Screenshots

1. The shell commands used in task1:

wifistatus.sh

```
#!/bin/sh

mac=`iw dev wlan0 station dump | grep -i station | awk '{printf $2","}'`
signal=`iw dev wlan0 station dump | grep -i signal: | awk '{printf $2","}
echo "$mac$signal"
```

I use iw dev command to get the wifi signal status, parse the macadress and SNR out, and then output the mac and SNR to stdout.

sendpacket.sh:

```
#!/bin/sh

while :
do
        Out=`sh wifistatus.sh`
        echo "[Sending packet...]"
        echo -n -e "\x04\x02\x00\x34\x00\x00\x00\x00$Out" | nc 192.168.2.254 6653
        echo "[Done]"
        sleep 20
done
```

First, I store the stdout of wifistatus.sh to a variable Out. Then, use nc command to send the packet which contains openflow header and the data to the controller located at 192.168.2.254:6653.

2. Event handler code:

```
@set_ev_cls(ofp_event.EventOFPEchoRequest,
    [HANDSHAKE_DISPATCHER, CONFIG_DISPATCHER, MAIN_DISPATCHER])
def echo_request_handler(self, ev):
    if ev.msg.data.decode(): # check whether the packet contains data
        datapath = ovs[0]
        ofproto = ovs[0].ofproto
        parser = ovs[0].ofproto_parser

        # parse data
        data = ev.msg.data.decode().split(',')
        SNR1 = int(data[2]) +90
        SNR2 = int(data[3]) +90
        SNR_ratio = SNR1 / SNR2;
        print("SNR: {} (device {})".format(SNR1, data[0]))
        print("SNR: {} (device {})".format(SNR2, data[1]))
        print("SNR ratio = {}".format(SNR_ratio))
        close_ports_num1 = 10 - round(SNR_ratio * (10 / (SNR_ratio + 1)))
        close_ports_num2 = 10 - close_ports_num1

        # delete all flow entries
        self.del_flow(datapath, data[0])
        self.del_flow(datapath, data[1])

        # add flow entries
        ports = [2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510]
        actions = []
        close_ports1 = random.sample(ports, close_ports_num1)
        for port in close_ports1:
            match = parser.OFPMatch(eth_src=data[0], eth_type=0x0800,
                ip_proto=17, udp_dst=port)
            self.add_flow(datapath, 3, match, actions)

        close_ports2 = random.sample(ports, close_ports_num2)
        for port in close_ports2:
            match = parser.OFPMatch(eth_src=data[1], eth_type=0x0800,
                ip_proto=17, udp_dst=port)
            self.add_flow(datapath, 3, match, actions)
```

First, I check whether the echo_request packet contains data since the router will send this type of packet to controller, too. Second, I parse the data out of the packet and split them into list, calculate the corresponding SNR and the SNR ratio of the two devices, also calculate the number of ports each device needs to drop. Third, I delete the flows which source mac is device 1 and 2. The del_flow code is below.

```
def del_flow(self, datapath, src_mac):
    ofproto = datapath.ofproto
    parser = datapath.ofproto_parser

    match = parser.OFPMatch(eth_src=src_mac)
    mod = parser.OFPFlowMod(datapath=datapath,command=ofproto.OFPFC_DELETE,
        buffer_id=ofproto.OFPCML_NO_BUFFER, out_port=ofproto.OFPP_ANY, out_group=OFPG_ANY, match=match)
    datapath.send_msg(mod)
```

It takes src_mac as input and will parse the flows that match that source mac and delete all of them.

Last, I use the random.sample function to sample the ports between 2501 to 2510. Adding the numbers of drop rules which are calculate above.

3. 2[TODO] parts mentioned previously:

SNR:

```
lab5@ubuntu:~/Desktop/project2$ ryu-manager 0716234_controller.py
loading app 0716234_controller.py
loading app ryu.controller.ofp_handler
instantiating app 0716234_controller.py of SimpleSwitch13
instantiating app ryu.controller.ofp_handler of OFPHandler
packet in 0009615023823478 ac:bc:32:97:b4:a1 08:be:ac:14:5a:76 2
packet in 0009615023823478 08:be:ac:14:5a:76 ac:bc:32:97:b4:a1 4294967294
packet in 0009615023823478 ac:bc:32:97:b4:a1 08:be:ac:14:5a:76 2
SNR: 36 (device fc:e2:6c:1f:60:aa)
SNR: 31 (device ac:bc:32:97:b4:a1)
SNR ratio = 1.1612903225806452
```

