南京大学本科生实验报告

课程名称：**计算机网络**　　任课教师：田臣/李文中　　助教：

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实验名称

Lab2

实验目的

对交换机的机制进行熟悉

实验内容

对交换机节点进行配置

实验结果

Task2

本实验是对集线器代码的修改，完成交换机功能的配置。交换机的主要工作逻辑是区分是否是广播地址，区分源地址和目的地址是否在交换机表中，若源地址不在交换机表中则添加，若目的地址不在交换机表中，则向除源节点外的节点广播。

根据以上逻辑编写代码（源码见`myswitch.py`）

在client节点中`ping -c 2 192.168.100.1`

```
root@njucs-VirtualBox:~/switchyard/lab-02-wjrzm# ping -c 2 192.168.100.1
PING 192.168.100.1 (192.168.100.1) 56(84) bytes of data.
64 bytes from 192.168.100.1: icmp_seq=1 ttl=64 time=836 ms
64 bytes from 192.168.100.1: icmp_seq=2 ttl=64 time=462 ms

--- 192.168.100.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 462.629/649.438/836.247/186.809 ms
root@njucs-VirtualBox:~/switchyard/lab-02-wjrzm# SSS
```

可以观察到如下INFO，和交换机的逻辑一致

```
(syenv) root@njucs-VirtualBox:~/switchyard/lab-02-wjrzm# swyard myswitch.py
14:39:30 2022/03/21     INFO Saving iptables state and installing switchyard rul
es
14:39:30 2022/03/21     INFO Using network devices: switch-eth1 switch-eth2 swit
ch-eth0
14:41:23 2022/03/21     INFO Received a boardcast which src is not saved
14:41:23 2022/03/21     INFO Broadcasting packet Ethernet 30:00:00:00:00:01->ff:
ff:ff:ff:ff:ff ARP | Arp 30:00:00:00:00:01:192.168.100.3 00:00:00:00:00:00:192.1
68.100.1 to switch-eth1
14:41:23 2022/03/21     INFO Broadcasting packet Ethernet 30:00:00:00:00:01->ff:
ff:ff:ff:ff:ff ARP | Arp 30:00:00:00:00:01:192.168.100.3 00:00:00:00:00:00:192.1
68.100.1 to switch-eth0
14:41:23 2022/03/21     INFO Received a packet which src is not saved
14:41:23 2022/03/21     INFO Flooding packet Ethernet 10:00:00:00:00:01->30:00:0
0:00:00:01 ARP | Arp 10:00:00:00:00:01:192.168.100.1 30:00:00:00:00:01:192.168.1
00.3 to switch-eth2
```

```
14:41:23 2022/03/21     INFO Received a packet which src already is saved
14:41:23 2022/03/21     INFO Flooding packet Ethernet 30:00:00:00:00:01->10:00:0
0:00:00:01 IP | IPv4 192.168.100.3->192.168.100.1 ICMP | ICMP EchoRequest 4540 1
 (56 data bytes) to switch-eth0
14:41:24 2022/03/21     INFO Received a packet which src already is saved
14:41:24 2022/03/21     INFO Flooding packet Ethernet 10:00:00:00:00:01->30:00:0
0:00:00:01 IP | IPv4 192.168.100.1->192.168.100.3 ICMP | ICMP EchoReply 4540 1 (
56 data bytes) to switch-eth2
14:41:24 2022/03/21     INFO Received a packet which src already is saved
14:41:24 2022/03/21     INFO Flooding packet Ethernet 30:00:00:00:00:01->10:00:0
0:00:00:01 IP | IPv4 192.168.100.3->192.168.100.1 ICMP | ICMP EchoRequest 4540 2
 (56 data bytes) to switch-eth0
14:41:24 2022/03/21     INFO Received a packet which src already is saved
14:41:24 2022/03/21     INFO Flooding packet Ethernet 10:00:00:00:00:01->30:00:0
0:00:00:01 IP | IPv4 192.168.100.1->192.168.100.3 ICMP | ICMP EchoReply 4540 2 (
56 data bytes) to switch-eth2
14:41:29 2022/03/21     INFO Received a packet which src already is saved
14:41:29 2022/03/21     INFO Flooding packet Ethernet 10:00:00:00:00:01->30:00:0
0:00:00:01 ARP | Arp 10:00:00:00:00:01:192.168.100.1 00:00:00:00:00:00:192.168.1
00.3 to switch-eth2
14:41:29 2022/03/21     INFO Received a packet which src already is saved
14:41:29 2022/03/21     INFO Flooding packet Ethernet 30:00:00:00:00:01->10:00:0
0:00:00:01 ARP | Arp 30:00:00:00:00:01:192.168.100.3 10:00:00:00:00:01:192.168.1
00.1 to switch-eth0
```

