Computer Networks
COL 334/672

Software Defined Networking

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Slides adapted from KR

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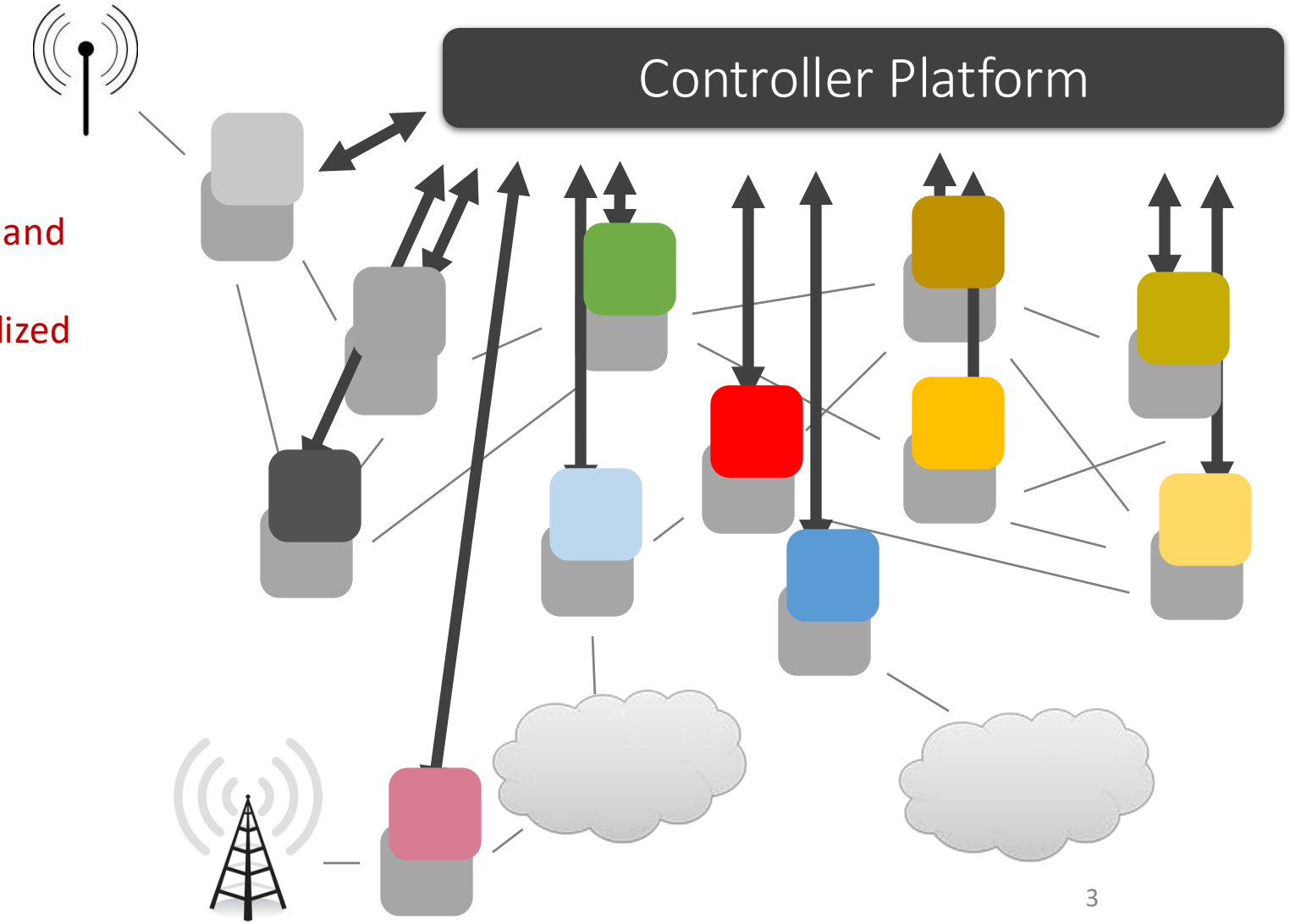
Quiz

