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Realizing Stateful Flow Processing with Forwarding Tables and In-Switch-Generated Messages

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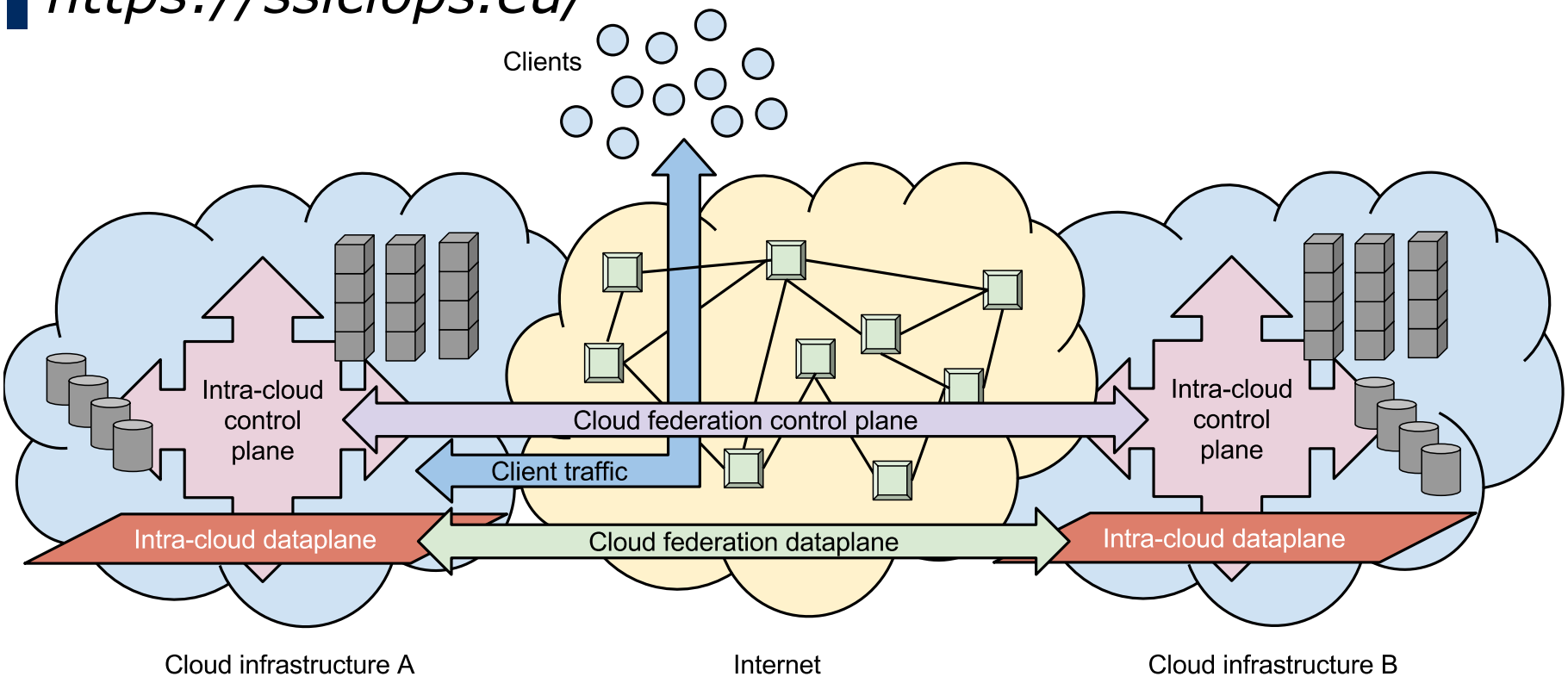
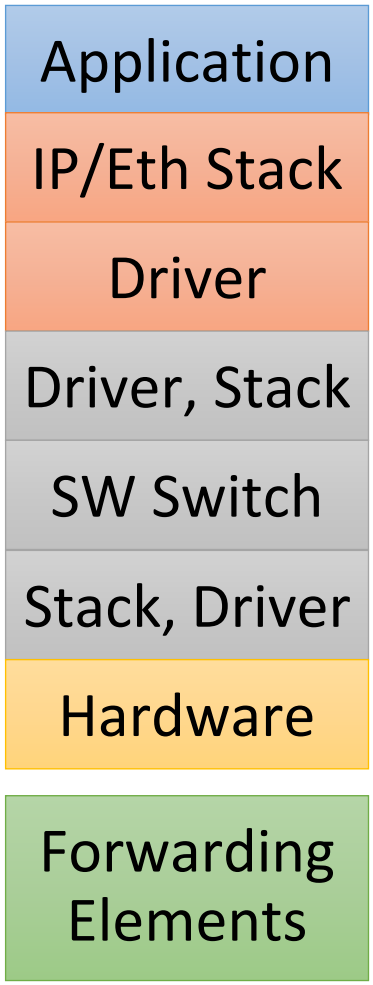
SSICLOPS H2020 Project

