ECE358: Computer Networks

Winter 2018

Project 3: Encapsulation and Network Utilities

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# Question 1: Protocol Header Analysis

## Frame 4:

0017 a486 2900 74d0 2b26 ff76 0800 4500

003c 366d 4000 4006 6a19 8161 380f 8368

5d5d b06e 0050 2244 81dc 0000 0000 a002

16d0 1d0b 0000 0204 05b4 0402 080a 6d5e

b7b1 0000 0000 0103 0307

Ethernet header:

00 17 a4 86 29 00: Ethernet destination address is 00 17 a4 86 29 00(unicast)

74 d0 2b 26 ff 76: Ethernet source address: 74 d0 2b 26 ff 76(unicast)

08 00: The payload type is IP(0x0800)

IP header:

45: This is an IP version 4 datagram,

45: The header length is 5\*4 = 20 bytes.

00

(0 0 0 0 0 0 0 0 in binary): This datagram has routine precedence (the lowest). The IP Precedence filed is used by some routers to determine which datagram to drop, therefore datagram with the lowest precedence will be dropped first.

(0 0 0 0 0 0 0 0 in binary): the 3 type of service (ToS) bits

0 0 0 *Normal delay*

0 0 0 *Normal throughput*

0 0 0 *Normal Reliability*

(0 0 0 0 0 0 0 0 in binary): The last two bits must be zero (for future use).

00 3c: Total length of the IP datagram is 3\*16+12 = 60 (0x003c) bytes.

36 6d: The identification of this datagram is 0x366d (for fragmentation purpose).

40 00: (0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0):

1 Don’t Fragment flag set

0 More Fragment flag unset

The fragment offset is 0.

This means that the datagram cannot be fragmented, and there are no fragments after this datagram. With a fragment offset equals to zero, we know that this is the only fragment of a datagram.

40: Time to live 64 = (0x40), meaning the datagram may exist for at most 64 more hops.

06: The protocol on top is TCP (0x06).

6a 19: This is the checksum of the datagram.

81 61 38 0f: Source IP address is 129.97.56.15

83 68 5d 5d: Destination IP address is 131.104.93.93

TCP header:

b0 6e: The Source port is 45166, which is an arbitrarily port number assigned by the operating system.

00 50: The Destination port is 80, which is the well-known port for HTTP

22 44 81 dc: The Seq. no .is 574915036

00 00 00 00: The Ack no. is 0

a0: Data offset is 40 (a\*4) bytes. (The number of 32 bit words in the TCP Header. This indicates where the data begins.)

There are 6 bits reserved for future uses. Must be zero.

02 (0 0 0 0 0 0 1 0): Control Bits: 6 bits

URG 0, ACK 0, PSH 0, RST 0, SYN 1, FIN 0

Only synchronize sequence numbers are set to 1.

16 d0: the receiver window size is 5840 (0x16d0) bytes

1d 0b: Checksum of the whole TCP segment.

00 00: Urgent pointer

Data:

0204 05b4 0402 080a 6d5e

b7b1 0000 0000 0103 0307

## Frame 14:

0017 a486 2900 14da e974 0821 0800 4500

0054 0000 4000 4001 209f 8161 380b 8e96

d207 0800 a34e db36 0001 0a77 8b52 0000

0000 23dd 0100 0000 0000 1011 1213 1415

1617 1819 1a1b 1c1d 1e1f 2021 2223 2425

2627 2829 2a2b 2c2d 2e2f 3031 3233 3435

Ethernet header:

00 17 a4 86 29 00: Ethernet destination address is 00 17 a4 86 29 00(unicast)

14 da e9 74 08 21: Ethernet source address: 14 da e9 74 08 21(unicast)

08 00: The payload type is IP(0x0800)

IP header:

45: This is an IP version 4 datagram,

45: The header length is 5\*4 = 20 bytes.

00

(0 0 0 0 0 0 0 0 in binary): This datagram has routine precedence (the lowest). The IP Precedence filed is used by some routers to determine which datagram to drop, therefore datagram with the lowest precedence will be dropped first.

(0 0 0 0 0 0 0 0 in binary): the 3 type of service (ToS) bits

0 0 0 *Normal delay*

0 0 0 *Normal throughput*

0 0 0 *Normal Reliability*

(0 0 0 0 0 0 0 0 in binary): The last two bits must be zero (for future use).

00 54: Total length of the IP datagram is 5\*16+4 = 84 (0x0054) bytes.

00 00: The identification of this datagram is 0x0000 (for fragmentation purpose).