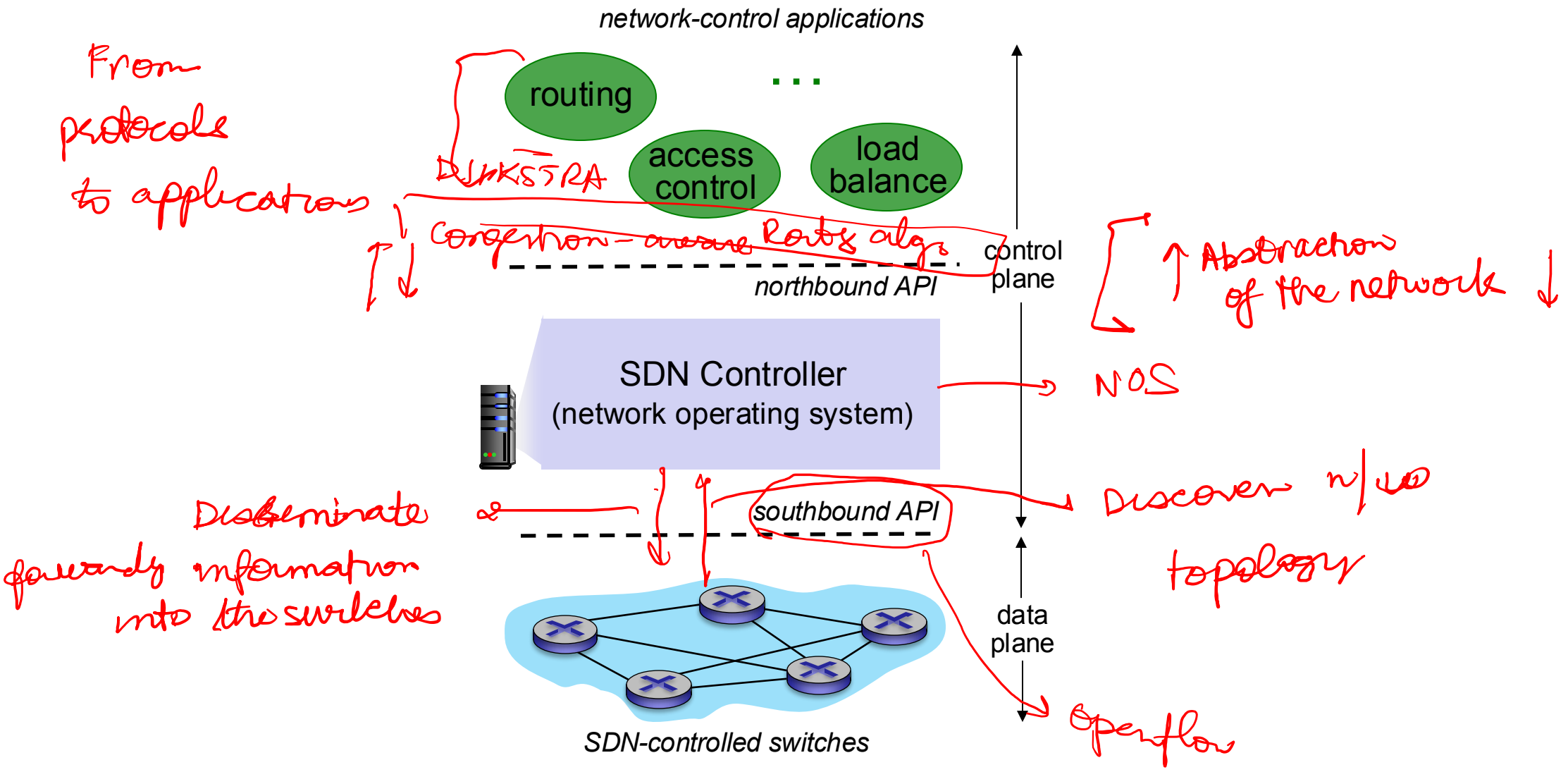
Password: openflow

Software-defined Networking