- "Scalable and Secure Infrastructures for Cloud Operations"
- Optimizing and securing packet transport in and across data centers
- *https://ssiclops.eu/*

SSICLOPS



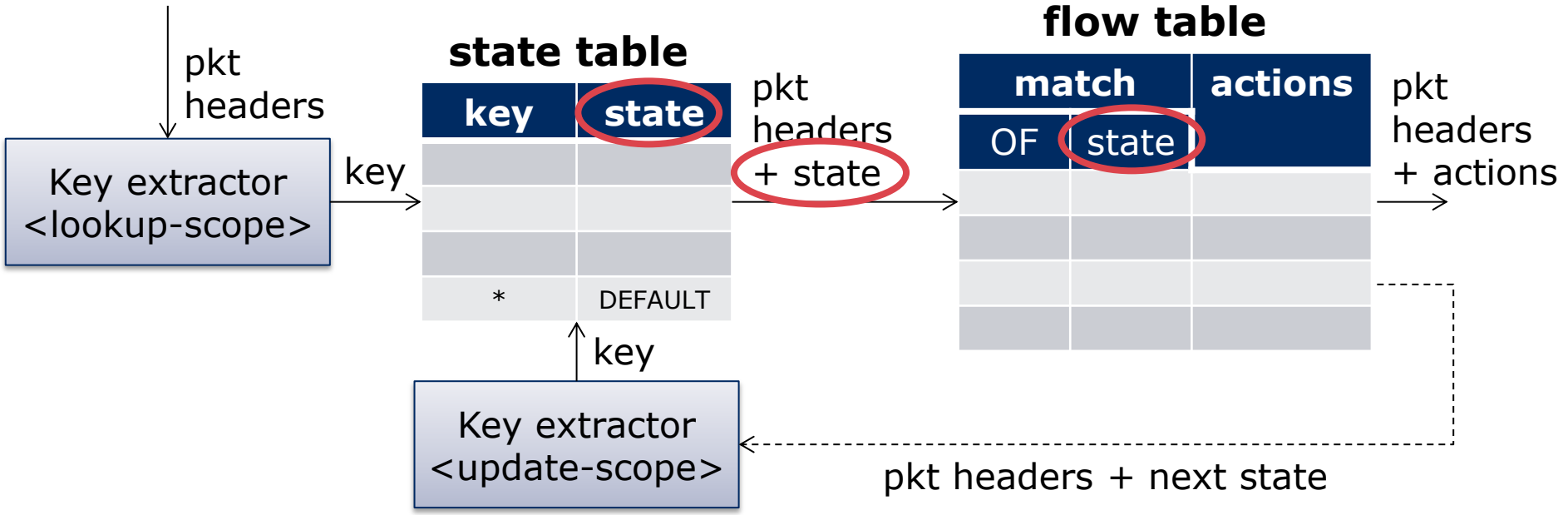
SSICLOPS H2020 Project



- Network stack includes various components: TCP/IP stack, congestion control, path management
- Existing work shows that drastic improvements are possible, including netmap, DCTCP, MPTCP, ...
- Includes SDN on various layers, including centralized control and towards forwarding elements

