

گزارش کار پروژه اول شبکه های کامپیوتری

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۱) مفهوم Network Namespace در لینوکس

ابتدا دستور ifconfig را در ترمینال لینوکس اجرا میکنیم. نتیجه به صورت زیر خواهد بود:

```
sadaf@ssadaf-ux310uq:~$ date
Thu Feb 28 20:56:08 +0330 2019

sadaf@ssadaf-ux310uq:~$ ifconfig
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 191 bytes 14428 (14.4 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 191 bytes 14428 (14.4 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlp2s0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 172.30.48.134 netmask 255.255.254.0 broadcast 172.30.49.255
    inet6 fe80::a552:c2ce:8201:7c43 prefixlen 64 scopeid 0x20<link>
    ether a4:02:b9:45:ff:a6 txqueuelen 1000 (Ethernet)
    RX packets 581 bytes 463836 (463.8 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 396 bytes 55193 (55.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

با توجه به شکل بالا، دو واسط `enp0s5` و `localhost` به ترتیب با آدرسهای `10.211.55.4` و `127.0.0.1` وجود دارند. حال با توجه به صورت پروژه دوکابل شبکه مجازی ساخته که دو سرکابل اول `s1-eth1` و `s1-eth0` نام داشته و دو سرکابل دوم `s1-eth2` و `s2-eth0` نام دارند. سپس یکی از سرهای واسط را به `namespace` متناظر و سر دیگر را به `switch` ساخته شده متصل میکنیم. در نهایت دوباره دستور `ifconfig` را اجرا کرده و نتایج زیر دیده میشود:

```
yasaman@ubuntu:~$ sudo ip link set s1-eth2 up
yasaman@ubuntu:~$ ifconfig
enp0s5: Link encap:Ethernet HWaddr 00:1c:42:a6:6f:99
    inet addr:10.211.55.4 Bcast:10.211.55.255 Mask:255.255.255.0
    inet6 addr: fdb2:2c26:f4e4:0:b04d:d5e8:1e90:8b32/64 Scope:Global
    inet6 addr: fe80::67aa:3ea4:4932:46a5/64 Scope:Link
    inet6 addr: fdb2:2c26:f4e4:0:6c1b:1bda:99fb:1401/64 Scope:Global
    UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
    RX packets:163386 errors:0 dropped:0 overruns:0 frame:0
    TX packets:94849 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:217265942 (217.2 MB) TX bytes:5210141 (5.2 MB)

lo: Link encap:Local Loopback
    inet addr:127.0.0.1 Mask:255.0.0.0
    inet6 addr: ::1/128 Scope:Host
    UP LOOPBACK RUNNING MTU:65536 Metric:1
    RX packets:656 errors:0 dropped:0 overruns:0 frame:0
    TX packets:656 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1
    RX bytes:54958 (54.9 KB) TX bytes:54958 (54.9 KB)

s1-eth1: Link encap:Ethernet HWaddr 9a:c8:7c:06:ea:a8
    UP BROADCAST MULTICAST MTU:1500 Metric:1
    RX packets:0 errors:0 dropped:0 overruns:0 frame:0
    TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)

s1-eth2: Link encap:Ethernet HWaddr 5a:0d:29:cf:ad:ae
    UP BROADCAST MULTICAST MTU:1500 Metric:1
    RX packets:0 errors:0 dropped:0 overruns:0 frame:0
    TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
    collisions:0 txqueuelen:1000
    RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)

yasaman@ubuntu:~$
```

سوالات

۱. به وسیله دستور `ip netns exec <namespace_name> <command>` که مثلاً برای اجرا دستور در `ip netns exec h1 <command>` به نام `h1` دستور زیر را وارد می‌کنیم:

۲. زیرا این `ip address`، بالا نیست و نمی‌توانیم به آن وصل شویم، برای حل این مشکل باید این `ip` را به یک `interface` اختصاص دهیم و سپس آن `interface` را بالا بیاوریم.

