

南京大学本科生实验报告

姓名：徐佳美 学号：181860117

专业：计算机科学与技术系

任课老师：李文中

邮箱：181860117@smail.nju.edu.cn

完成日期：3.25

一. 实验名称

Learning Switch

二. 实验目的

学习交换机的四种工作原理：普通交换机，基于时间的交换机，按最近最少使用过滤的交换机，按交通流量过滤的交换机。

三. 实验内容和核心代码

Task1:增加几个相关文件，无实质内容。

Task2: 普通交换机

如图，左侧为 server1 节点，收到了各两次 echo request 和 reply。
右侧的 server2 节点仅收到 ARP 包。

Time	Source	Destination	Protocol	Length	Info
1.0.00000000	38:00:00:00:00:01	Broadcast	ARP	42	Who has 192.168.100.1? Tell 192.168.100.3
2.0.10072936	Private_00:00:01	38:00:00:00:00:01	ARP	42	192.168.100.1 is at 10:00:00:00:00:01
3.0.517889847	192.168.100.3	192.168.100.1	ICMP	96	Echo (ping) request id=0xf01, seq=1/256, ttl=64
4.0.618485578	192.168.100.1	192.168.100.3	ICMP	96	Echo (ping) reply id=0xf01, seq=1/256, ttl=64
5.0.932852567	192.168.100.3	192.168.100.1	ICMP	96	Echo (ping) request id=0xf01, seq=2/512, ttl=64
6.1.032035837	192.168.100.1	192.168.100.3	ICMP	96	Echo (ping) reply id=0xf01, seq=2/512, ttl=64
7.5.010036551	Private_00:00:01	38:00:00:00:00:01	ARP	42	Who has 192.168.100.3? Tell 192.168.100.1
8.6.159243413	38:00:00:00:00:01	Private_00:00:01	ARP	42	192.168.100.3 is at 38:00:00:00:00:01

普通交换机收到包时，如果之前记录过源地址信息，检查与本次端口是否相同，不同则更新端口；检查是否记录过目的地信息，有则在相应端口发出，否则洪泛。
用 log_info 打印相关信息。第一次广播，client 查询一个 ip 地址的 mac，学习表里存下 client 对应 switch-eth2。Server1 回答自己的 mac 地址。表里存下 server1 对应 switch-eth0。接下来是 client 与 server1 的两次发送和应答。如下图所示，表里已经存下对应端口，因此没有洪泛信息，只打印学习表内的内容。

```
root@jucs-VirtualBox:~/switchyard$ source ./env/bin/activate
(syenv) root@jucs-VirtualBox:~/switchyard$ sward lab_2/myswitch.py
22:18:13 2020/03/24 INFO Saving iptables state and installing switchyard rule
22:18:13 2020/03/24 INFO Using network devices: switch-eth0 switch-eth2 sub
switch-eth1
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 10:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth2 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 10:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth2 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 10:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth2 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO port1: switch-eth0 mac: 10:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
22:18:14 2020/03/24 INFO port1: switch-eth2 mac: 30:00:00:00:00:01
22:18:14 2020/03/24 INFO finish a packet process
```

Task3:Time out

1.测试结果：

```
(syenv) njucs@njucs-VirtualBox:~/switchyard$ sward -t lab_2/testcase/switchtests_to.srpy lab_2/myswitch_to.py
22:55:18 2020/03/24 INFO Starting test scenario lab_2/testcase/switchtests_to.srpy

Results for test scenario switch tests: 9 passed, 0 failed, 0 pending

Passed:
1 An Ethernet frame with a broadcast destination address
  should arrive on eth1
2 The Ethernet frame with a broadcast destination address
  should be forwarded out ports eth0 and eth2
3 An Ethernet frame from 30:00:00:00:00:01 to
  30:00:00:00:00:02 should arrive on eth0
4 Ethernet frame destined for 30:00:00:00:00:02 should arrive
  on eth1 after self-learning
5 Timeout for 20s
6 An Ethernet frame from 30:00:00:00:00:01 to
  30:00:00:00:00:02 should arrive on eth0
7 Ethernet frame destined for 30:00:00:00:00:02 should be
  flooded out eth1 and eth2
8 An Ethernet frame should arrive on eth2 with destination
  address the same as eth2's MAC address
9 The hub should not do anything in response to a frame
  arriving with a destination address referring to the hub
  itself.

All tests passed!

(syenv) njucs@njucs-VirtualBox:~/switchyard$
```