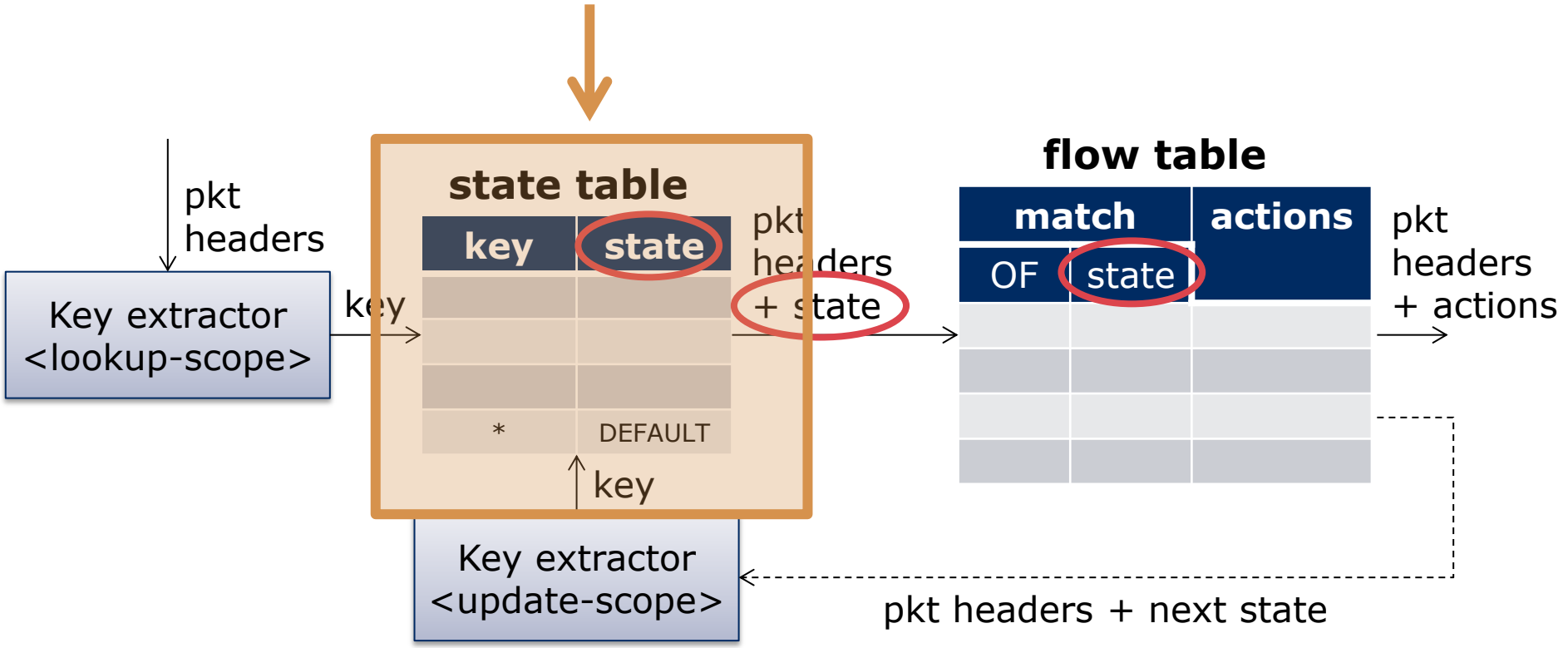
Stateful Flow Processing

- **Goal**: delegate processing from controller to forwarding elements (FEs)
- Keep state at FEs
- Forwarding behavior affected by state
- State affected by incoming packets



