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Software Defined Networking

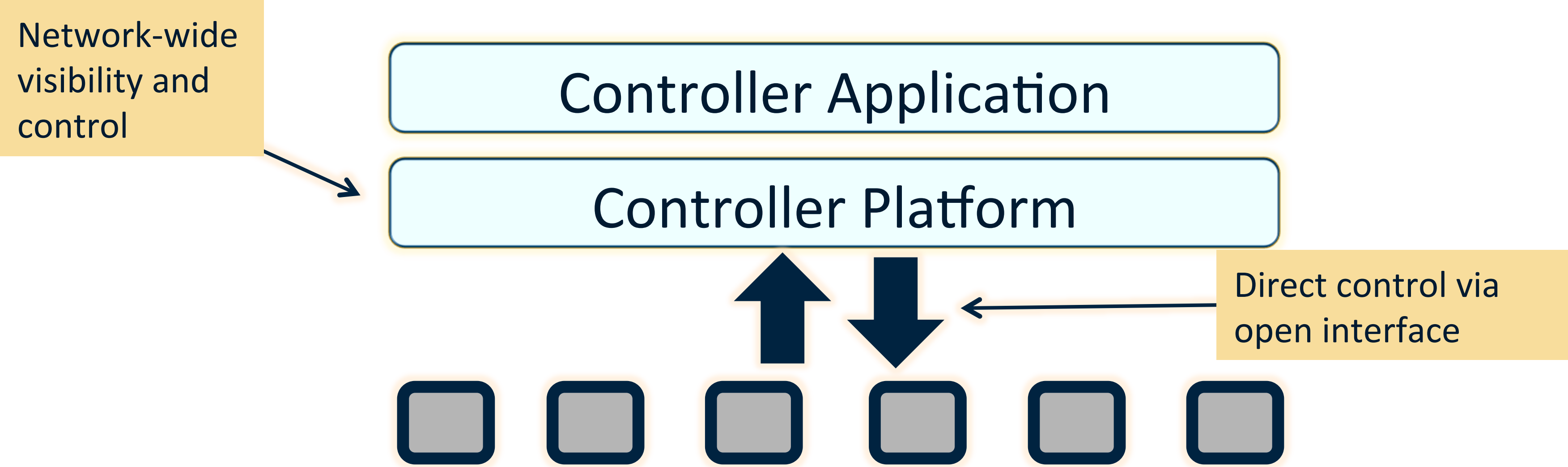
In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

This Module: Programming SDNs

- Lessons
  - Motivation for Programming SDNs
  - **Programming Languages for SDNs**
  - Composing SDN Control
    - Pyretic
  - Kinetic: Event-Driven SDN
- Programming Assignment
- Quiz

