# Comparison of different congestion control mechanisms: TFRC and TCP(a, b)

ENSC835 and CMPT885 project team 15

Jian(Jason) Wen and Yi Zheng

# Motivation

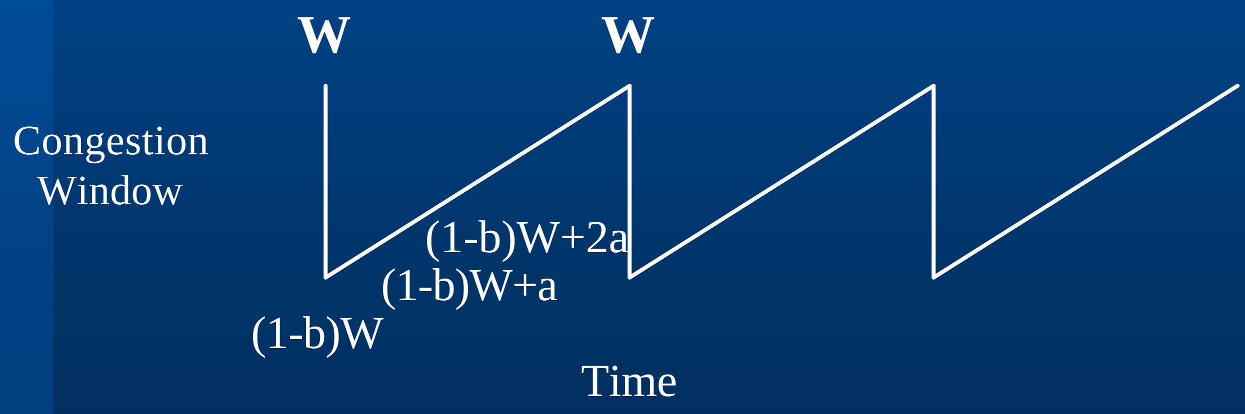
- Congestion control in packet networks has been proven a challenge in the Internet because of the different requirements of different kinds of applications running based on the Internet.
- The abrupt changes in the sending rate of  TCP congestion control mechanism have been a significant impediment to the deployment of TCP’s end-to-end congestion control by emerging applications such as steaming multimedia.
- We compare the performance of TCP and the other congestion control algorithms (AIMD($a$, $b$) and TFRC) under similar environment.

# TCP congestion control mechanism

- TCP congestion control mechanism is the dominant algorithm of current Internet.
- In TCP congestion control mechanism, the ‘sending rate’ is controlled by a congestion window which is halved for every window of data containing a packet drop, and increased by roughly one packet per window of data otherwise.
- TCP congestion control is very effective at rapidly using bandwidth when it becomes available.

# AIMD congestion control mechanism(1)

- AIMD(*a*,*b*) generalizes TCP by parameterizing the congestion window increase value and decrease ratio. That is, after a loss event the congestion window is decreased from *W* to *(1-b)W* packets, and otherwise the congestion window is increased from *W* to *W+a* packets each round-trip time.



# AIMD congestion control mechanism(2)

- The sending rate function of AIMD(*a*, *b*):

$$\hat{T} = \frac{\sqrt{2-b}\sqrt{a}}{\sqrt{2b}R\sqrt{p}}.$$

R: round trip time; p: packet drop rate

TCP is a specified example of AIMD as AIMD(1, 1/2). To make the sending rate of TCP and AIMD(*a*, *b*)comparable, let

$$\hat{T}_{1,1/2,R,p} = \frac{\sqrt{1.5}}{R\sqrt{p}}. = \frac{\sqrt{2-b}\sqrt{a}}{\sqrt{2b}R\sqrt{p}}.$$

From the equation above we can derive that AIMD (1/5, 1/8) and (3/7, 1/4) should compete reasonable fairly with AIMD(1,1/2) or say TCP.

# TFRC congestion control mechanism(1)

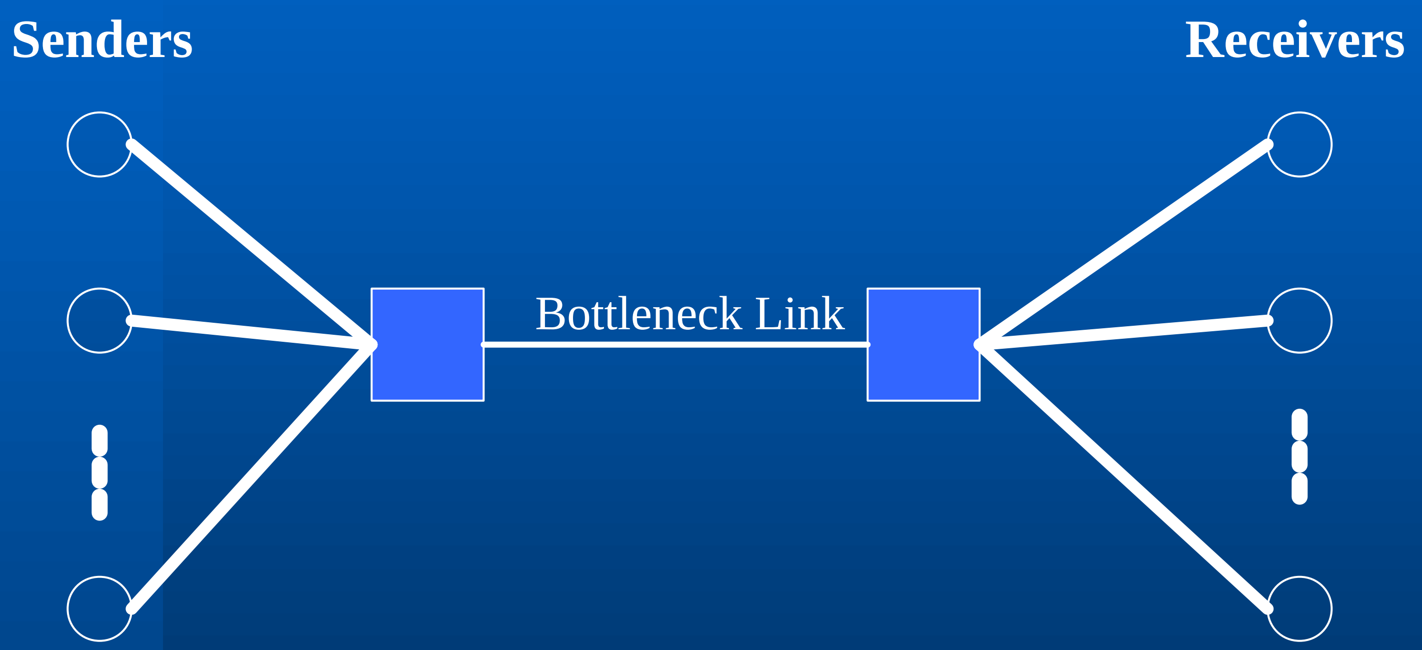
- The receiver measures the loss event rate and feeds this information back to the sender.
- The sender also uses these feedback messages to measure the round- trip time (RTT).
- The loss event rate and RTT are then fed into TFRC's throughput equation, giving the acceptable transmit rate.
- The sender then adjusts its transmit rate to match the calculated rate.