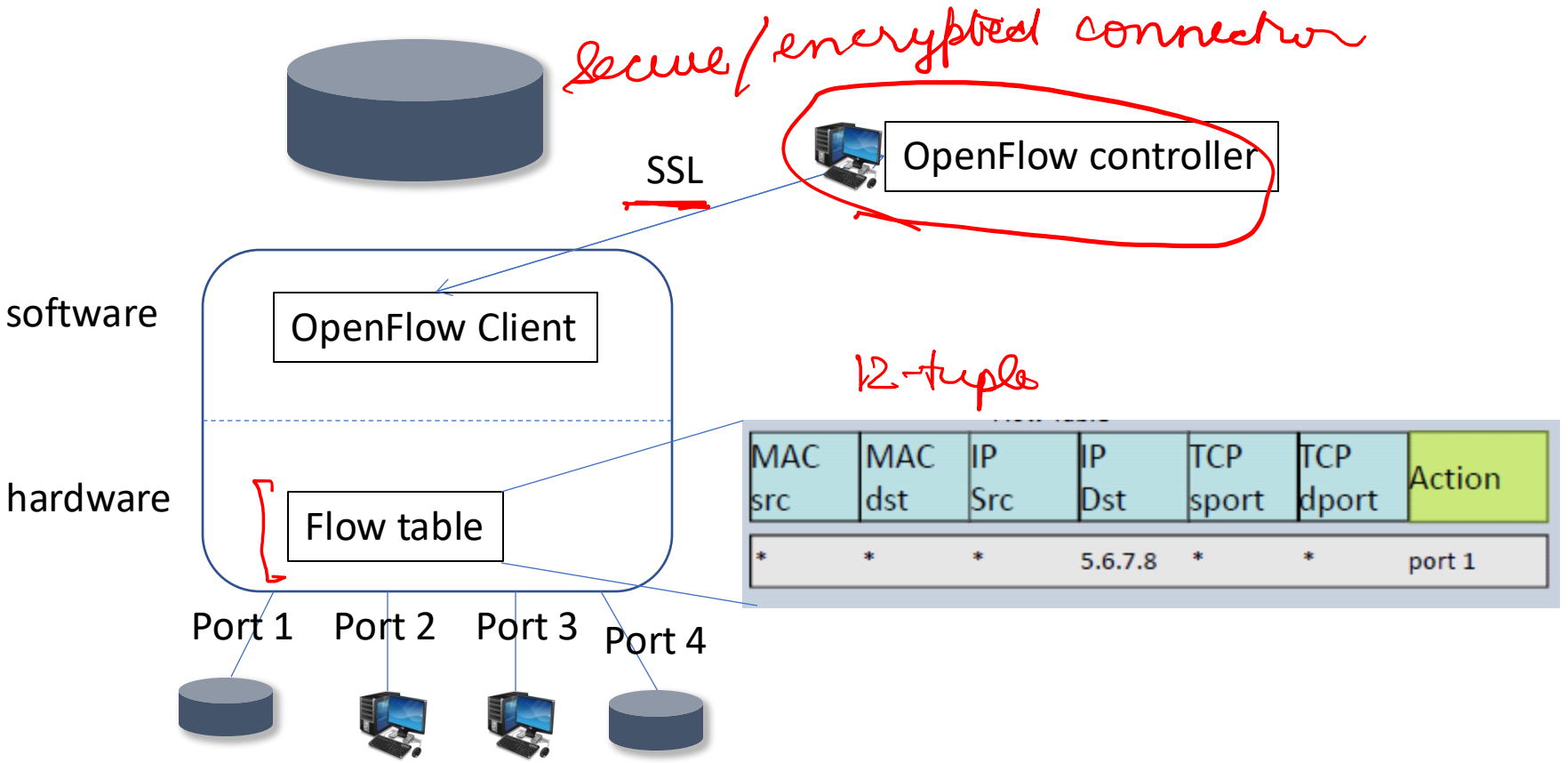
- Decouple control and data plane
- (Logically) Centralized Controller