server1中有如下信息：

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	30:00:00:00:00:01	Broadcast	ARP	42	Who has 192.168.100.1? Tell 192.168.100.3
2	0.100225825	Private_00:00:01	30:00:00:00:00:01	ARP	42	192.168.100.1 is at 10:00:00:00:00:01
3	0.411621916	192.168.100.3	192.168.100.1	ICMP	98	Echo (ping) request id=0x0ee4, seq=1/256, ttl=64 (rep
4	0.511882853	192.168.100.1	192.168.100.3	ICMP	98	Echo (ping) reply id=0x0ee4, seq=1/256, ttl=64 (req
5	1.036766086	192.168.100.3	192.168.100.1	ICMP	98	Echo (ping) request id=0x0ee4, seq=2/512, ttl=64 (rep
6	1.137590732	192.168.100.1	192.168.100.3	ICMP	98	Echo (ping) reply id=0x0ee4, seq=2/512, ttl=64 (req
7	5.739432429	Private_00:00:01	30:00:00:00:00:01	ARP	42	Who has 192.168.100.3? Tell 192.168.100.1
8	6.062372296	30:00:00:00:00:01	Private_00:00:01	ARP	42	192.168.100.3 is at 30:00:00:00:00:01

server2有如下信息：

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	30:00:00:00:00:01	Broadcast	ARP	42	Who has 192.168.100.1? Tell 192.168.100.3

可见，client首先向交换机发送广播，交换机表记录client的MAC和PORT，并向server1,server2广播，server1向交换机发送送给client的信息，交换机表记录server1的MAC和PORT，并在表中查询到client的mac，发向其对应的端口。随后client和server1进行ICMP协议的消息传输，一共有两个来回。最后server1发送给交换机发向client的信息，交换机查表将消息发送个client对应端口，server1通过arp协议完成了ip地址转换成mac地址的任务，最后client发向server1，交换机将信息转发给对应的端口。而server2中仅收到了广播信息，并未做出回应。