# TFRC congestion control mechanism(2)

$$T = \frac{s}{R\sqrt{\frac{2p}{3}} + t_{RTO}\left(3\sqrt{\frac{3p}{8}}\right)p(1+32p^2)}$$

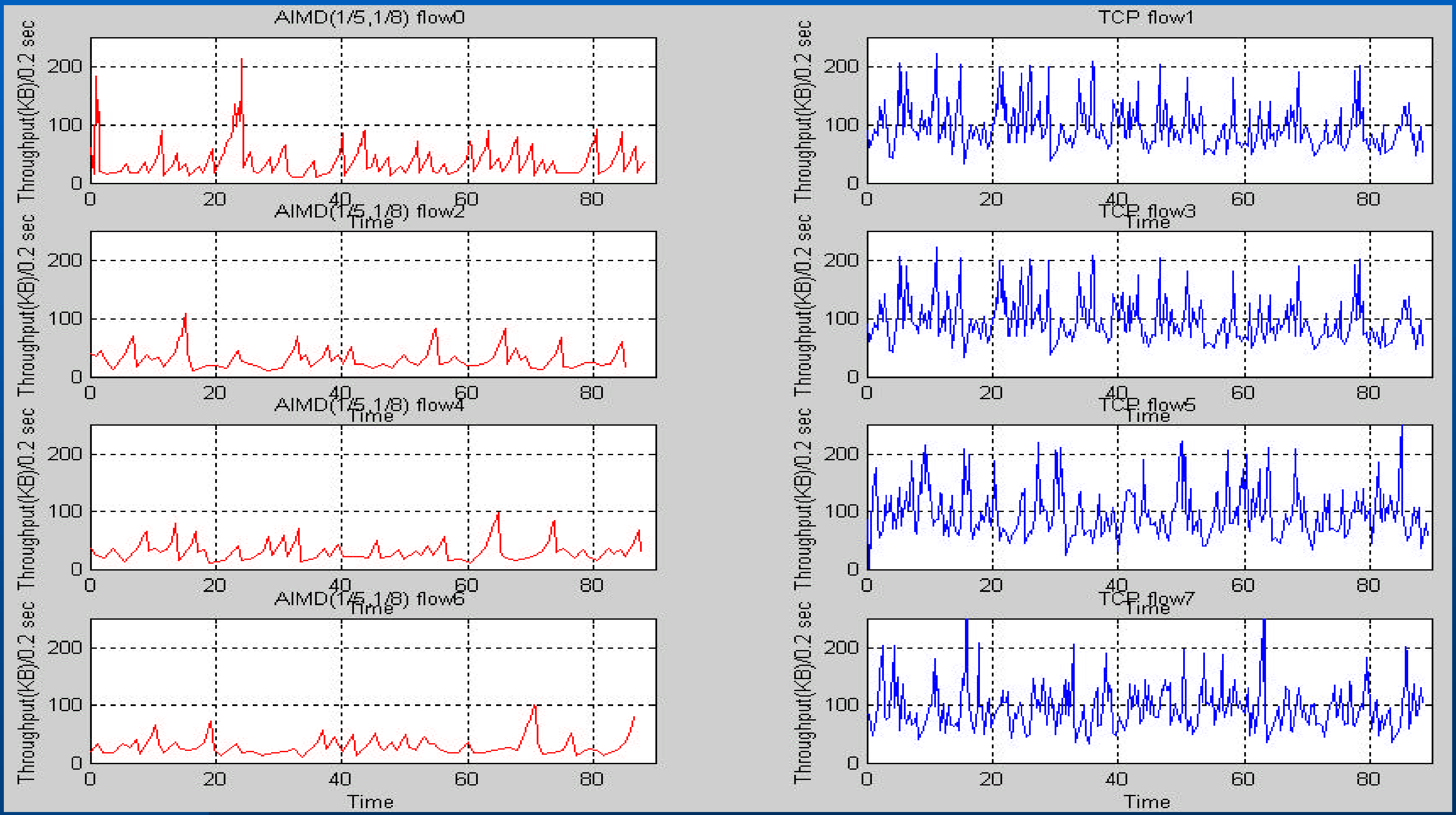
p: packet size
R: round trip time
p: steady-state loss event rate
$t_{RTO}$: TCP retransmit timeout value