Software-defined Network Architecture

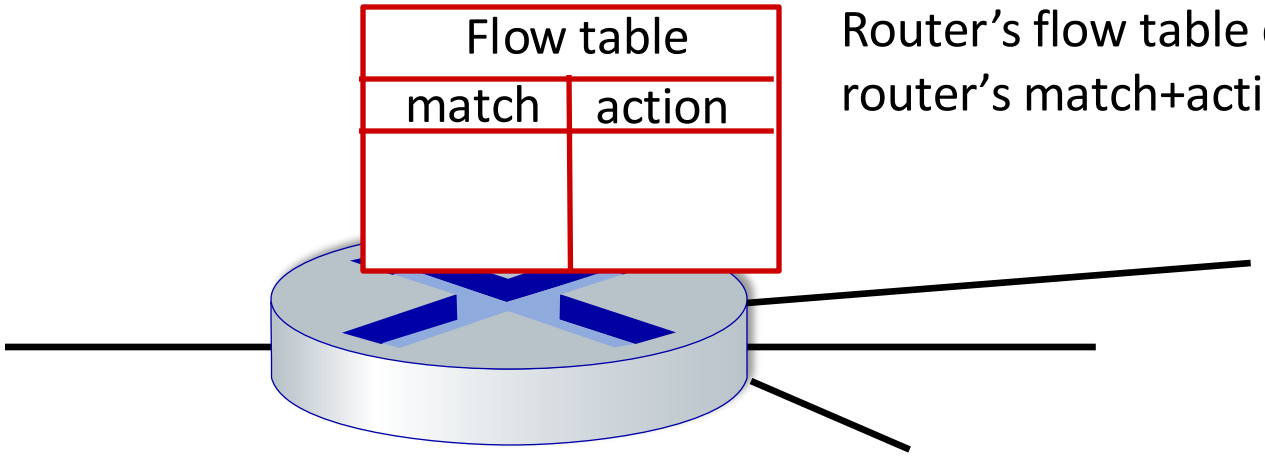


OpenFlow switch



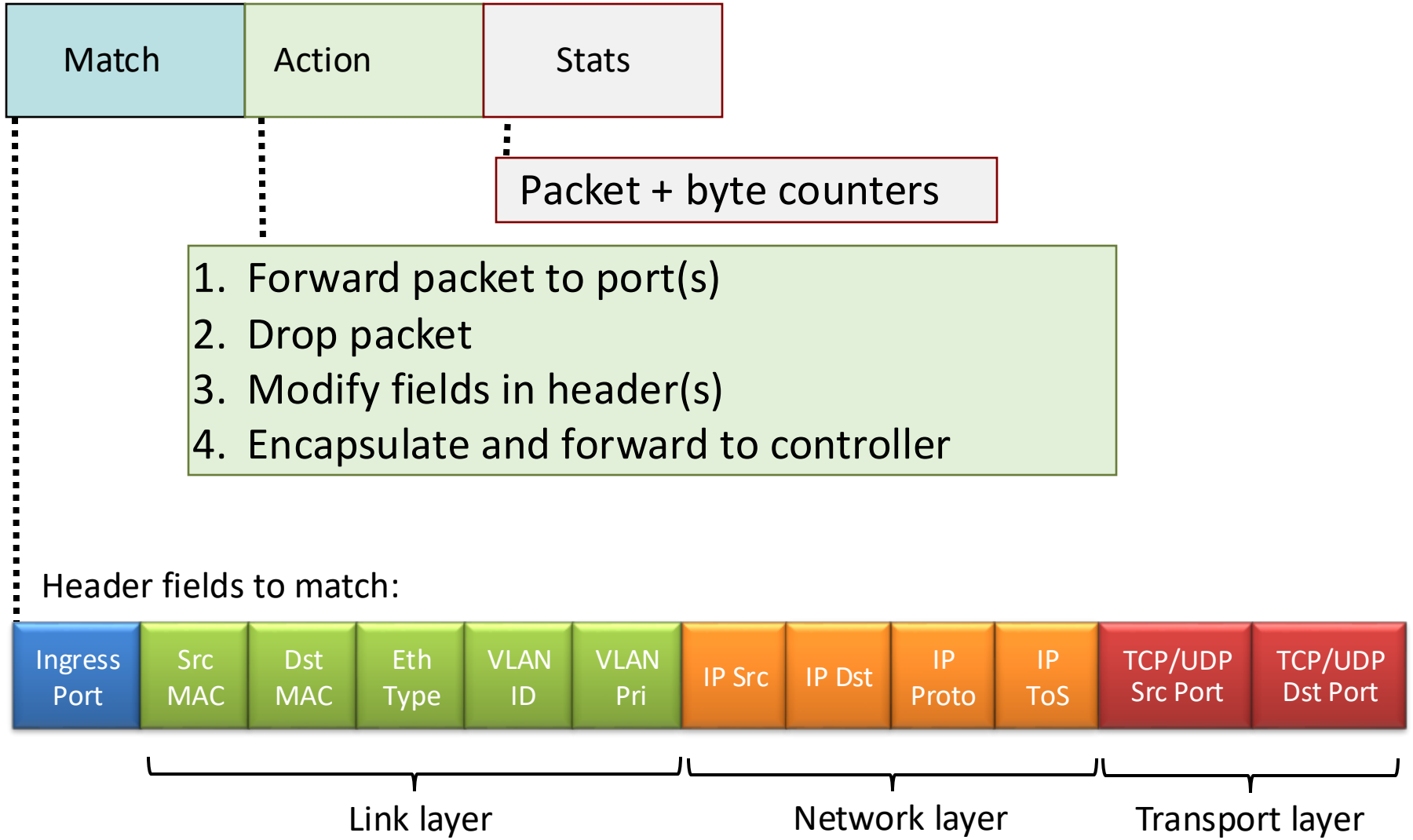
OpenFlow: Flow table abstraction

- flow: defined by header field values (in link-, network-, transport-layer fields)
- generalized forwarding: simple packet-handling rules
  - match: pattern values in packet header fields
  - actions: for matched packet: drop, forward, modify, matched packet or send matched packet to controller
  - priority: disambiguate overlapping patterns
  - counters: #bytes and #packets



