

## Network Overview, Network Utilities

1. (a) A single DVD provides:  $4.7\text{GB}/24\text{ hours} = 4.7 * 2^{32} * 8\text{ bits}/(24 * 60 * 60\text{ seconds}) = 467,276\text{bps}$ . Dividing 155 Mbps by 467 Kbps, we get 331.7, so Sprint would need to ship 332 DVDs.  
(b) The propagation delay over the OC-3 link is  $20,000\text{km}/(2.0 * 10^8\text{m/s}) = 1/10\text{s}$ . The bandwidth-delay product is  $155\text{Mbps} * 1/10\text{s} = 15.5\text{Mbit} \approx 1.85\text{MB}$ . For the DVD channel, the bandwidth is the same — 155 Mbps — but the delay is 24 hours. So the product is  $155\text{Mbps} * (24 * 60 * 60\text{ seconds}) = 13.392\text{Tbit} \approx 1.522\text{TB}$ . (terabit and terabyte respectively).
2. (a) No. This would violate the principle of separation of layers. To layer  $(N - 1)$ , the  $N$ -level PDU is simply data. The  $(N - 1)$  entity does not know about the internal format of the  $N$ -level PDU. It breaks that PDU into fragments and reassembles them in the proper order.  
(b) Each  $N$ -level PDU must retain its own header, for the same reason given in (a).  
(c) Since the "Application" sits on top of the  $n$ -layer protocol stack, each of the  $n$  layers adds  $h$  bytes to the message it receives from the layer (or application) on top. Hence, the total number of header bytes per message is  $nh$ . So, the relative space wasted on headers is  $nh/(M + nh)$ .
3. (a) The time to send the 2346-byte packet from  $A$  to the switch will consist of transmission time and propagation delay. The transmission time is  $2346\text{ bytes}/11\text{Mbps} = 2346 * 8/(11 * 10^6)\text{ seconds} = 1706\mu\text{s}$ . So the switch will receive the last bit of the packet after  $1706 + 20 = 1726\mu\text{s}$ . The switch will then transmit the packet and  $B$  will receive the last bit after another  $1726\mu\text{s}$ , for a total transfer time of  $3452\mu\text{s}$ .  
(b) The intermediate switch does not decrease the long term effective data rate because as soon as  $A$  is finished transmitting one packet, it will immediately start transmitting the next one. Therefore, the bandwidth is therefore the link speed of 11 Mbps times the overhead factor of  $(2346 - 44)/2346 = 0.981$  (for every 2346 bytes transmitted on the link, 2346-44 bytes of useful data are sent.) The effective bandwidth is  $11\text{Mbps} * 0.981 = 10.79\text{Mbps}$ .  
(c) As found in part (a), the latency for a single packet is  $3452\mu\text{s}$ . Similarly, the latency for a 100-byte acknowledgment is  $2 * (8 * 100/(11 * 10^6)\text{s} + 20\mu\text{s}) = 185\mu\text{s}$ . Therefore, the total time to send a packet and receive an acknowledgment is  $3637\mu\text{s}$ . Therefore,  $(2346 - 44) * 8 = 18,416$  bits of data can be sent every  $3637\mu\text{s}$ , so the effective bandwidth is  $18,416/(0.003637) = 5.064\text{Mbps}$ .
4. (a) Bandwidth x delay =  $100\text{Mbps} * 35\mu\text{s} = 3500$  bits.  
(b) In this case, one can treat the switch as another link that has a delay of  $(1518 * 8)\text{bits}/10\text{Mbps} = 1.214\text{ms}$ . The total delay is therefore  $1.214\text{ms} + 5 * 2\mu\text{s} = 1.224\text{ms}$ . The bandwidth-delay product in this case is  $10 * 10^6\text{bps} * 1.224 * 10^{-3}\text{s} = 12240$  bits.  
(c) Bandwidth x delay =  $622\text{Mbps} * 88\text{ms} = 54,736,000\text{bits}$ .  
(d) The propagation delay to the satellite is  $35,900\text{km}/(3.0 * 10^8\text{m/s}) = 120\text{ms}$ . There is another  $120\text{ms}$  spent on the way back down, for a total delay of  $240\text{ms}$ . Bandwidth x delay =  $500\text{Kbps} * 240\text{ms} = 120,000$  bits.

5. (a) i. > whois uiuc.edu

Whois Server Version 1.3

Domain names in the .com and .net domains can now be registered with many different competing registrars. Go to <http://www.internic.net> for detailed information.

Domain Name: UIUC.EDU  
Registrar: EDUCAUSE  
Whois Server: whois.educause.net  
Referral URL: <http://www.educause.edu/edudomain>  
Name Server: DNS2.CSO.UIUC.EDU  
Name Server: DNS1.CSO.UIUC.EDU  
Name Server: DNS1.IU.EDU  
Status: ACTIVE  
Updated Date: 19-jul-2006  
Creation Date: 18-jul-1985  
Expiration Date: 18-jul-2007

[...]