40 00: (0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0):

1 Don’t Fragment flag set

0 More Fragment flag unset

The fragment offset is 0.

This means that the datagram cannot be fragmented, and there are no fragments after this datagram. With a fragment offset equals to zero, we know that this is the only fragment of a datagram.

40: Time to live 64 = (0x40), meaning the datagram may exist for at most 64 more hops.

01: The protocol on top is ICMP (0x01).

20 9f: This is the checksum of the datagram.

81 61 38 0b: Source IP address is 129.97.56.11

8e 96 d2 07: Destination IP address is 142.150.210.7

ICMP header:

08: The type of this ICMP is Echo Request.

00: The subtype of this ICMP is Echo Reply.

a3 4e: Error checking data , calculated from the ICMP header and data.

db 36 00 01:

db 36 00 01: Echo Request Identifier.

db 36 00 01:Echo Request sequence number.

Data:

0a77 8b52 0000

0000 23dd 0100 0000 0000 1011 1213 1415

1617 1819 1a1b 1c1d 1e1f 2021 2223 2425

2627 2829 2a2b 2c2d 2e2f 3031 3233 3435

# Network Utilities

## Q2 ARP:

a) The arp utility helps diagnose problems associated with the Address Resolution Protocol (ARP). TCP/IP hosts use arp to determine the physical (MAC) address that corresponds with a specific IP address.

b) -bash-4.2$ /sbin/arp -a

ecelinux2.uwaterloo.ca (129.97.56.12) at 30:5a:3a:83:92:bf [ether] on enp0s31f6

ecewo.uwaterloo.ca (129.97.56.45) at ac:1f:6b:12:d2:2b [ether] on enp0s31f6

exsw02-circuitnet.uwaterloo.ca (129.97.56.1) at 00:24:a8:46:0c:00 [ether] on enp0s31f6

ecemail.uwaterloo.ca (129.97.56.26) at 30:5a:3a:7d:aa:6d [ether] on enp0s31f6

iqol.uwaterloo.ca (129.97.56.100) at 52:54:00:a6:1d:e3 [ether] on enp0s31f6

eceserv1.uwaterloo.ca (129.97.56.9) at 00:25:90:5d:b6:47 [ether] on enp0s31f6

ecetesla0.uwaterloo.ca (129.97.56.23) at 00:25:90:5e:d0:9c [ether] on enp0s31f6

ecesystem.uwaterloo.ca (129.97.56.7) at 52:54:00:0c:98:ec [ether] on enp0s31f6

ecelinux3.uwaterloo.ca (129.97.56.13) at c8:60:00:c9:51:37 [ether] on enp0s31f6

ecesvn.uwaterloo.ca (129.97.56.27) at c8:60:00:c8:77:8c [ether] on enp0s31f6

ecelinux4.uwaterloo.ca (129.97.56.14) at 60:a4:4c:53:e4:b1 [ether] on enp0s31f6

Explanation:

From the ARP ‘s –a option, we were able to display IP addresses that have been resolved to MAC address recently. We see that the machine connected is ecelinux, and it has 11 neighbors that uses IPv4 protocol. In order to identify each information, we have highlighted the results accordingly, Hostname/address of the neighbor ,IP address, MAC address, hardware type, interface name

## Q3 ifconfig

a) The Ifconfig utility is used to assign an address to a network interface and/or configure network interface parametres. It is used at boot time to set up interfaces as necessary.

b)-bash-4.2$ /sbin/ifconfig -a

enp3s0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500

inet 129.97.56.13 netmask 255.255.255.0 broadcast 129.97.56.255

inet6 fe80::ca60:ff:fec9:5137 prefixlen 64 scopeid 0x20<link>

ether c8:60:00:c9:51:37 txqueuelen 1000 (Ethernet)

RX packets 436797030 bytes 152544096567 (142.0 GiB)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 473827435 bytes 466116219746 (434.1 GiB)

TX errors 0 dropped 448 overruns 0 carrier 0 collisions 0

device interrupt 28 base 0xc000

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 1 (Local Loopback)

RX packets 251965235 bytes 1265139462000 (1.1 TiB)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 251965235 bytes 1265139462000 (1.1 TiB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

virbr0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500

inet 192.168.122.1 netmask 255.255.255.0 broadcast 192.168.122.255

ether 52:54:00:6f:cd:ad txqueuelen 1000 (Ethernet)

