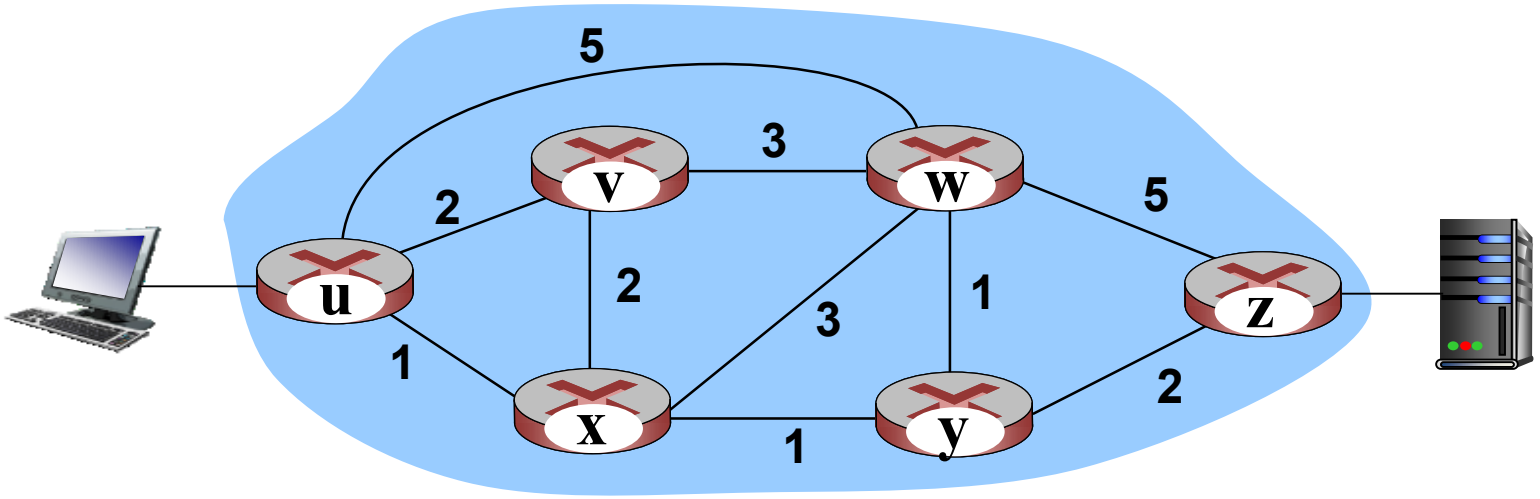
Control Plane (Traditionally…)

- Internet network layer: historically has been implemented via distributed, per-router approach
  - *monolithic* router contains switching hardware, runs proprietary implementation of Internet standard protocols (IP, RIP, IS-IS, OSPF, BGP) in proprietary router OS (e.g., Cisco IOS)
  - different "middleboxes" for different network layer functions: firewalls, load balancers, NAT boxes, ..

Software defined networking (SDN)

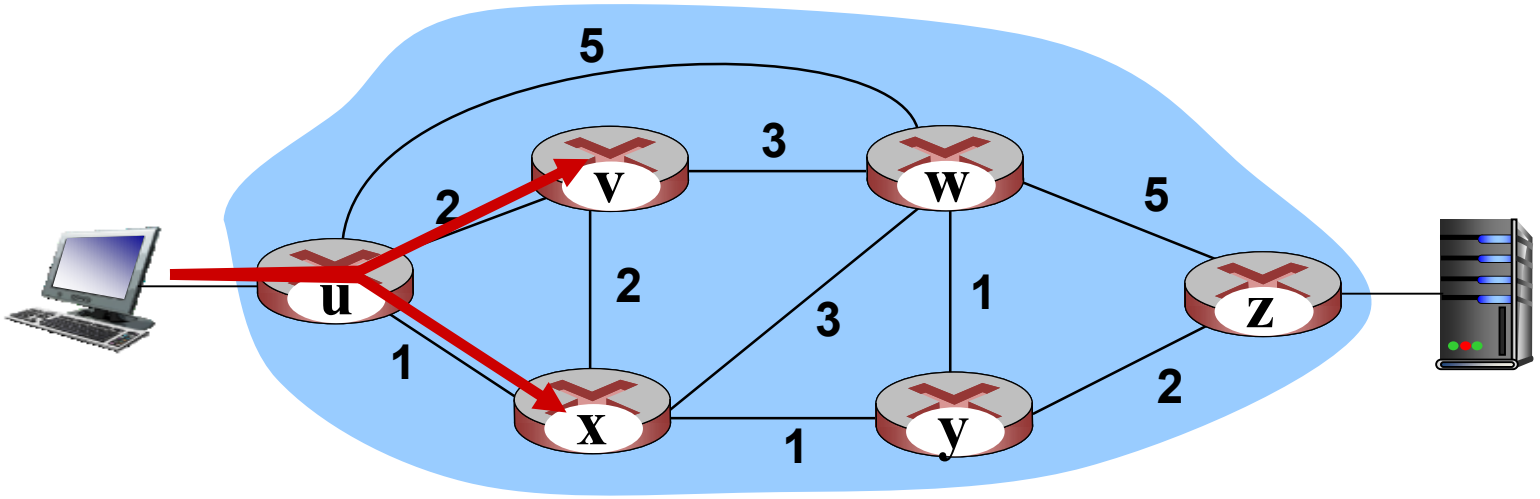
- ~2005: renewed interest in rethinking network control plane

