# Computer Networks COL 334/672

Software Defined Networking

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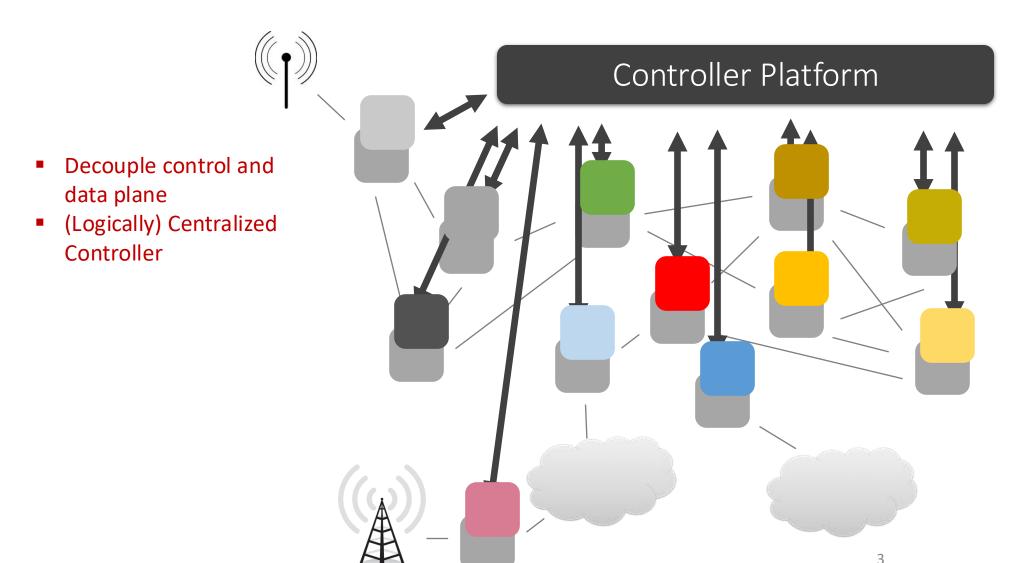
Slides adapted from KR

