:10.0.0.2

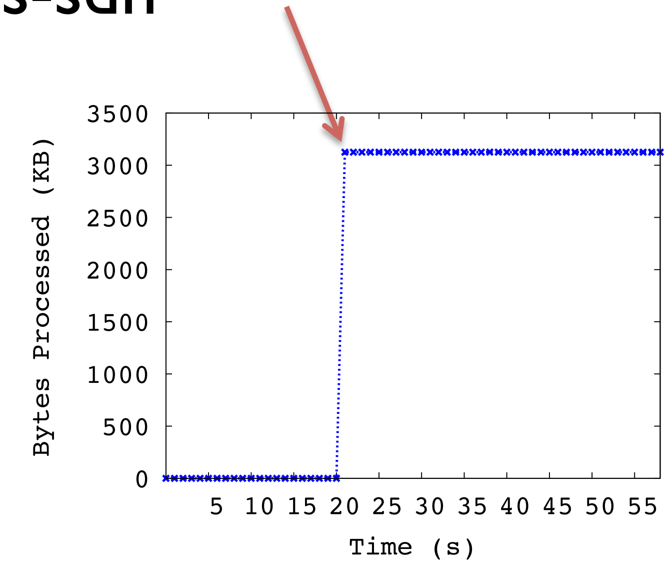
Modify: To: 10.0.0.3
DstIP: 10.0.0.4

Allow: 10.0.0.2 to 10.0.0.3



Solution: Bad Multi-app Interaction

- Using Off developer 2 can
  - – collect network traces (T1)
  - – prototype routing app using fs-sdn
  - – collect traces again (T2)
  - – runs diff reports (T1 and T2)
    - Rule set conflicts are found
  - – Change and iterate
  - – Verify firewall invariants



Conclusion

- OFf – a debugging and test environment for SDN developers
- OFf is simple, flexible, and light-weight
- We demonstrate OFf using three scenarios

Thank you!

Source Code
https://github.com/52-41-4d/fs-master

Questions?

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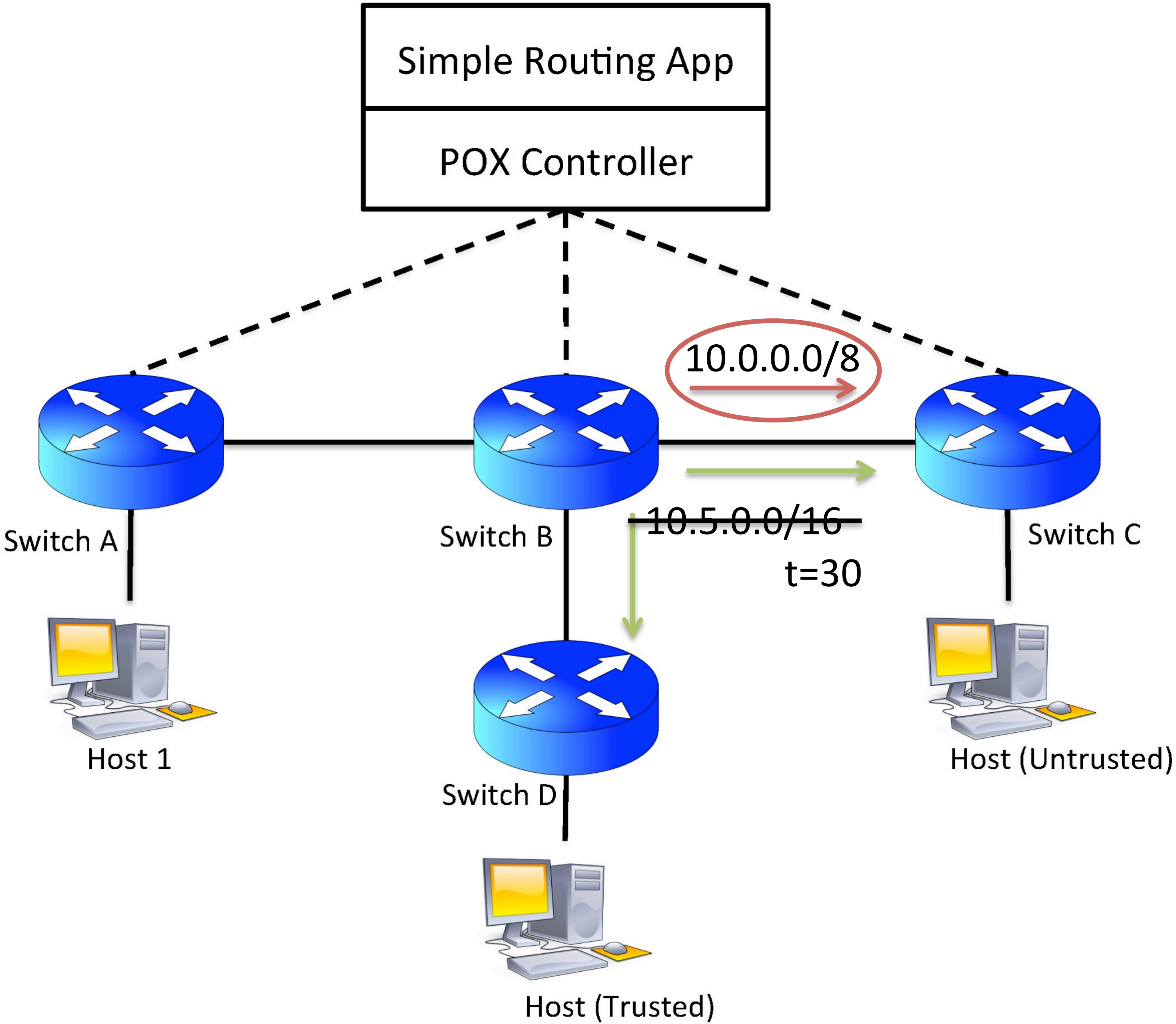
Backup Slides

Unexpected Rule Expiration



Simple Routing App

POX Controller

10.0.0.0/8

Switch A

Switch B

~~10.5.0.0/16~~

t=30

Switch C

Host 1

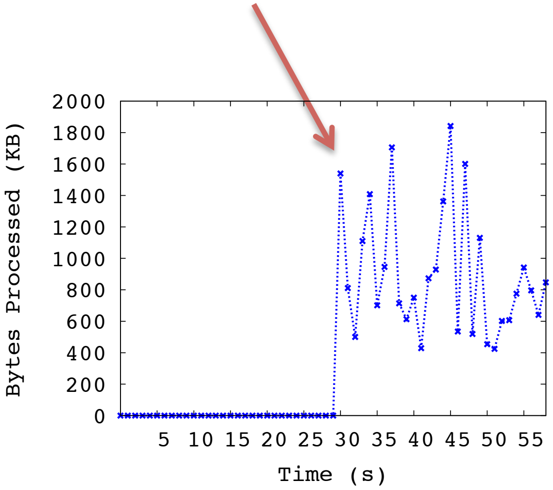
Switch D

Host (Untrusted)

Host (Trusted)

Solution: Unexpected Rule Expiration

- Using OFf
  - – prototype using fs-sdn and replay trace
  - – trace flow and rules
    - wrong rule triggered
  - – Change the timeout behavior
  - – Verify using diff reports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