Traffic engineering: difficult traditional routing



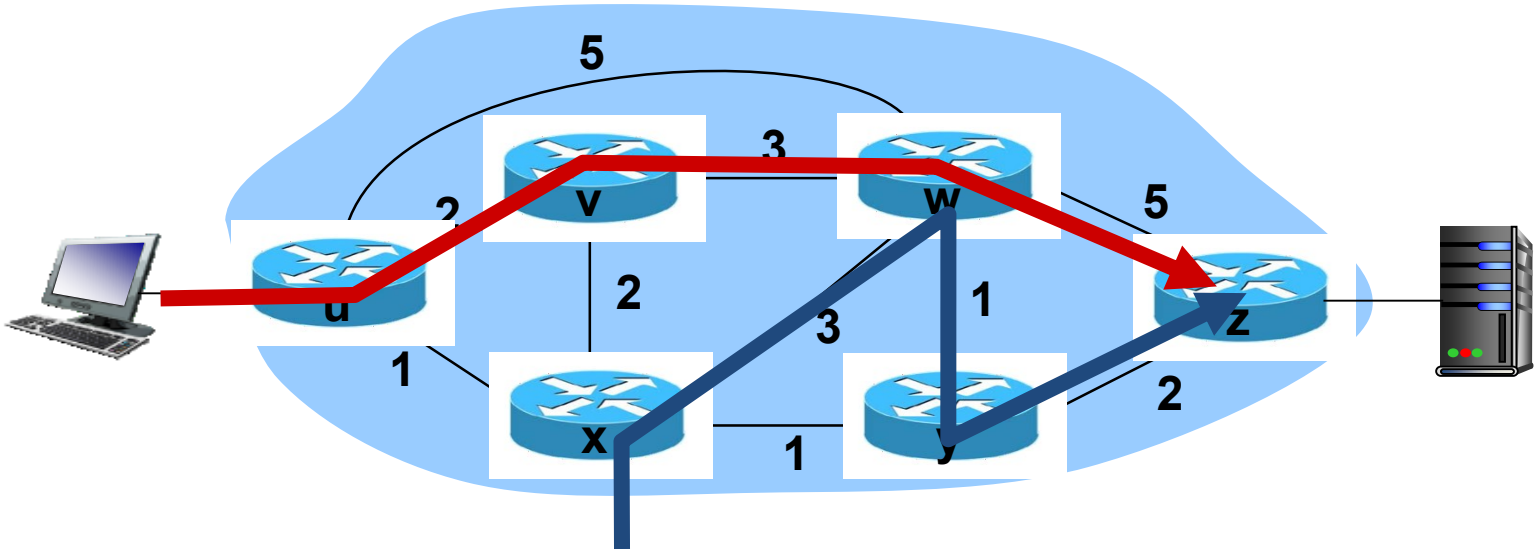
Q: what if network operator wants **u-to-z** traffic to flow along ***uvwz*, x-to-z** traffic to flow ***xwyz*?**

