Flow Table, Group Table and Meter Table
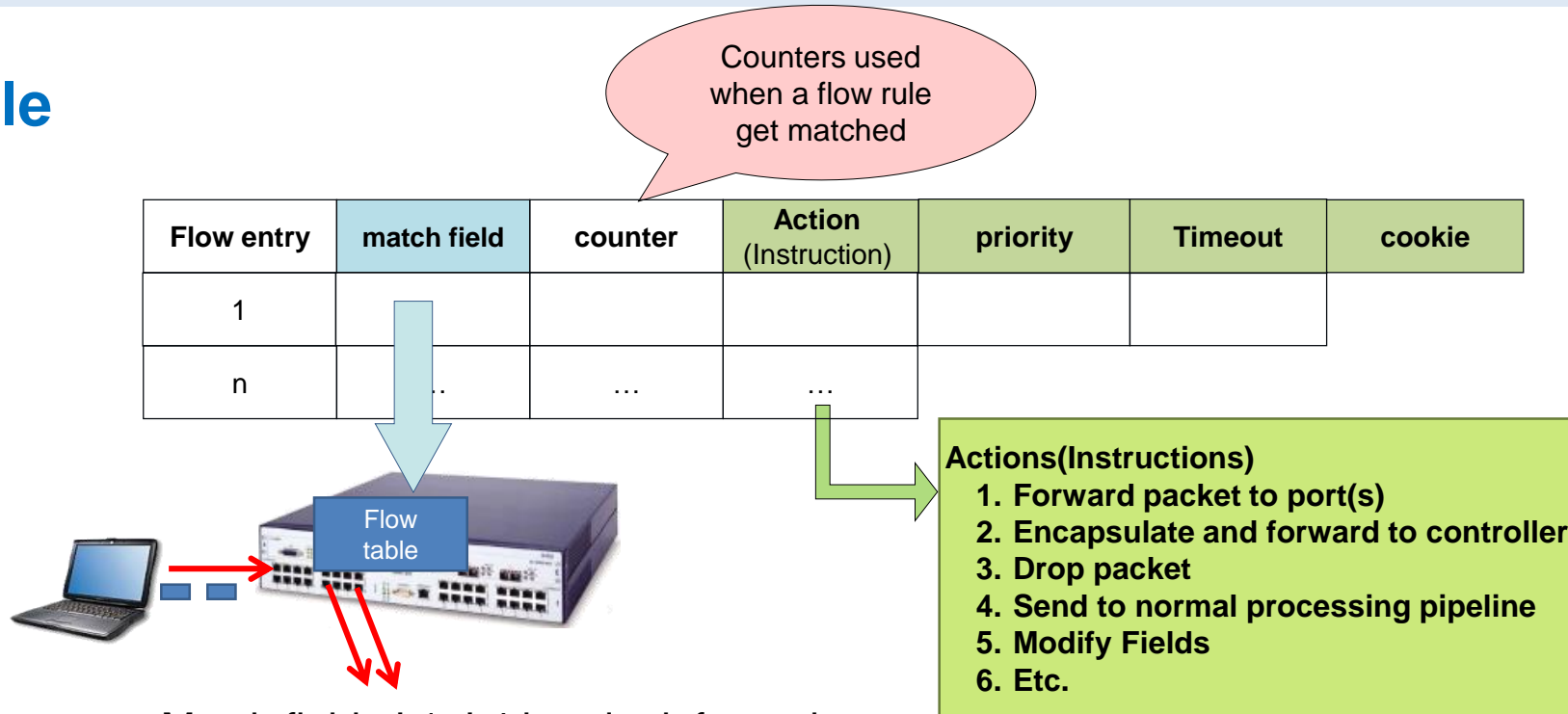
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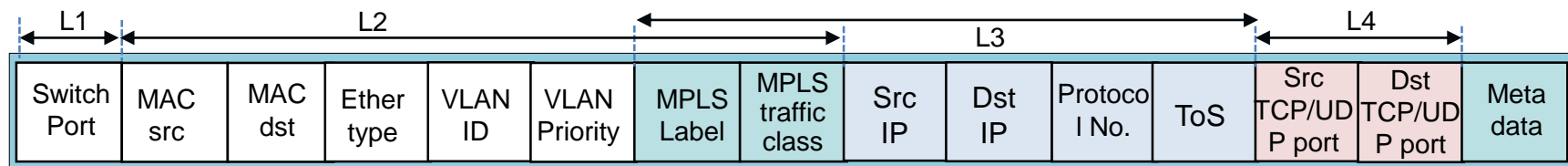**POSTECH**