Router's flow table define router's match+action rules

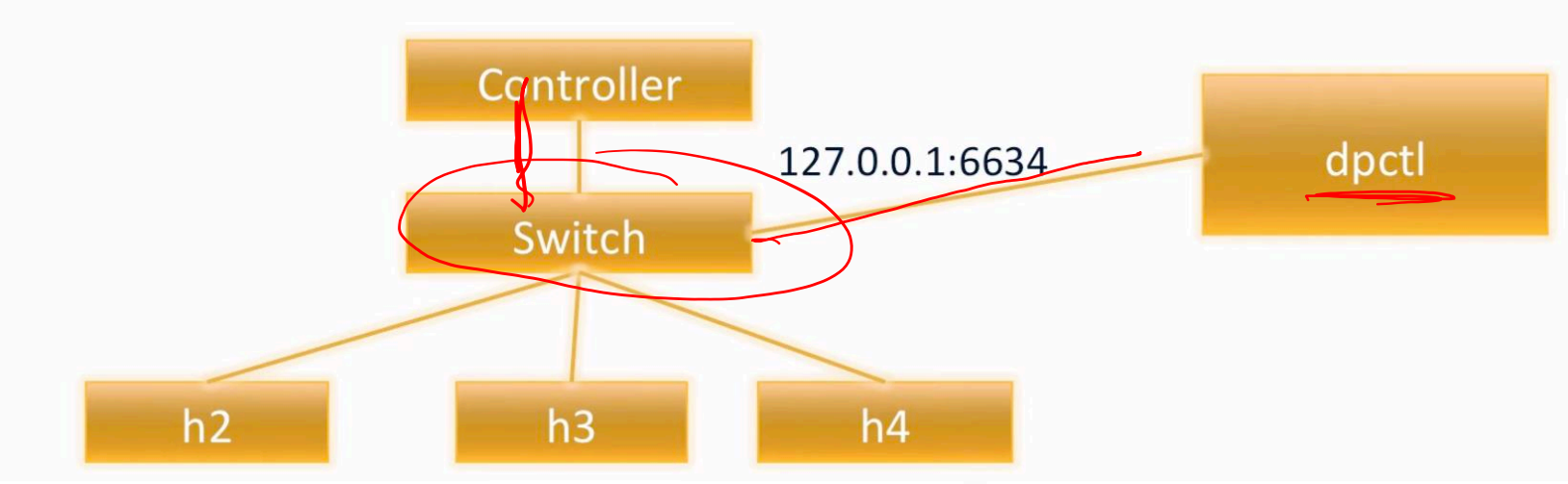
OpenFlow: flow table entries



OpenFlow Demo

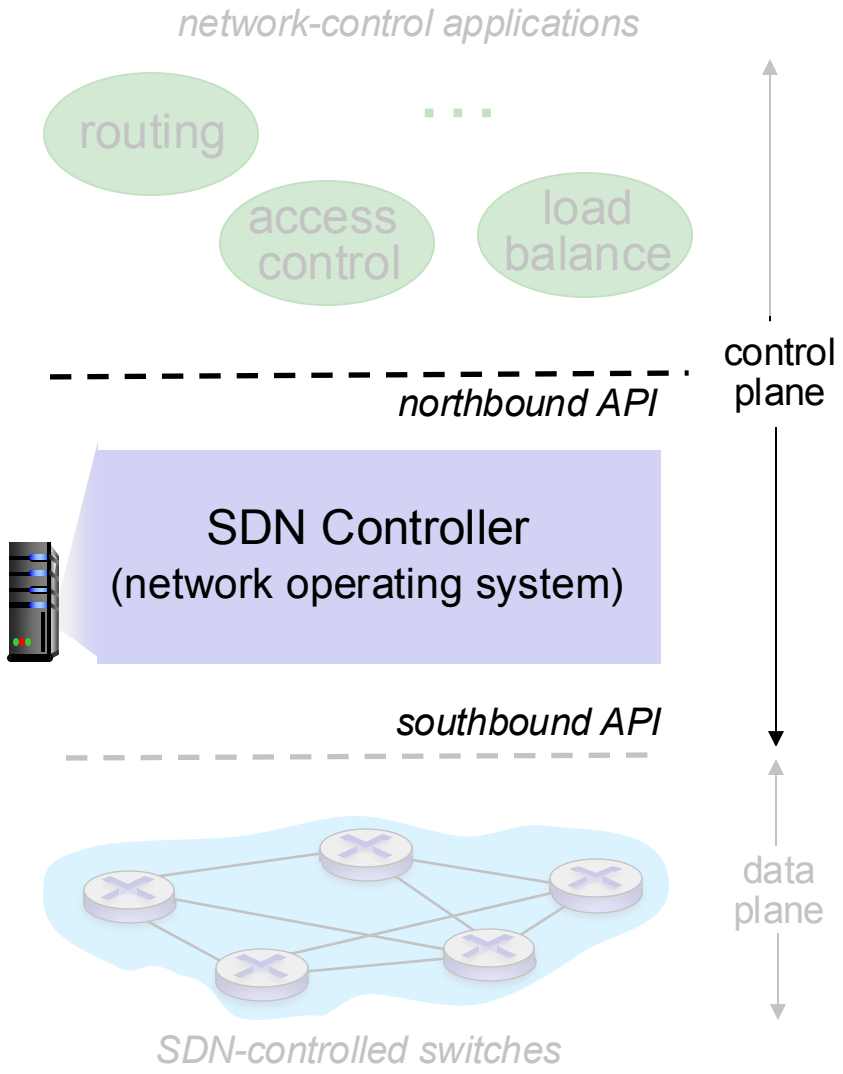
- Mininet: a network **emulation** and prototyping platform
  - A virtual network environment that can run on a single PC
  - Built in OpenFlow features

- Openflow switch: dpctl control channel



SDN Controller (Network OS)

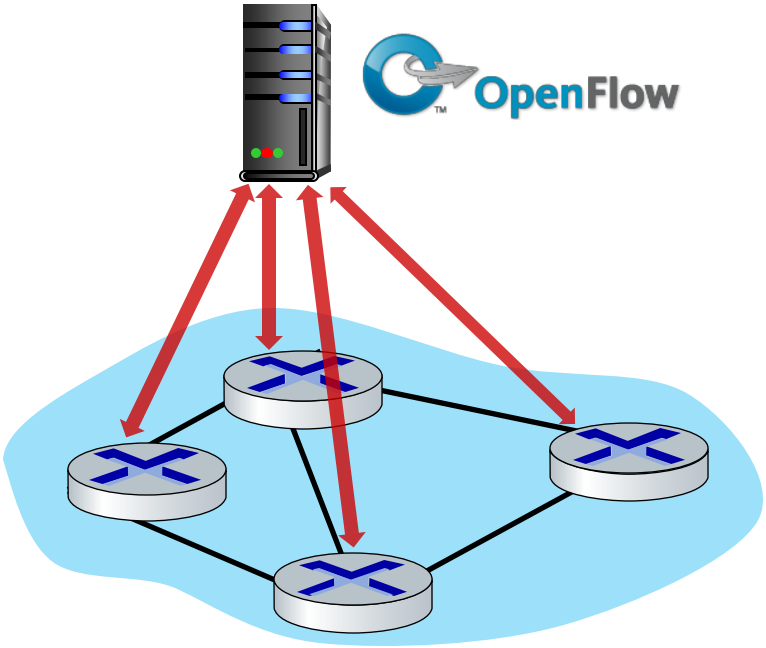
- maintains network state information
- interacts with network control applications "above" via northbound API
- interacts with network switches "below" via southbound API
- implemented as distributed system for performance, scalability, fault-tolerance, robustness