> whois -h whois.educause.net uiuc.edu

This Registry database contains ONLY .EDU domains.

[...]

-----  
Domain Name: UIUC.EDU

Registrant:

University of Illinois at Urbana Champaign  
CITES 1120 Digital Computer Laboratory  
1304 West Springfield Avenue  
Urbana, IL 61801-2910  
UNITED STATES

Administrative Contact:

Michael G. Gardner  
University of Illinois at Urbana-Champaign  
CITES 1120 Digital Computer Laboratory  
1304 West Springfield Avenue  
Urbana, IL 61801-4399  
UNITED STATES

(217) 244-0914  
mgg@uiuc.edu

Technical Contact:

Charles Kline  
University of Illinois at Urbana Champaign  
CITES 1120 Digital Computer Laboratory  
1304 West Springfield Avenue  
Urbana, IL 61801  
UNITED STATES  
(217) 333-3339  
kline@uiuc.edu

Name Servers:

DNS1.CSO.UIUC.EDU 128.174.5.103  
DNS2.CSO.UIUC.EDU 128.174.5.104  
DNS1.IU.EDU

Domain record activated: 18-Jul-1985  
Domain record last updated: 01-Jun-2006  
Domain expires: 31-Jul-2007  
Answer: Charles Kline

ii.

> whois disney.com

Whois Server Version 1.3

Domain names in the .com and .net domains can now be registered  
with many different competing registrars. Go to <http://www.internic.net>  
for detailed information.

Domain Name: DISNEY.COM  
Registrar: NETWORK SOLUTIONS, LLC.  
Whois Server: whois.networksolutions.com  
Referral URL: <http://www.networksolutions.com>  
Name Server: HUEY.DISNEY.COM  
Name Server: SENS01.DIG.COM  
Name Server: SENS02.DIG.COM  
Name Server: HUEY11.DISNEY.COM  
Status: REGISTRAR-LOCK  
Updated Date: 26-jun-2006  
Creation Date: 21-mar-1990  
Expiration Date: 22-mar-2008

[...]

> whois -h whois.networksolutions.com disney.com

[...]

Registrant:

Disney Enterprises, Inc.  
500 S. Buena Vista Street  
Burbank, CA 91521  
US

Domain Name: DISNEY.COM

Administrative Contact:

Nolda, Kathy kathy.nolda@dig.com  
500 S. Buena Vista Street  
Burbank, CA 91521  
US  
(818) 623-3523

Technical Contact:

dns ops dns-ops@dig.com  
506 2nd Ave., Suite 2100  
Seattle, WA 98104  
US  
206-664-4000

Record expires on 22-Mar-2008.

Record created on 21-Mar-1990.

Database last updated on 29-Aug-2006 19:34:35 EDT.

Domain servers in listed order:

HUEY.DISNEY.COM	204.128.192.10
HUEY11.DISNEY.COM	192.195.66.12
SENS01.DIG.COM	199.181.134.16
SENS02.DIG.COM	199.181.135.199

Answer: HUEY.DISNEY.COM — 204.128.192.10, HUEY11.DISNEY.COM — 192.195.66.12,  
SENS01.DIG.COM — 199.181.134.16, SENS02.DIG.COM — 199.181.135.199

(b)

> whois uiuc.edu

Whois Server Version 1.3

Domain names in the .com and .net domains can now be registered with many different competing registrars. Go to <http://www.internic.net> for detailed information.

```
Domain Name: UIUC.EDU
Registrar: EDUCAUSE
Whois Server: whois.educause.net
Referral URL: http://www.educause.edu/edudomain
Name Server: DNS2.CSO.UIUC.EDU
Name Server: DNS1.CSO.UIUC.EDU
Name Server: DNS1.IU.EDU
Status: ACTIVE
Updated Date: 19-jul-2006
Creation Date: 18-jul-1985
Expiration Date: 18-jul-2007
```

[...]

```
> ping 56 5 dns2.cso.uiuc.edu
```

```
ece438 [remsun2:~]> ping -s dns2.cso.uiuc.edu 56 5
PING dns2.cso.uiuc.edu: 56 data bytes
64 bytes from dns2.cso.uiuc.edu (128.174.5.104): icmp_seq=0. time=0. ms
64 bytes from dns2.cso.uiuc.edu (128.174.5.104): icmp_seq=1. time=0. ms
64 bytes from dns2.cso.uiuc.edu (128.174.5.104): icmp_seq=2. time=0. ms
64 bytes from dns2.cso.uiuc.edu (128.174.5.104): icmp_seq=3. time=0. ms
64 bytes from dns2.cso.uiuc.edu (128.174.5.104): icmp_seq=4. time=0. ms
```

```
----dns2.cso.uiuc.edu PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 0/0/0
```

```
> whois stanford.edu
```

```
Whois Server Version 1.3
```