```
yasaman@ubuntu:~$ sudo ip netns exec h1 ifconfig h1-eth0 10.0.0.2 up
[sudo] password for yasaman:
yasaman@ubuntu:~$ sudo ip netns exec h1 ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
```

۳. برای اختصاص دادن یک آدرس IP به یک `interface` متعلق به `host`، از دستور زیر استفاده می‌کنیم:

```
ip netns exec <namespace_name> ifconfig <interface_name> <ip_address> up
```

۴. `Interface` ای برای وصل کردن `network namespace` به دنیای بیرونی از طریق `global namespace` یا `default namespace`، جایی که `physical interface` ها وجود دارند. در واقع یک پیاده‌سازی مجازی از `Ethernet` است که ارتباط بین `logical partition` ها و `virtual machine` ها، بدون نیاز به سخت‌افزار فیزیکی را ممکن می‌کند.

۵. برای ساخت یک `virtual ethernet` از دستور زیر استفاده می‌کنیم:

```
ip link add <virtual_ethernet_name> type veth peer name <peer_virtual_ethernet_name>
```

۶. با دستور `ip link set <virtual_ethernet_name> netns <namespace_name>`

۷. لیست تمام `interface` ها و `ip` آدرس‌های مرتبط با `namespace_name` داده شده در دستور، نشان داده می‌شود. (بقیه `interface` ها یا آدرس‌های موجود در `global namespace` نشان داده نمی‌شوند.)

(۲) نوشتن یک شبیه‌ساز

فایل `bash` این بخش بارگذاری شده است.

```
sadaf@ubuntu:~$ date
Thu Feb 28 06:14:29 PST 2019
sadaf@ubuntu: ~/Documents/CN
sadaf@ubuntu:~/Documents/CN$ ./part2.sh
PING 10.0.0.3 (10.0.0.3) 56(84) bytes of data.
64 bytes from 10.0.0.3: icmp_seq=1 ttl=64 time=0.370 ms
64 bytes from 10.0.0.3: icmp_seq=2 ttl=64 time=0.067 ms
64 bytes from 10.0.0.3: icmp_seq=3 ttl=64 time=0.076 ms
64 bytes from 10.0.0.3: icmp_seq=4 ttl=64 time=0.072 ms
64 bytes from 10.0.0.3: icmp_seq=5 ttl=64 time=0.145 ms
64 bytes from 10.0.0.3: icmp_seq=6 ttl=64 time=0.085 ms
64 bytes from 10.0.0.3: icmp_seq=7 ttl=64 time=0.075 ms
64 bytes from 10.0.0.3: icmp_seq=8 ttl=64 time=0.099 ms
64 bytes from 10.0.0.3: icmp_seq=9 ttl=64 time=0.077 ms
64 bytes from 10.0.0.3: icmp_seq=10 ttl=64 time=0.094 ms
64 bytes from 10.0.0.3: icmp_seq=11 ttl=64 time=0.086 ms
64 bytes from 10.0.0.3: icmp_seq=12 ttl=64 time=0.068 ms
64 bytes from 10.0.0.3: icmp_seq=13 ttl=64 time=0.077 ms
64 bytes from 10.0.0.3: icmp_seq=14 ttl=64 time=0.078 ms
^C
--- 10.0.0.3 ping statistics ---
14 packets transmitted, 14 received, 0% packet loss, time 12996ms
rtt min/avg/max/mdev = 0.067/0.104/0.370/0.077 ms
sadaf@ubuntu:~/Documents/CN$
```

۳) استفاده از Mininet

پس از ساخت topology و اجرای دستورات nodes و net خواهیم داشت:

```
yasaman ~ -- bash -- 88x55
Last login: Tue Feb 26 14:13:48 on ttys001
daYasamans-MacBook-Pro:~ yasaman$ date
Tue Feb 26 14:24:10 +0330 2019
Yasamans-MacBook-Pro:~ yasaman$