Dump flows:

```
root@OpenWrt:~# ovs-ofctl dump-flows br-lan_ovs
 cookie=0x0, duration=41.230s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=fc:e2:6c:1f:60:aa,tp_dst=2503 actions=drop
 cookie=0x0, duration=41.229s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=fc:e2:6c:1f:60:aa,tp_dst=2509 actions=drop
 cookie=0x0, duration=41.229s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=fc:e2:6c:1f:60:aa,tp_dst=2502 actions=drop
 cookie=0x0, duration=41.229s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=fc:e2:6c:1f:60:aa,tp_dst=2510 actions=drop
 cookie=0x0, duration=41.217s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=fc:e2:6c:1f:60:aa,tp_dst=2505 actions=drop
 cookie=0x0, duration=41.216s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=ac:bc:32:97:b4:a1,tp_dst=2506 actions=drop
 cookie=0x0, duration=41.216s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=ac:bc:32:97:b4:a1,tp_dst=2505 actions=drop
 cookie=0x0, duration=41.216s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=ac:bc:32:97:b4:a1,tp_dst=2503 actions=drop
 cookie=0x0, duration=41.216s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=ac:bc:32:97:b4:a1,tp_dst=2510 actions=drop
 cookie=0x0, duration=41.215s, table=0, n_packets=0, n_bytes=0, priority=3,udp,dl_src=ac:bc:32:97:b4:a1,tp_dst=2508 actions=drop
 cookie=0x0, duration=65.857s, table=0, n_packets=24, n_bytes=2358, priority=1,in_port=LOCAL,dl_src=08:be:ac:14:5a:76,dl_dst=ac:bc:32:97:b4:a1 actions=output:wlan0
 cookie=0x0, duration=38.684s, table=0, n_packets=29, n_bytes=2258, priority=1,in_port=wlan0,dl_src=ac:bc:32:97:b4:a1,dl_dst=08:be:ac:14:5a:76 actions=LOCAL
 cookie=0x0, duration=9.740s, table=0, n_packets=0, n_bytes=0, priority=1,in_port=wlan0,dl_src=fc:e2:6c:1f:60:aa,dl_dst=08:be:ac:14:5a:76 actions=LOCAL
 cookie=0x0, duration=9.729s, table=0, n_packets=0, n_bytes=0, priority=1,in_port=LOCAL,dl_src=08:be:ac:14:5a:76,dl_dst=fc:e2:6c:1f:60:aa actions=output:wlan0
 cookie=0x0, duration=70.629s, table=0, n_packets=23, n_bytes=4396, priority=0 actions=CONTROLLER:65535
root@OpenWrt:~#
```

The SNR ratio of the two devices are 1.16, so its near 5:5. Each device need to add drop rules on random 5 ports. The first device drops packets at 2502, 2503, 2505, 2509, 2510. The second device drops packets at 2503, 2505, 2506, 2508, 2510.

Discussion

1. What information do you transport to the controller?

I send the mac address and wifi signal power of a device which are all in the results of iw dev to the controller.

2. What's the total throughput of each device respectively?

Txt files	1st device Throughput	2nd device Throughput
Server listening on 2501 --- Accepted connection from 192.168.1.151, port 61522 [5] local 192.168.2.254 port 2501 connected to 192.168.1.151 port 49156 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.00 sec 120 KBytes 982 Kbits/sec 41899978856.596 ms 0/15 (0%) [5] 1.00-2.00 sec 128 KBytes 1.05 Mbits/sec 14919498538.076 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.134 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.532 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.165 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.289 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.419 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.308 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.944 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.395 ms 0/16 (0%) [5] 10.00-10.01 sec 8.00 KBytes 4.56 Mbits/sec 3614506.444 ms 0/1 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-10.01 sec 1.25 MBytes 1.05 Mbits/sec 3614506.444 ms 0/160 (0%) receiv --- Server listening on 2501 --- Accepted connection from 192.168.1.146, port 50158 [5] local 192.168.2.254 port 2501 connected to 192.168.1.146 port 54237 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.02 sec 104 KBytes 834 Kbits/sec 47672864827.501 ms 0/13 (0%) [5] 1.02-2.00 sec 144 KBytes 1.20 Mbits/sec 14919498541.363 ms 0/18 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447470.441 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625114.288 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.605 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.453 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.511 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.152 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827725.096 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.405 ms 0/16 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [SUM] 0.0-10.0 sec 3 datagrams received out-of-order [5] 0.00-10.01 sec 1.24 MBytes 1.04 Mbits/sec 3855473.405 ms 0/159 (0%) receiv	1.25 MBytes	1.24 MBytes
--- Server listening on 2502 --- Accepted connection from 192.168.1.151, port 61518 --- Server listening on 2502 --- Accepted connection from 192.168.1.146, port 50157 [6] local 192.168.2.254 port 2502 connected to 192.168.1.146 port 56265 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [6] 0.00-1.02 sec 112 KBytes 896 Kbits/sec 44693310782.824 ms 0/14 (0%) [6] 1.02-2.00 sec 136 KBytes 1.14 Mbits/sec 14919498541.435 ms 0/17 (0%) [6] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447470.364 ms 0/16 (0%) [6] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625114.191 ms 0/16 (0%) [6] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.468 ms 0/16 (0%) [6] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.410 ms 0/16 (0%) [6] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.562 ms 0/16 (0%) [6] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.509 ms 0/16 (0%) [6] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827725.146 ms 0/16 (0%) [6] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.523 ms 0/16 (0%) [6] 10.00-10.01 sec 8.00 KBytes 5.96 Mbits/sec 3614506.543 ms 0/1 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [6] 0.00-10.01 sec 1.25 MBytes 1.05 Mbits/sec 3614506.543 ms 0/160 (0%) receiver	0 MBytes	1.25 MBytes
--- Server listening on 2503 --- Accepted connection from 192.168.1.151, port 61526 --- Server listening on 2503 --- Accepted connection from 192.168.1.146, port 50161	0 MBytes	0 MBytes