RX packets 0 bytes 0 (0.0 B)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 0 bytes 0 (0.0 B)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

virbr0-nic: flags=4098<BROADCAST,MULTICAST> mtu 1500

ether 52:54:00:6f:cd:ad txqueuelen 1000 (Ethernet)

RX packets 0 bytes 0 (0.0 B)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 0 bytes 0 (0.0 B)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

Explanation:

After connecting to the machine ecelinux using ssh and using ifconfig –a , we found it has 4 network interfaces as listed above. For each of the network interfaces, there is a flag filed that identifies the flags being set for the interfaces. For example, the UP flag means that the interface is activated and accessible, the BROADCAST flag means that it supports broadcasting and assign IP address through DHCP, the RUNNING flag means that the network driver has been loaded and has initialized the interface, the MULTICAST flag indicates that multicasting is supported by this interface, the LOOPBACK refers to the routing of electronic signal, digital data streams, or flows of item back to their source without intentional processing or modification. Other than the flag field, there is also the mtu = 1500 field, which sets the Maximum Transfer Unit (MTU) of an interface. The *inet 129.97.56.13* is the machine’s IPv4 address. The *netmask 255.255.255.0* is the network mask which was passed using the netmask option. The *broadcast 129.97.56.255* denotes the broadcast address. The *inet6 fe80::ca60:ff:fec9:5137 prefixlen 64* is the IPv6 address of the machine. The *scopeid 0x20<link>* is the scope of the IPv6 address. It is a link local address and is not routable. The *ether c8:60:00:c9:51:37* ismac address of the machine. The *txqueuelen 1000 (Ethernet)* is the transmit queue length of the network card which is 1000.

**RX packets 436797030 bytes 152544096567 (142.0 GiB):** Total number of packets received is 436797030. The total size received 152544096567 bytes or 142.0 GiB.

**RX errors 0 dropped 0 overruns 0 frame 0**: No packets received in error, no dropped packets, no overrun packets, and no frame.

**TX packets 473827435 bytes 466116219746 (434.1 GiB):** Total number of transmitted packets is473827435. The total size of the transmitted packets is 466116219746 bytes or approximately 434.1 GiB.

**TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0**: No packets transmission so far has resulted in error, dropped packet, overrun packet, carrier, or collision (indicating no congestion) since last reboot.

## Q4 netstat

a) Netstat, Network statistics, displays network connections (both incoming and outgoing), routing tables, and a number of network interface statistic, prints the information about the Linux networking subsystem. It is an important part of the Network + exam process, and it is a helpful tool in finding problems and determining the amount of traffic on network as a performance measurement.

b)-bash-4.2$ netstat -in

Kernel Interface table

Iface MTU RX-OK RX-ERR RX-DRP RX-OVR TX-OK TX-ERR TX-DRP TX-OVR Flg

enp0s31f 1500 485225300 0 0 0 602076485 0 0 0 BMRU

lo 65536 142306717 0 0 0 142306717 0 0 0 LRU

virbr0 1500 0 0 0 0 0 0 0 0 BMU

with the –in parameter contributes to displaying network interface and their statistics.

-bash-4.2$ netstat -s

Ip:

398188069 total packets received

0 forwarded

21 with unknown protocol

0 incoming packets discarded

397673709 incoming packets delivered

377324978 requests sent out

48 dropped because of missing route

4 reassemblies required

2 packets reassembled ok

7 fragments received ok

14 fragments created

Icmp:

142947 ICMP messages received

785 input ICMP message failed.

ICMP input histogram:

destination unreachable: 2112

timeout in transit: 2547

echo requests: 137142

echo replies: 1113

timestamp request: 12

address mask request: 21

140024 ICMP messages sent

0 ICMP messages failed

ICMP output histogram:

destination unreachable: 1699

echo request: 1185

echo replies: 137128

timestamp replies: 12

IcmpMsg:

InType0: 1113

InType3: 2112

InType8: 137142

InType11: 2547

InType13: 12

InType17: 21

OutType0: 137128

OutType3: 1699

OutType8: 1185

OutType14: 12

Tcp:

196985 active connections openings

78484 passive connection openings

1825 failed connection attempts

24874 connection resets received

63 connections established

518939659 segments received

734952748 segments send out

226683 segments retransmited

130 bad segments received.

47433 resets sent

Udp:

5756934 packets received

5696 packets to unknown port received.