Task3

按照手册里面的流程图进行代码编写，在原本的交换机代码中加入计时功能。

引入类：

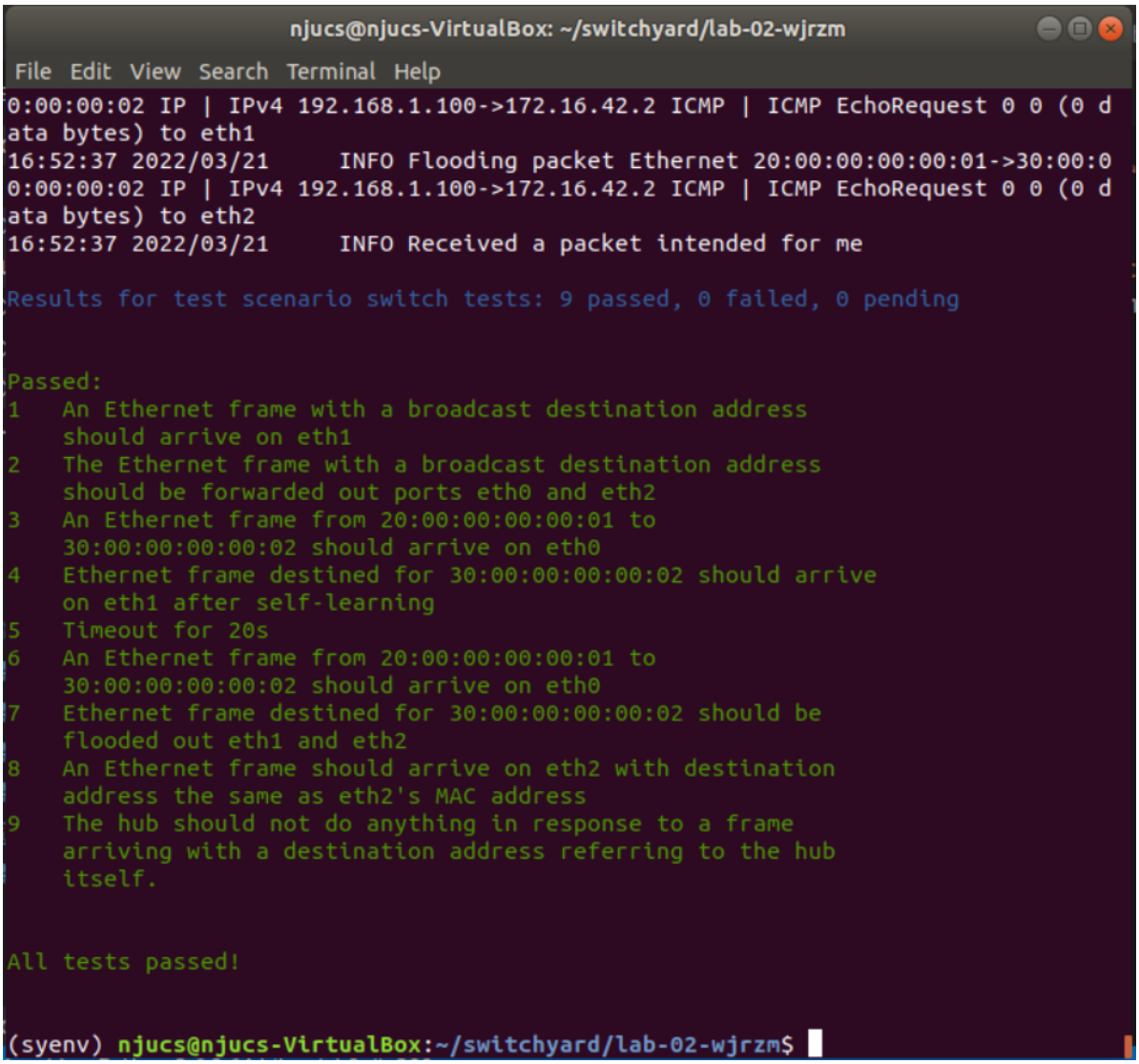
```
class table:
    def __init__(self,macs,ports,timestamps):
        self.mac = macs
        self.port = ports
        self.timestamp = timestamps
```

加入对时间的判断：

```
index = 0
while index < len(list_table):
    temp_time = time.time()
    if temp_time - list_table[index].timestamp >= 10:
        del(list_table[index])
    else:
        index += 1
```

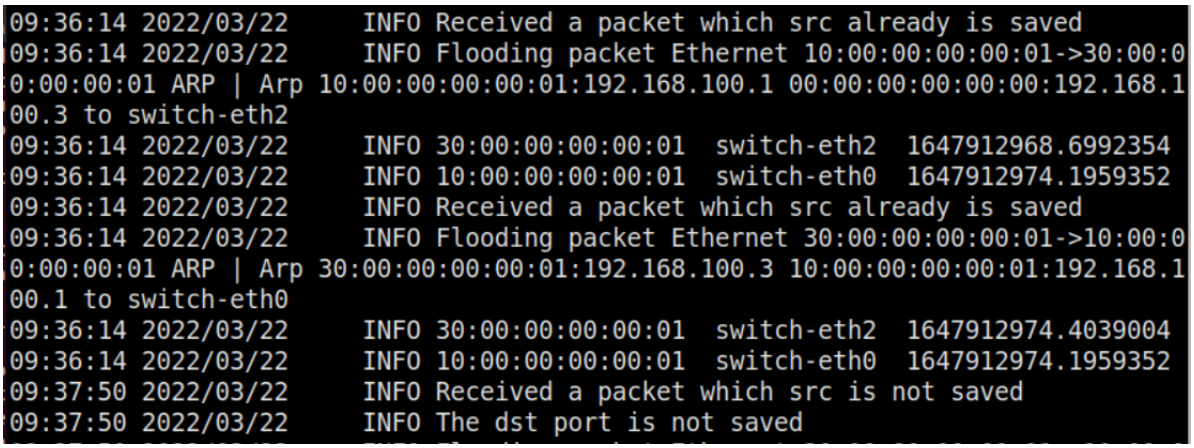
程序源码见`myswitch_to.py`

运行手册提供的测试代码，结果如下：



在mininet中试验得：

第一次在client中`ping -c 1 192.168.100.1`，可以看到switch中收到了一个没有收到过的src，并且在最后得到了交换机表项。隔一段时间后再`ping -c 1 192.168.100.1`



