Solutions to HW#1

1. end-to-end delay $= \left(\frac{L}{P}-1\right)\frac{P+H}{B} + N\left[D+\frac{P+H}{B}\right]$

$$= ND + \left(\frac{L}{P}-1+N\right)\frac{P+H}{B}$$

where $\frac{L}{P}$ = # of packets and $\frac{P+H}{B}$ = transmission delay/pack.

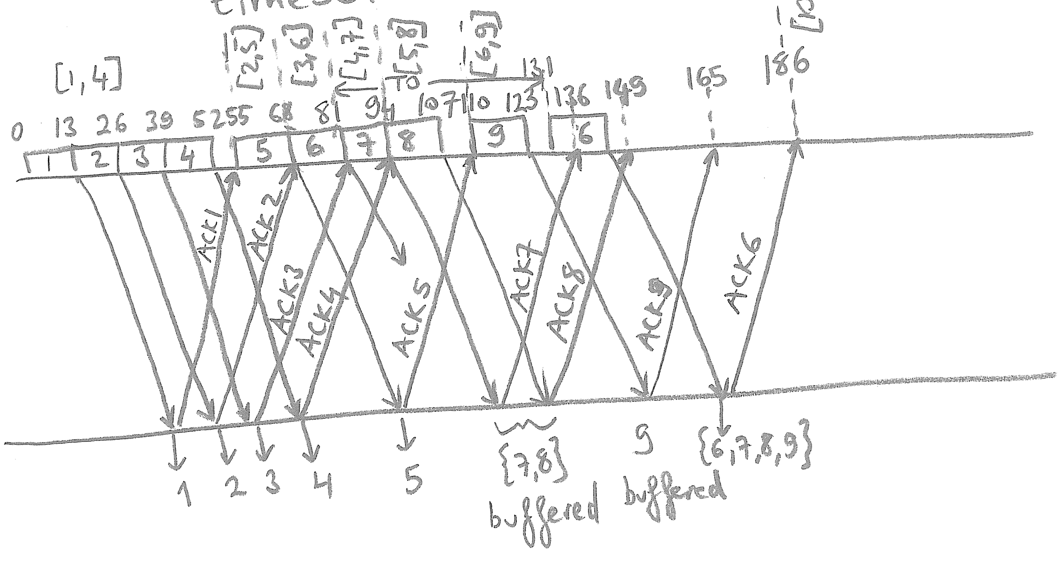
2. $$U_{sender} = \frac{\frac{1000\times 8\text{ bits}}{100\times 10^6\text{ bps}}}{\frac{1000\times 8\text{ bits}}{100\times 10^6\text{ bps}} + \frac{2\times 6000\text{ km}}{3\times 10^5\text{ km/s}}} = \frac{80\mu s}{40{,}080\mu s} = 0.2\%$$

3. $$\#\text{ of segments} = \left\lceil \frac{13{,}500}{1{,}500} \right\rceil = 9$$

$$\text{packet transmission time} = \frac{(1500+125)\times 8\text{ bits}}{1\times 10^6\text{ bps}} = 13\text{ msec}$$

$$\text{ACK transmission time} = \frac{125\times 8\text{ bits}}{1\times 10^6\text{ bps}} = 1\text{ msec}$$