Domain names in the .com and .net domains can now be registered with many different competing registrars. Go to <http://www.internic.net> for detailed information.

```
Domain Name: STANFORD.EDU
Registrar: EDUCAUSE
Whois Server: whois.educause.net
Referral URL: http://www.educause.edu/edudomain
Name Server: AVALLONE.STANFORD.EDU
Name Server: ATALANTE.STANFORD.EDU
```

Name Server: ARGUS.STANFORD.EDU  
Status: ACTIVE  
Updated Date: 05-oct-2005  
Creation Date: 04-oct-1985  
Expiration Date: 04-oct-2006

```
> ping -s avallone.stanford.edu 56 5
PING avallone.stanford.edu: 56 data bytes
64 bytes from Avallone.Stanford.EDU (171.64.7.88): icmp_seq=0. time=68. ms
64 bytes from Avallone.Stanford.EDU (171.64.7.88): icmp_seq=1. time=68. ms
64 bytes from Avallone.Stanford.EDU (171.64.7.88): icmp_seq=2. time=67. ms
64 bytes from Avallone.Stanford.EDU (171.64.7.88): icmp_seq=3. time=68. ms
64 bytes from Avallone.Stanford.EDU (171.64.7.88): icmp_seq=4. time=68. ms
```

```
----avallone.stanford.edu PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 67/67/68
Answer: 0 ms and 67 ms respectively.
```

```
(c) > traceroute www.stanford.edu
traceroute to www4.stanford.edu (171.67.20.36), 30 hops max, 40 byte packets
 1 uiuc-ewsl-vlan1.gw.uiuc.edu (130.126.160.1) 0.439 ms 0.218 ms 0.334 ms
 2 172.20.20.5 (172.20.20.5) 0.269 ms 0.252 ms 0.308 ms
 3 * * *
 4 t-fwbgw.uiuc.edu (130.126.0.13) 0.555 ms 2.129 ms 0.411 ms
 5 uiuc-exite-fw-net.gw.uiuc.edu (130.126.0.30) 1.018 ms 0.951 ms 0.866 ms
 6 t-dmzo.gw.uiuc.edu (130.126.0.70) 0.884 ms 0.920 ms 1.217 ms
 7 192.17.10.46 (192.17.10.46) 10.713 ms 11.358 ms 3.405 ms
 8 chin-mren-ge.abilene.ucaid.edu (198.32.11.97) 21.269 ms 3.338 ms 3.440 ms
 9 iplsng-chinng.abilene.ucaid.edu (198.32.8.77) 7.164 ms 7.375 ms 11.836 ms
10 kscyng-iplsng.abilene.ucaid.edu (198.32.8.81) 16.781 ms 16.417 ms 16.519 ms
11 dnvrng-kscyng.abilene.ucaid.edu (198.32.8.13) 27.252 ms 27.104 ms 35.479 ms
12 snvang-dnvrng.abilene.ucaid.edu (198.32.8.1) 51.858 ms 51.783 ms 52.833 ms
13 losang-snvang.abilene.ucaid.edu (198.32.8.94) 59.245 ms 59.188 ms 65.619 ms
14 hpr-lax-gsr1--abilene-LA-10ge.cenic.net (137.164.25.2) 59.947 ms 59.678 ms 59.836 ms
15 svl-hpr--lax-hpr-10ge.cenic.net (137.164.25.13) 67.041 ms 67.165 ms 66.997 ms
16 hpr-stan-ge--svl-hpr.cenic.net (137.164.27.162) 67.258 ms 67.361 ms 67.274 ms
17 bbr2-rtr.Stanford.EDU (171.64.1.133) 67.995 ms 67.616 ms 67.961 ms
18 www4.Stanford.EDU (171.67.20.36) 67.440 ms 69.450 ms 67.414 ms
> > ping -s 198.32.8.77
PING 198.32.8.77: 56 data bytes
64 bytes from iplsng-chinng.abilene.ucaid.edu (198.32.8.77): icmp_seq=0. time=10. ms
64 bytes from iplsng-chinng.abilene.ucaid.edu (198.32.8.77): icmp_seq=1. time=8. ms
64 bytes from iplsng-chinng.abilene.ucaid.edu (198.32.8.77): icmp_seq=2. time=12. ms
64 bytes from iplsng-chinng.abilene.ucaid.edu (198.32.8.77): icmp_seq=3. time=7. ms
64 bytes from iplsng-chinng.abilene.ucaid.edu (198.32.8.77): icmp_seq=4. time=7. ms
```

^C

-----198.32.8.77 PING Statistics-----

5 packets transmitted, 5 packets received, 0% packet loss  
round-trip (ms) min/avg/max = 7/8/12

Answer: 198.32.8.77 and, yes, the times reported are similar (in the same range).