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OpenFlow: Flow Table

❖ **Flow Table**

Counters used when a flow rule get matched

Flow entry	match field	counter	Action (Instruction)	priority	Timeout	cookie
1						
n	..	…	…			

Flow table

Actions(Instructions)
  1. **Forward packet to port(s)**
  2. **Encapsulate and forward to controller**
  3. **Drop packet**
  4. **Send to normal processing pipeline**
  5. **Modify Fields**
  6. **Etc.**

- Match field= L1~L4 header information
  - OpenFlow 1.0 → 12 tuples
  - OpenFlow 1.1 → 15 tuples
 - OpenFlow 1.3 → 40 tuples (158 bytes)

	L1		L2						L3				L4		
	Switch Port	MAC src	MAC dst	Ether type	VLAN ID	VLAN Priority	MPLS Label	MPLS traffic class	Src IP	Dst IP	Protocol No.	ToS	Src TCP/UDP port	Dst TCP/UDP port	Meta data

Match fields of OpenFlow 1.1

OpenFlow: Flow Table

❖ **Flow Table**
  ▪ Wild card (*) means "does not matter" – not important field

Operation Mode	Switch Port	MAC src	MAC dst	Ether type	VLAN ID	Src IP	Dst IP	Proto No.	TCP S_port	TCP D_port	Action	Counter
Switching	*	*	00:1f..	*	*	*	*	*	*	*	Port1	243
Flow Switching	Port3	00:20..	00:2f..	0800	vlan1	1.2.3.4	1.2.3.9	4	4666	80	Port7	123
Routing	*	*	*	*	*	*	1.2.3.4	*	*	*	Port6	452
VLAN Switching	*	*	00:3f..	*	vlan2	*	*	*	*	*	Port6 Port7 Port8	2341
Firewall	*	*	*	*	*	*	*	*	*	22	Drop	544
Default Route	*	*	*	*	*	*	*	*	*	*	Port1	1364