# Simulation Scenario

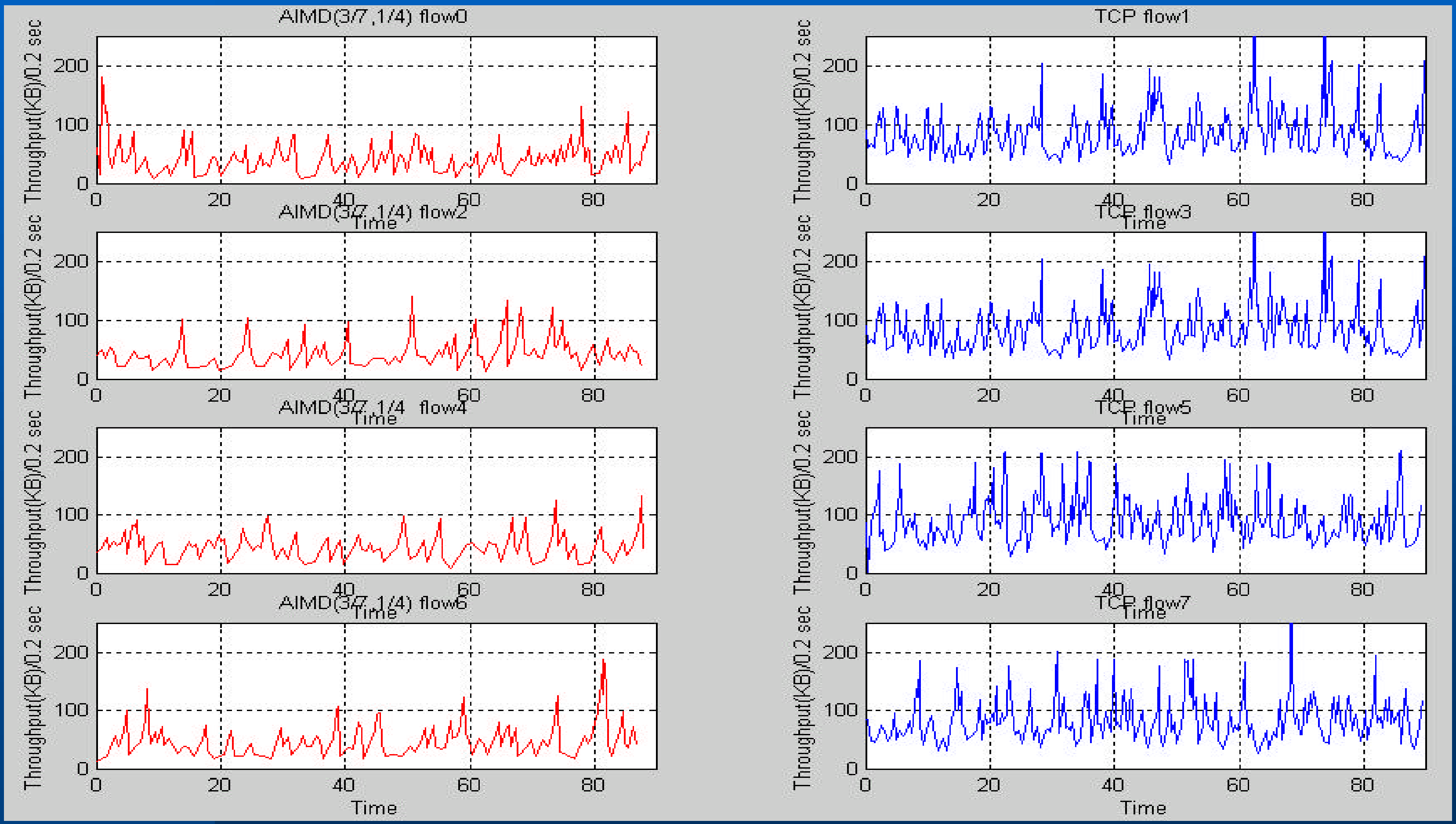



- Topology: Dumb-bell
- Metrics: *throughput*, *loss rate*

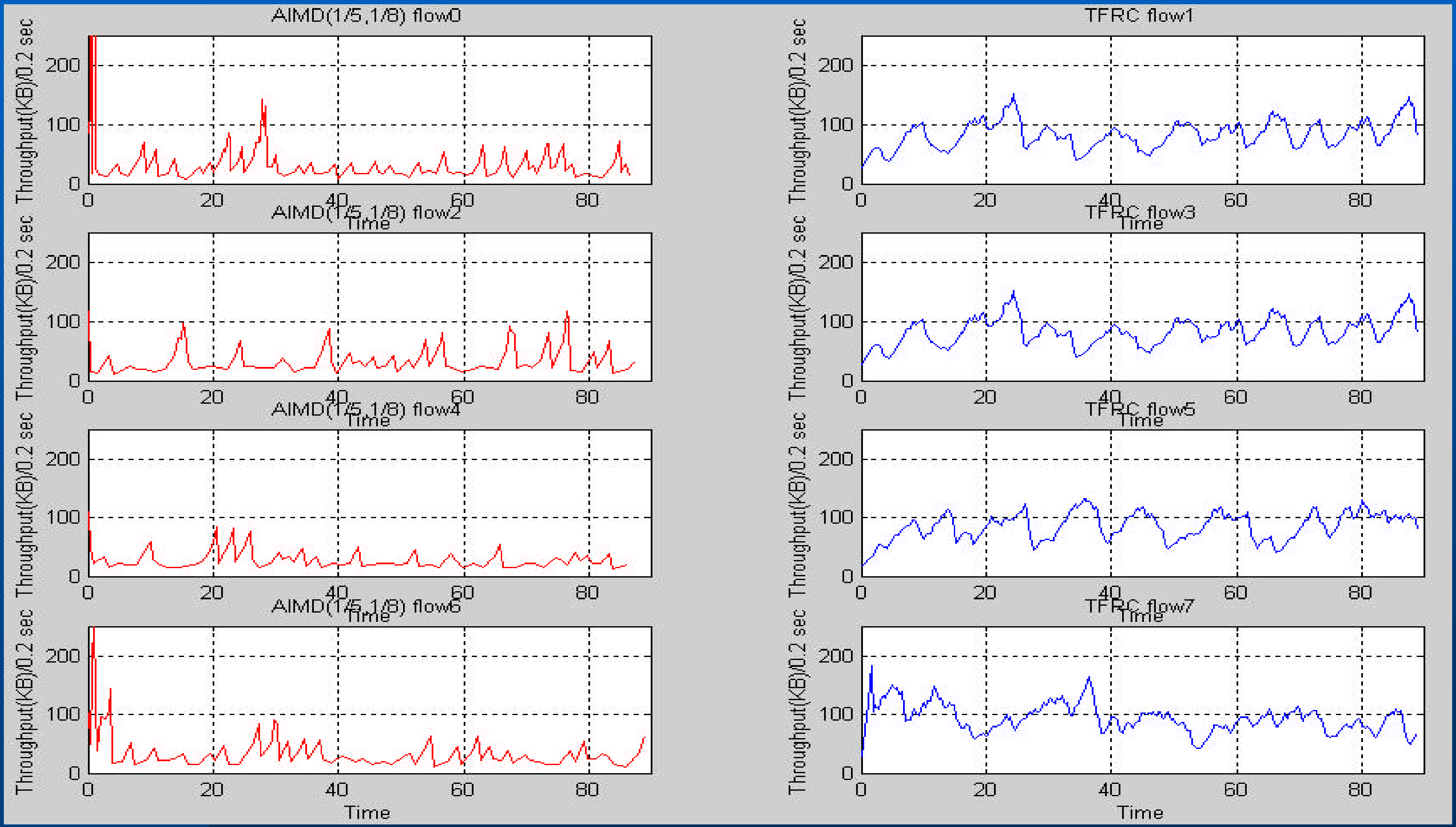
# Simulation result: AIMD(1/5,1/8) compares with TCP