在9.37分时，又进行的一次ping中可以见，src和dst都没有储存在交换机表中，可知switch表已经被清空。

Task4

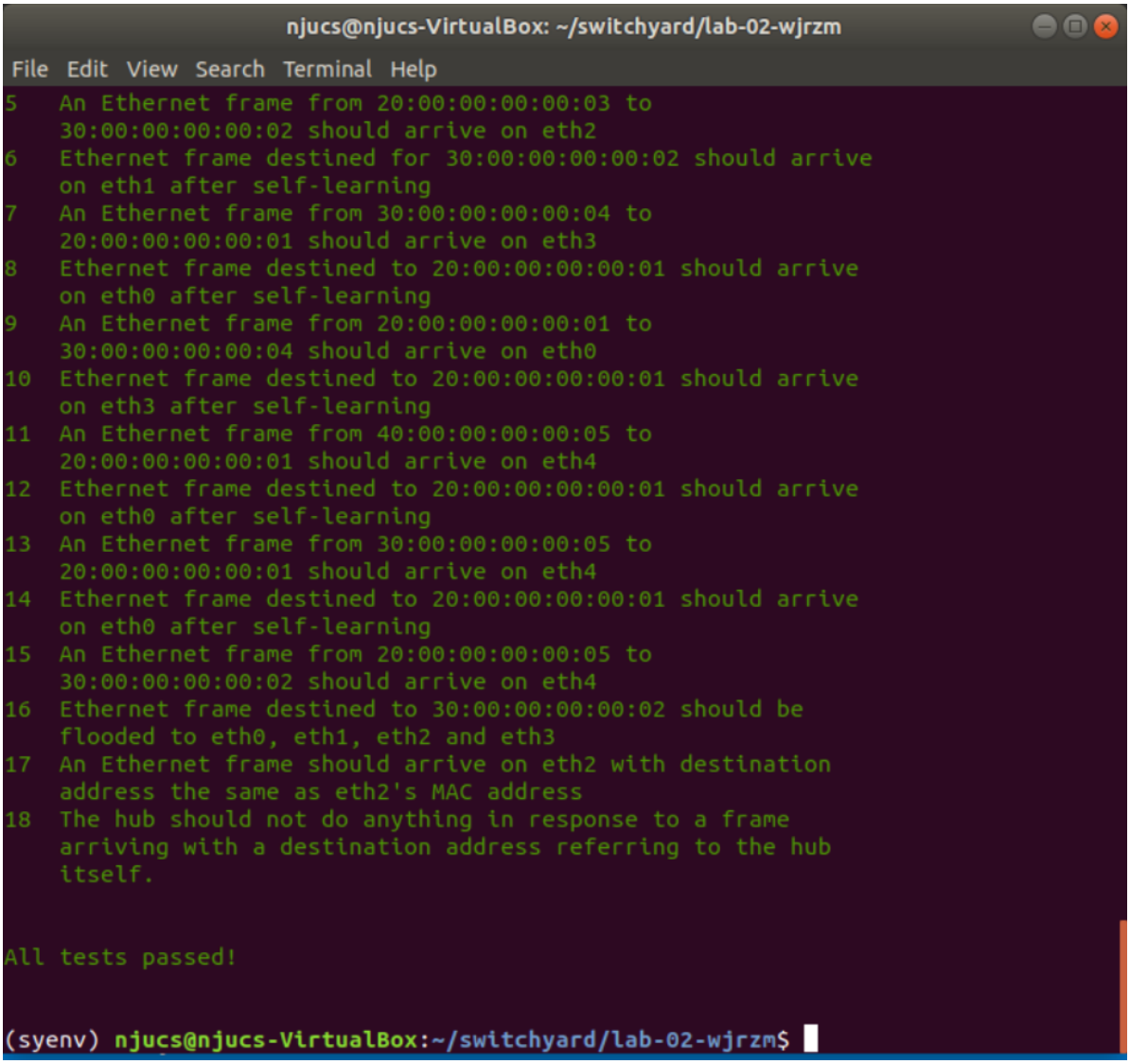
在这任务中，我们仍然依赖时间戳，在每一次交换机表项数超过5的时候，我们将其中时间戳最小的那一项清楚，这意味着这个被清除的项就是满足lru算法的项，因为它是最近最少被使用的数据。