Traffic engineering: difficult



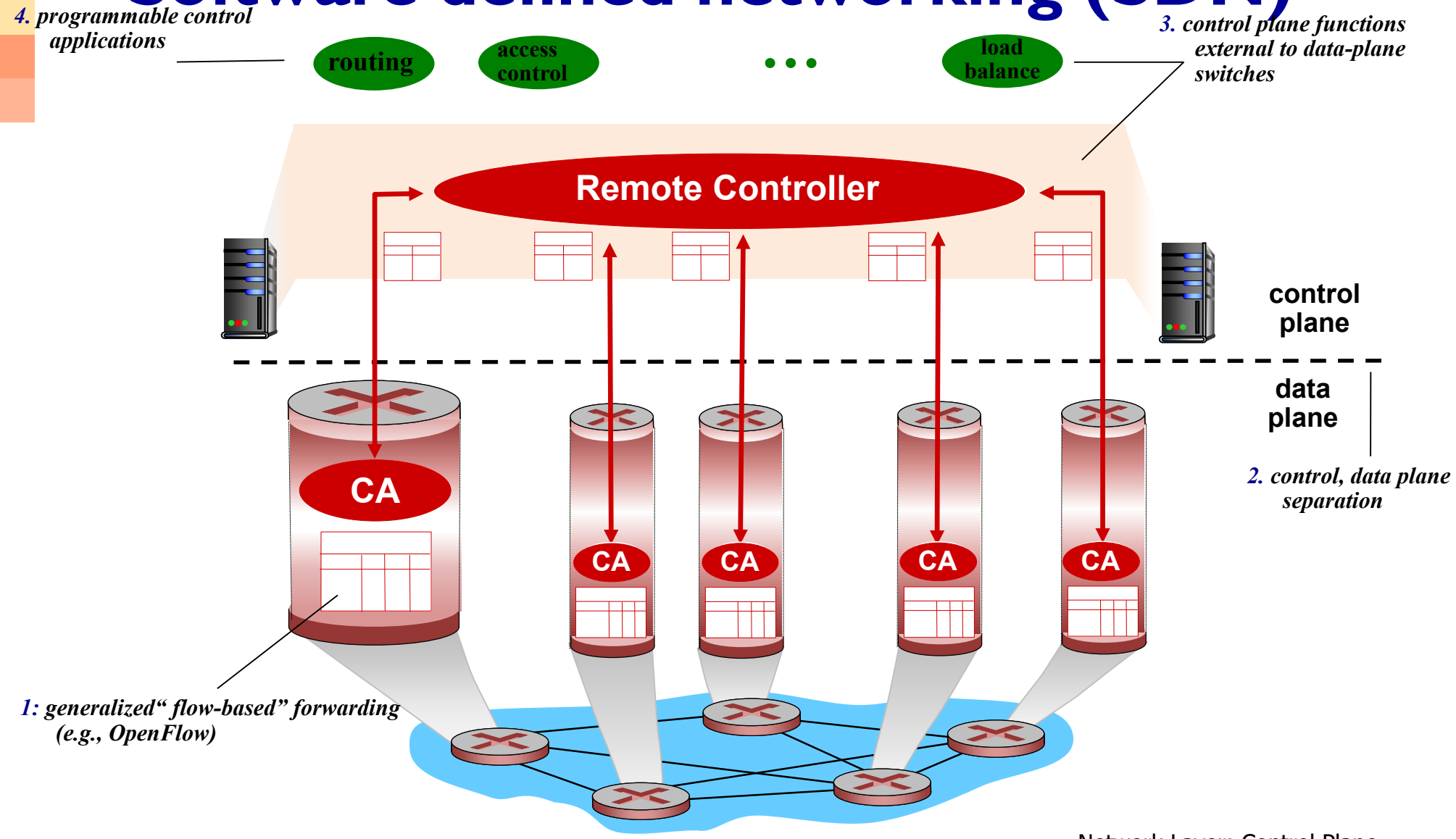
Q: what if network operator wants to split u-to-z traffic along **uvwz *and* uxyz (load balancing)?**

