Summary of Post-1987 TCP Specification
(References are to Comer’s 1999 editions of Internetworking with TCP/IP.)

Let
- \( RTT_i \) = estimated round trip time just after arrival of acknowledgement of the \( i \)-th segment sent without retransmission (initially 0 [p. 242 in Comer Vol. II])
- \( DEV_i \) = estimated variance in \( RTT_i \) (initially 0 in Comer, 1.5 in Stevens)
- \( RTO_i \) = retransmission time value just after arrival of acknowledgement of the \( i \)-th segment sent without retransmission
- \( RTO \) = current value of retransmission timer (initially 0.5 sec. in Comer Vol. II)
- \( SSTHRESH \) = threshold to switch from slow start to additive increase
- \( CWND \) = current value of congestion window (initially 1)

1. **Round trip variance estimation** (Jacobson Appendix A, Comer Vol. I 13.19, Comer Vol. II 15.9 and Stevens Section 8.4)\(^1\) -- used only upon reception of an ack for segment that was not retransmitted:

   1a. \( RTT_{\text{sample}} = (\text{time when ack for S arrived}) - (\text{time when S was sent}) \)
   1b. \( \text{DIFF} = RTT_{\text{sample}} - RTT_i \)
   1c. \( RTT_{i+1} = RTT_i + \delta \cdot \text{DIFF} \)
   1d. \( DEV_{i+1} = DEV_i + \delta \cdot (|\text{DIFF}| - DEV_i) \) (Typically \( \delta = 2^{-3} \))
   1e. \( RTO_{i+1} = RTT_{i+1} + 2DEV_{i+1} \)
   1f. \( RTO = RTO_{i+1} \)

2. **Exponential retransmit timer backoff** (Comer Vol. I 13.18 and Vol. II 15.8) -- used immediately after retransmission of a segment:

   \( RTO = 2 \cdot RTO. \)

3. **Slow start** (Comer Vol. 1, p. 215) coupled with multiplicative decrease/additive increase congestion control (see pp. 320-321 and Appendix B of Jacobson):

   3a. Used immediately after retransmission of a segment:

   - \( SSTHRESH = \min(CWND/2,1) \)
   - \( CWND = 1 \)

   3b. Upon arrival of first acknowledgement of a segment sent without retransmission:

   \[
   \begin{align*}
   \text{if} & \quad (CWND < SSTHRESH) \\
   \text{then} & \quad CWND = CWND + 1 \quad /\!\!/ \text{do slow start} \\
   \text{else} & \quad CWND = CWND + 1/CWND \quad /\!\!/ \text{do additive increase}
   \end{align*}
   \]

   *Note:* Sometimes there is not a one-to-one correspondence between segments sent and received. For example, some TCP implementations acknowledge once for every two segments received. Or an acknowledgement could be lost. In these cases, letting \( nc0 \) denote the number of previously unacknowledged segments that are acknowledged by an arriving segment, replace "1" by "\( nc0 \)" in formula 3b above.

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\(^1\)The entire computation is scaled by \( 1/d \) to perform integer arithmetic only; see Jacobson App. A.2 and Comer Vol. II pp. 302-304.