Sem 1, 2024-25

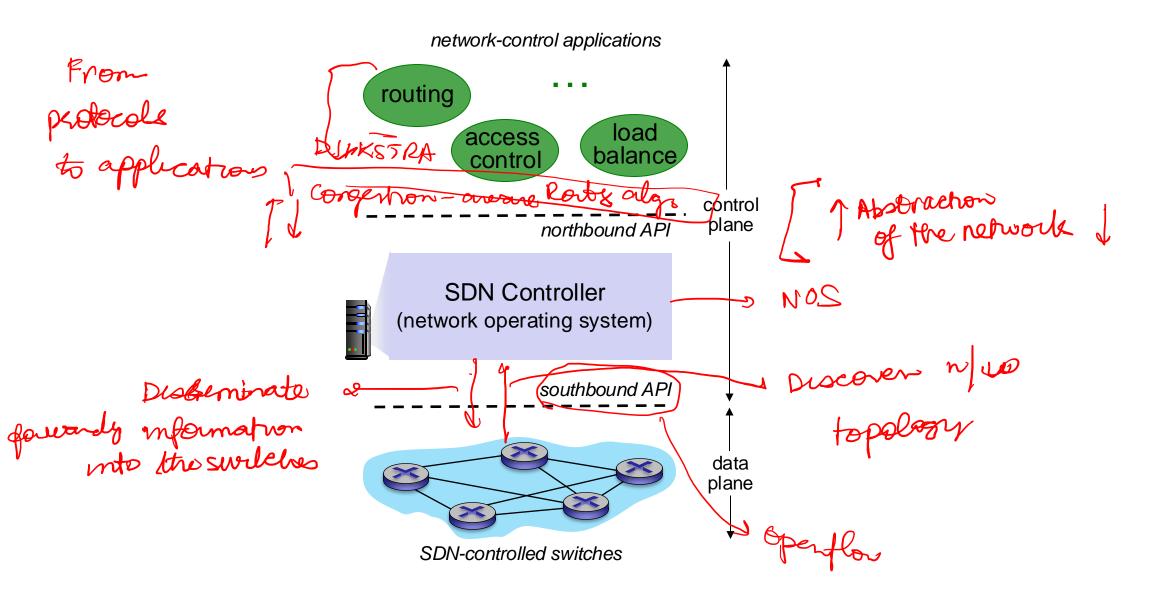
## Quiz

Password: openflow

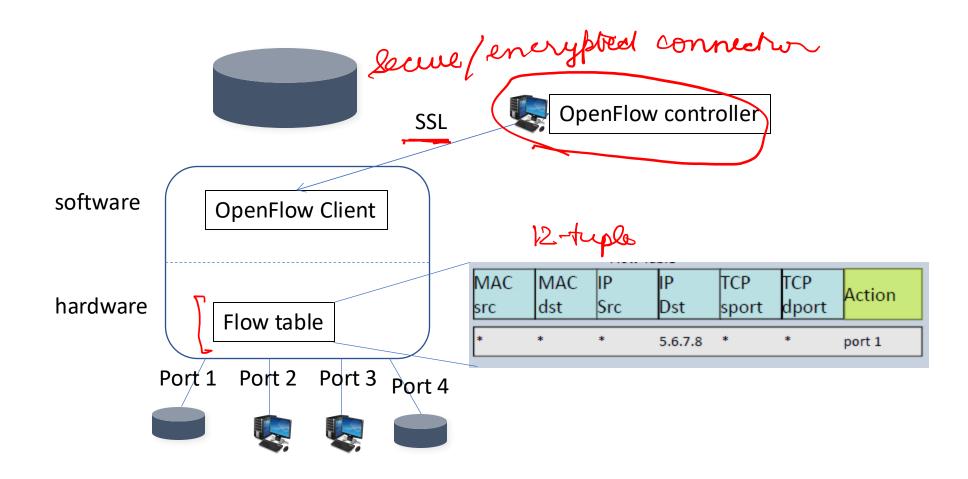
# Software-defined Networking



### 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

optional in fust vernos • match: pattern values in packet header fields

actions: for matched packet: drop, forward, modify, matched packet or send

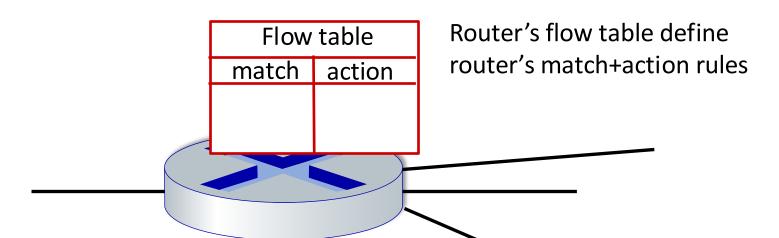
matched packet to controller

priority: disambiguate overlapping patterns

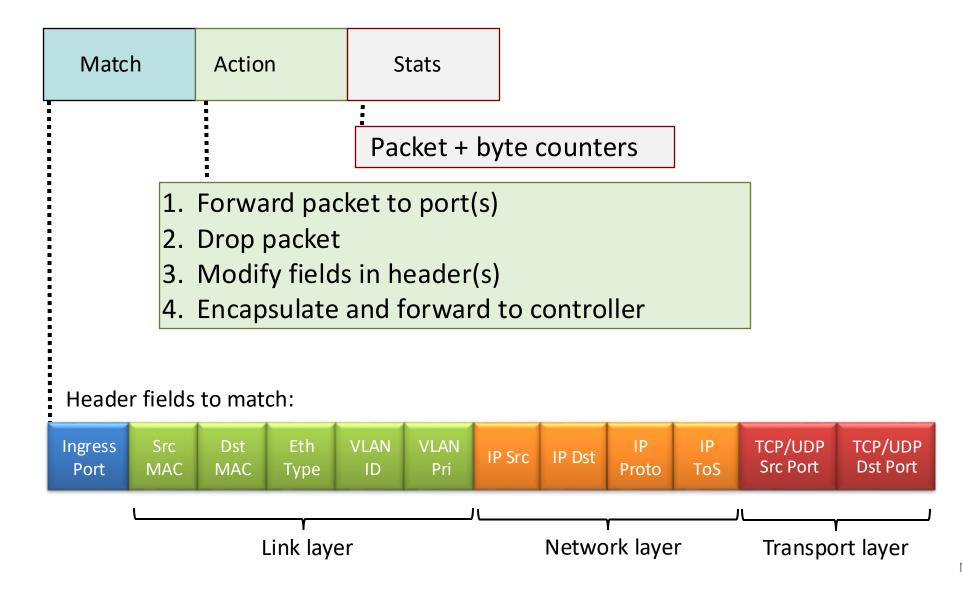
counters: #bytes and #packets

Flow rule: plat port 122
