Data-Plane Verification

COS 597E: Software Defined Networking

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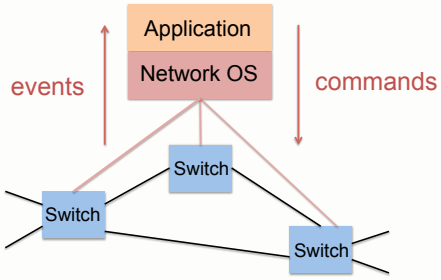
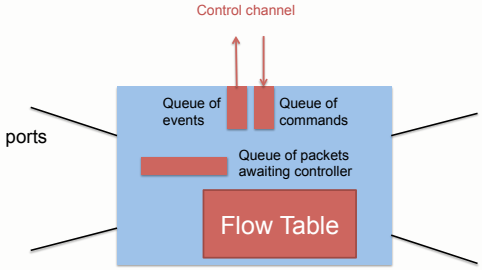
Princeton University
MW 11:00am-12:20pm

Writing SDN Controller Apps

Event-Driven Programming

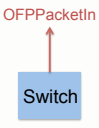


OpenFlow 1.0 Switch



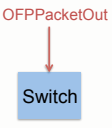
Receiving a Packet

- Switch (aka datapath)
- Input port
- Reason (no-match, action)
- Packet data
- Buffer-id for packet



Sending a Packet

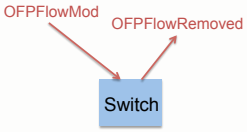
- Switch (aka datapath)
- Actions
- Packet
  - Packet data (if any)
  - Buffer-id for packet (if any)



How to create a very simple hub?

Installing a Rule

- Switch (aka datapath)
- Add, modify, delete
- Rule
  - Header fields to match
  - Set of actions
  - Hard and soft timeout
- Buffered packet to apply to (if any)



How to create a more efficient hub?

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Creating a Learning Switch

- Learning the sender's location
  - Learn host's location when sending a packet
  - Associate the source MAC with the input port
- Forwarding to the destination
  - Unknown destination: flood
  - Known destination: unicast

How to program this as a controller app?

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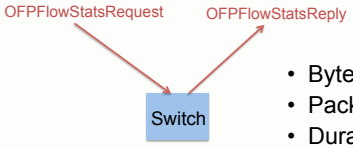
Collecting Traffic Statistics

- Switch (aka datapath)
- Header fields to match



- Byte count
- Packet count
- Duration
- …

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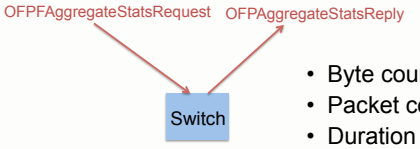
Aggregate Traffic Statistics

- Switch (aka datapath)
- Header fields to match



- Byte count
- Packet count
- Duration
- …

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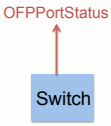
Topology Changes

- Switch (aka datapath)
- Reason (add, delete, modify)



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Data-Plane Verification

Header-Space Analysis
and VeriFlow

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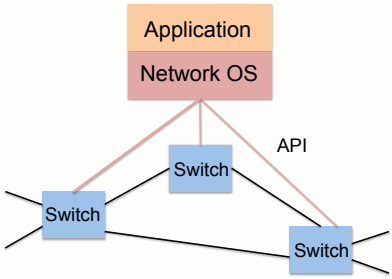
What Bugs to Catch?



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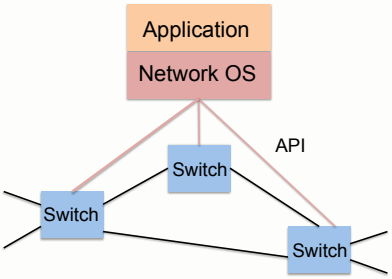
Where to Verify?



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Data-Plane Verification

- Input
  - Snapshot of the rules
- Output
  - Whether an invariant holds
  - Counter-example(s)
- Example
  - No loops
  - No blackholes
  - Access control

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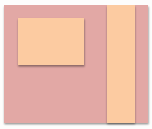
Packets in Multiple Dimensions

- Packets as points in a geometric space
  - A dimension for every bit in the header
- Policies as functions
  - Mapping a packet and its location
  - … to a new packet and location
- Many packets treated the same way
  - E.g., all packets with TCP dest port 80



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Two Approaches

- Header-space analysis
  - Ternary symbolic execution
  - Follow a symbolic packet through the network
  - Algorithms for checking specific invariants
- VeriFlow
  - Generate equivalence classes of packets
  - Generate per-class forwarding graphs
  - Traverse graphs to check specific invariants

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Discussion

- Efficiency
  - Usable in real time?
- Limitations
  - What invariants can(not) be checked?
  - How are invariants specified?

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Next Time

- Get started on assignment 2 (due Oct 1)
  - Programming in Ryu
  - Use the references from assignments page
- Reading for Wednesday
  - Testing and debugging
  - NICE and ndb

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