Some slide material courtesy of Jennifer Rexford

Programming SDNs



Network-wide visibility and control

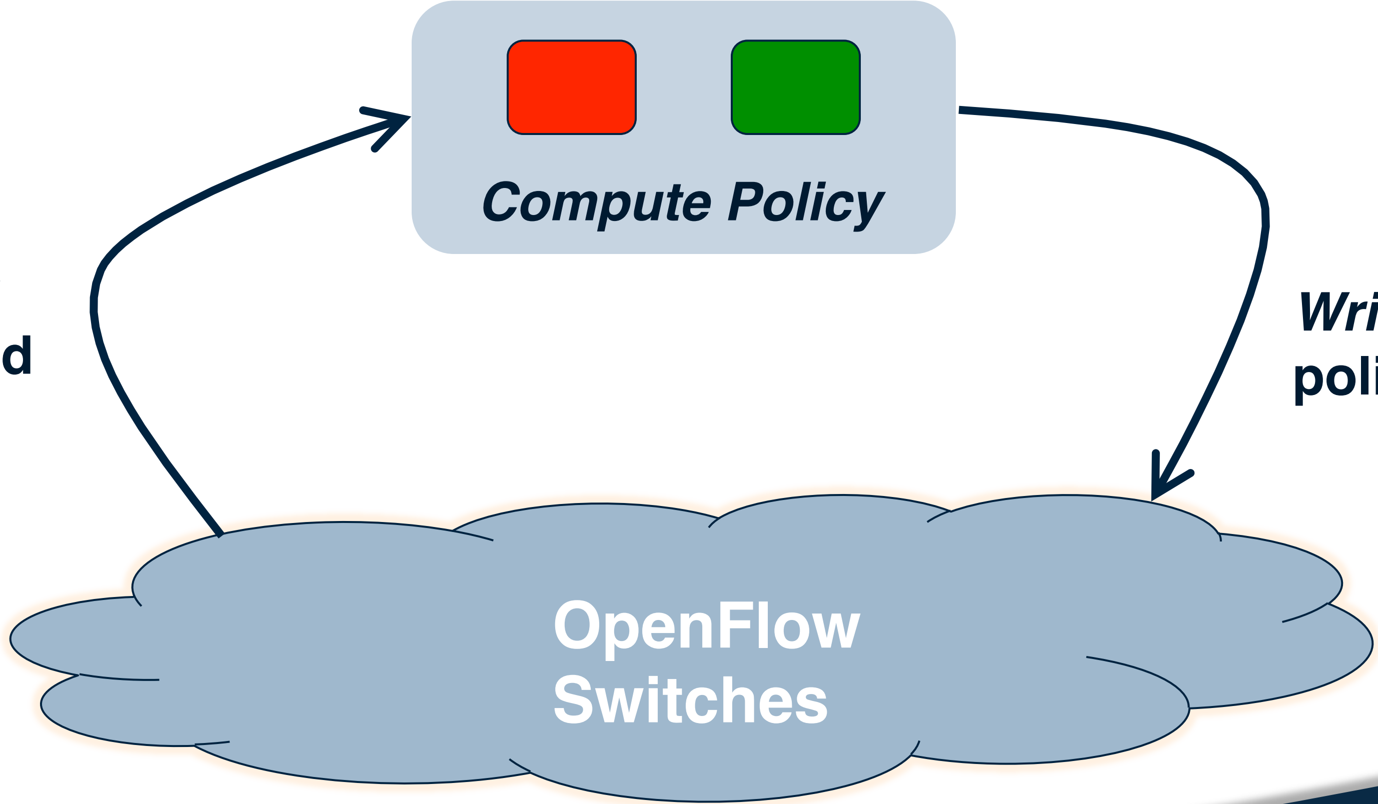
Controller Application

Controller Platform

Direct control via open interface

Southbound APIs such as OpenFlow are tied to the underlying hardware

SDN Programming: Three Steps



Compute Policy

Read/ Monitor state and events

Write policy

OpenFlow Switches

Reading State: Multiple Rules

- Traffic counters
  - Each rule counts bytes and packets
  - Controller can poll the counters
- Multiple rules
  - E.g., Web server traffic except for source 1.2.3.4

1. srcip = 1.2.3.4, srcport = 80
2. srcport = 80

- **Solution:** predicates
  - E.g., (srcip != 1.2.3.4) && (srcport == 80)
  - Run-time system
    translates into switch patterns

Reading State: Unfolding Rules

- Limited number of rules
  - Switches have limited space for rules
  - Cannot install all possible patterns
- Must add new rules as traffic arrives
  - E.g., histogram of traffic by IP address
  - … packet arrives from source 5.6.7.8