Traffic engineering: difficult



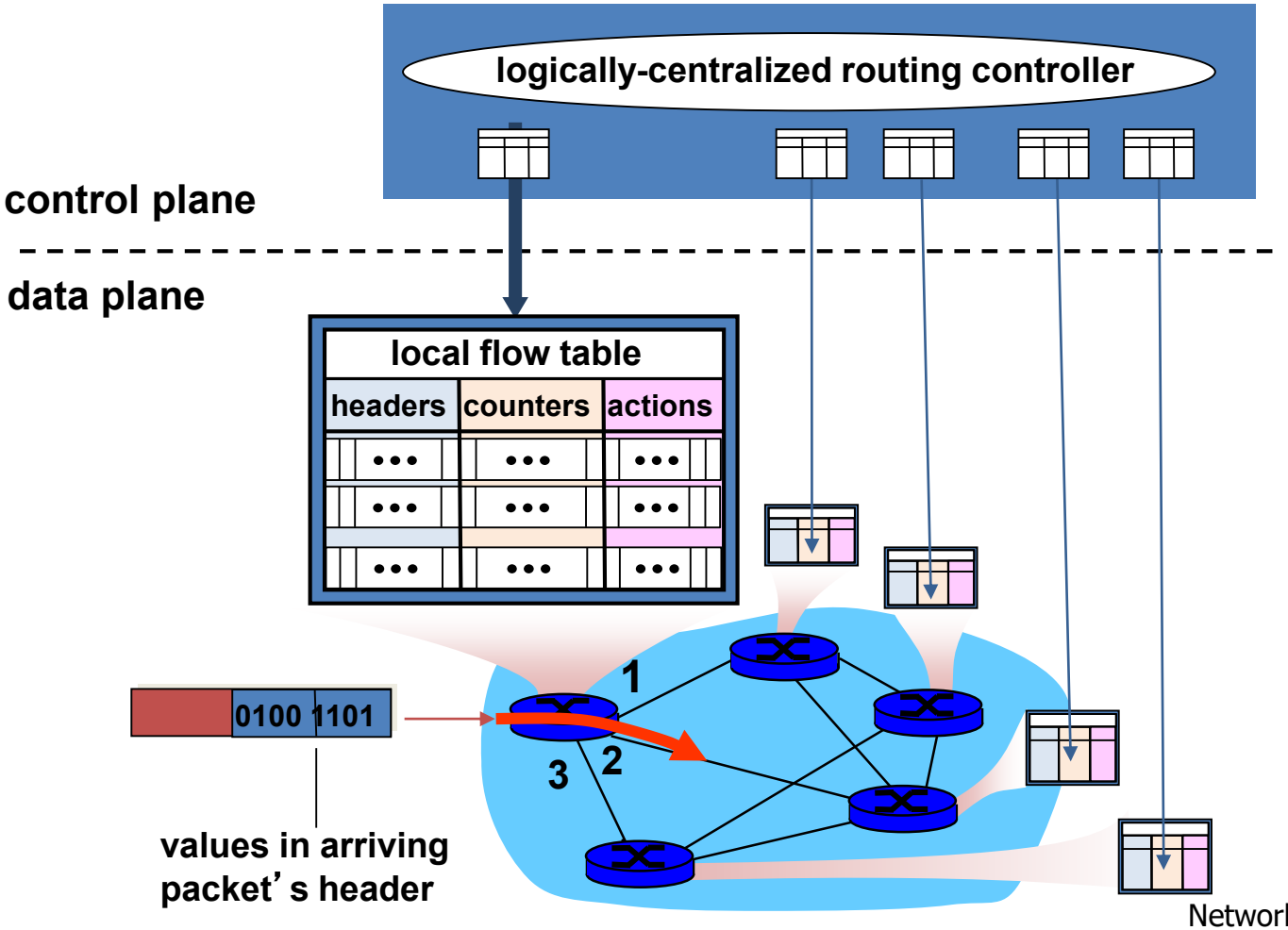
Q: what if **w** wants to route **blue** and **red** traffic differently**?**

Software defined networking (SDN)



