Q1

(a)

```
  0110011001100000
+ 0101010101010101
------------------
  1011101110110101
->two's compliment
->0100010001001010
```

(b)

Sum up all words (contain checksum). If the result is all all 1, there is no error.

(c)

No. If the error bits do not change the checksum, the receiver can not detect the error.

Example: 00000000000000010000000000000000

```
  0000000000000001  ->  0000000000000000
+ 0000000000000000  ->  0000000000000001
------------------      ----------------
  0000000000000001  ->  0000000000000001
```

Q2

Go-Back-N:

- B1: send ack0
- B2: 0 1 2 3 4 5 6

SR:

- B1: send ack2
- B2: 0 1 2 3 4 5 6

Q3

AIAD would not converge to an equal throughput. The throughput curve will oscillate repeatedly between points A and B.

This is because the additive increase causes the throughput to rise along a trajectory parallel to the 45-degree line. Conversely, the additive decrease causes the throughput to decline along a trajectory that is also parallel to the 45-degree line. Such parallel movements do not lead towards the 'Equal bandwidth share' line.

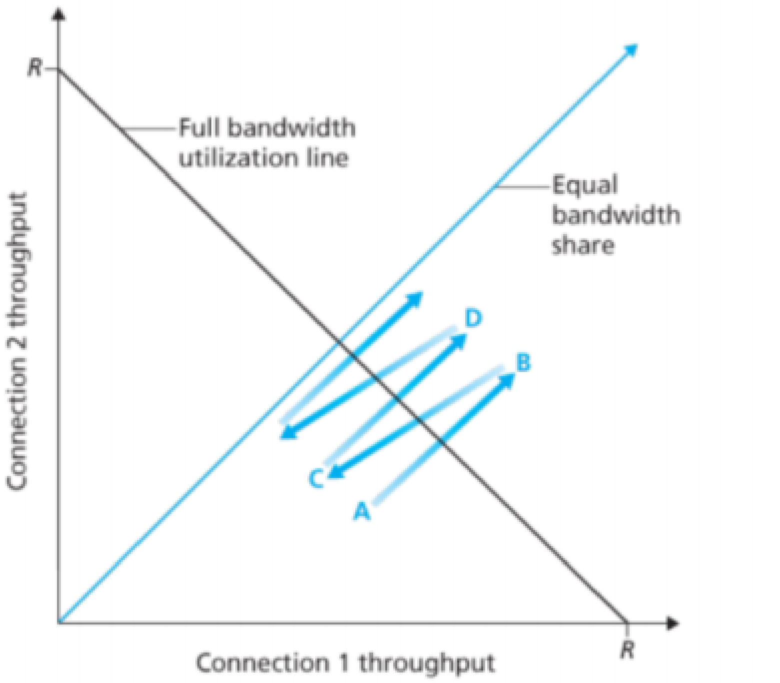
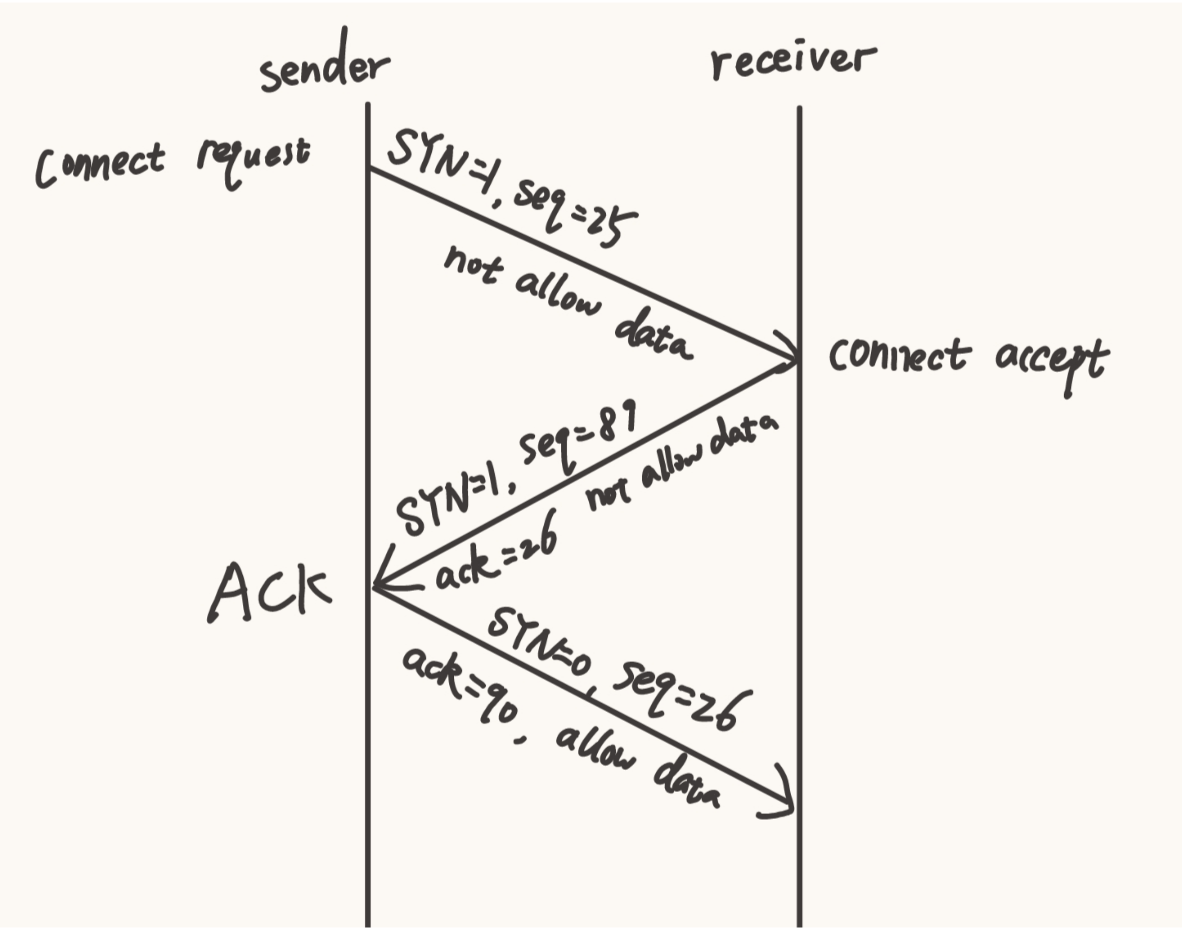