0 packet receive errors

6221343 packets sent

0 receive buffer errors

0 send buffer errors

UdpLite:

TcpExt:

5572 invalid SYN cookies received

1099 resets received for embryonic SYN\_RECV sockets

1 packets pruned from receive queue because of socket buffer overrun

90 ICMP packets dropped because they were out-of-window

184241 TCP sockets finished time wait in fast timer

159 packets rejects in established connections because of timestamp

3770428 delayed acks sent

135925 delayed acks further delayed because of locked socket

Quick ack mode was activated 92606 times

5679935 packets directly queued to recvmsg prequeue.

164127037 bytes directly in process context from backlog

1668787489 bytes directly received in process context from prequeue

358286732 packet headers predicted

4973942 packets header predicted and directly queued to user

44044475 acknowledgments not containing data payload received

310661632 predicted acknowledgments

21039 times recovered from packet loss by selective acknowledgements

Detected reordering 31 times using FACK

Detected reordering 131 times using SACK

Detected reordering 299 times using time stamp

211 congestion windows fully recovered without slow start

284 congestion windows partially recovered using Hoe heuristic

3511 congestion windows recovered without slow start by DSACK

6680 congestion windows recovered without slow start after partial ack

TCPLostRetransmit: 3583

4812 timeouts after SACK recovery

168 timeouts in loss state

61055 fast retransmits

3263 forward retransmits

14392 retransmits in slow start

7055 other TCP timeouts

TCPLossProbes: 156095

TCPLossProbeRecovery: 98164

1486 SACK retransmits failed

1366 packets collapsed in receive queue due to low socket buffer

94956 DSACKs sent for old packets

709 DSACKs sent for out of order packets

59429 DSACKs received

840 DSACKs for out of order packets received

3607 connections reset due to unexpected data

9349 connections reset due to early user close

3304 connections aborted due to timeout

TCPSACKDiscard: 1

TCPDSACKIgnoredOld: 136

TCPDSACKIgnoredNoUndo: 31056

TCPSpuriousRTOs: 3645

TCPSackShifted: 119273

TCPSackMerged: 134938

TCPSackShiftFallback: 161197

TCPRetransFail: 10

TCPRcvCoalesce: 12286839

TCPOFOQueue: 434960

TCPOFOMerge: 490

TCPChallengeACK: 157

TCPSYNChallenge: 137

TCPSpuriousRtxHostQueues: 740

TCPAutoCorking: 16468688

TCPFromZeroWindowAdv: 3249

TCPToZeroWindowAdv: 3249

TCPWantZeroWindowAdv: 361533

TCPSynRetrans: 951

TCPOrigDataSent: 649588196

TCPHystartTrainDetect: 3357

TCPHystartTrainCwnd: 195564

TCPHystartDelayDetect: 741

TCPHystartDelayCwnd: 32168

TCPACKSkippedSynRecv: 440

TCPACKSkippedPAWS: 43

TCPACKSkippedSeq: 932

IpExt:

InMcastPkts: 32380

InBcastPkts: 771321

OutBcastPkts: 272127

InOctets: 259784861059

OutOctets: 425183626235

InMcastOctets: 1036160

InBcastOctets: 229775563

OutBcastOctets: 73515984

InNoECTPkts: 489832389

InECT1Pkts: 6956

InECT0Pkts: 6444027

InCEPkts: 815

c)-bash-4.2$ netstat -r

Kernel IP routing table

Destination Gateway Genmask Flags MSS Window irtt Iface

default exsw02-circuitn 0.0.0.0 UG 0 0 0 enp0s31f6

129.97.56.0 0.0.0.0 255.255.255.0 U 0 0 0 enp0s31f6

192.168.122.0 0.0.0.0 255.255.255.0 U 0 0 0 virbr0

## Q5 NSLookup

a) NSLookup provides a command-line utility for diagnosing DNS problems. In its most basic usage, NSLookup returns the IP address with the matching host name.

b) First time ecelinux.uwaterloo.ca:

-bash-4.2$ nslookup ecelinux.uwaterloo.ca

Server: 129.97.2.2

Address: 129.97.2.2#53

Non-authoritative answer:

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.12

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.11

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.13

Name: ecelinux.uwaterloo.ca

### Second time ecelinux.uwaterloo.ca:

Address: 129.97.56.23

-bash-4.2$ nslookup ecelinux.uwaterloo.ca

Server: 129.97.2.2

Address: 129.97.2.2#53

Non-authoritative answer:

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.11

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.13

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.23

Name: ecelinux.uwaterloo.ca

Address: 129.97.56.12

### www.mit.edu:

-bash-4.2$ nslookup www.mit.edu

Server: 129.97.2.2

Address: 129.97.2.2#53

Non-authoritative answer:

www.mit.edu canonical name = www.mit.edu.edgekey.net.

www.mit.edu.edgekey.net canonical name = e9566.dscb.akamaiedge.net.