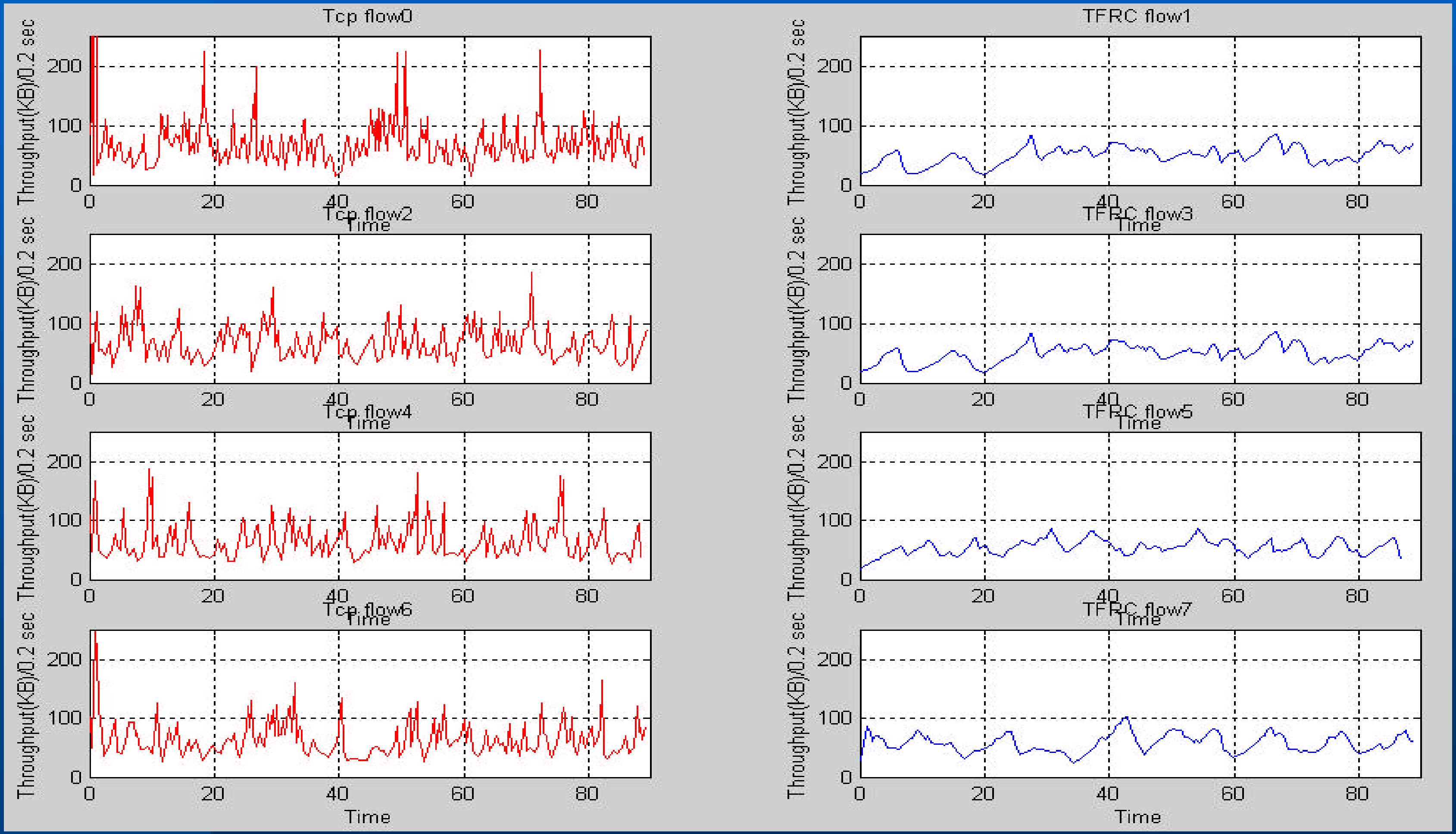
# Simulation result: AIMD(3/7,1/4) compares with TCP



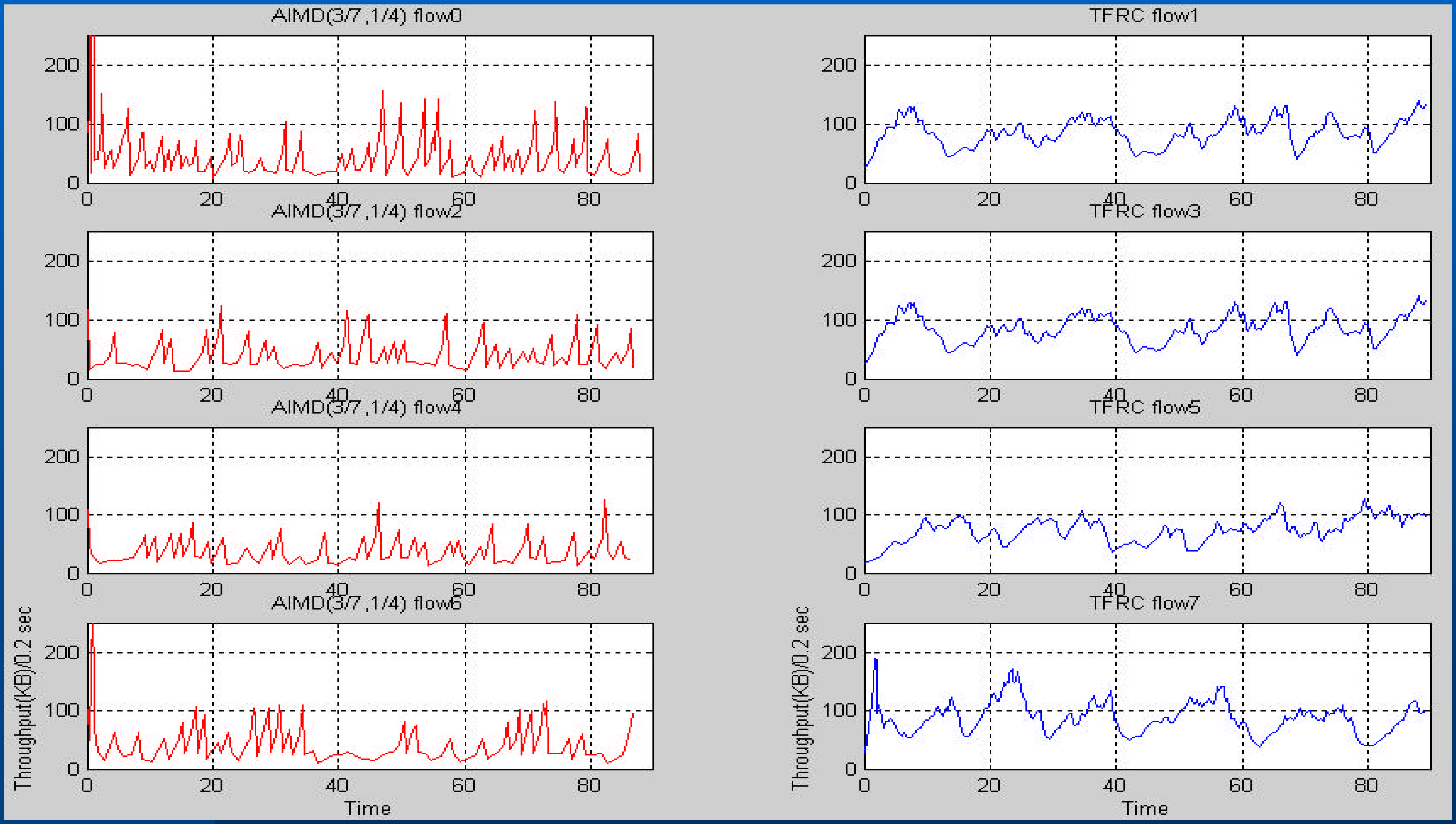
# Simulation result: AIMD(1/5,1/8) compares with TFRC