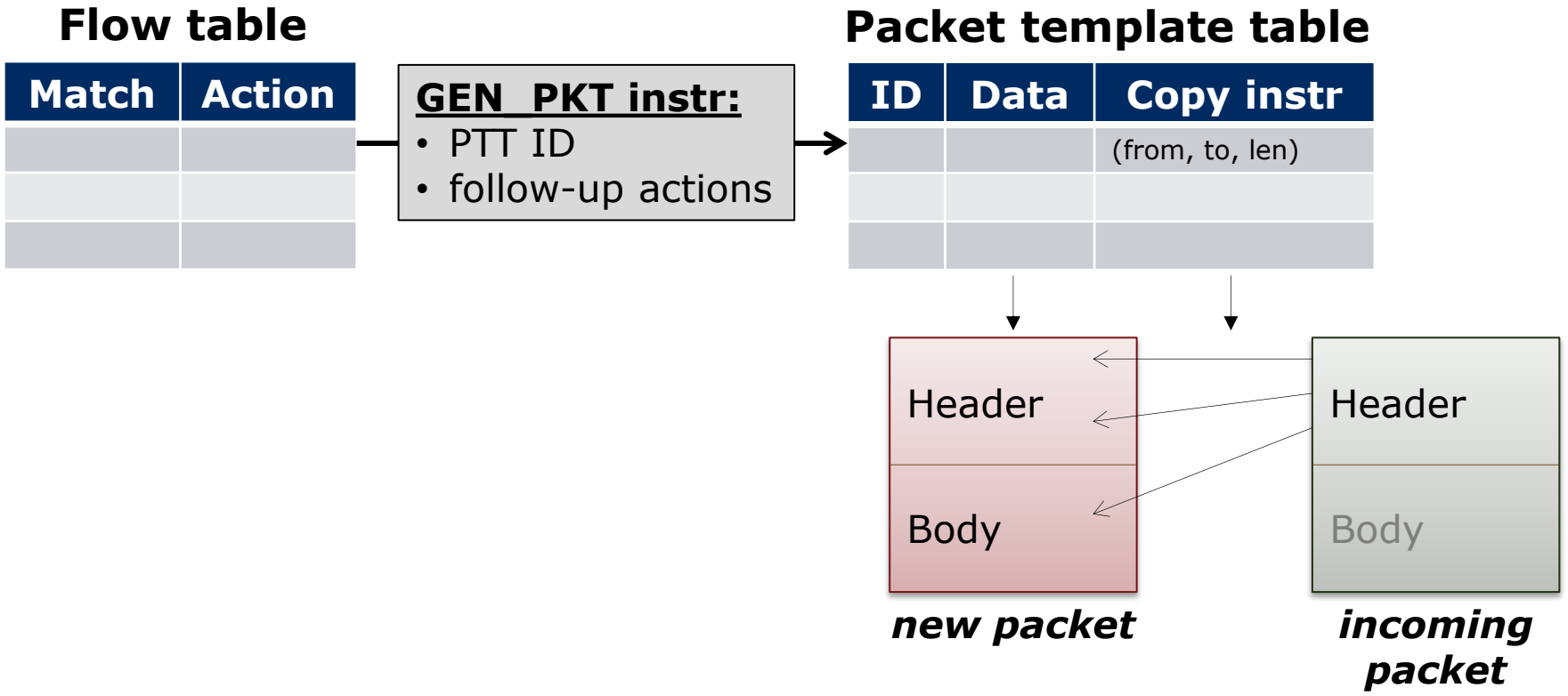
Stateful Flow Processing

- State keeping is typically done in a state table, which is additional to other FE components
- **Issue**: added components (TCAM) and complexity

