Fast, Accurate Simulation for SDN Prototyping

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Motivation

- Prototyping, evaluating and debugging SDN applications is hard
  - Increasing scale, diversity, and complexity of apps
  - Will my SDN app behave as expected when deployed in the wild?
  - Does it operate correctly and efficiently at scale?

SDN prototyping and debugging landscape

Custom fluid-flow simulators (e.g., Al-Fares et al., 2008)

Extensions to packet-level simulators (e.g., Klein and Jarschel, 2013)

fs-sdn

Mininet (Handigol *et al.*, 2012)

Testbed experiments (e.g., Greenberg *et al.*, 2009)

Virtual slice of a live network (e.g., with FlowVisor, Sherwood et al., 2010)

Simulation — Emulation — Live Deployment

Also:

- Debuggers, *e.g.*, ndb (Handigol *et al.*, 2012)
- Static analysis and symbolic execution tools, *e.g.*, VeriFlow (Kurshid *et al.*, 2012), Header space analysis (Kazemian *et al.*, 2012) NICE (Canini *et al.*, 2012)

Goals of our work

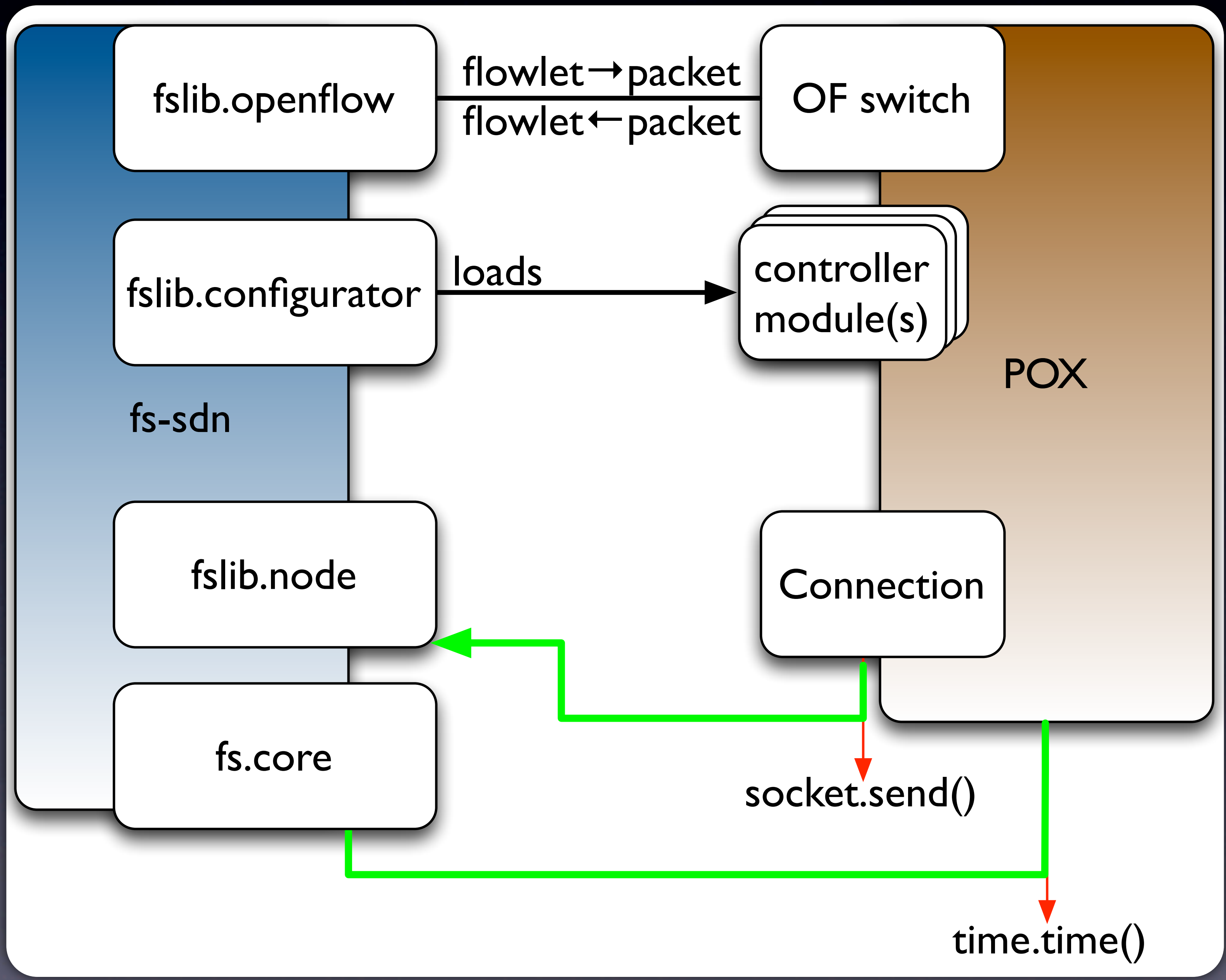
- Develop an SDN simulation capability that complements existing development and debugging tools
  - A controller API environment to facilitate transition to live environments
  - Ability to generate realistic application traffic flows
  - Capability to scale up to large networks
  - Facilities for detailed debugging and tracing