加入对时间戳最小表项的判断：

```
if len(list_table) == max_len:
    index = 0
    timestamp_min = list_table[index].timestamp
    for i in range(0,len(list_table)):
        if list_table[i].timestamp < timestamp_min:
            index = i
            timestamp_min = list_table[i].timestamp
    del(list_table[index])
list_table.append(table(eth.src,fromIface,time.time()))
```

程序源码见`myswitch_lru.py`

运行手册的测试代码，结果如下：



在mininet中试验得：

添加测试代码

```
    for i in range(len(list_table)):
    log_info(f"{list_table[i].mac}  {list_table[i].port}
{list_table[i].timestamp}")
```

并且修改`max_len=2`以便于测试，我们首先在client中`ping -c 1 192.168.100.1`可以看到交换机表中如下显示：

```
09:26:29 2022/03/22     INFO Received a packet which src already is saved
09:26:29 2022/03/22     INFO Flooding packet Ethernet 30:00:00:00:00:01->10:00:0
0:00:00:01 ARP | Arp 30:00:00:00:00:01:192.168.100.3 10:00:00:00:00:01:192.168.1
00.1 to switch-eth0
09:26:29 2022/03/22     INFO 30:00:00:00:00:01  switch-eth2  1647912389.1875746
09:26:29 2022/03/22     INFO 10:00:00:00:00:01  switch-eth0  1647912388.9769588
```

然后在client中`ping -c 1 192.168.100.2`可以看到交换机表中如下显示：

```
09:26:39 2022/03/22     INFO Received a packet which src already is saved
09:26:39 2022/03/22     INFO Flooding packet Ethernet 30:00:00:00:00:01->20:00:0
0:00:00:01 ARP | Arp 30:00:00:00:00:01:192.168.100.3 20:00:00:00:00:01:192.168.1
00.2 to switch-eth1
09:26:39 2022/03/22     INFO 30:00:00:00:00:01  switch-eth2  1647912399.7960076
09:26:39 2022/03/22     INFO 20:00:00:00:00:01  switch-eth1  1647912399.4726014
```

