

TCP

CS 168 Discussion
Week 6

Many thanks to past EE 122 GSIs

These are TCP Details!

- These details **ARE NOT** representative of all sliding window protocols!

TCP Sequence Numbers

- Initial sequence number not necessary 0
- Sequence number refers to **first byte in TCP payload**

e.g.

Initial Sequence Number = **N**

Packet with payload bytes 100 – 1000 has seq. no.

N + 100

TCP Acknowledgements

- ACK Number = **Next expected byte**
- ACK for Sequence Number 1000, payload size 500?
 - 1500 (packet has bytes 1000,1001...,1499)
- Cumulative ACKs

TCP Flow Control

- Keep **sender from overwhelming receiver**
- **Window Size:** Maximum number of bytes a receiver can accept
- Doesn't say anything about whether the **network** is overwhelmed...

Congestion Control

- Avoid **overwhelming the network**
- **CWND** – Congestion Window maintained at sender
- **SSTHRESH** – Threshold until which exponential slow start happens
- How much can a sender send?
 - **MIN(CWND, Receiver Window Size)**

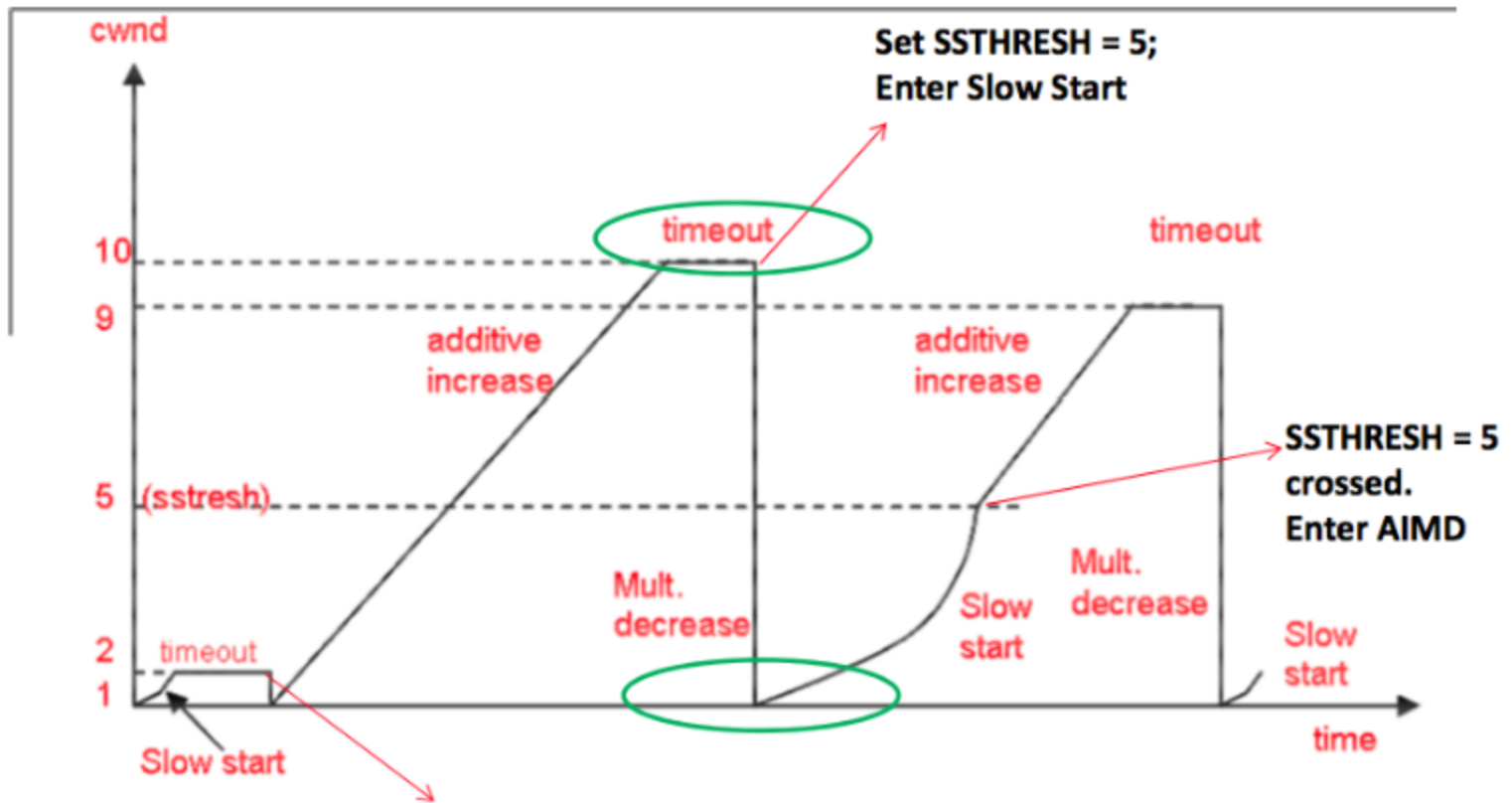
Congestion Control: States

- TCP in *slow start* or “*Additive Increase, Multiplicative Decrease (AIMD)*”
- **Slow Start:** For Each ACK: $CWND += MSS$
- **AIMD:** For Each Window: $CWND += MSS$

Congestion Control: Loss

- Triple Duplicate ACK: Indicates **single packet loss**
 - Retransmit single packet
 - $SSTHRESH = CWND / 2$
 - $CWND = SSTHRESH$
- Timeout: Indicates **congestion**
 - $SSTHRESH = CWND / 2$
 - $CWND = 1$

'Vanilla' TCP



Set Ssthresh = 1; Enter directly into AIMD since Ssthresh is already crossed.

Worksheet!

Question 1: TCP Sequence Numbers

- a)
 - Lowest: **10001** (first un-ACKed byte)
 - Highest: **15000** (first un-ACKed byte + window size)
- b) **1501** (Sequence Number + Payload Size)
- c)
 - Lowest: **1501**
 - Highest: **1550**
- d) **No – A sends $\text{MIN}(\text{CWND}, \text{Window})!$**