...: ~ -- ssh -X mininet@192.168.56.101 ~/Desktop/CA1_Network -- bash
Yasamans-MacBook-Pro:~ yasaman$ ssh -X mininet@192.168.56.101
ssh: connect to host 192.168.56.101 port 22: Operation timed out
Yasamans-MacBook-Pro:~ yasaman$ ssh -X mininet@192.168.56.101
mininet@192.168.56.101's password:
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 4.2.0-27-generic x86_64)

 * Documentation:  https://help.ubuntu.com/
New release '16.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Mon Feb 25 09:12:54 2019 from 192.168.56.1
mininet@mininet-vm:~$ sudo mn --custom Q3.py --topo mytopo --link tc
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4
*** Adding switches:
s1 s2
*** Adding links:
(h1, s1) (h2, s1) (h3, s2) (h4, s2) (50ms delay) (50ms delay) (s1, s2)
*** Configuring hosts
h1 h2 h3 h4
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ... (50ms delay) (50ms delay)
*** Starting CLI:
mininet> nodes
available nodes are:
c0 h1 h2 h3 h4 s1 s2
mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
h3 h3-eth0:s2-eth1
h4 h4-eth0:s2-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0 s1-eth3:s2-eth3
s2 lo: s2-eth1:h3-eth0 s2-eth2:h4-eth0 s2-eth3:s1-eth3
c0
mininet>
```

پس از اضافه کردن تاخیرها در کد داریم:

```
yasaman ~ -- bash -- 88x55
Yasamans-MacBook-Pro:~ yasaman$ date
Tue Feb 26 14:31:08 +0330 2019
Yasamans-MacBook-Pro:~ yasaman$

...: ~ -- ssh -X mininet@192.168.56.101 ~/Desktop/CA1_Network -- bash
mininet@mininet-vm:~$ sudo mn --custom Q3.py --topo mytopo --link tc
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4
*** Adding switches:
s1 s2
*** Adding links:
(20ms delay) (20ms delay) (h1, s1) (20ms delay) (20ms delay) (h2, s1) (15ms delay) (15
ms delay) (h3, s2) (1ms delay) (1ms delay) (h4, s2) (50ms delay) (50ms delay) (s1, s2)

*** Configuring hosts
h1 h2 h3 h4
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ... (20ms delay) (20ms delay) (50ms delay) (15ms delay) (1ms delay) (50ms delay)
*** Starting CLI:
mininet> nodes
available nodes are:
c0 h1 h2 h3 h4 s1 s2
mininet> net
h1 h1-eth0:s1-eth1
h2 h2-eth0:s1-eth2
h3 h3-eth0:s2-eth1
h4 h4-eth0:s2-eth2
s1 lo: s1-eth1:h1-eth0 s1-eth2:h2-eth0 s1-eth3:s2-eth3
s2 lo: s2-eth1:h3-eth0 s2-eth2:h4-eth0 s2-eth3:s1-eth3
c0
mininet>
```

سوالات

۱. دستور (pingall)، اتصالات را با تلاش برای ping کردن همه نودها به یکدیگر تست می‌کند.

```

yasaman --- -bash --- 88x55
~ --- -bash
Yasamans-MacBook-Pro:~ yasaman$ date
Tue Feb 26 14:39:10 +0330 2019
Yasamans-MacBook-Pro:~ yasaman$

...: ~ --- ssh -X mininet@192.168.56.101 --- ssh -X mininet@192.168.56.101...
~/Desktop/CA1_Network --- -bash
mininet@mininet-vm:~$ sudo mn --custom Q3.py --topo mytopo --link tc
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4
*** Adding switches:
s1 s2
*** Adding links:
(20ms delay) (20ms delay) (h1, s1) (20ms delay) (20ms delay) (h2, s1) (15ms delay) (15
ms delay) (h3, s2) (1ms delay) (1ms delay) (h4, s2) (50ms delay) (50ms delay) (s1, s2)
*** Configuring hosts
h1 h2 h3 h4
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ... (20ms delay) (20ms delay) (50ms delay) (15ms delay) (1ms delay) (50ms delay)
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4
h2 -> h1 h3 h4
h3 -> h1 h2 h4
h4 -> h1 h2 h3
*** Results: 0% dropped (12/12 received)
mininet>

```

۲. نتیجه به صورت زیر است:

```

yasaman --- -bash --- 88x55
~ --- -bash
Yasamans-MacBook-Pro:~ yasaman$ date
Tue Feb 26 14:43:01 +0330 2019
Yasamans-MacBook-Pro:~ yasaman$

"Node: h1"
root@mininet-vm:~$ ifconfig
h1-eth0  Link encap:Ethernet  HWaddr ee:b1:75:b9:a4
          inet addr:10.0.0.1  Bcast:10.255.255.255  Mask:255.0.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:15  errors:0  dropped:0  overruns:0  frame:0
          TX packets:12  errors:0  dropped:0  overruns:0  carrier:0
          collisions:0  txqueuelen:1000
          RX bytes:966 (966.0 B)  TX bytes:840 (840.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:836  errors:0  dropped:0  overruns:0  frame:0
          TX packets:836  errors:0  dropped:0  overruns:0  carrier:0
          collisions:0  txqueuelen:0
          RX bytes:3305828 (3.3 MB)  TX bytes:3305828 (3.3 MB)

root@mininet-vm:~$

"Node: h3"
root@mininet-vm:~$ ifconfig
h3-eth0  Link encap:Ethernet  HWaddr 76:31:2b:34:19:8b
          inet addr:10.0.0.3  Bcast:10.255.255.255  Mask:255.0.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:15  errors:0  dropped:0  overruns:0  frame:0
          TX packets:12  errors:0  dropped:0  overruns:0  carrier:0
          collisions:0  txqueuelen:1000
          RX bytes:966 (966.0 B)  TX bytes:840 (840.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:1049  errors:0  dropped:0  overruns:0  frame:0
          TX packets:1049  errors:0  dropped:0  overruns:0  carrier:0
          collisions:0  txqueuelen:0
          RX bytes:3326516 (3.3 MB)  TX bytes:3326516 (3.3 MB)

root@mininet-vm:~$

```

۴) بررسی عوامل تاثیرگذار بر ترافیک شبکه

Delay = 20

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	3a:bd:4d:55:0a:f2	Broadcast	ARP	42	Who has 10.0.0.2? Tell 10.0.0.1
2	0.107087000	b2:9d:a8:ac:f1:aa	3a:bd:4d:55:0a:f2	ARP	42	10.0.0.2 is at b2:9d:a8:ac:f1:aa
3	0.127141000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0dc5, seq=1/256, ttl=64 (reply in 4)
4	0.231464000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0dc5, seq=1/256, ttl=64 (request in 3)
5	1.001914000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0dc5, seq=2/512, ttl=64 (reply in 6)
6	1.105555000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0dc5, seq=2/512, ttl=64 (request in 5)
7	2.003715000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0dc5, seq=3/768, ttl=64
8	2.106025000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0dc5, seq=3/768, ttl=64 (request in 7)


```

mininet> h1 ping h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=252 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=124 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=123 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=123 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=122 ms
^C
--- 10.0.0.2 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6010ms
rtt min/avg/max/ndev = 122.594/141.519/252.354/45.252 ms
mininet>

```

Delay = 90

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	52:e3:4a:6c:86:2c	Broadcast	ARP	42	Who has 10.0.0.2? Tell 10.0.0.1
2	0.459714000	ce:1a:f4:b0:c0:93	52:e3:4a:6c:86:2c	ARP	42	10.0.0.2 is at ce:1a:f4:b0:c0:93
3	0.550419000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0fc0, seq=1/256, ttl=64
4	1.007252000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0fc0, seq=2/512, ttl=64
5	1.007707000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0fc0, seq=1/256, ttl=64 (request in 3)
6	1.461045000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0fc0, seq=2/512, ttl=64 (request in 4)
7	2.014869000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x0fc0, seq=3/768, ttl=64
8	2.466852000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x0fc0, seq=3/768, ttl=64 (request in 7)