Name: e9566.dscb.akamaiedge.net

Address: 184.86.32.128

### [www.gmail.com](http://www.gmail.com):

-bash-4.2$ nslookup www.gmail.com

Server: 129.97.2.2

Address: 129.97.2.2#53

Non-authoritative answer:

www.gmail.com canonical name = mail.google.com.

mail.google.com canonical name = googlemail.l.google.com.

Name: googlemail.l.google.com

Address: 172.217.1.165

### [www.facebook.com](http://www.facebook.com):

-bash-4.2$ nslookup www.facebook.com

Server: 129.97.2.2

Address: 129.97.2.2#53

Non-authoritative answer:

www.facebook.com canonical name = star-mini.c10r.facebook.com.

Name: star-mini.c10r.facebook.com

Address: 31.13.80.36

## Q6 Ping

a) The PING utility tests connectivity between two hosts. PING uses a special protocol called Internet Control Message Protocol (ICMP) to determine whether the remote machine (website, server, etc.) can receive the test packet and reply. It also can be used to verify whether you have TCP/IP installed and your network card is working.

b)

### www.ualberta.ca

-bash-4.2$ ping -c10 www.ualberta.ca

PING alb-uofa-prod-itm-sc8cds-1708315660.us-east-1.elb.amazonaws.com (34.233.186.209) 56(84) bytes of data.

--- alb-uofa-prod-itm-sc8cds-1708315660.us-east-1.elb.amazonaws.com ping statistics ---

10 packets transmitted, 0 received, 100% packet loss, time 8999ms

### www.lemonde.fr

-bash-4.2$ ping -c10 www.lemonde.fr

PING cs205.wac.edgecastcdn.net (72.21.91.239) 56(84) bytes of data.

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=1 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=2 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=3 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=4 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=5 ttl=49 time=15.9 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=6 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=7 ttl=49 time=16.0 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=8 ttl=49 time=15.8 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=9 ttl=49 time=15.7 ms

64 bytes from 72.21.91.239 (72.21.91.239): icmp\_seq=10 ttl=49 time=15.8 ms

--- cs205.wac.edgecastcdn.net ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9015ms

rtt min/avg/max/mdev = 15.794/15.884/16.098/0.112 ms

### www.ucla.edu

-bash-4.2$ ping -c10 www.ucla.edu

PING gateway.lb.it.ucla.edu (164.67.228.152) 56(84) bytes of data.

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=1 ttl=40 time=79.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=2 ttl=40 time=80.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=3 ttl=40 time=79.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=4 ttl=40 time=80.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=5 ttl=40 time=79.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=6 ttl=40 time=79.7 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=7 ttl=40 time=79.6 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=8 ttl=40 time=79.5 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=9 ttl=40 time=79.4 ms

64 bytes from gateway.lb.it.ucla.edu (164.67.228.152): icmp\_seq=10 ttl=40 time=79.4 ms

--- gateway.lb.it.ucla.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9013ms

rtt min/avg/max/mdev = 79.464/79.809/80.695/0.503 ms

## Q7 traceroute

a) Traceroute is very similar to Ping, except that Traceroute identifies pathways taken along each hop, rather than the time it takes for each packet to return.

b)

### [www.uwaterloo.ca](http://www.uwaterloo.ca):

-bash-4.2$ traceroute www.uwaterloo.ca

traceroute to www.uwaterloo.ca (129.97.208.23), 30 hops max, 60 byte packets

1 exsw02-circuitnet.uwaterloo.ca (129.97.56.1) 3.460 ms 3.498 ms 3.493 ms

2 v490-eng-rt-e2.ns.uwaterloo.ca (172.16.32.193) 5.530 ms 5.528 ms 5.524 ms

3 g1-13-dist-rt-phy.ns.uwaterloo.ca (172.18.7.21) 0.622 ms 0.717 ms 0.815 ms

4 \* \* \*

5 te2-12-dist-rt-mc-global.ns.uwaterloo.ca (172.31.0.161) 1.309 ms 1.075 ms 1.191 ms

6 te2-16-cn-rt-rac.ns.uwaterloo.ca (172.16.31.113) 0.774 ms 0.845 ms 0.852 ms

7 e1-1-cr-rt-mc.ns.uwaterloo.ca (172.16.16.65) 1.217 ms 1.341 ms 1.566 ms

8 xe4-0-1-22-cr-sa-bb2.ns.uwaterloo.ca (172.16.16.7) 1.098 ms 1.137 ms 1.253 ms

9 e1-25-20-cr-rt-mc-area2.ns.uwaterloo.ca (172.16.16.27) 1.587 ms 1.910 ms 1.876 ms