Server listening on 2504 --- Accepted connection from 192.168.1.151, port 61527 [5] local 192.168.2.254 port 2504 connected to 192.168.1.151 port 53706 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.00 sec 120 KBytes 982 Kbits/sec 41899978856.577 ms 0/15 (0%) [5] 1.00-2.00 sec 128 KBytes 1.05 Mbits/sec 14919498538.021 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.228 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.523 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558767.812 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.276 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.548 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.216 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.994 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.266 ms 0/16 (0%) [5] 10.00-10.10 sec 8.00 KBytes 659 Kbits/sec 3614506.314 ms 0/1 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-10.10 sec 1.25 MBytes 1.04 Mbits/sec 3614506.314 ms 0/160 (0%) rece --- Server listening on 2504 --- Accepted connection from 192.168.1.146, port 50156 [5] local 192.168.2.254 port 2504 connected to 192.168.1.146 port 57279 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.02 sec 112 KBytes 896 Kbits/sec 44693310775.770 ms 0/14 (0%) [5] 1.02-2.00 sec 136 KBytes 1.14 Mbits/sec 14919498541.532 ms 0/17 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447470.442 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625114.185 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.304 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.247 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.512 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.233 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827725.005 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.357 ms 0/16 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [SUM] 0.0-10.0 sec 1 datagrams received out-of-order [5] 0.00-10.01 sec 1.24 MBytes 1.04 Mbits/sec 3855473.357 ms 0/159 (0%) rece	1.25 MBytes	1.24 MBytes
--- Server listening on 2505 --- Accepted connection from 192.168.1.151, port 61524 --- Server listening on 2505 --- Accepted connection from 192.168.1.146, port 50160	0 MBytes	0 MBytes
--- Server listening on 2506 --- Accepted connection from 192.168.1.151, port 61525 [5] local 192.168.2.254 port 2506 connected to 192.168.1.151 port 52220 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.00 sec 120 KBytes 982 Kbits/sec 41899978856.741 ms 0/15 (0%) [5] 1.00-2.00 sec 128 KBytes 1.05 Mbits/sec 14919498538.120 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.276 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.504 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558767.994 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.060 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.343 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.043 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.965 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.581 ms 0/16 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [SUM] 0.0-10.0 sec 1 datagrams received out-of-order [5] 0.00-10.02 sec 1.24 MBytes 1.04 Mbits/sec 3855473.581 ms 0/159 (0%) rece --- Server listening on 2506 --- Accepted connection from 192.168.1.146, port 50159	1.24 MBytes	0 MBytes

