xmit time	send	recv	RTT timer	actual delta(ms)	nticks	t_srtt (ticks*8)	t_rttvar (ticks*4)	t_rxtcur (ticks)	t_rxtshift	delta
0.000						0	24	12		
	SYN		on		**0**	**8**	**2**	**3**		
0.005		SYN,ACK	off	4.641	0	7	3	3		-1
0.005	ACK									
96.857	1:7(6)		on							
96.925		ack 7	off	67.919	1	8	4	5		1
126.355	7:25(18)		on							
126.545		ack 25	off	189.645	1	8	3	4		0
138.216	25:31(6)		on							
139.884	25:31(6)		off			8	3	8	1	
143.884	25:31(6)		off			8	3	16	2	
151.885	25:31(6)		off			8	3	32	3	
167.885	25:31(6)		off			0	4	64	4	
167.975		ack 31								
179.475	31:39(8)		on		**1**	**16**	**4**	**6**		
179.585		ack 39	off	109.161	0	14	5	6		-2
184.805	39:46(7)		on							
184.985		ack 46	off	179.767	1	14	4	5		0

Init:
t_srtt = 0
t_rttvar = 24
RTO = 12

First:
t_srtt = (nticks+1) × 8
t_rttvar = (nticks+1) × 2
RTO = (nticks+1) × 3

Other:

$$delta = nticks - \frac{t\_srtt}{8}$$

$$t\_srtt = t\_srtt + delta$$

$$t\_rttvar = t\_rttvar + |delta| - \frac{t\_rttvar}{4}$$

$$RTO = \frac{t\_srtt}{8} + t\_rttvar$$

```
$ ./updown.sh
```

```
$ cat ./updown.sh
trap 'ifconfig en1 up; exit' HUP INT QUIT TERM

while :
do
ifconfig en1 down
perl -e 'select undef,undef,undef,0.5'
ifconfig en1 up
sleep 1
done
```

```
% ./sock -D -v -i -n16 -w256 -R512 -S512 22.236.180.217 discard
SO_RCVBUF = 512
SO_SNDBUF = 512
connected on 22.236.180.216.55056 to 22.236.180.217.9
SO_DEBUG set
TCP_MAXSEG = 500
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
wrote 256 bytes
% ./strpt | grep -p 55056 >./cong.strpt

% tcpdump -n -ttttt -r ./cong.pcap 'port 55056' >./cong.pcap.first
% tcpdump -n -ttt -r ./cong.pcap 'port 55056' >./cong.pcap.pre
% tcpdump -S -n -ttt -r ./cong.pcap 'port 55056' >./cong.pcap.pre.abs
% paste -d'\t\t\t\t' cong.pcap.pre cong.pcap.pre.abs >./cong.pcap.merge
% awk '{print NR"\t"$0"\n"}' cong.pcap.merge >cong.pcap.merge.tab
```

Segment#	Action			Variable	
	Send	Receive	Comment	cwnd	ssthresh
	SYN		init	500	1073725440
	SYN				
		SYN,ACK	timeout rxmt	500	2920
	ACK				
1	1:257(256)				
2		ack 257	slow start	1000	2920
3	257:757(500)				
4	757:769(12)				
5		ack 769	slow start	1500	2920
6	769:1025(256)				
7	1025:1525(500)				
8		ack 1525	slow start	2000	2920
9	1525:1537(12)				
10	1537:2037(500)				
11	1525:2025(500)		timeout rxmt	500	1000
12		ack 2037	slow start	1000	1000
13	2037:2305(268)				
14	2305:2805(500)				
15		ack 2805	slow start	1500	1000
16	2805:2817(12)				
17	2817:3317(500)				
18		ack 3317	cong.avoid	1666	1000
19	3317:3585(268)				
20	3585:4085(500)				
21	4085:4097(12)				
22		ack 4098	cong.avoid	1816	1000

(Segment 11 note: max(2MSS, cwnd/2))

Congestion avoidance:

$$cwnd \leftarrow cwnd + \frac{segsize \times segsize}{cwnd}$$

```
% dd if=/dev/zero of=./nullfile bs=64k count=1
% ./sock -D -v -w256 -R512 -S512 22.236.193.249 discard <./nullfile
SO_RCVBUF = 512
SO_SNDBUF = 512
connected on 22.236.180.216.55107 to 22.236.193.249.9
SO_DEBUG set
TCP_MAXSEG = 500
process 6947018: connection closed normally

% tcpdump -w ./icmp.pcap -i en1
(no icmp error packet)
```

```
sleep 5
route delete -host 22.236.193.249 22.236.180.1
sleep 30
route add -host 22.236.193.249 22.236.180.1
ksh -i route.sh
```