```

mininet> s1 s2 ... (90ms delay) (90ms delay) (90ms delay)
*** Starting CLI:
mininet> xterm h1
mininet> h1 ping h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1098 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=544 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=542 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=542 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 4 received, 20% packet loss, time 4015ms
rtt min/avg/max/ndev = 542.021/681.849/1098.651/240.643 ms, pipe 2
mininet>

```

همان طور که مشاهده می شود با اضافه شدن تاخیر ارتباطات زمان ping شدن زیاد شده است و از حدود ۱۲۲ms به حدود ۵۴۴ms رسیده است.

تعداد packet های ارسال شده قبل از اولین پاسخ همان یکی باقی مانده است.

Bandwidth = 1

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	6a:60:b6:c4:43:19	Broadcast	ARP	42	who has 10.0.0.2? Tell 10.0.0.1
2	0.001547000	be:0b:97:1b:8b:fc	6a:60:b6:c4:43:19	ARP	42	10.0.0.2 is at be:0b:97:1b:8b:fc
3	0.001552000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=1/256, ttl=64 (reply in 4)
4	0.002711000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=1/256, ttl=64 (request in 3)
5	1.002341000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=2/512, ttl=64 (reply in 6)
6	1.002870000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=2/512, ttl=64 (request in 5)
7	2.001342000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=3/768, ttl=64 (reply in 8)
8	2.001375000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=3/768, ttl=64 (request in 7)
9	3.002995000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=4/1024, ttl=64 (reply in 10)
10	3.003052000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=4/1024, ttl=64 (request in 9)
11	4.001984000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=5/1280, ttl=64 (reply in 12)
12	4.002012000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=5/1280, ttl=64 (request in 11)
13	5.000981000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1f64, seq=6/1536, ttl=64 (reply in 14)
14	5.001010000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1f64, seq=6/1536, ttl=64 (request in 13)

0000	ff	ff	ff	ff	ff	ff	6a	60	b6	c4	43	19	08	06	00	01C....
nnnn	08	06	00	01	00	01	6a	60	b6	c4	43	19	0a	00	00	01C....

Bandwidth = 15

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=1/256, ttl=64 (reply in 2)
2	0.001984000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=1/256, ttl=64 (request in 1)
3	1.000789000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=2/512, ttl=64 (reply in 4)
4	1.003445000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=2/512, ttl=64 (request in 3)
5	2.001550000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=3/768, ttl=64 (reply in 6)
6	2.002069000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=3/768, ttl=64 (request in 5)
7	3.003903000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=4/1024, ttl=64 (reply in 8)
8	3.003948000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=4/1024, ttl=64 (request in 7)
9	4.002913000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=5/1280, ttl=64 (reply in 10)
10	4.003261000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=5/1280, ttl=64 (request in 9)
11	5.004905000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1d8a, seq=6/1536, ttl=64 (reply in 12)
12	5.004943000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1d8a, seq=6/1536, ttl=64 (request in 11)
13	5.012153000	32:a7:2d:3f:46:97	32:a7:2d:3f:46:97	ICMP	98	Echo (ping) request id=0x1d8a, seq=6/1536, ttl=64 (reply in 11)
14	5.012160000	32:a7:2d:3f:46:97	32:a7:2d:3f:46:97	ICMP	98	Echo (ping) reply id=0x1d8a, seq=6/1536, ttl=64 (request in 13)

0000	ff	ff	ff	ff	ff	ff	32	a7	2d	3f	46	97	08	06	00	01C....
nnnn	08	06	00	01	00	01	32	a7	2d	3f	46	97	0a	00	00	01C....