Matching and Instruction Execution

❖ **Matching and Instruction Execution**

Instructions in OpenFlow
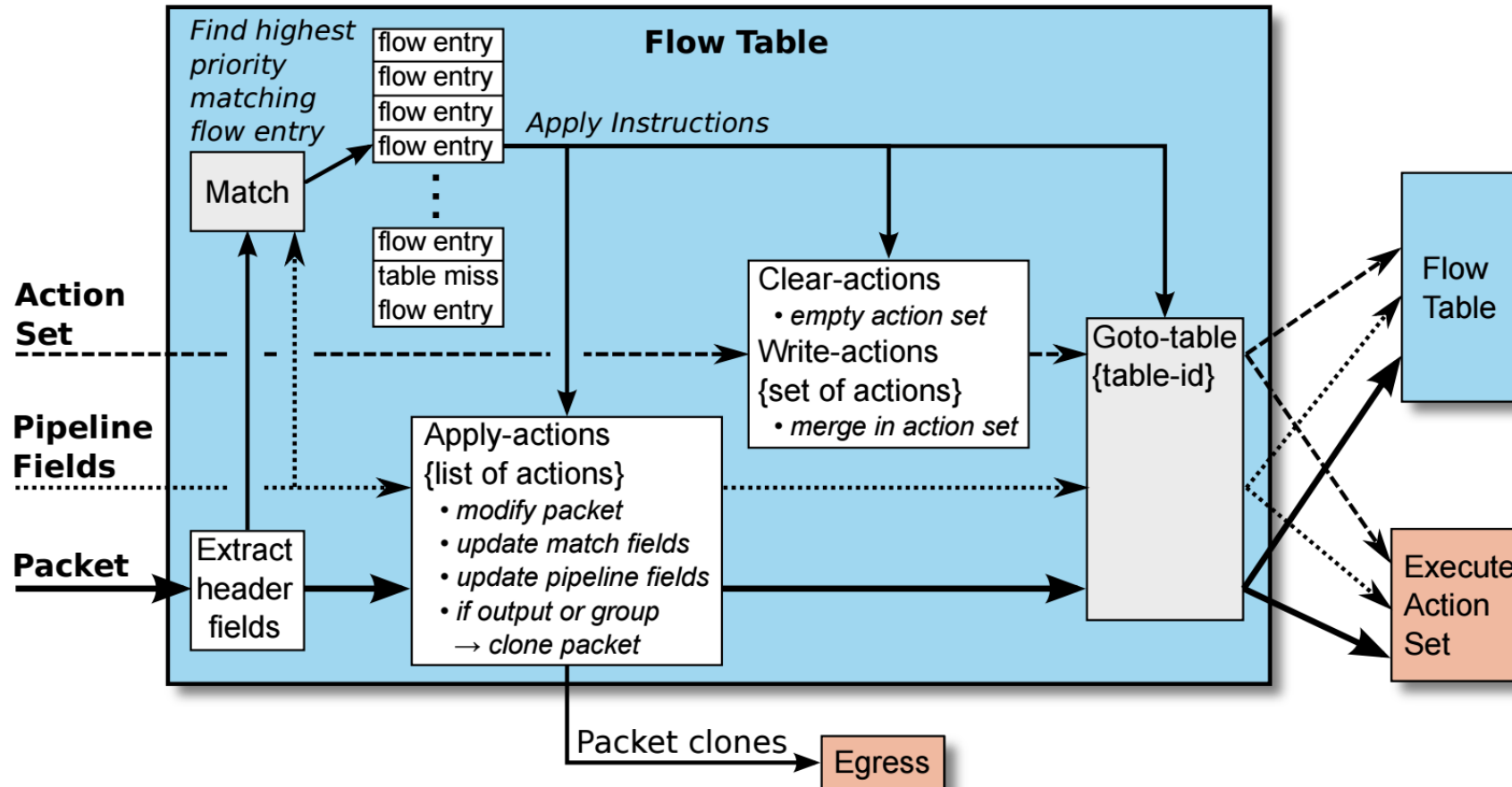
❖ **Instructions**

- Instructions are executed when a packet matches an entry in a table
- Instructions result in changes to the packet, action set and/or pipeline processing

| Syntax	Description
Meter meter_id	Direct packet to the specified meter
Apply-Actions actions	Apply the specific actions immediately. Execute multiple actions of the same type.
Clear-Actions	Clear all the actions in the action set immediately
Write-Actions actions	Merge the specified actions into the current action set, if exists try to overwrite, otherwise try to add.
Goto-Table next-table-id	Indicate the next table in the processing pipeline. The table-id must be greater than the current table-id.

Actions in OpenFlow

❖ **Actions**

- An action is associated with each packet
- When the instruction set does not contain a Goto-Table instruction, pipeline processing stops and the actions are executed

Syntax	Description
set	Apply all set-field actions to the packet
qos	Apply all QoS actions, such as set_queue to the packet
group	If a group action specified, apply the actions of the relevant group bucket(s) in the order specified by this list
output	If no group action is specified, forward the packet on the port specified by the output action
push_MPLS	Apply MPLS tag push action to the packet
push_VLAN	Apply VLAN tag push action to the packet
pop	Apply all tag pop actions to the packet

