Exercise for Lecture
Software Defined Networking

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Web: `http://www.ps.tu-darmstadt.de/teaching/ws1617/sdn/`
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Problem 5.1 - NEC guest lecture: ShadowSwitch

This assignment refers to the ShadowSwitch concept presented in the lecture. For answering the questions, refer to the slides and the original paper on ShadowSwitch: `http://conferences.sigcomm.org/sigcomm/2015/pdf/papers/p343.pdf`.

a) ShadowSwitch tackles the problem of low flow installation performance of current SDN hardware switches. Which two approaches are combined in the ShadowSwitch concept? Discuss their respective advantages and disadvantages.

Combination of software & hardware switching.

Software:
Advantage: high performance with flow-table entry installation;
Disadvantage: low throughput in forwarding;

Hardware:
Advantage: high throughput in forwarding;
Disadvantage: poor performance with flow-table entry installation.

b) Having two flow tables may cause the issue of cross dependencies. Assume a switch's software and hardware tables contain the following entries. Which entry matches a packet with SRC_IP=A,DST_IP=B?

Hardware table:

H1: SRC_IP=A,DST_IP=B,PRIORITY=30

H2: SRC_IP=A,DST_IP=*,PRIORITY=20

HD: SRC_IP=*,DST_IP=*,PRIORITY=0

Software table:

S1: SRC_IP=A,DST_IP=*,PRIORITY=40

S2: SRC_IP=A,DST_IP=B,PRIORITY=20

HD: SRC_IP=*,DST_IP=*,PRIORITY=0

Because entries in hardware table always have a higher priority than in software table, this packet will be firstly looked up in the hardware table.

So, the entry H1 is matched to the packet.

c) Discuss how the existence of two flow tables may affect programming the switch with a controller software.

The sSwLogic, implemented as a user-level application, works as a proxy between the switches and an OpenFlow controller, which we implemented using POX on the same server.

In normal SDN design there is only 1 flow table, so controller could simply send requests to install or delete entries. But in ShadowSwitch there are 2 flow tables, so the controller must implement following functions:
1. regularly check the entries in both tables to detect if there is overlapping entries;
2. move entries from software switch to hardware switch(send request to delete entries in software table & add in hardware);
3. if overlapping exists, find & delete overlapping entries in hardware table;
4. other ShadowSwitch logic.

Problem 5.2 - NEC guest lecture: In-switch Processing (InSP)

This assignment refers to the InSP concept presented in the lecture. For answering the questions, refer to the slides and the original paper on InSP: `http://conferences.sigcomm.org/sosr/2016/papers/sosr_paper42.pdf`.

a) InSP allow to generate packets from within switches. Please discuss two scenarios, where the possibility to generate packets via the switch itself instead of using the controller may be beneficial.

1. Generate the ARP Reply packet in the switch & send it back to source address. Otherwise, based on basic OpenFlow actions the packet could only be replied until this packet forwarded to the destination or processed by controller, this may lead to unaccepted delay.

2. Generate a ICMP TimeExceeded packet, which is usually used in traceroute/tracepath/tracert function. Otherwise a OpenFlow switch must send the packet with TTL=1 to the controller and wait the response from the controller.

b) InSP introduces a Packet Template Table. Explain the concept of this table and the respective entries.

Packet Template Table is the data structure used to store the content of the packets the switch will generate, it contains many entries(PTEs). Using these entries an InSP switch is able to generate a packet without asking the controller.

Each PTE consists of 3 parts: packet template id, packet content template, array of copy operations.
Packet template id is used to identify a PTE, so that a PTE could be referenced by an action or other data structures defined in the InSP API.
Packet content template contains the common information of specified type of packet with some empty block to be filled in, e.g. ARP Reply packet without src/dst ip & mac address.
Copy operations could change part of the content template, for example copy the src ip from the incoming packet to the dst ip address of the packet to be generated.

c) You are given the same InSP tables as on slide 41 of the lecture on InSP. Describe the reaction of the switch, if the following triggering packets arrive. If InSP is triggered to generate a packet, describe the structure of the packet.

P1: SRC_MAC=MAC_D,
DST_MAC=BROADCAST,
TYPE=ARP-Request,
ARP_IPS=1.2.3.5,
ARP_IPD=1.2.3.4

P2: SRC_MAC=MAC_E,
DST_MAC=BROADCAST,

TYPE=ARP-Request,
ARP_IPS=1.2.3.6,
ARP_IPD=1.2.3.4

P3: SRC_MAC=MAC_E,
DST_MAC=BROADCAST,
TYPE=ARP-Request,
ARP_IPS=1.2.3.6,
ARP_IPD=1.2.3.5

P1: The packet matched the entry to generate a packet like below, and then the generated packet will be forwarded with matching of the OpenFlow Table:
SRC_MAC=MAC_A,
DST_MAC=MAC_D,
TYPE=ARP_Reply,
ARP_MACS=MAC_A,
ARP_MACD=MAC_D,
ARP_IPS=1.2.3.4,
ARP_IPD=1.2.3.5

P2: The packet matched the entry to generate a packet like below, and then the generated packet will be forwarded with matching of the OpenFlow Table:
SRC_MAC=MAC_A,
DST_MAC=MAC_E,
TYPE=ARP_Reply,
ARP_MACS=MAC_A,
ARP_MACD=MAC_E,
ARP_IPS=1.2.3.4,
ARP_IPD=1.2.3.6

P3: the ARP_IPD in this packet does not match the entry, so the packet will match to another entry, or be sent to controller.