OpenFlow Messages

- TCP used to exchange messages
  - optional encryption
- Three classes of OpenFlow messages:
  - controller-to-switch
  - asynchronous (switch to controller)
  - symmetric (misc.)
- distinct from OpenFlow API
  - API used to specify generalized forwarding actions

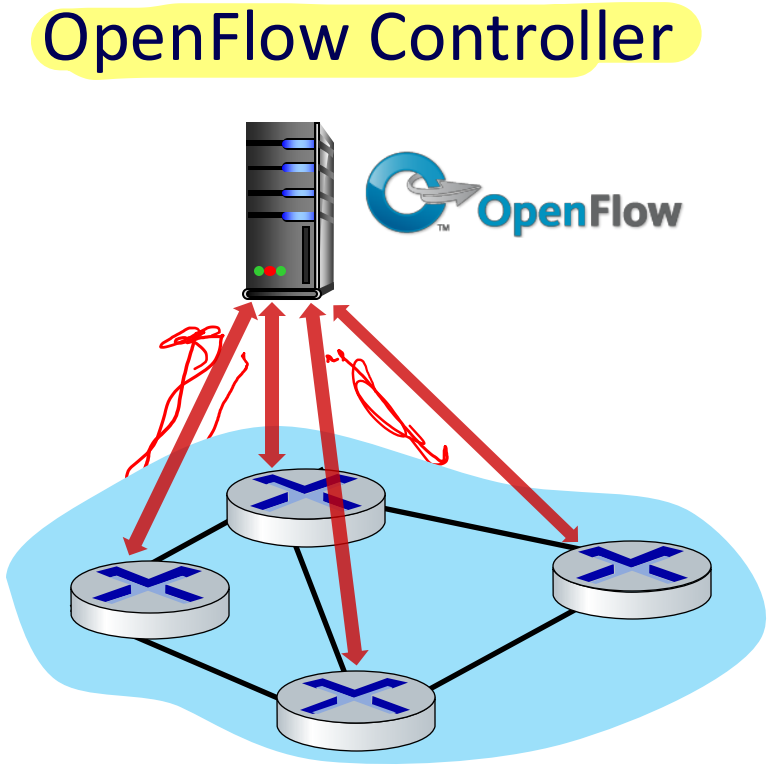
OpenFlow Controller



OpenFlow: controller-to-switch messages

Key controller-to-switch messages

- *features:* controller queries switch features, switch replies
- *configure:* controller queries/sets switch configuration parameters
- *modify-state:* add, delete, modify flow entries in the OpenFlow tables
- *packet-out:* controller can send this packet out of specific switch port

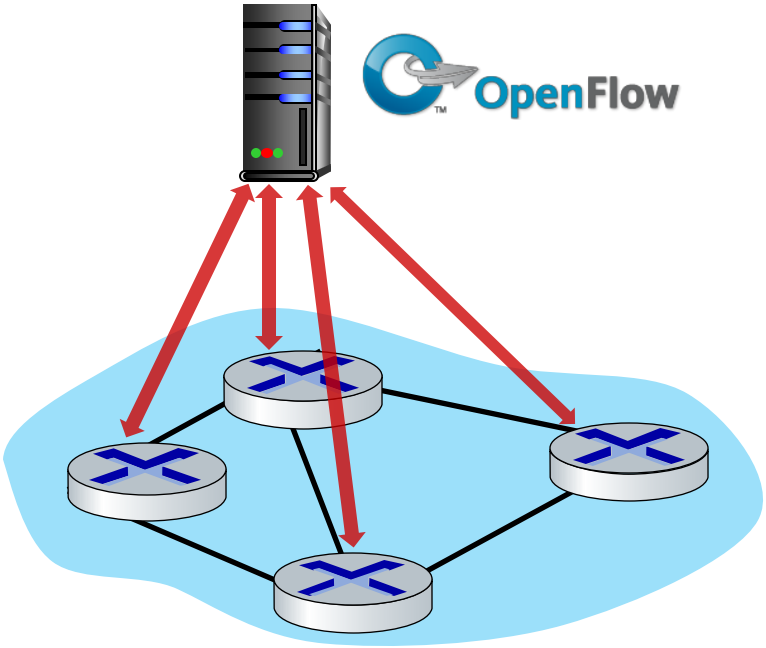


OpenFlow: switch-to-controller messages

Key switch-to-controller messages

- *packet-in:* transfer packet (and its control) to controller. See packet-out message from controller
- *flow-removed:* flow table entry deleted at switch
- *port status:* inform controller of a change on a port.

