#6.

a) $d_{prop} = m/s$ (sec)

b) $d_{trans} = 2/R$ (sec)

c) $d_{end} = m/s + 2/R$ (sec)

d) 此 bit 剛離開 host A

e) 第一個 bit 仍在 link 之中, 尚未抵達 host B.

f) 第一個 bit 已經抵達 host B.

g) $m = ?$

$$m = \left(\frac{2}{R}\right) \cdot S = \frac{120}{56 \times 10^3} \cdot 2.5 \times 10^8 = 536 \, km$$

#9   link: 1 Mbps   rate: 100 kbps

$p = 0.1$ 1 Mbps → 1 Gbps

a) $N = ?$

$$\frac{1G}{100k} : \frac{10^9}{100 \times 10^3} = 10^4 = 10000.$$

b) packet switching : binomial distribution

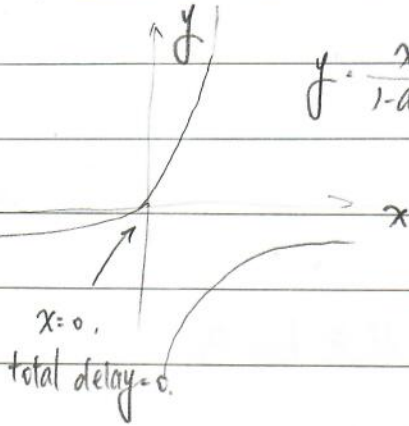$$\Rightarrow \sum_{n=N+1}^{M} \binom{M}{n} p^n (1-p)^{M-n}.$$

N+1 是因为 "more than N users"

#14 a) transmission delay : $2/R$.

total delay

$$= \frac{I2}{R(1-I)} + \frac{2}{R} = \frac{2/R}{1-I}$$

b) let $x = 1/R$, total delay $= \dfrac{x}{1-ax}$.

$y = \dfrac{x}{1-ax}$, a given

$x = 0$,
total delay $= 0$.

#18

#24 $40T = 40 \times 10^{12} \times 8$ bits.

$$\dfrac{40 \times 10^{12} \times 8}{100 \times 10^6} = 3200000 \text{ sec} = \dfrac{3200000}{60^2 \times 24} \doteq 37 \text{ days.}$$

cf FedEx. overnight delivery → 24 hrs. ∴ cost ≤ 100 $
以內就抵達   所以用 FedEx 較好.

#25. $d_{A\,to\,B}$ = 20000 km = 2×10^7 m.

R = 2Mbps   speed = 2.5×10^8 m/s

a) $\dfrac{d_{A\,to\,B}}{speed}$. $\dfrac{2 \times 10^7}{2.5 \times 10^8}$ = 0.08 = d_{prop}

R × d_{prop} = 2×10^6 × 0.08 = 16×10^4 = 160000 bits.

b) file size = 800000 bits

max = 160000 bits.

c) bandwidth-delay product of a link
  = maximum # of bits in the link.

d) width of a bit = 2×10^7 m / 160000 = 125 m. / 1 bit

football field length = 109.73m , 一丁 bit 的 width 較寬

e) S/R

#31

a) t = $\dfrac{8 \times 10^6}{2 \times 10^6}$ = 4 sec. , |source host| —— t —→ |1st packet switch|

4sec × 3 hops = 12 sec , total time from source host to destination host

b) $\dfrac{1 \times 10^4}{2 \times 10^6}$. 5 msec = 0.005 sec , 1st packet 從 src 到 1st packet switch.

2×5m = 0.01 sec , 2nd packet 在 1st packet switch 被 received

c) 0.005 sec × 3 hops = 15 msec = 0.015, 1st packet 抵達 destination.

0.015 + 799 × 0.005 = 4.01 sec, 800th packet ——"——

∴ delay in using message segmentation is significant less. (1/3rd)

Per-Duet

同一個Continent（台灣的清華大學）

3/19 00:11

```
$ traceroute www.nthu.edu.tw
traceroute to www.nthu.edu.tw (140.114.69.135), 64 hops max, 52 byte
packets
 1  www.asusnetwork.net (192.168.2.1)  19.007 ms  0.938 ms  0.998 ms
 2  h254.s98.ts.hinet.net (168.95.98.254)  3.875 ms  6.639 ms  4.509 ms
 3  168.95.22.102 (168.95.22.102)  4.278 ms  7.000 ms  3.783 ms
 4  220-128-11-222.hinet-ip.hinet.net (220.128.11.222)  4.058 ms
    220-128-11-250.hinet-ip.hinet.net (220.128.11.250)  2.766 ms  17.874
ms
 5  220-128-9-98.hinet-ip.hinet.net (220.128.9.98)  10.431 ms  9.938 ms
    tyfo-3011.hinet.net (220.128.8.94)  14.916 ms
 6  sczs-3201.hinet.net (220.128.9.21)  9.536 ms
    sczs-3201.hinet.net (220.128.8.25)  6.045 ms
    sczs-3201.hinet.net (220.128.9.21)  11.767 ms
 7  ty-fo-c76r2.router.hinet.net (220.128.8.245)  8.629 ms  11.212 ms
8.791 ms
 8  211-20-113-69.hinet-ip.hinet.net (211.20.113.69)  12.504 ms  6.521 ms
12.325 ms
 9  140.114.1.129 (140.114.1.129)  13.465 ms  6.426 ms  9.486 ms
10  c7609-1-c7609c.nthu.edu.tw (140.114.1.182)  6.051 ms  7.238 ms
17.504 ms
```