由此可见eth2端口的时间戳被更新，且由于lru原则，eth0端口对应的表项已经被删除。

Task5

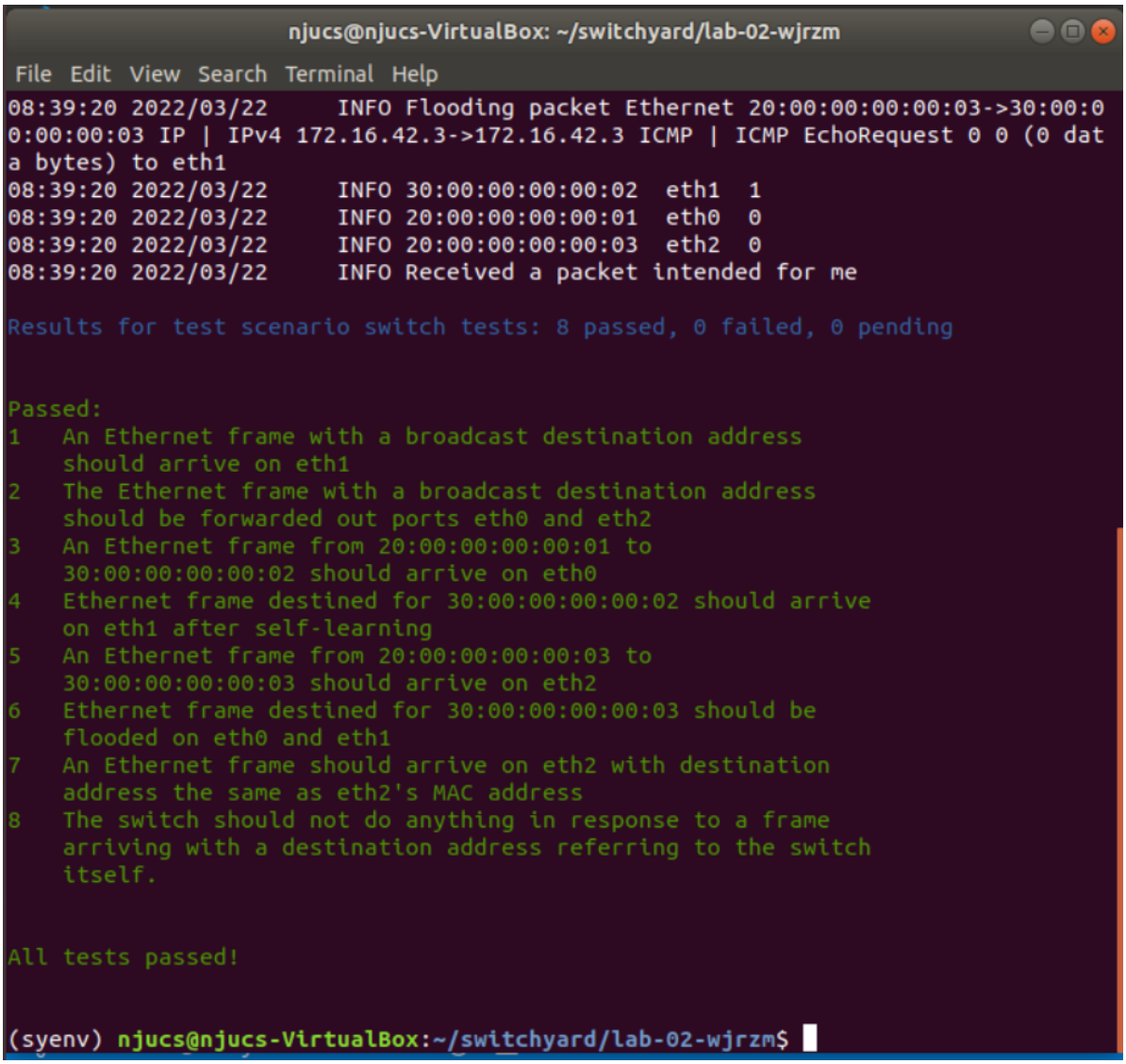
在这个任务中，我们将交换机表项中记录的时间戳改换为`traffic volume`，按照手册中流程图中的规则，如果`Destination MAC address == MAC address of entry`，则对改端口vol值加一。

加入对vol值的判断：

```
if len(list_table) == max_len:
    index = 0
    vol_min = list_table[index].vol
    for i in range(0,len(list_table)):
        if list_table[i].vol < vol_min:
            index = i
            vol_min = list_table[i].vol
    del(list_table[index])
list_table.append(table(eth.src,fromIface,0))
```

具体代码见`myswitch_traffic.py`文件。

运行手册的测试代码，结果如下：



在mininet中运行得：（修改`max_len=2`以便于测试）

首先在client中`ping -c 1 192.168.100.1`

得到最终结果如下：

```
09:13:32 2022/03/22     INFO Received a packet which src already is saved
09:13:32 2022/03/22     INFO Flooding packet Ethernet 30:00:00:00:00:01->10:00:0
0:00:00:01 ARP | Arp 30:00:00:00:00:01:192.168.100.3 10:00:00:00:00:01:192.168.1
00.1 to switch-eth0
09:13:32 2022/03/22     INFO 30:00:00:00:00:01  switch-eth2  3
09:13:32 2022/03/22     INFO 10:00:00:00:00:01  switch-eth0  2
```

再在client中`ping -c 1 192.168.100.2`

得到最终结果如下：

```
09:13:45 2022/03/22     INFO Received a packet which src already is saved
09:13:45 2022/03/22     INFO Flooding packet Ethernet 30:00:00:00:00:01->20:00:0
0:00:00:01 ARP | Arp 30:00:00:00:00:01:192.168.100.3 20:00:00:00:00:01:192.168.1
00.2 to switch-eth1
09:13:45 2022/03/22     INFO 30:00:00:00:00:01  switch-eth2  6
09:13:45 2022/03/22     INFO 20:00:00:00:00:01  switch-eth1  2
```

可见，在traffic volume中删去了最小的那个端口表项。

实验总结

在实验中，要注意关注实验手册中的流程图，一些细节性的要求，例如在哪些情况下更改拓扑结构不改变对应的信息，例如在哪些情况下会进行表项的排序等。本实验基本上是按照对于交换机的理解，在基础代码上进行一点修改即可。