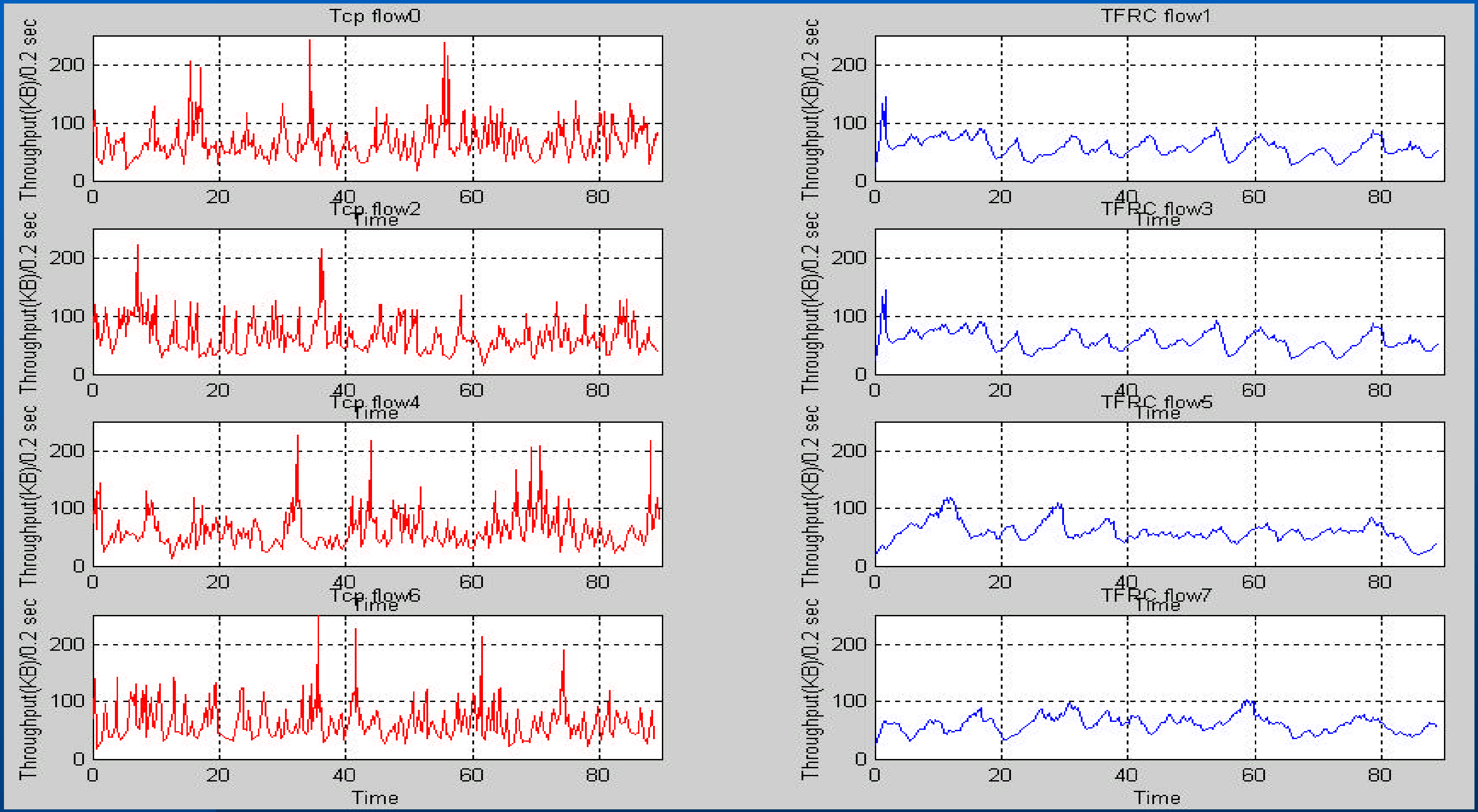
# Simulation result: TCP compares with TFRC



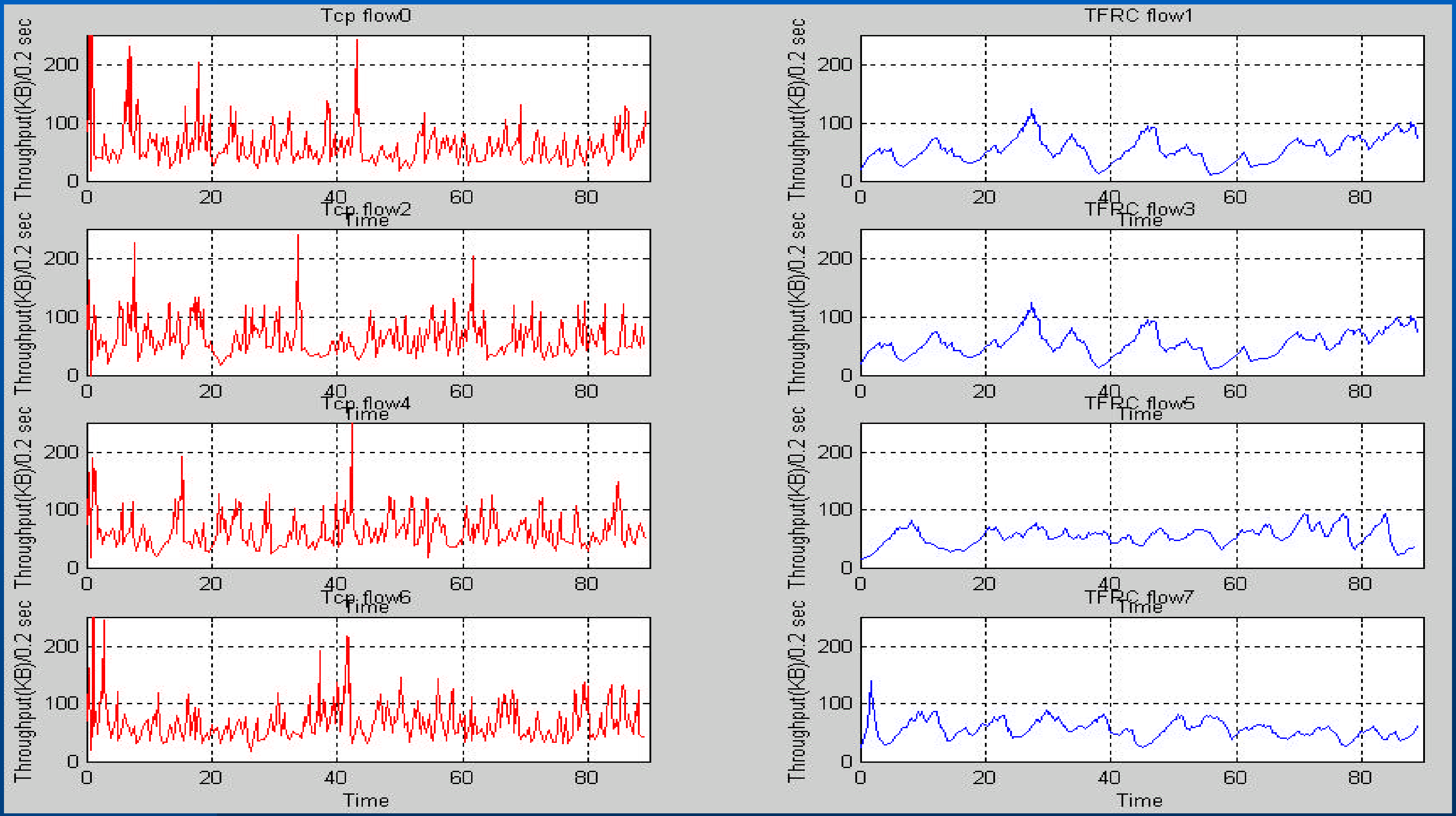
# Simulation result: AIMD(3/7,1/4) compares with TFRC