fs-sdn overview and background

- Designed as extensions to the *fs* network flow record generator (Sommers *et al.*, INFOCOM 2011)
  - Uses discrete event simulation to drive flow record generation
  - Flowlets instead of packets
  - Accurate to 1 second time scales, way faster than ns2
    - Example from earlier work: speedup of 50x in scenario with 800 new flows/sec
  - Written in Python
- SDN extensions leverage and integrate the POX controller platform
  - Provides OpenFlow 1.0 environment

fs-SDN design and implementation

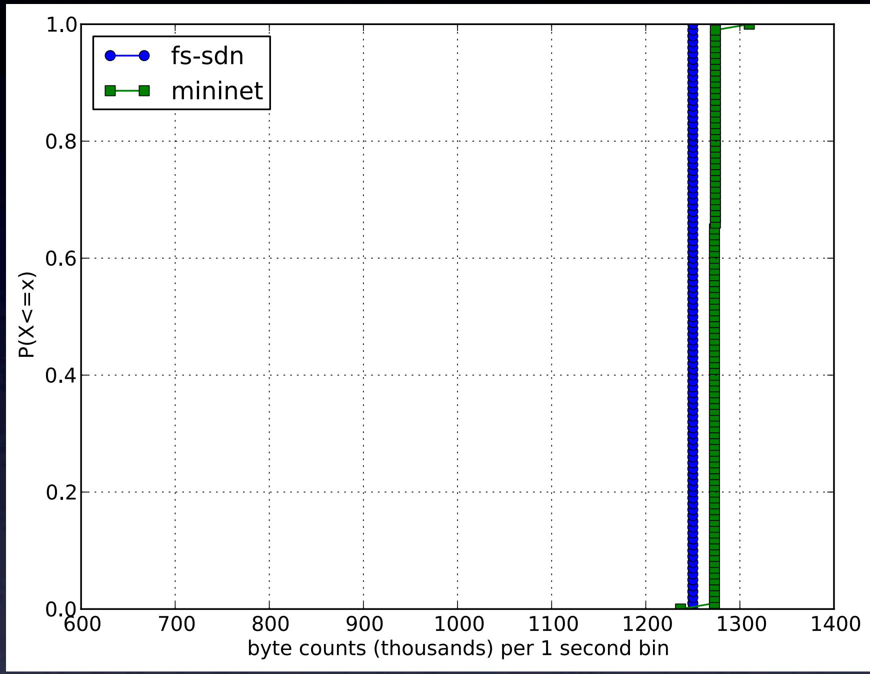
- Integrate POX controller and library code via monkeypatching
  - Key aspects: calls that get or set external state (time, network) and packet/flowlet translation
- Upshot: POX controller modules can be used without modification in fs
  - discovery, spanning tree, l2 learning, hub, l2 pairs, etc., all work out of the box