# OpenFlow Pipelining

❖ Pipelining

- The flow tables of a switch are sequentially numbered, starting at 0
- A packet is processed sequentially in multiple flow tables (version 1.1)
  - If a flow entry is found, the instruction set included in that flow entry is executed
  - Instructions may explicitly direct the packet to another flow table ("**goto-table**")
  - Pipeline processing can only go forward and not backward
- Two stage pipeline processing (version 1.5)
  - Ingress processing
    - Mandatory, performed before egress processing, use the rules specified in ingress tables
  - Egress processing
    - Optional, performed in the context of output port, use the rules specified in egress tables
- Useful to manage complicated processing
  - E.g., table 1 for VLAN processing, table 2 for multicast group processing
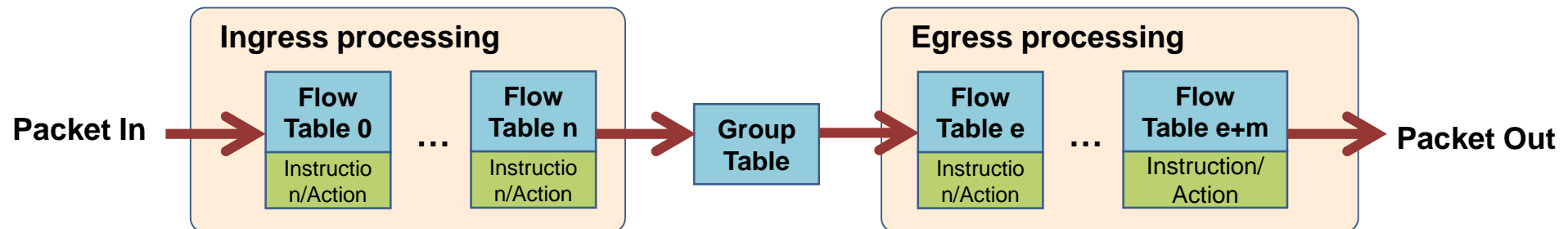
OpenFlow Group Table

❖ Group Table & Types (version 1.1)

- All: multicast
- Select: load sharing
- Indirect: simple indirection
- Fast-failover: rerouting

Multicast   Load sharing

Indirection   Rerouting
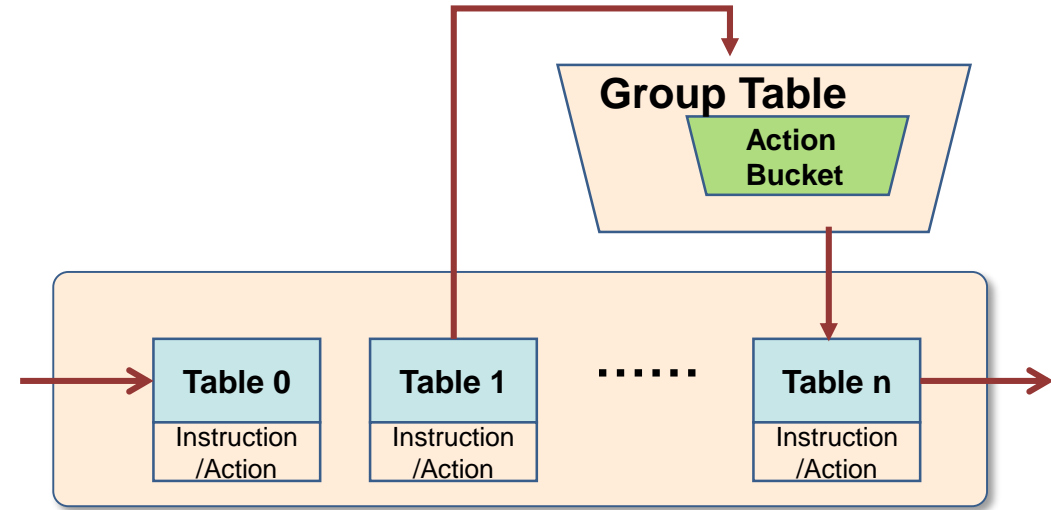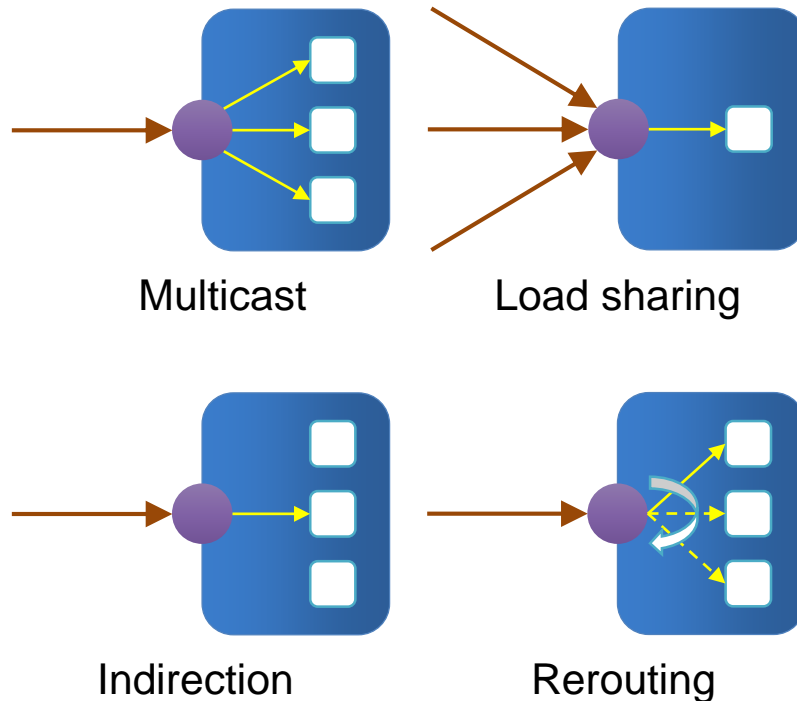
Each packet is duplicated before processed by individual action bucket

