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1. Answer:

Bandwidth in the cable Internet access is shared among homes. On the downstream stream, the packets are enumerated from one single source, the head end. So there are no collisions on the downstream channel.

2. Answer:

(a). In circuit switching, the circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. So we can only support 2 users because each user will require half of the link bandwidth.

(b). When less than two users are using the link, the bandwidth(2Mbps) can support both users' transmission ($2 * 1\text{Mbps} = 2\text{Mbps}$), so there will be no queuing delay. But when three users are transmitting, the 3Mbps bandwidth is required, which is more than given 2Mbps. So there will be queuing delaying.

(c). Probability that a user is transmitting = 0.2.

$$\binom{3}{4} * p^3(1-p)^1 + \binom{4}{4} * p^4 = 0.0272$$

The queue grows when more than two users are transmitting, so the fraction of time is 0.0272.

3. Answer:

(a). $t = 3 * (\frac{L}{R} + \frac{d}{s})$

(b). $t = 3 * \frac{d}{s} + \frac{L}{R}$

4. Answer:

(a). For every packet, it will require $\frac{L}{R}$ time to transmit. So, for packet i , it will

require $(i - 1) * \frac{L}{R}$ queuing delay. *Average time* = $\frac{(0 + \frac{L}{R} + \frac{2L}{R} + \dots + \frac{(N-1)L}{R})}{N} = \frac{(N-1)L}{2R}$

(b) The last packet of N packets need to wait for $\frac{(N-1)L}{R}$ time, which is less than $\frac{NL}{R}$.

Therefore, for every N packets arrive, the queue is empty because the last batch

if packets have been transmitted. So the average time is equal to every packet's

average queuing delay. *Average time* = $\frac{(N-1)L}{2R}$

Answer:

(a).

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Command Prompt
Microsoft Windows [Version 10.0.17134.523]
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C:\Users\ZS>tracert www.targethost.com

Tracing route to www.targethost.com [104.28.18.245]
over a maximum of 30 hops:

  0  1 ms    2 ms    1 ms  192.168.1.1
  1  2 ms    2 ms    1 ms  192.168.0.1
  2  9 ms   12 ms    9 ms  cpe-72-229-48-1.nyc.res.rr.com [72.229.48.1]
  3 11 ms   11 ms   10 ms  be58.nymanyfo02h.nyc.rr.com [68.173.202.174]
  4 20 ms   12 ms   19 ms  agg115.nyquny9101r.nyc.rr.com [68.173.198.66]
  5 17 ms   15 ms   14 ms  bu-ether25.nycmny837aw-bcr00.tbone.rr.com [107.14.19.22]
  6 18 ms   15 ms   14 ms  0.ae2.pr0.nyc20.tbone.rr.com [107.14.19.147]
  7 12 ms   15 ms   11 ms  ix-ae-6-0.tcore1.n75-new-york.as6453.net [66.110.96.53]
  8 24 ms   19 ms   18 ms  if-ae-9-2.tcore1.nto-new-york.as6453.net [63.243.128.121]
  9 22 ms   19 ms   17 ms  if-ae-7-2.tcore1.n0v-new-york.as6453.net [63.243.128.26]
 10 23 ms   21 ms   21 ms  if-ae-0-2.tcore3.njy-newark.as6453.net [216.6.90.14]
 11 17 ms   23 ms   28 ms  if-ae-1-3.tcore4.njy-newark.as6453.net [216.6.57.6]
 12 22 ms   18 ms   15 ms  if-ae-12-3.tcore2.aeq-ashburn.as6453.net [216.6.87.200]
 13 21 ms   25 ms   23 ms  216.6.87.221
 14 18 ms   17 ms   18 ms  104.28.18.245

Trace complete.

C:\Users\ZS>

```

Average round-trip delay: $\frac{18+17+18}{3}$ ms = 17.67ms

Number of routers: 14

Number of ISP Network: 6

(b).

```
Command Prompt

C:\Users\ZS>tracert nc.cutv.com

Tracing route to 1016433.sp.tencdns.net [42.56.76.36]
over a maximum of 30 hops:

  1    2 ms    2 ms    1 ms    cc-wlan-1-vlan3540-1.net.columbia.edu [160.39.208.2]
  2    5 ms    2 ms    64 ms   phi-core-1-x-cc-wlan-1.net.columbia.edu [128.59.255.225]
  3    5 ms    3 ms    3 ms    nyser111-gw-1-x-phi-core-1.net.columbia.edu [128.59.255.14]
  4    *      4 ms    2 ms    nyser32-gw-1-x-nyser111-gw-1.net.columbia.edu [128.59.255.9]
  5    5 ms    4 ms    3 ms    be4222.rcr24.jfk01.atlas.cogentco.com [38.122.8.209]
  6    6 ms    6 ms    3 ms    be2897.ccr42.jfk02.atlas.cogentco.com [154.54.84.213]
  7   12 ms   11 ms    9 ms    be2807.ccr42.dca01.atlas.cogentco.com [154.54.40.110]
  8   22 ms   22 ms   21 ms    be2113.ccr42.atl01.atlas.cogentco.com [154.54.24.222]
  9   38 ms   35 ms   35 ms    be2690.ccr42.iah01.atlas.cogentco.com [154.54.28.130]
 10   56 ms   51 ms   54 ms    be2928.ccr21.elp01.atlas.cogentco.com [154.54.30.162]
 11   87 ms   62 ms   71 ms    be2929.ccr31.phx01.atlas.cogentco.com [154.54.42.65]
 12   72 ms   75 ms   73 ms    be2931.ccr41.lax01.atlas.cogentco.com [154.54.44.86]
 13   73 ms   76 ms   76 ms    be3271.ccr41.lax04.atlas.cogentco.com [154.54.42.102]
 14   83 ms   73 ms   78 ms    38.88.197.118
 15    *     432 ms 303 ms    219.158.98.17
 16  299 ms  300 ms  407 ms    219.158.3.177
 17  291 ms  304 ms  305 ms    219.158.5.153
 18  391 ms  304 ms  304 ms    219.158.105.74
 19  282 ms  233 ms  274 ms    113.230.172.214
 20  235 ms  237 ms  239 ms    175.167.112.114
 21  287 ms  303 ms  234 ms    175.167.117.246
 22  393 ms  254 ms  305 ms    42.56.76.36

Trace complete.
```

Average round-trip delay: $\frac{393+253+305}{3}ms = 317.33ms$

Number of routers: 21

ISP Network: 7