Figure 3.55 Throughput realized by TCP connections 1 and 2

Q4



Q5

Estimated RTT in short E, Sample RTT in short S.

$$E = (1 - \alpha)E + S$$

(a)

$$\begin{aligned}
E_4 &= (1-\alpha)E_3 + S_4 \\
&= (1-\alpha)((1-\alpha)E_2 + S_3) + S_4 \\
&= (1-\alpha)^2 E_2 + (1-\alpha)S_3 + S_4 \\
&= (1-\alpha)^2((1-\alpha)E_1 + S_2) + (1-\alpha)S_3 + S_4 \\
&= (1-\alpha)^3 E_1 + (1-\alpha)^2 S_2 + (1-\alpha)S_3 + S_4 \\
&= (1-\alpha)^4 E_0 + (1-\alpha)^3 S_1 + (1-\alpha)^2 S_2 + (1-\alpha)S_3 + S_4
\end{aligned}$$

(b)

$$\begin{aligned}
E_n &= (1-\alpha)E_{n-1} + S_n \\
&= (1-\alpha)((1-\alpha)E_{n-2} + S_{n-1}) + S_n \\
&= (1-\alpha)^2 E_{n-2} + (1-\alpha)S_{n-1} + S_n \\
&\cdots\cdots \\
&= (1-\alpha)^n E_0 + \sum_{i=1}^{n} (1-\alpha)^{n-i} S_i
\end{aligned}$$