2.分析与验证

基于时间淘汰的交换机。用 `time()` 获取当前时间。收到包后先检查表项内的时间戳，若与当前时间差大于 10s，则移除。之后再遍历表项，如果之前记录过源地址信息，检查与本次端口是否相同，不同则更新端口；检查是否记录过目的地信息，有则在相应端口发出，否则洪泛。

在 client 节点 ping 一次 server1 之后，如下图所示，表内存下相关信息：

Client 对应 switch-eth2,server1 对应 switch-eth0

几分钟后再在 client 端 ping server1.如下图所示，loginfo 显示两次删除。

第一次， 删除 client 与 eth2 的表项，只留下 server1-eth0。之后会重新存入 client 与 eth2 信息。

第二次， 删除 server1 与 eth0 的表项，只留下 client-eth2。之后会重新存入 server1 与 eth0 信息。

下一次表内留下这两项信息，并打印了出来。

备注：（下图 mac 和 port 顺序打印反了，不过不影响理解）

```
"Node: switch"
09:33:17 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:33:17 2020/03/25 INFO finish a packet process
09:33:17 2020/03/25 INFO port: 30:00:00:00:00:01 mac: switch-eth2
09:33:17 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:33:17 2020/03/25 INFO finish a packet process
09:33:22 2020/03/25 INFO port: 30:00:00:00:00:01 mac: switch-eth2
09:33:22 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:33:22 2020/03/25 INFO finish a packet process
09:33:23 2020/03/25 INFO port: 30:00:00:00:00:01 mac: switch-eth2
09:33:23 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:33:23 2020/03/25 INFO finish a packet process
09:37:11 2020/03/25 INFO delete port: 30:00:00:00:00:01 mac: switch-eth2
09:37:11 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:37:11 2020/03/25 INFO finish a packet process
09:37:11 2020/03/25 INFO delete port: 10:00:00:00:00:01 mac: switch-eth0
09:37:11 2020/03/25 INFO port: 30:00:00:00:00:01 mac: switch-eth2
09:37:11 2020/03/25 INFO finish a packet process
09:37:16 2020/03/25 INFO port: 30:00:00:00:00:01 mac: switch-eth2
09:37:16 2020/03/25 INFO port: 10:00:00:00:00:01 mac: switch-eth0
09:37:16 2020/03/25 INFO finish a packet process
```