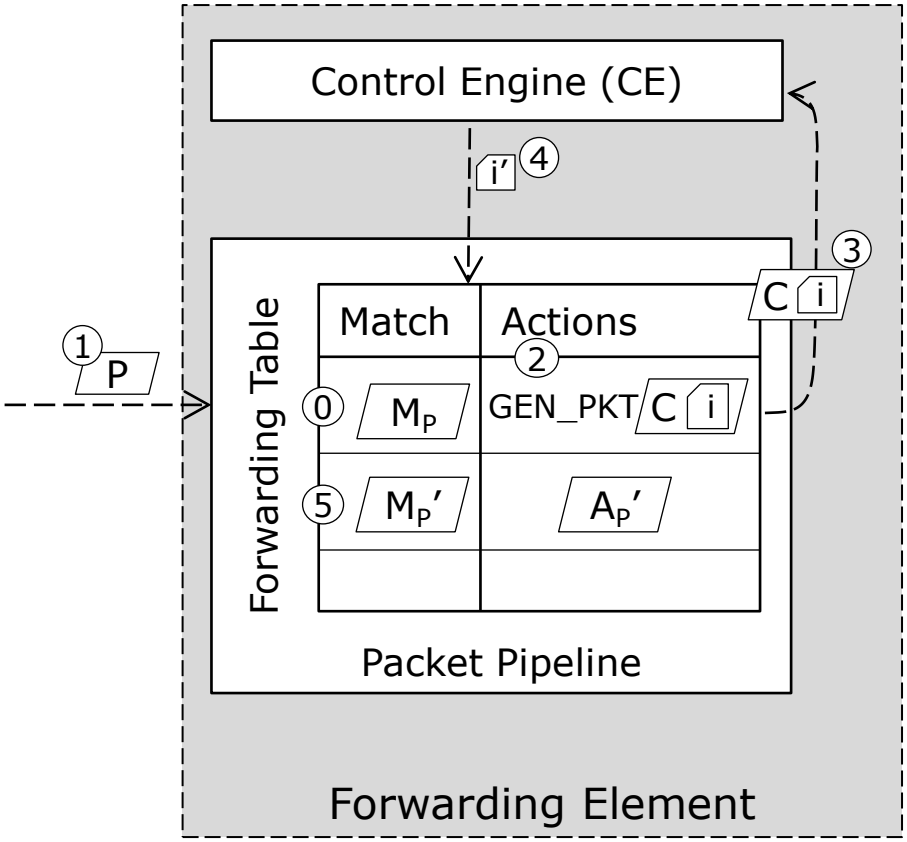


In-Switch Packet Generation

- **Idea**: let switches generate and send packets
- Based on controller instructions and incoming packets
- Can be realized as new OpenFlow action



Stateful Processing with Packet Generation



- **Idea**: get rid of separate state table by manipulating the forwarding table
- **Assumption**: packet generation capability available
- Switch sends OF control messages to itself
- Such messages update forwarding table to reflect state changes