OpenFlow Controller



Example of Controllers

- **Ryu**
- **Floodlight**
- **NOX/POX**
- **OpenDayLight (ODL)**
- **Open Network Operating System (ONOS)**
- Pyretic
- Frentic
- Procera

Floodlight

ONOS
Open Network Operating System

OPEN DAYLIGHT

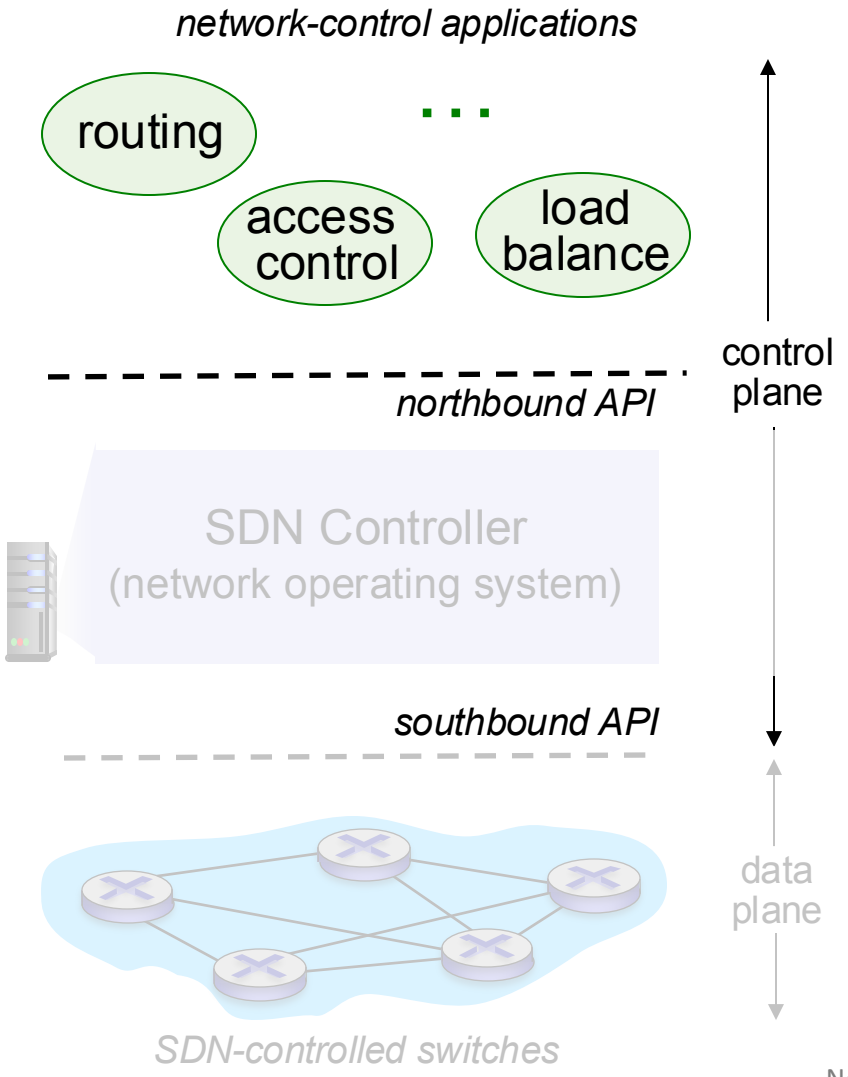
Choosing the right SDN controller?

- Use case
- Learning curve, programming language
- Focus (Southbound API, Northbound API)
- Community support