Task4:Least Recently Used

1. 测试结果:

```
njucs@njucs-VirtualBox: ~/switchyard
File Edit View Search Terminal Help
RUN
VAR (syenv) njucs@njucs-VirtualBox:~/switchyard$ swyard -t lab_2/testcase/switchtests_lru.srpy lab_2/nys
WAI 15:55:33 2020/03/24 INFO Starting test scenario lab_2/testcase/switchtests_lru.srpy
> Results for test scenario switch tests: 18 passed, 0 failed, 0 pending
>
Passed:
1 An Ethernet frame with a broadcast destination address
  should arrive on eth1
2 The Ethernet frame with a broadcast destination address
  should be forwarded out ports eth0, eth2, eth3 and eth4
3 An Ethernet frame from 20:00:00:00:00:01 to
  30:00:00:00:00:02 should arrive on eth0
4 Ethernet frame destined for 30:00:00:00:00:02 should arrive
  on eth1 after self-learning
5 An Ethernet frame from 20:00:00:00:00:03 to
  30:00:00:00:00:02 should arrive on eth2
6 Ethernet frame destined for 30:00:00:00:00:02 should arrive
  on eth1 after self-learning
7 An Ethernet frame from 30:00:00:00:00:04 to
  20:00:00:00:00:01 should arrive on eth3
8 Ethernet frame destined to 20:00:00:00:00:01 should arrive
  on eth0 after self-learning
9 An Ethernet frame from 20:00:00:00:00:01 to
  30:00:00:00:00:04 should arrive on eth0
10 Ethernet frame destined to 20:00:00:00:00:01 should arrive
  on eth3 after self-learning
11 An Ethernet frame from 40:00:00:00:00:05 to
  20:00:00:00:00:01 should arrive on eth4
12 Ethernet frame destined to 20:00:00:00:00:01 should arrive
  on eth0 after self-learning
13 An Ethernet frame from 30:00:00:00:00:05 to
  20:00:00:00:00:01 should arrive on eth4
14 Ethernet frame destined to 20:00:00:00:00:01 should arrive
  on eth0 after self-learning
15 An Ethernet frame from 20:00:00:00:00:05 to
  30:00:00:00:00:02 should arrive on eth4
16 Ethernet frame destined to 30:00:00:00:00:02 should be
  flooded to eth0, eth1, eth2 and eth3
17 An Ethernet frame should arrive on eth2 with destination
  address the same as eth2's MAC address
18 The hub should not do anything in response to a frame
  arriving with a destination address referring to the hub
  itself.
```

2. 分析与验证:

LRU 交换机。新建的 LearnTable 最多只容纳五个表项，存储原则是，下标越靠后的，越是之前使用的。已存入 src 的检查是否更新端口信息。若没存 src 信息，当表未满时，前面的元素依次后移，src 存在下标 0 位置，

显然这时数组是按时间使用前后排列的；当表满时，显然 LearnTable[0] 是 LRU，下标为 0-3 的依次向后移动到 1-4 的位置，新的存入下标 0。

包的发送：检查是否存入 dest 信息，有则从相关端口发，无则洪泛。

以下的验证将容纳量改为了 2。

第一次 client ping server1，如图打印两次 add 信息，client-eth2,server1-eth0。

```
"Node: switch"
root@njucs-VirtualBox:~/switchyard# source ./syenv/bin/activate
(syenv) root@njucs-VirtualBox:~/switchyard# swyard lab_2/myswitch_lru.py
10:18:31 2020/03/25 INFO Saving iptables state and installing switchyard rules
10:18:31 2020/03/25 INFO Using network devices: switch-eth0 switch-eth1 switch-eth2
10:18:47 2020/03/25 INFO add mac: 30:00:00:00:00:01 port: switch-eth2
10:18:47 2020/03/25 INFO finish a packet process
10:18:47 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:18:47 2020/03/25 INFO add mac: 10:00:00:00:00:01 port: switch-eth0
10:18:47 2020/03/25 INFO finish a packet process
10:18:47 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:18:47 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0
10:18:47 2020/03/25 INFO finish a packet process
```

第二次 client ping server2，如图显示要新添加 server2-eth1。此时表内已打印两条信息，即满。接下来显示删除了 LRU，表内留下了 server1-eth0,server2-eth1。

```
"Node: switch"
10:18:53 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:18:53 2020/03/25 INFO finish a packet process
10:21:52 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:21:52 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0
10:21:52 2020/03/25 INFO finish a packet process
10:21:53 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:21:53 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0
10:21:53 2020/03/25 INFO add mac: 20:00:00:00:00:01 port: switch-eth1
10:21:53 2020/03/25 INFO delete LRU,add mac: 20:00:00:00:00:01 port: switch-eth1
10:21:53 2020/03/25 INFO finish a packet process
10:21:53 2020/03/25 INFO mac: 20:00:00:00:00:01 port: switch-eth1
10:21:53 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2
10:21:53 2020/03/25 INFO finish a packet process
```