10 wms.uwaterloo.ca (129.97.208.23) 1.503 ms 1.304 ms 1.273 ms

11 \* \* \*

12 \* \* \*

13 \* \* \*

14 \* \* \*

15 \* \* \*

16 \* \* \*

17 \* \* \*

18 \* \* \*

19 \* \* \*

20 \* \* \*

21 \* \* \*

22 \* \* \*

23 \* \* \*

24 \* \* \*

25 \* \* \*

26 \* \* \*

27 \* \* \*

28 \* \* \*

29 \* \* \*

30 \* \* \*

### [www.youtube.com](http://www.youtube.com):

-bash-4.2$ traceroute www.youtube.com

traceroute to www.youtube.com (172.217.1.14), 30 hops max, 60 byte packets

1 exsw02-circuitnet.uwaterloo.ca (129.97.56.1) 3.574 ms 3.606 ms 3.599 ms

2 v490-eng-rt-e2.ns.uwaterloo.ca (172.16.32.193) 4.572 ms 4.618 ms 4.610 ms

3 gi3-1-dist-rt-mc.ns.uwaterloo.ca (172.18.7.17) 0.456 ms 0.554 ms 0.845 ms

4 \* \* xe1-0-0-u10-dist-sa-mc-trust.ns.uwaterloo.ca (172.31.0.145) 0.463 ms

5 te2-12-dist-rt-mc-global.ns.uwaterloo.ca (172.31.0.161) 1.289 ms 1.175 ms 1.050 ms

6 te2-16-cn-rt-rac.ns.uwaterloo.ca (172.16.31.113) 0.835 ms 0.811 ms 0.871 ms

7 te-0-0-2-1-ext-rt-mc.ns.uwaterloo.ca (172.16.31.229) 1.463 ms 1.563 ms 3.879 ms

8 66.97.28.65 (66.97.28.65) 1.696 ms 1.687 ms 1.742 ms

9 be119.p01-york.orion.on.ca (66.97.16.109) 4.619 ms 4.661 ms 4.660 ms

10 be202.gw01-toro.orion.on.ca (66.97.16.26) 5.223 ms 4.940 ms 4.885 ms

11 74.125.48.230 (74.125.48.230) 3.624 ms 3.646 ms 3.586 ms

12 108.170.250.225 (108.170.250.225) 4.727 ms 108.170.250.241 (108.170.250.241) 4.179 ms 4.402 ms

13 216.239.35.235 (216.239.35.235) 4.551 ms 4.591 ms 4.466 ms

14 iad23s25-in-f14.1e100.net (172.217.1.14) 5.203 ms 5.244 ms 5.181 ms

### [www.nytimes.com](http://www.nytimes.com):

-bash-4.2$ traceroute www.nytimes.com

traceroute to www.nytimes.com (151.101.125.164), 30 hops max, 60 byte packets

1 exsw02-circuitnet.uwaterloo.ca (129.97.56.1) 3.571 ms 3.610 ms 3.604 ms

2 v490-eng-rt-e2.ns.uwaterloo.ca (172.16.32.193) 4.505 ms 4.504 ms 4.501 ms

3 gi3-1-dist-rt-mc.ns.uwaterloo.ca (172.18.7.17) 0.462 ms 0.772 ms 0.872 ms

4 \* \* \*

5 te2-12-dist-rt-mc-global.ns.uwaterloo.ca (172.31.0.161) 1.093 ms 1.436 ms 1.188 ms

6 te2-16-cn-rt-mc.ns.uwaterloo.ca (172.16.31.117) 28.344 ms 27.975 ms 27.742 ms

7 te0-0-2-0-ext-rt-mc.ns.uwaterloo.ca (172.16.32.149) 1.335 ms 1.602 ms 1.719 ms

8 unallocated-static.rogers.com (72.142.108.181) 1.481 ms 1.445 ms 1.972 ms

9 24.156.146.189 (24.156.146.189) 7.220 ms 7.223 ms 5.751 ms

10 9044-cgw01.wlfdle.rmgt.net.rogers.com (209.148.230.45) 4.841 ms 4.672 ms 4.765 ms

11 209.148.235.34 (209.148.235.34) 8.267 ms 8.264 ms 8.246 ms

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