Server listening on 2507 --- Accepted connection from 192.168.1.151, port 61520 [5] local 192.168.2.254 port 2507 connected to 192.168.1.151 port 60581 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.00 sec 120 KBytes 982 Kbits/sec 41899978856.521 ms 0/15 (0%) [5] 1.00-2.00 sec 128 KBytes 1.05 Mbits/sec 14919498537.899 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.206 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.667 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.238 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.415 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.606 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.323 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.859 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.248 ms 0/16 (0%) [5] 10.00-10.11 sec 8.00 KBytes 620 Kbits/sec 3614506.214 ms 0/1 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-10.11 sec 1.25 MBytes 1.04 Mbits/sec 3614506.214 ms 0/160 (0%) recei --- Server listening on 2507 --- Accepted connection from 192.168.1.146, port 50162 [5] local 192.168.2.254 port 2507 connected to 192.168.1.146 port 51569 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.02 sec 120 KBytes 961 Kbits/sec 41899978852.228 ms 0/15 (0%) [5] 1.02-2.00 sec 128 KBytes 1.07 Mbits/sec 14919498536.942 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447468.965 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.684 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.303 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.345 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.619 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.294 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827725.104 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.229 ms 0/16 (0%) [5] 10.00-10.01 sec 8.00 KBytes 5.71 Mbits/sec 3614506.227 ms 0/1 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [SUM] 0.0-10.0 sec 4 datagrams received out-of-order [5] 0.00-10.01 sec 1.25 MBytes 1.05 Mbits/sec 3614506.227 ms 0/160 (0%) recei	1.25 MBytes	1.25 MBytes
--- Server listening on 2508 --- Accepted connection from 192.168.1.151, port 61519 [5] local 192.168.2.254 port 2508 connected to 192.168.1.151 port 54539 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-1.00 sec 120 KBytes 982 Kbits/sec 41899978856.586 ms 0/15 (0%) [5] 1.00-2.00 sec 128 KBytes 1.05 Mbits/sec 14919498538.015 ms 0/16 (0%) [5] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.156 ms 0/16 (0%) [5] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.654 ms 0/16 (0%) [5] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558768.185 ms 0/16 (0%) [5] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836853.443 ms 0/16 (0%) [5] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399699.518 ms 0/16 (0%) [5] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408624.178 ms 0/16 (0%) [5] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.980 ms 0/16 (0%) [5] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855473.327 ms 0/16 (0%) [5] 10.00-10.11 sec 0.00 Bytes 0.00 bits/sec 3855473.327 ms 0/0 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [5] 0.00-10.11 sec 1.24 MBytes 1.03 Mbits/sec 3855473.327 ms 0/159 (0%) rec --- Server listening on 2508 --- Accepted connection from 192.168.1.146, port 50164	1.24 MBytes	0 MBytes
--- Server listening on 2509 --- Accepted connection from 192.168.1.151, port 61521 --- Server listening on 2509 --- Accepted connection from 192.168.1.146, port 50165 [6] local 192.168.2.254 port 2509 connected to 192.168.1.146 port 62761 [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [6] 0.00-1.02 sec 112 KBytes 901 Kbits/sec 44693310781.994 ms 0/14 (0%) [6] 1.02-2.00 sec 136 KBytes 1.13 Mbits/sec 14919498540.697 ms 0/17 (0%) [6] 2.00-3.00 sec 128 KBytes 1.05 Mbits/sec 5312447469.849 ms 0/16 (0%) [6] 3.00-4.00 sec 128 KBytes 1.05 Mbits/sec 1891625113.530 ms 0/16 (0%) [6] 4.00-5.00 sec 128 KBytes 1.05 Mbits/sec 673558767.638 ms 0/16 (0%) [6] 5.00-6.00 sec 128 KBytes 1.05 Mbits/sec 239836852.736 ms 0/16 (0%) [6] 6.00-7.00 sec 128 KBytes 1.05 Mbits/sec 85399698.922 ms 0/16 (0%) [6] 7.00-8.00 sec 128 KBytes 1.05 Mbits/sec 30408623.648 ms 0/16 (0%) [6] 8.00-9.00 sec 128 KBytes 1.05 Mbits/sec 10827724.408 ms 0/16 (0%) [6] 9.00-10.00 sec 128 KBytes 1.05 Mbits/sec 3855472.732 ms 0/16 (0%) - [ID] Interval Transfer Bitrate Jitter Lost/Total Datagrams [6] 0.00-10.01 sec 1.24 MBytes 1.04 Mbits/sec 3855472.732 ms 0/159 (0%) receiver	0 MBytes	1.24 MBytes
--- Server listening on 2510 --- Accepted connection from 192.168.1.151, port 61523 --- Server listening on 2510 --- Accepted connection from 192.168.1.146, port 50163	0 MBytes	0 MBytes
Total throughput	6.23 MBytes	6.22 MBytes

3. Is the ratio close to the SNR ratio? Why or why not?

Yes, it is close to SNR ratio (6.23/6.22 = 1.00160772 $\approx$ 1.16). Since we add drop rules on 5 ports of each device, the throughput ratio will close to 1 which is also close to the SNR ratio.

Bonus

1. Problem encountered?

The problem that bothering me for a long time is how to delete a flow, since the original simple_switch13 doesn't contain the delete flow function. I follow the spec on the ryu website and still can't delete the flow. Then, I figure out I need to specify the out_port and out_group to any in the OFPFlowMod function, otherwise the default values of these two parameters are 0 which make me can't delete the flows.

2. Any advises?

The spec should specify which SNR to use in measurement (there are signal power and average signal power in the result of iw dev). I end up with using signal power instead of average signal power in the measurement of SNR. Since I think we will measure SNR every 20 seconds, the more unsteady signal power may be a better choice.