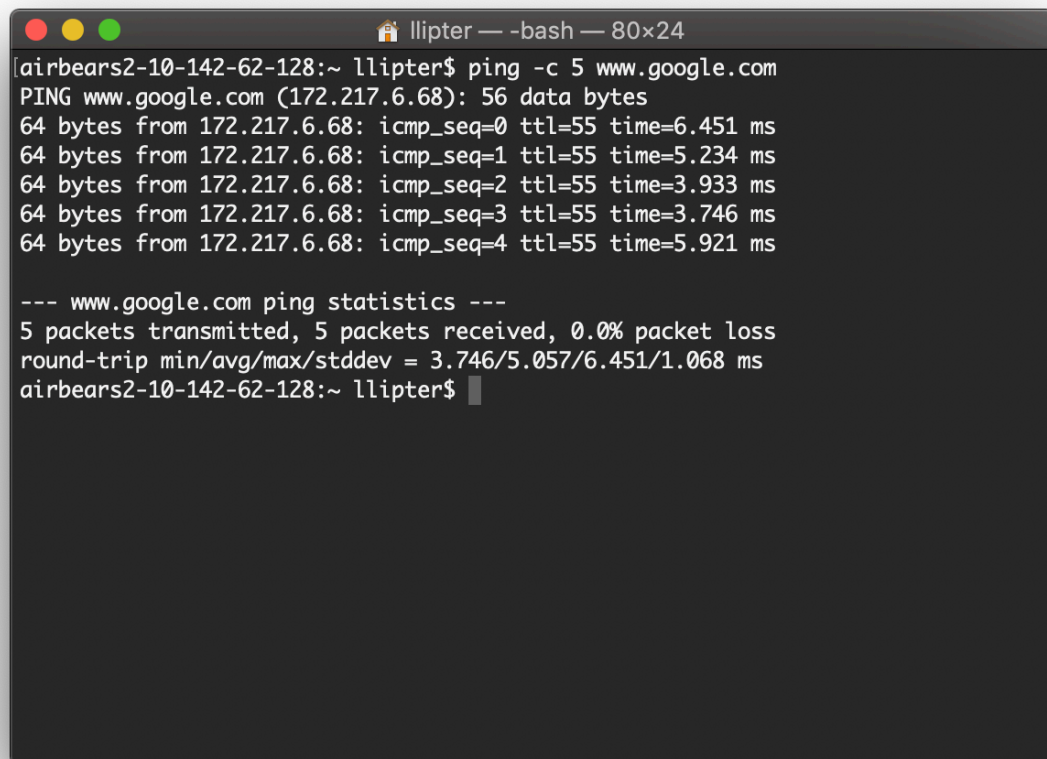


Networks and Distributed Computing — Spring 2019 — Homework 1

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2019 年 2 月 22 日

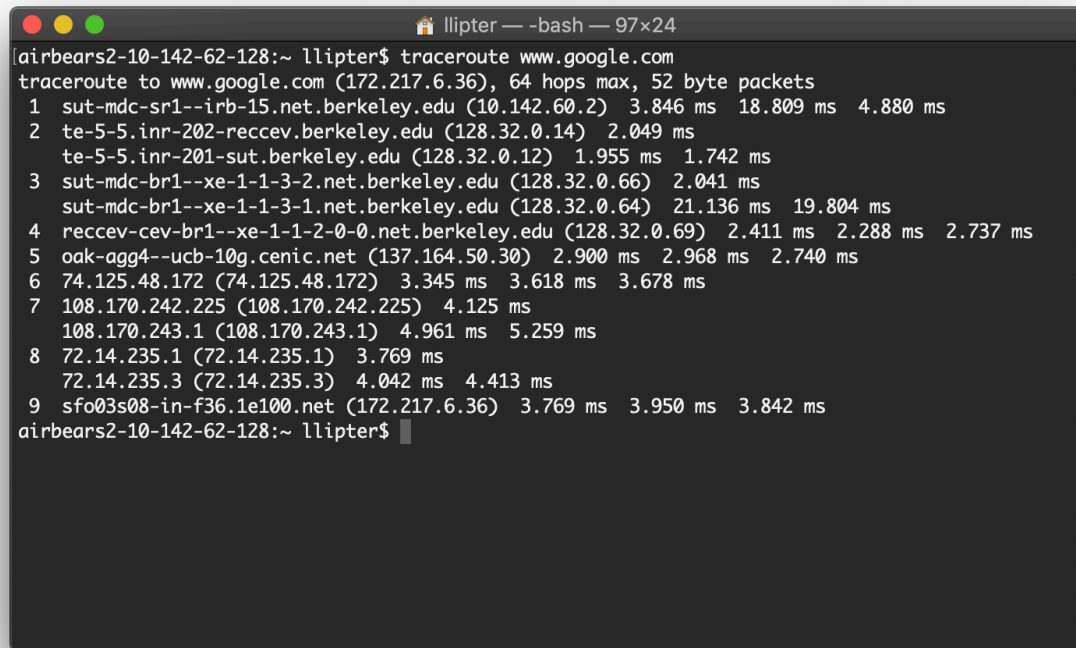
1 Ping

A terminal window titled "llypter — -bash — 80x24" with standard macOS window controls (red, yellow, green buttons). The terminal shows the execution of the command "ping -c 5 www.google.com" from the host "airbears2-10-142-62-128". The output displays five successful ping responses from IP 172.217.6.68, each with 56 data bytes and varying round-trip times. A summary line shows 0.0% packet loss and average round-trip statistics.

```
[airbears2-10-142-62-128:~ llypter$ ping -c 5 www.google.com  
PING www.google.com (172.217.6.68): 56 data bytes  
64 bytes from 172.217.6.68: icmp_seq=0 ttl=55 time=6.451 ms  
64 bytes from 172.217.6.68: icmp_seq=1 ttl=55 time=5.234 ms  
64 bytes from 172.217.6.68: icmp_seq=2 ttl=55 time=3.933 ms  
64 bytes from 172.217.6.68: icmp_seq=3 ttl=55 time=3.746 ms  
64 bytes from 172.217.6.68: icmp_seq=4 ttl=55 time=5.921 ms  
  
--- www.google.com ping statistics ---  
5 packets transmitted, 5 packets received, 0.0% packet loss  
round-trip min/avg/max/stddev = 3.746/5.057/6.451/1.068 ms  
airbears2-10-142-62-128:~ llypter$
```

图 1: Ping Google

2 Traceroute



```
airbears2-10-142-62-128:~ llipter$ traceroute www.google.com
traceroute to www.google.com (172.217.6.36), 64 hops max, 52 byte packets
 1  sut-mdc-sr1--irb-15.net.berkeley.edu (10.142.60.2)  3.846 ms  18.809 ms  4.880 ms
 2  te-5-5.inr-202-reccev.berkeley.edu (128.32.0.14)  2.049 ms
    te-5-5.inr-201-sut.berkeley.edu (128.32.0.12)  1.955 ms  1.742 ms
 3  sut-mdc-br1--xe-1-1-3-2.net.berkeley.edu (128.32.0.66)  2.041 ms
    sut-mdc-br1--xe-1-1-3-1.net.berkeley.edu (128.32.0.64)  21.136 ms  19.804 ms
 4  reccev-cev-br1--xe-1-1-2-0-0.net.berkeley.edu (128.32.0.69)  2.411 ms  2.288 ms  2.737 ms
 5  oak-agg4--ucb-10g.cenic.net (137.164.50.30)  2.900 ms  2.968 ms  2.740 ms
 6  74.125.48.172 (74.125.48.172)  3.345 ms  3.618 ms  3.678 ms
 7  108.170.242.225 (108.170.242.225)  4.125 ms
    108.170.243.1 (108.170.243.1)  4.961 ms  5.259 ms
 8  72.14.235.1 (72.14.235.1)  3.769 ms
    72.14.235.3 (72.14.235.3)  4.042 ms  4.413 ms
 9  sfo03s08-in-f36.1e100.net (172.217.6.36)  3.769 ms  3.950 ms  3.842 ms
airbears2-10-142-62-128:~ llipter$
```

图 2: Tracerout Google

3 Problem 6