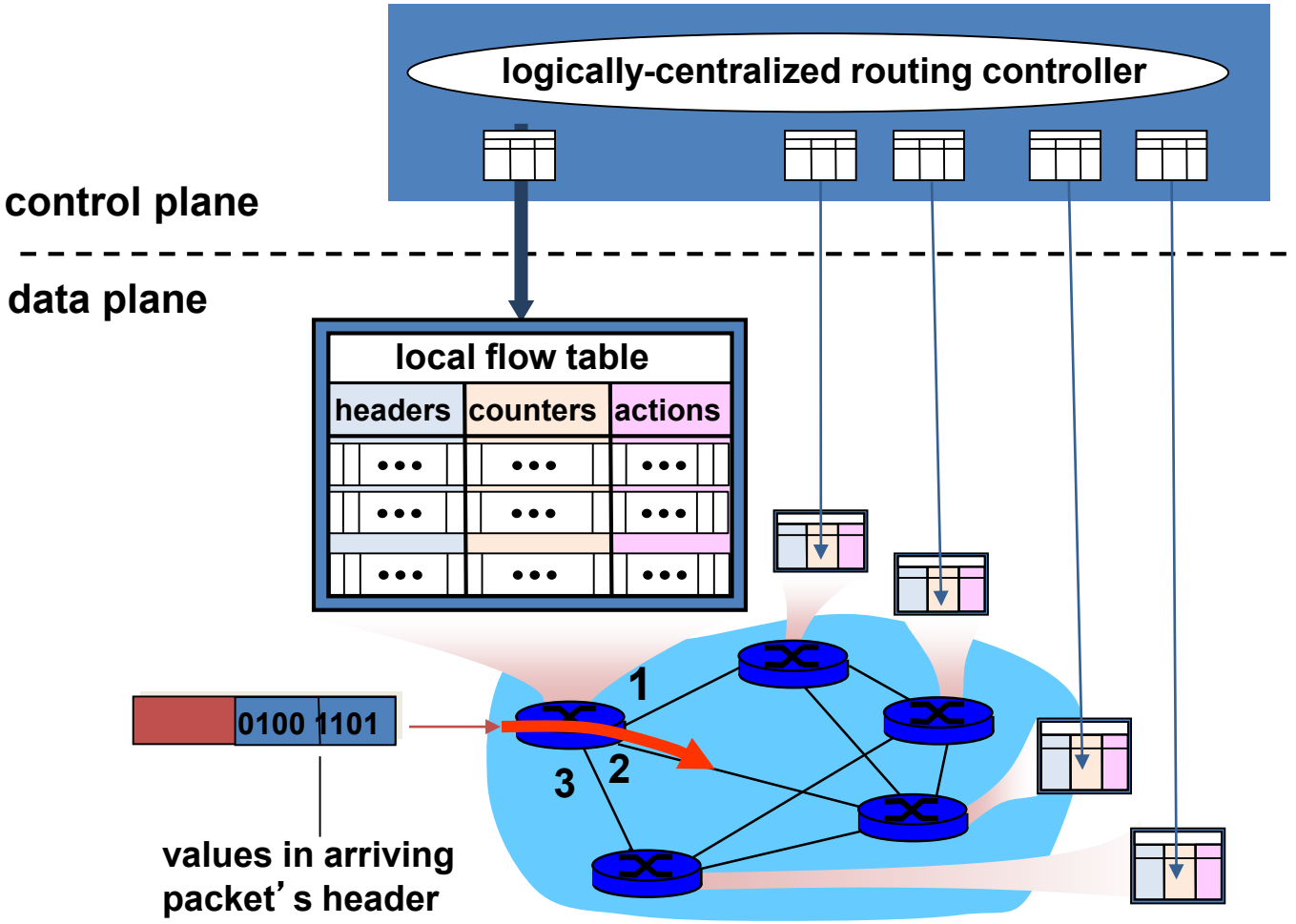
Generalized Forwarding and SDN

Each router contains a *flow table* that is computed and distributed by a *logically centralized* routing controller