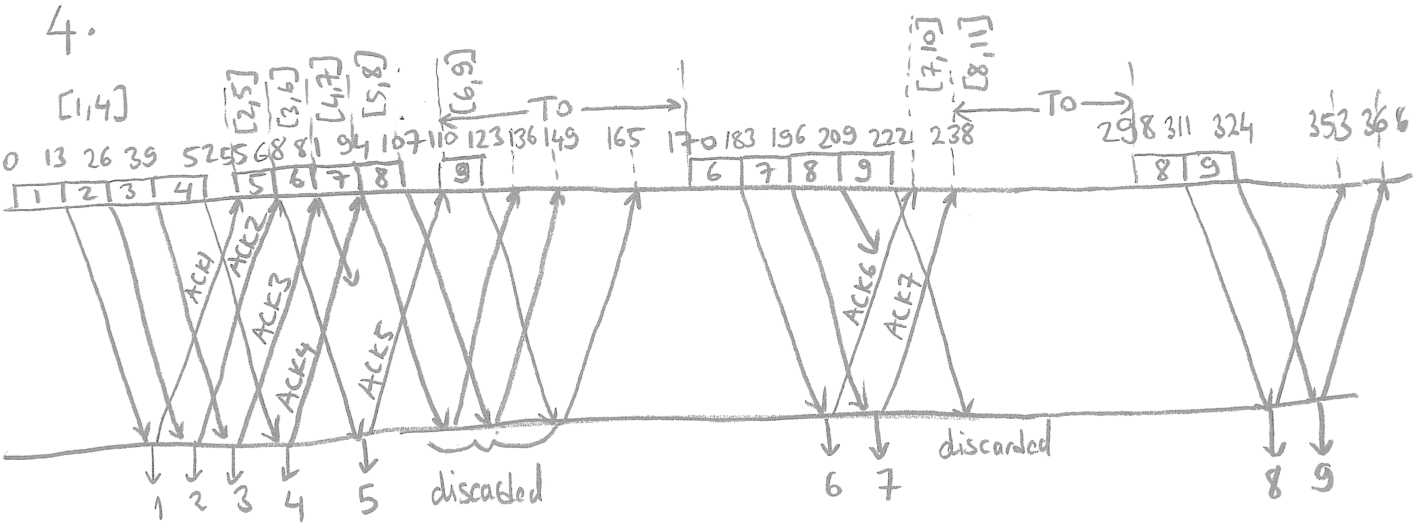
timeout = 50 msec



Transfer is completed in 186 msec.

$$\text{average data tranfer rate} = \frac{13{,}500\times 8\text{ bits}}{186\text{ msec}} = 580.6\text{ Kbps}$$

4.



Transfer is completed in 366 msec.

average data tranfer rate $= \dfrac{13{,}500 \times 8\,\text{bits}}{366\ \text{msec}} = 295.1$ Kbps

5. EstimatedRTT $= E[RTT] = 20\times0.6 + 40\times0.3 + 100\times0.1 = 34$ msec

a) Timeout $= 2\times34 = 68$ msec $\Rightarrow$ 10% of segments will be assumed lost (incorrectly!)

b) DevRTT $= E[\,|\text{EstimatedRTT} - \text{SampleRTT}|\,]$

$= 0.6\times|20-34| + 0.3\times|40-34| + 0.1\times|100-34|$

$= 16.8$ msec

Timeout $= 34 + 4\times16.8 = 101.2$ msec $\Rightarrow$ no segments will be assumed lost (correctly)

6. We would like to avoid a scenario where we measure a large SampleRTT and the Timeout computed after this measurement turns out to be less than the last SampleRTT! Since this situation can only arise when SampleRTT is large, assume that

SampleRTT > $\text{EstimatedRTT}_{old}$

$$\text{Timeout} = \text{EstimatedRTT}_{new} + \gamma\, \text{DevRTT}_{new}$$

$$= (1-\alpha)\,\text{EstimatedRTT}_{old} + \alpha\, \text{SampleRTT}$$

$$+ \gamma\left[(1-\beta)\,\text{DevRTT}_{old} + \beta\left(\text{SampleRTT} - \text{EstimatedRTT}_{old}\right)\right]$$

$$= (\alpha + \gamma\beta)\,\text{SampleRTT} + (1-\alpha-\gamma\beta)\,\text{EstimatedRTT}_{old}$$

$$+ \gamma(1-\beta)\,\text{DevRTT}_{old}$$

Since $\text{DevRTT} \geq 0$ →

$$\geq (\alpha+\gamma\beta)\,\text{SampleRTT} + (1-\alpha-\gamma\beta)\,\text{EstimatedRTT}_{old}$$

$$= (\alpha+\gamma\beta-1)\underbrace{\left(\text{SampleRTT} - \text{EstimatedRTT}_{old}\right)}_{\geq 0 \text{ by hypothesis}}$$

$$+ \text{SampleRTT}$$

$\therefore$ Timeout $\geq$ SampleRTT if $\alpha + \gamma\beta - 1 \geq 0$

Note that in TCP $\alpha = \frac{1}{8}$, $\beta = \frac{1}{4}$, $\gamma = 4$ and

$$\alpha + \gamma\beta - 1 = \frac{1}{8} \geq 0 \checkmark$$

7. Buffer at 1 sec $= (1\times10^6 - 1\times10^6)^+ = 0$

Buffer at 2 sec $= (2\times10^6 - 1\times10^6)^+ = 1\times10^6$ bits $= 125{,}000$ Bytes

RcvWin $= 150{,}000 - 125{,}000 = 25{,}000$ Bytes

8. After 1st ACK : CongWin = CongWin + MSS = 8,000 Bytes

" 2nd " : CongWin = 9,000 Bytes

" 3rd " : CongWin = 10,000 Bytes

" 4th " : CongWin = CongWin + MSS $\times \frac{\text{MSS}}{\text{CongWin}}$ = 10,100 Bytes

" 5th " : CongWin = 10,199 Bytes

" 6th " : CongWin = 10,297 Bytes

" 7th " : CongWin = 10,394 Bytes