Forward(1)

(2) . det IP = X, Forward(2)



# OpenFlow: flow table entries

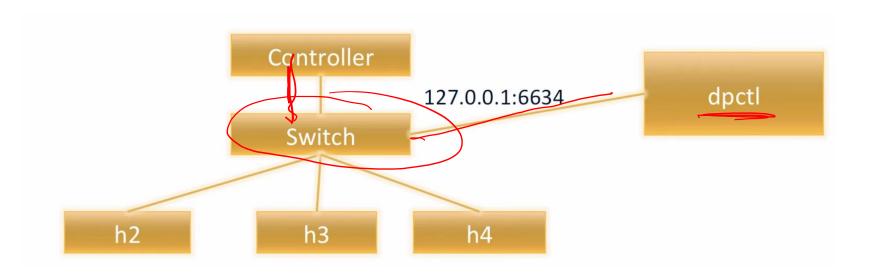


## OpenFlow Demo

Simulation

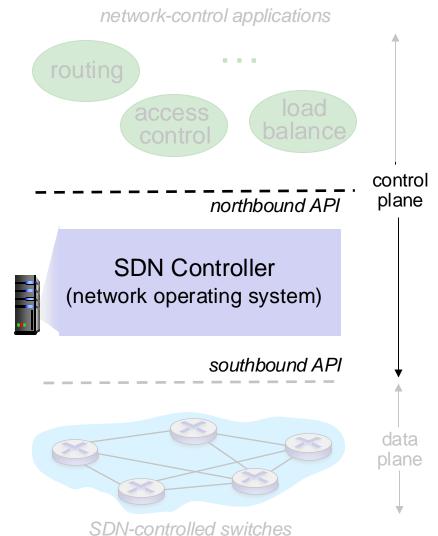
real-world Cesty

- 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)

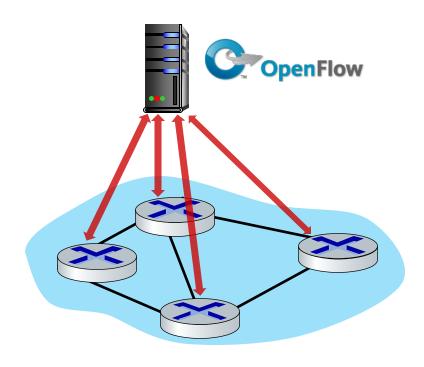
- maintains network state information
- interacts with network control applications "above" via northbound API
- interacts with network switches "below" via southbound API
- implemented as distributed system for performance, scalability, faulttolerance, robustness