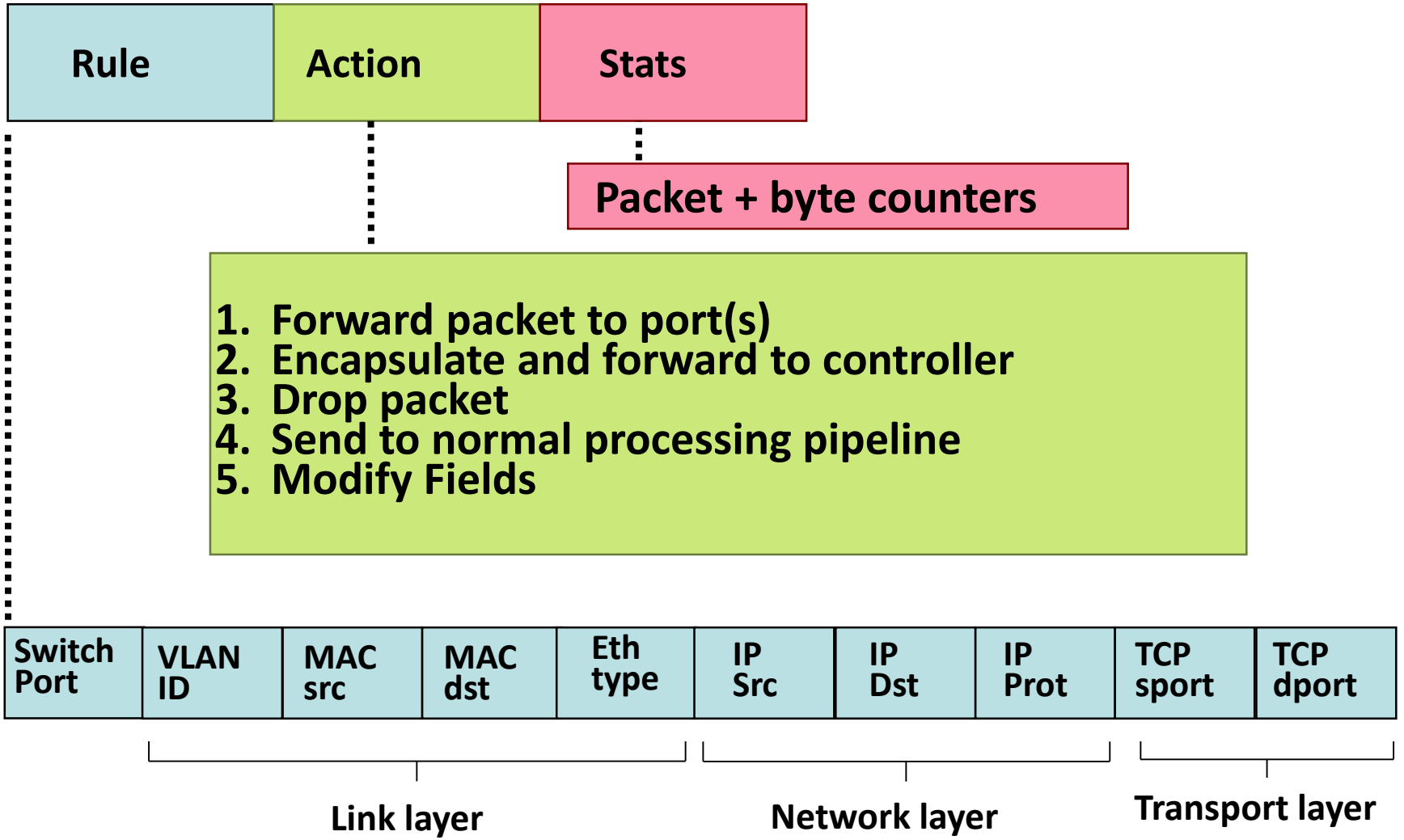


Generalized Forwarding and SDN

Headers (across protocols) [source/destination/port]
counters (how many packts) e.g UDP packets
Actions



OpenFlow Protocol: Flow Table Entries



OpenFlow Protocol: Flow Table Entries

- Example of a Flow Table based on the OpenFlow protocol.
- OpenFlow protocol operates between SDN controller and the SDN-controlled device implementing the OpenFlow

Examples

Destination-based forwarding:

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	*	*	*	*	51.6.0.8	*	*	*	port6

IP datagrams destined to IP address 51.6.0.8 should be forwarded to router output port 6

Firewall:

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Forward
*	*	*	*	*	*	*	*	*	22	drop

do not forward (block) all datagrams destined to TCP port 22

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Forward
*	*	*	*	*	128.119.1.1	*	*	*	*	drop

do not forward (block) all datagrams sent by host 128.119.1.1