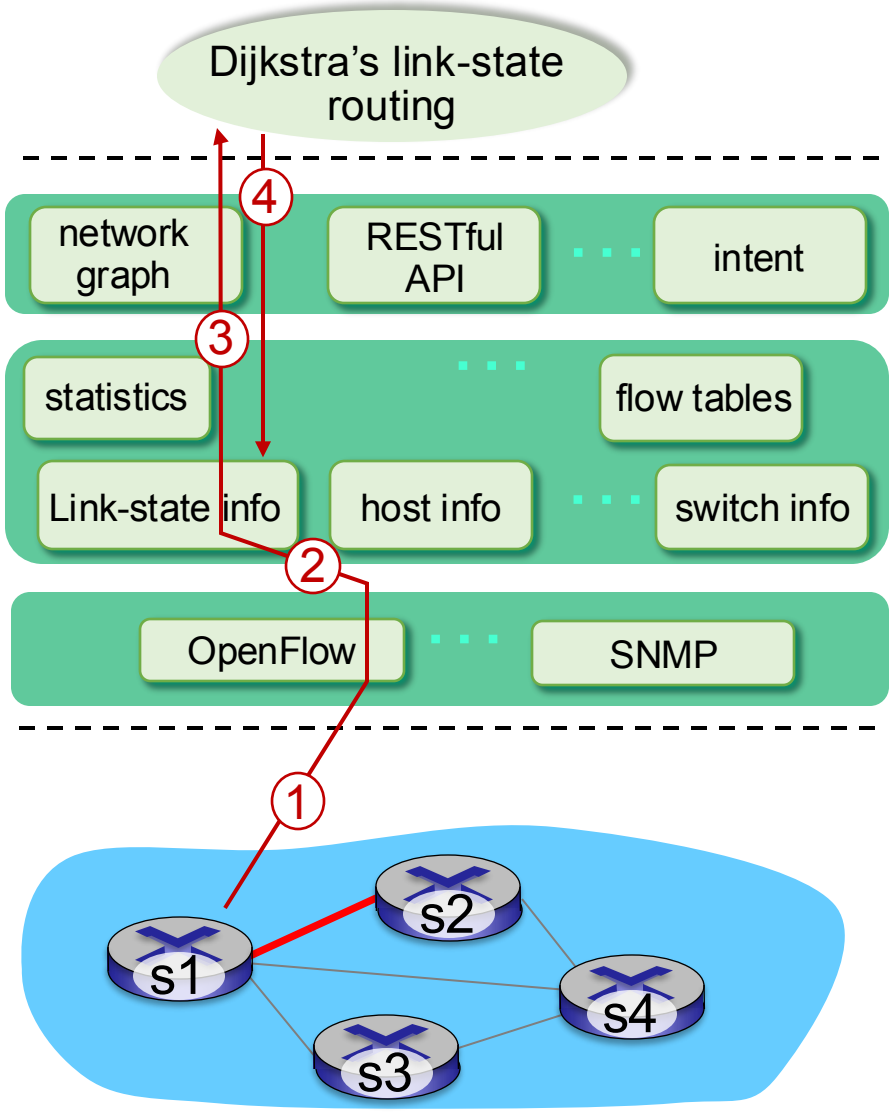
Ryu Demo

Software defined networking (SDN)

- operators don't "program" switches by creating/sending OpenFlow messages directly.
- Instead use higher-level abstraction at controller
- "brains" of control: implement control functions using lower-level services, API provided by SDN controller
- *unbundled:* can be provided by 3rd party: distinct from routing vendor, or SDN controller



SDN: control/data plane interaction example



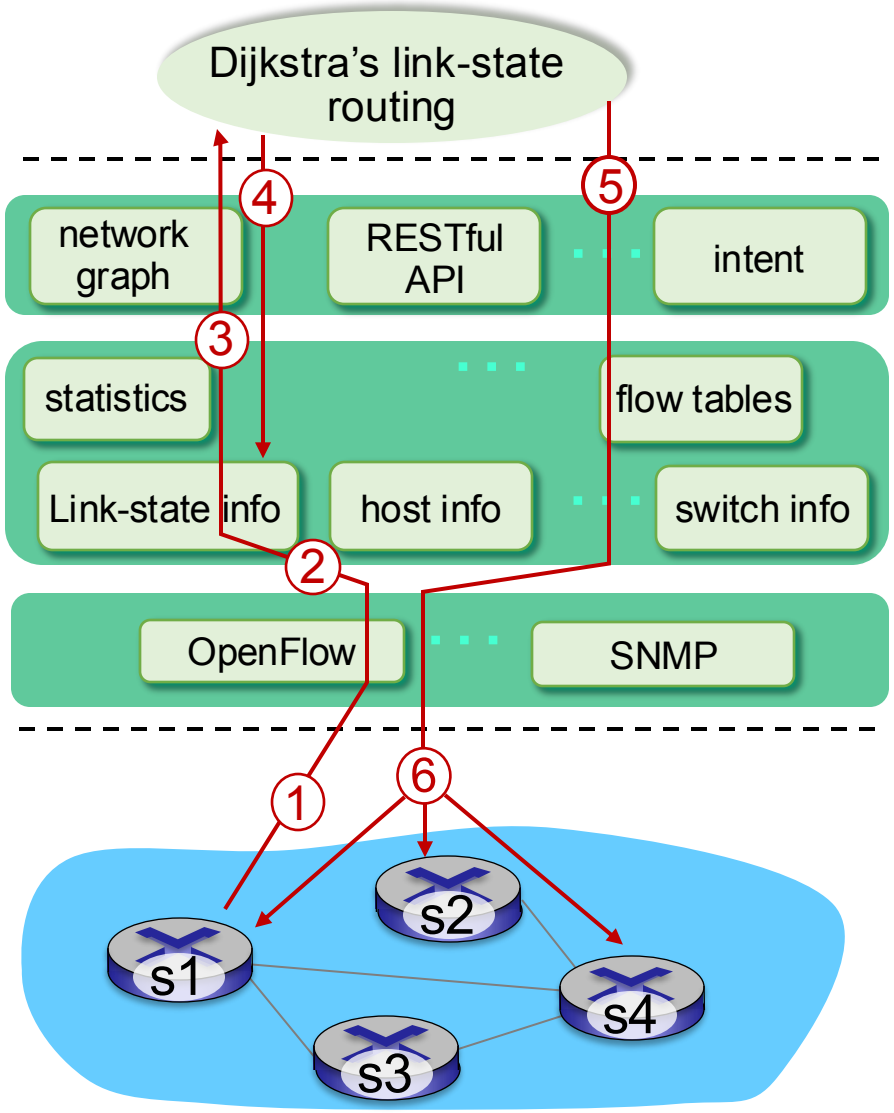
① S1, experiencing link failure uses OpenFlow port status message to notify controller

② SDN controller receives OpenFlow message, updates link status info

③ Dijkstra's routing algorithm application has previously registered to be called when ever link status changes. It is called.

④ Dijkstra's routing algorithm access network graph info, link state info in controller, computes new routes

SDN: control/data plane interaction example



⑤ link state routing app interacts with flow-table-computation component in SDN controller, which computes new flow tables needed

⑥ controller uses OpenFlow to install new tables in switches that need updating

SDN: Key Challenges

- Hardening the control plane
  - Scalability
  - Reliability
  - Consistency
  - Security

- Internet-scaling: beyond a single AS (?)

Attendance