Example: Stateful Firewall

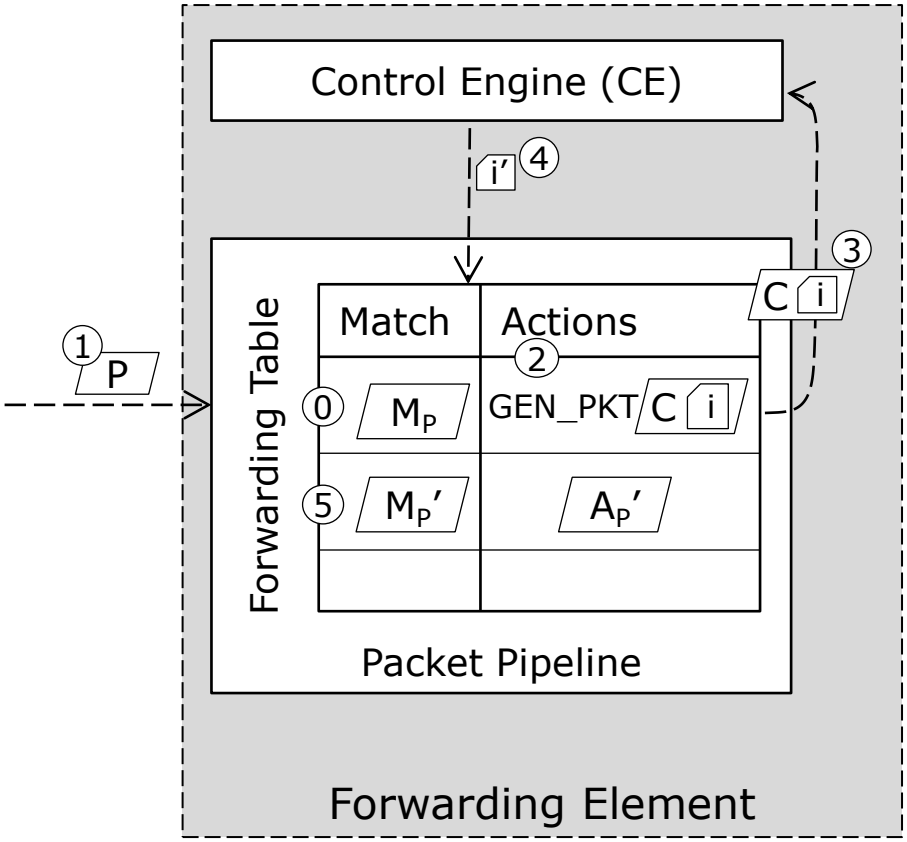
Flow Table

Match	Prio	Actions
in-port == *EXT*	low	drop
in-port == *INT*	low	output(*EXT*) & gen-pkt(id=*1,* output(*LO*)) & gen-pkt(id=*2,* output(*LO*))
src-ip==C, dst-ip==S, L4proto=*TCP*, src-port==*pC*, dst-port==*pS*,	high	output(*EXT*)
src-ip==*S*, dst-ip==*C*, L4proto=*TCP*, src-port==*pS*, dst-port==*pC*,	high	output(*INT*)

Packet Template Table

ID	Data	Copy instructions
1	src-ip=<switchIP>, dst-ip=<switchIP>, L4proto=UDP, body=flow_mod(*match*, action = output(*EXT*), prio = high)	In *match*: src-ip=**src-ip**, dst-ip=**dst-ip**, L4proto=**L4proto**, src-port=**src-port**, dst-port=**dst-port**
2	src-ip=<switchIP>, dst-ip=<switchIP>, L4proto=UDP, body=flow_mod(*match*, action = output(*INT*), prio = high)	In *match*: src-ip=**dst-ip**, dst-ip=**src-ip**, L4proto=**L4proto**, src-port=**dst-port**, dst-port=**src-port**

Implementation Aspects



Packet transfer

- *patch cable*: send out port and receive on another
- *loopback*: use an internal loopback port
- *internal*: transfer separate from regular data path

Connection

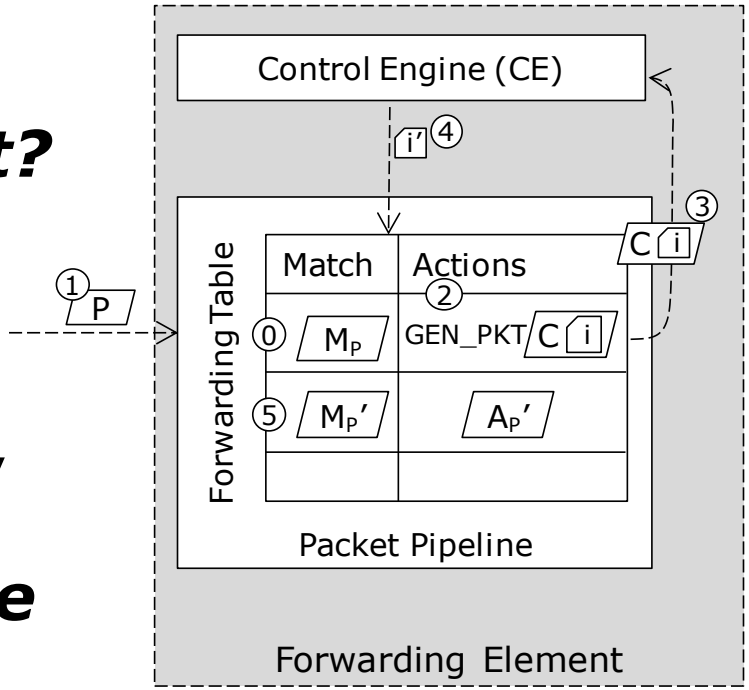
- use UDP, to avoid TCP overhead (connection setup, state management, flow control, ...)
- possible with OpenFlow's auxiliary connections

Summary

- Stateful processing can enhance programmability
- Implementation in hardware costly (money and complexity)
- Proposed to use in-switch packet generation to realize stateful flow processing by generating OF control messages

Discussion

- Proposal requires packet generation functionality in switches: ***how realistic is that?***
  - might need packet generation table
  - does not need to reside in TCAM, rather regular DRAM
- No added complexity on switch, but impact on control program unclear: ***is gain on switch side worth increased complexity of controller?***
- Processing of control messages needs time (slow path!) → state updates reflected with delay ("eventual consistency"): ***which applications can tolerate this? Which cannot?***

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