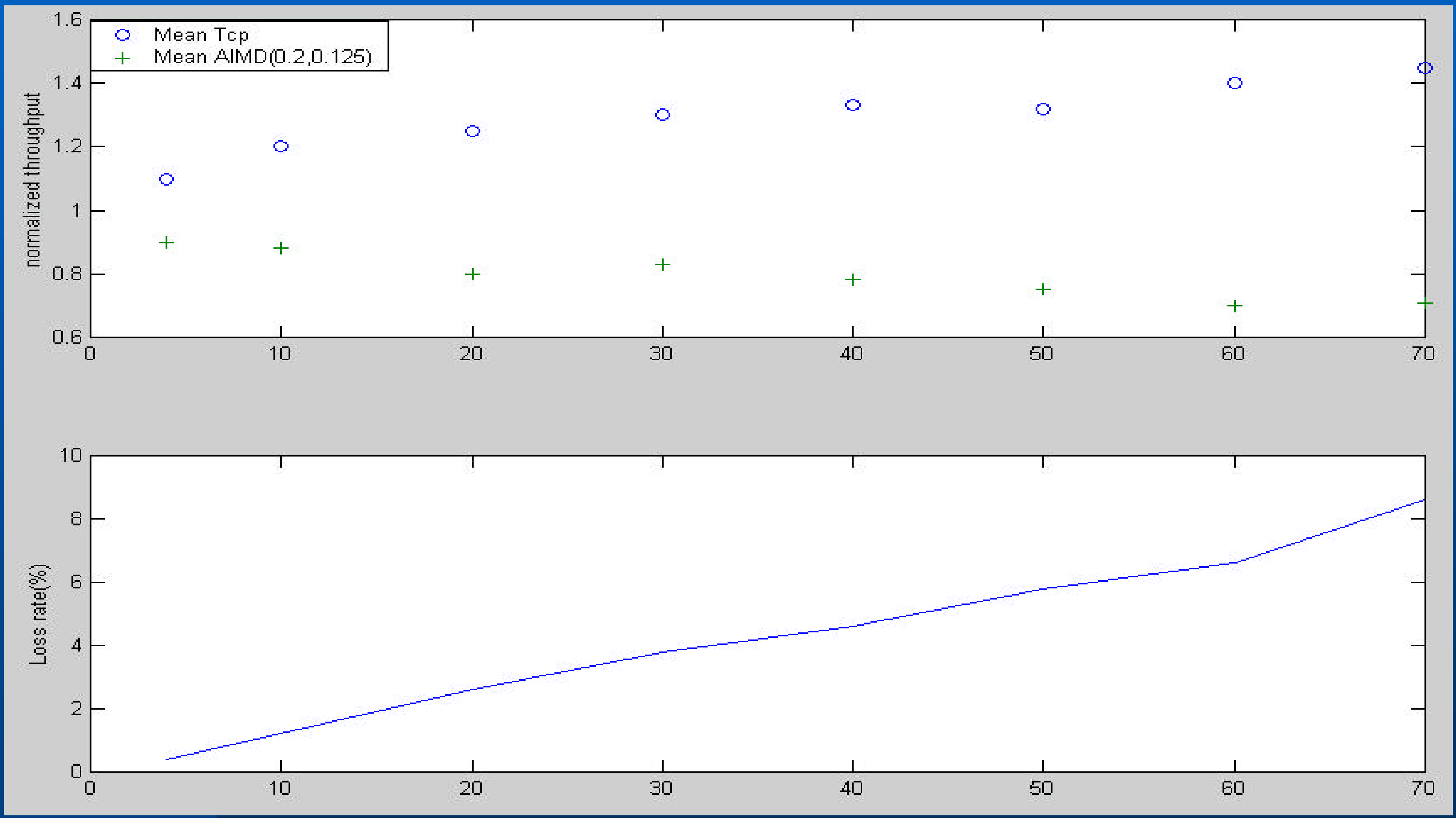
# Simulation result: TCP(window size =20 ) compares with TFRC