(d)

> traceroute www.scott.aq

traceroute to www.scott.aq (203.167.246.34), 30 hops max, 40 byte packets

```
 1 uiuc-ewsl-vlan1.gw.uiuc.edu (130.126.160.1) 0.425 ms 0.213 ms 0.319 ms
 2 172.20.20.21 (172.20.20.21) 0.291 ms 0.269 ms 0.319 ms
 3 * * *
 4 t-fwbgw.uiuc.edu (130.126.0.13) 0.513 ms 0.426 ms 1.047 ms
 5 uiuc-exite-fw-net.gw.uiuc.edu (130.126.0.30) 0.464 ms 0.487 ms 0.695 ms
 6 t-dmzo.gw.uiuc.edu (130.126.0.70) 0.793 ms 0.545 ms 0.689 ms
 7 t-dmzb.gw.uiuc.edu (130.126.0.86) 0.893 ms 0.888 ms 0.606 ms
 8 champaign.illinois.net (192.17.10.30) 1.008 ms 0.922 ms 0.857 ms
 9 206.166.53.253 (206.166.53.253) 1.191 ms 0.972 ms 0.996 ms
10 POS-3-0-1-NapSOB2-CHI-P2-7-Iron-CHM-P2.lincon.net (206.166.5.94) 5.039 ms 5.165 ms 5
11 p6-3.hsal.chi1.bbnplanet.net (4.24.203.65) 5.337 ms 5.156 ms 5.222 ms
12 ae-2-54.bbr2.Chicago1.Level3.net (4.68.101.97) 5.524 ms 5.916 ms 5.968 ms
13 ae-0-0.bbr1.Washington1.Level3.net (64.159.0.229) 21.946 ms
   ae-2-0.bbr2.Washington1.Level3.net (209.247.10.130) 21.351 ms 21.280 ms
14 ae-14-53.car4.Washington1.Level3.net (4.68.121.81) 22.165 ms
   ae-24-52.car4.Washington1.Level3.net (4.68.121.49) 22.712 ms
   ae-14-51.car4.Washington1.Level3.net (4.68.121.17) 22.530 ms
15 0.so-2-1-0.BR1.DCA5.ALTER.NET (204.255.168.97) 30.641 ms
   mci-level3-oc48.Washington1.Level3.net (209.244.219.158) 30.666 ms
   0.so-2-1-0.BR1.DCA5.ALTER.NET (204.255.168.97) 30.029 ms
16 0.so-5-0-0.XL1.DCA5.ALTER.NET (152.63.43.170) 30.412 ms
   0.so-5-0-0.XL2.DCA5.ALTER.NET (152.63.43.178) 30.754 ms
   0.so-5-0-0.XL1.DCA5.ALTER.NET (152.63.43.170) 30.883 ms
17 0.so-7-0-0.XL2.LAX1.ALTER.NET (152.63.117.201) 83.927 ms
   0.so-6-0-0.XL1.LAX1.ALTER.NET (152.63.57.77) 79.036 ms 158.108 ms
18 POS7-0.GW1.LAX1.ALTER.NET (152.63.112.213) 84.366 ms
   POS6-0.GW1.LAX1.ALTER.NET (152.63.112.217) 78.968 ms
   POS7-0.GW1.LAX1.ALTER.NET (152.63.112.213) 84.533 ms
19 telstraclear-gw.customer.alter.net (157.130.245.22) 78.905 ms 83.964 ms 78.624 ms
20 at-0-1-0-1.xcore1.acld.telstraclear.net (203.98.42.38) 218.821 ms 220.299 ms 213.074
21 ge-0-2-0-21.jcore2.acld.clix.net.nz (203.98.50.8) 219.454 ms 213.213 ms 218.358 ms
22 g9-927.u12.brh.telstraclear.net (218.101.61.4) 214.931 ms 231.470 ms 347.967 ms
23 218.101.61.70 (218.101.61.70) 231.190 ms 234.390 ms 228.007 ms
24 218.101.61.73 (218.101.61.73) 233.814 ms 228.159 ms 235.161 ms
>
```

The transoceanic link is between routers 19 and 20 — 203.98.42.38 and 203.98.50.8. You can tell due to the large jump in the round-trip times (140 ms). This link is likely using an undersea

cable. A satellite link has a round-trip latency of around 240 ms, as calculated in 4.d. The one-way latency of this link is 70 ms, which suggests a 14,000 km cable using the  $2.0 * 10^8 m/s$  speed of light in a cable, a plausible length for an undersea cable between Los Angeles to New Zealand. Notice how for hops 13–18 different routers are used for successive probe packets.