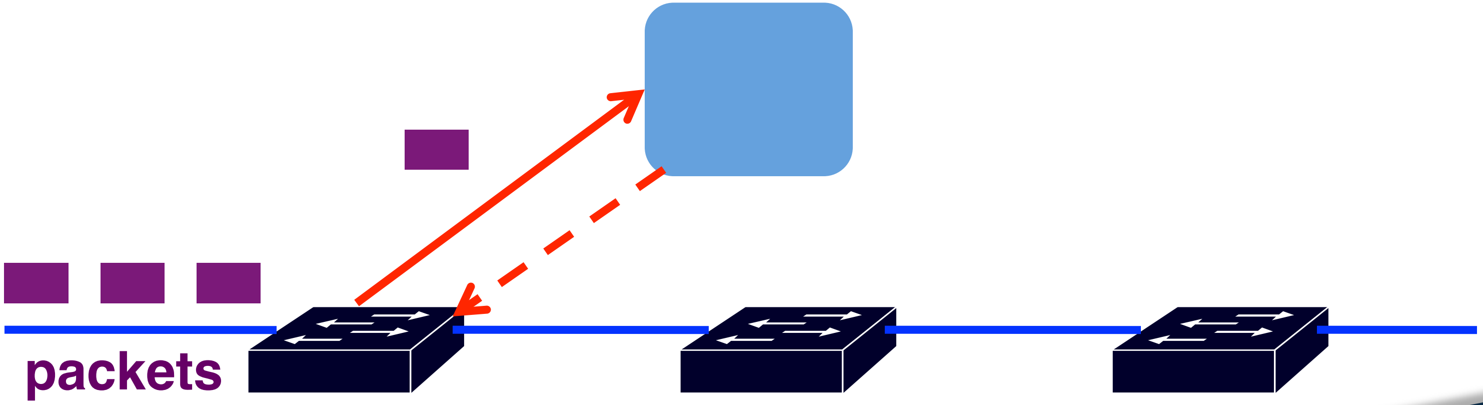
1. srcip = 1.2.3.4

1. srcip = 1.2.3.4
2. srcip = 5.6.7.8

- **Solution:** dynamic unfolding
  - Programmer specifies GroupBy(srcip)
  - Run-time system dynamically adds rules

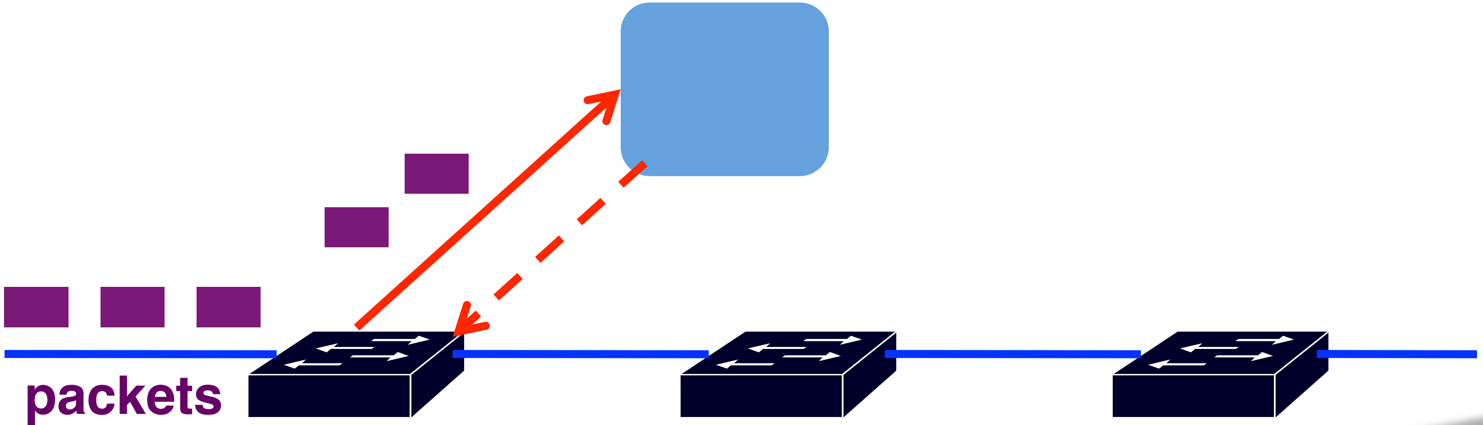
Reading State: Extra Unexpected Events

- Common programming idiom
  - First packet goes to the controller
  - Controller application installs rules



