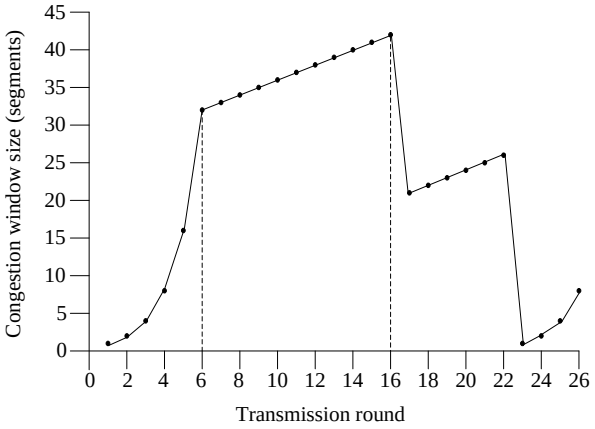
1、Consider the graph below, which shows the size of the TCP sender's congestion control window as a function of time (transmission round) in an idealized timing scenario where the sender sends a window's worth of packets and then receives ACKs at the end of the RTT. Answer the following questions:



(a) Why does the congestion window curve have one form from rounds 1 to 6, and then another form from rounds 6 through 16?

From rounds 1 to 6，TCP 拥塞控制处于 slow start 阶段，cwnd 从 1 开始以 2 的指数级别增长，在 cwnd=32 时，达到 threshold，开始进入 congestion avoidance 阶段，from rounds 6 to 16, cwnd 呈现线性增长。到 t=16 时，由于网络拥塞，congestion avoidance 阶段结束。

(b) What event occurs at t=16, given that the result of this event is the sender cutting its congestion control window in half.

在 congestion avoidance 阶段使用 reno 算法。

在 t=16 时，由于网络拥塞等原因造成数据报的丢失，发送端将 threshold 值置为当前 cwnd 的 1/2；同时在快速重传机制下，接收端在返回对某数据报的 ACK 后，又再次返回了 3 次 ACK，发送端检测到这种情况后，将 cwnd 值置为当前值的一半。此时 cwnd 与 threshold 值相等，直接进入 congestion avoidance 阶段。

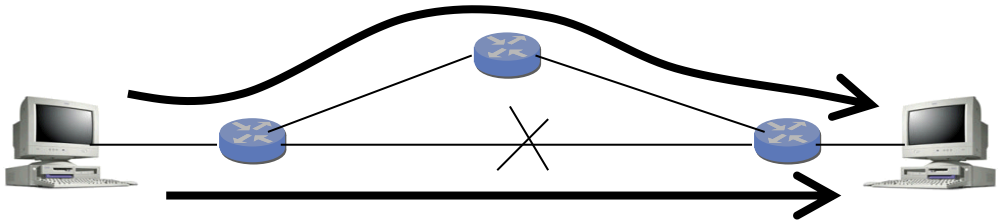
(c) What event occurs at t=22, given that the result of this event is the sending cutting its congestion window to 1? How is this event different from that which happened at t=16?

在 congestion avoidance 阶段使用 reno 算法。

在 t=22 时，由于网络拥塞等原因造成数据报的丢失，发送端将 threshold 值置为当前 cwnd 的 1/2；同时发送端检测到发送超时仍未接收到 ACK，认为此时网络拥塞的状况较严重，直接将 cwnd 值置为 1，重新开始 slow start 阶段。

不同之处在于，发送端在数据报丢失时，由于检测到的原因不同，判断网络拥塞的严重程度有所不同，从而对发送速率的减少也不同。由于超时而丢失时，网络拥塞严重，cwnd 值置 1；快速重传多次守到同一 ACK 时，网络拥塞不是特别严重，cwnd 值减半。

2、Suppose two hosts have a long-lived TCP session over a path with a 100 msec round-trip time (RTT). Then, a link fails, causing the traffic to flow over a longer path with a 500 msec RTT.



1) Suppose the router on the left recognizes the failure immediately and starts forwarding data packets over the new path, without losing any packets. (Assume also that the router on the right recognizes the failure immediately and starts directing ACKs over the new path, without losing any ACK packets.) Why might the TCP sender retransmit some of the data packets anyway?

尽管路由器都做出了正确的判段，改变了发送路径，但由于新的路径比使用原路径花费的时间更长，而发送端并没有因为新路径花费的时间长而更改 timeout 值，故在到达 timeout 时，发送端将不会接收到接收端返回的 ACK，从

而造成超时重传。

2) Suppose instead that the routers do not switch to the new paths all that quickly, and the data packets (and ACK packets) in flight are all lost. What new congestion window size does the TCP sender use? Why?

新的 cwnd 值将为 1。

因为由于数据报和 ACK 都可能丢失，且发送端的 timeout 值并未在原路径断掉时作出改变，发送端会在达到 timeout 时作出判断，认为网络出现了严重的拥塞，从而将 cwnd 值置 1，重新开始 slow start 阶段。