This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B.

- (a) **Express the propagation delay, d_{prop} , in terms of m and s .**

$$d_{prop} = \frac{m}{s}$$

- (b) **Determine the transmission time of the packet, d_{trans} , in terms of L and R .**

$$d_{trans} = \frac{L}{R}$$

- (c) **Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.**

$$d_{end-to-end} = d_{prop} + d_{trans} = \frac{m}{s} + \frac{L}{R}$$

- (d) **Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet?**

It just leaved A.

- (e) **Suppose d_{prop} is greater than d_{trans} . At time $t = d_{prop}$, where is the first bit of the packet?**

It's still in the link and hasn't reach B.

- (f) **Suppose d_{prop} is less than d_{trans} . At time $t = d_{trans}$, where is the first bit of the packet?**

It has reached B.

- (g) **Suppose $s = 2.5 \times 10^8$, $L = 120$ bits, and $R = 56$ kbps. Find the distance m so that d_{prop} equals d_{trans} .**

$$m = \frac{L}{R}s = \frac{120}{56 \times 10^3} 2.5 \times 10^8 \approx 5.36 \times 10^5 \text{m}$$

4 Problem 8

Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in Section 1.3.)

- (a) **When circuit switching is used, how many users can be supported?**

$$\text{Number of users supported} = \frac{3 \text{ Mbps}}{150 \text{ kbps}} = 20$$

- (b) **For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.**

$$p = 0.1$$

- (c) **Find the probability that at any given time, exactly n users are transmitting simultaneously. (Hint: Use the binomial distribution.)**

$$P = \binom{120}{n} p^n (1 - p)^{120-n}$$

- (d) **Find the probability that there are 21 or more users transmitting simultaneously.**

$$P = 1 - \sum_{n=0}^{20} \binom{120}{n} p^n (1 - p)^{120-n}$$

5 Problem 9

Consider the discussion in Section 1.3 of packet switching versus circuit switching in which an example is provided with a 1 Mbps link. Users are generating data at a rate of 100 kbps when busy, but are busy generating data only with probability $p = 0.1$. Suppose that the 1 Mbps link is replaced by a 1 Gbps link.

- (a) **What is N , the maximum number of users that can be supported simultaneously under circuit switching?**

$$N = \frac{1 \text{ Gbps}}{100 \text{ kbps}} \frac{1}{p} = 100000$$

- (b) **Now consider packet switching and a user population of M users. Give a formula (in terms of p , M , N) for the probability that more than N users are sending data.**

$$P = 1 - \sum_{n=0}^N \binom{M}{n} p^n (1-p)^{M-n}$$