(a)
Average: 10.26ms
Std: 6.2981
(b-1)
# of routers: 9
(c)
# of ISP: 5

largest delay是不是發生在換ISP時？ YES

3/20 09:45
```
$ traceroute www.nthu.edu.tw
traceroute to www.nthu.edu.tw (140.114.69.135), 64 hops max, 52 byte
packets
 1  www.asusnetwork.net (192.168.2.1)  998.697 ms  29.066 ms  23.889 ms
 2  h254.s98.ts.hinet.net (168.95.98.254)  14.797 ms  44.519 ms  6.234 ms
 3  168.95.22.102 (168.95.22.102)  5.343 ms  6.606 ms  7.548 ms
 4  220-128-11-250.hinet-ip.hinet.net (220.128.11.250)  16.181 ms * *
 5  tyfo-3011.hinet.net (220.128.8.94)  14.117 ms
    tyfo-3012.hinet.net (220.128.9.94)  14.789 ms
    tyfo-3011.hinet.net (220.128.8.94)  9.809 ms
 6  sczs-3201.hinet.net (220.128.9.21)  18.060 ms
    sczs-3201.hinet.net (220.128.8.25)  9.273 ms  5.759 ms
 7  ty-fo-c76r2.router.hinet.net (220.128.8.245)  3.812 ms
    220-128-8-253.hinet-ip.hinet.net (220.128.8.253)  4.781 ms  5.976 ms
 8  211-20-113-69.hinet-ip.hinet.net (211.20.113.69)  8.565 ms  10.900 ms
7.780 ms
 9  140.114.1.129 (140.114.1.129)  4.538 ms  8.547 ms  7.285 ms
10  c7609-1-c7609c.nthu.edu.tw (140.114.1.182)  3.819 ms  8.238 ms  8.096
ms
```

(a)

Average: 6.716ms
Std: 2.5113
(b-1)
# of routers: 9
(c)
# of ISP: 5
largest delay是不是發生在換ISP時？ YES


```
3/21 00:16
$ traceroute www.nthu.edu.tw
traceroute to www.nthu.edu.tw (140.114.69.135), 64 hops max, 52 byte
packets
 1  www.asusnetwork.net (192.168.2.1)  2.193 ms  0.941 ms  2.877 ms
 2  h254.s98.ts.hinet.net (168.95.98.254)  13.787 ms  6.330 ms  3.638 ms
 3  168.95.22.102 (168.95.22.102)  8.027 ms  7.446 ms  3.850 ms
 4  220-128-11-250.hinet-ip.hinet.net (220.128.11.250)  4.288 ms  7.019
ms
    220-128-11-222.hinet-ip.hinet.net (220.128.11.222)  4.800 ms
 5  tyfo-3012.hinet.net (220.128.9.94)  6.713 ms
    tyfo-3011.hinet.net (220.128.8.94)  5.721 ms
    220-128-9-98.hinet-ip.hinet.net (220.128.9.98)  9.956 ms
 6  sczs-3201.hinet.net (220.128.8.25)  4.065 ms
    sczs-3201.hinet.net (220.128.9.21)  3.611 ms  8.420 ms
 7  ty-fo-c76r2.router.hinet.net (220.128.8.245)  9.659 ms
    220-128-8-253.hinet-ip.hinet.net (220.128.8.253)  6.233 ms
    ty-fo-c76r2.router.hinet.net (220.128.8.245)  6.058 ms
 8  211-20-113-69.hinet-ip.hinet.net (211.20.113.69)  6.841 ms  4.865 ms
7.227 ms
 9  140.114.1.129 (140.114.1.129)  5.776 ms  6.497 ms  6.567 ms
10  c7609-1-c7609c.nthu.edu.tw (140.114.1.182)  14.175 ms  4.945 ms
8.573 ms
```


(a)
Average: 9.231ms
Std: 4.65005
(b-1)
# of routers: 9
(c)
# of ISP: 5
largest delay是不是發生在換ISP時？ YES