# Simulation result: TCP(window size =1000 ) compares with TFRC

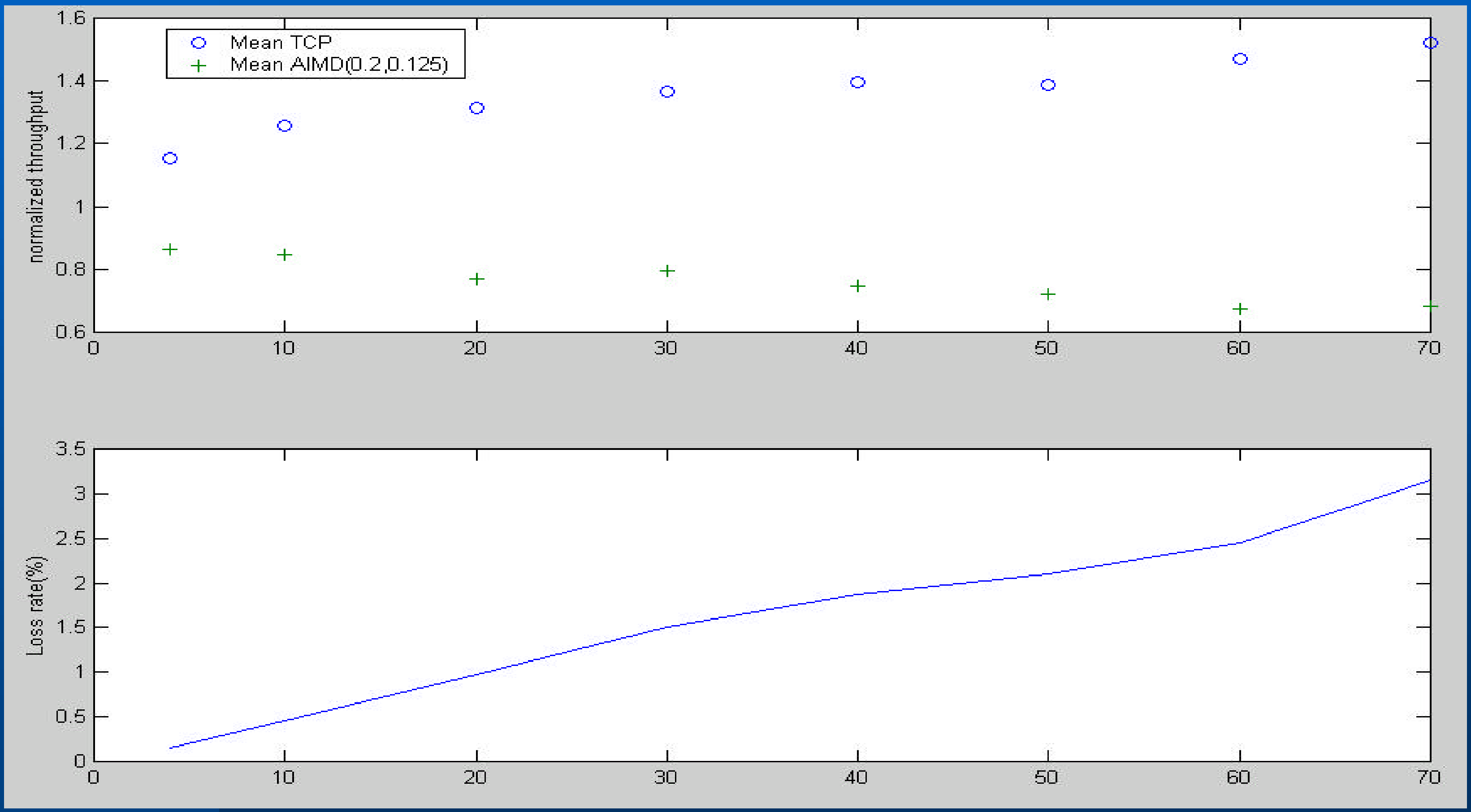


# Simulation result: TCP compares with AIMD(1/5, 1/8)



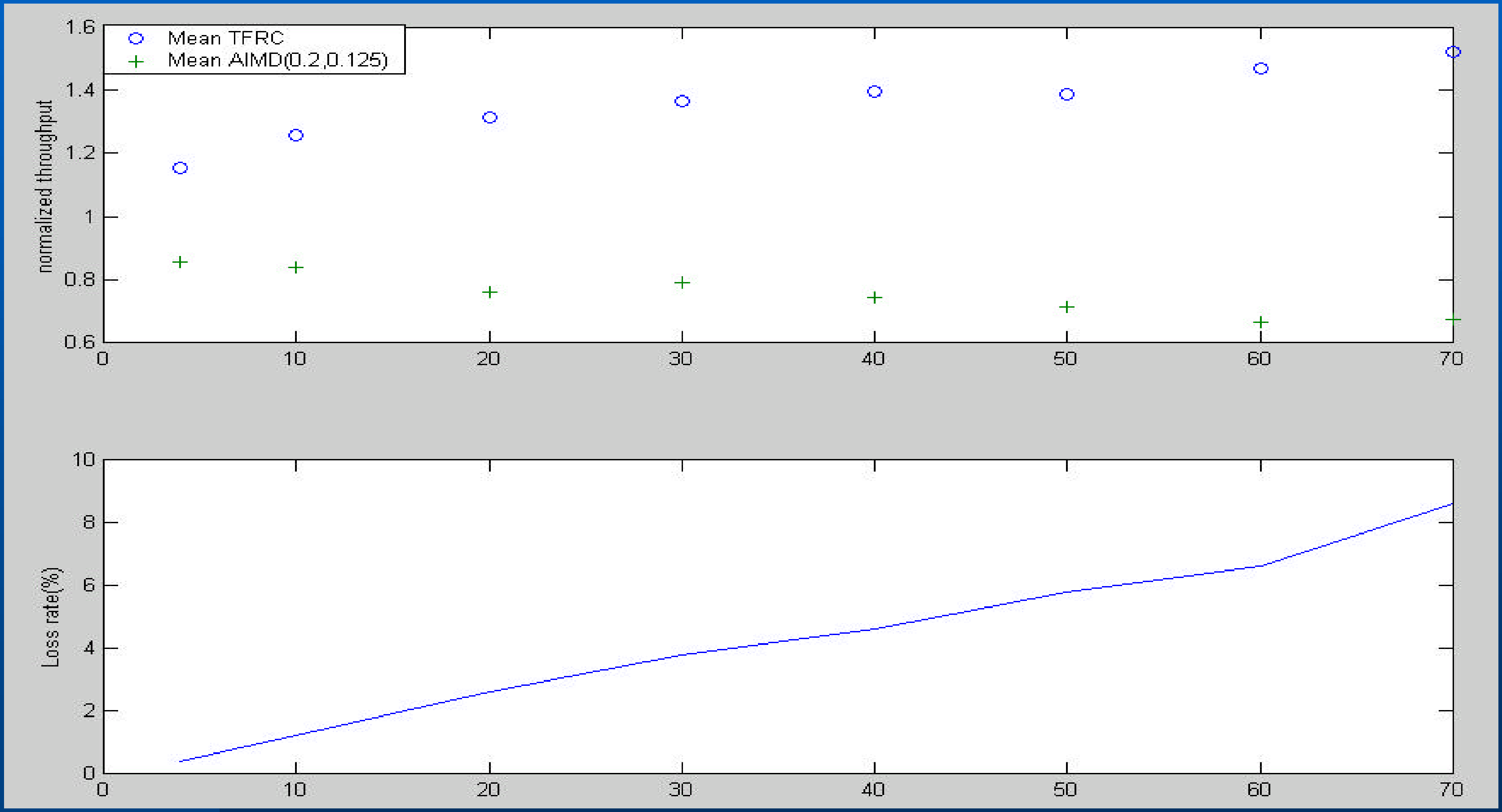

Trunk link capacity:15Mbps

# Simulation result: TCP compares with AIMD(1/5, 1/8)



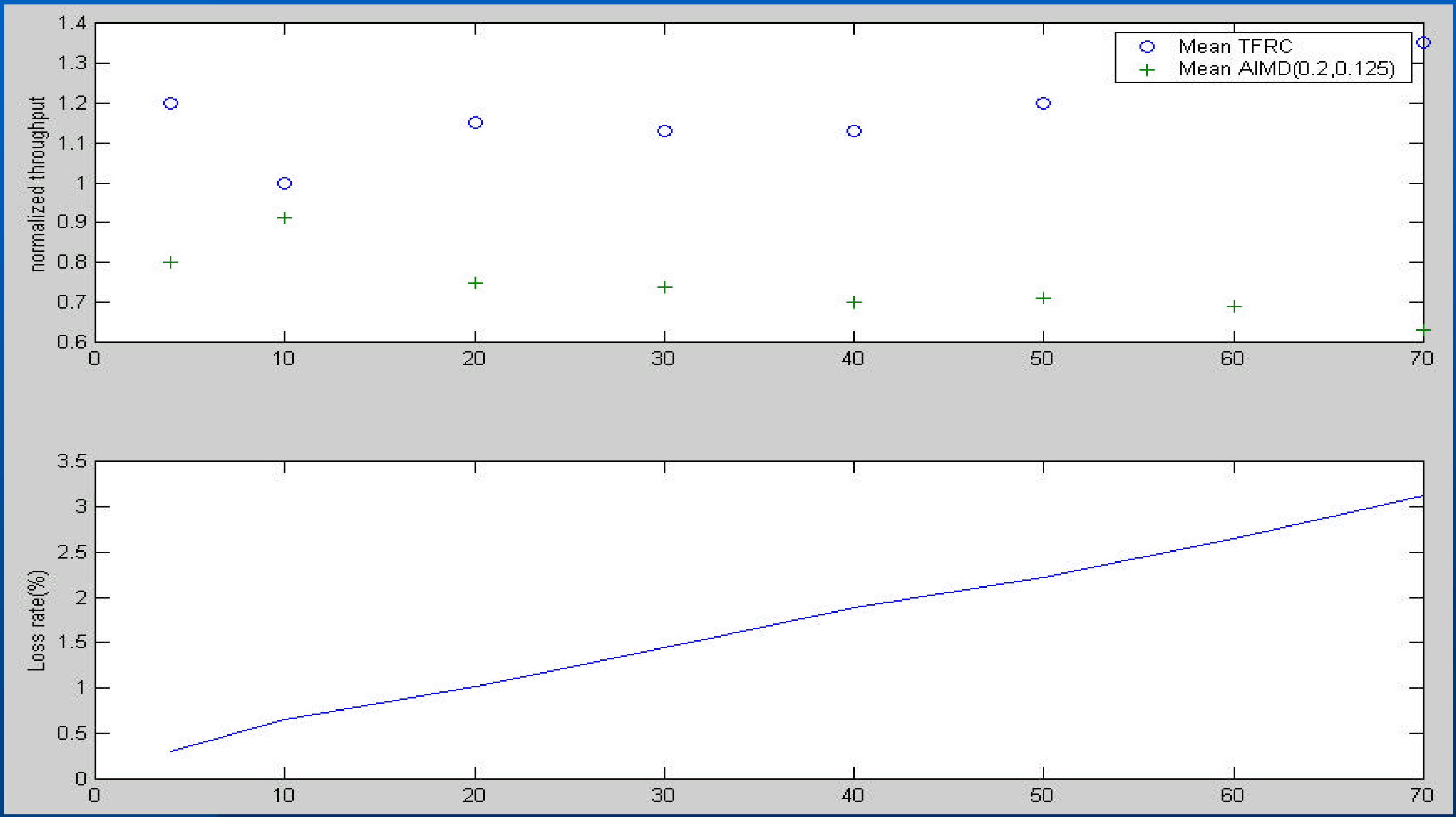

Trunk link capacity:60Mbps

# Simulation result: TFRC compares with AIMD(1/5, 1/8)




Trunk link capacity:15Mbps

# Simulation result: TFRC compares with AIMD(1/5,1/8)




Trunk link capacity:60Mbps

# Comparison of different queuing effects

- Drop-tail
- FQ(Fair Queuing)
- SFQ(Stochastic Fair Queuing)
- DRR(Deficit Round Robin)
- RED (Random Early Drop)
- CBQ (Class-Based Queuing)

# Conclusions

- The AIMD(3/7, 1/4) and AIMD(1/5, 1/8) flows are smoother than the TCP flows, but less smooth than the TFRC flows.
- The throughput of the TCP(1/5, 1/8) is smaller than TCP(3/7, 1/4) but smoother than the latter.
- When AIMD(3/7, 1/4) and AIMD(1/5, 1/8) compared with TCP, the mean throughput of TCP is higher.
- When TCP with very small window size compared with TFRC, the throughput of TFRC does not take too much bandwidth of the link.It proves its “friendly relation with TCP”.
