

A1.) $MSS = 1 \text{ Kbyte}$ $th = 64 \text{ Kbytes}$

a.) timeout, $CW = 16 \text{ Kbytes}$

\rightarrow slow start $\rightarrow th = \frac{1}{2} CW = 8$

$CW = 1 \text{ MSS}$		
1st transmission	↓ CW	1
2nd	- " -	2
3rd	- " -	4
4th	- " -	8
5th	- " -	9
6th	- " -	10
7th	- " -	11

exponential
linear

b.) 3 dup ACKs ~~Fast~~ $CW = 16 \text{ KB}$

\rightarrow Fast Retransmit + Fast Recovery

$\rightarrow th = \frac{1}{2} CW = 8 \text{ KB}$

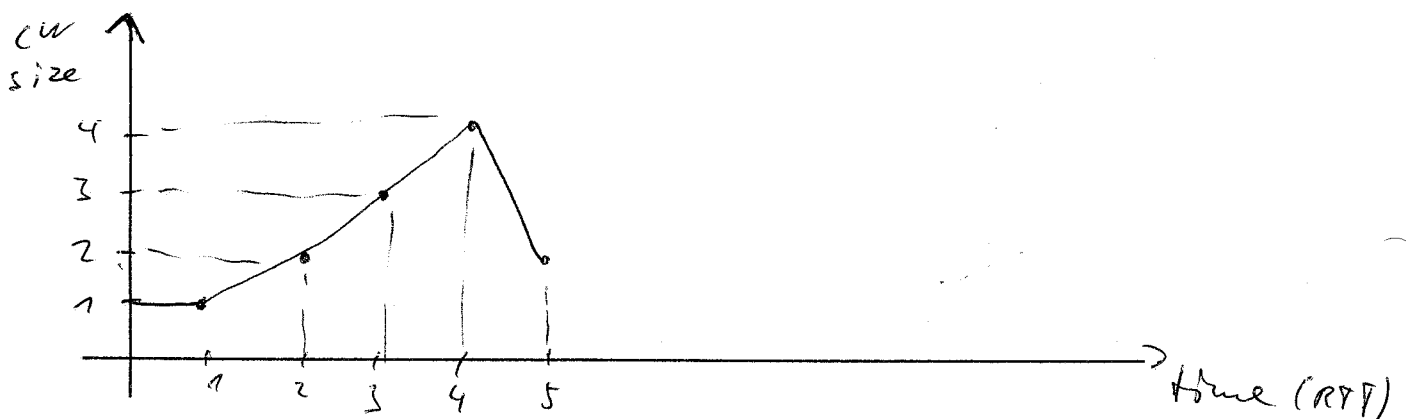
$\rightarrow CW = th = 8$

	↓ CW
1st transmit	8
2nd	9
3rd	10
4th	11
5th	12
6th	13
7th	14

2.) TCP with AIMD

Lost Packets: 9, 25, 30, 38, 50

time	cw size	segment size
1st RTT	1	1
2	2	2, 3
3	3	4, 5, 6 ← lost
4	4	7, 8, 9 , 10
5	2	9, 10
6	3	11, 12, 13
7	4	14, 15, 16, 17
8	5	18, -22,
9	6	23 , 24, 25 , 26, 27, 28
10	3 ↓	25, 26, 27
11	4	28, 29, 30 , 31
12	2	30, 31
13	3	32, 33, 34
14	4	35, 36, 37, 38
15	2	38, 39
16	3	40, -42
17	4	43 - 46
18	5	47, 48, 49, 50 , 51
19	2	50, 51



5.)

Initially we send 1 segment. So, after 1 RTT we can send 2 segments

we need 1 RTT before sending 2 segments

2 RTT

$$4 = 2^2$$

3 RTT

$$8 = 2^3$$

4 RTT

$$16 = 2^4$$

⋮

⋮

x RTT

$$N = 2^x$$

$$\Rightarrow x = \log_2(N)$$

6.)

a.) 50 Mbps

satellite, $h = 36000 \text{ km}$

$$RTT = 2 \left(\frac{\text{distance}}{\text{speed of light}} \right) = 2 \left(\frac{h}{c} \right) = \frac{72000 \cdot 10^3}{3 \cdot 10^8} = \underline{\underline{0,24 \text{ s}}}$$

TCP-Header: 16 bits for window size

$$\Rightarrow 2^{16} \text{ bytes} = 65536 \text{ bytes} \rightarrow \text{Full window}$$

$$\Rightarrow \text{we send } 65536 \text{ bytes every } 1 \text{ RTT} = 0,24 \text{ s}$$

$$\frac{65536}{0,24} \approx \underline{\underline{273066 \text{ bytes/sec}}}$$

↓
Throughput

Line Efficiency:

$$\frac{273066 \cdot 8}{50 \cdot 10^6} = 0,044$$

5b.)

$$(0,12) \cdot (50 \cdot 10^6) = 60\,000\,000 \text{ bits}$$

$$= 750\,000 \text{ bytes}$$

in order to "fill" the link

\Rightarrow the network should allow at least 750.000 bytes