همان طور که مشاهده می‌شود با اضافه شدن bandwidth ارتباطات زمان ping شدن زیاد شده‌است و از حدود ۰/۶ms به حدود ۰/۹ms رسیده‌است.

تعداد packet های ارسال شده قبل از اولین پاسخ همان یکی باقی‌مانده‌است.

Switch queue = 1

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	6e:6f:b6:39:98:d9	Broadcast	ARP	42	who has 10.0.0.2? Tell 10.0.0.1
2	0.001416000	96:40:5a:a2:68:4e	6e:6f:b6:39:98:d9	ARP	42	10.0.0.2 is at 96:40:5a:a2:68:4e
3	0.001420000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1979, seq=1/256, ttl=64 (reply in 4)
4	0.002766000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1979, seq=1/256, ttl=64 (request in 3)
5	1.002744000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1979, seq=2/512, ttl=64 (reply in 6)
6	1.002744000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1979, seq=2/512, ttl=64 (request in 5)
7	2.004556000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1979, seq=3/768, ttl=64 (reply in 8)
8	2.004582000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1979, seq=3/768, ttl=64 (request in 7)

CA1_Network — mininet@mininet-vm: ~ — ssh -X mininet@192.168.56.101	mininet@mininet-vm: ~ — ssh -X mininet@192.168.56.101
~/Desktop/CA1_Network — -bash	~/Desktop/CA1_Network — -bash
*** Starting 2 switches	mininet@mininet-vm:~\$ date
s1 s2 ...O O O O	Tue Feb 26 03:58:14 PST 2019
*** Starting CLI:	mininet@mininet-vm:~\$
mininet> xterm h1	
mininet> h1 ping h2	
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:	
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=2.78 ms	
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.687 ms	
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.044 ms	
AC	

10.0.0.2 ping statistics ---	
3 packets transmitted, 3 received, 0% packet loss, time 2004ms	
rtt min/avg/max/ndev = 0.044/1.170/2.780/1.168 ms	
mininet> #	

Switch queue = 15

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	96:48:02:e6:e6:5b	Broadcast	ARP	42	who has 10.0.0.2? Tell 10.0.0.1
2	0.001427000	e6:28:4c:23:fd:22	96:48:02:e6:e6:5b	ARP	42	10.0.0.2 is at e6:28:4c:23:fd:22
3	0.001431000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1c3a, seq=1/256, ttl=64 (reply in 4)
4	0.002728000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1c3a, seq=1/256, ttl=64 (request in 3)
5	1.002310000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1c3a, seq=2/512, ttl=64 (reply in 6)
6	1.002863000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1c3a, seq=2/512, ttl=64 (request in 5)
7	2.001314000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1c3a, seq=3/768, ttl=64 (reply in 8)
8	2.001353000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1c3a, seq=3/768, ttl=64 (request in 7)

CA1_Network — mininet@mininet-vm: ~ — ssh -X mininet@192.168.56.101	mininet@mininet-vm: ~ — ssh -X mininet@192.168.56.101
~/Desktop/CA1_Network — -bash	~/Desktop/CA1_Network — -bash
*** Starting 2 switches	mininet@mininet-vm:~\$ date
s1 s2 ...O O O O	Tue Feb 26 03:52:05 PST 2019
*** Starting CLI:	mininet@mininet-vm:~\$
mininet> xterm h1	
mininet> h1 ping h2	
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:	
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=2.74 ms	
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.572 ms	
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.061 ms	
AC	

10.0.0.2 ping statistics ---	
3 packets transmitted, 3 received, 0% packet loss, time 2001ms	
rtt min/avg/max/ndev = 0.061/1.125/2.742/1.162 ms	
mininet> #	

همان طور که مشاهده می‌شود با اضافه شدن switch queue زمان ping شدن ارتباطات خاصه نکرده‌است اما کمی کم شده‌است و از حدود ۰/۶۴ms به حدود ۰/۶۲ms رسیده‌است.

تعداد packet های ارسال شده قبل از اولین پاسخ همان یکی باقی‌مانده‌است.

تعداد switch ها = ۲

No.	Time	Source	Destination	Protocol	Length	Info