Group table

Group ID	Group type	Counter	Action buckets
100	all		Port1 : output Port3 : output Port5 : output ....

Match field	Counter	Action	**Flow table**
Dst IP= 224.2.3.9		Group 100	

OpenFlow Group Table (1/4)

❖ **Multicast**
  ▪ Type=all

Group Table

Group ID	Group Type	Counter	Action Buckets
100	All	999	Port2, Port3, Port4

Flow Table

Switch Port	MAC src	MAC dst	Ether Type	VLAN ID	Src IP	Dst IP	Proto No.	TCP S Port	TCP D Port	Action
*	*	00:FF:..	*	*	*	*	*	*	*	Port 6
Port 1	*	*	0800	*	224…	224…	4	4566	6633	Group 100
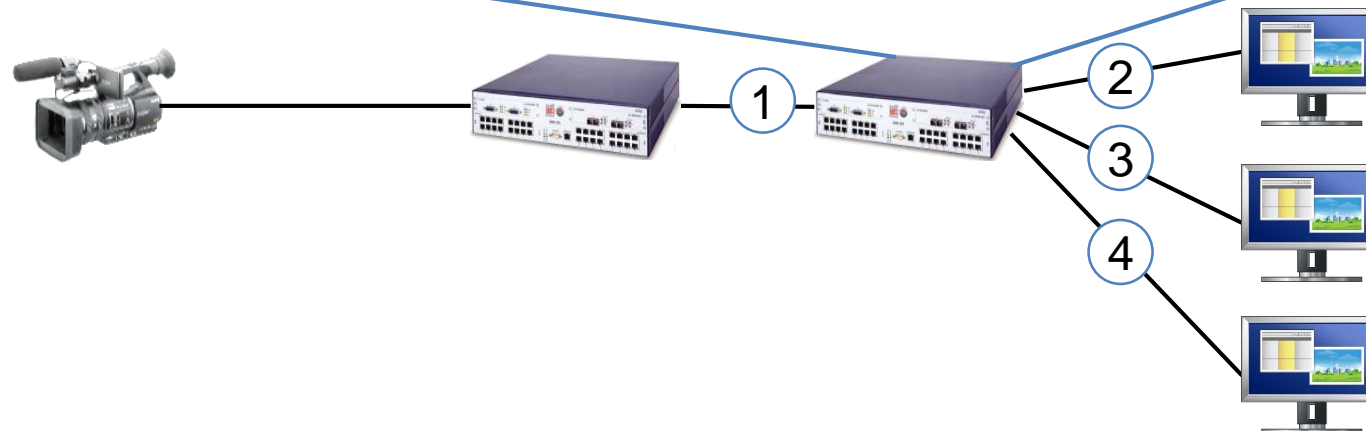
OpenFlow Group Table (2/4)