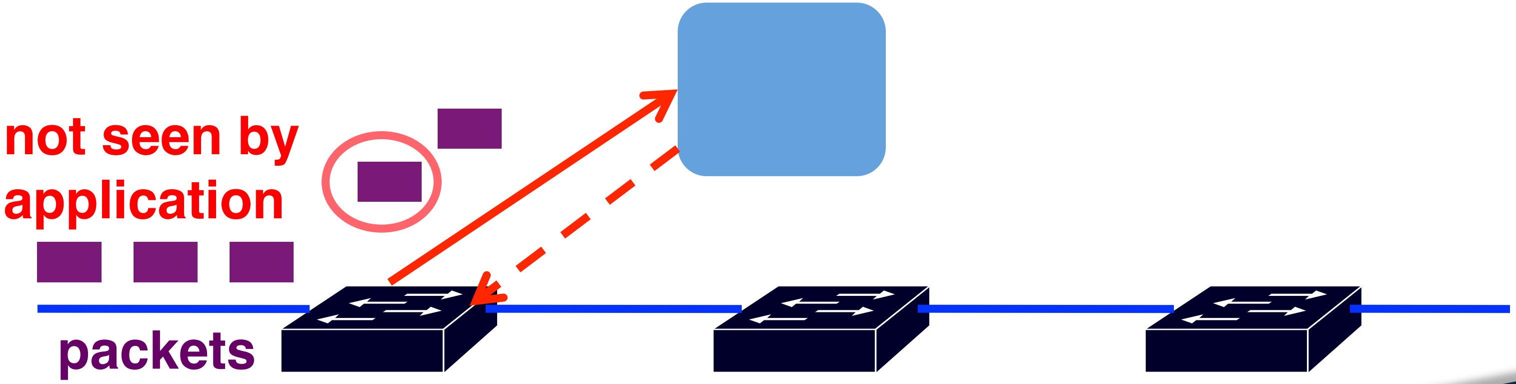
Reading State: Extra Unexpected Events

- More packets arrive before rules installed?
  - Multiple packets reach the controller



Reading State: Extra Unexpected Events

- **Solution:** suppress extra events
  - Programmer specifies “Limit(1)”
  - Run-time system hides the extra events



Frenetic: SQL-Like Query Language

- **Get what you ask for**
  - Nothing more, nothing less
- SQL-like query language
  - Familiar abstraction
  - Returns a stream
  - Intuitive cost model
- Minimize controller overhead
  - Filter using high-level patterns
  - Limit the # of values returned
  - Aggregate by #/size of packets

Traffic Monitoring

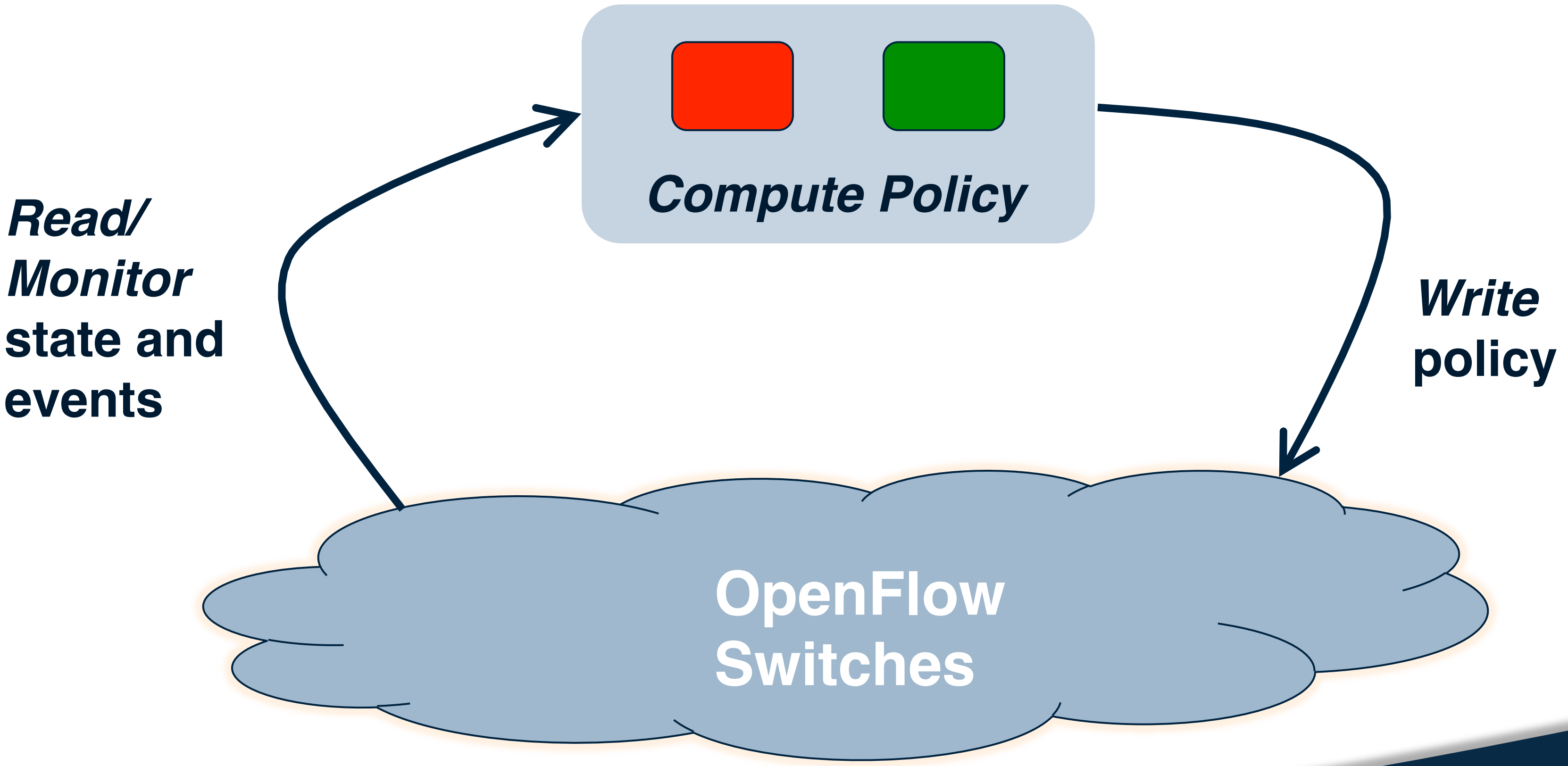
```
Select(bytes) *
Where(in:2 & srcport:80) *
GroupBy([dstmac]) *
Every(60)
```