8	5.015917000	46:66:7c:5b:03:89	72:df:92:48:0e:ab	ARP	42	10.0.0.1 is at 46:66:7c:5b:03:89
9	18.66942000X	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x2530, seq=1/256, ttl=64 (reply in 10)
10	18.67079600X	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x2530, seq=1/256, ttl=64 (request in 9)
11	19.67102300X	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x2530, seq=2/512, ttl=64 (reply in 12)
12	19.67105800X	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x2530, seq=2/512, ttl=64 (request in 11)
13	20.67028100X	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x2530, seq=3/768, ttl=64 (reply in 14)
14	20.67030900X	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x2530, seq=3/768, ttl=64 (request in 13)
15	21.67028100X	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x2530, seq=4/1024, ttl=64 (reply in 16)

<pre> > Frame 1: 42 bytes on wire (336 bits) captured on interface eth0 > Ethernet II, Src: 46:66:7c:5b:03:89, Dst: 72:df:92:48:0e:ab > Address Resolution Protocol 2 packets transmitted, 2 received, 0% packet loss, time 1000ms rtt min/avg/max/ndev = 0.907/2.292/3.678/1.366 ms mininet> h1 ping h2 PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data. 64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=1.39 ms 64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.869 ms 64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.948 ms 64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.065 ms 64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=0.049 ms ^C --- 10.0.0.2 ping statistics --- 5 packets transmitted, 5 received, 0% packet loss, time 4000ms rtt min/avg/max/ndev = 0.048/0.323/1.395/0.536 ms mininet> </pre>	<pre> mininet@mininet-vm:~\$ date Tue Feb 26 04:31:26 PST 2019 mininet@mininet-vm:~\$ </pre>
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تعداد switch ها = ۷

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	ae:c7:b6:ea:0c:e3	Broadcast	ARP	42	Who has 10.0.0.1? Tell 10.0.0.1
2	0.008051000	b2:07:67:f6:f4:44	ae:c7:b6:ea:0c:e3	ARP	42	10.0.0.2 is at b2:07:67:f6:f4:44
3	0.008057000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1ff3, seq=1/256, ttl=64 (reply in 4)
4	0.014022000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1ff3, seq=1/256, ttl=64 (request in 3)
5	1.000855000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1ff3, seq=2/512, ttl=64 (reply in 6)
6	1.001806000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1ff3, seq=2/512, ttl=64 (request in 5)
7	2.002330000	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x1ff3, seq=3/768, ttl=64 (reply in 8)
8	2.002389000	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x1ff3, seq=3/768, ttl=64 (request in 7)

<pre> > Frame 1: 42 bytes on wire (336 bits) captured on interface eth0 > Ethernet II, Src: ae:c7:b6:ea:0c:e3, Dst: ff:ff:ff:ff:ff:ff > Address Resolution Protocol s1 s2 s3 s4 s5 s6 s7 ... *** Starting CL1: mininet> xterm h1 mininet> h1 ping h2 PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data. 64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=14.0 ms 64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=0.977 ms 64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=0.985 ms 64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=0.183 ms ^C --- 10.0.0.2 ping statistics --- 4 packets transmitted, 4 received, 0% packet loss, time 3000ms rtt min/avg/max/ndev = 0.085/3.880/14.036/5.920 ms mininet> </pre>	<pre> mininet@mininet-vm:~\$ date Tue Feb 26 03:57:31 PST 2019 mininet@mininet-vm:~\$ </pre>
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همان طور که مشاهده می شود با اضافه شدن تعداد switch ها ارتباطات زمان ping شدن به مقدار زیادی افزایش پیدا کرده است و از حدود ۰/۳۲۳ ms به ۳/۸ms رسیده است.

تعداد packet های ارسال شده قبل از اولین پاسخ همان یکی باقی مانده است.