❖ **Load Balancing**

- Type=select

Group Table

Group ID	Group Type	Counter	Action Buckets
100	Select	999	Port2, Port3

Flow Table

Switch Port	MAC src	MAC dst	Ether Type	VLAN ID	Src IP	Dst IP	Proto No.	TCP S Port	TCP D Port	Action
*	*	00:FF:..	*	*	*	*	*	*	*	Port 1
Port 1	*	*	0800	*	1.2.3 …	*	4	*	80	Group 100

OpenFlow Group Table (3/4)
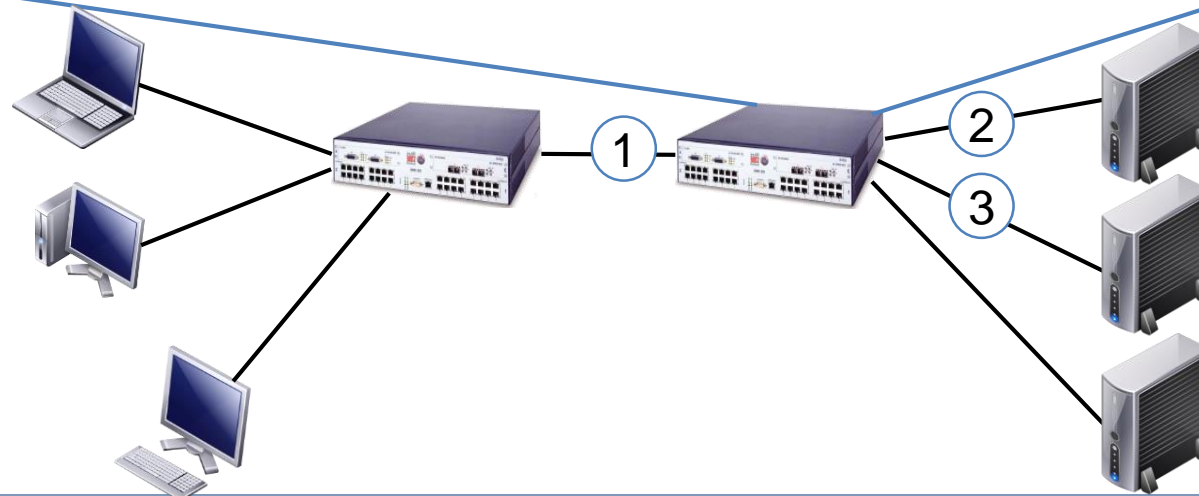
❖ **Indirection**
- ▪ Type=indirect

Group Table

Group ID	Group Type	Counter	Action Buckets
100	Indirect	777	Port 5

Flow Table

Switch Port	MAC src	MAC dst	Ether Type	VLAN ID	Src IP	Dst IP	Proto No.	TCP S Port	TCP D Port	Action
*	00:FF…	*	0800	*	1.2.2…	11.1…	*	*	*	Group 100
*	00:FF...	*	0800	*	1.2.3…	11.1…	*	*	*	Group 100
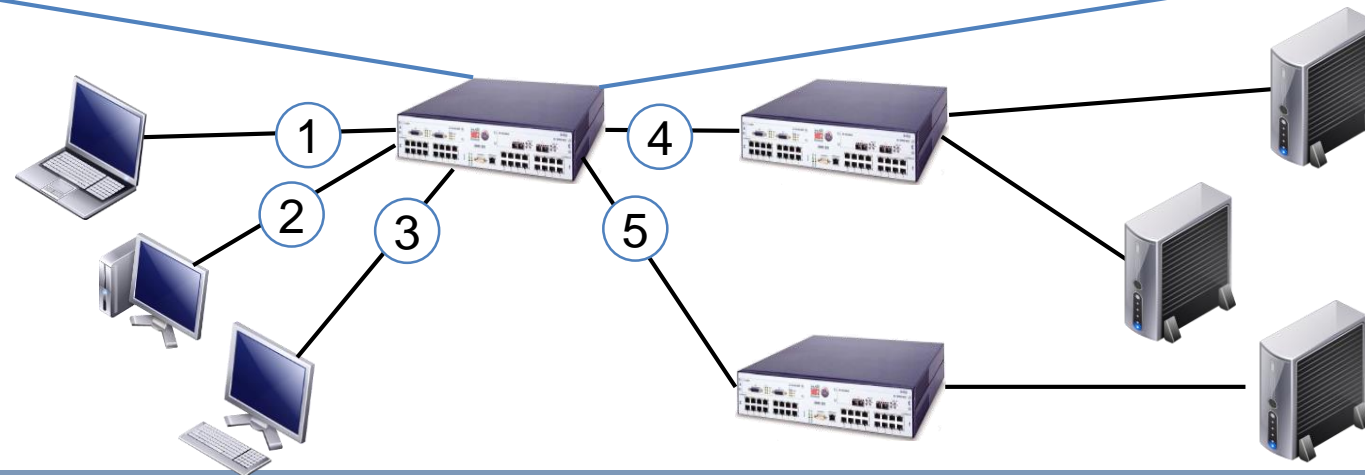
OpenFlow Group Table (4/4)