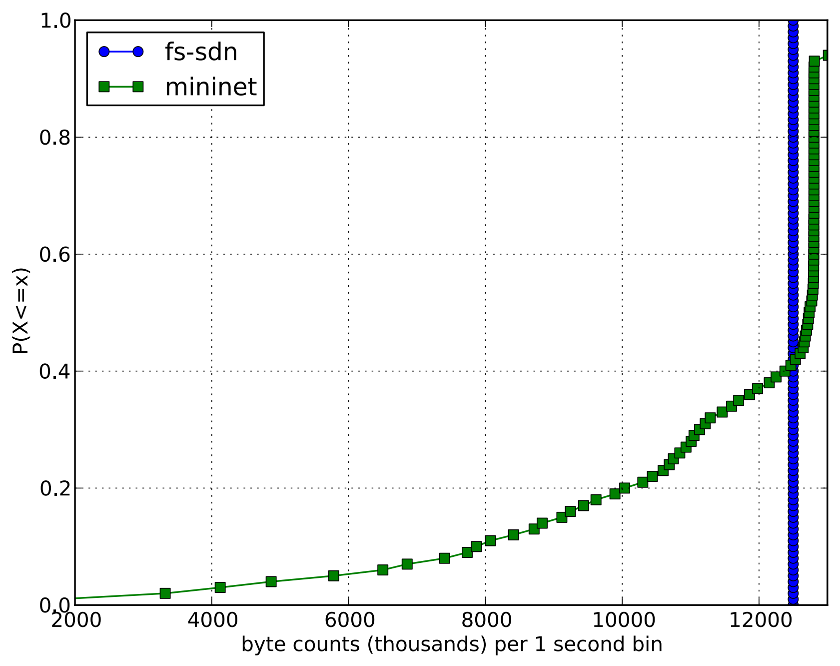
System evaluation

- Evaluate accuracy and scalability of fs-sdn
- Set up congruent experiments in fs-sdn and Mininet
  - Background traffic: CBR stream or Harpoon flows at two different loads each
  - Linear topologies in 4 configurations of increasing size (up to 100 switches)
  - Simple layer-3 shortest paths controller module

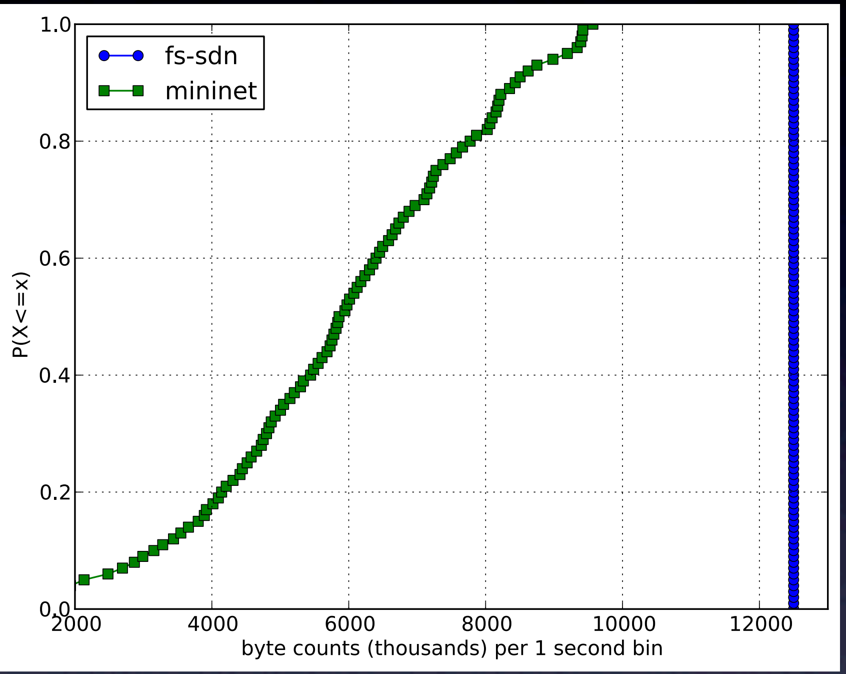
Results: accuracy



CBR low load (10 Mb/s), small topology (10 switches)



CBR high load (100 Mb/s), small topology (10 switches)



CBR high load (100 Mb/s), medium topology (50 switches)

- Plots show byte counts per second collected in fs and an equivalent setup in Mininet
- As topology and/or traffic load increase, measurements collected in Mininet degrade
  - I/O bottlenecks limit system performance

Results: speedup

- Tables show fs-sdn execution times for scenarios with 900 simulated seconds
    - Mininet takes 900 seconds for each experiment
    - pypy interpreter with JIT compiler was used for experiments

UDP CBR traffic				
Load	Tiny	Small	Medium	Large
Low	6	8	33	72
High	4	8	31	76

Harpoon traffic (Pareto distr. flow sizes)				
Load	Tiny	Small	Medium	Large
Low	16	33	104	193
High	30	62	194	337

Summary and future work

- fs-sdn provides a fast and accurate simulation environment for prototyping and debugging SDN/OpenFlow applications
  - (Nearly) seamless transition of controller modules to "real" deployments
  - Code available: https://github.com/jsommers/fs
- Future work
  - Complete packet/flowlet translations to truly make the environment seamless
  - Better tracing and debugging capabilities
  - Improve scalability through parallelizing fs
  - Is it possible to bridge other (including non-Python) controller platforms?