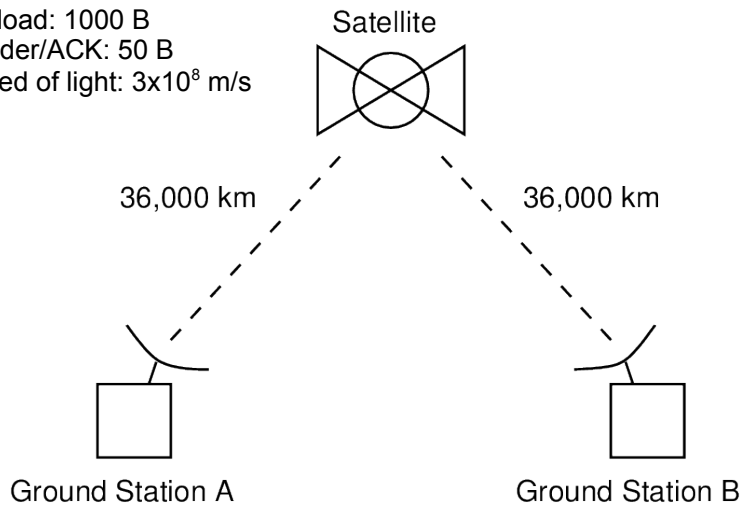
Data rate: 1 Mb/s
Payload: 1000 B
Header/ACK: 50 B
Speed of light: $3x10^8$ m/s



Propagation delay: 36,000 km @ $3x10^8$ m/s = 120 ms

DATA transmission delay: 1050 B @ 1 Mb/s = 8.4 ms

ACK transmission delay: 50 B @ 1 Mb/s = 0.4 ms

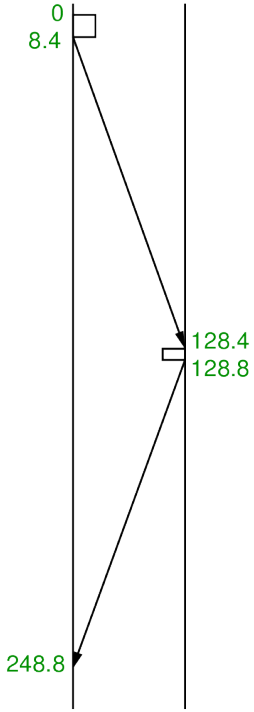
Stop and Wait (Window = 1)

Time to receive ACK: 8.4 + 120 + 0.4 + 120 = 248.8 ms

Real data delivered: 1000 B

Throughput: 1000 B / 248.8 ms = 32,154 b/s

Efficiency: 32,154 b/s out of 1 Mb/s = 3.2 %



Propagation delay: 36,000 km @ $3x10^8$ m/s = 120 ms

DATA transmission delay: 1050 B @ 1 Mb/s = 8.4 ms

ACK transmission delay: 50 B @ 1 Mb/s = 0.4 ms

Sliding Window (Window = 7)

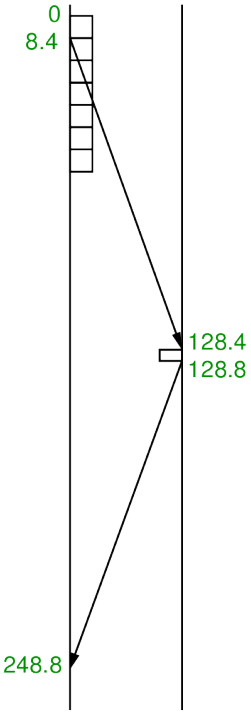
Time to receive ACK: 8.4 + 120 + 0.4 + 120 = 248.8 ms

Time to send window of frames: 7 x 8.4 = 58.8 ms

Real data delivered: 7000 B

Throughput: 7000 B / 248.8 ms = 225,080 b/s

Efficiency: 225,080 b/s out of 1 Mb/s = 22.5 %



What size window to achieve highest efficiency?

Time to receive ACK: 248.8 ms

DATA Transmission delay: 8.4 ms

Aim: continuously send DATA frames (no waiting)

DATA frames in time to receive ACK: 248.8 / 8.4 = 29.6

Window size of 30 frames is sufficient

With 5 bit sequence number, maximum window size is 31 frames

W = 31:

Efficiency: 1000 B / 1050 B = 95.2 %

Throughput: 952,381 b/s