❖ **Fast Failover**
- Type=fast-failover (ff)

Group Table

Group ID	Group Type	Counter	Action Buckets
100	Fast-failover	777	Port4, Port5, Port6

Flow Table

Switch Port	MAC src	MAC dst	Ether Type	VLAN ID	Src IP	Dst IP	Proto No.	TCP S Port	TCP D Port	Action
Port 1	*	*	*	*	1.2.2	*	*	*	*	Port 7
Port 1	00:FF…	*	0800	*	1.2.3…	11.1…	*	*	*	Group 100

OpenFlow Meter Table
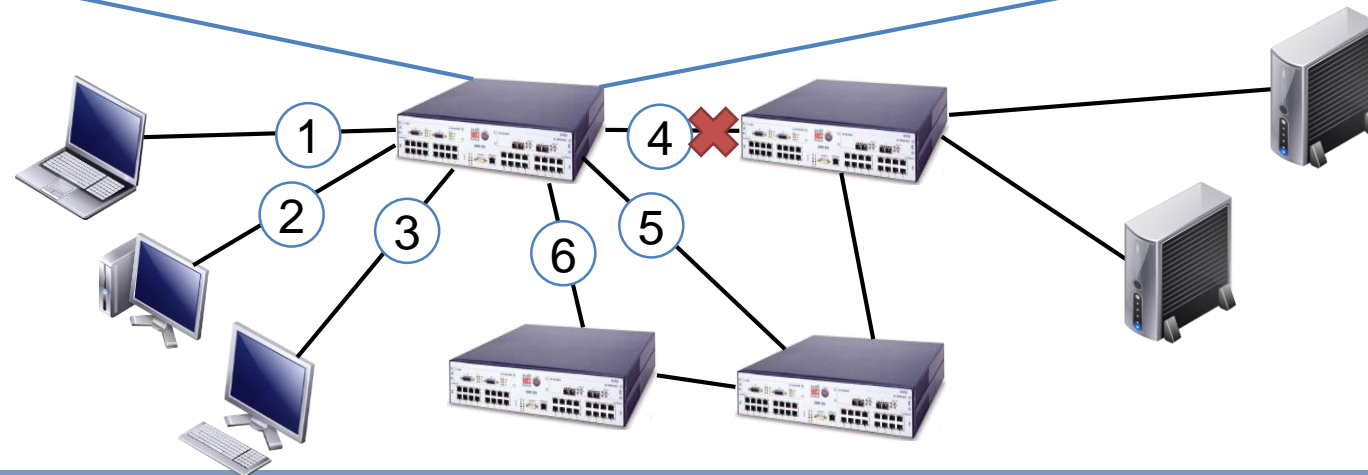
❖ Meter Table (ver 1.3)

- Counts packet rate of a matched flow
- QoS control → Rate-limit, DiffServ …

Meter Table

Meter ID	Band Type	Rate	Counter	Argument
100	Drop (remark DSCP)	1000 kbps	1000	xxx

Flow Table

Switch Port	MAC src	MAC dst	Ether Type	Src IP	Dst IP	Proto No.	TCP S Port	TCP D Port	Inst. Meter	Action
Port 1	*	*	*	1.2.2	*	*	*	*	N/A	Port 7
Port 1	00:FF…	*	0800	1.2.3…	11.1…	*	*	*	Meter 100	Port 2