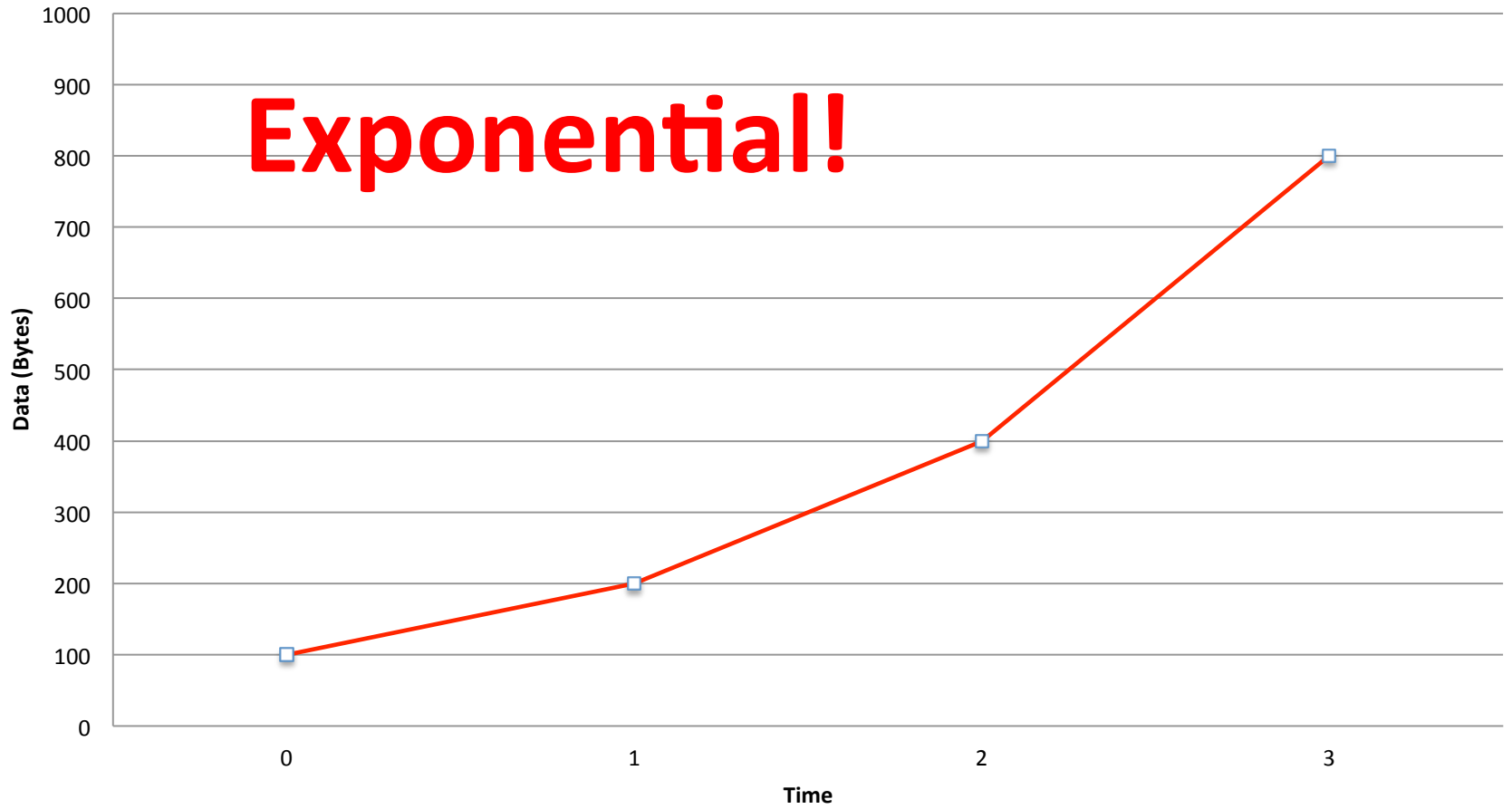
Question 2a

††

At Time:	When the sender receives ACK #:	She sets her CWND to:	And Sends Packets with the following sequence numbers:
0	---	100	1
1	101	200	101, 201
2	201	300	301, 401
2	301	400	501, 601
3	401	500	701, 801
3	501	600	901, 1001
3	601	700	1101, 1201
3	701	800	1301, 1401

□

Question 2b,c



Question 3a

Time	ACK	CWND	SSTHRESH
0	801	1000	800
1	901	1010	800
2	1001	1020	800
3	1101	1030	800
4	1101 (1)	1030	800
5	1101 (2)	1030	800

Question 3b,c

- 3b) Isolated Packet Loss
- 3c) Linear

Question 3d

Time	ACK	CWND	SSTHRESH
0	801	1000	800
1	901	1010	800
2	1001	1020	800
3	1101	1030	800
4	1101 (1)	1030	800
5	1101 (2)	1030	800
6	1101 (3)	815	515
7	1101	915	515
8	1101	1015	515
9	1101	1115	515
10	1801	515	515
11	1901	535	515

Question 3e,f

- 3e) Congestion in the Network
- 3f) No need to throttle traffic aggressively for single packet drop. When congested: need to slow down!

Question 4: Analyzing the TCP Congestion Window

- a) 1-6, 22-25
- b) 6-14, 15-21
- c) Triple Duplicate ACK
- d) 32
- e) 20
- f) 12
- g)
 - $SSTHRESH = CWND / 2 = 8 / 2 = 4$
 - $CWND = CWND / 2 = 4$