Learning Host Location

```
Select(packets) *
GroupBy([srcmac]) *
SplitWhen([inport]) *
Limit(1)
```

Foster, Nate, et al. "Frenetic: A network programming language." *ACM SIGPLAN Notices* 46.9 (2011): 279-291.

SDN Programming: Three Steps



Compute Policy

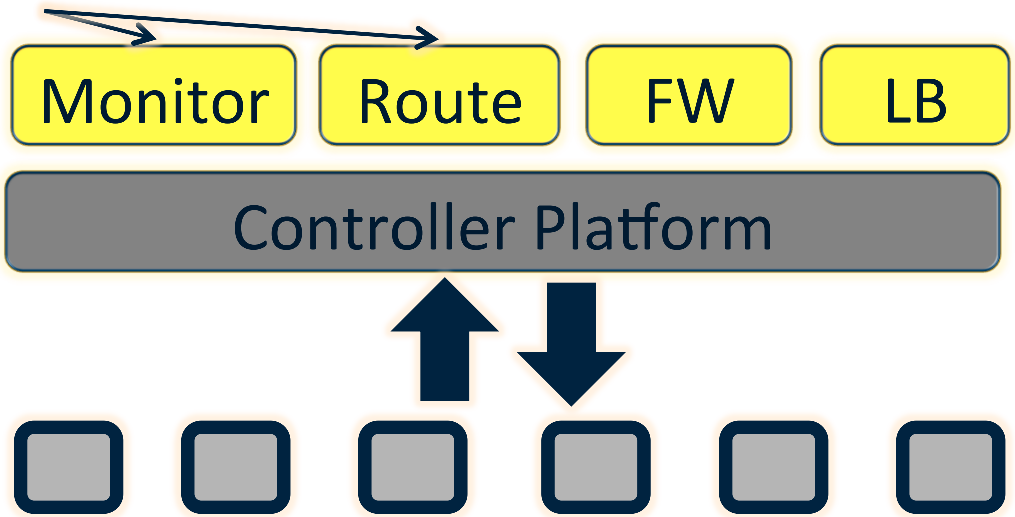
Read/ Monitor state and events

Write policy

OpenFlow Switches

But, Modules Affect the Same Traffic

Each module *partially* specifies the handling of the traffic



Next Lesson:
How to combine modules
into a complete application?

Summary

- SDN control programs: common abstractions
  - Reading and monitoring state and events
  - Computing policy
  - Writing state
- Frenetic: SQL-Like query language to control the traffic seen at the controller
- Other challenges: *Composing* policy, responding to events, compilation