(b-2)
Does path change? NO

不同Continent（美國的MIT）

```
3/19 00:11
$ traceroute www.mit.edu
traceroute to e9566.dscb.akamaiedge.net (104.116.5.218), 64 hops max, 52
byte packets
 1  www.asusnetwork.net (192.168.2.1)  26.783 ms  4.281 ms  4.280 ms
 2  h254.s98.ts.hinet.net (168.95.98.254)  6.546 ms  2.747 ms  9.408 ms
 3  168.95.22.102 (168.95.22.102)  7.144 ms  11.369 ms  5.324 ms
 4  220-128-11-222.hinet-ip.hinet.net (220.128.11.222)  9.985 ms
```

```
        220-128-11-250.hinet-ip.hinet.net (220.128.11.250)  47.789 ms  92.227
ms
  5  tpdt-3011.hinet.net (220.128.1.110)  33.861 ms
     tpdt-3012.hinet.net (220.128.4.82)  9.371 ms
     tpdt-3011.hinet.net (220.128.3.22)  8.435 ms
  6  tpdt-3301.hinet.net (220.128.2.49)  19.146 ms  6.016 ms  3.346 ms
  7  a104-116-5-218.deploy.static.akamaitechnologies.com (104.116.5.218)
4.847 ms  3.403 ms  15.852 ms
```

(a)
Average: 8.034ms
Std: 6.8089
(b-1)
# of routers: 6
(c)
# of ISP: 4
largest delay是不是發生在換ISP時? YES


```
3/20 09:45
$ traceroute www.mit.edu
traceroute to e9566.dscb.akamaiedge.net (104.116.5.218), 64 hops max, 52
byte packets
  1  www.asusnetwork.net (192.168.2.1)  1.330 ms  0.922 ms  0.817 ms
  2  h254.s98.ts.hinet.net (168.95.98.254)  4.893 ms  1.568 ms  3.954 ms
  3  168.95.22.102 (168.95.22.102)  4.472 ms  4.388 ms  4.018 ms
  4  220-128-11-250.hinet-ip.hinet.net (220.128.11.250)  10.672 ms  6.267
ms
     220-128-11-222.hinet-ip.hinet.net (220.128.11.222)  4.947 ms
  5  tpdt-3011.hinet.net (220.128.1.110)  9.882 ms  8.360 ms
     tpdt-3012.hinet.net (220.128.2.170)  9.420 ms
  6  tpdt-3301.hinet.net (220.128.3.149)  4.560 ms  4.966 ms  3.980 ms
  7  a104-116-5-218.deploy.static.akamaitechnologies.com (104.116.5.218)
4.768 ms  4.688 ms  3.853 ms
```

(a)
Average: 4.43633ms
Std: 0.50676
(b-1)
# of routers: 6
(c)
# of ISP: 4
largest delay是不是發生在換ISP時? YES


```
3/21 00:16
$ traceroute www.mit.edu
traceroute to e9566.dscb.akamaiedge.net (104.124.246.60), 64 hops max, 52
byte packets
  1  www.asusnetwork.net (192.168.2.1)  1.434 ms  12.971 ms  5.425 ms
  2  h254.s98.ts.hinet.net (168.95.98.254)  9.343 ms  3.557 ms  12.357 ms
  3  168.95.22.102 (168.95.22.102)  11.032 ms  9.357 ms  13.932 ms
  4  220-128-11-222.hinet-ip.hinet.net (220.128.11.222)  5.482 ms  4.982
ms  14.853 ms
  5  pcpc-3202.hinet.net (220.128.5.130)  13.764 ms
     tpdt-3011.hinet.net (220.128.3.22)  14.525 ms
     tpdt-3011.hinet.net (220.128.1.110)  13.725 ms
  6  220-128-10-177.hinet-ip.hinet.net (220.128.10.177)  7.386 ms
```

```
        220-128-10-253.hinet-ip.hinet.net (220.128.10.253)  19.112 ms
        220-128-10-177.hinet-ip.hinet.net (220.128.10.177)  17.841 ms
   7  203-75-228-65.hinet-ip.hinet.net (203.75.228.65)  6.298 ms
        203-75-228-5.hinet-ip.hinet.net (203.75.228.5)  5.939 ms
        203-75-228-193.hinet-ip.hinet.net (203.75.228.193)  6.069 ms
   8  r1010-asr.tpix.net.tw (223.26.65.20)  11.775 ms  14.280 ms  6.705 ms
   9  202.133.244.58 (202.133.244.58)  68.465 ms  21.691 ms  22.522 ms
  10  a104-124-246-60.deploy.static.akamaitechnologies.com (104.124.246.60)
  10.000 ms  12.606 ms  13.422 ms
```

(a)
Average: 12.0093ms
Std: 1.78732
(b-1)
# of routers: 9
(c)
# of ISP: 7
largest delay是不是發生在換ISP時? YES

(b-2)
Does path change? YES