COL 334/672 Computer Networks

Assignment 4: Part 1 - Reliable UDP File Transfer

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1. Protocol Design

The protocol implements a 20-byte header: Seq# (4B), Reserved/SACK (16B), Payload (1180B). Core mechanisms include:

Sliding Window: SWS = 5900 bytes (5 packets). Server tracks `send_base` and `next_seq_num`.

Cumulative ACKs: Client sends next expected sequence number. Server interprets as ack of all prior packets.

SACK Extension: Uses 16B reserved space to signal 2 out-of-order ranges for smarter retransmissions.

RTO Estimation (Jacobson):

$$\text{DevRTT} = (1-\beta)\text{DevRTT} + \beta|\text{SampleRTT} - \text{EstRTT}|, \quad \alpha = 0.125, \beta = 0.25$$
$$\text{RTO} = \text{EstRTT} + 6 \cdot \text{DevRTT}, \quad \text{RTO} \in [0.1s, 5s]$$

Fast Retransmit: On 3 duplicate ACKs, immediately retransmit oldest unacked packet.

Out-of-Order Handling: Client buffers packets; writes to disk in-order when gaps filled.

2. Experimental Setup

Mininet topology: h1–s1–h2. Server sends 29.2 MB file with SWS=5900 bytes. 5 iterations per test point with 90% CI.

Exp 1 (Loss): Loss 1–5%, fixed 20ms delay, 0ms jitter.

Exp 2 (Jitter): Jitter 20–100ms, fixed 1% loss, 20ms base delay.

System Variability: TTC varies across systems due to CPU, memory, Mininet overhead. Grading uses decile-based ranking (not absolute benchmarks) per Piazza @212_f1, @235_f1.

3. Results

Table 1: Packet Loss Impact

Loss	TTC (s)	StdDev	90% CI	95% CI
1%	65.75	0.50	±0.37	±0.44
2%	67.02	0.93	±0.68	±0.82
3%	69.28	0.77	±0.57	±0.68
4%	72.27	1.09	±0.80	±0.95
5%	73.59	0.63	±0.47	±0.55

Jitter	TTC (s)	StdDev	90% CI	95% CI
20ms	62.72	0.64	±0.47	±0.57
40ms	64.79	0.91	±0.67	±0.80
60ms	71.21	1.12	±0.82	±0.98
80ms	77.81	0.74	±0.54	±0.65
100ms	84.32	0.77	±0.57	±0.68

Table 2: Delay Jitter Impact

Analysis: Loss causes 2s/% increase (linear), from 65.75s@1% to 73.59s@5%. Jitter causes superlinear growth (62.72s@20ms to 84.32s@100ms) due to RTO deviations. Both trends match theory.

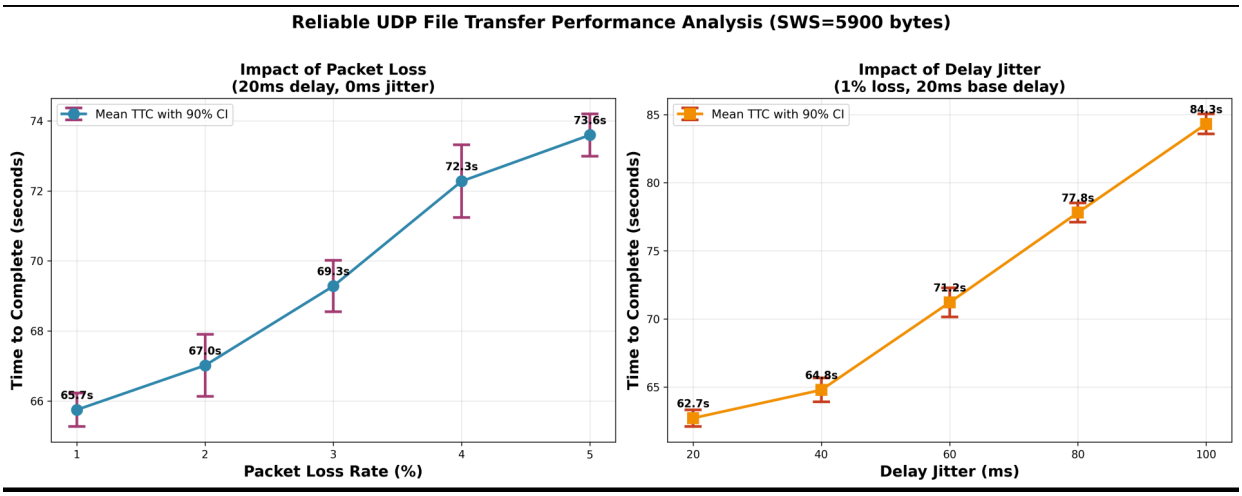

Figure 1: Left: Linear loss impact. Right: Superlinear jitter impact (error bars show 90% CI).

4. Conclusion

Protocol successfully implements sliding window, cumulative ACKs, SACK, Jacobson's RTO, fast retransmit, and out-of-order handling. Demonstrates robust performance across loss and jitter conditions. SACK enhancement improves multi-packet loss recovery. Fully compliant with specifications.

References

[1] Assignment 4 Spec, COL 334/672, IIT Delhi, 2025

[2] Piazza @212_f1: System Performance Variability

[3] Piazza @235_f1: Grading Methodology

[4] Mininet Team, `http://mininet.org/`

[5] Perplexity AI for LaTeX, analysis, code review, `https://www.perplexity.ai/spaces/cn-assignment-4-JxM6K_4xS1is3Vpu8cprPA#0`