- AIMD(1/5, 1/8) and AIMD(3/7, 1/4) compete fairly with TCP and with TFRC , while avoiding TCP’s reduction of the sending rate in half in response to a single packet drop.

# Main References


- Jamal Golestani, A Class of End-to-End Congestion Control Algorithms for the Internet , Proceedings of ICNP, 1998.
- S. Kunniyur and R. Srikant, "End-To-End Congestion Control: Utility Functions, Random Losses and ECN Marks", Longer version of the paper that appeared in Proceedings, INFOCOM 2000, Tel-Aviv, Israel, March 2000. Also submitted to IEEE Transactions on Networking
- S. Kunniyur and R. Srikant, "Fairness of Congestion Avoidance Schemes in Heterogeneous Networks", Proceedings, International Teletraffic Congress-16, Edinburgh, Scotland, 1999
- Yair Bartal, J. Byers and D. Raz, Global Optimization using Local Information with Applications to Flow Control, STOC, October 1997.
- TCP Friendly Rate Control (TFRC): Protocol Specification, Handley, M., Pahdye, J., Floyd, S., and Widmer, J. Internet draft draft-ietf-tsvwg-tfrc-02.txt, work in progress, May 2001.
- R. Rejaie, M. Handley, and D. Estrin. “An End-to-end Rate-based Congestion Control Mechanism for Real-time Streams in the Internet”. In *Proceedings of INFOCOMM 99*, 1999.