## 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**

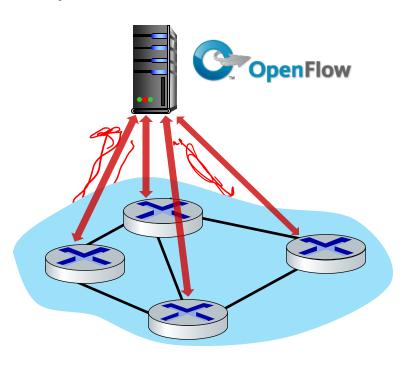


# OpenFlow: controller-to-switch messages

#### 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 Controller**

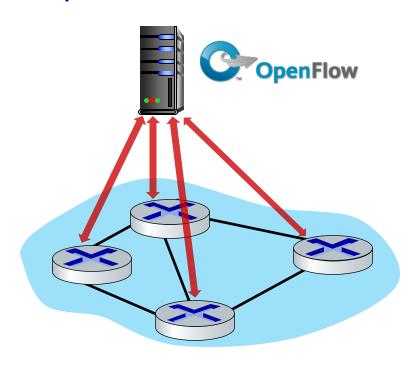


# OpenFlow: switch-to-controller messages

#### 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** 



Floodlight









- OpenDayLight (ODL) 1
- Open Network Operating System (ONOS)





Pyretic

Frentic

Procera

SQL-like abstraction
to control the gnoosing the right SDN controller?

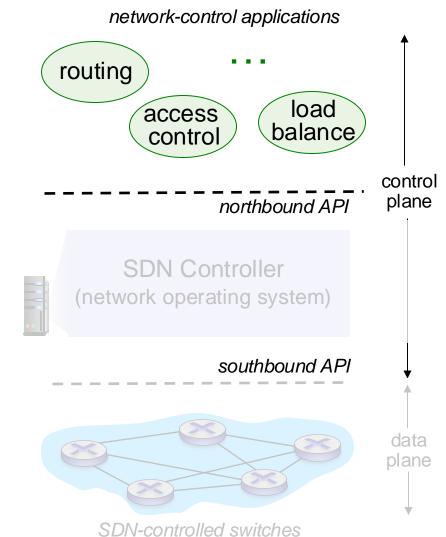
data plantso case

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

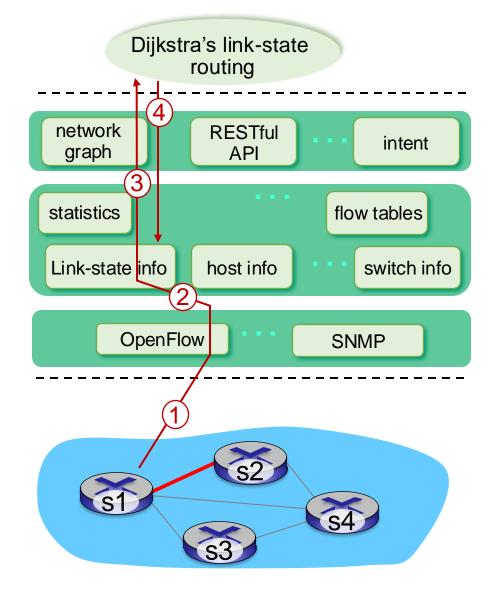
# Ryu Demo

# 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 3<sup>rd</sup> party: distinct from routing vendor, or SDN controller

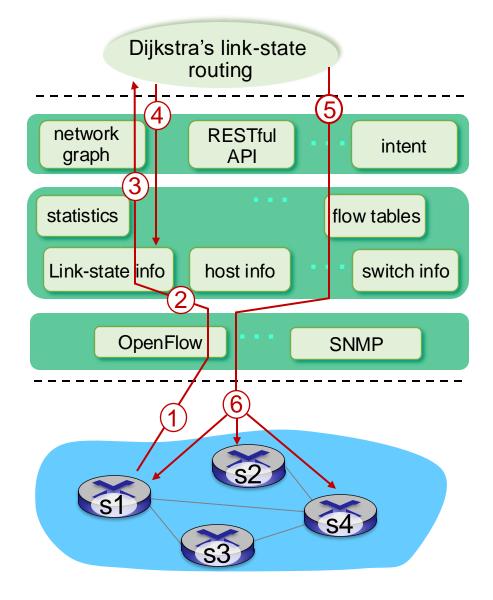


# SDN: control/data plane interaction example



- 1 S1, experiencing link failure uses OpenFlow port status message to notify controller
- 2 SDN controller receives OpenFlow message, updates link status info
- Oijkstra's routing algorithm application has previously registered to be called when ever link status changes. It is called.
- 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