Task5:Least Traffic Volume

1. 测试结果

```

bash: ./bin/syenv/activate: No such file or directory
njucs@njucs-VirtualBox:~/switchyard$ source ./bin/syenv/activate
bash: ./bin/syenv/activate: No such file or directory
njucs@njucs-VirtualBox:~/switchyard$ source ./bin/syenv/activate
(syenv) njucs@njucs-VirtualBox:~/switchyard$ swyard -t lab_2/testcase/switchtests_traffic.srpy lab_2/myswitch_traffic.py
20:43:16 2020/03/24 INFO Starting test scenario lab_2/testcase/switchtests_traffic.srpy

Results for test scenario switch tests: 8 passed, 0 failed, 0 pending

Passed:
1 An Ethernet frame with a broadcast destination address
  should arrive on eth1
2 The Ethernet frame with a broadcast destination address
  should be forwarded out ports eth0 and eth2
3 An Ethernet frame from 20:00:00:00:01 to
  30:00:00:00:02 should arrive on eth0
4 Ethernet frame destined for 30:00:00:00:02 should arrive
  on eth1 after self-learning
5 An Ethernet frame from 20:00:00:00:03 to
  30:00:00:00:03 should arrive on eth2
6 Ethernet frame destined for 30:00:00:00:03 should be
  flooded on eth0 and eth1
7 An Ethernet frame should arrive on eth2 with destination
  address the same as eth2's MAC address
8 The switch should not do anything in response to a frame
  arriving with a destination address referring to the switch
  itself.

All tests passed!

```

2. 分析与验证:

基于流量的交换机。Src 已存入时，对应流量加 1。Src 未存入，遍历 LearnTable 中的每一项，找出流量最小的一项并移除，将新的 src 加入，流量设为 1。

包的发送，已有 dest 信息时，从对应端口发送，没有则洪泛。

以下验证表容量改为了 2。

第一次 client ping server1。表内存下 client-eth2-2。Server1-eth0-3。

```

"Node: switch"
root@njucs-VirtualBox:~/switchyard# source ./syenv/bin/activate
(syenv) root@njucs-VirtualBox:~/switchyard# swyard lab_2/myswitch_traffic.py
11:01:26 2020/03/25 INFO Saving iptables state and installing switchyard rules
11:01:26 2020/03/25 INFO Using network devices: switch-eth2 switch-eth1 switch-eth0
11:01:38 2020/03/25 INFO add mac: 30:00:00:00:00:01 port: switch-eth2,volume:1
11:01:38 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:1
11:01:38 2020/03/25 INFO add mac: 10:00:00:00:00:01 port: switch-eth0,volume:1
11:01:38 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:1
11:01:38 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:1
11:01:38 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:01:38 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:1
11:01:44 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:01:44 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:2
11:01:44 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:01:44 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:3

```

第二次 client ping server2。表内更新一项为 client-eth2-4。表内已满，删除流量少的 server1-eth0-3。加入 server2-eth1-1。

```

"Node: switch"
11:04:14 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:1
11:04:15 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:04:15 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:1
11:04:20 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:04:20 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:2
11:04:20 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:2
11:04:20 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:3
11:04:37 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:3
11:04:37 2020/03/25 INFO mac: 10:00:00:00:00:01 port: switch-eth0 volume:3
11:04:37 2020/03/25 INFO delete LTV,mac: 10:00:00:00:00:01 port: switch-eth0,volume:3
11:04:37 2020/03/25 INFO add mac: 20:00:00:00:00:01 port: switch-eth1,volume:1
11:04:37 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:4
11:04:37 2020/03/25 INFO mac: 20:00:00:00:00:01 port: switch-eth1 volume:1
11:04:38 2020/03/25 INFO mac: 30:00:00:00:00:01 port: switch-eth2 volume:5

```

四. 感想与总结:

1.实验中遇到的问题:

关于数组的运用:对 `python` 数组运用的不熟练,`python` 数组内可以存任何变量,也可以直接在里面存入数组,学习了数组的遍历。

问题理解:对 `timeout` 的理解。用的应该是实时的时间,用 `time()` 获取当前时间,如果一开始把收包时间用变量存下来,则该时间被固定了。影响之后的超时判断。